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Opening Remark and speech by Rector Dr Aung Win University of Myitkyina

Good Morning....

Chief Minister of Kachin State, speakers from Japan, Malaysia, Vietnam and Myanmar Pro-rectors of Myitkyina University, Professors, University Teachers and students from Myitkyina University, invited guests and all participants.

I am very pleased to welcome all of you to the first Myanmar International Science and Culture Conference 2019 (MISCC 2019) organized by Myitkyina University. The main aim of this conference is to promote, strengthen and expand the networking among local researchers and international researchers. First of all, I wish all of you to be in health of body and peace of mind. I would like to extend a welcome to every to this special occasion. Firstly, I'd like to express the brief history of Myitkyina University. The Aged University of Myitkyina was first opened on the 14th July, 1958. Myitkyina College was changed into the regional college of Myitkyina on 23rd of May 1977. Myitkyina College was upgraded into Myitkyina Degree College on 12th February, 1986 and Myitkyina Degree College was developed into Myitkyina University in 1998. The area of the campus is 220.788 acres. There are 14 academics departments, 294 teaching staff and 260 office staff at Myitkyina University. The courses offered by Myitkyina University are B.A, B.Sc., M.A and M.Sc. Degrees.

Secondly, as you all know, Today's world is called a global villaage and IT age. I am glad to hear there are over 200 papers that are going to be presented to MISCC 2019. It is hoped that participants who are going to present their respective papers related with Natural Science, Life Science and Social Science, and Culture and Linguistics will contribute a lot of benefits to our society. Because research is the life blood of Universities. Finally, I's like to say "No research, no good result at University Campus". I am sure this conference will make us beneficial to some extend so I would like to remind all the participants to take part in this conference actively. Thank you very much.

Plant-based bioplastics for sustainable development: recent progress and advancement

Prof. Dr. Hiroshi Uyama
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Using biomass as starting material for chemicals and plastics contributes to global sustainability without depletion of scarce resources, because of their large potential to substitute petrochemical derivatives to bio-based ones in industries. Poly(L-lactic acid) (PLLA) is one of the most typical plant-based bioplastics (biomass plastics) showing good biodegradability. However its demerits such as low physical properties and slow molding process have restricted the development of industrial applications of PLA. The present talk deals with recent progress and advancement of biomass plastics applications.

We have focused biomass products such as plant oils and cellulose for preparation of functional bio-based materials. For example, natural plant oil sources are found in abundance in the world; and hence, are expected as an ideal alternative chemical feedstock. Inexpensive triglyceride natural oils have been utilized extensively for coatings, inks, plasticizers, lubricants, resins and agrochemicals in addition to their applications in food industry.

We have developed biocomposites from epoxidized plant oils and cellulose fibers. Cellulose nanofibers reinforced oil polymer-based polymers to provide good mechanical and thermal properties of the composites. Green nanocomposite coatings were prepared by an acid-catalyzed curing of epoxidized plant oils with 3 glycidoxypropyltrimethoxysilane. The nanocomposite showed excellent film properties; the hardness and mechanical strength improved by incorporating the silica network into the organic polymer matrix and the good flexibility was observed. The dynamic viscoelasticity analysis clearly showed reinforcement effect by the inorganic network.

We have synthesized branched bio-based polyesters from lactic acid and a plant oil and examined their applications to improve properties of PLLA. Castor oil was used as initiator for synthesis of a branched bio-based polymer by ring-opening polymerization of L-lactide or polycondensation of L-lactic acid. The addition of only a small amount of the branched polymer to PLLA improved the strain at break, showing good plasticization effect of the branched polymer for PLLA. The terminal hydroxyl group in this branched polymer was modified by phthalic anhydride. The product with potassium salt form greatly induced the crystallization of PLLA to improve the thermal and mechanical properties of PLLA.

Eucommia ulmoides accumulates trans-1,4-polyisoprene (EuTPI) in the leaves, bark, root, and fruit coatings, which exhibits higher modulus and less flexibility than cis-1,4-polyisoprene. EuTPI can be regarded as a new class of high-performance bio-based elastomers. The blending of EuTPI with PLLA significantly improved the toughness and impact resistance of PLA.

A Glimpse on Enchanting Kachin State

Prof. Dr. Toe Hla

Scholars, Collages, Ladies & Gentlemen

It's a great honor to me for being invited as a keynote speaker in this international symposium held on this very auspicious day of 30 November 2019 and in this grandiose university of Myitkyina, Kachin state. When I recall my memory, I am still remembering the date of my first arrival at Myitkyina Intermediate College which was then newly open for welfare of the youths living in this Kachin State. It was 9 September 1963 that I reported my first university service duty as a tutor in History Department.

A saying has it that one should not forget the first place where one has overcome difficulties encountered in one's life. I started my university service carrier in this University (then an Intermediate College enrolled less than a hundred students) on 9 September 1963; It is now over 50 years past. Indeed, Myitkyina is an unforgettable place in my life for two amazing event. One is that I started my service life here and another is that I got imarried a beautiful girl of Myitkyina native.

Ladies and Genetlemen

Myanmar or the Republic of the Union of Myanmar is a fairly big nation on the main land Southeast Asia. It was on 4 January 1948 that Myanmar reemerged as a Union together with its old family members. There are seen States incorporated to form to form a Union; they are the Chin State, the Kachin State, the Kavah State, the Kayin State, the Mon State, the Rakhine State and the Shan state. They all had been parts of Myanmar Kingdom since the Bagan Period. One can come across in Bagan Inscriptions a racial name of Kachin. Inscriptions mention a Kachin race as Jingphaw (Theinphaw). Among the ethnic races more commonplace are the Chins, Kachins, Kayins, Mons, Rakhines and the Shans respectively. Among them I would like to present some points of the Kachin State history very briefly.

Geographically, Ka,chin State in the northern part of the Union bordering from the northeast with the People's Republic of China, It is a hilly region in the middle of which lies the Mogaung-Monyin Plain. Rice and sugar cane cultivation are commonplace in this state. Moreover, it has nature resources that could raise their standard of living to a greater extent had they been under good government with many technical know-how and skill workers. At least, half of the State is covered with dense forests underneath of which there lies invaluable deposits of mineral ores. Kachin State is known worldwide as a Land of the best Jades. The most valuable jades occur in this state and nowhere else as far as we know. What we urgently need in the Kachin State is to have an able and responsible government that could efficiently manage the mining business and extracting forest products. Firstly peace and tranquility should prevail in the State. Without peace how can people enjoy better life? How can they manage production of natural resources and economic prosperity without good governance? Scholars in this symposium could I do hope enhance the audience their scholarly views on social development plans. We also need to educate the youths to be free from narcotic drug abuse. It is because the drug abuse could ruin the society and enslave the State as Chinese people had been dearly suffered by the British imperialists in the 19 and early 20 centuries. And what matters most is the loss of one's characters.

Building an Academic Atmosphere

Professor Than Tun had once said that a University without any implementation of research work could not live long. A university always enhances not only new subjects to acquire but also latest innovative information and findings. Anthropologists and historians as well should dig up all of forgotten customs, traditions and events that led to changes of any form, of the people in the State irrespective of then race and religion... We have no authentic ethnic histories so far to rely on for national history, Scholars mostly do researches only on Bamar history. What we now need is to write ethnic histories using all available source materials. We have to foster ethnic or equipped with research techniques and writing systems or inspired and interested in ethnology, anthology, old traditions and form of changes taken place in the State they could better write own histories all available and reliable source materials collected from every nook and cranny.

In harmony with the political, social and economic developments of the Kachin State, some changes in education could also be now observed a little bit. But many challenges are ahead of us to overcome. We the educators as well as university professors are responsible to do for their best in order to carry out development schemes for the State and also for the Union.

MATHS 001

Some Properties of Convex Cones, Recession Cones and Ordering Cones in Real Linear Spaces

Saw Win, Assistant Lecturer, Dr., Department of Mathematics, Banmaw University

Abstract

In this paper, firstly, basic definitions and some properties of convex cones in real linear spaces are established. Secondly, some useful examples of recession cones in real linear spaces are obtained by using convex sets. Finally, some properties of ordering cones in real linear spaces are investigated.

Keywords: convex, recession and ordering cones

1. Convex Cones in Real Linear Spaces

1.1 Definition

Let X be a given set. Assume that an addition on X , i.e., a map from $X \times X$ to X , and a scalar multiplication on X , i.e., a map from $\sim \times X$ to X , is defined. The set X is called a **real linear space**, if the following axioms are satisfied (for arbitrary $x, y, z \in X$ and $\lambda, \mu \in \sim$):

- (a) $(x+y)+z = x+(y+z)$,
- (b) $x+y = y+x$,
- (c) there is an element $0_X \in X$ with $x+0_X = x$ for all $x \in X$,
- (d) for every $x \in X$ there is a $y \in X$ with $x+y = 0_X$,
- (e) $\lambda(x+y) = \lambda x + \lambda y$,
- (f) $(\lambda+\mu)x = \lambda x + \mu x$,
- (g) $\lambda(\mu x) = (\lambda\mu)x$,
- (h) $1x = x$.

The element 0_X given under (c) is called the **zero element** of X .

1.2 Definition

Let C and T be nonempty subsets of a real linear space X . Then we define the **algebraic sum** of C and T as

$$C+T = \{x+y \mid x \in C \text{ and } y \in T\}$$

and the **algebraic difference** of C and T as

$$C-T = \{x-y \mid x \in C \text{ and } y \in T\}.$$

For an arbitrary $\lambda \in \sim$ the notation λC will be used as

$$\lambda C = \{\lambda x \mid x \in C\}.$$

1.3 Definition

Let X be a real linear space. The set X' is defined to be the set of all linear mappings from X to $\sim$. If we define for all $\phi, \psi \in X'$ and all $\lambda \in \sim$

$$(\phi + \psi)(x) = \phi(x) + \psi(x) \text{ for all } x \in X \text{ and}$$

$$(\lambda\phi)(x) = \lambda\phi(x) \text{ for all } x \in X,$$

then X' is a real linear space itself and it is called the **algebraic dual space** of X .

The algebraic dual space of X' is denoted by X'' and it is called the **second algebraic dual space** of X .

1.4 Definition

Let C be a subset of a real linear space X .

- (a) Let some $\bar{x} \in C$ be given. The set C is called **starshaped at $\bar{x}$** , if for every $x \in C$

$$\lambda x + (1-\lambda)\bar{x} \in C \text{ for all } \lambda \in [0,1].$$

- (b) The set C is called **convex**, if for every $x, y \in C$

$$\lambda x + (1-\lambda)y \in C \text{ for all } \lambda \in [0,1].$$

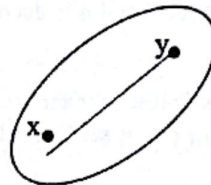


Figure 1. Convex set

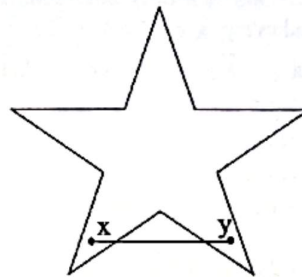


Figure 2. Non-convex set

1.5 Remark

Let C and T be convex subsets of a real linear space X .

- (a) The intersection of arbitrarily many convex sets is convex.
- (b) If C and T are nonempty, then the algebraic sum $\alpha C + \beta T$ is convex for all $\alpha, \beta \in \sim$.

Consequently, for every $\bar{x} \in X$ the translated set $C + \{\bar{x}\}$ is convex as well.

1.6 Definition

Let C be a nonempty subset of a real linear space X . The intersection of all convex subsets of X that contain C is called the **convex hull** of C and is denoted $\text{co}(C)$.

1.7 Remark

For two nonempty subsets C and T of a real linear space we obtain for all $\alpha, \beta \in \mathbb{R}$

$$\text{co}(\alpha C + \beta T) = \alpha \text{co}(C) + \beta \text{co}(T).$$

1.8 Definition

Let C be a nonempty subset of a real linear space X .

(a) The set $\text{cor}(C) = \{\bar{x} \in C \mid \text{for every } x \in X \text{ there is a } \bar{\lambda} > 0 \text{ with } \bar{x} + \lambda x \in C \text{ for all } \lambda \in [0, \bar{\lambda}]\}$ is called the **algebraic interior** of C (or the **core** of C).

(b) The set C with $C = \text{cor}(C)$ is called **algebraically open**.

(c) The set of all elements of X which do not belong to $\text{cor}(C)$ and $\text{cor}(X \setminus C)$ is called the **algebraic boundary** of C .

(d) An element $\bar{x} \in X$ is called **linearly accessible** from C , if there is an $x \in C$, $x \neq \bar{x}$, with the property $\lambda x + (1-\lambda)\bar{x} \in C$ for all $\lambda \in (0, 1]$.

The union of C and the set of all linearly accessible elements from C is called the **algebraic closure** of C and it is denoted by

$$\text{lin}(C) = C \cup \{x \in X \mid x \text{ is linearly accessible from } C\}$$

In the case of $C = \text{lin}(C)$ the set C is called **algebraically closed**.

(e) The set C is called **algebraically bounded**, if for every $\bar{x} \in C$ and every $x \in X$

there is a $\bar{\lambda} > 0$ such that $\bar{x} + \lambda x \notin C$ for all $\lambda \geq \bar{\lambda}$.

1.9 Definition

Let C be a nonempty subset of a real linear space X .

(a) The set C is called a **cone**, if $x \in C, \lambda \geq 0 \Rightarrow \lambda x \in C$.

(b) A cone C is called **pointed**, if $C \cap (-C) = \{0_X\}$.

(c) A cone C is called **reproducing**, if $C - C = X$.

By definition each cone contains the zero element of the real linear space. The simplest cones in a real linear space X are $\{0_X\}$ and X itself. $\{0_X\}$ is also called the **trivial cone**. From a geometric point of view a nontrivial cone is a set of rays emanating from the origin.

1.10 Definition

Let C be a nonempty subset of a real linear space X . The cone

$\text{cone}(C) = \{x \in X \mid x = \lambda s \text{ for some } \lambda \geq 0 \text{ and some } s \in C\}$ is called the **cone generated by C** .

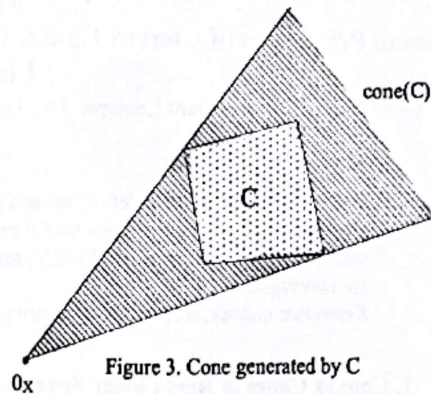


Figure 3. Cone generated by C

1.11 Lemma

A cone C in a real linear space is convex if and only if $C + C \subset C$.

Proof

Assume that C is a convex cone. Then for every $x, y \in C$ we have

$$\lambda x + (1-\lambda)y \in C \quad \text{for all } \lambda \in [0, 1].$$

Choose

$$\lambda = \frac{1}{2}. \text{ Therefore,}$$

$$\frac{1}{2}x + \frac{1}{2}y = \frac{1}{2}(x+y) \in C.$$

Since C is a cone, we obtain $x+y \in C$ and hence $C+C \subset C$.

For arbitrary $x, y \in C$ and $\lambda \in [0, 1]$, we obtain $\lambda x \in C$ and $(1-\lambda)y \in C$.

With the inclusion $C+C \subset C$ we then get $\lambda x + (1-\lambda)y \in C$.

Therefore the cone C is convex.

1.12 Lemma

Let C be a nonempty convex subset of a real linear space X . Then

(a) $\text{cor}(C)$ is convex,

(b) $\text{cor}(\text{cor}(C)) = \text{cor}(C)$.

Proof

(a) Take any $k_1, k_2 \in \text{cor}(C)$ and $\mu \in [0, 1]$.

Since $k_1, k_2 \in \text{cor}(C)$,

$\forall v \in X, \exists \lambda_0 > 0, \forall \lambda \in [0, \lambda_0]$ such that

$$k_1 + \lambda v \in C \text{ and } k_2 + \lambda v \in C.$$

Since C is a convex set,

$$\mu(k_1 + \lambda v) + (1-\mu)(k_2 + \lambda v) \in C.$$

Then $\mu k_1 + (1-\mu)k_2 + \lambda v \in C$. So,

$$\mu k_1 + (1-\mu)k_2 \in \text{cor}(C).$$

Therefore $\text{cor}(C)$ is a convex set.

(b)

$$\text{cor}(\text{cor}(C)) = \{k \in \text{cor}(C) \mid \forall v \in X, \exists \lambda_0 > 0, \forall \lambda \in [0, \lambda_0], k + \lambda v \in \text{cor}(C)\}$$

$$= \{k \in C \mid \forall v \in X, \exists \lambda_0 > 0, \forall \lambda \in [0, \lambda_0], k + \lambda v \in C\} = \text{cor}(C).$$

Therefore $\text{cor}(\text{cor}(C)) = \text{cor}(C)$.

1.13 Lemma

Let C be a convex cone in a real linear space X with a nonempty algebraic interior. Then

- (a) $\text{cor}(C) \cup \{0_X\}$ is a convex cone,
 (b) $\text{cor}(C) = C + \text{cor}(C)$.

Proof

(a) Take arbitrary $\bar{x} \in \text{cor}(C)$ and $\mu > 0$.

For every $x \in X$ there is a $\bar{\lambda} > 0$ with $\bar{x} + \frac{\lambda}{\mu}x \in C$ for all $\lambda \in [0, \bar{\lambda}]$.

Since C is a cone, we get $\mu(\bar{x} + \frac{\lambda}{\mu}x) = \mu\bar{x} + \lambda x \in C$ for all $\lambda \in [0, \bar{\lambda}]$.

So, we obtain $\mu\bar{x} \in \text{cor}(C)$ and with Lemma 1.12(a) the assertion is obvious.

(b) The inclusion $\text{cor}(C) = \{0_X\} + \text{cor}(C) \subset C + \text{cor}(C)$ is clear.

For the proof of the converse inclusion we take arbitrary $\bar{x} \in C$, $\bar{x} \in \text{cor}(C)$ and $x \in X$.

Then there is a $\bar{\lambda} > 0$ with $\bar{x} + \lambda x \in C$ for all $\lambda \in [0, \bar{\lambda}]$.

Since C is assumed to be convex, we conclude with Lemma 1.11

$$\bar{x} + \bar{x} + \lambda x \in C \text{ for all } \lambda \in [0, \bar{\lambda}]$$

implying $\bar{x} + \bar{x} \in \text{cor}(C)$. So, we conclude $C + \text{cor}(C) \subset \text{cor}(C)$.

1.14 Lemma

A cone C in a real linear space X is reproducing, if $\text{cor}(C) \neq \emptyset$.

Proof

If $\text{cor}(C)$ is nonempty, take some $\bar{x} \in \text{cor}(C)$ and any $x \in X$.

Then there is a $\lambda > 0$ and $\bar{\lambda} \in [0, \lambda]$ with $\bar{x} + \bar{\lambda}x \in C$ implying

$$x \in \frac{1}{\bar{\lambda}}C - \left\{ \frac{1}{\bar{\lambda}}\bar{x} \right\} \subset C - C.$$

2. Recession Cones in Real Linear Spaces**2.1 Definition**

Let C be a non-empty convex set in $\sim^n$. The set

$0^+C = \{y | x + \lambda y \in C, \text{ for every } \lambda \geq 0 \text{ and } x \in C\}$ is called the **recession cone** of C .

2.2 Examples

As example of recession cone 0^+C_1 of convex set C_1 in $\sim^2$, for

So, we get $X \subset C - C$ and together with the trivial inclusion $C - C \subset X$ we obtain the assertion.

1.15 Definition

Let X be a real linear space with a convex cone C_X . The cone

$C_{X'} = \{x' \in X' | x'(x) \geq 0 \text{ for all } x \in C_X\}$ is called the **dual cone** for C_X .

Notice that $C_{X'}$ is also a convex cone.

For $C_X = \{0_X\}$ we obtain $C_{X'} = X'$, and for $C_X = X$, we have $C_{X'} = \{0_{X'}\}$.

1.16 Lemma

If C_X is a convex cone in a real linear space X , then

$$\text{cor}(C_X) \subset \{x \in X | x'(x) > 0 \text{ for all } x' \in C_{X'} \setminus \{0_{X'}\}\}.$$

Proof

Take any $\bar{x} \in \text{cor}(C_X)$ and any $x' \in C_{X'} \setminus \{0_{X'}\}$.

Consequently, there are an $x \in X$ with $x'(x) < 0$ and a $\bar{\lambda} > 0$ with $\bar{x} + \bar{\lambda}x \in C_X$.

Hence, we obtain $x'(\bar{x} + \bar{\lambda}x) \geq 0$ and $x'(\bar{x}) \geq -\bar{\lambda}x'(x) > 0$ which leads to the assertion.

1.17 Lemma

Let C_X be a convex cone in a real linear space X . If $\text{cor}(C_X)$ is nonempty, then $C_{X'}$ is pointed.

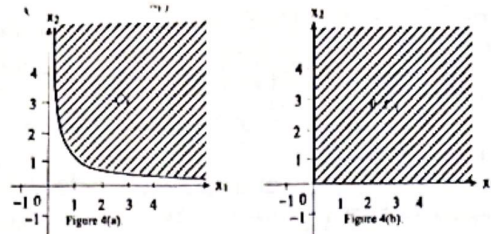
Proof

For every $x' \in C_{X'} \cap (-C_{X'})$ we have $x'(x) = 0$ for all $x \in C_X$ and especially for some $\bar{x} \in \text{cor}(C_X)$ we get $x'(\bar{x}) = 0$.

With Lemma 1.16 we obtain $x' = 0_{X'}$, and this implies $C_{X'} \cap (-C_{X'}) = \{0_{X'}\}$.

$$C_1 = \left\{ (x_1, x_2) | x_1 > 0, x_2 \geq \frac{1}{x_1} \right\}, \text{ one has}$$

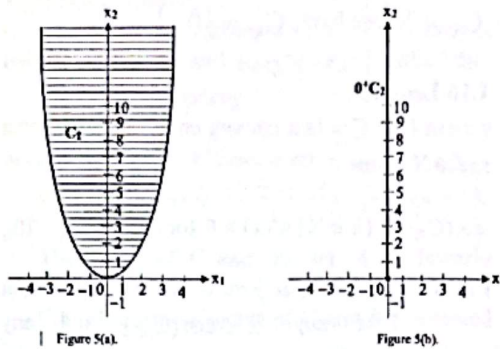
$$0^+C_1 = \left\{ (x_1, x_2) | x_1 \geq 0, x_2 \geq 0 \right\}.$$



As example of recession cone O^+C_2 of convex set C_2 in $\mathbb{R}^2$, for

$$C_2 = \{(x_1, x_2) \mid x_2 \geq x_1^2\}, \text{ one has}$$

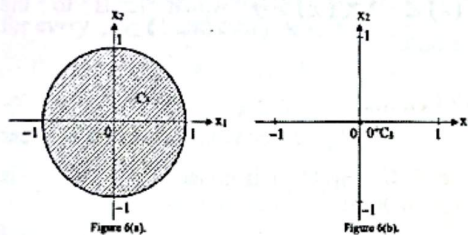
$$O^+C_2 = \{(x_1, x_2) \mid x_1 = 0, x_2 \geq 0\}.$$



As example of recession cone O^+C_3 of convex set C_3 in $\mathbb{R}^2$, for

$$C_3 = \{(x_1, x_2) \mid x_1^2 + x_2^2 \leq 1\}, \text{ one has}$$

$$O^+C_3 = \{(x_1, x_2) \mid x_1 = 0 = x_2\} = \{(0, 0)\}.$$

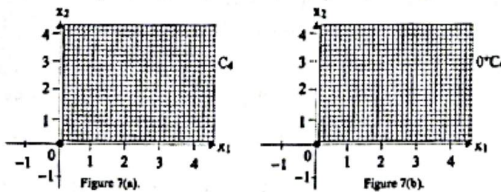


As example of recession cone O^+C_4 of convex set C_4 in $\mathbb{R}^2$, for

$$C_4 = \{(x_1, x_2) \mid x_1 > 0, x_2 > 0\} \cup \{(0, 0)\},$$

one has

$$O^+C_4 = \{(x_1, x_2) \mid x_1 > 0, x_2 > 0\} \cup \{(0, 0)\} = C_4.$$



3. Ordering Cones in Real Linear Spaces

3.1 Definition

Let X be a real linear space.

(a) Each nonempty subset R of the product space $X \times X$ is called a **binary relation**

R on X (we write xRy for $(x, y) \in R$).

(b) Every binary relation $\leq$ on X is called a **partial ordering** on X , if the following

axioms are satisfied (for arbitrary $w, x, y, z \in X$):

- (i) $x \leq x$;
- (ii) $x \leq y, y \leq z \Rightarrow x \leq z$;
- (iii) $x \leq y, w \leq z \Rightarrow x + w \leq y + z$;
- (iv) $x \leq y, \alpha \in \mathbb{R}_+ \Rightarrow \alpha x \leq \alpha y$.

(c) A partial ordering $\leq$ on X is called **antisymmetric**, if the following implication holds for arbitrary $x, y \in X$:

$$x \leq y, y \leq x \Rightarrow x = y.$$

In Definition 3.1, (b) with axiom (i) the partial ordering is **reflexive** and with (ii) it is **transitive**. The axioms (iii) and (iv) guarantee the compatibility of the partial ordering with the linear structure of the space.

3.2 Definition

A real linear space equipped with a partial ordering is called a **partially ordered linear space**.

3.3 Theorem

Let X be a real linear space.

(a) If $\leq$ is a partial ordering on X , then the set

$$C = \{x \in X \mid 0_X \leq x\}$$

is a convex cone. If, in addition, $\leq$ is antisymmetric, then C is pointed.

(b) If C is a convex cone in X , then the binary relation

$$\leq_C = \{(x, y) \in X \times X \mid y - x \in C\}$$

is a partial ordering on X . If, in addition, C is pointed, then $\leq_C$ is antisymmetric.

Proof

(a) Suppose $\leq$ is a partial ordering on X .

Take any $x \in C$ and $\lambda \geq 0$. So, $0_X \leq x$.

Since $\leq$ is a partial ordering on X , $0_X \leq \lambda x$.

Therefore, C is a cone.

Then take any $x, y \in C$ and $\lambda \in [0, 1]$.

Since C is a cone, $\lambda x \in C$ and $(1 - \lambda)y \in C$.

So, $0_X \leq \lambda x$ and $0_X \leq (1 - \lambda)y$.

Since $\leq$ is a partial ordering on X ,

$0_X \leq \lambda x + (1 - \lambda)y$. Therefore, C is a convex.

Suppose $\leq$ is antisymmetric.

Take any $x \in C \cap (-C)$. So, $x \in C$ and

$-x \in C$, $0_X \leq x$ and $0_X \leq -x$. Then $x \leq 0_X$.

Since $\leq$ is antisymmetric, $x = 0$.

Therefore, C is pointed.

(b) Suppose C is a convex cone in X and $x, y, z \in X$.

Let $\leq_C = \{(x, y) \in X \times X \mid y - x \in C\}$ be a binary relation.

Since $x - x = 0 \in C$, we get $x \leq_C x$. Therefore, the relation is reflexive.

Suppose $x \leq_C y$ and $y \leq_C z$. Therefore, $y - x \in C$ and $z - y \in C$.

Then there exist $d_1 \in C$ such that $y - x = d_1$ and $d_2 \in C$ such that $z - y = d_2$.

Since C is convex, by Lemma 1.11, we obtain $x \leq_C z$ and hence the relation is transitive.

Suppose $x \leq_C y$ and $w \leq_C z$. Therefore, $y - x \in C$ and $z - w \in C$.

Then there exist $d_1 \in C$ such that $y - x = d_1$ and $d_2 \in C$ such that $z - w = d_2$.

Since C is convex, by Lemma 1.11, we obtain $x + w \leq_C y + z$.

Suppose $x \leq_C y$ and $\alpha \in \mathbb{R}_+$. Therefore, $y - x \in C$.

Since C is a cone, we get $\alpha(y - x) \in C$ which implies $\alpha x \leq_C \alpha y$.

Therefore, $\leq_C$ is a partial ordering on X .

In addition, suppose C is pointed. Take any $x \leq_C y$ and $y \leq_C x$.

Therefore, $y - x \in C$ and $x - y \in C$.

This implies $y - x \in C$ and $y - x \in (-C)$ and hence $y - x \in C \cap (-C)$.

Since C is pointed, $y - x = 0_X$ and we obtain $x = y$.

Therefore, $\leq_C$ is antisymmetric.

3.4 Definition

A convex cone characterizing a partial ordering in a real linear space is called an **ordering cone**.

Several authors also call an ordering cone a **positive cone**. We denote $\leq_C$ as a partial ordering induced by a convex cone C .

3.5 Definition

Let X be a partially ordered linear space. For arbitrary elements $x, y \in X$ with $x \leq y$ the set

$$[x, y] = \{z \in X \mid x \leq z \leq y\}$$

is called the **order interval between x and y** .

If C is the ordering cone in a partially ordered linear space, then the order interval between x and y can be written as

$$[x, y] = (\{x\} + C) \cap (\{y\} - C).$$

3.6 Lemma

Let X be a partially ordered linear space with the ordering cone C . Let $x, y \in X$ with $x \in \{y\} - C$ (i.e., $x \leq_C y$) be

given arbitrarily. Then we have for $z = \frac{1}{2}(x + y)$

such that

(a) If $\text{cor}(C) \neq \emptyset$ and $x \in \{y\} - \text{cor}(C)$, then $z \in \text{cor}([x, y])$.

(b) If C is algebraically closed, then $[x, y]$ is algebraically closed.

(c) If C is algebraically closed and pointed, then $[x, y]$ is algebraically bounded.

Proof

(a) Since $z = x + \frac{1}{2}(y - x) \in \{x\} + \text{cor}(C)$ and $z = y - \frac{1}{2}(y - x) \in \{y\} - \text{cor}(C)$, we conclude $z \in \text{cor}([x, y])$.

(b) Because of the equality $[x, y] = (\{x\} + C) \cap (\{y\} - C)$ this assertion is evident.

(c) First, if the pointed convex cone C is algebraically closed, then the complement set $X \setminus C$ is algebraically open.

For if we assume that $X \setminus C$ is not algebraically open, then there is an $\bar{x} \in X \setminus C$ and an $h \in X$ so that for all $\bar{\lambda} > 0$

$$\bar{x} + \lambda h \in C \text{ for some } \lambda \in (0, \bar{\lambda}).$$

Since C is convex, we conclude for some $x = \bar{x} + \lambda h \in C$

$\mu x + (1 - \mu)\bar{x} \in C$ for all $\mu \in (0, 1]$ which implies $\bar{x} \in \text{lin}(C) = C$. But this contradicts the assumption $\bar{x} \notin C$.

So, the complement set $X \setminus C$ is algebraically open.

In order to prove that $[x, y]$ is algebraically bounded we take any $v \in [x, y]$ and any $w \in X \setminus \{0_X\}$.

Then we consider the two cases $w \notin C$ and $w \in C$.

Assume that $w \notin C$. Since $X \setminus C$ is algebraically open, there is a $\bar{\lambda} > 0$ with

$$w + \lambda(v - x) \in X \setminus C \text{ for all } \lambda \in [0, \bar{\lambda}).$$

The set $(X \setminus C) \cup \{0_X\}$ is a cone and, therefore, we obtain

$$\frac{1}{\lambda}(w + \lambda(v - x)) \in X \setminus C \text{ for all } \lambda \in (0, \bar{\lambda})$$

or alternatively

$$\lambda(w + \frac{1}{\lambda}(v - x)) \in X \setminus C \text{ for all } \lambda \in [\frac{1}{\bar{\lambda}}, \infty).$$

But then we have

$$v - x + \lambda w \in X \setminus C \text{ for all } \lambda \in [\frac{1}{\bar{\lambda}}, \infty)$$

and

$$v + \lambda w \notin \{x\} + C \text{ for all } \lambda \in [\frac{1}{\lambda}, \infty)$$

which

implies

$$v + \lambda w \notin [x, y] \text{ for all } \lambda \in [\frac{1}{\lambda}, \infty).$$

Next, assume that $w \in C$.

Since the ordering cone C is assumed to be pointed and $w \neq 0_X$, we conclude $w \notin -C$.

With the same arguments as before there is a $\bar{\lambda} > 0$ with

$$v + \lambda w \notin [x, y] \text{ for all } \lambda \in [\bar{\lambda}, \infty).$$

Hence, the order interval $[x, y]$ is algebraically bounded.

Conclusion

In this paper, some properties of convex cones, recession cones and ordering cones in real linear spaces are obtained. It also extends that the results studied in topological vector spaces also continue its true in real linear spaces.

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MATHS 002

Difference Between Permutations and Combinations

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Abstract

The aim of this paper is to discuss the concepts of permutations and combinations. It deals with nature of permutations and combinations, basic rules of permutations and combinations, some important deductions of permutations and combinations and its application with real world examples.

Keywords: permutations, combinations

Introduction

It is often necessary to calculate the number of different ways in which something can be done or can happen. In this paper, we will present some techniques of answering some counting problems without actually counting or listing all of them. These techniques are useful in determining the number of different ways of arranging or selecting different items.

Fundamental Principle of Counting**Additive principle**

Let P and Q be two events that cannot occur simultaneously. Then if P can occur in m ways and Q can occur in n ways, it follows that the number of ways in which either P or Q can occur in $m + n$.

This principle can be generated, for more than events, as follows:

If one event can happen in m_1 ways, following which another event can happen in m_2 ways, following which another event can happen in m_3 ways and so on that all events, in succession can happen in $m_1 + m_2 + m_3 + \dots$ different ways.

For example, in a class room there are 15 boys and 25 girls. If teacher wants to select either a boy or a girls to represent the class, the number of ways in which the teacher can perform the selection is $15 + 25$, that is, 40 ways.

Multiplication principle

If an event can happen in m different ways following which another event can happen in n different ways, then both event in succession can happen in exactly $m \times n$ different ways.

This principle can also be generalized, for even more than two operations, as follows:

If an event can happen in m_1 different ways, following which another event can happen in m_2 different ways, following which another event can happen in m_3 different ways and so on, then all event in succession can happen in exactly $m_1 \times m_2 \times m_3 \times \dots$ different ways.

For example, in a classroom there are 15 boys and 25 girls. If the teacher wants to select one boy and one girl to represent the class, the number of ways in which the teacher can perform the selection is 15×25 , that is, 375 ways.

Consider the following illustration:

There are 3 stations A, B and C and 3 routes to go from A to B and 2 routes from B to C. This is shown in the following figure:

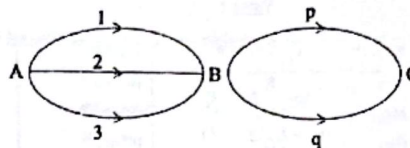


Figure 1

A person can go from station A to B in 3 different ways and from B to C in 2 different ways.

By the fundamental principle of counting, the number of ways for a person to go from A to C is $3 \times 2 = 6$, that is, (1, p), (1, q), (2, p), (2, q), (3, p) and (3, q).

Example

A customer forgets a four-digit code for an Automatic Teller Machine (ATM) in a bank. However, he remembers that this code consists of digits 1, 5, 6 and 8. The number of ways of choosing the first digit is 4, the second digit is 3, the third digit is 2 and the last digit is 1. Then the total number of ways of choosing four digits are $4 \times 3 \times 2 \times 1 = 24$. In all there will be 24 codes and customer would have to try 24 trials to obtain the correct code.

Counting bit strings

In computer systems, we frequently encounter string of 0's and 1's, and these strings often are used as the names of objects. For example, we may purchase a computer with 64 megabytes of main memory. Each of the bytes has a name, and that name is a sequence of 26 bits, each of which is either a 0 or 1. The string of 0's and 1's representing the name is called a bit string.

We consider bit strings of length 26, there are 2^{26} possible strings. The exact value of 2^{26} is 67,108,864. In computer parlance, this number is thought of as 64 million, although obviously the true number is about 5% higher. The box about power of 2 tells us a little about the subject and tries to explain the general rules involved in naming the powers of 2.

K's and M's and powers of 2

A useful trick for converting powers of 2 into decimals is to notice that 2^{10} , or 1024, is very close to one thousand. Thus 2^{30} is $(2^{10})^3$, or about 1000^3 , that is, a billion. Then, $2^{32} = 4 \times 2^{30}$ or about four billion. In fact, computer scientists often

accept the fiction that 2^{10} is exactly 1000 and speak of 2^{10} as 1K, the K stands for killo.

We convert 2^{15} , for example, into 32K, because $2^{15} = 2^5 \times 2^{10} = 32 \times 1000$.

But 2^{20} , which is exactly 1,048,576, we call 1M or one million, rather than 1000K or 1024K. For powers of 2 between 20 and 29, we factor out 2^{20} . Thus 2^{26} is $2^6 \times 2^{20}$ or 64 million. That is why 2^{26} bytes is referred to as 64 million bytes or 64 megabytes.

Table 1 gives the terms for various powers of 10 and their rough equivalents in powers of 2.

Table 1

PREFIX	LETTER	VALUE
Kilo	K	10^3 or 2^{10}
Mega	M	10^6 or 2^{20}
Giga	G	10^9 or 2^{30}
Tera	T	10^{12} or 2^{40}
Peta	P	10^{15} or 2^{50}

This table suggests that powers of 2 beyond 29 we factor out 2^{30} , 2^{40} , or 2 raised to whatever multiple-of-10 power we can. The remaining powers of 2 name the number of giga-, tera-, or peta- of whatever unit we are measuring. For example, 2^{43} bytes is 8 terabytes.

Factorial Notation

There are some occasions when we wish to consider the product of first n natural numbers. The continued product of first n natural numbers is called n -factorial or factorial n and is denoted by $n!$.

Thus $n! = 1 \times 2 \times 3 \times \dots \times (n-1) \times n$.

Remarks

(i) $0! = 1$

(ii) $1! = 1$

(iii) $7! = 1 \times 2 \times 3 \times 4 \times 5 \times 6 \times 7 = 5040$

(iv) $n! = (n-1)! \times n$.

Permutations

An arrangement in a definite order of a number of things taking some or all of them at a time is called a **permutation**. The total number of permutations of n distinct things taking r ($1 \leq r \leq n$) at a time is denoted by ${}^n P_r$, or by $P(n, r)$.

The number of permutations of n things taking r at a time is given by

${}^n P_r = n(n-1)(n-2)\dots r$ factors, $1 \leq r \leq n$.

Alternatively, ${}^n P_r = \frac{n!}{(n-r)!}$, $1 \leq r \leq n$.

Remarks

(i) ${}^n P_n = \frac{n!}{(n-n)!} = \frac{n!}{0!} = n!$

(ii) It will be noted carefully that in ${}^n P_r$, one count only those permutation in which repetition of

things is not allowed.

(iii) The number of all permutation of n different objects taking r at a time, when a particular

object is always included in each arrangement is ${}^{n-1}P_{r-1}$.

(iv) The number of all permutation of n different objects taking r at a time, when a particular object is always excluded in each arrangement is ${}^{n-1}P_r$.

Example

The 2018-2019 season was the 28th of the English Premier League after its formation in 1992. Contested by 20 clubs, it operates on a system of promotion and relegation with the English Football League. The League takes place between August and May and involves the teams playing each other home and away the season, the total of ${}^{20}P_2 = \frac{20!}{18!} = 380$ matches.

Example

A family of 3 brothers and 4 sisters is to be arranged for a photograph in one row.

(i) We take 3 brothers as one unit, the number of units to be arranged = $1 + 4 = 5$. The number of ways to arrange all units = $5!$.

The number of ways to arrange all brothers among themselves = $3!$.

The number of ways in which all brothers sit together = $5! \times 3! = 120 \times 6 = 720$.

The required number of arrangements is 720.

(ii) First we arrange 4 sisters, the number of ways to arrange the sisters = $4!$.

$\times S \times S \times S \times S \times$

There are 5 places in which 3 brothers can be seated.

The number of ways to arranged the brother = 5P_3 .

The number of ways in which all can be seated = $4! \times {}^5P_3 = 24 \times 60 = 1440$.

The required number of no two brothers sit together is 1440.

Permutations with identical items

In problems of counting, sometimes repetitions are allowed in the arrangements of objects or distinctions between some of the objects are ignored.

The number of permutations of n things taken all at a time, when p things are of one kind, q of second kind, r of third kind and so on is given by $\frac{n!}{p! q! r! \dots}$

For example consider the word BALL.

We take first L as L_1 and second L as L_2 . The word has 4 letters, and the number of permutation in which 4 letters can be arranged is $4!$, that is, 24 [BAL L_1 L L_2 , BA L L_2 L L_1 , B L L_1 AL L_2 , B L L_2 AL L_1 , B L L_1 L L_2 A, BL L_2 L L_1 A, ABL L_1 L L_2 , AL L_1 BL L_2 , AL L_2 BL L_1 , AL L_1 L L_2 B, AL L_2 L L_1 B, L L_1 ABL L_2 , L L_2 ABL L_1 , L L_1 AL L_2 B, L L_2 AL L_1 B, L L_1 BL L_2 A, L L_2 BL L_1 A, L L_1 L L_2 AB, L L_2 L L_1 AB, L L_1 L L_2 BA, L L_2 L L_1 BA, L L_1 BAL L_2 , L L_2 BAL L_1].

Clearly,

$$\left. \begin{matrix} BAL_1L_2 \\ BA L_2L_1 \end{matrix} \right\} \text{ is BALL}$$

$$\left. \begin{matrix} BL_1AL_2 \\ BL_2AL_1 \end{matrix} \right\} \text{ is BLAL}$$

$$\left. \begin{matrix} BL_1L_2A \\ BL_2L_1A \end{matrix} \right\} \text{ is BLLA}$$

$$\left. \begin{matrix} ABL_1L_2 \\ ABL_2L_1 \end{matrix} \right\} \text{ is ABLL}$$

$$\left. \begin{matrix} AL_1BL_2 \\ AL_2BL_1 \end{matrix} \right\} \text{ is ALBL}$$

$$\left. \begin{matrix} AL_1L_2B \\ AL_2L_1B \end{matrix} \right\} \text{ is ALLB}$$

$$\left. \begin{matrix} L_1ABL_2 \\ L_2ABL_1 \end{matrix} \right\} \text{ is LABL}$$

$$\left. \begin{matrix} L_1AL_2B \\ L_2AL_1B \end{matrix} \right\} \text{ is LALB}$$

$$\left. \begin{matrix} L_1BL_2A \\ L_2BL_1A \end{matrix} \right\} \text{ is LBLA}$$

$$\left. \begin{matrix} L_1L_2AB \\ L_2L_1AB \end{matrix} \right\} \text{ is LLAB}$$

$$\left. \begin{matrix} L_1L_2BA \\ L_2L_1BA \end{matrix} \right\} \text{ is LLBA}$$

$$\left. \begin{matrix} L_1BAL_2 \\ L_2BAL_1 \end{matrix} \right\} \text{ is LBAL}$$

Thus the number of ways in which the letters of the word BALL can be arranged is 12, that is $\frac{4!}{2!}$.

Example

An explorer has rations for two weeks, consisting of 4 cans of Tuna, 7 cans Spam and 3 cans of Beanie Weenies. Here, there are 14 items divided into groups of 4, 7 and 3 identical items. If he open one can each day, the number of orders is

$$\frac{14!}{4! 7! 3!}$$

We begin by canceling the 7! in the denominator with the last 7 factors in 14! of the numerator. That gives

$$\frac{14 \times 13 \times 12 \times 11 \times 10 \times 9 \times 8}{4 \times 3 \times 2 \times 1 \times 3 \times 2 \times 1}$$

Continuing to cancel factors in the numerator and denominator, we find the resulting product is 120, 120. That is, there are over a hundred thousand ways in which to consume the rations.

Combinations

A selection (group) of a number of things taking some or all of them at a time is called a **combination**. The selections are different from permutations in the sense that in a permutation, the order of things is taken into consideration whereas in case of selection, the order of things is immaterial and we consider only the things which are occurring in a selection. For example, ab and ba are two distinct permutations but same selection.

The total number of combinations of n distinct things taking r ($1 \leq r \leq n$) at a time is denoted by nC_r , or by $C(n, r)$.

Consider the following example:

The permutation of 3 things a, b, c taking 2 at a time are ab, bc, ac, ca, cb, ba. Therefore ${}^3P_2 = 6$.

But the combination of 3 things a, b, c taking 2 at a time are ab, bc, ca.

Therefore ${}^3C_2 = 3$.

ab and ba represents the same combination and two different permutations.

Thus permutations are arrangements in definite order, whereas combinations are selections in which order of objects does not matter.

The number of combinations of n things taking r at a time is equal to

$${}^nC_r = \frac{n!}{r!(n-r)!}, \quad 1 \leq r \leq n.$$

Let the required number of combinations of n things taken r at a time be x .

Take one of these combinations. It contains r things which can be arranged among themselves in $r!$ ways.

Thus one combination gives rise to $r!$ permutations.

The total number of permutations of n things taken r at a time = nP_r .

$$\text{Therefore } x r! = {}^nP_r \quad \text{or} \quad x = \frac{{}^nP_r}{r!}$$

$${}^nC_r = \frac{{}^nP_r}{r!} = \frac{1}{r!} \frac{n!}{(n-r)!}$$

$$\text{Hence } {}^nC_r = \frac{n!}{r!(n-r)!}$$

Remarks

$$(i) {}^nC_n = \frac{n!}{n!(n-n)!} = \frac{n!}{n!0!} = \frac{n!}{n!} = 1.$$

$$(ii) {}^nC_{n-r} = \frac{n!}{(n-r)!(n-(n-r))!} = \frac{n!}{(n-r)!r!} = {}^nC_r.$$

$$(iii) {}^nC_0 = \frac{n!}{0!(n-0)!} = \frac{n!}{1.n!} = 1.$$

$$(iv) {}^nC_r = \frac{n(n-1)(n-2)\dots r \text{ terms}}{1.2.3\dots r}, \text{ that is } {}^nC_r = \frac{{}^nP_r}{r!}.$$

(v) The number of combinations of n different objects taken r at a time in such a way that a particular object is always included is

$${}^{n-1}C_{r-1}.$$

(vi) The number of combinations of n different objects taken r at a time in such a way that a particular object is always excluded is

$${}^{n-1}C_r.$$

Example

A committee of 5 members is to be formed out of 6 men and 4 ladies.

(i) If exactly two women are to be selected, then only three men can be selected. The number of ways to select the committee of 5

$$= {}^4C_2 \times {}^6C_3 = 6 \times 20 = 120.$$

The required number of ways is 120.

(ii) If at least two women are to be selected, the number of women may be 2, 3 or 4. The committee may consist as follow:

Women	Men
2	3
3	2
4	1

The number of ways to select the committee of 5 members

$$\begin{aligned}
 &= ({}^1C_2 \times {}^6C_1) + ({}^1C_1 \times {}^6C_2) + ({}^1C_1 \times {}^6C_1) \\
 &= (6 \times 20) + (4 \times 15) + (1 \times 1) \\
 &= 120 + 60 + 1 \\
 &= 181.
 \end{aligned}$$

The required number of ways is 181.

(iii) If at most two women are to be selected, then the number of women may be 0, 1 or 2.

Selection in made as follows:

Women	Men
0	5
1	4
2	3

The number of ways to select the committee of 5 members

$$\begin{aligned}
 &= ({}^1C_0 \times {}^6C_5) + ({}^1C_1 \times {}^6C_4) + ({}^1C_2 \times {}^6C_3) \\
 &= (1 \times 6) + (4 \times 15) + (6 \times 20) \\
 &= 6 + 60 + 120 \\
 &= 186.
 \end{aligned}$$

The required number of ways is 186.

Example

A team of 11 players is to be selected from a group of 20 players and one of the player is then to be selected as captain and another as vice-captain. The number of ways in which 11 players can be selected from 20 players is ${}^{20}C_{11}$. In selection of captain and vice-captain, the order of selection does matter. The number of ways in which the captain and vice-captain are selected from 11 players in ${}^{11}P_2$.

The number of ways in which the team is selected $= {}^{20}C_{11} \times {}^{11}P_2 = 167960 \times 110 = 18475600$.

The required number of ways is 18475600.

Ordered and Unordered Selections

Example

A horse race awards prizes to the first three finishers; the first horse is said to win, the second to place and the third to show. Suppose there are 10 horses in a race.

Clearly, any of the 10 horses can be winner. Given which horse is the winner, any of the 9 remaining horses can place. Thus there are $10 \times 9 = 90$ choices for horses in first and second positions. For any of these 90 selections of win and place, there are 8 remaining horses. Any of these can finish third. Thus there are $90 \times 8 = 720$ selections of win, place and show. Figure 2 suggests all these possible selections, concentrating on the case where 3 is selected first and 1 is selected second.

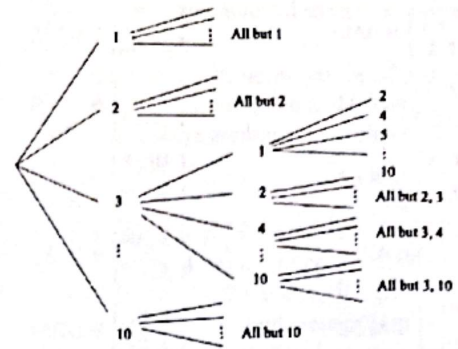


Figure 2

Example

We know from the previous example that there are 720 ways to select three horses, say A, B, and C, to be the win, place, and show horses, respectively. However, now we do not care about the order of finish of these horses, only that A, B and C were the first three finishers in some order. Thus we will get the answer A, B and C are the three best horses in six different ways, corresponding to the ways that these horses can be ordered among the top three. We know there are exactly six ways, because the number of ways to order 3 items is ${}^3P_3 = 3! = 6$. However, if there is any doubt, the six ways are seen in Figure 3.

Win	Place	Show
A	B	C
A	C	B
B	A	C
B	C	A
C	A	B
C	B	A

Figure 3

The set of the horses A, B and C is true for any set of three horses. Each set of three horses will appear exactly 6 times, in all of their possible orders, when we count the ordered selections of three horses out of 10. Thus if we wish to count only the sets of three horses that may be the three top finishers, we must divide ${}^{10}P_3$ by 6. Thus there are $\frac{720}{6} = 120$ different sets of three horses out of 10.

Example

We will count the number of poker hands. In poker, each player is dealt five cards from a 52-card deck. We do not care in what order the five cards are dealt, just what five cards we have. To count the number of sets of five cards we may be dealt, we could start by calculating ${}^{52}P_5$, which is the number of ordered selections of five objects out of 52. This number is $\frac{52!}{(52-5)!}$, which is

$$\frac{52!}{47!} \text{ or } 52 \times 51 \times 50 \times 49 \times 48 = 311,875,200.$$

However, just as the three faster horses in the previous example appear in $3! = 6$ different

orders, any set of five cards to appear in ${}^5P_5 = 5! = 120$ different orders. Thus to count the number of poker hands without regard to order of selection, we must take the number of ordered selections and divide by 120. The result is $\frac{311,875,200}{120} = 2,598,960$ different hands.

Conclusion

Permutations are all possible ways of arranging the elements of a set. Permutations see differently ordered arrangements as different answers. Combinations are the happy-go-lucky cousin of permutations. Order does not matter to them. We can mix the order up, and they are still happy. The world looks the same to them whether its ordered or not ordered.

Acknowledgements

I would like to express my heartfelt gratitude to Dr Aung Win, Rector, Dr Aye Aye Ko and Dr Soe Myint Aye, Pro-Rector, University of Myitkyina for their permission to carry out the research and their encouragement. And then, I would like to thank Dr Daw Win Sein, Professor and Head of Department of Mathematics and Dr Nang Baw, Professor, Department of Mathematics, University of Myitkyina, for their exhortation and helpful comments on this research.

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MATHS 003

Matrix Algebra and its Application in Real Life

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Abstract

We will introduce the matrix, a rectangular array of numbers arranged in rows and columns, the array being enclosed in round (or square) brackets. The numbers are called entries or elements of the matrix. We can find the solutions of the system of linear equations by using the application of matrices. If the matrix is square, it is possible to deduce some of its properties by computing its determinant. The matrices are used in real life for plotting graphs statistics and also to do scientific studies, research in almost different fields. Matrix algebra is used in statistics to express collection of data, in representing the real world data's like the population of people infant mortality rate, habits, economics, etc.. They are the best representation methods for plotting surveys. Matrices can be applied widely in civil engineering. The engineers draw the scale of buildings by using the transformation of the matrices that represents the composition of two transformations. The product of two transformation matrices is a matrix.

Introduction

The theory of matrices is, in the main, a part of algebra. But it becomes clear that matrices possessed a utility that extended beyond the domain of algebra and into other regions of mathematics. It was found that they were the means necessary for expressing many ideas of applied mathematics. Today, matrices are used in mathematics and other sciences.

1. Operations on Matrices

1.1 Definitions

A **matrix** (Plural: matrices) is a rectangular array of real numbers arranged in rows and columns, the array being enclosed in round (or square) brackets.

The **rows** of a matrix are the arrays of numbers that go across the page. The **columns** are those that go down the page.

The **order** of a matrix is given by the number of rows followed by the number of columns, and it is denoted by $m \times n$, if the matrix has m rows and n columns.

We refer to m and n as the **dimensions** of the matrix. The numbers that appear in the matrix are called its **entries**. We customarily use capital letter $A, B, C, \dots$ for the names of matrices.

For examples

- (i) $\begin{bmatrix} 4 & 3 \\ 2 & 5 \end{bmatrix}$ is a 2×3 matrix, since it has
 2 rows and 3 columns.
- (ii) Consider two simultaneous linear equations, in two unknowns, x and y ,

$$\begin{aligned} 3x + y &= 5 \\ 4x - y &= 2. \end{aligned}$$

The coefficients of x and y could be put down in the form of a rectangular array without altering their relative positions in the equations, thus $\begin{bmatrix} 3 & 1 \\ 4 & -1 \end{bmatrix}$. Such an array is called a matrix.

1.2 Matrix Addition, Subtraction and Multiplication

Two matrices can be added (or subtracted) if and only if they have the same dimensions. To add (or subtract) two matrices of the same dimension, we add (or subtract) the corresponding entries. More formally, if A and B are $m \times n$ matrices, then $A+B$ and $A-B$ are the matrices whose entries are given by

$(A+B)_{ij} = A_{ij} + B_{ij}$, ij^{th} entries of the sum = sum of the ij^{th} entries.

Step 1:

Write the coefficients of the items in a matrix.

Step 2:

Write the costs in a one column matrix.

Step 3:

Multiply the matrices.

Step 4:

Write the unit.

$(A-B)_{ij} = A_{ij} - B_{ij}$, ij^{th} entries of the difference = difference of the ij^{th} entries.

In general for the matrices A and B , we can take the product AB only if the number of columns of A equals the number of rows of B (so that we can multiply the rows of A by the columns of B). The product AB is then obtained by taking its ij^{th} entry to be row i of $A \times$ column j of B .

1.3 Example

The A-plus auto parts store chain has two outlets, one in Vancouver and one in Quebec. Among other things, it sells wiper blades, windshield cleaning fluid and floor mats. The monthly sales of these items at the two stores for two months are given in the following tables.

January Sales		
	Vancouver	Quebec
Wiper Blades	20	15
Cleaning fluid(bottles)	10	12
Floor Mats	8	4

February Sales		
	Vancouver	Quebec
Wiper Blades	23	12
Cleaning fluid (bottles)	8	12
Floor Mats	4	5

We use matrix arithmetic to calculate the change in sales of each product in each store from January to February.

The tables suggest two matrices,

$$J = \begin{bmatrix} 20 & 15 \\ 10 & 12 \\ 8 & 4 \end{bmatrix} \text{ and } F = \begin{bmatrix} 23 & 12 \\ 8 & 12 \\ 4 & 5 \end{bmatrix}$$

We compute the change in sales of each product for both stores, we want to subtract corresponding entries in the two matrices.

$$F - J = \begin{bmatrix} 3 & -3 \\ -2 & 0 \\ -4 & 1 \end{bmatrix}$$

Thus, the change in sales of each product is the following.

	Vancouver	Quebec
Wiper Blades	3	-3
Cleaning fluid (bottles)	-2	0
Floor Mats	-4	1

2. Solving a Systems of Linear Equations and Word Problem Using Matrices

Costumes are needed for the school play. Boy's costumes require 8 yards of fabric, 5 yards of ribbon, and 4 packets of sequins. Girl's costumes require 6 yards of fabric, 9 yards of ribbon, and 5 packets of sequins. Fabric costs \$6 per yard, ribbon costs \$5 per yard, and sequins cost \$5 per packet. We will find the cost of each costume.

$$\begin{array}{l} \text{Boy's} \begin{bmatrix} 8 & 5 & 4 \end{bmatrix} \begin{bmatrix} 6 \\ 5 \\ 5 \end{bmatrix} = \begin{bmatrix} 93 \end{bmatrix} \\ \text{Girl's} \begin{bmatrix} 6 & 9 & 5 \end{bmatrix} \begin{bmatrix} 6 \\ 5 \\ 5 \end{bmatrix} = \begin{bmatrix} 106 \end{bmatrix} \end{array}$$

The cost of Boy's costume = \$93
The cost of Girl's costume = \$106

2.1 Example

We will find the solutions of the system of linear equations $5x + 6y = 25$ and $3x + 4y = 17$ by matrix method.

We first need to transform the matrix form.

2.2 Stochastic matrices

Many types of involve a finite set of states $\{S_1, S_2, \dots, S_n\}$ of a given population. For instance, residents of a city may live downtown or in the suburbs. Votes may vote Democrat,

Republican, or Independent, Soft drink consumers may buy coca-cola, Pepsi Cola, or another brand.

The probability that a member of a population will change from the j^{th} state to the i^{th} state is represented by a number P_{ij} , where $0 \leq P_{ij} \leq 1$. A probability of $P_{ij} = 0$ means that the member is certain not to change from the j^{th} state to the i^{th} state, whereas a probability of $P_{ij} = 1$ means that the member is certain to change from the j^{th} state to the i^{th} state.

$$P = \begin{matrix} & \begin{matrix} \text{from} \\ S_1 & S_2 & \dots & S_n \end{matrix} \\ \begin{matrix} \text{to} \\ S_1 \\ S_2 \\ \vdots \\ S_n \end{matrix} & \begin{bmatrix} P_{11} & P_{12} & \dots & P_{1n} \\ P_{21} & P_{22} & \dots & P_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ P_{n1} & P_{n2} & \dots & P_{nn} \end{bmatrix} \end{matrix}$$

$$\text{Let } A = \begin{bmatrix} 5 & 6 \\ 3 & 4 \end{bmatrix}, X = \begin{bmatrix} x \\ y \end{bmatrix}, B = \begin{bmatrix} 25 \\ 17 \end{bmatrix}$$

The system of linear equations becomes,

$$AX = B$$

$$X = A^{-1}B$$

$$A^{-1} = \frac{1}{\det A} \begin{bmatrix} 4 & -6 \\ 3 & 5 \end{bmatrix}$$

where the determinant of A, $\det A = 20 - 18 = 2$

$$A^{-1} = \frac{1}{2} \begin{bmatrix} 4 & -6 \\ 3 & 5 \end{bmatrix}$$

$$\text{Thus } X = \frac{1}{2} \begin{bmatrix} 4 & -6 \\ 3 & 5 \end{bmatrix} \begin{bmatrix} 25 \\ 17 \end{bmatrix}$$

Therefore $x = -1, y = 5$.

P is called the matrix of transition probabilities because it gives the probabilities of each possible type of transition (or change) within the population.

$$\begin{array}{l} P = \begin{bmatrix} 0.70 & 0.15 & 0.15 \\ 0.20 & 0.80 & 0.15 \\ 0.10 & 0.05 & 0.70 \end{bmatrix} \begin{bmatrix} 15,000 \\ 20,000 \\ 55,000 \end{bmatrix} \\ PX = \begin{bmatrix} 23,250 \\ 28,750 \\ 28,000 \end{bmatrix} \end{array}$$

At each transition, each member in a given state must either stay in that state or change to another state. For probabilities, this means that the sum of the entries in any column of P is 1. For instance, in the first column,

$$P_{11} + P_{21} + \dots + P_{n1} = 1.$$

Such a matrix is called stochastic. That is, an $n \times n$ matrix P is a stochastic matrix when each entry is a number between 0 and 1 inclusive, and the sum of the entries in each column of P is 1.

2.3 Example

Two competing companies offer satellite television service to a city with 100,000 households. Figure 1 shows that the changes in satellite subscriptions each year. Company A now has 15,000 subscribers and Company B has 20,000 subscribers. The matrix representing the given transition probabilities is and the state matrix representing

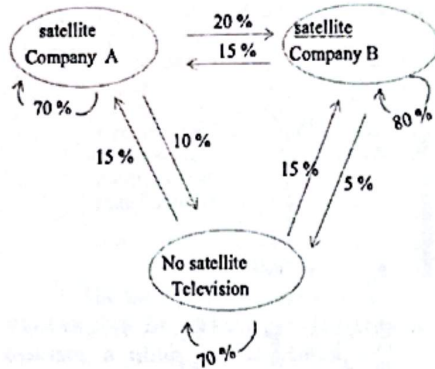


Figure 1

the current populations in the three states is

$$X = \begin{bmatrix} 15,000 \\ 20,000 \\ 5,000 \end{bmatrix} \begin{matrix} A \\ B \\ \text{None} \end{matrix}$$

We will find the state matrix representing the population in the three states in one year, multiply P by X to obtain

In one year, Company A will have 23,250 subscribers and Company B will have 28,750

$$P = \begin{matrix} \text{from} \\ \begin{matrix} A & B & \text{None} \end{matrix} \\ \begin{bmatrix} 0.70 & 0.15 & 0.15 \\ 0.20 & 0.80 & 0.15 \\ 0.10 & 0.05 & 0.70 \end{bmatrix} \begin{matrix} A \\ B \\ \text{None} \end{matrix} \end{matrix} \quad \text{to}$$

subscribers.

We can also find the number of subscribers each satellite television company will have after 3 years, 5 years and 10 years. Round each answer to the nearest whole number.

The matrix of transition probabilities is the same from the first year to the third year, the numbers of subscribers after 3 years, 5 years, 10 years are expressed as follows.

After 3 years,

$$P^3 X = \begin{bmatrix} 30,283 \\ 29,042 \\ 30,675 \end{bmatrix} \begin{matrix} A \\ B \\ \text{None} \end{matrix}$$

After 5 years,

$$P^5 X = \begin{bmatrix} 32,411 \\ 31,812 \\ 33,777 \end{bmatrix} \begin{matrix} A \\ B \\ \text{None} \end{matrix}$$

After 10 years,

$$P^{10} X = \begin{bmatrix} 33,287 \\ 47,147 \\ 39,566 \end{bmatrix} \begin{matrix} A \\ B \\ \text{None} \end{matrix}$$

After 10 years, Company A will have 33,287 subscribers and Company B will have 47,147 subscribers.

3. The Scales of X and Y-Direction

The scaling in arbitrary dimensions as a special case of linear transformation, it can be achieved also by multiplying each point (viewed as a column vector) with a diagonal matrix whose entries on the diagonal are all equal.

3.1 Matrix representation

A scaling can be represented by a scaling matrix to scale an object by a vector

$v = (v_x, v_y, v_z)$ each point $P = (P_x, P_y, P_z)$ would need to be multiplied with this scaling matrix.

$$S_v = \begin{bmatrix} v_x & 0 & 0 \\ 0 & v_y & 0 \\ 0 & 0 & v_z \end{bmatrix}$$

As shown below, the multiplication will give the expected result.

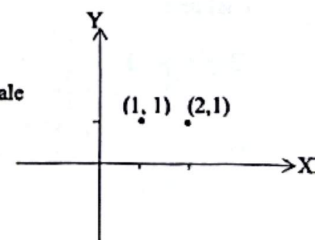
$$S_v P = \begin{bmatrix} v_x & 0 & 0 \\ 0 & v_y & 0 \\ 0 & 0 & v_z \end{bmatrix} \begin{bmatrix} P_x \\ P_y \\ P_z \end{bmatrix} = \begin{bmatrix} v_x P_x \\ v_y P_y \\ v_z P_z \end{bmatrix}$$

Such a scaling changes the diameter of an object by a factor between the scale factors, the areas by a factor between the smallest and the largest product of two scale factors and the volume by the product of all three.

Scale in X-Direction

$$A = \begin{bmatrix} k & 0 \\ 0 & 1 \end{bmatrix}, k \text{ is Scale}$$

$$X = \begin{bmatrix} 1 \\ 1 \end{bmatrix}$$



Double in X-Direction

$$X' = AX = \begin{pmatrix} 2 & 0 \\ 0 & 1 \end{pmatrix} \begin{pmatrix} x \\ y \end{pmatrix} = \begin{pmatrix} 2x \\ y \end{pmatrix}$$

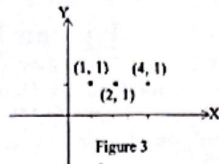


Figure 3

Scale in Y-Direction

$$A = \begin{pmatrix} 1 & 0 \\ 0 & k \end{pmatrix}$$

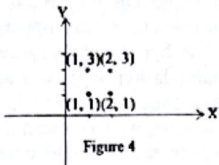


Figure 4

Say: multiple of 3 in Y-Direction

$$X' = AX = \begin{pmatrix} 1 & 0 \\ 0 & 3 \end{pmatrix} \begin{pmatrix} x \\ y \end{pmatrix} = \begin{pmatrix} x \\ 3y \end{pmatrix}$$

Scale in X and Y Direction at the same time.

$$A = \begin{pmatrix} k_x & 0 \\ 0 & k_y \end{pmatrix}$$

Say: Stretch horizontally multiply by 4

Stretch vertically multiply by $\frac{1}{2}$

$$X' = AX = \begin{pmatrix} 4 & 0 \\ 0 & \frac{1}{2} \end{pmatrix} \begin{pmatrix} x \\ y \end{pmatrix} = \begin{pmatrix} 4x \\ \frac{y}{2} \end{pmatrix}$$

$$X' = AX = \begin{pmatrix} 4 & 0 \\ 0 & \frac{1}{2} \end{pmatrix} \begin{pmatrix} x \\ y \end{pmatrix} = \begin{pmatrix} 4x \\ \frac{y}{2} \end{pmatrix}$$

$$P_1 = \begin{pmatrix} 2 \\ 1 \end{pmatrix}, P_2 = \begin{pmatrix} 4 \\ 2 \end{pmatrix}, P_3 = \begin{pmatrix} 6 \\ 3 \end{pmatrix}$$

$$T = \begin{pmatrix} 2 & 1 \\ 1 & 2 \end{pmatrix}$$

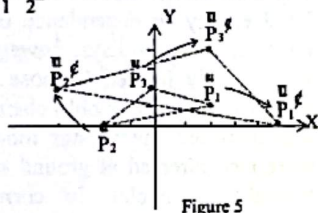


Figure 5

$$\begin{aligned} T \cdot \begin{pmatrix} P_1 & P_2 & P_3 \end{pmatrix} &= \begin{pmatrix} 2 & 1 & 2 \\ 1 & 2 & 1 \end{pmatrix} \begin{pmatrix} 2 & 4 & 6 \\ 1 & 2 & 3 \end{pmatrix} \\ &= \begin{pmatrix} 4+1 & -4 & 2 \\ 2+2 & 2 & 4 \end{pmatrix} \\ &= \begin{pmatrix} 5 & -4 & 2 \\ 4 & 2 & 4 \end{pmatrix} \end{aligned}$$

$f: X \rightarrow Y$

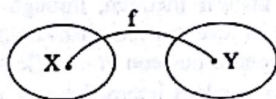


Figure 6

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$$f(x) = X^2, f: X \rightarrow X^2 \text{ Vectors } X \in \mathbb{R}^n$$

$$R^n = \{n\text{-tuples } (x_1, x_2, \dots, x_n) \mid x_1, x_2, \dots, x_n \in \mathbb{R}\}$$

$$X = \begin{pmatrix} x_1 \\ x_2 \\ \vdots \\ x_n \end{pmatrix}, x_1, x_2, \dots, x_n \in \mathbb{R}$$

$$f(x_1, x_2, x_3) = (x_1 + 2x_2, 3x_3)$$

$$\begin{aligned} f \begin{pmatrix} x_1 \\ x_2 \\ x_3 \end{pmatrix} &= \begin{pmatrix} x_1 + 2x_2 \\ 3x_3 \end{pmatrix} \\ f \begin{pmatrix} 1 \\ 2 \\ 3 \end{pmatrix} &= \begin{pmatrix} 1 + 2 \cdot 2 \\ 3 \cdot 3 \end{pmatrix} \\ &= \begin{pmatrix} 5 \\ 9 \end{pmatrix} \end{aligned}$$

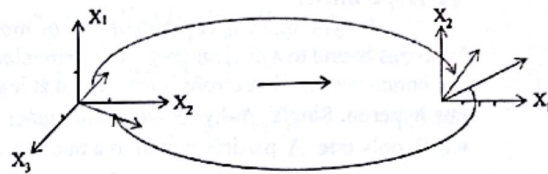


Figure 7

Transformation function operation on vector T.

$$T: \mathbb{R}^3 \rightarrow \mathbb{R}^2 \text{ by } T(x_1, x_2, x_3) = (x_1 + 2x_2, 3x_3).$$

$$T \begin{pmatrix} 1 \\ 2 \\ 3 \end{pmatrix} = \begin{pmatrix} 1 + 2 \cdot 2 \\ 3 \cdot 3 \end{pmatrix} = \begin{pmatrix} 5 \\ 9 \end{pmatrix}$$

Conclusion

In this research paper, we study the sales data to determine how much money for a days, a month, a year, etc. And then, we discuss the scale of building can calculate by the matrix transformation method.

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PHY 001

Two Body Structure Calculation of ^{12}C Hypernucleus System

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Abstract

In this research, structure of two body ^{12}C hypernucleus system has been analyzed by determining the total energy, average kinetic energy, average potential energy and root mean square distances of the states. The ^{12}C hypernucleus system is assuming that two body system which consists of one Λ hyper particle and one carbon core nucleus. The binding energy of ^{12}C hypernucleus system is calculated by solving the Schrodinger equation. In our calculation, we have been transformed the Woods-Saxon potential reduced into Gaussian potential. We have used the Gaussian basis wave function to solve the Schrodinger equation. The experimental value of binding energy for ^{12}C hypernucleus system is 10.76 ± 0.19 MeV. The value of the total binding energy, average kinetic energy, average potential energy and root mean square distances of the states of ^{12}C hypernucleus system were calculated with the help of FORTRAN PROGRAM.

Keywords: Schrodinger equation, Gaussian wave function, binding energy.

Introduction

 Λ -Hypernuclei

A hypernucleus consists of one or more hyperons bound to a nuclear core. A hypernucleus is a bound system of neutrons, protons and at least one hyperon. Single Λ -hypernuclei are nuclei in which only one Λ particle bound to a nucleus. A

Λ -hypernucleus is represented by $^{\Lambda}Z$ where Λ means that there is one Λ -hyperon and A is the total number of baryons. The Λ -hyperon, neutral particle, can stay in a nucleus deeply without having to obey the Pauli Exclusion Principle, due to the strangeness number. The strange particle, hyperon is a good probe to study deep inside of nuclei. One can study nuclear matter by the energy levels of hyperon in nuclei and its decay. In the same time, the property of hyperon inside is also an interesting subject. A Λ hyperon is a baryon with mass 1115.634 ± 0.006 MeV/ c^2 . It is larger than the mass of the nucleon about 20%. It has zero charge and zero isospin. It carries a new quantum number which is strangeness number S and Λ hyperon has $S = -1$. A Λ hyperon is unstable and decays with lifetime 263 ± 2 ps which is the characteristic life time of a weak decay process. In weak decay, the strangeness does not conserve. However in the strong decay, the strangeness must conserve. The free Λ hyperon decays into a nucleon and a pion ($\Lambda \rightarrow N + \pi$) under weak interaction. Since Λ hyperon is the lightest particle in the family of hyperons, it can stay in contact with nucleons inside nuclei and form Λ hypernuclei long enough to be observed experimentally. The added hyperon may increase the stability of some nuclear configuration, for example, ^3He and ^8Be become particle-stable by accepting a Λ hyperon as a constituent member. The Λ particle can reside deep inside, and attract the surrounding nucleons towards the interior of the nucleus. Thus, the Λ particle plays a "glue like role" of a nucleus. One can study nuclear matter by the energy levels of hyperon in nuclei and its decay. In the same time,

the property of hyperon inside nuclei is also an interesting subject. In the first two decades, emulsion experiments provided a unique source of information on hypernuclei, which were binding energies and weak decay rates of hypernuclei. The binding energy data told us qualitative properties of the Λ nucleon (ΛN) interaction and the single particle potential depth for Λ particle in hypernuclei. The alpha-cluster model is based on two assumptions that the proton-neutron pair interactions are responsible for the adherence between alpha-clusters and that N - N interactions in the α -cluster structure are isospin independent. It allows one to estimate the Coulomb energy and the short range inter-cluster bond energy in dependence on the number of clusters. In those days, however, available data were largely limited to those on ground states from emulsion or bubble chamber experiments, and therefore the cluster model investigations were also directed at ground state properties of typical hypernuclei. In correspondence with recent experimental developments, the hypernuclear cluster model has also been improved so as to describe various structure properties and excitations particularly with genuine hypernuclear character. We are going to study the two body calculation of ^{12}C system.

Calculation

Woods-Saxon Interaction

The study of the behaviour of a hyperon embedded in the nuclear medium, through the theoretical analysis of level spectra, sheds light on the nature of the hyperon-nucleon (Y - N) effective interactions. For Λ -nucleon interaction, we will use phenomenological Woods-Saxon potential form. In our calculation, we use the phenomenological potential between Λ and the core nucleus which has Woods-Saxon potential. The Woods-Saxon term is

Where, $V_{\Lambda}(r)$ = interaction between Λ and the core nucleus

V_s = strength of Woods-Saxon potential
 r = radial distance from the centre
 R = nuclear radius
 a = density fall-off at the surface

Gaussian potential between Λ and core nucleus has the following form

$$V_\Lambda(r) = \sum_{i=1}^N V_i e^{-\left(\frac{r}{\mu_i}\right)^2}$$
 The transformation equation can be expressed as

$$\frac{V_s}{1 + e^{\left(\frac{r-R}{a}\right)}} = \sum_{i=1}^N V_i e^{-\left(\frac{r}{\mu_i}\right)^2} \quad (1)$$

Multiplying both sides of the equation by from the right and integration through the equation. Therefore we have obtained the following equation,

$$\int_0^\infty \frac{V_s}{1 + e^{\left(\frac{r-R}{a}\right)}} e^{-\left(\frac{r}{\mu_j}\right)^2} dr = \sum_{i=1}^N V_i \int_0^\infty e^{-\left(\frac{r}{\mu_i}\right)^2} e^{-\left(\frac{r}{\mu_j}\right)^2} dr$$

The left-hand side of the above equation was numerically solved and the right hand side was solved by using standard integral form.

$$\int_0^\infty X^{2n} e^{-a^2 X^2} dX = \frac{(2n-1)!! \sqrt{\pi}}{2^{n+1} a^{2n+1}}$$

The above equation becomes

$$\int_0^\infty \frac{V_s}{1 + e^{\left(\frac{r-R}{a}\right)}} e^{-\left(\frac{r}{\mu_i}\right)^2} dr = \frac{1}{2} \sum_{i=1}^N V_i \sqrt{\frac{\pi}{\mu_i^2 + \mu_j^2}}$$

Let,

$$A_j = \int_0^\infty \frac{V_s}{1 + e^{\left(\frac{r-R}{a}\right)}} e^{-\left(\frac{r}{\mu_j}\right)^2} dr$$

$$B_{ji} = \frac{1}{2} \sqrt{\frac{\pi}{\mu_i^2 + \mu_j^2}}$$

The equation (3) becomes

$$A_j = \sum_{i=1}^N B_{ji} V_i \quad (4)$$

Where, j goes from 1 to N

$$A_j = B_{j1} V_1 + B_{j2} V_2 + B_{j3} V_3 + \dots$$

$$A_1 = B_{11} V_1 + B_{12} V_2 + B_{13} V_3 + \dots$$

$$A_2 = B_{21} V_1 + B_{22} V_2 + B_{23} V_3 + \dots$$

Then the above N linear equations are obtained. The optimum set of parameters are found to be

$\mu_1 = 0.1 \text{ fm}$ and $\mu_2 = 10 \text{ fm}$ and $N = 20$ which are shown in Table (1).

At $N = 20$, the transformed Gaussian potential reproduces the original Woods-Saxon potential which can be seen in Figure (1).

Two-Body Calculations

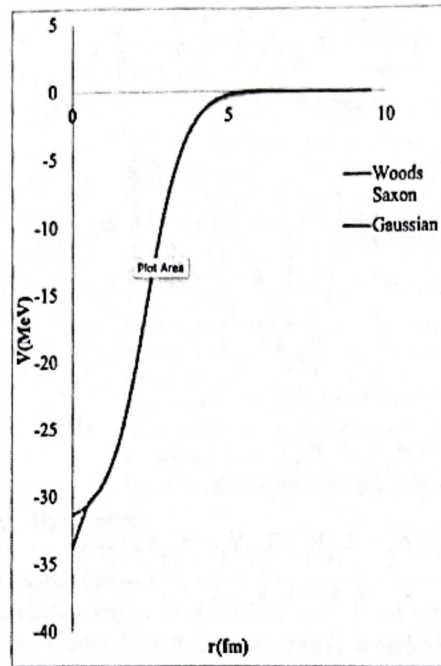


Figure (1) The potential between Λ and core nucleus, Woods-Saxon and Gaussian potential respectively

Table (1) The range parameters and potential strengths of the transformed Gaussian potential.

Range parameters	Woods Saxon V(MeV)	Gaussian V(MeV)
0	-33.8453	-31.3954
0.5	-30.6456	-30.6421
1	-29.0335	-29.039
1.5	-25.9244	-25.9189
2	-20.7834	-20.7812
2.5	-14.2488	-14.2718
3	-8.32141	-8.29396
3.5	-4.25422	-4.22346
4	-1.93813	-1.98353
4.5	-0.76706	-0.89335
5	-0.22891	-0.39447
5.5	-0.01317	-0.17264
6	0.048669	-0.07526
6.5	0.045206	-0.03275
7	0.021553	-0.01424
7.5	-0.00128	-0.00619
8	-0.01558	-0.00269
8.5	-0.02049	-0.00117
9	-0.01824	-0.00051
9.5	-0.01191	-0.00022

In order to calculate the structure of two-body quantum system, Schrodinger equation is solved.

$$(\hat{H}_0 + \hat{V})\Psi = E\Psi \quad (5)$$

$$\hat{H}\Psi = E\Psi$$

where, $\hat{H}$ = Hamiltonian operator

E = energy eigen value

Ψ = eigen wave function

$\hat{H}_0$ = kinetic energy operator and

$\hat{V}$ = potential energy operator

Since, the interaction between Λ and core nucleus is central force, so we choose the spherical coordinate for the wave function. $\Psi(\vec{r}) = R(r)\Theta(\theta)\Phi(\varphi)$

Where, $R(r)$ is a radial part and $\Theta(\theta)\Phi(\varphi)$ is an angular part and

$Y_l^m(\theta, \varphi) = \Theta(\theta)\Phi(\varphi)$ is spherical harmonics which are well known.

We have to solve only the radial part $R(r)$. By using the separable method, the following radial equation

$$\left\{ -\frac{\hbar^2}{2\mu} \frac{d^2}{dr^2} + \frac{\hbar^2 l(l+1)}{2\mu r^2} + V(r) \right\} \Psi(r) = E\Psi(r) \quad (6)$$

Where, μ = reduced mass = $\frac{m_1 m_2}{m_1 + m_2}$

m_1 = mass of carbon core nucleus, m_2 = mass of lambda hypernucleus

To solve the Schrodinger equation, we will use the Gaussian basis wave function

$$\Psi(r) = r^{\ell+1} \sum_j C_j e^{-\left(\frac{r}{\mu_j}\right)^2} \quad (7)$$

Where C_j are expansion coefficients and μ_j are range parameters.

The Schrodinger equation for radial part becomes μ_j

$$\left\{ -\frac{\hbar^2}{2\mu} \frac{d^2}{dr^2} + \frac{\hbar^2}{2\mu} \frac{\ell(\ell+1)}{r^2} + V(r) \right\} \sum_j C_j r^{\ell+1} e^{-\left(\frac{r}{\mu_j}\right)^2} = E \sum_j C_j r^{\ell+1} e^{-\left(\frac{r}{\mu_j}\right)^2}$$

Multiplying both sides of the equation by $r^{\ell+1} e^{-\left(\frac{r}{\mu_i}\right)^2}$ from the left and integration through the equation.

$$\int r^{\ell+1} e^{-\left(\frac{r}{\mu_i}\right)^2} \left\{ -\frac{\hbar^2}{2\mu} \frac{d^2}{dr^2} + \frac{\hbar^2}{2\mu} \frac{\ell(\ell+1)}{r^2} + V(r) \right\} \sum_j C_j r^{\ell+1} e^{-\left(\frac{r}{\mu_j}\right)^2} dr = E \sum_j C_j \int r^{\ell+1} e^{-\left(\frac{r}{\mu_i}\right)^2} \sum_j C_j r^{\ell+1} e^{-\left(\frac{r}{\mu_j}\right)^2} dr$$

$$\sum_j C_j \left[\int r^{\ell+1} e^{-\left(\frac{r}{\mu_i}\right)^2} \left\{ -\frac{\hbar^2}{2\mu} \frac{d^2}{dr^2} \right\} r^{\ell+1} e^{-\left(\frac{r}{\mu_j}\right)^2} dr + \frac{\hbar^2}{2\mu} \int r^{\ell+1} e^{-\left(\frac{r}{\mu_i}\right)^2} \frac{\ell(\ell+1)}{r^2} r^{\ell+1} e^{-\left(\frac{r}{\mu_j}\right)^2} dr + \int r^{\ell+1} e^{-\left(\frac{r}{\mu_i}\right)^2} V(r) r^{\ell+1} e^{-\left(\frac{r}{\mu_j}\right)^2} dr \right] = E \sum_j C_j \int r^{2(\ell+1)} e^{-\left(\frac{r}{\mu_i}\right)^2} e^{-\left(\frac{r}{\mu_j}\right)^2} dr \quad (8)$$

$$\sum_j [T_{ij} + V_{ij}^{\ell} + V_{ij}] C_j = E \sum_j N_{ij} C_j \quad (9)$$

T_{ij} is the kinetic energy matrix element.

$$T_{ij} = \int r^{\ell+1} e^{-\left(\frac{r}{\mu_i}\right)^2} \left\{ -\frac{\hbar^2}{2\mu} \frac{d^2}{dr^2} \right\} r^{\ell+1} e^{-\left(\frac{r}{\mu_j}\right)^2} dr \quad (10)$$

V_{ij}^{ℓ} is the centrifugal potential energy matrix element.

$$V_{ij}^{\ell} = \frac{\hbar^2}{2\mu} \int r^{\ell+1} e^{-\left(\frac{r}{\mu_i}\right)^2} \frac{\ell(\ell+1)}{r^2} r^{\ell+1} e^{-\left(\frac{r}{\mu_j}\right)^2} dr \quad (11)$$

$$N_{ij} = \int r^{\ell+1} e^{-\left(\frac{r}{\mu_i}\right)^2} V(r) r^{\ell+1} e^{-\left(\frac{r}{\mu_j}\right)^2} dr \quad (12)$$

$$H_{ij} = \int r^{2(\ell+1)} e^{-\left(\frac{r}{\mu_i}\right)^2} e^{-\left(\frac{r}{\mu_j}\right)^2} dr \quad (13)$$

H_{ij} is the Hamiltonian matrix element.

$$H_{ij} = T_{ij} + V_{ij}^{\ell} + V_{ij} \quad (14)$$

$$\sum_j H_{ij} C_j = E \sum_j N_{ij} C_j \quad (17)$$

The Schroedinger equation can be written in matrix form

$$\begin{bmatrix} H_{11} & H_{12} & \dots & H_{1N} \\ H_{21} & H_{22} & \dots & H_{2N} \\ \vdots & \vdots & \ddots & \vdots \\ H_{N1} & H_{N2} & \dots & H_{NN} \end{bmatrix} \begin{bmatrix} C_1 \\ C_2 \\ \vdots \\ C_N \end{bmatrix} = E \begin{bmatrix} N_{11} & N_{12} & \dots & N_{1N} \\ N_{21} & N_{22} & \dots & N_{2N} \\ \vdots & \vdots & \ddots & \vdots \\ N_{N1} & N_{N2} & \dots & N_{NN} \end{bmatrix} \begin{bmatrix} C_1 \\ C_2 \\ \vdots \\ C_N \end{bmatrix}$$

$$[H][C] = E[N][C]$$

$$[N]^{-1}[H][C] = E[C]$$

$$[B][C] = E[C]$$

which is eigen value equation with $[B] = [N]^{-1}[H]$, $[H]$, $[N]$ is called the norm matrix, $[C]$ is column matrix which is the expansion coefficient

A_{ij}^c and $[H]$ is the Hamiltonian matrix. By diagonalizing the matrix B , the eigen value is obtained. The lowest energy eigen values is the first excited state binding energy of the two-body system. In this way we obtain the kinetic energy, potential energy and norm matrix elements analytically since our basis are Gaussian form. The minimum energy eigen value gives the bound state of the $^{12}_{\Lambda}C$ system. We obtain it by applying the power inverse iteration method to evaluate the above Schrödinger equation for $^{12}_{\Lambda}C$ system.

Results and Discussions

We have carried out two-body calculation to study the structure of system in coordinate space. We have calculated the total energy and the root-mean-square distance for two body system to analyze the structure of $^{12}_{\Lambda}C$ hypernucleus system.

We have obtained the energy eigenvalue of $^{12}_{\Lambda}C$ in two body system. We calculate the first excited state energy of $^{12}_{\Lambda}C$ by diagonalizing the Hamiltonian with energy matrix elements and norm matrix elements which are obtained by employing the Gaussian basis wave function. The structure of p-shell $^{12}_{\Lambda}C$ is investigated within the framework of two-body calculation. For above mention, Λ -hypernuclei is considered as a Table 2. Calculated results experimental values

of $^{12}_{\Lambda}C$ hyper nucleus system.

System	Average kinetic energy (MeV)	Average potential energy (MeV)	Binding energy (MeV)
Our calculated result	7.57	-17.23	9.66
Experimental result	-	-	10.76±0.19

system consists of one lambda hyperon and one core nucleus. In our calculation, the wave function parameters are used which are the number of expansion coefficient $N=40$, range parameter $b_1 = 0.1$ fm and $b_N = 20.0$ fm. For first excited state, our calculated binding energy result for $^{12}_{\Lambda}C$ is 9.66 MeV. We have been calculated the average kinetic energy, average potential energy and root-mean-square distance of the hypernucleus system. Our calculated the value of average kinetic energy and average potential energy. The experimental values for Λ -binding energy of $^{12}_{\Lambda}C$ is 10.76 ± 0.19 MeV. The comparison for experimental value and our calculated results are shown in Table (2). The aim of this thesis is to calculate the binding energy of the hypernucleus system. To find the first excited state energy of lambda hypernucleus, we use the phenomenological Woods-Saxon potential. This is transformed into Gaussian potential. We calculate the Hamiltonian and norm matrix elements by employing the Gaussian basis wave function. To get the first excited state energy, we have to solve the Schroedinger equation by using the Gaussian basis wave function. Our calculated the first excited state binding energy is 9.66 MeV and the experimental value is 10.76 ± 0.19 MeV. We can conclude that the theoretical results are in good nearly agreement with the experimental values and it indicates that our Gaussian wave function and the phenomenological potential are good to describe the two body lambda hypernuclear systems. In our research, the binding energy of $^{12}_{\Lambda}C$ system is calculated with the help of FORTRAN PROGRAM.

We also calculated the root mean square distance between lambda and carbon core nucleus. We have been used the root mean square distance below equation.

$$\rho_{(r)} = \int \psi^*(r) \psi(r) dr$$

$$= \int \sum_i N_i C_i e^{-\frac{1}{2} \frac{r^2}{b_i^2}} r^{i+1} \sum_j N_j C_j e^{-\frac{1}{2} \frac{r^2}{b_j^2}} r^{j+1} dr$$

$$T_{ij} + V'_{ij} + V_{ij} = -\frac{\hbar^2}{2\mu} N_{ij} \left(\frac{4l+6}{\mu_j^4 \left(\frac{1}{\mu_i^2} + \frac{1}{\mu_j^2} \right)} - \frac{4l+6}{\mu_j^2} \right) + N_{ij} \sum_k V_k \left(\frac{\pi}{\frac{1}{\mu_i^2} + \frac{1}{\mu_j^2} + \frac{1}{\mu_k^2}} \right)^{l+1/2}$$

$$\text{Thus, } H_{ij} = N_{ij} \left[\sum_k V_k \left(\frac{\pi}{\frac{1}{\mu_i^2} + \frac{1}{\mu_j^2} + \frac{1}{\mu_k^2}} \right)^{l+1/2} - \frac{\hbar^2}{2\mu} \left(\frac{4l+6}{\mu_j^4 \left(\frac{1}{\mu_i^2} + \frac{1}{\mu_j^2} \right)} - \frac{4l+6}{\mu_j^2} \right) \right]$$

For first excited state, $l=1$

$$N_{ij} = \frac{3}{8} \frac{\sqrt{\pi}}{\left(\frac{1}{\mu_i^2} + \frac{1}{\mu_j^2} \right)^{5/2}}$$

$$V'_{ij} = \frac{\hbar^2}{2\mu} \frac{1}{2} \frac{\sqrt{\pi}}{\left(\frac{1}{\mu_i^2} + \frac{1}{\mu_j^2} \right)^{3/2}} \quad (15)$$

$$T_{ij} = -\frac{\hbar^2}{2\mu} \left\{ \frac{15}{4\mu_j^4} \frac{\sqrt{\pi}}{\left(\frac{1}{\mu_i^2} + \frac{1}{\mu_j^2} \right)^{7/2}} - \frac{15}{4\mu_j^2} \frac{\sqrt{\pi}}{\left(\frac{1}{\mu_i^2} + \frac{1}{\mu_j^2} \right)^{5/2}} + \frac{1}{2} \frac{\sqrt{\pi}}{\left(\frac{1}{\mu_i^2} + \frac{1}{\mu_j^2} \right)^{3/2}} \right\}$$

$$V_{ij} = \frac{3}{8} \frac{\sqrt{\pi}}{\left(\frac{1}{\mu_i^2} + \frac{1}{\mu_j^2} \right)^{5/2}} \sum_k V_k \left(\frac{\pi}{\frac{1}{\mu_i^2} + \frac{1}{\mu_j^2} + \frac{1}{\mu_k^2}} \right)^{3/2} = N_{ij} \sum_k V_k \left(\frac{\pi}{\frac{1}{\mu_i^2} + \frac{1}{\mu_j^2} + \frac{1}{\mu_k^2}} \right)^{3/2}$$

$$H_{ij} = T_{ij} + V'_{ij} + V_{ij}$$

$$H_{ij} = \frac{\sqrt{\pi}}{\left(\frac{1}{\mu_i^2} + \frac{1}{\mu_j^2} \right)^{5/2}} \left\{ -\frac{\hbar^2}{2\mu} \left[\frac{15}{4\mu_j^4} \frac{1}{\left(\frac{1}{\mu_i^2} + \frac{1}{\mu_j^2} \right)} - \frac{15}{4\mu_j^2} \right] + \frac{3}{8} \sum_k V_k \left[\frac{\pi}{\left(\frac{1}{\mu_i^2} + \frac{1}{\mu_j^2} + \frac{1}{\mu_k^2} \right)} \right]^{3/2} \right\}$$

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$$\sum_j H_{ij} C_j = E \sum_j N_{ij} C_j$$

(17)

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We also calculated the root mean square distance between lambda and carbon core nucleus. We have been used the root mean square distance below equation.

$$\rho_{(r)} = \int \psi^*(r) \psi(r) dr$$

$$= \int \sum_i N_i C_i e^{-1/4 r_i^2} r_i^{l+1} \sum_j N_j C_j e^{-1/4 r_j^2} r_j^{l+1} dr$$

$$\begin{aligned}
\langle r_{rms}^2 \rangle &= \int \psi^*(r) r^2 \psi(r) dr \\
\langle r_{rms}^2 \rangle &= \sum_j c_j c_j N^2 \int r^2 e^{-\left(\frac{1}{b_i^2} + \frac{1}{b_j^2}\right) r^2} r^{2(l+1)} dr \\
\langle r_{rms}^2 \rangle &= \sum_j c_j c_j N^2 \int r^{2(l+2)} e^{-\left(\frac{1}{b_i^2} + \frac{1}{b_j^2}\right) r^2} dr \\
\langle r_{rms}^2 \rangle &= \sum_j c_j c_j N^2 \left[\frac{(2l+3)!!}{2^{l+1}} \frac{\sqrt{\pi}}{\left(\frac{1}{b_i^2} + \frac{1}{b_j^2}\right)^{l+\frac{3}{2}}} \right] \\
\langle r_{rms}^2 \rangle &= \sum_j c_j c_j N^2 \frac{(2l+3)(2l+1)}{2^{l+1}} \frac{\sqrt{\pi}}{\left(\frac{1}{b_i^2} + \frac{1}{b_j^2}\right)^{l+\frac{3}{2}}}
\end{aligned}$$

We have calculated the relative density distribution and root mean square distance between lambda and carbon core nucleus in $^{12}_{\Lambda}\text{C}$ system. The result of root mean square distance in $^{12}_{\Lambda}\text{C}$ hypernucleus system is 2.32fm.

Acknowledgements

I wish to express my gratitude of Professor Dr. Yi Yi Myint (Head) and Professor Dr. May Thida Win, Department of Physics, Yadanabon University, for her valuable advice in this research work. I would like to thank all of my friends and member of the Theoretical Nuclear Physics Group for their various kinds of help.

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PHY 003

Environmental Impacts due to Radionuclides Pollution of Slag Samples from Mu River in Pinlebu Township, Sagaing Region

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Abstract

Mu River is the life blood of people from Pinlebu Township, Sagaing Region. Pinlebu town and many villages are located near Mu River. Therefore, the aim of this research is to determine the radionuclides pollution from Mu River. The activity concentrations and natural radionuclides of slag samples from five places of Mu River with two samples in one place were investigated in this research. High Purity Germanium (HPGe) detector was used to measure the activity concentration of these ten samples and Gamma Vision 32 software was used to analyze the results. The radionuclides such as Potassium (^{40}K , 1460.83 keV), Actinium (^{228}Ac , 968.97 keV, 911.204 keV, 338.32 keV), Bismuth (^{214}Bi , 609.312 keV), Thallium (^{208}Tl , 583.191 keV, 510.77 keV), lead (^{214}Pb , 351.932 keV, 295.224 keV), lead (^{212}Pb , 238.632 keV, 77.11 keV) were found in slag samples. The radionuclides found in measured samples were Potassium, daughter nuclei of Uranium series and Thorium series. Uranium, Thorium and Potassium are concentrated in slag samples. The mean outdoor absorbed dose rates, the mean outdoor annual effective dose rates and the average lifetime cancer risks of slag samples were more than the world average values. Thus, the radiation levels are above the recommended levels for people who are working agriculture along the Mu River of five researched places.

Keywords: Mu River, radionuclides pollution, high purity germanium (HPGe) detector

Introduction

Mu River is the natural resource of agriculture for people from Pinlebu Township, Sagaing Region. Most people near Mu River are farmers and they plant vegetables and groundnuts on the soils, sands and slags of Mu River. Therefore, they can be affected by the natural radionuclide pollutions of slags from Mu River. The natural radionuclides are always present in our environment since the formation of the earth. Potassium, Thorium, Uranium and the members of the long decay chains of Uranium and Thorium are the most important components for natural radioactivity. Uranium, thorium and radium are all members of long decay chains involving daughter nuclei emitted as a mixed spectrum of alpha, beta, and gamma rays. In natural gamma-ray spectrum, the daughter nuclei can be found that ^{228}Ac , ^{224}Ra , ^{212}Bi , ^{212}Pb , ^{208}Tl are in thorium series, ^{226}Ra , ^{214}Pb , ^{214}Bi are in uranium series. Thus, the knowledge for the activity concentrations of ^{238}U , ^{232}Th and ^{40}K is very important for farmers who plant on River sites in estimation of their radiological hazards.

Materials and Methods

Study area

The five sampling areas are in Mu River, Pinlebu Township, Sagaing Region. They lie between $24^{\circ} 04' 52.604''$ N latitude and $95^{\circ} 21' 23.533''$ E longitude, between $24^{\circ} 03' 33.537''$ N latitude and $95^{\circ} 20' 54.537''$ E longitude, between $24^{\circ} 01' 43.161''$ N latitude and $95^{\circ} 21' 22.423''$ E longitude, between $24^{\circ} 00' 59.645''$ N latitude and $95^{\circ} 20' 56.382''$ E longitude and between $24^{\circ} 00' 09.630''$ N latitude and $95^{\circ} 21' 09.209''$ E longitude. Among them, the first place is near Pinlebu town. Therefore, it is the place where is no gold production. There were many gold productions in other four places until a few years ago. The concentration of the slag samples in the sands increased due to gold production. But now,

the main economics for people near Mu River is agriculture.

Samples Collection and Preparation

People are working for the agricultures among the areas shown in Figure (1). So, the slag samples were collected from five places, two samples in each place. And then, the slag samples were dried at room temperature, avoiding the loss of any volatile radionuclides. The dried samples were pulverized and sieved to pass through a 100 mesh sieve. The meshed samples, 300g of each, were transferred to plastic containers for gamma activity analysis.

High purity germanium (HPGe) detector was used for gamma-ray measurement as shown in Figure (2). To reduce a possible background radiation that comes from the environment, lead (Pb) shielding was used in this measurement. For the present measurement, firstly, the background spectrum was measured for 10800 s. And then, the samples (300g) were measured with the same condition.

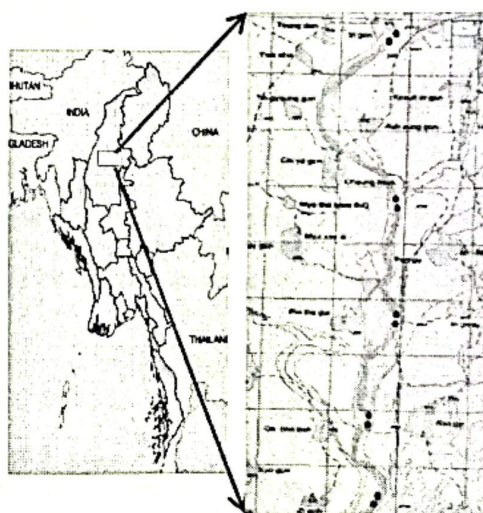
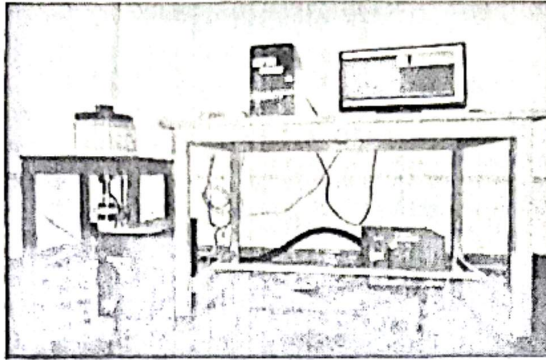


Figure (1) Ten Sampling points in Study Areas



Calculation of Activity

The net radiation counts of each sample from five places of Mu River were analyzed by subtracting the background radiation counts from the gross radiation counts. The net activity concentration of each sample was calculated by following equation,

$$A = \frac{N_A}{m \varepsilon P_\gamma T} (\text{Bqkg}^{-1})$$

Where, N_A = net count rate for sample
 m = mass of sample
 P_γ = gamma ray intensity
 T = counting time
 ε = efficiency of detector

Determination of Gamma Dose Rates

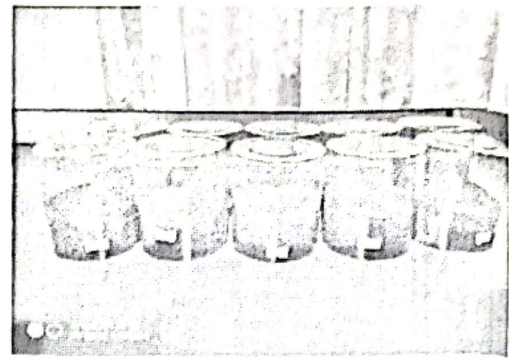
The gamma outdoor absorbed doses rates of slag samples from five places of Mu River in air for one meter above the ground surface were determined by using the following equation:

$$D_0 = 0.462 A_U + 0.604 A_{Th} + 0.0417 A_K (\text{nGyh}^{-1})$$

where D_0 is the gamma absorbed dose rate (nGyh^{-1}), A_U , A_{Th} , A_K are the specific activities of Uranium, Thorium, and Potassium series respectively and 0.462, 0.604 and 0.0417 nGyh^{-1} per Bqkg^{-1} are the absorbed dose rate conversion factors for Uranium series, Thorium series and Potassium respectively (UNSCEAR 2000). The external outdoor Annual Effective Dose Rates (E_0) for slag samples were calculated by using the following equation (UNSCEAR 2000).

$$E_0 = D_0 \times DCF \times OF \times T (\text{mSvy}^{-1})$$

where E_0 is the external outdoor Annual Effective Dose Rates, D_0 is the gamma absorbed dose rate (nGyh^{-1}), DCF is dose conversion factor (0.7 Sv Gy^{-1}) in UNSCEAR (2000), OF is the outdoor occupancy factor for Myanmar and T is the annual exposure time (8766h) respectively. The working hour per day for Myanmar is 8 hours (30%) according to Employment Law in Myanmar, November 2017. Thus, the average outdoor occupancy factor is 0.3. The world average outdoor occupancy is 0.2 (UNSCEAR 2000).



Investigation of Excess Lifetime Cancer Risk

The Excess Lifetime Cancer Risks (ELCR) for slag samples were calculated to investigate the results of exposure to external gamma radiation. The Excess Lifetime Cancer Risk is the probability of an individual developing cancer over a given period of time. This was determined by the following equation.

$$ELCR = E_0 \times DL \times RF$$

where DL is the duration of life expected to be 57 years (WHO, Myanmar (August 2008)), and RF is the risk factor per sievert given as 0.05 Sv^{-1} (ICRP 1990).

Results and Discussion

The presence of radionuclides in ten slag samples from five places of Mu River, Pinlebu Township, Sagaing Region were investigated by using HPGe detector and analyzed by using Gamma Vision 32 software. The radionuclides presence in samples were Potassium (^{40}K , 1460.83 keV), Actinium (^{228}Ac , 968.97 keV, 911.204 keV, 338.32 keV), Bismuth (^{214}Bi , 609.312 keV), Thallium (^{208}Tl , 583.191 keV, 510.77 keV), lead (^{214}Pb , 351.932 keV, 295.224 keV), lead (^{212}Pb , 238.632 keV, 77.11 keV). The activity concentrations of two slag samples in the same place were taken to be average respectively. ^{228}Ac , ^{208}Tl and ^{212}Pb are the daughter nuclei of ^{232}Th decay series and ^{214}Bi and ^{214}Pb are the daughter nuclei of ^{238}U decay series. So, it can be found that the radionuclides in samples are Potassium and the daughter nuclei of Uranium series, Thorium series.

In three radioactive decay series, the specific activity concentration of second place was the highest in Uranium series and Thorium series and that of fourth place was the highest in Potassium. The specific activity concentration of fifth place was the lowest in Uranium series and that of first place was the lowest in Thorium series and Potassium respectively. The mean total activity concentration for second place was the highest and that for the first place was the lowest in all places of Mu River. The activity concentrations of Potassium, Uranium series and Thorium series for all five places of Mu River were much higher than the world averages, 420 Bq/kg, 33 Bq/kg, 45 Bq/kg respectively. The activity concentration for second place was 28.80 times in Uranium series, 16.55 times in Thorium series and that for fourth place was 1.89 times in Potassium higher than

World average values (UNSCEAR 2000) shown in Table (1) and Figure (3).

Table (1) Specific Activity Concentration of ^{40}K , ^{238}U , ^{232}Th in rock samples from ten small gold mines

Slag Samples	Uranium Series	Thorium Series	Potassium	Mean Total Activity Concentration
S1	542.40±10.44	744.75±12.82	417.25±41.59	1704.40±64.85
S2	950.46±13.75	1394.32±17.81	609.10±50.98	2953.88±82.54
S3	612.41±10.07	1235.52±20.19	476.95±46.29	2324.88±76.55
S4	668.29±10.47	1305.19±23.09	796.93±58.36	2770.41±91.92
S5	539.75±9.52	880.11±13.80	680.21±53.67	2100.07±76.99
World	33	45	420	498

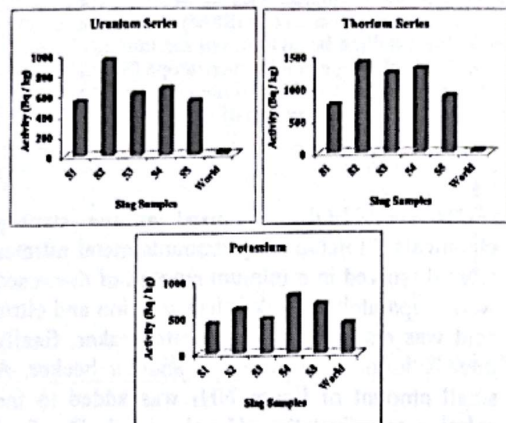


Figure (3) Comparisons of world average values and Specific Activity Concentration of ^{238}U , ^{232}Th , ^{40}K for slag samples

The results of the outdoor absorbed dose rates at one meter height above the ground, the outdoor annual effective dose rates and the Excess Lifetime Cancer Risk for slag samples from five places of Mu River are shown in Table (2) and Figure (4).

The outdoor absorbed dose rates of all samples from five places of Mu River were very higher than the world average value, 59 nGy/h⁻¹ (UNSCEAR 2008, 2000). Among them, the sample from the second place was the highest outdoor absorbed dose rate and 22.15 times higher than world average value. The outdoor annual effective dose rates of all slag samples were also higher than world average value, 0.07 mSv/y⁻¹ and the maximum permissible dose limit, 1 mSv/y⁻¹ (ICRP 1990). The outdoor annual effective dose rate for second place was the highest in all five places and 34.43 times higher than world average value and 2.41 times higher than maximum permissible limit. And then, the average Excess lifetime cancer risks for all places were very higher than the world average value of 0.245 (UNSCEAR 2000). It was 28 times higher than the world average for the second place of Mu River.

Conclusion

The radioactivity concentrations in slag samples for five places of Mu River from Pinlebu Township, Sagaing Region were determined by HPGe detector. It can be observed that the radionuclides in samples from five places of Mu River were Potassium and daughter nuclei of Uranium series and Thorium series. For all samples, the mean outdoor absorbed dose rates,

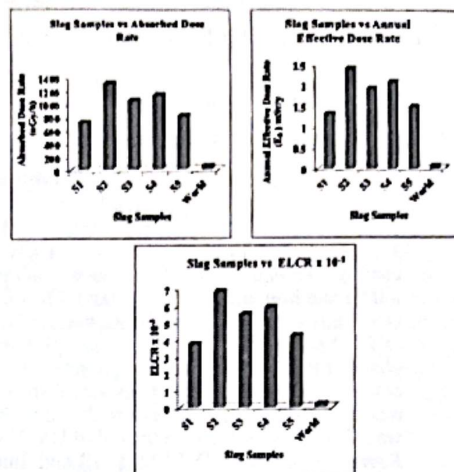


Figure (4) Comparisons of world average values and Specific Activity Concentration of ^{238}U , ^{232}Th , ^{40}K for slag samples

Table (2) Outdoor Absorbed Dose Rate, Annual Effective Dose Rate and Excess Lifetime Cancer Risk for slag samples from five places of Mu River

Sample	Absorbed Dose Rate (nGy/h)	Annual Effective Dose Rate (ED) mSv/y	ELCR x 10 ⁻³
S1	717.82±14.30	1.32±0.03	3.77±0.08
S2	1396.68±19.23	2.41±0.04	6.86±0.10
S3	1049.07±18.77	1.91±0.03	5.51±0.09
S4	1130.32±21.22	2.08±0.04	5.93±0.11
S5	809.31±14.97	1.49±0.02	4.24±0.08
World	59	0.07	0.245

the mean outdoor annual effective dose rates and the average lifetime cancer risks were very higher than the world average value. The mean outdoor annual effective dose rates for the slag samples in all five places were higher than the maximum permissible limit. The radiation levels of slag samples from second place of Mu River were highest in all five places. Therefore, farmers from these five places of Mu River should avoid the places where slag samples are present in agricultures.

Acknowledgements

We would like to acknowledge to members of Experimental Nuclear Physics Lab for allowing us to use HPGe detector and other lab equipment. We specially thank to Professor Dr San San Kyi, Head of Department of Physics, Mandalay Degree College for her valuable advices and permission.

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PHY 004

Microstructure and Electrical Properties of Nickel Doped Bismuth Ferrite Thin Films

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Abstract

The preparation of Ni doped Bismuth ferrite thin film on Si substrate was done by using spin coating technique. Sol-gel process was adopted to prepare the films using bismuth nitrate, nickel nitrate and iron nitrate as precursors. The microstructure and surface morphology of the film were characterized using X-ray diffraction (XRD) and scanning electron microscope (SEM). The peaks of BFO phase were found in all samples suggesting polycrystalline behaviour, but the impurity phase of $\text{Bi}_2\text{Fe}_4\text{O}_9$ and $\text{Bi}_{24}\text{Fe}_2\text{O}_{20}$ were also observed. The Scanning electron microscope (SEM) studies revealed a homogenous size distribution with a grain size of 120 - 130 nm. The surface resistance of these films were analyzed with four point probe. The energy gap of these materials was also investigated with the aid of UV-Vis spectrophotometer.

Keywords: BFO, XRD, SEM, FTIR and four point probe method.

Introduction

Bismuth ferrite (BiFeO_3 , BFO) is one of the most promising lead-free piezoelectric materials exhibiting multi ferroic properties at room temperature. In this material, both ferroelectric and anti-ferromagnetic properties coexist simultaneously. It is an inorganic chemical compound with a perovskite structure.

Bismuth ferrite (BiFeO_3 , BFO) is a rhombohedrally distorted perovskite. It is one of such few materials that belongs to the multiferroic material due to coexistence of ferroelectricity (T_c , bulk = 830°C) and antiferromagnetism (T_N , bulk = 370°C). The specific characteristics, such as simple crystal structure, high Curie temperature (electrical), and high Neel temperature (magnetic), are advantageous for research and various applications. Bismuth ferrite (BFO) is useful material due to its stable ferroelectric and antiferromagnetic coupling at room temperature, and due to the fact that its ferroelectric properties are very much enhanced in thin film form.

In present work, nickel (Ni^{3+}) as dopant to substitute Fe^{3+} in BiFeO_3 system was performed by sol-gel method and these films were also obtained by using spin coating process. The phase identification and microstructure of these films were analyzed by XRD and SEM. The energy band gap of this material was investigated by using UV-Vis spectrophotometer. The surface resistance of this film was also analyzed with four-point probe method.

Materials and Methods**Preparation of Nickel doped Bismuth Ferrite films**

Nickel II Nitrate Hexahydrate [$\text{Ni}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$], Bismuth II Nitrate Pentahydrate [$\text{Bi}(\text{NO}_3)_3 \cdot 5\text{H}_2\text{O}$] and Iron (III) Nanohydrate

$[\text{Fe}(\text{NO}_3)_3 \cdot 9\text{H}_2\text{O}]$ were used as the starting chemicals. Stoichiometry amounts metal nitrates were dissolved in minimum amount of deionised water separately to make clear solution and citric acid was dissolved in a separate beaker, finally three solutions are mixed in another beaker. A small amount of liquor NH_3 was added to the solution to adjust the pH value at 7. The final solution was simultaneously heated and mixed using magnetic stirrer. The neutralized solution was evaporated to dryness by heating at 100°C on a hot plate with continuous stirring. As water evaporated, the solution became viscous and finally formed a very viscous brown gel. Films from the stock solution were deposited on Si(100) wafers substrates. The substrates were cleaned thoroughly by ultrasonication in alcohol and acetone. The depositions were carried out by spin coating at 5500 rpm for 15 s. In order to get perovskite phase, the films were annealed at 300, 400 and 500°C for 1 h. The flow chart of sample preparation was shown in figure 1.

Results and discussion**Structural Characterization Analysis (XRD)**

The XRD pattern of ferrite powder was shown in figure 2. Nano particles of ferrite samples were identified with an X-ray powder diffraction technique {Schimadzu model: XRD 6100 using $\text{CuK}\alpha$ ($\lambda=0.154\text{ nm}$) radiation}, with a diffraction angle between 10° to 70° . Figure 2 presented the XRD patterns of Ni doped BFO thin films deposited on silicon substrate. It shows the formation of BiFeO_3 and $\text{Bi}_2\text{Fe}_4\text{O}_9$ phases. Preparation of single phase BiFeO_3 is a critical task because the temperature stability range is very narrow. Moreover, bismuth and iron show the affinity of oxygen and to form multiphase materials.

Stoichiometric ratio amounts

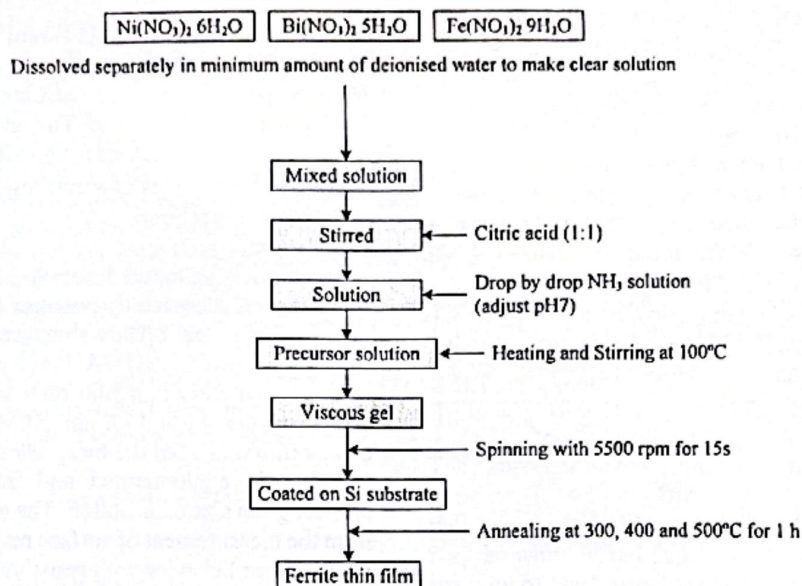


Figure 1 : The flow chart of preparation of Ni doped Bi ferrite films on Si substrate.

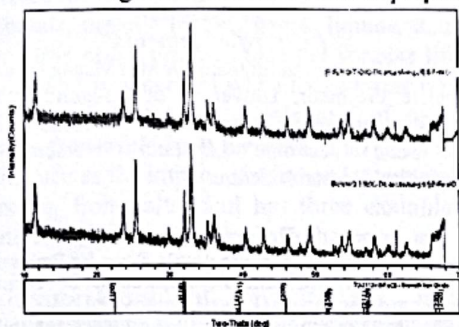
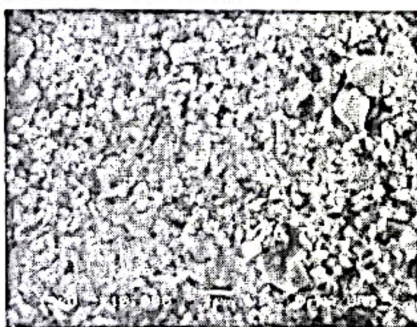
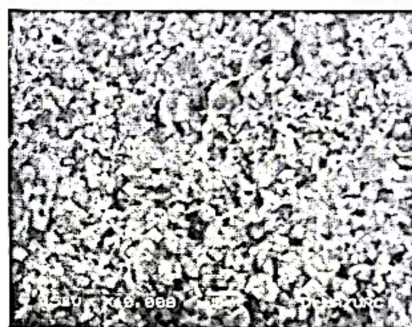


Figure 2 : The XRD pattern of Ni doped BFO thin film on Si substrate.

Morphology Analysis (SEM)

The Microstructural properties of Ni doped BFO thin film on Si substrate was studied by Scanning Electron Microscopy (SEM). The SEM image depicted that it was largely agglomerated and well-defined nano particles with inhomogeneous broader grain size distribution. Such broader size distribution was characteristics of mechanically activated Nano sized particles. The SEM microstructures of Ni doped BFO thin film were also shown in figure 3(a) and (b). The grain size of this thin film was in the range of 120 – 130 nm.

Figure 3 (a) : The SEM microstructure of Ni doped bismuth ferrite annealing at 300°C Figure 3 (b) : The SEM microstructure of Ni doped bismuth ferrite annealing at 400°C

FTIR Analysis

Figure 4 showed the FTIR spectra of prepared samples. The strong absorption peaks around $400\text{--}600\text{ cm}^{-1}$ were attributed to the Fe – O stretching and bending vibrations which were fundamental absorptions characteristics of FeO_6 octahedral group in the perovskite structure. The formation of perovskite structure could be confirmed by the metal oxygen band. The band at 1387.52 cm^{-1} was due to the presence of trapped nitrate. Typical band characteristics of oxygen metal bonds were observed in the $450\text{--}640\text{ cm}^{-1}$ region.

A distinct change was noticed that the both side nickel substituted BiFeO_3 sample shown two positive peaks near 3000 cm^{-1} compared to the other two compositions. The bands between 3400 and 3784 cm^{-1} could be attributed to the O–H stretching vibration of H_2O absorbed by the sample and the

surface O-H or EG. The bands with the peaks at 488, 670 and 809 cm^{-1} were assigned to the deformation vibration of Fe-OH groups. The two main metal-oxygen bands at 670 cm^{-1} and 488 cm^{-1} were observed in the FT-IR spectrum of the synthesized Ni doped BiFeO₃ samples. These two bands were usually assigned to vibration of ions in the crystal lattices. This indicates the presence of uniformly distributed ferrite particles. The band at 1050 cm^{-1} shows the presence of C-O group vibration modes. At 1360 cm^{-1} there was a significant change in the irrelevant peak of -CH bending band. The 1316 cm^{-1} peak was attributed to the characteristic -CH₃ bending.

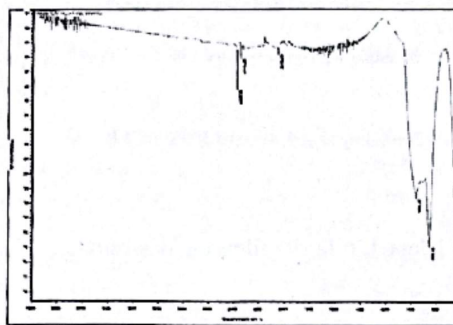


Figure 4 : The FTIR spectrum of Ni doped bismuth ferrite.

Energy band gap

The energy band gap of the material was determined by using UV-visible spectra according to Tauc relation $\alpha h\nu = A(h\nu - E_g)^n$, Where E_g the energy gap, constant A is different for different transitions, $(h\nu)$ is the energy of the photon and n is an index which assumes the value 1/2, 3/2, 2 and 3 depending on the nature of the electronic transition responsible for the reflection. The value of n is 1/2 for allowed and 2 for forbidden direct energy gap for ferrites. Further, the value of α has been calculated by the following relation, $\alpha = 4\pi k/\lambda$, where λ is wavelength in nm and k is absorption index. Figure 5 illustrated the UV-visible absorbance spectra of the Ni substituted Bi ferrites, the absorbance decreases as the doping of Ni. The value of optical energy band gap E_g has been calculated for the all samples by $(\alpha h\nu)^2$ vs $h\nu$ plots. The values of E_g for different samples were found by extrapolating the linear portion to the $h\nu$ determine the energy band gap E_g to be about 4.5eV.

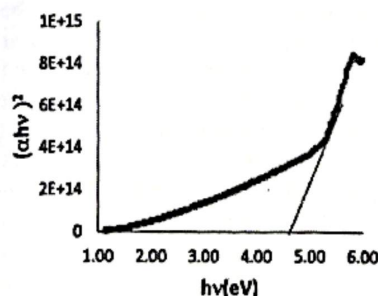


Figure 5 : The

investigated energy band gap of Ni doped bismuth ferrite.

Surface Resistance measurement

The surface resistance of Ni doped bismuth ferrite thin film was obtained by using four point probe method. The average surface resistance of this film was observed 47k Ω , 40k Ω , and 35k Ω for samples of annealing 300°C, 400°C and 500°C respectively.

Conclusion

Nickel Doped bismuth Ferrites (BFO) thin film was successfully prepared by sol-gel and spin coating process. Their structural analysis was reported by using XRD. Average crystallite size of fabricated BFO thin film observed that in the range between 41 and 46 nm. SEM micrographs of this film indicated the morphology of particles was largely agglomerated and inhomogeneous broader grain size distribution. The obtained result from the measurement of surface resistance, it was to be a linear behavior with resistivity of the order of 0.1 Ω -cm and the ohmic behavior in milli-Ampere range.

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PHY 005

Study of Transfer Factor of Radionuclides from Soil to Plants and Fruits in**Dragon Fruit (*Hylocereus*) by Using Hpgc Detector**

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Abstract

This research work was to analyze the transfer factor of radionuclides from soil, plant and fruit samples which were collected from Meiktila Garden, Meiktila Township, Mandalay Region and Sei Pauk Garden, Kyaukpadaung Township, Mandalay Region. The HPGe detector was used for the study of radionuclides in soil, plant and fruit samples then analyzed by using Gamma Vision 32 Software. The radionuclides present in soil, plant and fruit samples are ^{207}Bi (74.97 keV), ^{214}Pb (77.11 keV), ^{212}Pb (238.63 keV), ^{214}Pb (295.22 keV), ^{214}Pb (351.00 keV), ^{207}Bi (609.32 keV) and ^{40}K (1460.75 keV). The transfer factor of Pyi Thar Yar soil to plant sample is 0.30 for ^{207}Bi and 2.51 for ^{40}K and that of Sei Pauk soil to plant sample is 0.24. For soil to fruit sample 0.35 and 0.10 for ^{207}Bi and 0.39 and 2.15 for ^{40}K for Pyi Thar Yar and Sei Pauk respectively.

Introduction**Types of Soil**

Soil is a term that has a very broad definition and refers to a loose layer of earth that covers the surface of the planet. Soil is the mixture of minerals, organic matter, gases, liquids, and the countless organisms that together support life on earth. Soil is generated when rocks break up into their constituent parts. A plethora of different forces then work upon the broken up parts of the soil, such as the impact of wind and water and the reaction from salts. Soil has three examples of state solid soil, soil with air in the pores and soil with water in the pores. Due to the number of different forms of organic and mineral compositions, there are various types of soil that undergoes different environmental pressures.

Dragon Fruit

Dragon fruit is also known as Pitaya, Dragon Fruit, Red Pitahaya, Night blooming Cereus, Strawberry Pear, Belle of the Night, Cinderella plant. The Dragon fruit is among the most nutritious and wonderful exotic fruits. It is a favorite to many, particularly people of Asian origin. It features a mouth watering light sweet taste, an intense shape and color, not forgetting its outstanding flowers. In addition to being tasty and refreshing, this beautiful fruit boasts of a lot of water and other vital minerals with varied nutritional ingredients.

The Dragon plant is a vine, epiphytic cacti of the genus *Hylocereus*. Dragon plant has fleshy stems that grow up to 20 ft long when matured. Dragon plant may grow from the ground or climb onto trees using aerial roots. Dragon plant bears flowers are ornate and beautiful with fragrant scent. Pitahaya plants can have up to 4.6 fruiting cycles per year.

Dragon fruit is tropical fruit, drought, high temperature, hi-light, strict requirements of the soil, plains, hills, sand and gravel to be planted, the optimum soil pH of 6 to 7.5 the best choice rich organic matter and drainage good land to grown.

The dragon fruit has spines that grows up to 1 kilogram in weight. Dragon fruit skin may be yellowish to dark red in color with edible flesh that may be white or red depending on the variety. It has a lot of black small seeds that is also edible.

Pitaya or Dragon fruit is also known to have some health benefits that includes preventing memory loss, anti cancer activity, control of blood glucose level in diabetes, anti oxidant properties, aids in healing of wounds and others Pitahaya fruits are high of concentrated with Vitamin C, minerals and boasts of high fiber content.

Dragon fruit has an extremely low amount of cholesterol, which ultimately helps the body break down this fruit quickly. Dragon fruit is an excellent source of monounsaturated fats, helping the heart stay in great condition. To clean up your digestive system, eat a dragon fruit. They have a high fiber content, which can assist with poor digestion and constipation. The high amount of fiber in dragon fruit can ultimately help regulate diabetes, as it can stabilize blood sugar levels by suppressing sugar spikes. Eating a dragon fruit with its rich antioxidants can keep the skin tight and young. Dragon fruit juice is an excellent agent for treating colored hair.

The seeds of dragon fruits are high in polyunsaturated fats (omega-3 and omega-6 fatty acids) that reduce triglycerides and lower the risk of cardiovascular disorders. Eating dragon fruit can help the body maintain such normal function as ridding the body of toxic heavy metals and improved eyesight.

Dragon fruit promotes healing of wounds and cuts. Dragon fruit improves appetite, eye sight and memory. Dragon fruit can aid in weight reduction. Dragon fruit is safe for consumption even by pregnant and breast feeding mothers. Dragon fruits are also made into jams, puree, sherbets, salads, fruit pizza, juice and beverages.

Materials and Methods

Sample Collection and Preparation for Gamma Ray Detection Method

The soil, plant and fruit samples were collected from the gardens in Pyi Thar Yar (Meiktila) and Sei Pauk (Kyauk Padaung). Soil sample S1, plant sample P1 and fruit sample F1 are collected from Pyi Thar Yar (Meiktila) and soil sample S2, plant sample P2 and fruit sample F2 are collected from Sei Pauk (Kyauk Padaung). Soil Sample S1 and S2 had been collected from surface to 5cm depth around the plant. Plant sample P1 and P2, fruit sample F1 and F2 had been taken from the plants that soil samples were collected. The collected samples were dried at room temperature, avoiding the loss of any volatile radionuclides. The dried soil samples were pulverized and sieved to pass through a 1-2 mm mesh to get fine powder. The samples, 100g each, were transferred to the cylindrical plastic containers of about 250 cm³ volume.

Experimental Set-Up for Gamma Emission Measurement

In this experiment, the measurement of radionuclides in the granite and marble samples was made with a gamma-ray spectrometry system. The system consists of HPGe detector ORTEC (model GMX 10P4-70-RB-SMN), cooler (model CFG-X-COOL-III-230), preamplifier (model A257N), fast spectroscopy amplifier ORTEC (model-671), high voltage power supply, photomultiplier tube, digital signal processor (DESPEC-LF), a 16k pulse stored Multi-Channel Analyzer together with Gamma Vision-32 software installed in pc and data readout devices. The operation voltage for HPGe detector is negative 1500V dc. The experimental setup of HPGe detection system is as shown in Figure (1).

Calculation of Activity

The activity of the soil sample was calculated by following equation

$$A = \frac{N_A}{m \epsilon P_r T}$$

Where, N_A = net count rate for sample
 m = mass of sample
 P_r = gamma ray intensity
 T = counting time (in second)
 ϵ = efficiency of the interest gamma ener

Calculation of Transfer Factor

The transfer factor of the soil to plant sample was calculated by following equation

$$TF = \frac{\text{Activity of radionuclides in plant (Bq/kg dry weight)}}{\text{Activity of radionuclides in soil (Bq/kg dry weight)}}$$

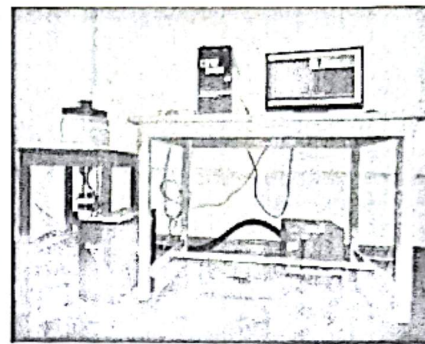
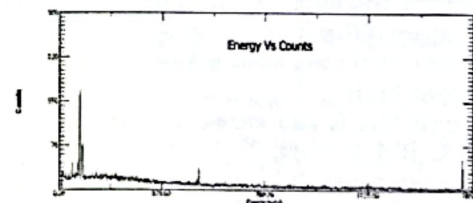


Figure (1) Experimental Setup of HPGe Detection System

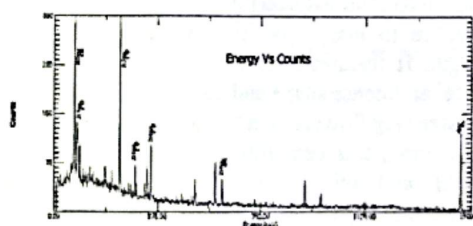
Results

The presence of radionuclide in sediment samples were investigated with HPGe detector and analyzed using Gamma Vision-32 Software. The radionuclide present in sediments samples are ²⁰⁷Pb (74.97 keV), ²¹⁴Pb (77.11 keV), ²¹²Pb (238.63 keV), ²¹⁴Pb (295.22 keV), ²¹⁴Pb (351.99), ²⁰⁷Pb (609.32 keV) and ⁴⁰K (1460.75 keV).

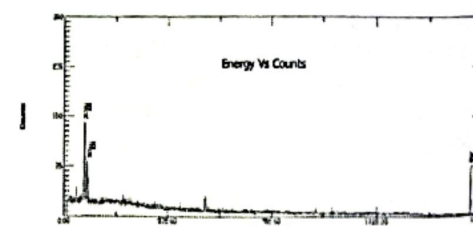
The collected background and soil, plant and fruit sample spectra were shown in Figure (2) to (8). The analysed data are shown in Table (1) to (6). The activity concentration of the samples based on the analysed data and different efficiencies are shown in Table (7) and (8). The transfer factor from soil, plant and fruit samples are shown in Table (9) and (10).



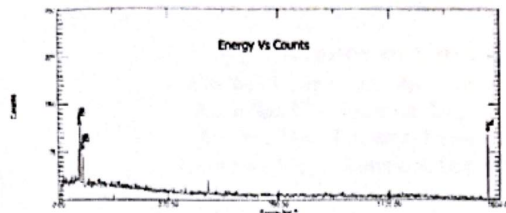
Fig(2) Background Spectrum of HPGe for Counting Time 3hr



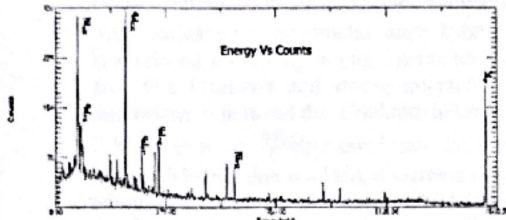
Fig(3) Energy Spectrum of Soil S1 from Meiktila for Counting Time 3hr



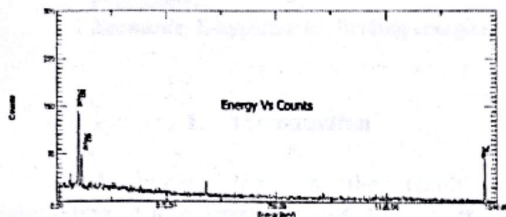
Fig(4) Energy Spectrum of Plant P1 from Meiktila for Counting Time 3hr



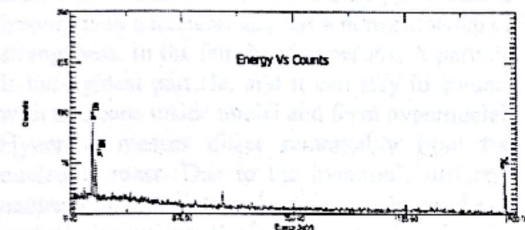
Fig(5) Energy Spectrum of Fruit F1 from Meiktila for Counting Time 3hr



Fig(6) Energy Spectrum of Soil S2 from Sei Pauk for Counting Time 3hr



Fig(7) Energy Spectrum of Plant P2 from Sei Pauk for Counting Time 3hr



Fig(8) Energy Spectrum of Fruit F2 from Sei Pauk for Counting Time 3hr

Table (1) The Analyzed Data for Soil (White) Sample S₁ in Meiktila Garden

Sr. No	Element	Gamma Energy (keV)	Gross Area Counts	Net Area Counts
1	Bi-207	74.97	1971	620±41
2	Pb-214	77.11	1521	388±33
3	Pb-212	238.63	3449	2116±78
4	Pb-214	295.22	673	307±31
5	Pb-214	351.99	816	482±33
6	Bi-207	609.32	494	288±27
7	K-40	1460.75	1576	1413±46

Table (2) The Analyzed Data for Plant (white) Sample P₁ in Meiktila Garden

Sr. No	Element	Gamma Energy (keV)	Gross Area Counts	Net Area Counts
1	Bi-207	74.97	947	377±30
2	Bi-207	84.76	712	271±29
3	K-40	1460.75	791	709±31

Table (3) The Analyzed Data for Fruit (white) Sample F₁ in Meiktila Garden

Sr. No	Element	Gamma Energy (keV)	Gross Area Counts	Net Area Counts
1	Bi-207	74.97	860	407±31
2	Bi-207	84.76	630	205±27
3	K-40	1460.75	1013	966±33

Table (4) The Analyzed Data for Soil (red) Sample S₂ in Sei Pauk Garden

Sr. No	Element	Gamma Energy (keV)	Gross Area Counts	Net Area Counts
1	Bi-207	74.97	2094	924±47
2	Pb-214	77.11	1513	538±36
3	Pb-212	238.63	3352	2202±76
4	Pb-214	295.22	721	301±33
5	Pb-214	351.99	816	512±34
6	Bi-214	609.32	485	341±25
7	K-40	1460.75	1769	1662±46

Table (5) The Analyzed Data for Plant (red) Sample P₂ in Sei Pauk Garden

Sr. No	Element	Gamma Energy (keV)	Gross Area Counts	Net Area Counts
1	Bi-207	74.97	1051	586±35
2	Bi-207	84.76	881	386±45
3	K-40	1460.75	740	647±31

Table (6) The Analyzed Data for Fruit Sample F₂

Sr. No	Element	Gamma Energy (keV)	Gross Area Counts	Net Area Counts
1	Bi-207	74.97	947	438±32
2	Bi-207	84.76	824	355±39
3	K-40	1460.75	798	713±32

Table (7) Activity Calculation for Radionuclides in Samples S₁, P₁ and F₁

Sr. No	Element	Gamma Energy (keV)	Activity (Bq/kg)		
			S ₁ (Soil)	P ₁ (Plant)	F ₁ (Fruit)
1	Bi-207	74.97	326.81	99.34	113.52
2	Pb-214	77.11	685.20		
3	Bi-207	84.76		142.22	107.60
4	Pb-212	238.63	76.96		
5	Pb-214	295.22	28.57		
6	Pb-214	351.99	29.27		
7	Bi-214	609.32	25.74		
8	K-40	1460.75	1222.5	3067.5	4179.63

Table (8) Activity Calculation for Radionuclides in Samples S₂, P₂ and F₂

Sr. No	Element	Gamma Energy (keV)	Activity (Bq/kg)		
			S ₂ (Soil)	P ₂ (Plant)	F ₂ (Fruit)
1	Bi-207	74.97	487.14	115.46	50.92
2	Pb-214	77.11	102.31		
3	Bi-207	84.76		202.62	186.34
4	Pb-212	238.63	76.48		
5	Pb-214	295.22	27.88		
6	Pb-214	351.99	31.22		
7	Bi-214	609.32	30.44		
8	K-40	1460.75	1432	2799.5	3084.98

Table (9) Transfer Factor in Soil to Plant Sample P₁ and P₂

Sr. No	Element	Gamma Energy (keV)	Transfer Factor from Soil to Plant	
			P ₁	P ₂
1	Bi-207	74.97	0.30	0.24
2	K-40	1460.75	2.51	1.95

Table (10) Transfer Factor in Soil to Fruit Sample F₁ and F₂

Sr. No	Element	Gamma Energy (keV)	Transfer Factor from Soil to Plant	
			F ₁	F ₂
1	Bi-207	74.97	0.35	0.10
2	K-40	1460.75	0.39	2.15

Discussion

According to the Table(4.1) and (4.4), observed that two soil samples have same radioactive elements, ²⁰⁷Bi (74.97 keV, 609.32 keV), ²¹²Pb (238.63 keV), ²¹⁴Pb (77.11 keV, 295.22 keV, 351.99 keV) and ⁴⁰K (1460.75 keV). The activity of all elements in soil sample from Sei Pauk garden are higher than that of Pyi Thar Yar garden. It is due to the fact that Sei Pauk garden is situated near the Mt.Popa, old volcano. So radionuclides are more concentrated in soil than that of Pyi Thar Yar.

In plant samples only found ²⁰⁷Bi and ⁴⁰K. Although ²⁰⁷Bi activity of Sei Pauk plant sample is greater than that of Pyi Thar Yar plant sample, but ⁴⁰K activity of Pyi Thar Yar plant sample is greater than that of Sei Pauk plant sample. In fruit samples, only found ²⁰⁷Bi and ⁴⁰K. The same process was found that ²⁰⁷Bi activity of Sei Pauk fruit sample

is greater than that of Pyi Thar Yar fruit sample but ^{40}K activity of Pyi Thar Yar fruit sample is greater than that of Sei Pauk fruit sample. It may be the amount of fertilizer used in each garden at different rate.

According to the Table(4.9) and (4.10), the transfer factor of Pyi Thar Yar soil to plant sample is 0.30 for ^{207}Bi and 2.51 for ^{40}K and that of Sei Pauk is 0.24 for ^{207}Bi and 1.95 for ^{40}K . For soil to fruit sample 0.35 and 0.10 for ^{207}Bi and 0.39 and 2.15 for ^{40}K for Pyi Thar Yar and Sei Pauk respectively.

Conclusion

The different activity and different rate of transfer rate are observed in this research. Moreover all elements observed in the sample are not dangerous to human health and the radioactivity level also stand within the standard value. The concentration of all radioactive elements found in samples from Sei Pauk is always greater than that of Pyi Thar Yar except ^{40}K . It can be concluded that Sei Pauk garden is near the old volcano, Mt. Popa. So radioactive element from the deep ground are come out with lava. But ^{40}K concentration of sample from Pyi Thar Yar is greater than that of Sei Pauk, it is due to the rate of fertilizer feeding to the plant and sometimes spray to the plant.

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PHY 006

Significance of Coulomb Effect in Σ -Hypernuclei

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Abstract

The purpose of this research is to calculate the contributions of strong and Coulomb interactions to the binding energies of various Σ -hypernuclei (${}_{\Sigma}^{12}\text{Be}$, ${}_{\Sigma}^{22}\text{Mg}$, ${}_{\Sigma}^{209}\text{Hg}$). Classification of Σ -hypernuclear states into nuclear state, hybrid state and atomic state is proposed. The nuclear state is produced mainly by strong interaction. The hybrid state is formed by the combination of attractive Coulomb and strong interactions; the atomic state is caused by pure Coulomb interaction. It is found that Coulomb interaction plays a significant role in binding mechanism of Σ -hypernuclei. In ${}_{\Sigma}^{209}\text{Hg}$ ground state, the strong interaction gives only 7.01 MeV binding. When Coulomb interaction is added, it increases up to 30.98 MeV which gives 23.97 MeV of Coulomb effect. However pure atomic state which is formed by Coulomb interaction alone is found to have 21.32 MeV binding. Hence Coulomb effect is enhanced with the aid of strong interaction and these hybrid states or Coulomb assisted nuclear states may play an important role to produce Σ -hypernuclei.

Keywords: Σ -hypernuclei, binding energies, strong and Coulomb interaction.

1. Introduction

A hypernucleus is the result of implanting of a hyperon, such as Λ , Σ , Ξ , in an ordinary nucleus. A hyperon is a baryon which is heavier than a nucleon and has a nonzero value of strangeness. In the family of hyperons; Λ particle is the lightest particle, and it can stay in contact with nucleons inside nuclei and form hypernuclei. Hyperons masses differ remarkably from the nucleonic mass. Due to the hyperon's different nature from a nucleon, a hyperon can be used as a probe to investigate the low-lying levels of nuclei in which the hyperon is not forbidden by Pauli principle. Thus information concerning inner region of nuclei and also nucleon-hyperon interaction can be extracted from hypernuclear study and this field of study has attracted much attentions of scientists from the beginning. Spectroscopic studies of hypernuclei can provide information on the hyperon behaviour in a nucleus.

In Σ -hypernuclei, a nucleon is replaced by a Σ hyperon, and experimental evidence of the existence of Σ -hypernuclei was claimed in CERN (European Centre for Nuclear Research) [1]. The Σ -hyperons (Σ^- , Σ^0 , Σ^+) are baryon family, like the nucleon, with mass about 1200 MeV, greater than the mass of the nucleon. Their charges are -1, 0 and +1 and spin $\frac{1}{2}$. They have a mean life around 10^{-10} sec, comparable to Λ decay. The investigation of the ΣN interaction is more difficult than that of the ΛN interaction. Concerning Σ -hypernuclei, up to now the experimental situation is not satisfactory. Σ -hypernuclei production has been investigated at

CERN, and later at Brookhaven and KEK (High Energy Accelerator Research Organization) [2], but the statistical accuracy of the available data is not very good, because of the strong conversion the Σ undergoes in the nucleus ($\Sigma N \rightarrow \Lambda N$).

2. The Possible Existence of Σ Hypernuclei

The possible existence of Σ hypernuclei was first suggested by ${}^9\text{Be} (K^-, \pi^-)$ reaction at CERN [1] and the following experiments [3] in which the observation of narrow peaks has been reported in (K^-, π^+) spectra for several p-shell nuclei. All the peaks lie in continuum region above the Σ -emission threshold. The widths are about 8 MeV. The observation of Σ states as narrow as the corresponding Λ states is quite surprising because unlike Λ particles that can only decay weakly inside the nucleus, the Σ particles can decay via strong interactions, the widths of Σ states were believed to be large due to the strong ΣN - ΛN conversion process. The level width must be not less than 20 MeV. In spite of many theoretical efforts [4] it remains a puzzle for some time why such narrow peak structures could exist in the Σ -continuum region. Finally, in the ${}^{12}\text{C}$ (stopped K^-, π^-) reaction at KEK, a better statistics eventually revealed that those peak-like structures disappear in the pion spectra [2]. The hypernuclear bound state in ${}^4_{\Sigma}\text{He}$ with a narrow width was first observed at KEK by Hayano et al., [5]. The possible existence of the bound states in ${}^4_{\Sigma}\text{He}$ has been theoretically predicted by Harada et al., [6]. This development encourages us to search for Σ -hypernuclear states with narrow widths in other nuclei. Because the Σ -hypernuclear study would

become broader and more interesting if the phenomenon is not limited to some particular light nuclei but extended to various nuclei.

3. Σ^- -Nucleus Interaction

The interaction between Σ^- -nucleon and consequently Σ^- -nucleus is likely more complicated and richer than those of Λ . This is because of a stronger isospin and spin dependence of the former one. In this work, we investigated Σ^- -hypernuclei only, in which additional Coulomb attraction is expected to increase the binding energy resulting from strong interaction.

Σ^- -hypernuclei can be produced by (K^-, π^+) reactions on various targets such as ^{12}C , ^{28}Si , and ^{208}Pb . It is necessary to know the interaction between Σ^- particle and (^{11}B , ^{27}Al , and ^{207}Tl) core nuclei.

The Woods-Saxon form potential for the nucleus and Σ^- is

$$V(r) = \frac{-V_0}{1 + \exp[(r-R)/a]} \quad (1)$$

where, V_0 is strength of Wood-Saxon potential, R is nuclear radius and a is diffuseness parameter. If the core nucleus is assumed as a point charge, the Coulomb potential is as follows,

$$V_{\text{Coul}} = -\frac{Ze^2}{4\pi\epsilon_0 r} \quad (2)$$

If the core nucleus is assumed as a uniformly charged sphere with radius R , $R =$

$1.1(A-1)^{1/3}$, the Coulomb potential consists of two parts, namely, exterior and interior parts.

For the exterior part, Σ^- is outside the nuclear radius, i.e. radial distance between Σ^- and the center of mass of the core nucleus is greater than R , the potential is $V_{\text{Coul}}(\text{out}) = -\frac{Ze^2}{4\pi\epsilon_0 r}$

(3)

For the interior part, Σ^- lies inside the nucleus, i.e. radial distance is smaller than R , the potential is

$$V_{\text{Coul}}(\text{in}) = -\frac{Ze^2}{4\pi\epsilon_0 R} + \frac{Ze^2}{2 \times 4\pi\epsilon_0 R^3} [r^2 - R^2] \quad (4)$$

where, R is the radius of core nucleus, r is the distance between Σ^- particle and the center of mass of the core nucleus.

The Woods-Saxon potential is represents the strong interaction between Σ^- and core nucleus. The electromagnetic interaction between the two particles is also properly taken into account in our work. The strong interaction and Coulomb interaction between Σ^- and core nuclei are shown in Fig (1) and Fig (2), which display the significant role of Coulomb interaction in heavy Σ hypernucleus.

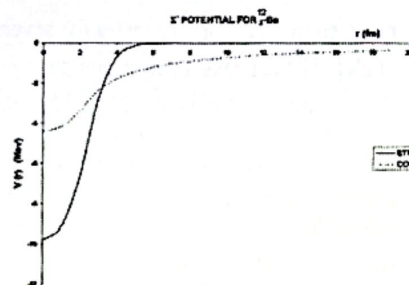


Fig.(1) Σ^- and ^{11}B interaction

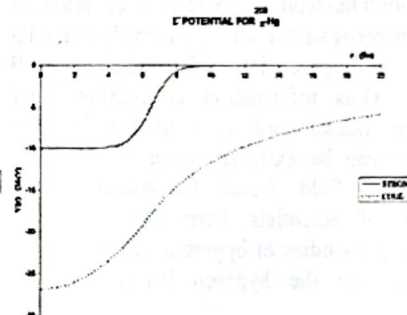


Fig.(2) Σ^- and ^{207}Tl interaction

4. Numerical Calculation

In order to calculate the binding energy of two-body quantum system we solved Schrodinger equation

$$H\psi = E\psi \quad (5)$$

where, H is Hamiltonian operator, E is energy eigen value, ψ = eigen vector.

Since, the interaction between Σ^- and core nucleus is central force, we choose the spherical coordinate for the wave function.

$$\Psi(\vec{r}) = R(r)\Theta(\theta)\Phi(\phi) \quad (6)$$

where, $R(r)$ is a radial part and $\Theta(\theta)\Phi(\phi)$ is an angular part and $Y_\ell^m(\theta, \phi) = \Theta(\theta)\Phi(\phi)$ is spherical harmonic.

We have to solve only the radial part $R(r)$. By using the separable method,

$$\left\{ -\frac{\hbar^2}{2\mu} \frac{d^2}{dr^2} + \frac{\hbar^2}{2\mu} \frac{\ell(\ell+1)}{r^2} + V(r) \right\} U(r) = EU(r) \quad (7)$$

where, $U(r) = r R(r)$, the reduced mass, $\mu = \frac{M_0 M_{\Sigma^-}}{M_0 + M_{\Sigma^-}}$,

M_0 = mass of core nucleus and M_{Σ^-} = mass of Σ^- particle.

To solve the radial equation (7), we will use the Gaussian basis wave function,

$$U(r) = r^{\ell+1} \sum_j c_j e^{-(r/b_j)^2} \quad (8)$$

where c_j 's are expansion coefficients and b_j 's are adjustable range parameters.

By substituting the Gaussian expansion of $U(r)$ in equation (7), it becomes

$$\left\{ -\frac{\hbar^2}{2\mu} \frac{d^2}{dr^2} + \frac{\hbar^2}{2\mu} \frac{\ell(\ell+1)}{r^2} + V(r) \right\} \sum_j c_j r^{\ell+1} e^{-(r/b_j)^2} = E \sum_j c_j r^{\ell+1} e^{-(r/b_j)^2} \quad (9)$$

Multiplying both sides of the above equation by $r^{\ell+1} e^{-(r/b_j)^2}$ from the left and performing integration throughout the equation,

$$\begin{aligned} \int r^{\ell+1} e^{-(r/b_i)^2} \left\{ -\frac{\hbar^2}{2\mu} \frac{d^2}{dr^2} + \frac{\hbar^2}{2\mu} \frac{\ell(\ell+1)}{r^2} + V(r) \right\} \sum_j c_j r^{\ell+1} e^{-(r/b_j)^2} dr \\ = E \int r^{\ell+1} e^{-(r/b_i)^2} \sum_j c_j r^{\ell+1} e^{-(r/b_j)^2} dr \end{aligned} \quad (10)$$

Equation (10) is rewritten as

$$\sum_j [T_{ij} + F_{ij} + V_{ij}] c_j = \sum_j H_{ij} c_j = E \sum_j N_{ij} c_j \quad (11)$$

Where, T_{ij} is the kinetic energy matrix element, F_{ij} is the centrifugal potential energy matrix element,

V_{ij} is the potential energy matrix element, N_{ij} is the norm matrix element and H_{ij} is the Hamiltonian matrix element.

$$\sum_j H_{ij} c_j = E \sum_j N_{ij} c_j \quad (12)$$

$$[H][c] = E[N][c] \quad (13)$$

where, $[H]$ and $[N]$ are square matrices and $[c]$ is a column matrix.

The matrix elements are analytically solved to get the following equations;

$$N_{ij} = \frac{(2\ell+1)!!}{2^{\ell+2}} \frac{\sqrt{\pi}}{\left(\frac{1}{b_i^2} + \frac{1}{b_j^2}\right)^{\ell+3/2}} \quad (14)$$

$$T_{ij} + F_{ij} = \frac{\hbar^2}{2\mu} N_{ij} \frac{(4\ell+6)}{b_i^2 + b_j^2} \quad (15)$$

For Woods-Saxon potential, the potential energy matrix element is

$$\begin{aligned} V_{ij}^{\text{strong}} &= \int_0^\infty U^*(r) V_{\text{strong}} U(r) dr \\ &= \int r^{2(\ell+1)} \left[-\frac{V_0}{1 + e^{(r-R)/a}} \right] e^{-\left(\frac{1}{b_i^2} + \frac{1}{b_j^2}\right)r^2} dr \end{aligned} \quad (16)$$

For Coulomb potential, the potential energy matrix element is

$$V_{ij}^{\text{Coul}} = \int_0^\infty U^*(r) V_{\text{Coul}} U(r) dr$$

$$= \frac{Ze^2}{4\pi\epsilon_0} \int_0^R r^{2(l+1)} e^{-\left(\frac{1}{b_1} + \frac{1}{b_2}\right)r} \left\{ -\frac{1}{R} + \frac{(r^2 - R^2)}{2R^3} \right\} dr$$

$$- \frac{Ze^2}{4\pi\epsilon_0} \int_R^\infty r^{2l+1} e^{-\left(\frac{1}{b_1} + \frac{1}{b_2}\right)r} dr \quad (17)$$

If the potential is the phenomenological Woods-Saxon Σ^- core nucleus potential, the matrix element has to be solved numerically. For a Σ^- particle, the strong attractive Coulomb potential between the core nucleus and Σ particle is also added. The Schrodinger equation which is rewritten in matrix form, $[H][c] = E[N][c]$ is solved by using the above calculated matrix element. Power inverse iteration method is employed to obtain the eigenvector $[c]$ and eigenvalue E of the above equation.

5. Results and Discussion

We have calculated the binding energies of Σ^- hypernuclei ($^{12}_\Sigma\text{Be}$, $^{28}_\Sigma\text{Mg}$, $^{208}_\Sigma\text{Hg}$), which are assumed to be composed of Σ^- and the corresponding core nuclei. Phenomenological Woods-Saxon potential is employed to represent strong interaction between Σ^- and core nucleus. Coulomb attractive force acting between Σ^- and core nucleus is also included in our calculation. Thus these Σ -hypernuclear states are classified into three categories such as nuclear state, hybrid state and atomic state. The nuclear state is produced mainly by strong interaction. The hybrid state is formed by the combination of attractive Coulomb and strong interactions; the atomic state is caused by pure Coulomb interaction. Σ -hypernuclei ($^{12}_\Sigma\text{Be}$, $^{28}_\Sigma\text{Mg}$, $^{208}_\Sigma\text{Hg}$) are divided into three groups such as light Σ -hypernucleus ($^{12}_\Sigma\text{Be}$), medium Σ -hypernucleus ($^{28}_\Sigma\text{Mg}$) and heavy Σ -hypernucleus ($^{208}_\Sigma\text{Hg}$) in our investigation.

5.1 Light Σ -Hypernucleus

Hypernucleus $^{12}_\Sigma\text{Be}$ can be produced by $^{12}\text{C}(K^-, \pi^+) ^{12}_\Sigma\text{Be}$ reaction. $^{12}_\Sigma\text{Be}$ is composed of Σ^- and the core nucleus $^{11}_5\text{B}$. The binding energy of $^{12}_\Sigma\text{Be}$ is 0.5 MeV for strong interaction and when the attractive Coulomb interaction is added, it becomes 2.87 MeV which gives 2.37 MeV of Coulomb effect. However the binding energy of Coulomb interaction alone is 0.5 MeV, see [Table (1)]. Large enhancement of Coulomb effect due to strong interaction is clearly seen from Fig (3) which displays the Σ^- density distribution in $^{12}_\Sigma\text{Be}$. It is found that the

maximum of Σ^- distribution of the Coulomb interaction extends outside compared to that of strong interaction and the combination of strong and Coulomb interactions.

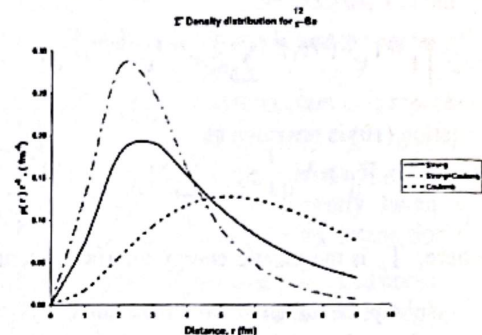


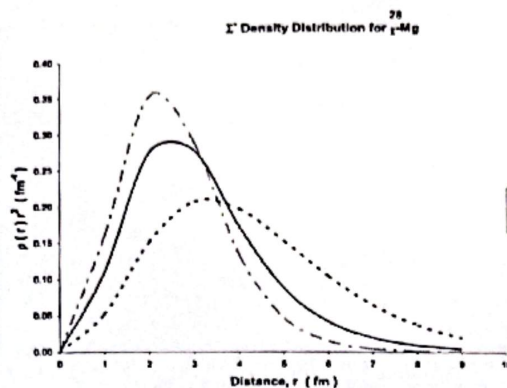
Fig. (3) Σ^- density distribution for $^{12}_\Sigma\text{Be}$

5.2 Medium Σ -Hypernucleus

$^{28}_\Sigma\text{Mg}$ hypernucleus has configuration of $^{27}\text{Al} + \Sigma^-$ which can be produced by $^{28}\text{Si}(K^-, \pi^+) ^{28}_\Sigma\text{Mg}$ reaction.

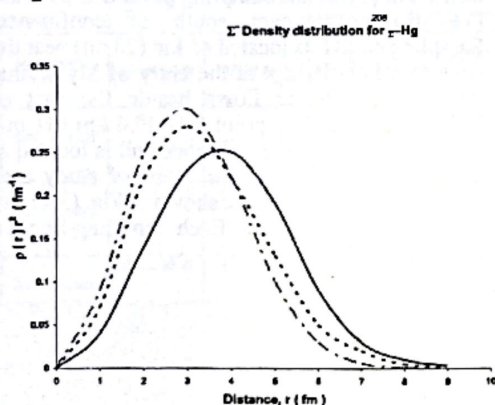
For a hypernucleus $^{28}_\Sigma\text{Mg}$, there exists a ground state with the binding energy of 2.39 MeV with strong interaction, when the attractive Coulomb interaction is added, it becomes 8.72 MeV which gives 6.33 MeV of Coulomb effect. But the binding energy of Coulomb interaction alone is 3.14 MeV. In Fig (4) we show Σ^- density distributions for $^{28}_\Sigma\text{Mg}$. It is found that the

maximum of Σ^- distribution of the Coulomb interaction extends outside compared to that of strong interaction and the combination of strong and Coulomb interactions.

Fig. (4) Σ^- density distribution for ^{28}Mg

5.3 Heavy Σ -Hypernuclei

Hypernucleus $^{208}_{\Sigma^-}\text{Hg}$ can be produced by $^{208}\text{Pb}(K^-, \pi^+) ^{208}_{\Sigma^-}\text{Hg}$ reaction. $^{208}_{\Sigma^-}\text{Hg}$ is composed of Σ^- and the core nucleus $^{207}_{81}\text{Tl}$. The binding energies of strong interaction is 7.01 MeV, when the attractive Coulomb interaction is added, it becomes 30.98 MeV which gives 23.97 MeV of Coulomb effect. But the binding energy of Coulomb interaction alone is 21.32 MeV. It is seen that in heavier nuclei more bound states were observed. In heavy nuclei, Σ^- distribution of the strong interaction extends outside compared to that of Coulomb interaction. It is clearly seen from Fig (5) which displays the Σ^- density distribution in $^{208}_{\Sigma^-}\text{Hg}$.

Fig. (5) Σ^- density distribution for $^{208}_{\Sigma^-}\text{Hg}$ Table 1. Ground state energies of the Σ -Hypernuclei

Σ Hypernuclei	Strong E (MeV)	Strong + Coulomb E (MeV)	Coulomb E (MeV)
$^{12}_{\Sigma^-}\text{Be}$	-0.5	-2.87	-0.5
$^{28}_{\Sigma^-}\text{Mg}$	-2.39	-8.72	-3.14
$^{208}_{\Sigma^-}\text{Hg}$	-7.01	-30.98	-21.32

6. Conclusion

The phenomenological Woods-Saxon potential is used to study the structure of Σ -hypernuclei ranging from light to heavy hypernuclei. It is found that the binding energies of light Σ -hypernucleus $^{12}_{\Sigma^-}\text{Be}$ is very shallow for strong interaction. These bound states exist near the Σ^- threshold. When Coulomb interaction is added, the binding energies increase up to 2.87 MeV, which gives 2.37 MeV of Coulomb effect. However pure atomic states which are formed by Coulomb interaction alone are found to have 0.5 MeV binding. The enhancement of Coulomb effect is caused by combination of strong and Coulomb interactions. In heavy Σ -hypernuclei, large enhancement of Coulomb effect is more prominent.

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Assessment of Heavy Metal Contamination in Surface Sediments along the Upper Ayeyarwaddy Riverbank of Myitkyina, Kachin State

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Abstract

The main objective of the present work is to assess heavy metal contamination in sediments from upper Ayeyarwaddy River bank in Myitkyina region. Surface sediments from six sampling points along river bank were collected for metal concentrations. The concentrations of metals were 0-212.12 (mg/kg) for Cr, 56.24-120.51 (mg/kg) for Zn, 549.86-1587.64 (mg/kg) for Mn, 2.58-5.85 (%) for Fe; 0.34-0.83 (%) for Ti; 0-167.76 (mg/kg) for Cu and 42.28-388.98 (mg/kg) for Sr. The degree of heavy metal contaminations in sediments were determined using enrichment factor (EF), geo-accumulation index (Igeo), pollution index (PI) and pollution load index (PLI). In this work, average EF of the heavy metals were between 0 and 3, therefore the river sediments were between no enrichment and minor enrichment. The average Igeo values of these metals except Cu were less than zero (Igeo < 0), indicating that the river sediments were not polluted by these metals. The average Igeo value of Cu was between 0 and 1 (0 < Igeo < 1) indicating that surface sediments were uncontaminated to moderately contaminated for the study area. In sampling point B, the average PI values of Cr, Fe, Sr, Cu and Zn were greater than other sampling points. Therefore, the PLI value of sampling point B was 1.47 (PLI > 1) indicating that Mali H'ka river was polluted with the heavy metals. PLI values of sampling points D, E and F are greater than 1 (PLI > 1) which indicate that Ayeyarwaddy River is deterioration of site quality with the studied heavy metals in studied area. The study revealed that on the basis of computed indexes, the river is classified uncontaminated to moderately contaminated.

Keywords: Ayeyarwaddy River; heavy metals; indexes; surface sediment; contamination

1. Introduction

The Ayeyarwaddy River flows through the centre of Myanmar. It starts in Kachin State, at the confluence of the N'Mai Hka and Mali Hka rivers. Both the N'Mai Hka and Mali Hka rivers find their sources in the Himalayan glaciers of upper Myanmar near 28°N. The Ayeyarwaddy River bisects the country from north to south and empties through a nine armed delta into the Indian Ocean.

Gold mining is becoming an issue of debate in Kachin State as it has been expanding rapidly in the middle of 1990. It has resulted in serious social and environmental problems not only for those living in gold mining area but also the larger Kachin population. Gold mining companies operate along all the major rivers and also on-land where gold yielding sediments are found. The main mining centers appear to be along the Ayeyarwaddy River north of the state capital Myitkyina.

On land, more and more areas are deforested in order to make way for mining and to build the necessary infrastructure. Mining waste is discharged straight into rivers or onto land. Bioaccumulation of mining chemicals will continue to take its toll on species diversity and human health. Aside from the obvious pollution, mining causes structural changes to rivers which can cause severe ecological damage. Rivers are diverted for riverbed mining operations, while water blasting of sediments destroys riverbanks. These structural changes result in the loss of many riverine habitats for endemic fish species.

The Mali Hka River is one of the main centers of mining activities in Kachin State. In contrast to the N'Mai Hka River, most of the mining on the Mali Hka is done with floating dredges scooping up sediments from the bottom of the river. At some places the river is wide enough to allow river bank mining. Deforestation is a major concern since the trees of the surrounding forests are being cut to clear land, for the construction of mining camps, fuel wood or simply to make space for mining. Waste from the mining sites contaminates the rivers. Many people do not understand that the river is polluted, and continue to take their drinking water from the river.

2. Objective

Calculation of Pollution Indices

In an attempt to understand the pattern of metal contamination in the study area, useful tools including pollution indices such as; enrichment factor (EF), geo-accumulation index (Igeo) and pollution load index (PLI) were used to calculate heavy metal concentration in sediments.

3. Material and Methods

3.1 Study Area and Sampling Points

The six sampling points were selected for the present study. In Nmai H'ka, sampling point A is 1.6 km (1 mi) upstream north of the confluence. In Mali H'ka, sampling point B is situated about 1.6 km (1 mi) upstream north of confluence. Confluence, it lies 45 km (28 mi) north of Myitkyina, capital of the Kachin State. In Ayeyarwaddy River, sampling point C is located on 1.6 km (1 mi) and sampling point D is 22.4 km (14 mi) downstream south of confluence. Sampling point E is located 45 km (28 mi) near the Bala Min Htin Bridge at the entry of Myitkyina. Ayeyarwaddy River flows beside the east of Myitkyina. Sampling point F is 49.6 km (31 mi) downstream south of confluence and is located at the east of Myitkyina. The maps of study area showing sampling sites are shown in Fig. (3.1) and Fig. (3.2). Coordinates of Each Sampling Site are shown in Table (3.1).

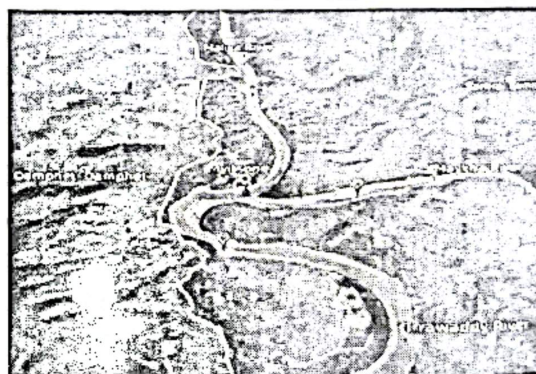


Fig. (3.1) Map of study area showing sampling sites A, B and C

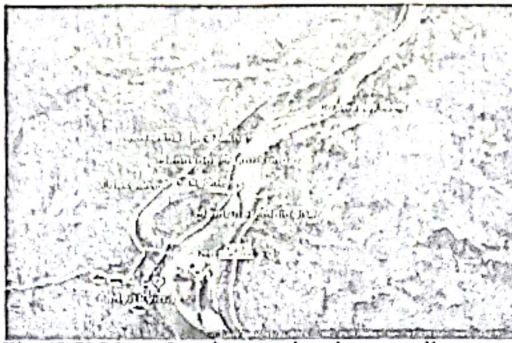


Fig. (3.2) Map of study area showing sampling sites D, E and F

3.2 Sample Collection and Preparation

The sediment samples from shallow water near the banks of Ayeyarwaddy River at different sites were collected with the help of PVC pipe during the month of March 2018 where flow rate were low. The samples were air dried at room temperature. From the bulk sediment, a representative sub sample was powdered and sieved through 100 mesh. After getting the fine powder of sediment samples, they are analyzed by EDXRF technique.

3.3 Experimental Setup

The EDX-7000 system is composed of two parts: the X-ray spectrometer and personal computer (PC). The spectrometer contains: the X-ray generating elements: X-ray tube of Rhodium,

(mg/kg): Cr (177.91 ± 64.03), Fe (%) (5.38 ± 1.04), Sr (357.27 ± 83.71), Cu (143.79 ± 34.69) and Zn (106.45 ± 14.95) were higher than in the samples from the sampling points A, C, D, E and F. The mean concentrations of heavy metals in sediments collected from the sampling point C: Mn (%) (1217.83 ± 274.70) was higher than in the samples collected from other sampling points. The mean concentrations of the heavy metals collected from the sampling point D, Ti (%) (0.58 ± 0.1) was the highest.

Average shale value was used as reference baseline in this study to provide elemental background concentration. Comparison of the values obtained in this was with local and global reference value indicates that the concentration of Cr, Mn and Cu were higher than the reference baseline of average shale. The concentrations of Fe, Ti, Zn and Sr were below the reference baseline of average shale shown in Fig. (4.1).

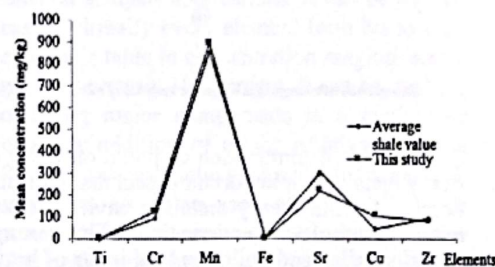


Fig. (4.1) Mean concentrations of heavy metals compared with average shale values

Table (3.1) Coordinates of Each Sampling Site

Sites	Latitude	Longitude	Sample Code	Depth(cm)
Nmai H'ka (A)	25° 42.58' N	97° 31.65' E	MK11	60
			MK12	45
			MK21	30
			MK22	15
Mali H'ka (B)	25° 44.88' N	97° 30.12' E	ML11	60
			ML12	45
			ML21	30
			ML22	15
Ayeyarwaddy (C)	25° 41.57' N	97° 29.95' E	A11	60
			A12	45
			A21	30
			A22	15
Ayeyarwaddy (D)	25° 32.09' N	97° 29.33' E	A31	60
			A32	45
			A41	30
			A42	15
Ayeyarwaddy (E)	25° 25.42' N	97° 25.41' E	A51	60
			A52	45
			A61	30
			A62	15
Ayeyarwaddy (F)	25° 22.93' N	97° 24.22' E	A71	60
			A72	45
			A81	30
			A82	15

sample chamber, silicon drift detector (SDD), microprocessor controller, air cooling system and associated powers supplied. The personal computer (PC) includes the data memory board and other standard PC elements. The collected spectra were analyzed using the EDX-7000 qualitative and quantitative analysis software. The X-rays from the Rhodium target are used for the excitation of the sample. The characteristic X-rays from each element contained in each sample were detected by the silicon drift detection system. The X-rays spectrum is analyzed with the help of the personal computer to obtain the concentration of each element in the sample.

4. Results and Discussion

From the results, the mean concentrations of heavy metals found in the samples collected from the sampling point B

The EF was calculated for a better assessment of anthropogenic input for each metal. In sampling point A, average EF values of Ti, Cr, Mn, Fe, Sr and Zn were found to be no enriched (< 1) and Cu was minor enriched (< 3). In sampling points B, E and F, average EF values of Ti, Mn, Fe, Sr and Zn were no enriched (< 1) and Cr and Cu were minor enriched (< 3). In sampling point C, Ti, Cr, Fe, Sr and Zn were no enriched (< 1) and Mn and Cu were minor enriched (< 3). In sampling point D, Mn, Fe, Sr and Zn were no enriched (< 1) and Ti, Cr and Cu were minor enriched (< 3). The EF value above 1.5 indicates an anthropogenic contribution and if EF is less than 1.5, the metal concentration is considered crustal or natural weathering origin. In this work, the studied heavy metals were determined to be between no enrichment and minor enrichment. Comparison of average EF for each heavy metal in difference sites is shown in Fig. (4.2).

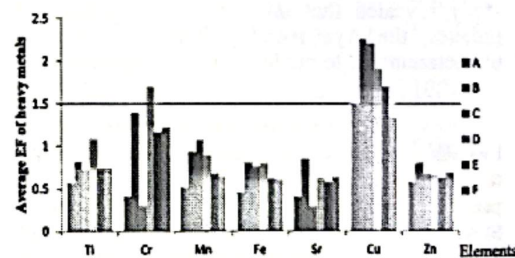


Fig. (4.2) Comparison of average EF for each heavy metal in difference sites

Based on the results of average Igeo values, the ranking of intensity of heavy metal pollution of surface sediments is as follow: $\text{Cu} > \text{Cr} > \text{Mn} > \text{Ti} > \text{Zn} > \text{Fe} > \text{Sr}$. The average Igeo values of these metals except Cu were less than zero ($\text{Igeo} < 0$), indicating that the river sediments were not polluted by these metals. The average Igeo value of Cu was between 0 and 1 ($0 < \text{Igeo} < 1$) indicating that surface sediments are uncontaminated to moderately contaminated for the study area. Comparison of average Igeo values for each heavy metal in study area is shown in Fig. (4.3).

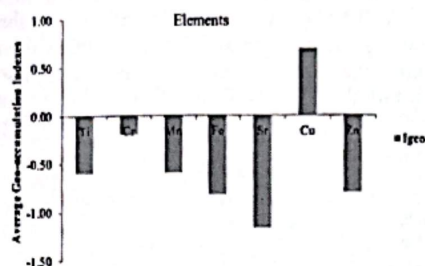


Fig. (4.3) Comparison of average Igeo values for each heavy metal in study area

The determination of pollution index of heavy metals is an important aspect that indicates degree of risk of heavy metals to environment in relation with its retention time. The average pollution index and pollution load index of heavy metals in the surface sediments based on average shale were calculated. Comparison of average PLI values for each sampling site is shown in Fig. (4.4).

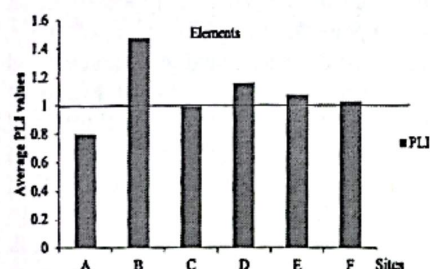


Fig. (4.4) Comparison of average PLI values for each sampling site

In sampling point B, the average PI values of Cr, Fe, Sr, Cu and Zn are greater than other sampling points. Therefore PLI value of sampling point B is highest value indicating that Mali H'ka River is polluted with the studied heavy metals. PLI values of sampling points D, E and F are greater than 1 ($\text{PLI} > 1$) which indicate that Ayeyarwaddy River is deterioration of site quality with the studied heavy metals in studied area. The study revealed that on the basis of computed indexes, the Ayeyarwaddy River is classified uncontaminated to moderately contaminated.

Acknowledgements

I would like to express our gratitude and sincere thanks to Rector Dr Thura Oo, Monywa University for his permission to do this work. I would like to thank Dr Shwe Zin Aung, Professor and Head, Department of Physics, Monywa University for her precious advice and guidance.

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PHY 009

Analysis of Elemental Concentration in Cowhage Plant (*Mucuna Pruriens* (L.) DC) in Myitkyina Township by EDXRF Technique

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Abstract

It is aimed to study the elemental concentration of three parts of cowhage plant (Khawelayar) are leaf, seed and stem samples and soil sample where the plant was grown. MESA-50 software was used to analyze concentration of elements contained in these samples of interest. These elements were Calcium (Ca), Potassium (K), Manganese (Mn), Silicon (Si), Iron (Fe), Sulphur (S), Phosphorus (P), Chlorine (Cl), Zinc (Zn), Titanium (Ti), Copper (Cu) and Arsenic (As) are found. In analyzed elements, some kinds of moderately toxic metal are slightly found in these samples. It is found that iron, manganese, titanium, copper, zinc and arsenic elements, highly toxic to all organisms were very few. These elements in all samples are low concentrated.

Introduction

The analysis of elemental concentration in cowhage plant (*Mucunapruriens* (L.) DC) was carried out by the EDXRF technique. In this present work, the three parts of cowhage plant (Khawelayar) are leaf, seed, stem samples and soil sample where the plant was grown, were observed using EDXRF technique.

Khawelayar leaf shapes have names including oval, truncate, elliptical, lanceolate, and linear. Compound leaves are further described as pinnately, palmately and doubly compound.

Khawelayar bean-shaped is roughly kidney-shaped (reniform), with the ends lobed on either side of the hilum.

In this research, the elemental concentration of these samples were determined by using MESA - 50 EDXRF analyzer at URC (Myitkyina University).

MATERIALS & METHODS

Energy Dispersive X-ray Fluorescence Analysis

Energy dispersive X-ray fluorescence analysis (EDXRF) employs detectors that directly measure the energy of the X-ray by collecting the ionization producers in a suitable detecting medium.

The samples is placed in the excitation flux, and the characteristic X-rays resulting from the de excitation of inner shell vacancies are detected by the energy-dispersive semiconductor spectrometer.

The total ionization produced by each X-ray striking the detector is converted to a voltage signal with amplitude proportional to the incident energy. A multi-channel analyzer accumulates and energy spectrum of the sequential events in a histogram memory. The principle advantages EDXRF device from the capability for simultaneous detection of characteristics X-rays from multiple elements with high geometric efficiency.

X-ray fluorescence is mainly concerned with all elements ($Z > 5$) in the periodic table. The EDXRF technique also provides a smoothly varying sensitivity for all elements. EDXRF becomes now an alternative elemental analysis method to the wavelength dispersive X-ray fluorescence method. Due to the development in the solid state detectors, the detector systems with

higher counting rates and increased sensitivity for low energy X-rays are now commercially available.

Applications of EDXRF

Energy Dispersive X-Ray Fluorescence (EDXRF) can be used for a tremendous variety of elemental analysis applications. It can be used to measure virtually every element from Na to U in the periodic table in concentration ranging from a few ppm to nearly 100 percent. It can be used for monitoring major components in a product or process or addition of minor additive. Because XRF is popularity in the geological field, EDXRF instruments are often used alongside WDXRF instruments for measuring major and minor components in geological sample. Energy Dispersive X-ray Fluorescence (EDXRF) Spectrometry has been used for nearly 20 years, and its use of analysis of environmental soils has grown rapidly in the last 12 years. Early instruments that were designed primarily for laboratory use, suffered from poor resolution, and could not easily resolve multiple elements in a single analytical run. These instruments are required a highly trained operator.

Some Data of Experimental Measured Condition in EDXRF Analysis System

sample	Comment	- Solid
	Group	- Solid air
	Instrument	- MESA-
50	Atmosphere	- Air
	Collimator	- 7mm
	Analyzed element	- Al-U
	Target	-
	Palladium (Pd)	-
	X-ray tube voltage	- 50kV
	X-ray tube current	- 6 μ A
	Detector	- SDD (Si
	Drift Detector)	-
	Live time	- 100s
	Scientific classification	-
	Order	: Fabales
	Family	: Fabaceae
	Genus	: <i>Mucuna</i>
	Species	: <i>Pruriens</i>
	Common Name	: Cowhage

Local Name :
 Khawclayar
 Botanical Name :
Mucuna Pruriens (L.) DC

Sample Collection

Cowhage (Khawclayar) plant and the soil where the plant was grown were collected to do research. Cowhage was divided into 3 parts: leaf sample (L), seed sample (M) and stem sample (C). The soil sample (S) was gathered from the one feet depth of surface. Three parts of cowhage which are leaf, seed, stem and soil where the plant was grown were collected in April, 2018. These samples were collected from the Takkone quarter, Ra Da Kaung (B) in Myitkyina. The photographs of three samples of cowhage plant and soil sample where the plant was grown were shown in Fig. (1) and Fig. (2) respectively.

Sample Preparation

Sample preparation is a very important process to actual experiment. Firstly the collected sample were dried separately at room temperature for one month. And then they were crushed and ground in order to get fine powder. After that, these powder samples were kept in plastic bags and systematically labeled. The list of samples are shown in Table (1).

Measurements Condition of MESA-50 EDXRF Analyzer

The X-ray fluorescence analyzer was used throughout this investigation is a computer controlled Horiba MESA-50 software. Fig. (3) shows experimental set up of Horiba MESA-50 EDXRF analyzer. EDXRF spectrometer is an elemental analysis method and has many advantages over other methods. The qualitative analysis of elements can be carried out easily because of the simplicity of the X-ray spectra in which the characteristic lines of elements are hardly influenced by chemical bounding. The interference between the lines can be overcome with the help of spectral fitting. EDXRF has the advantage of being a non-destructive technique compared to other multi-element analysis technique such as atomic emission spectrometry and mass spectrometry.



Fig. (1) P



Fig. (2) Photograph of Khawclayar seed

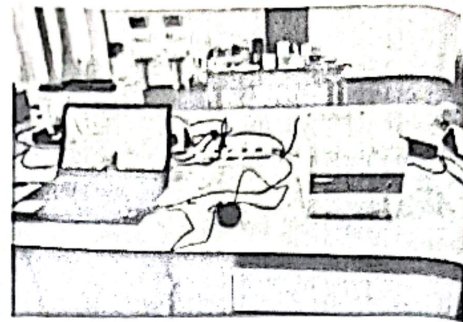


Fig. (3) Experimental set up of Horiba MESA 50 EDXRF Analyzer

Table (1) List of samples

Code	Sample name
L	Leaf sample of Cowhage, Takkone quarter, Ra Da Kaung (B) in Myitkyina
M	Seed sample of Cowhage, Takkone quarter, Ra Da Kaung (B) in Myitkyina
C	Stem sample of Cowhage, Takkone quarter, Ra Da Kaung (B) in Myitkyina
S	Soil sample where the plant was grown in Cowhage plant, Takkone quarter, Ra Da Kaung (B) in Myitkyina

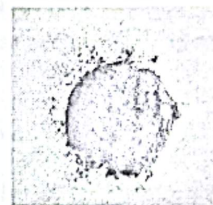


Fig. (4) Powder sample of leaf of Khawclayar plant



Fig. (5) Powder sample of seed of Khawclayar plant

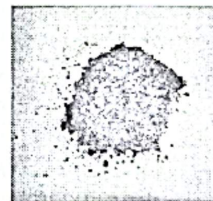


Fig. (6) Powder sample of stem of Khawclayar plant

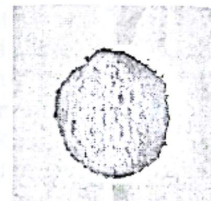


Fig. (7) Powder sample of soil where the Khawclayar plant was grown

Results

In this research, the concentration of elements contained in leaf sample, seed sample and stem sample of cowhage plant and soil sample where the plant was grown, were analyzed by MESA 50 software at Myitkyina University Research Center. The comparison of elemental concentration for these samples by using EDXRF technique was shown in Table (2). The concentration of elements for four kinds of samples were illustrated in Fig. (8) to Fig. (11) respectively.

Discussion

In the analysis of all samples by using EDXRF technique, twelve kinds of elements were generally found in these samples. These elements are Calcium (Ca), Potassium (K), Manganese (Mn), Silicon (Si), Iron (Fe), Sulphur (S), Phosphorus (P), Chlorine (Cl), Zinc (Zn), Titanium (Ti), Copper (Cu) and Arsenic (As).

In the analysis of leaf sample L of cowhage plant contains eleven kinds of elements which are Ca, K, Mn, Si, Fe, S, P, Cl, Zn, Ti and Cu. In leaf sample, Calcium (Ca) is the most abundant and Copper (Cu) is the least abundant.

In the analysis of seed sample M of cowhage plant contains seven kinds of elements which are K, Mn, Fe, S, P, Zn and Cu. In seed sample Potassium (K) is the most abundant and Zinc (Zn) is the least abundant.

In the analysis of stem sample C of cowhage plant contains eleven kinds of elements which are Ca, K, Mn, Si, Fe, S, Cl, Zn, Ti, Cu and As. In stem sample, Potassium (K) is the most abundant and Arsenic (As) is the least abundant.

In the analysis of soil sample S of cowhage plant contains ten kinds of elements are Ca, K, Mn, Si, Fe, S, Zn, Ti, Cu and As. In soil samples, Silicon (Si) is the most abundant and Arsenic (As) is the least abundant.

Conclusion

The cowhage plant samples and soil sample where the plant was grown were collected from Takkone quarter, Ra Da Kaung (B) in Myitkyina Township. According to the comparison of concentration of elements in soil samples by using EDXRF (7000) technique were discussed. The concentration amounts of Calcium (Ca) element is contained in three samples of cowhageplant. Calcium (Ca) is necessary for people to have strong teeth, strong bones and the proper function of nerves and muscles. Calcium plays a key role in the formation of enamel. Calcium is essential constituent in the growing of plants. Calcium is the secondary nutrients for plants. Potassium (K) element is contained in all soil samples. Potassium (K) is an essential plant nutrient and required in large amount for proper growth and reproduction of plants. Its present is great importance for soil health, plant growth and animal nutrition. Some people with kidney disease are advice to avoid large quantities of dietary potassium.

Manganese (Mn) element is contained in all samples. Manganese (Mn) is an essential element for human nutrition. Manganese (Mn) can cause both toxicity and deficiency symptoms in plant.

Silicon (Si) is the most abundant element in the crust of the earth. It may be assumed that the natural landform contain sand stone. Iron (Fe) is the most widely used and second most abundant metal on earth. Iron reusts in damp air, but not in dry air.

Sulphur (S) is contained in all samples. Sulphur (S) can be found in the air, in the water, in many different forms. And then sulphur is essential plant food for production of protein. All living things need sulphur (S).

Phosphorus (P) element is contained in leaf and seed samples of cowhage plant. Phosphorus can be found in the environment most commonly as phosphates. Phosphates can be found commonly in plants.

Chlorine (Cl) is highly effective in killing bacteria. Chlorine bonds to the hair, stripping hair of the oils that are naturally to protect and nourish our hair. This can cause the hair to become dry, fizzy or brittle. Chlorine in excess has also been shown to cause damage to the hair follicles and increase the risk of hair breakage. The more hair is exposed to chlorine, the more that damage becomes a possibility because of the exposure.

Zinc (Zn) is essential in small, but critical concentration for the normal healthy growth of either plants or animals.

Arsenic (As) can be harmful to crops even at low concentrations. Heavy metals which were known to effect human health were arsenic. Arsenic can be released in larger quantities through volcanic activity, erosion of rocks, forest fires and human activity. Arsenic is odorless and tasteless. Inorganic arsenic is known carcinogen and can cause cancer of the skin, lungs, liver and bladder. All these samples can support to human being. People in Kachin State, used to the leaves, seed and stem of Khawelayer plant as a traditional medicines.

Table (2) Elemental concentration for leaf, weed, stem samples of Cowhage plant and soil sample where the plant was grown in Myitkyina

Elements	Concentration (Result %)			
	L	M	C	S
Cu	4.7305	-	38.2028	3.9638
K	21.7990	26.3117	22.4572	7.7427
Mn	15.1701	2.3176	0.3646	0.7247
Si	7.8198	-	0.8971	27.7479
Fe	5.3480	2.4534	6.5906	22.3320
S	2.0169	7.8792	1.0362	0.0130
P	0.6904	8.2800	-	-
Cl	0.6216	-	7.5117	-
Zn	0.5101	0.4653	0.4757	0.0950
Ti	0.4636	-	0.9421	1.9221
Ca	0.1052	0.5186	0.7512	0.0294
As	-	-	0.1537	0.0119

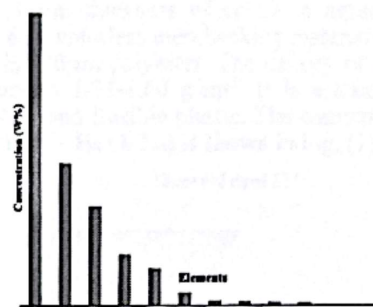


Fig. (6) Elemental concentration for powder of leaf sample of Khawelayer plant in Myitkyina

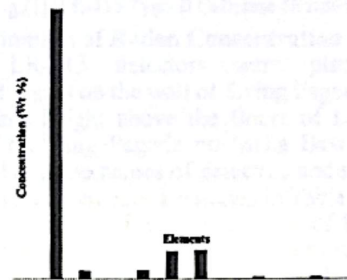


Fig. (7) Elemental concentration for powder of seed sample of Khawelayer plant in Myitkyina

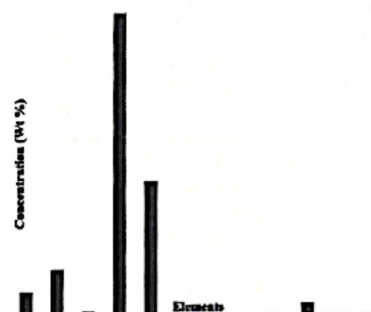


Fig. (11) Elemental concentration for powder of soil sample where the Khawelayer plant in Myitkyina

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I would like to thank Dr Thura Oo, Rector, Monywa University, for his encouragement. I am also grateful to Dr Thet Naing Oo and Dr Khin San San Win, Pro-Rectors, Monywa University, for their advice. I wish to thank Dr Shwe Zin Aung, Professor and Head of Department of Physics, Monywa University for her valuable suggestions. Finally, special thanks go to members of Materials Research Lab, Department of Physics, University of Mandalay, for their help in experimental work.

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PHY 010

Investigation of Radon Concentrations at Laykyun Setkyar Standing Buddha Statue and Lying Pagoda on Maha Baw Di Ta Htaung Hill

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Abstract

The radon concentrations, especially alpha radiation were measured in locations at Laykyun Setkyar Standing Buddha Statue and Lying Pagoda on Maha Baw Di Ta Htaung Hill using LR-115 detectors. These pagodas are in the form of caves. These detectors are placed for about 100 days on the walls of the cave inside the pagodas. The radon concentrations are calculated by observing the number of counts for alpha tracks recorded by LR-115 detector. These results are found to be much below the harmful affect as indicated by International Commission on Radiological Protection (ICRP, 2009).

Keywords: Solid State Nuclear Tract Detectors Technique, NaOH solution, Optical microscope

Introduction

Radon is a naturally occurring radioactive gas. Radon is no smell, colour or taste. It is naturally in the atmosphere in trace amounts. Radon with half-life 3.8 days forms naturally from the decay of radioactive elements, such as uranium, which are found at different levels in soil and rock throughout the world.

Radon is present outdoors and indoors. It is normally found at very low levels in outdoor air and in drinking water from rivers and lakes. It can be found at higher levels in the air inside houses and other buildings, as well as in water from underground sources, such as well water. Radon (^{222}Rn) and its progeny naturally being out radioactive isotopes that emit mostly alpha particles. As we breathe, the particles are deposited on the cells lining the airways and potentially cause the lung cancer. Radon is most important cause of lung cancer after smoking. It may be affected to human's health in the environment due to the radiations [4]. The environmental issue today is human health. So, to prevent the human's health, indoor radon concentration is measured in Laykyun Setkyar Standing Buddha Statue and Lying Pagoda on Maha Bodhi Ta Htaung Hill.

In our research work, the radon concentrations, especially alpha radiation were measured in various locations at Lying Pagoda and in Laykyun Setkyar Standing Buddha Statue on Maha Baw Di Ta Htaung Hill using solid state nuclear track detector (SSNTD), LR-115 detectors. These pagodas are in the form of caves. These places do not generally have the same level of air flow and so there may be different levels of radon concentrations. Based on radon concentration inside the Pagodas on Maha Baw Di Ta Htaung Hill, our research work is carried out in order to know whether it is dangerous or not for human being.

Solid State Nuclear Track Detectors

Solid State Nuclear Track Detector (SSNTD) [1] is a simple solid material exposed to nuclear radiation, etched and examined microscopically. There are several types of detectors including organic and inorganic detectors. Plastics are included in inorganic detectors while all other detectors such as glasses, minerals etc. fall under the second category. The technique of SSNTDs is based upon the damage created in an insulating solid along the path of a heavily ionizing particle such as an alpha particle or a fission fragment. The damage along the path,

called a track, may become visible under an ordinary optical microscope after etching with suitable chemical.

LR-115 detector called the plastic track detector is used in our research work. These detectors are based on cellulose nitrate and has been commonly used for measurement of concentration of radon gas and radon progeny. The sensitive surface for alpha particle, red dyed, is of $12\mu\text{m}$ thickness of cellulose nitrate (CN) layer on a colorless inert backing material and the base is $100\mu\text{m}$ polyester. The density of LR-115 detector is $1.33\text{--}1.60\text{ g/cm}^3$. It is a transparent, colorless and flexible plastic. The composition of LR-115 ($\text{C}_6\text{H}_8\text{O}_9\text{N}_2$) is shown in Fig. (1)[2].

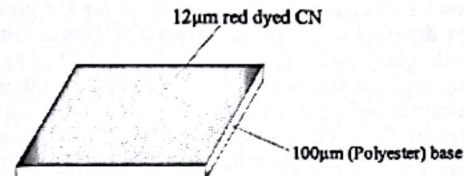


Fig.(1) LR-115 Type-II Cellulose Nitrate Film

Determination of Radon Concentration

LR-115 detectors were placed in different places on the wall of Lying Pagoda cave and some height above the floors of Laykyun Setkyar Standing Pagoda on Maha Baw Di Ta Htaung Hill. The names of detectors and selected places of these pagodas are shown in Table (1) and Table (2). ($1\text{cm} \times 1\text{cm}$) dimension of LR-115 detectors were placed in these different locations.

Shwe Thar Hlaung Pagoda called lying pagoda is situated on Maha Baw Di Ta Htaung Hill in Monywa Township. It is 17.71 km (11 miles) away from downtown of Monywa. For few years ago, the Palin of this pagoda having 222-feet 6-inch by 60-feet laid foundation in 1991. The head of Lying Pagoda having 60-height-feet , 300-feet laid foundation.

Table (1) Detector Names and Places in Lying Pagoda

No.	Detector Names	Places in Lying Pagoda
1	D ₁	30 feet from right side of the entrance to the pagoda's head
2	D ₂	50 feet from right side of the entrance to the pagoda's head
3	D ₃	70 feet from right side of the entrance to the pagoda's head
4	D ₄	90 feet from right side of the entrance to the pagoda's head
5	D ₅	Upper wall of pagoda's head
6	D ₆	The entrance in the middle of pagoda
7	D ₇	30 feet from left side of the entrance to the pagoda's foot
8	D ₈	36 feet from left side of the entrance to the pagoda's foot
9	D ₉	56 feet from left side of the entrance to the pagoda's foot
10	D ₁₀	68 feet from left side of the entrance to the pagoda's foot

Laykyun Setkyar Standing Pagoda is situated behind the lying pagoda on Maha Baw Di Ta Htaund Hill. It is 1150 feet high above sea level and built in 1995. Laykyun Setkyar Buddha Statue is 424 feet (129 m) high with thirty one floors. Each floor in this pagoda is about 12 feet high. It is the second largest Buddha statue in the world. It is constructed as a form of cave inside the Standing Pagoda.

Table(2) Detector Names and Places in Laykyun Setkyar Standing Pagoda

No.	Detector Names	Places in Standing Pagoda
1	D ₁	8 feet in height from the 5 th floor
2	D ₂	9 feet in height from the 6 th floor
3	D ₃	3 feet in height from the 7 th floor
4	D ₄	6 feet in height from the 8 th floor
5	D ₅	3 feet in height from the 9 th floor
6	D ₆	10 feet in height from the 10 th floor
7	D ₇	3 feet in height from the 11 th floor
8	D ₈	9 feet in height from the 12 th floor

Experimental Procedure for Data Analysis

The LR-115 detectors were placed in wall of the Lying Pagoda in a form of cave. These detectors were 100 days in these places and then were removed from the cave and were etched in 2.5 N NaOH 100 ml at 60°C for 60 minutes.

To obtain 2.5N NaOH 100ml, 10g of NaOH was put into measuring cylinder and poured the distilled water 100ml. Then NaOH was stirred with glass rod to dissolve all crystals. During etching, the temperature was kept constant with accuracy of $\pm 1^\circ\text{C}$ and without stirring. After etching these detectors, the solution in the beaker was poured into another beaker through small plastic sieve. Then, these detectors were washed with water until the surfaces of the detectors become clean. Finally, the detectors were taken out and dried on the filter paper and the tracks produced by alpha particles were observed under binocular microscope.

In our research, binocular microscope with 100 $\times$ magnification is used. Track visualization, track photographing, track counting and measuring the diameter of alpha etch track pits in LR-115 detectors were performed by using the binocular microscope which is attached with computer.

Track Density Calculation

The number of tracks viewed on the computer was counted by changing the vertical and horizontal position of detector under the microscope. Then the average values of these alpha tracks were calculated. The track density of each sample was calculated by using track density equation:

$$\text{Track Density} = \frac{\text{Number of Net Tracks}}{\text{Microscopic View Area}} \times \frac{\text{Magnification}}{\text{Exposure Time}} \quad (1)$$

(Track $\text{cm}^{-2} \text{ day}^{-1}$)

Radon concentration was also calculated by following equation:

$$\text{Radon Concentration} = \frac{\text{Track Density}}{0.05016 \text{ Track cm}^{-2} \text{ day}^{-1} / \text{Bq m}^{-3}} \quad (2)$$

(Bq m^{-3})

In this project, the background of alpha track density per day for LR-115 detector is $\pm 0.12 \text{ track cm}^{-2} \text{ day}^{-1}$. Then, the radon concentrations were also calculated. By using calibration factor $0.05016 \text{ track cm}^{-2} \text{ day}^{-1} = 1 \text{ Bq m}^{-3}$

, radon concentration can be calculated from alpha track density.



Fig. (2) Location of Maha Baw Di Ta Htaund Hill

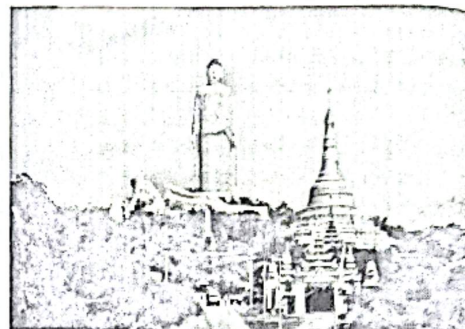


Fig. (3) Maha Baw Di Ta Htaund Hill



Fig. (4) Lying Pagoda



Fig. (5) Laykyun Setkyar Buddha Statue



Fig. (6) Photomicrograph of alpha tracks in detector D1 from Lying Pagoda

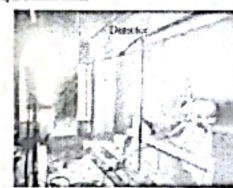


Fig. (7) Photomicrograph of alpha tracks in detector D8 from Lying Pagoda

Results and Discussion

Radon concentrations, especially alpha radiation in various places in these pagodas were measured using LR-115 detectors and the calculated values for the radon concentrations in Lying Pagoda are shown in Table (3) and that for Standing Buddha Statue are shown in Table (4). The calculated values of radon concentration inside the Pagodas are within the reference level (1000 Bq m^{-3}) recommended by the International Commission on Radiological Protection (ICRP, 2009).

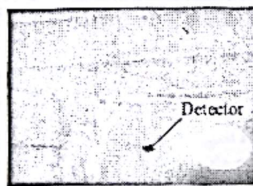
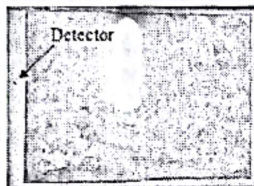
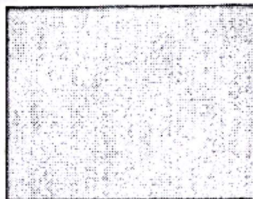
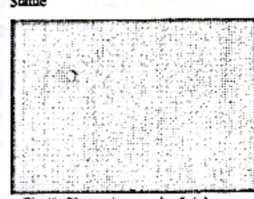
Table (3) Radon Concentration at Lying Pagoda

Sr. No	Name of Detectors	Alpha Track Density (track cm ⁻² day ⁻¹)	Radon Concentration (Bqm ⁻³)
1	D ₁	0.3079±0.0514	6.1384±1.0247
2	D ₂	0.3609±0.0235	7.1949±0.4685
3	D ₃	0.3822±0.0356	7.6196±0.7097
4	D ₄	0.3928±0.0605	7.8309±1.2061
5	D ₅	1.8259±0.2507	36.4015±4.998
6	D ₆	0.0573 ± 0.0295	1.1423 ± 0.5881
7	D ₇	0.0764 ± 0.0315	1.5231 ± 0.6279
8	D ₈	0.1528 ± 0.0408	3.0462 ± 0.8134
9	D ₉	0.3755 ± 0.0403	7.4860 ± 0.8034
10	D ₁₀	0.1146 ± 0.0319	2.2847 ± 0.6359

Table(4) Radon Concentration at Laykyun Setkyar Standing Buddha Statue

Sr. No	Name of Detectors	Alpha Track Density (track cm ⁻² day ⁻¹)	Radon Concentration (Bq-m ⁻³)
1	D' ₁	0.2546 ± 0.0409	5.0758 ± 0.8154
2	D' ₂	0.2355 ± 0.0405	4.6949 ± 0.8074
3	D' ₃	0.4074 ± 0.0333	8.1220 ± 0.6639
4	D' ₄	0.1973 ± 0.0362	3.9334 ± 0.7217
5	D' ₅	0.2482 ± 0.0370	4.9482 ± 0.7376
6	D' ₆	0.0637 ± 0.0303	1.2699 ± 0.6041
7	D' ₇	0.1909 ± 0.0380	3.8058 ± 0.7576
8	D' ₈	0.1400 ± 0.0359	2.7910 ± 0.7157

Discussion for Radon Concentration in Lying Pagoda

Fig.(8) Photomicrograph of alpha tracks in detector D'₃ from Laykyun Setkyar Buddha StatueFig.(8) Photomicrograph of alpha tracks in detector D'₄ from Laykyun Setkyar Buddha StatueFig.(8) Photomicrograph of alpha tracks in LR-115 detector D₅Fig.(9) Photomicrograph of alpha tracks in LR-115 detector D₁₀Fig.(10) Photomicrograph of alpha tracks in LR-115 detector D₇Fig.(11) Photomicrograph of alpha tracks in LR-115 detector D₆

In Lying Pagoda, it is found that detector D₅ has the highest radon concentration among these detectors. This detector is collected from the head of the Lying Pagoda and it is also the inner most part of the Lying Pagoda. So, it is dark at this place where air ventilation is poor among the places in the cave and no window in this place.

Detector D₁₀ is collected from the foot-end of the Lying Pagoda but there is a window at this place. It is directed to the south part and so air passes through this window. Air ventilation is good. So, the radon concentration of detector D₁₀ is the lower than other detectors in this cave.

Detector D₆ is placed in the opposite side of the entrance of the Lying Pagoda. This entrance is the middle of the Lying Pagoda. So, the radon concentration of detector D₃ is the lowest one as the visitors and the prayers always pass through this place.

The other detectors were placed different positions from the entrance inside the Lying Pagoda. These places are rather dark than the entrance and no sunlight is incident and air ventilation is very poor. So, the concentration level is rather higher than entrance detector D₆.

Discussion for Radon Concentration in Laykyun Setkyar Standing Buddha Statue

In this pagoda, the first floor to fourth floor is incident sunlight and windows are always opened. So, radon concentrations were detected from fifth floor to twelfth floor inside the Standing Buddha Statue.

By comparing these results, they are slightly different for each detector except Detector D₃. The radon concentration for D₃ is the maximum value that has 8.1220 ± 0.6639 Bqm⁻³. The detected place in seventh floor is placed under the ladder. It is darker than the other place.

The radon concentration in detector D'₆ is minimum. Although it is placed on the wall-painting in 10th floor, air is not directly arrived and no sun light. This place is slightly inside the 10th floor.

The other detectors are slightly differing in radon concentration because a small window is present near the detected place. So, the light and air can enter this place.

Conclusion

The calculated values for radon concentrations from two pagodas are lower than the permissible safe limit from International Commission on Radiological Protection ICRP (2009). The value for the reference level for radon gas recommended action level 1000 Bqm⁻³ by the ICRP (2009) [3]. So, we can conclude that the radon concentrations inside Laykyun Setkyar Standing Buddha Statue and Lying pagodas on Maha Baw Di Ta Htaung Hill cannot be harmful to the prayers and visitors. So, these famous pagodas in the form of caves are not harmful for peace and meditation.

Acknowledgements

I would firstly thank Professor Dr Daw Mya Mya, Head of Department of Physics, Myitkyina University for her permission to present our research work. I would sincere thank to Rector Dr Thura Oo, Monywa University for his permission to do this work. I wish to thank Dr Shwe Zin Aung, Professor and Head, Department of Physics, Monywa University for her exhortation.

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PHY 011

Correlation Analysis of Heavy Metal Contamination in Some Vegetables

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Abstract

The purpose of this paper is the correlation analysis of heavy metal contamination in vegetables. The vegetable samples were collected from the municipal market, Shwebo, Shwebo Township. These samples are white pumpkin, golden pumpkin, eggplant (aubergine), cucumber, goa bean, green bean and navy bean. The SPECTRO XEPOS EDXRF Spectrometer was used to analyze the samples. The results were analyzed (i) the heavy metal distribution in vegetable and (ii) statistical correlations of the heavy metal concentration were discussed. The correlation means that the elements have similar chemical property. It was not found in significantly high positive (+1) and negative (-1) correlation.

Keywords: correlation, vegetable, EDXRF Spectrometer, elemental distribution, chemical property

Introduction

Heavy metals are classified in two main categories i.e. essential and toxic heavy metals. Essential heavy metals (Cu, Co, Zn, Fe, Se, Ni and Mn) are required in very trace quantities for the proper functioning of enzyme systems, hemoglobin formation and vitamin synthesis in human but metabolic disturbances are encountered in case of excess of these essential metals. In recent time, the rapid and exponential industrial growth increased production of waste.

Heavy metal pollution is of significant ecological or environmental concern because they are not easily biodegradable or metabolized thus precipitating far-reaching effects on the biological system such as human, animals, plants and other soil biota. Food chain contamination is the major pathway of heavy metal exposure for humans. Heavy metal elements, such as lead (Pb), cadmium (Cd), arsenic (As), etc., have toxic effects on human health. Toxic metals can accumulate persistently in the body over a lifetime.

In the present work, the seven samples of vegetables have been collected from the Shwebo municipal market. These vegetable samples were analyzed by using the SPECTRO XEPOS system. Measurements for all vegetable samples have been done in Experimental Nuclear Physics Laboratory, Department of Physics, Mandalay University. The results were analyzed (i) the elemental distribution in vegetable (ii) statistical correlations of the elemental concentration were discussed.

Theory of Correlation

Correlation is a statistical tool that helps to measure and analyze the degree of relationship between two variables. The degree of relationship between the variables under consideration is measure through the correlation analysis. The measure of correlation called the correlation coefficient.

The value of correlation coefficient 'r' ranges from -1 to +1

If $r = +1$, then the correlation between the two variables is said to be positive

If $r = -1$, then the correlation between the two variables is said to be negative

If $r = 0$, then there exists no correlation between the variables.

If $r = 0.5$ to 1.0 (or) -0.5 to 1.0 , the correlation is strong correlation.

If $r = 0.3$ to 0.5 (or) -0.3 to 0.5 , the correlation is good correlation.

If $r = 0.1$ to 0.3 (or) -0.1 to 0.3 , the correlation is weak correlation.

Karl Pearson's Coefficient of Correlation

The correlation coefficient 'r' was calculated using the equation

$$r(x, y) = \frac{\sum xy}{\sqrt{\sum x^2 \sum y^2}} \quad (1)$$

Study Area and Sample Collection

Sampling sites includes many farmland areas of the Shwebo Township, Sagaing Region, Central Myanmar. As a geographic grid the area is located between the north latitudes $22^{\circ}10'$ and $22^{\circ}32'$ between the longitudes of $95^{\circ}35'$ east and $96^{\circ}5'$ east. The area of Shwebo Township is (514.58) square miles. The samples location map (Shwebo Township) was shown in Fig. (1).

In the present work, the seven samples of vegetables have been collected from the Shwebo market. The collected vegetable samples are white pumpkin, golden pumpkin, eggplant (aubergine), cucumber, goa bean, green bean and navy bean. The vegetable species used in the experiment were shown in Table (1).



Fig. (1) The samples location map (Shwabo Township)

Sample Preparation for XRF Measurement

The edible parts of the vegetables were separated from the plants, dried under the room temperature for one week until the weight of the sample remained constant. All samples were ground to fine powder by using a stainless steel grinder (RT-02B, China), and passed through a 100-mesh sieve, then kept in clean polyethylene container for further analysis. The samples were air-dried at room temperature, ground to fine powder by using an agate mortar and pestle, and passed through a 325-mesh sieve, then kept in clean polyethylene containers before analysis.

After getting very fine powder, the sample was weighed nearly 5g. So the powdered samples were prepared as pellets. All the prepared pellets were put into the sample changer. Sample identification and changer number were carefully recorded. All of the pellet samples were analyzed 300 sec for each filter.

Results and Discussion

The elemental concentration of heavy metals in vegetable was shown in Table (2).

The correlation analysis for elemental concentration of heavy metals in vegetable was shown in Table (3).

From Table (1), the mean value of copper (Cu) is $7.7 \pm 1.01 \mu\text{g/kg}$. The oral reference dose for the concentration of copper (Cu) in the vegetable is $40 \mu\text{g/kg}$. The maximum concentration in cucumber is $16.9 \mu\text{g/kg}$ and the minimum concentration is $4.5 \mu\text{g/kg}$ in goa bean. These result obtained are within the permissible level for vegetable.

The mean value of nickel (Ni) is $0.97 \pm 0.20 \mu\text{g/kg}$. The oral reference dose for the concentration of nickel (Ni) in the vegetable is $20 \mu\text{g/kg}$. The maximum concentration in cucumber is $1.7 \mu\text{g/kg}$ and the minimum concentration is $0.3 \mu\text{g/kg}$ in goa bean. These result obtained are within the permissible level for vegetable.

Table (1) Vegetable species used in the experiment

Sr. No	Sample Code	Sample Name
1.	S-1	White pumpkin
2.	S-2	Golden pumpkin
3.	S-3	Eggplant (aubergine)
4.	S-4	Cucumber
5.	S-5	Goa bean
6.	S-6	Green beans
7.	S-7	Navy beans

The mean value of arsenic (As) is $0.54 \pm 0.05 \mu\text{g/kg}$. The oral reference dose for the concentration of arsenic (As) in the vegetable is $0.3 \mu\text{g/kg}$. The maximum concentration in cucumber is $0.8 \mu\text{g/kg}$ and the minimum concentration is $0.4 \mu\text{g/kg}$ in goa bean. These result obtained are higher than the permissible level for vegetable.

The mean value of cadmium (Cd) is $1.38 \pm 0.28 \mu\text{g/kg}$. The oral reference dose for the concentration of cadmium (Cd) in the vegetable is $1 \mu\text{g/kg}$. The maximum concentration in cucumber is $2.3 \mu\text{g/kg}$ and the minimum concentration is $0.2 \mu\text{g/kg}$ in goa bean. These result obtained are higher than the permissible level for vegetable.

The mean value of mercury (Hg) is $1.3 \pm 0.07 \mu\text{g/kg}$. The oral reference dose for the concentration of mercury (Hg) in the vegetable is $0.5 \mu\text{g/kg}$. The maximum concentration in white pumpkin, goa bean and green bean was $1.5 \mu\text{g/kg}$ and the minimum concentration is $1 \mu\text{g/kg}$ in cucumber. These result obtained are higher than the permissible level for vegetable.

The mean value of lead (Pb) is $1.07 \pm 0.31 \mu\text{g/kg}$. The oral reference dose for the concentration of lead (Pb) in the vegetable is $4 \mu\text{g/kg}$. The maximum concentration in cucumber is $2.8 \mu\text{g/kg}$ and the minimum concentration is $0.4 \mu\text{g/kg}$ in goa bean. These result obtained are within the permissible level for vegetable. The comparisons of the elemental concentration of heavy metal in vegetables are shown in Fig. (2).

According to the elemental concentration of heavy metal, (except arsenic, cadmium and mercury), the rest of other heavy metal are lower than the Environmental Protection Agency (EPA) recommended level.

According to correlation analysis, the positive strong correlation exists between Cu-Ni (0.7521), As-Cd (0.8331), Cu-Hg (0.5507) and

Pb-Cu (0.5178) respectively. The negative strong correlation exists between Cu-As (-0.4044).

Table (2) The elemental concentration of heavy metals in vegetable

Sample Name	Elemental Concentration ($\mu\text{g/g}$)					
	Cu	Ni	As	Cd	Hg	Pb
White Pumpkin	14.1	0.9	0.5	0.9	1.5	0.6
Golden Pumpkin	16.9	1.4	0.4	1	1.2	2.8
Eggplant	4.5	0.3	0.6	2	1.3	1.5
Cucumber	4.6	0.6	0.4	0.2	1	0.4
Goat bean	11.5	1.7	0.6	2.3	1.5	1
Green bean	12.1	1.4	0.5	1.3	1.5	0.6
Navy bean	6.3	0.5	0.8	2	1.1	0.6

The positive good correlation exists between Hg-Ni (0.3865). The negative good correlation exists between As-Ni (-0.3156) and Cd-Cu (-0.3017) respectively.

The positive weak correlation exists between Cd-Hg (0.2169) and Ni-Pb (0.2595) respectively.

The negative weak correlation exists between Cd-Pb (-0.2432), As-Pb (-0.2981), Ni-Cd (-0.0378), As-Hg (-0.0721) and Hg-Pb (-0.0685) respectively.

As-Pb, Ni-Cd, As-Hg and Hg-Pb respectively. The correlation means that the elements have similar chemical property. It was not found in significantly high positive (+1) and negative (-1) correlation.

Table (3) Analysis of Correlation Data for Vegetable Samples

	Cu	Ni	As	Cd	Hg	Pb
Cu	1					
Ni	0.7521	1				
As	-0.4044	-0.3156	1			
Cd	-0.3017	-0.0378	0.8331	1		
Hg	0.5507	0.3865	-0.0721	0.2169	1	
Pb	0.5178	0.2595	-0.2981	-0.2432	-0.0685	1

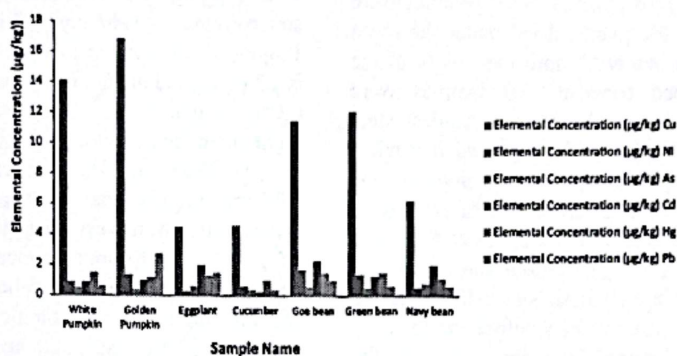


Fig. (2) Comparisons of the elemental concentration of heavy metal in vegetables

Conclusion

The elemental concentrations of metal such as Cu, Ni, As, Cd, Hg and Pb are contained in samples. These elements originate from the soil-characteristic, the use of fertilizers, the use of pesticides, the combustion of fossil fuel and other conditions (industrial waste, radioactive fallout and method of chemical use). Heavy metals are stable and persistent environmental contaminants since they cannot be degraded or destroyed. According to this research work, the elemental concentrations of heavy toxic metal are within WHO recommendations or WHO limitations.

According to correlation analysis, the positive strong correlation exists between Cu-Ni, As-Cd, Cu-Hg and Pb-Cu respectively. The negative strong correlation exists between Cu-As. Some level of correlations are also found in the positive good correlation exists between Hg-Ni. The negative good correlation exists between As-Ni and Cd-Cu respectively.

The positive weak correlation exists between Cd-Hg and Ni-Pb respectively. The negative weak correlation exists between Cd-Pb,

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PHY 012

Energy States of Sigma Hypernucleus $^{208}_{\Sigma}\text{Hg}$

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Abstract

The purpose of our research work is to calculate the possible existence of Σ hypernucleus $^{208}_{\Sigma}\text{Hg}$. In this work, the energy states of $^{208}_{\Sigma}\text{Hg}$ are calculated by solving the Schrödinger equation for two body system. It is difficult to observe the Σ hypernuclear states because of the strong decay from ΣN to ΛN . However, inside the nuclear medium, ΣN to ΛN strong interaction is strongly suppressed by the Pauli exclusion principle. Therefore, we expect that the narrow Σ hypernuclear states may exist in heavy hypernuclei. We used the interaction between Σ^- and ^{207}Tl core nucleus which form the $^{208}_{\Sigma}\text{Hg}$ hypernucleus. The $\Sigma^- - \text{Tl}$ interaction consists of the real part and imaginary part. The imaginary part represents the ΣN to ΛN decay. Since Σ^- and ^{207}Tl core nucleus are charged particles, the Coulomb potential is also included in our calculations. We investigated the contributions of strong interaction and Coulomb interaction to the energy states of $^{208}_{\Sigma}\text{Hg}$ system for different angular momentum states. It is found that the lowest h-state with $E_R = -6.61$ MeV and level width $\Gamma = 1.66$ MeV is a typical Coulomb-assisted hybrid state since its Σ distribution function lies just outside the nuclear surface and within the range of the strong interaction.

Keywords: Energy states, hypernucleus $^{208}_{\Sigma}\text{Hg}$, ΣN to ΛN decay.

1. Introduction

The proton and particles heavier than proton are known as baryons. A special class of baryons is hyperon. Hyperons are Λ , Σ , Ξ and Ω . Kaon and hyperons have strange behaviour. These particles are produced copiously. Their production time is about 10^{-23} sec, but their decay time is about 10^{-10} sec. They are produced by the strong force but they decay with the weak process. These particles are known as the strange particles.

Because of the hyperon's different nature from a nucleon, a hyperon can be used as a probe to investigate the low-lying levels of nuclei in which the hyperon is not forbidden by Pauli exclusion principle. The information concerning inner region of nuclei and also nucleon-hyperon interaction can be extracted from hypernuclear study. This field of study has attracted much attention of scientists. Among the hyperons, Λ -hypernuclei are studied extensively and there are rich information on ΛN interaction and Λ hypernuclear structure. But it is only an early stage for Σ and Ξ hypernuclear study and we pay our attention to Σ hypernuclei in this work.

2. Σ hypernuclei

A hypernucleus is a nucleus which contains at least one hyperon in addition to the normal protons and neutrons. In 1980, Σ hypernuclear states with narrow width were first reported at CERN (European Centre for Nucleus Research) [1] in the ^9Be (in-flight K^- , π^-) spectrum. The observation of Σ states as narrow as

the corresponding Λ states has attracted the interest of nuclear physicists. It is very difficult to observe the Σ hypernuclear states with narrow width because of the strong interaction process ΣN to ΛN which gives very large width for the hypernuclear states. However, Harada *et al.* [2] theoretically predicted the possible existence of a hypernuclear bound state in $^4_{\Sigma}\text{He}$ with narrow width. This calculation was experimentally confirmed by the first observation of $^4_{\Sigma}\text{He}$ bound state at KEK (High Energy Accelerator Research Organization) by Hayano *et al.* [3]. This development encourages us to search for Σ hypernuclear states in other nuclei. If the narrow-width phenomenon is not limited to some particular light nuclei but is extended to heavy nuclei, the Σ hypernuclear study would become broader and more interesting. Inside the nuclear medium, ΣN to ΛN strong interaction is strongly suppressed by the Pauli exclusion principle. Therefore, we expect that the narrow Σ hypernuclear states may exist in heavy hypernuclei. Bando *et al.* [4] investigated the possibility of observing Σ hypernucleus $^{28}_{14}\text{Si}$, $^{56}_{26}\text{Fe}$ in (π^-, K^+) reactions. In order to know if there is any possibility to observe Σ hypernuclear states even in heavy nuclei, we make our investigations into the $^{207}\text{Tl} + \Sigma^-$ or $^{208}_{\Sigma}\text{Hg}$ system which can be produced by the (K^-, π^+) reaction on the target ^{208}Pb .

3. Nucleus- Σ Interaction

The ΣN (sigma-nucleon) potential consists of the repulsive core potential (V_c), real part of long range potential (V_L) and imaginary part of long range potential (W_L). This potential has the following form:

$$V_{\Sigma N}(r) = V_c \exp\left\{-(r/0.40)^2\right\} + (V_L + iW_L) \exp\left\{-(r/1.00)^2\right\} \quad (1)$$

According to the spin-isospin formulating, $\Sigma^- p$ and $\Sigma^- n$ interactions in closed shell nucleus have the following ratios of spin and isospin states.

$$\bar{V}_{\Sigma p} = \frac{1}{12} \left\{ 3V_{\Sigma N}^{\text{eff}} \left[\frac{1}{2}, 1 \right] + V_{\Sigma N}^{\text{eff}} \left[\frac{3}{2}, 0 \right] + 6V_{\Sigma N}^{\text{eff}} \left[\frac{1}{2}, 1 \right] + 2V_{\Sigma N}^{\text{eff}} \left[\frac{1}{2}, 0 \right] \right\}, \quad (2)$$

$$\bar{V}_{\Sigma n} = \frac{1}{12} \left\{ 9V_{\Sigma N}^{\text{eff}} \left[\frac{1}{2}, 1 \right] + 3V_{\Sigma N}^{\text{eff}} \left[\frac{3}{2}, 0 \right] \right\}, \quad (3)$$

where the terms in the square brackets represent isospin and spin, respectively.

$\Sigma^- n$ interaction has no conversion into Λn , due to isospin selection rule. $V_{\Sigma N}^{\text{eff}}$ is the effective ΣN interaction in nuclear medium. It is different from the ΣN interaction in free space where the scattered Σ and nucleon can take place in any quantum states. But, in nuclear medium, the

scattered nucleon can occupy only states which are above the Fermi level due to the Pauli exclusion

principle. Thus the effective ΣN interaction $V_{\Sigma N}^{\text{eff}}$ is obtained by taking into account short range correlation or Pauli effect between nucleons [5].

The Nucleus- Σ potential is obtained by folding the effective ΣN interaction with the nuclear density,

(4)

$$V_{\Sigma N}(\vec{R}) = \sum_{N \neq \Sigma} \int \bar{V}_{\Sigma N}(\vec{R} - \vec{r}) \rho_N(\vec{r}) d\vec{r}$$

where R is the distance between the Σ particle and center of mass of the ^{207}Tl core nucleus and $\rho_N(\vec{r})$ is the Fermi-type density distribution of the core nucleus.

$$\rho_N(\vec{r}) = \rho_0 \left(1 + \exp \frac{r - R_0}{a_0} \right)^{-1} \quad (5)$$

where $R_0 = 1.12 A^{1/3} \text{ fm}$, $a_0 = 0.53 \text{ fm}$.

By using normalization, we get

(6)

$$\rho_0 = \frac{1}{4\pi \int_0^\infty r^2 \left[1 + \exp \left(\frac{r - R_0}{a_0} \right) \right]^{-1} dr}$$

We started with the following equation

$$V_{\Sigma N}(\vec{R}) = 81 \int \bar{V}_{\Sigma p}(\vec{R} - \vec{r}) \rho_p(\vec{r}) d\vec{r} + 126 \int \bar{V}_{\Sigma n}(\vec{R} - \vec{r}) \rho_n(\vec{r}) d\vec{r} \quad (7)$$

And we get the nucleus- Σ potential is

$$V_{\Sigma N}(\vec{R}) = 2\pi\rho_0 \sum_{i=1}^{12} V_i e^{-\left(\frac{R}{\eta_i}\right)^2} \frac{\eta_i^2}{2R} \int_0^\infty \frac{r \left[e^{-\frac{1}{\eta_i^2}(r^2 - 2Rr)} - e^{-\frac{1}{\eta_i^2}(r^2 + 2Rr)} \right]}{1 + e^{\frac{r - R_0}{a_0}}} dr \\ + i 2\pi\rho_0 \sum_{i=13}^{14} V_i e^{-\left(\frac{R}{\eta_i}\right)^2} \frac{\eta_i^2}{2R} \int_0^\infty \frac{r \left[e^{-\frac{1}{\eta_i^2}(r^2 - 2Rr)} - e^{-\frac{1}{\eta_i^2}(r^2 + 2Rr)} \right]}{1 + e^{\frac{r - R_0}{a_0}}} dr \quad (8)$$

Since, Σ^- and ^{207}Tl are charged particles, we must consider the Coulomb interaction between them. ^{207}Tl core nucleus is assumed as a uniformly charged sphere with radius r . When Σ^- is outside the nucleus, i.e. $R > r$, the potential is

$$V_{\text{coul}}(R) = \frac{-ze^2}{4\pi\epsilon_0 R} \quad (9)$$

If Σ^- is inside the nucleus, i.e. $R < r$, the potential is

$$V_{\text{coul}}(R) = \frac{-ze^2}{4\pi\epsilon_0 r} + \frac{ze^2}{2 \times 4\pi\epsilon_0 r^3} [R^2 - r^2] \quad (10)$$

An interesting characteristic is observed in the real part of strong interaction between Σ^- and ^{207}Tl . It

has a repulsive bump near the nuclear surface. In the case of NN or ΛN interaction, the attractive

strength is much stronger than that of repulsive one and there does not appear such an unusual feature. ΣN interaction has a repulsive core and strengths of repulsive and attractive parts are not very different from one another. The appearance of the bump is due to a delicate balance of

repulsive and attractive contributions of ΣN interaction and is the characteristic feature of nucleus- Σ interaction. The parametrized Σ -Tl interaction is very similar to that of our folding potential. [5]

4. Solving the Schrödinger Equation for Two-Body System

In order to calculate the structure of two-body system we solved Schrödinger's equation $H\Psi = E\Psi$, (11)

where, H = Hamiltonian operator, E = energy eigen value and Ψ = eigen vector.

Since, the interaction between Σ and core nucleus is central force, so we choose the spherical coordinate for the wave function.

$$\Psi(\vec{r}) = R(r) \Theta(\theta) \Phi(\phi) \quad (12)$$

where, $R(r)$ is a radial part and $\Theta(\theta) \Phi(\phi)$ is an angular part.

We have to solve only the radial part $R(r)$. By using the separable method, we get the equation

$$\left\{ -\frac{\hbar^2}{2\mu} \frac{d^2}{dr^2} + \frac{\hbar^2}{2\mu} \frac{\ell(\ell+1)}{r^2} + V(r) \right\} \Psi = E \Psi \quad (13)$$

$$\text{where, the reduced mass, } \mu = \frac{m_1 m_2}{m_1 + m_2}$$

m_1 = mass of core nucleus, m_2 = mass of Σ^- particle.

To solve the above equation, we will use the Gaussian basis wave function.

$$\Psi(r) = r^{\ell+1} \sum_j c_j e^{-(r/b_j)^2} \quad (14)$$

where c_j 's are expansion coefficients and b_j 's are range parameters.

The Schrödinger equation becomes

$$\left\{ -\frac{\hbar^2}{2\mu} \frac{d^2}{dr^2} + \frac{\hbar^2}{2\mu} \frac{\ell(\ell+1)}{r^2} + V(r) \right\} \sum_j c_j r^{\ell+1} e^{-(r/b_j)^2} = E \sum_j c_j r^{\ell+1} e^{-(r/b_j)^2} \quad (15)$$

$$\sum_j H_{ij} c_j = E \sum_j N_{ij} c_j \quad (16)$$

$$H_{ij} = \int e^{-(r/b_i)^2} r^{\ell+1} H e^{-(r/b_j)^2} r^{\ell+1} dr \quad \text{and} \quad N_{ij} = \int r^{2(\ell+1)} e^{-(r/b_i)^2} e^{-(r/b_j)^2} dr$$

To solve the above equation, we must know the matrix elements. Hamiltonian matrix element consists of kinetic energy matrix element (T_{ij}), centrifugal matrix element (F_{ij}), potential matrix element (V_{ij}) and

Coulomb potential matrix element (AV_{ij}).

$$T_{ij} = \int r^{\ell+1} e^{-(r/b_i)^2} \left(-\frac{\hbar^2}{2\mu} \right) \left(\frac{d^2}{dr^2} \right) r^{\ell+1} e^{-(r/b_j)^2} dr. \quad (17)$$

$$F_{ij} = \frac{\hbar^2}{2\mu} \ell(\ell+1) \int \frac{r^{2(\ell+1)}}{r^2} e^{-\left(\frac{1}{b_i^2} + \frac{1}{b_j^2}\right) r^2} dr. \quad (18)$$

$$V_{ij} = \int_0^\infty R^{2(\ell+1)} e^{-\left(\frac{1}{b_i^2} + \frac{1}{b_j^2}\right) R^2} V(R) dR \quad (19)$$

$$AV_{ij} = \int_0^\infty R^{2(\ell+1)} e^{-\left(\frac{1}{b_i^2} + \frac{1}{b_j^2}\right) R^2} V_{\text{coul}} dR \quad (20)$$

By using the power inverse iteration method we calculated the eigenvalues E with corresponding wave functions.

5. Results and Discussion

In this work, we solved the Schrödinger equation to obtain complex eigenvalues $E = E_R - i\frac{\Gamma}{2}$ where E_R and Γ are energy and level width of Σ hypernuclear states, respectively. We investigated the contributions of strong interaction and Coulomb interaction to the energy states of $^{208}_{\Sigma}\text{Hg}$ system for different angular momentum states. The 1s state is at $E_R = -27.94$ MeV with conversion width $\Gamma = 12.38$ MeV. In order to understand the nature of the bound s-states, we calculated the Σ probability density $|\Psi(R)|^2$ and its distribution is shown in Figure (1) together with the nucleus- Σ interaction. It is found that the maximum of Σ distribution of the lowest state is inside the repulsive bump of the interaction, while that of the third upper state is just outside of the bump. The fourth upper state is far away from the nucleus. Thus we would like to classify these hypernuclear states into three categories such as nuclear state, hybrid state and atomic state which are denoted by N, H and A, respectively.

The single particle energy levels and conversion widths of $^{208}_{\Sigma}\text{Hg}$ system are shown in Figure (2). The first s-state 1s and the second s-state 2s are very close to each other. The states 2s and 3s overlap since they have large level widths and the level spacing between them is small. Therefore, it is difficult to separate them as single particle energy states. Similarly, p-states, d-states and f-states have narrow level spacing and large level widths. These states are not interesting, because it would be difficult to observe these states experimentally.

Although 1g-state and 1h-state are found at smaller binding energies, the level widths are narrow. The 1g state of $^{208}_{\Sigma}\text{Hg}$ system with strong and Coulomb interaction is at $E_R = -9.06$ MeV with conversion width $\Gamma = 3.44$ MeV. The

1h state of $^{208}_{\Sigma}\text{Hg}$ system with combination of strong and Coulomb interaction is at $E_R = -6.61$ MeV with conversion width $\Gamma = 1.66$ MeV. So, it may be possible to investigate the single particle energy levels with narrow width in higher angular momentum states. It is due to the centrifugal potential which pushes out the wave function. Level width is proportional to the overlapping between the wave function and imaginary part of strong potential.

6. Concluding Remark

In the heavy Σ hypernucleus $^{208}_{\Sigma}\text{Hg}$ system, Coulomb interaction is very significant due to the large number of protons in core nucleus Tl. This system has narrow energy level spacing and broad level width for lower angular momentum states. In higher angular momentum states, the value of binding energy is not very low but level width is narrow. Nucleus- Σ interaction between ^{207}Tl and Σ which is calculated on the basis of realistic ΣN interaction, has a peculiar shape with a bump near the nuclear surface. On the basis of the appearance of this bump, we would like to classify Σ -hypernuclear states as nuclear (N) state, hybrid (H) state and atomic (A) state.

Figure (3) shows h-wave and s-wave hypernuclear states. Although the binding energy for the lowest h-state is smaller than that of s-state, the level width for the lowest h-state is narrower than that of s-state. The lowest h-state with $E_R = -6.61$ MeV and level width $\Gamma = 1.66$ MeV is a typical Coulomb-assisted hybrid state since its Σ distribution function lies just outside the nuclear surface and within the range of the strong interaction. This state is found to be a favourable candidate for experimental observation. Thus by taking into account all the strong interaction, Coulomb interaction and centrifugal potential, there is a possibility of the existence of Σ hypernuclear states with narrow widths even in heavy nuclei.

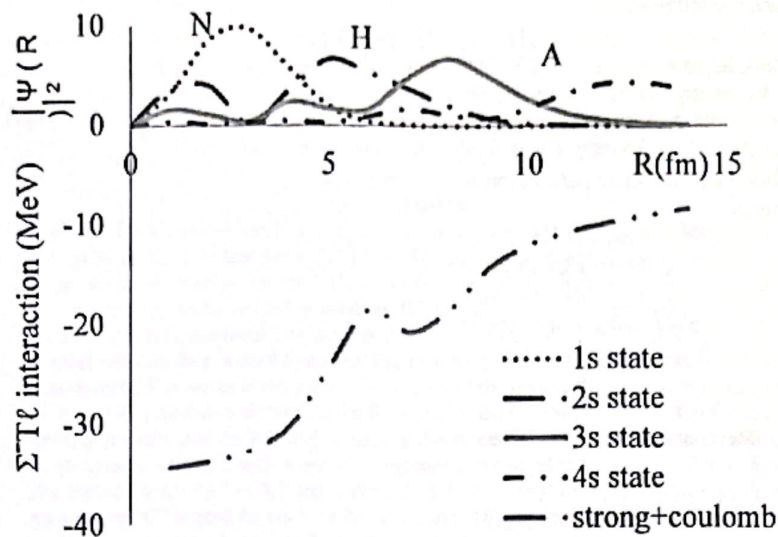


Figure (1) Total interaction between ^{207}Tl and Σ^- with s -wave Σ hypernuclear states

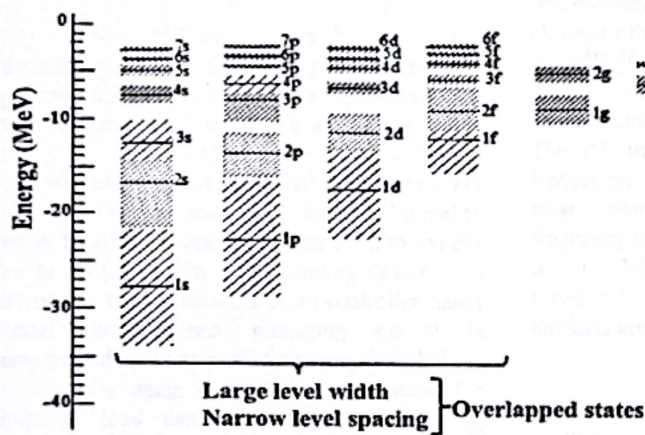


Figure (2) Single particle energy levels and widths of $^{208}_{\Sigma}Hg$

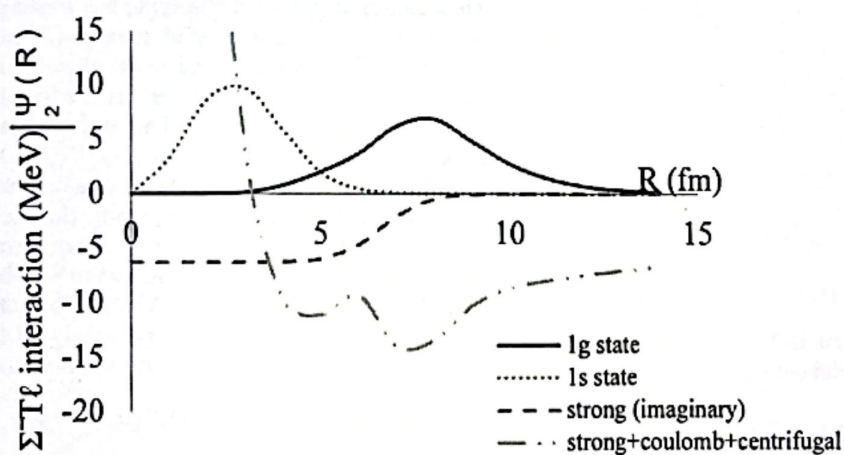


Figure (3) Σ hypernuclear states in h-wave and s-wave

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We are very deeply grateful to Professor Dr Mya Mya, Head of Department of Physics, University of Myitkyina for her valuable guidance, helpful advice and technical suggestions to complete this research.

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Microcontroller Based Smart Home Power Managing System Using RF Link

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Abstract

The aim of this research work is to construct a microcontroller based smart home power managing system by using radio frequency (RF) link. The developed system is not only easy to use but also helps to reduce energy waste. The whole system is constructed by using PIC16F628A microcontroller, 4-channel relay module, RF transmitter module and RF receiver module. The PIC16F628A microcontroller is used as the main control unit (MCU) of the whole system. A 4-channel relay module is used to control the switching of household appliances. The RF transmitter module and RF receiver module are used to control the household appliances from a distance. The RF transmitter module can transmit the RF signal to the distance up to 100 ft in the open space. The working frequency of the RF module used in this research is 315 MHz. The control program for the whole system is written with Assembly language and compiled by MPLAB IDE (v.8.50) software. The button switch "A" of RF transmitter module is used for lighting, "B" is used for fan or air conditioner, "C" is used for cooking facilities, and "D" is used for multi-purpose outlets. Each relay used in this research can handle the load up to 2.5 kW.

Keywords: Power managing, microcontroller, radio frequency.

1. Introduction

Now technologies are improving and therefore home power managing systems are also getting smarter. In the past, a user controlled various home appliances such as electric lights, fan, air conditioner, etc. through wired communication. Most traditional wall switches are situated in various parts of the home and it makes waste time for the user to go near them to switch-on or switch-off the corresponding devices. To overcome this situation, a microcontroller based smart home power managing system is constructed by using radio frequency (RF) link.

By using the constructed system, the required load can be controlled by pressing corresponding switch of RF transmitter. It can reduce the physical efforts and also control for various appliances using single control unit. Even further it turns into more problematic for the old persons and physically handicapped people to do so. The smart home power managing system implements an easier solution with RF technology. In order to implement this, a pair of RF transmitter and receiver can be used. The RF transmitter sends ON/OFF signals to the receiver which is interfaced with microcontroller. The microcontroller controls the various loads with the help of corresponding relays. By pressing the switches on the RF transmitter, the corresponding loads can be turned ON/OFF using wireless technology. The RF signals can cross obstacles and do not miss the communication in front of misalignment.

2. Electronic Components Used in this Research Work

In this research work, RF transmitter and RF receiver modules, PIC16F628A microcontroller, 4-channel relay module, and DC

5V power supply are used to complete the whole system.

Generally, RF module is a small size electronic device that is used to transmit or receive radio signals between two devices. The main application of RF module is an embedded system to communicate with another device wirelessly. The RF transmitter module operates at radio frequency. The corresponding frequency range varies between 30 kHz and 300 GHz. The working frequency of the RF module used in this research is 315 MHz [1]. The photographs of RF transmitter (XY-T4) and RF receiver (XD-YK04) modules are shown in Fig. (1).

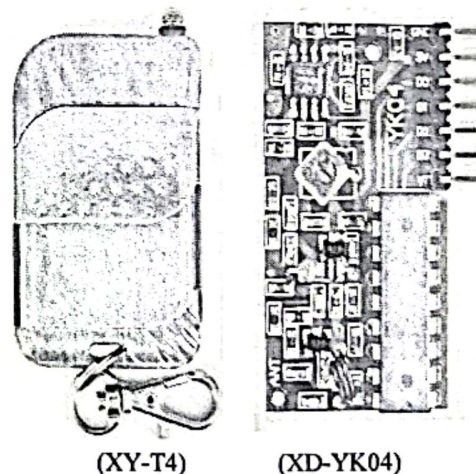


Fig. (1) Photographs of RF transmitter and RF receiver modules

The PIC16F628A is used as the main control and processing device of the whole system because of its economical and low cost, available of the chip and its related software and developer. The PIC16F628A have enhanced core features, eight-level deep stack, and multiple internal and external interrupt sources. A total of 35

instructions (reduced instruction set) are available, complemented by a large register set. PIC16F628A device have integrated features to reduce external components, thus reducing system cost, enhancing system reliability and reducing power consumption. The pin diagram and photograph of PIC16F628A microcontroller are shown in Fig. (2). The PIC16F628A has two ports, PORTA and PORTB. Some pins for these I/O ports are multiplexed with alternate functions for the peripheral features on the device. The PIC16F628A can be operated in eight different oscillator options. The user can program three configuration bits (FOSC2 through FOSC0) to select one of these eight modes: LP Low Power Crystal, XT Crystal/Resonator, HS High Speed Crystal/Resonator, RC External Resistor/Capacitor (2 modes), INTOSC Internal Precision Oscillator (2 modes) and EC External Clock In [2].

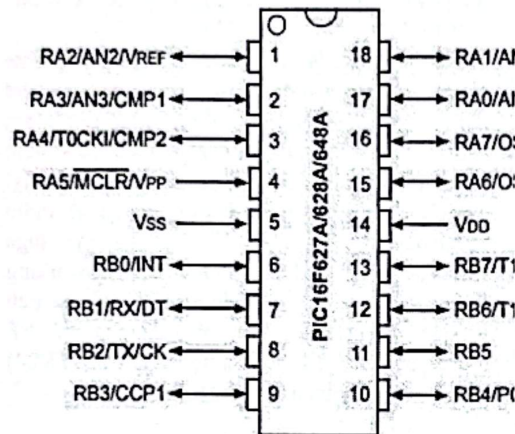


Fig. (2) Pin diagram and photograph of PIC16F628A microcontroller

The 4-channel relay module can be used to interface any microcontroller with electrical appliances or loads. It can also be used in driving high power motors. Each relay output can handle the load up to AC 250V (10A). The module is supplied with power via the pin labelled VCC and ground via the pin labelled GND. The relays are energized with low inputs to the IN1, IN2, IN3 and IN4 inputs [4]. The photograph of 4-channel relay module is shown in Fig. (3).

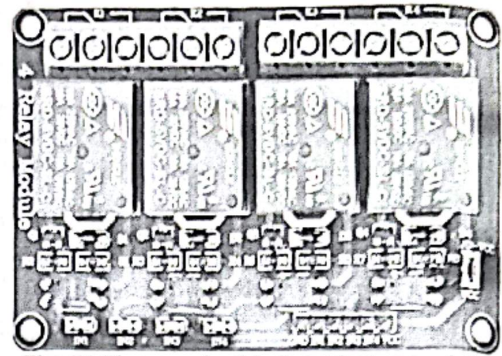


Fig. (3) Photograph of 4-channel relay module

3. General Descriptions of Smart Home Power Managing System

The developed smart home power managing system includes six units namely RF transmitter module, RF receiver module, main control unit (MCU), power switching unit, power supply unit, and AC outlets.

The function of RF transmitter module is to manage the power of various home appliances by sending the ON/OFF RF signal through the antenna. The function of RF receiver module is to receive the RF signal from the transmitter via the receiving antenna and also to interface with the main control unit. The functions of main control unit are to control power switching unit based on the trigger signal of RF receiver module. The function of power switching unit is to switch-on or switch-off the power of home appliances. The function of power supply unit is to apply the regulated +5 V for other units. The AC outlets can be used for lighting, fan, cooking facilities and multi-purpose outlets. The block diagram of constructed smart home power managing system is shown in Fig. (4).

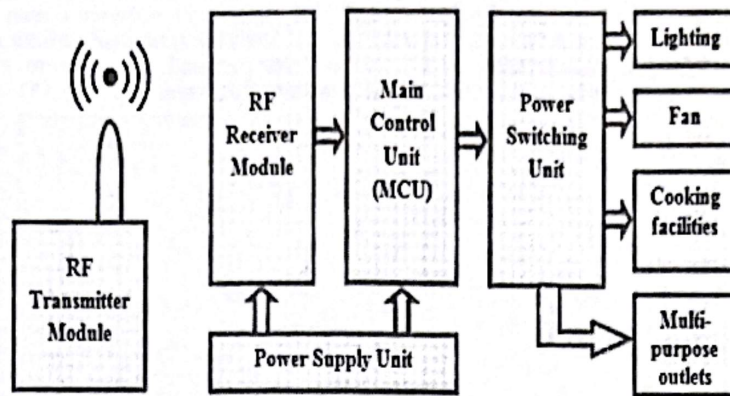


Fig. (4) Block diagram of constructed smart home power managing system

4. Circuit Construction of Smart Home Power Managing System

In circuit construction, the whole system is constructed by using RF transmitter (XY-T4) and RF receiver (XD-YK04) modules, PIC16F628A microcontroller, 4-channel relay module and other required electronic components.

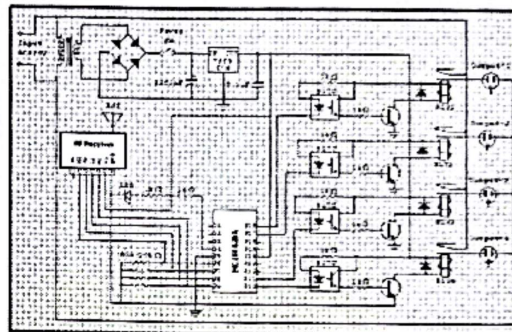
In microcontroller configuration, the lower four bits (RB0 to RB3) of PIC16F628A microcontroller are used as the digital inputs to receive RF signals of XD-YK04 module. The lower two bits (RA0 and RA1) and higher two bits (RB4 and RB5) of PIC16F628A microcontroller are used as digital outputs to control power switching circuit. Therefore, TRISA of PIC16F628A microcontroller is configured as binary xxxxxx00 and TRISB of microcontroller is configured as binary xx001111, in which x may be 0 or 1. The internal oscillator of 4 MHz frequency is used as the clock circuit for PIC16F628A microcontroller by configuring program software. Therefore any other external oscillator is not required for the PIC16F628A microcontroller.

In circuit connection, D0, D1, D2 and D3 of RF receiver are fed to RB0, RB1, RB2 and RB3 of PIC16F628A microcontroller. These pins are also connected to the ground by inserting 10 k Ω resistors in order to obtain the certain digital LOW state. RB4 and RB5 of PIC16F628A microcontroller are connected to IN1 and IN2 of relay module (cathodes of LEDs). RA0 and RA1 of PIC16F628A microcontroller are connected to IN3 and IN4 of relay module. The relays are energized with low inputs to the IN1, IN2, IN3 and IN4 inputs.

In AC wiring, the neutral wire of AC 220 V is directly connected to one pin of AC Output-1 to Output-4. The live wire of AC 220 V is applied to the inputs of four relays and their outputs are connected to the remaining pin of corresponding AC outputs (Output-1 to Output-4). When RB4 of PIC16F628A microcontroller is LOW, the relay (RL1) will activate. When RB4 of microcontroller is HIGH, RL1 will not activate. The remaining

relays (RL2, RL3 and RL4) are controlled by RB5, RA0 and RA1 respectively.

In the power supply section, AC 220V main line is fed to the primary input of transformer. The secondary output of transformer is converted into DC voltage by using full wave bridge rectifier. The output of rectifier is filtered by using 2200 μ F capacitor to reduce voltage fluctuations. The filtered output voltage is regulated by 7805 voltage regulator. An LED is also provided at the output of 7805 to indicate the



power status of the constructed system. In this way, a +5 V power supply is obtained and it is used for RF receiver module, microcontroller and relay module. The complete circuit diagram of the whole system is shown in Fig. (5). The photograph of constructed smart home power managing system is shown in Fig. (6).

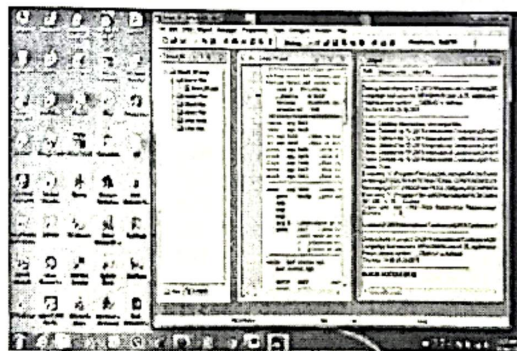


Fig. (5) Complete circuit diagram of the whole system

Fig. (7) Photograph of the MPLAB IDE v8.50 software screen

5. Source Code Development

In this research, the source code is written using Assembly programming language. Firstly, the

Assembly code (Smart_RF.asm) file is developed in the text editor. Then it is compiled into machine code (Smart_RF.hex) using MPLAB IDE v8.50

software. The obtained machine code (Smart_RF.hex) is imported to the PICkit 2 v2.61 software. Finally, the machine code is downloaded from the USB port of the personal computer into the PIC16F628A microcontroller by using PICkit

2 programmer board. The photograph of the MPLAB IDE v8.50 software screen is shown in Fig. (7). The photograph of writing the machine code from personal computer to PIC16F628A microcontroller is shown in Fig. (8).

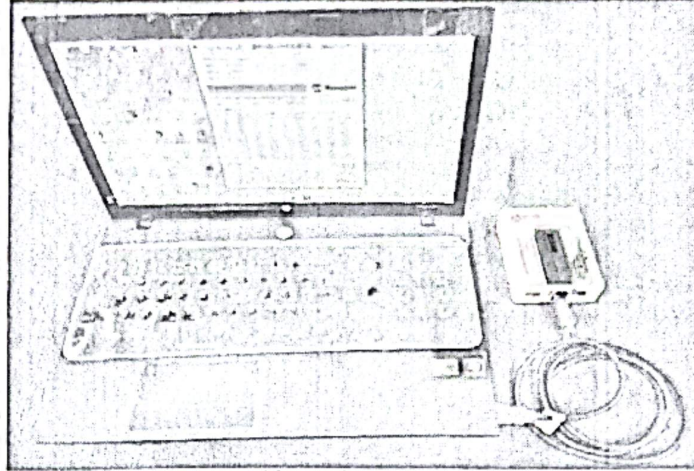


Fig. (8) Photograph of writing the machine code from personal computer to PIC16F628A microcontroller

6. Discussion

In this research, a smart home power managing system is designed and constructed to control the power of electric appliances at home remotely. Each appliance can be managed by the RF remote control. A pair of RF transmitter and receiver used in this research is compact size, ideal for multipurpose of data receiving and signal controlling. From the RF signal testing results, the RF transmitter module can transmit RF signal to the distance up to 100 ft in the open space. The working frequency of the RF module used in this research work is 315 MHz. The main control and processing device of the whole system is PIC16F628A microcontroller. In the pin configurations of PIC16F628A microcontroller, four pins of PORTB are used as digital inputs to receive the output data (D0, D1, D2 and D3) of RF receiver. Two pins of PORTB and two pins of PORTA are used as digital outputs to control the relay module. The power status LED and RF signal status LED are also provided in the developed system. The whole system is operated with DC 5V, a 7805 voltage regulator is used in this work. In Myanmar, most of home appliances use AC 220V, and therefore a 4-channel relay module is used for switching the power of home appliances. When the button switch "A" of RF transmitter module is pressed, the lighting will switch-on. When the button switch "A" is pressed again, the lighting will switch-off. The performances of the remaining switches are similar to that of switch "A". The switch "B" is used for fan or air conditioner, the switch "C" is used for cooking facilities, and the switch "D" is used for multi-purpose outlets. Each relay used in this research can handle the load up to 2.5 kW.

7. Conclusion

In the past, the various home appliances such as electric lights, fans, ovens and refrigerator are controlled by using wired communication rather than wireless communication. To control these appliances, the man power is needed. In this work, we developed the smart home power

managing system to turn-on or turn-off all electric appliances at home through the use of RF communication. By using the developed system, the user can easily control the electric appliances remotely with click of the corresponding switches. The user can also view the power status of each appliance. Therefore, the constructed system is reliable for wireless control applications.

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Neutron Single-Particle Energy Levels of Even-Even Nickel Isotopes

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Abstract

The purpose of this research is to investigate the neutron single-particle energy levels of even-even nickel isotopes such as ^{56}Ni , ^{58}Ni , ^{60}Ni , ^{62}Ni , ^{64}Ni and ^{68}Ni . In this calculation, a single neutron moves in a potential well produced by the action of all the other nucleons. The Schrödinger equation was solved with the phenomenological Woods-Saxon potential including spin-orbit interaction. The potential well depth is taken into account 53 MeV which is in fairly good agreement with the experimental results. The calculated energy levels of neutron in nickel isotopes are compared with the experimental results. There is slightly difference between the calculated results and experimental results for isotopes ^{58}Ni and ^{60}Ni . Among these nickel isotopes, the calculated energy values and the level ordering of ^{56}Ni and ^{68}Ni give in good agreement with experimental values. The average kinetic energy, average potential energy and average centrifugal potential energy are calculated. Then the last neutron separation energy and root-mean square radius of the outermost filled neutron states are also calculated. The calculated results are compared with the experimental values. The discrepancy is due to the fact that in which need to consider the paring interaction of two-nucleon, core excitation and admixtures of single-particle states.

Keywords: neutron single-particle energy levels, even-even nickel isotopes, last neutron energy levels, root-mean square radius.

1. Introduction

The understanding of nuclear structure is important in various astrophysical applications and in tests of fundamental symmetries. One of the most important and useful models of nuclear structure is the nuclear shell model. The shell model of the nucleus, also called the independent-particle model because it assumes that each nucleon moves independently of all the other nucleons, and is acted on by an average nuclear field produced by the action of all the other nucleons. The basic assumption of the shell model is that a single nucleon moves in a potential which is the effect of all other nucleons. Since every nucleon of a nucleus is bounded, this potential is expected to be a potential well. In this model, each nucleon is assumed to exist in a shell, similar to an atomic shell for an electron. The nucleons exist in quantized energy states, in which the occupation nucleons can be described by a set of quantum numbers ($n l m$). The number of nucleons in each

shell is limited by Pauli exclusion Principle. The most important piece of experimental information on shell structure is the existence of magic numbers. Spin-orbit splitting (ℓs coupling) is also important in the structure of nuclei. A large ℓs splitting between single particle orbits with the same orbital angular momentum is responsible for the shell structure of nuclei. With ℓs coupling, the theoretical order of levels for a given potential shapes was able to account for the known nuclear discontinuities, or magic numbers 2,8,20,28,50,82 and 126. The nuclei which possess the magic numbers are more tightly bound than that having the other number of protons or neutrons. A nucleus has Z protons and N neutrons and if either Z or N equal to a magic number the nucleus is said to be a single closed shell nucleus. One in which Z and N are magic it is said to be a doubly-magic nucleus or doubly-closed-shell.

2. Interactions

2.1 Phenomenological Wood-Saxon potential

The nuclear interaction is very complicated. The interaction is attractive in the nuclear region and repulsive when the two nucleons are very close. To investigate the single-particle energy levels of ordinary nuclei, the phenomenological Woods-Saxon neutron-nucleus potential is employed which has the following form;

$$V(r) = V_0(r) + V_{so}(r)\vec{\ell} \cdot \vec{s} \quad (2.1.1)$$

$$\text{where, spin-independent central potential } V_0(r) = \frac{V_0}{1 + e^{\frac{r-R}{a}}} \quad (2.1.2)$$

$$\text{For neutron, } V_0 = -53 - \frac{(N-Z)}{A} V_1 \quad (2.1.3)$$

$$V_1 = -30 \text{ MeV}$$

V_0 = the strength of the Woods-Saxon potential

a = the diffuseness parameter = 0.65 fm

R = the nuclear radius = $r_0 A^{1/3}$

A = mass number

r = the radial distance from the center

$r_0 = 1.25 \text{ fm}$.

2.2 Spin-Orbit Interaction

The spin-orbit potential $V_{so}(r)$ is expressed as;

$$V_{so}(r) = V_{so} \left(\frac{\hbar}{m_\pi c} \right)^2 \bar{\ell} \cdot \bar{s} \frac{1}{r} \frac{d}{dr} \frac{1}{1 + e^{-r/R/a}} = - V_{so} \left(\frac{\hbar}{m_\pi c} \right)^2 \bar{\ell} \cdot \bar{s} \frac{1}{ra} \frac{e^{-r/R/a}}{\left(1 + e^{-r/R/a} \right)^2} \quad (2.2.1)$$

where, V_{so} = the spin-orbit constant = 22MeV

$\left(\frac{\hbar}{m_\pi c} \right)$ = the Compton wavelength of the pion

The total angular momentum operator is given by $\bar{J} = \bar{L} + \bar{S}$, where $\bar{L}$ is orbital angular momentum and $\bar{S}$ is spin angular momentum.

$$\bar{L} \cdot \bar{S} = \frac{1}{2} (j^2 - \ell^2 - s^2) = \frac{1}{2} [j(j+1) - \ell(\ell+1) - s(s+1)] \quad (2.2.2)$$

For a neutron with spin 1/2,

For $j = \ell + 1/2$ state, $\bar{L} \cdot \bar{S} = \frac{\ell}{2}$ and then the spin-orbit potential can be expressed as following;

$$V_{\ell s}(r) = - V_{so} \left(\frac{\hbar}{m_\pi c} \right)^2 \left(\frac{1}{2} \ell \right) \frac{1}{ra} \frac{e^{-r/R/a}}{\left(1 + e^{-r/R/a} \right)^2} \quad (2.2.3)$$

For $j = \ell - 1/2$ ($\ell \neq 0$) state, $\bar{L} \cdot \bar{S} = -\frac{(\ell+1)}{2}$ the spin-orbit potential can express as

$$V_{\ell s}(r) = V_{so} \left(\frac{\hbar}{m_\pi c} \right)^2 \left(\frac{1}{2} (\ell+1) \right) \frac{1}{ra} \frac{e^{-r/R/a}}{\left(1 + e^{-r/R/a} \right)^2} \quad (2.2.4)$$

3. Mathematical Calculation

3.1 Solving the Schrödinger equation with the Gaussian Basis Wave function

The time independent Schrödinger equation $\hat{H}\Psi = E\Psi$ is

$$(\hat{T} + \hat{V})\Psi = E\Psi \quad (3.1.1)$$

where, $\hat{H}$ = Hamiltonian operator, E = energy eigen value, Ψ = eigen vector, $\hat{T}$ = kinetic energy operator and $\hat{V}$ = potential energy operator. The Gaussian basis wave function as the reduced radial wave function of one-body system which has the following form

$$U(r) = r^{\ell+1} \sum_{j=1}^N c_j e^{-\left(\frac{r}{b_j} \right)^2} \quad (3.1.2)$$

where, c_j 's are expansion coefficients and b_j 's are range parameters which are adjusted with as follow;

$$b_{j+1} = c b_j \text{ and } c = \left(\frac{b_N}{b_1} \right)^{\frac{1}{N-1}} \quad (3.1.3)$$

where, N is the number of basis. Then the Schrödinger equation becomes;

$$\left[-\frac{\hbar^2}{2M} \frac{d^2}{dr^2} + \frac{\hbar^2}{2M} \frac{\ell(\ell+1)}{r^2} + V(r) \right] \sum_{j=1}^N c_j r^{\ell+1} e^{-\left(\frac{r}{b_j} \right)^2} = E \sum_{j=1}^N c_j r^{\ell+1} e^{-\left(\frac{r}{b_j} \right)^2} \quad (3.1.4)$$

Multiplying both sides of the equation by $r^{\ell+1} e^{-\left(\frac{r}{b_i} \right)^2}$ from the left and integration throughout the whole space,

$$\int r^{\ell+1} e^{-\left(\frac{r}{b_i}\right)^2} \left[-\frac{\hbar^2}{2M} \frac{d^2}{dr^2} + \frac{\hbar^2}{2M} \frac{\ell(\ell+1)}{r^2} + V(r) \right] \sum_{j=1}^N c_j r^{\ell+1} e^{-\left(\frac{r}{b_j}\right)^2} dr = E \int r^{\ell+1} e^{-\left(\frac{r}{b_i}\right)^2} \sum_{j=1}^N c_j r^{\ell+1} e^{-\left(\frac{r}{b_j}\right)^2} dr$$

$$\sum_j [T_{ij}^{\ell} + F_{ij}^{\ell} + V_{ij}^{\ell}] c_j = E \sum_j N_{ij}^{\ell} c_j \quad (3.1.5)$$

where N_{ij}^{ℓ} , T_{ij}^{ℓ} , F_{ij}^{ℓ} and V_{ij}^{ℓ} are analytically solved and then the norm matrix element is

$$N_{ij}^{\ell} = \int r^{2\ell+1} e^{-\left(\frac{r}{b_i}\right)^2} e^{-\left(\frac{r}{b_j}\right)^2} d^3r = \frac{(2\ell+1)!!}{2^{\ell+2}} \frac{\sqrt{\pi}}{\left(\frac{1}{b_i^2} + \frac{1}{b_j^2}\right)^{\ell+\frac{3}{2}}} \quad (3.1.6)$$

the kinetic energy matrix element; $T_{ij}^{\ell} = \int r^{\ell+1} e^{-\left(\frac{r}{b_i}\right)^2} \left(-\frac{\hbar^2}{2M} \frac{d^2}{dr^2} \right) r^{\ell+1} e^{-\left(\frac{r}{b_j}\right)^2} d^3r$ (3.1.7)

$$T_{ij}^{\ell} = -\frac{\hbar^2}{2M} N_{ij}^{\ell} \left[\frac{2(2\ell+3)}{b_j^2 \left(\frac{1}{b_i^2} + \frac{1}{b_j^2}\right)} - \frac{(4\ell+6)}{b_j^2} + \frac{2(2\ell+1) \left(\frac{1}{b_i^2} + \frac{1}{b_j^2}\right)}{(2\ell+1)} \right] \quad (3.1.8)$$

the centrifugal potential energy matrix element;

$$F_{ij}^{\ell} = \frac{\hbar^2}{2M} \int r^{\ell+1} e^{-\left(\frac{r}{b_i}\right)^2} \frac{\ell(\ell+1)}{r^2} r^{\ell+1} e^{-\left(\frac{r}{b_j}\right)^2} d^3r = \frac{\hbar^2}{2M} N_{ij}^{\ell} \frac{2\ell(\ell+1) \left(\frac{1}{b_i^2} + \frac{1}{b_j^2}\right)}{(2\ell+1)} \quad (3.1.9)$$

$$T_{ij}^{\ell} + F_{ij}^{\ell} = \frac{\hbar^2}{2M} N_{ij}^{\ell} \left[\frac{(4\ell+6)}{(b_i^2 + b_j^2)} \right] \quad (3.1.10)$$

and the potential energy matrix element is

$$V_{ij}^{\ell} = \int r^{\ell+1} e^{-\left(\frac{r}{b_i}\right)^2} V(r) r^{\ell+1} e^{-\left(\frac{r}{b_j}\right)^2} d^3r \quad (3.1.11)$$

If the potential is the phenomenological Woods-Saxon neutron-nucleus potential, the above equation cannot be analytically solved. Thus, the potential energy matrix elements is determined

numerically. The potential term include two states $j = \ell + \frac{1}{2}$ state and $j = \ell - \frac{1}{2}$ state. For $j = \ell + \frac{1}{2}$ state, the potential matrix element is

$$V_{ij}^{\ell} = \int r^{2\ell+2} e^{-\left(\frac{1}{b_i^2} + \frac{1}{b_j^2}\right)r^2} \left[-\frac{V_0}{1 + e^{\frac{r-R}{a}}} - V_{so} \left(\frac{\hbar}{m_x c} \right)^2 \left(\frac{1}{2} \ell \right) \frac{1}{ra} \frac{e^{\frac{r-R}{a}}}{\left(1 + e^{\frac{r-R}{a}} \right)^2} \right] dr \quad (3.1.12)$$

For $j = \ell - \frac{1}{2}$ state, the potential matrix element is

$$V_{ij}^{\ell} = \int r^{2\ell+2} e^{-\left(\frac{1}{b_i^2} + \frac{1}{b_j^2}\right)r^2} \left[-\frac{V_0}{1 + e^{\frac{r-R}{a}}} + V_{so} \left(\frac{\hbar}{m_x c} \right)^2 \left(\frac{1}{2} (\ell+1) \right) \frac{1}{ra} \frac{e^{\frac{r-R}{a}}}{\left(1 + e^{\frac{r-R}{a}} \right)^2} \right] dr$$

(3.1.13)

The Schrödinger equation (3.1.5) can be written as the following matrix equation form

$$\begin{aligned}
[H][C] &= E[N][C] \\
[N]^{-1}[H][C] &= E[C] \\
[A][C] &= E[C]
\end{aligned}
\tag{3.1.14}$$

which is an eigenvalue equation with $[A] = [N]^{-1}[H]$, $[N]$ is called the norm matrix and $[H]$ is the Hamiltonian matrix. By using power inverse iteration method, the eigenvalues E with corresponding eigenvectors C .

a. **Power Inverse Iteration Method**

Let an operator $\hat{B} = (A - E_0 I)^{-1}$ is introduced where E_0 is an arbitrary parameter. The function ϕ is written as $\alpha_1 y_1 + \alpha_2 y_2 + \alpha_3 y_3 + \dots + \alpha_n y_n$, where y_i 's are eigenvectors of A and α_i 's are expansions coefficients. In $A y_n = \beta_n y_n$ ($n=1,2,3,\dots$) where β_i 's are eigenvalues of A . Then ϕ is operated by $\hat{B}$,

$$\hat{B}\phi = (A - E_0 I)^{-1}(\alpha_1 y_1 + \alpha_2 y_2 + \dots) = (\beta_1 - E_0)^{-1} \alpha_1 y_1 + (\beta_2 - E_0)^{-1} \alpha_2 y_2 + \dots \tag{3.2.1}$$

Then the above equation is operated by $\hat{B}$ iteratively as follow;

$$\hat{B}^n \phi = (\beta_1 - E_0)^{-n} \alpha_1 y_1 + (\beta_2 - E_0)^{-n} \alpha_2 y_2 + (\beta_3 - E_0)^{-n} \alpha_3 y_3 + \dots \tag{3.2.2}$$

If E_0 value is the closest to an eigenvalue β_j (i.e $E_0 \approx \beta_j$), then $(\beta_j - E_0)^{-n} \gg (\beta_i - E_0)^{-n}$ where $i \neq j$ for $n \rightarrow \infty$.

$$\hat{B}^{n+1} \phi = (\beta_j - E_0)^{-n-1} \alpha_j y_j \tag{3.2.3}$$

$$\beta_j = E_0 + \frac{\hat{B}^n \phi}{\hat{B}^{n+1} \phi} \tag{3.2.4}$$

Thus the eigenvalue E which is closest to E_0 is obtained by

$$E = \beta_j = E_0 + \frac{\hat{B}^n \phi}{\hat{B}^{n+1} \phi} \tag{3.2.5}$$

The corresponding eigenvector can be written as $\hat{B}^{n+1} \phi = C^{n+1}$ and $\hat{B}^n \phi = C^n$. Therefore eigenvalue equation is

$$E = E_0 + \frac{C^n}{C^{n+1}}. \tag{3.2.6}$$

This value of E is substituted in the Schrödinger matrix equation (3.1.14).

$$[H][C^{n+1}] = [N] \left(E_0 + \frac{C^n}{C^{n+1}} \right) [C^{n+1}] \tag{3.2.7}$$

$$[H][C^{n+1}] = E_0 [N][C^{n+1}] + [N][C^n] \tag{3.2.8}$$

$$\begin{bmatrix} H_{11} - E_0 N_{11} & H_{12} - E_0 N_{12} & \dots & H_{1N} - E_0 N_{1N} \\ H_{21} - E_0 N_{21} & H_{22} - E_0 N_{22} & \dots & H_{2N} - E_0 N_{2N} \\ \vdots & \vdots & \dots & \vdots \\ H_{N1} - E_0 N_{N1} & H_{N2} - E_0 N_{N2} & \dots & H_{NN} - E_0 N_{NN} \end{bmatrix} \begin{bmatrix} c_1^{n+1} \\ c_2^{n+1} \\ \vdots \\ c_N^{n+1} \end{bmatrix} = \begin{bmatrix} N_{11} & N_{12} & \dots & N_{1N} \\ N_{21} & N_{22} & \dots & N_{2N} \\ \vdots & \vdots & \ddots & \vdots \\ N_{N1} & N_{N2} & \dots & N_{NN} \end{bmatrix} \begin{bmatrix} c_1^n \\ c_2^n \\ \vdots \\ c_N^n \end{bmatrix} \tag{3.2.9}$$

These equations are N linear equations with unknown C_i^{n+1} , where N is the number of basis and n is the number of iterations. As the first step $C_i^{(1)}$'s are given as

$$C^{(1)} = \begin{bmatrix} \frac{1}{\sqrt{N}} \\ \frac{1}{\sqrt{N}} \\ \vdots \\ \frac{1}{\sqrt{N}} \end{bmatrix} \tag{3.2.10}$$

and $C_i^{(2)}$'s are obtained from the above N linear equation. Similarly, $C^{(3)}$ are obtained after getting $C^{(2)}$. By repeating this procedure up to sufficiently large number of n , the energy eigenvalue E and the corresponding eigenvector C_i^{n+1} are obtained.

3.3 Calculation of the Physical Quantities of Nickel Isotopes

In this calculation the following normalized Gaussian wave function is used

$$U(r) = A \sum_{j=1}^N c_j r^{\ell+1} e^{-\left(\frac{r}{b_j}\right)^2}, \quad (3.3.1)$$

and the normalization constant becomes

$$A = \frac{1}{\sqrt{\sum_i \sum_j c_i^* c_j N_{ij}^{\ell}}} \quad (3.3.2)$$

After obtaining the normalization wave function, the physical quantities such as average kinetic energy, average centrifugal potential energy, average potential energy and root mean square radius are calculated. The average kinetic energy is

$$\langle \hat{T} \rangle = \int U^*(r) \hat{T} U(r) dr = A^2 \sum_i \sum_j c_i^* c_j T_{ij} \quad (3.3.4)$$

The average centrifugal potential energy,

$$\langle \hat{F}_\ell \rangle = \int U^*(r) \hat{F}_\ell U(r) dr = A^2 \sum_i \sum_j c_i^* c_j F_{ij}^{\ell} \quad (3.3.5)$$

The, average potential energy with Woods-Saxon potential is

$$\langle \hat{V} \rangle = \int U^*(r) V(r) U(r) dr = A^2 \sum_i \sum_j c_i^* c_j V_{ij} \quad (3.3.6)$$

For $j = \ell + \frac{1}{2}$ state,

$$V_{ij}^{\ell} = \int r^{2\ell+2} e^{-\left(\frac{1}{b_i^2} + \frac{1}{b_j^2}\right)r^2} \left[-\frac{V_0}{1 + e^{\frac{r-R}{a}}} - V_{so} \left(\frac{\hbar}{m_n c} \right)^2 \left(\frac{1}{2} \ell \right) \frac{1}{ra} \frac{e^{\frac{r-R}{a}}}{\left(1 + e^{\frac{r-R}{a}} \right)^2} \right] dr \quad (3.3.7)$$

For $j = \ell - \frac{1}{2}$ state,

$$V_{ij}^{\ell} = \int r^{2\ell+2} e^{-\left(\frac{1}{b_i^2} + \frac{1}{b_j^2}\right)r^2} \left[-\frac{V_0}{1 + e^{\frac{r-R}{a}}} + V_{so} \left(\frac{\hbar}{m_n c} \right)^2 \left(\frac{1}{2} (\ell+1) \right) \frac{1}{ra} \frac{e^{\frac{r-R}{a}}}{\left(1 + e^{\frac{r-R}{a}} \right)^2} \right] dr \quad (3.3.8)$$

Therefore, the average total energy is

$$\langle \hat{E} \rangle = \langle \hat{T} \rangle + \langle \hat{F} \rangle + \langle \hat{V} \rangle \quad (3.3.9)$$

Then the root-mean-square distance of neutron-nucleus is calculated as follow;

$$\langle r_{rms}^2 \rangle = \int U^*(r) r^2 U(r) dr = |A|^2 \sum_i \sum_j c_i^* c_j \frac{(2\ell+3)!!}{2^{\ell+3}} \frac{\sqrt{\pi}}{\left(\frac{1}{b_i^2} + \frac{1}{b_j^2} \right)^{\ell+\frac{5}{2}}} \quad (3.3.10)$$

The calculated value of the root-mean-square radius is derived from the neutron density distribution.

3.4 Last Neutron Separation Energies and Radius of Nickel Isotopes

The energy required to remove the last neutron from a nucleus is called the separation energy of the last neutron. If a neutron is removed from a nuclide (Z,N), a nuclide (Z,N-1) is obtained. The energy needed for removal the last neutron is the difference in binding energies between these two nuclides. The root-mean-square radius of the outermost filled neutron states are also calculated.

4. The Calculated Results

The single neutron energy levels of even-even nickel isotopes, namely ^{56}Ni , ^{58}Ni , ^{60}Ni , ^{62}Ni , ^{64}Ni and ^{68}Ni are investigated by solving one body Schrodinger equation. It is assumed that a neutron moves independently in an averaged potential well. The phenomenological Woods-Saxon neutron-nucleus potential including spin-orbit interaction, with Gaussian basis wave function is used as a trial wave function.

Some physical quantities of nickel isotopes such as single-particle energy levels,

average kinetic energy, centrifugal potential energy and potential energy, root mean square radius and neutron separation energy were also calculated. The calculated results of single-particle neutron energy levels expressed in Table (1) and Table (2) are compared with the available experimental values [1]. The calculated results for, average kinetic energy, centrifugal potential

energy, potential energy, total energy and root mean square radius are shown in Table (3). The calculated last neutron separation energy values and the root-mean square radius of the outermost filled neutron states are also expressed in Table (4) and compare with the available experimental values [2,3].

Table (1) Calculated single- particle neutron energies of $^{56}_{28}\text{Ni}$, $^{58}_{28}\text{Ni}$ and $^{60}_{28}\text{Ni}$ with experimental values

	$^{56}_{28}\text{Ni}(\text{MeV})$		$^{58}_{28}\text{Ni}(\text{MeV})$		$^{60}_{28}\text{Ni}(\text{MeV})$	
	cal	exp	cal	exp	cal	exp
$1s_{1/2}$	-42.81	-	-42.06	-	-41.36	-
$1p_{3/2}$	-34.65	-	-34.1	-	-33.56	-
$1p_{1/2}$	-32.33	-	-31.84	-	-31.39	-
$1d_{5/2}$	-25.78	-	-25.41	-	-25.07	-
$2s_{1/2}$	-21.46	-20.4	-21.16	-	-20.88	-
$1d_{3/2}$	-20.74	-19.84	-20.51	-19.83±0.06	-20.29	-
$1f_{7/2}$	-16.38	-16.65	-16.2	-15.21±0.17	-16.07	-15.16±0.22
$2p_{3/2}$	-11.35	-10.25	-11.23	-9.81±0.08	-11.12	-8.81±0.35
$1f_{5/2}$	-8.1	-9.14	-8.12	-10.55±0.15	-8.15	-9.20±0.24
$2p_{1/2}$	-8.52	-9.48	-8.45	-8.63±0.72	-8.39	-8.17±0.19
$1g_{9/2}$	-6.63	-6.55	-6.66	-	-6.7	-

Table (2) Calculated single-particle neutron energies of $^{62}_{28}\text{Ni}$, $^{64}_{28}\text{Ni}$ and $^{68}_{28}\text{Ni}$ with experimental values

	$^{62}_{28}\text{Ni}(\text{MeV})$		$^{64}_{28}\text{Ni}(\text{MeV})$		$^{68}_{28}\text{Ni}(\text{MeV})$	
	cal	exp	cal	exp	cal	exp
$1s_{1/2}$	-40.7	-	-40.09	-	-38.97	-
$1p_{3/2}$	-33.08	-	-32.63	-	-31.8	-
$1p_{1/2}$	-30.96	-	-30.57	-	-29.85	-
	$^{62}_{28}\text{Ni}(\text{MeV})$		$^{64}_{28}\text{Ni}(\text{MeV})$		$^{68}_{28}\text{Ni}(\text{MeV})$	
	cal	exp	cal	exp	cal	exp
$1d_{5/2}$	-24.76	-	-24.47	-	-23.95	-
$2s_{1/2}$	-20.63	-	-20.4	-	-19.98	-
$1d_{3/2}$	-20.1	-	-19.92	-	-19.6	-
$1f_{7/2}$	-15.94	-	-15.81	-	-15.6	-
$2p_{3/2}$	-11.03	-8.85±0.40	-10.95	-9.10±0.04	-10.81	-9.0±0.09
$1f_{5/2}$	-8.18	-8.47±0.70	-8.21	-8.72±0.60	-8.3	-8.3±0.09
$2p_{1/2}$	-8.34	-7.62±0.63	-8.3	-7.62±0.06	-8.25	-7.8±0.08
$1g_{9/2}$	-6.74	-5.42±0.26	-6.78	-5.56	-6.89	-

Table (3) The Physical Quantities of even-even nickel isotopes

Nuclide	Single-particle state	$\langle \hat{T} \rangle$ (MeV)	$\langle \hat{F} \rangle$ (MeV)	$\langle \hat{V} \rangle$ (MeV)	$\langle E \rangle$ (MeV)	$\langle \text{rms} \rangle$ (fm)
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$^{56}_{28}\text{Ni}$	s	6.87	0.00	-49.68	-42.81	2.63
	p	6.33	6.24	-47.22	-34.65	3.22
	d	6.48	12.24	-44.49	-25.77	3.7
	f	6.49	18.54	-41.42	-16.38	4.1
$^{58}_{28}\text{Ni}$	s	6.71	0.00	-48.77	-42.06	2.66
	p	6.0	6.1	-46.39	-34.09	3.26
	d	6.36	11.97	-43.74	-25.41	3.73
	f	6.38	18.16	-40.76	-16.22	4.15
$^{60}_{28}\text{Ni}$	s	6.56	0.00	-47.92	-41.36	2.69
	p	6.08	5.96	-45.6	-33.56	3.29
	d	6.25	11.72	-43.04	-25.07	3.77
	f	6.28	17.8	-40.15	-16.07	4.19
$^{62}_{28}\text{Ni}$	s	6.42	0.00	-47.11	-40.7	2.72
	p	5.96	5.83	-44.87	-33.08	3.33
	d	6.14	11.48	-42.38	-24.76	3.81
	f	6.19	17.46	-39.58	-15.94	4.22
$^{64}_{28}\text{Ni}$	s	6.28	0.00	-46.37	-40.09	2.75
	p	5.85	5.71	-44.19	-32.63	3.37
	d	6.04	11.26	-41.77	-24.47	3.85
	f	6.09	17.13	-39.04	-15.81	4.26
$^{68}_{28}\text{Ni}$	s	6.04	0.00	-45.01	-38.97	2.81
	p	5.65	5.49	-42.94	-31.8	3.43
	d	5.85	10.84	-40.64	-23.95	3.92
	f	5.93	16.53	-38.06	-15.6	4.34

Table (4) The last neutron energies and root-mean square distances of even-even nickel isotopes with experimental values

Nuclide	Last neutron state	Last neutron energy (MeV) (cal)	Last neutron separation energy (MeV) (exp)	$\langle \text{rms} \rangle$ (fm) (cal)	$\langle \text{rms} \rangle$ (fm) (exp)
$^{56}_{28}\text{Ni}$	1f _{7/2}	-16.38	-	4.11	-
$^{58}_{28}\text{Ni}$	2p _{3/2}	-11.23	-12.22	4.21	3.76±0.002
$^{60}_{28}\text{Ni}$	2p _{3/2}	-11.12	-11.39	4.24	3.82±0.0016
$^{62}_{28}\text{Ni}$	2p _{1/2}	-8.34	-10.6	4.35	3.84±0.0019
$^{64}_{28}\text{Ni}$	1f _{5/2}	-8.2	-9.06	4.14	3.86±0.0023
$^{68}_{28}\text{Ni}$	2p _{1/2}	-8.25	-7.8	4.5	-

5. Discussion

From the results of Table (1) and Table (2), it can be summarized the following facts. For ^{56}Ni , N=28, the neutrons are filled up until 1f_{7/2} level. In this level, the calculated value is comparable with the experimental value. The level ordering of calculated energy levels are also agree with the experimental levels.

For ^{58}Ni , N = 30, the neutrons are filled until 2p_{3/2} level. In this level, the calculated value is significantly differ from the experimentally observed value. It is found that the calculated level of 1f_{5/2} lies over the 2p_{1/2} and 2p_{3/2} levels.

For ^{60}Ni , N = 32, the neutrons are filled up until 2p_{3/2} level. In this level, the calculated

value is significantly differ from the experimentally observed value. It is also found that $1f_{5/2}$ lies above the $2p_{1/2}$ and $2p_{3/2}$ levels.

For ^{62}Ni , $N = 34$, the neutrons are filled up until $2p_{1/2}$ level. In this level, the calculated value is comparable with the experimental value. It can be seen that $1f_{5/2}$ level lies above the $2p_{1/2}$ level.

For ^{64}Ni , $N = 36$, the neutrons are filled up until $1f_{5/2}$ level. In this level, the calculated value is comparable with the experimental value. In the filled region, it is found that $1f_{5/2}$ level lies above the $2p_{1/2}$ level.

For ^{68}Ni , $N = 40$, the neutrons are filled up until $2p_{1/2}$ level. For $1f_{5/2}$ and $2p_{1/2}$ subshells, the calculated energy values give in good agreement with the experimental values. The level ordering of calculated energy levels are also agree with the experimental level.

There can be noticed from Table (3) that the increasing of the neutron numbers of the successive isotopes leads to a gradually increasing of the root-mean-square values. The calculated results in Table (4) show that although the results of the root mean square values are comparable with the experiment values, the neutron separation energy values are not exactly agree with the experimental results. Therefore, in nickel isotopes, the larger the number of neutrons in nuclei is the smaller of the neutron separation energy of nuclei.

The discrepancy between theoretical and experimental results may be due to the factors such as the effect of the paring energy of two-nucleon interaction, core excitations and admixtures of single-particle states are not included. Since nuclear structure is more complicated it is not possible to describe it with a sample phenomenological Wood-Saxon potential. It may be improved by including above factors as perturbation in potential.

Acknowledgements

I would like to express my sincere thanks to Dr Aung Win (Rector), University of Technology (Yatanarpon Cyber City) for his encouragement. I am also grateful to Prof. Dr Su Su Thein, Head of Department of Engineering Physics, University of Technology (Yatanarpon Cyber City), for her kind permission to perform this research.

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PHY 015

Elastic scattering of protons with stable and exotic lithium isotopes

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Abstract

The differential cross section of stable lithium isotopes (${}^6,{}^7\text{Li}$) have been calculated by using Eikonal theory for proton scattering in wide energy region (30-204MeV). The optical potential of lithium is given by a folding integral of nucleon nucleon transition amplitude and density profile of it. Density distributions of lithium isotopes are obtained from harmonic well nuclear matter density which is suitable for light nucleus. The calculated cross sections of proton lithium scattering are good agreement with experimental value. For exotic lithium isotopes, the parameterized form of nucleon nucleon transition amplitude is used to fit the experimental data. The differential cross sections also calculated in the frame work of Eikonal theory are used in determining the free parameters of Harmonic oscillator. By using free density parameters the charge and matter radii of ${}^{11}\text{Li}$ are deduced.

Keywords: Eikonal theory, Optical potential, Harmonic oscillator

1. Introduction

The scattering of particles from nuclei has provided invaluable information on charge, matter densities distribution and root-mean-square radius of stable nuclei on and near the stability line. So many theoretical and experimental data of stable nuclei are available in literature. There are about 286 stable nuclei found in nature. Scientist estimate that 6500 nuclei can exist in the universe. Only about 2000 nuclei have been studied and synthesized now. However there is very little information about the unstable and exotic nuclei. Heavier element are much rare than lighter ones which means that the light elements are more stable than heavy ones. In light nuclei the mass number A is roughly double the atomic number Z but the heavy nuclei have higher mass number which is more than double the atomic number. It is observed that nuclei which possess magic number of both proton and neutron are highest stability. Nuclei having either the number of proton or number of neutron belong to magic number (2, 8, 20, 50, 82, 126) are high stability as compared to their neighbors. Similarly nuclei with semi magic number (14, 28, 40) are slightly less stable but more stable than the rest. The stability conditions of nuclei are shown in table 1 and figure 1(a) and (b). Recent development of radioactive isotope beam techniques has opened a

new field for the study of exotic or unstable nuclei far from the stability line. As a result, our knowledge of nuclear physics has been extended from stable nuclei to unstable nuclei. Experiments with radioactive isotope beams have already shown that the properties of unstable nuclei are quite different from those of stable one. Their lifetimes, masses or sizes are often unknown, their modes of radioactive decay have seldom been identified and information on their excited levels is very limited or nonexistent. It contains more neutrons than a stable isotope of the same element. Nowadays, the exploration of exotic, short-lived nuclei having large neutron-to-proton imbalance has demonstrated that the ideas of nuclear properties are in fact not completely correct. For example, the size of the orbits of weakly bound neutrons in the lithium isotope (${}^{11}\text{Li}$) is comparable with the size of a lead nucleus ${}^{208}\text{Pb}$. This points out that the generally accepted size of a nucleus depends only on the total number of neutrons and protons are not always valid. Unstable nuclei are useful objects in nuclear physics in order to obtain the information such as halo structure, magic number, nuclear matter properties and many other things which is very different from stable nuclei.

Table 1. Stability Conditions

Protons	Neutrons	Stability
Odd	Odd	Least stable
Odd	Even	Less stable
Even	Odd	More stable
Even	Even	Most stable
Magic No	Magic	Most stable

2. Theory

Figure 1(a) Stable nuclei: proton and neutrons homogeneously mixed, no decoupling of proton and neutron distributions

Figure 1(b) Unstable nuclei: decoupling of proton and neutron distributions such as neutron halos and neutron skins

The eikonal scattering amplitude is used to calculate the differential cross section and is express as follow,

$$f_E = \frac{k}{2\pi i} \int d^2\vec{b} e^{i(\Delta \cdot \vec{b})} [\exp\{i\chi(k, b)\} - 1] \quad (1)$$

where, eikonal phase shift function is

$$\chi(k, \vec{b}) = -\frac{1}{2k} \int_{-\infty}^{+\infty} U(\vec{b}, z) dz \quad (2)$$

where, the impact parameter $d^2\vec{b} = b db d\phi$ for cylindrical coordinate system

$$f_E = \frac{k}{2\pi i} \int_0^\infty b db \int_0^{2\pi} d\phi e^{i(\Delta \cdot b \cos(\phi))} [\exp\{i\chi(k, b)\} - 1] \quad (3)$$

The ordinary Bessel Function J_0 is given by

$$J_0(x) = \frac{1}{2\pi} \int_0^{2\pi} d\phi e^{ix \cos \phi} \quad (4)$$

$$f_E = \frac{k}{i} \int_0^\infty b db J_0(\Delta \cdot b) [\exp\{i\chi(k, b)\} - 1] \quad (5)$$

where, b is the impact parameter, k is the relative momentum of the projectile-target system in the center of mass (CM) frame. The differential cross section is given by

$$\frac{d\sigma}{d\Omega} = |f(\theta)|^2 \quad (6)$$

Differential cross sections are function of eikonal phase function which depends on the optical potential, as shown in equation (2). For Nucleus-Nucleus (AA) scattering, the optical potential can be expressed as

$$U(q) = A_p A_T t_{NN}(\vec{q}) \rho_p(\vec{q}) \rho_T(\vec{q}) \quad (7)$$

Where, A is the number of nucleon, p is projectile, T represent the target, t_{NN} is NN transition amplitude and ρ_T and ρ_p are nuclear matter density of target and projectile.

the harmonic-well nuclear matters density is given by

$$\rho_A(q) = \rho_0 \pi^{3/2} a^3 \left[\left(1 + \frac{3\gamma}{2} - \frac{3\gamma a^2}{4} q^2 \right) \right] e^{(q^2 - s^2)}$$

The central part of NN transition amplitude is given by [5]

$$\frac{B(e)q^2}{2} \quad (8)$$

The spin dependent parts of NN transition amplitude is given by [8]

$$t^s(q) = \frac{ik_0 \theta}{4\pi} [i - i\alpha] (q^2 / 4M^2)^{\frac{1}{2}} e^{-B(e)q^2}$$

where, $\hbar$ is Planck's constant, μ is the reduced mass of the NN system, k is the relative momentum in, e is the kinetic energy of two nucleon center of momentum system, $B(e)$ is the slope parameter of pp (pn) elastic scattering cross section, $\sigma(e)$ is the pp (pn) total cross section and $\kappa(e)$ is the real to imaginary ratio of the pp(nn) cross section. The input parameters of NN transition amplitude are displayed in table (2).

3. Results and discussion

Table 2(a). Input parameters for central part of NN transition amplitude [2]

E(MeV)	σ (mb)	κ	B (fm ²)
30	19.6	0.87	0.685
50	10.4	0.94	0.390
65	9.15	1.173	0.376

Table 2(b). Input parameters for spin dependent part of NN transition amplitude [8]

Energy (MeV)	σ_{pp} (fm ²)	σ_{nn} (fm ²)	σ_{pn}	α_{nn}	β_{pp} (fm ²)	β_{nn} (fm ²)	θ (fm ²)	α_e	B_e
62	3.1	10.5	1.73	0.950	0.305	0.406	-3.45	-4.4	0.35

The differential cross section of proton lithium isotopes scattering are calculated with wide incident energies (30MeV- 204 MeV). The harmonic well nuclear matter density parameter which is used in equation (7) are $\gamma = 0.258$, $a = 1.67$ for ${}^6\text{Li}$ and $\gamma = 0.327$ and $a = 1.77$ for ${}^7\text{Li}$. In the calculation of differential cross section for proton ${}^6\text{Li}$ lithium scattering, we assumed that proton density and neutron density are the same inside the nucleus. However, in the exotic nuclei such as ${}^{11}\text{Li}$, we take into account different value between nucleon densities. Moreover, the energy dependent parameters of NN transition amplitude are also considered different value between stable and unstable nuclei. The calculated results are shown in figure 2,3 for ${}^6\text{Li}$ and figure 4 for ${}^7\text{Li}$. It is found that the calculated cross section of both

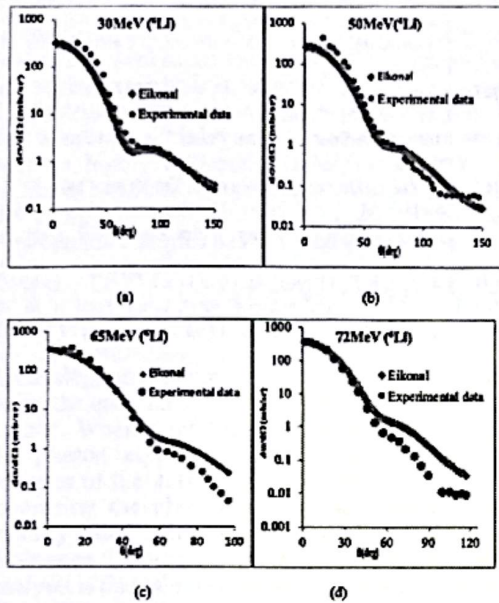


Figure 2. The differential cross section of proton lithium (${}^6\text{Li}$) scattering with a projectile energy in the laboratory frame of 30MeV(a), 50MeV(b), 65MeV(c) and 72MeV(d). The experimental data are taken from ref [4].

proton ${}^6\text{Li}$ and ${}^7\text{Li}$ scattering with low incident energy (below 72 MeV) disagree with experimental data. Above 72 MeV the calculated results are good agreement with experimental value up to scattering angle of 60 degree. In the fitting procedure, we found that the differential cross section of P - ${}^{11}\text{Li}$ scattering decrease with increasing strength parameter and the diffuseness parameter is small dominant to the differential cross section. The parameter of harmonic well nuclear density are obtained to be $\gamma = 1.57$ and $a = 3.95$ by fitting the experimental differential cross section of proton lithium ${}^{11}\text{Li}$. The charge and matter radius of ${}^{11}\text{Li}$ has been calculated using harmonic well density which is fitted from the experimental values and is obtained to be 5.86 fm and 5.66 fm.

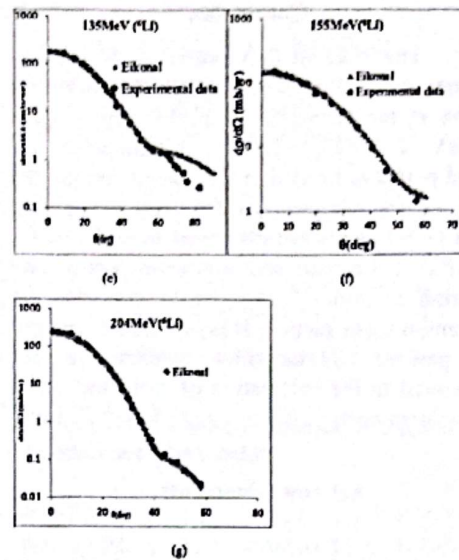


Figure 3. The differential cross section of proton lithium (${}^7\text{Li}$) scattering with a projectile energy in the laboratory frame of 135MeV (e), 155MeV (f) and 204 MeV(g). The experimental data are taken from ref [4].

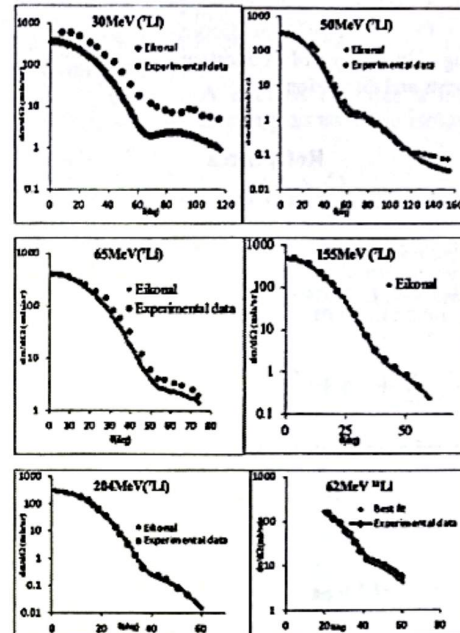


Figure 4. The differential cross section of Proton - ${}^7\text{Li}$ scattering at different incident energy, and the result obtained from fitting experimental differential cross section at 62MeV. The experimental data are taken from ref [4].

4. Conclusion

The Eikonal approximation is used to calculate the elastic scattering of proton from ${}^{6,7}\text{Li}$ isotope at the range of incident energy region (30MeV-204MeV). The input parameters for optical potential needed in the calculation are the NN transition amplitude and density distribution in the target nuclei are displayed in table 2(a,b). Both the central part and spin orbit part of NN transition amplitude are used to compute the differential cross section. It is found that the spin orbit part of NN transition amplitude is not contributed in the calculation of cross section at low incident energy. According to figure 2, 3 and

4, the calculated cross section of proton lithium scattering are not agreement with experimental data below 65 MeV but from 65 MeV to 72 MeV it gives satisfactory explanation of the data up to only small scattering angles. Beyond 72 MeV the calculated cross sections for P - Li scattering are good agreement with experimental data until the scattering angle of 60 degree. This provided that the Eikonal approximation can be used in high energy scattering but cannot predicted for large angle scattering. The strength and diffuseness parameters of density profile are obtained to be larger than those for the stable nuclei. This shows that it has extended neutron distribution of lithium ${}^{11}\text{Li}$ and provided the halo structure.

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PHY 016

Calculation of Half-Life of Manganese by Using NAA Method

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Abstract

The natural manganese has 33 isotopes, but only one stable isotope, ^{55}Mn (99%). The three possible neutron-induced nuclear reactions for manganese are $^{55}\text{Mn}(n,2n)^{54}\text{Mn}$, $^{54}\text{Mn}(n,\gamma)^{55}\text{Mn}$ ($T_{1/2} = 312$ days), and $^{55}\text{Mn}(n,\gamma)^{56}\text{Mn}$ ($T_{1/2} = 2.576$ hrs). The sample was irradiated with neutrons emitted from the Am-Be isotopic neutron source (average energy $\sim 3\text{MeV}$). A wax moderator was used to thermalize neutrons. The half-life of neutron-irradiated sample was determined by plotting the activities of the sample and cooling time by using MS excel and calculating the equation $T_{1/2} = \ln 2/\lambda$. Since, the calculated value of half-life of the sample is 2.557 hours; its reference value from Table of Isotope is 2.576 hours, the discrepancy is 0.74%. It stands within 99 percent confidence level.

Keywords: Half-life, NAA method, HPGe detector, Isotopic Neutron Source method, reactor neutron sources, and gamma rays detection are given below.

Introduction

Activation analysis achieves a qualitative and quantitative analysis of an unknown sample by irradiating the sample and thus producing radioactive nuclides from stable or unstable isotopes present in the sample. The basic principle of activation analysis is not new. It was applied for the first time in 1936 by Hevesy and Levi found that samples containing certain rare earth elements become highly radioactive after exposure to a source of neutrons. When an atom emits a photon, the energy of the photon equals the difference between the energies of the initial and final states. By measuring photon energies it is possible to infer the chemical nature of the emitting atoms. Spectroscopic analysis exploits this principle.

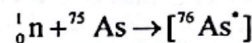
An analogous situation exist which nuclei. Like an atom, the quantized energy states of an nucleus are unique. When a nucleus emits photon energy of the photon equals the difference between the energies of the initial and final number states. By measuring the photon energies it is possible to identify the emitting nuclei. The primary difference between the atomic and nuclear analysis is one of energy scale, photons emitted by atoms have energies in the electron volt range. Photons emitted by atoms have energies in the electron in the MeV range. This places the nuclear photons on the gamma region of the electromagnetic spectrum.

Neutron activation analysis is a sensitive analytical technique useful for performing both qualitative and quantitative multi-element analysis of major, minor and trace elements on samples from almost every conceivable field of scientific or technical interest. For many elements and applications, NAA offers sensitivities that are superior to those attainable by other methods, on the order of parts per billion or better. In addition, because of its accuracy and reliability, NAA is generally recognized as the "referee method" of choice when new procedures are being developed or when other methods yield results that do not agree.

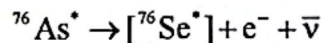
The basic essential required to carry out an analysis of samples by NAA are a source of neutrons, instrumentation suitable for detecting gamma rays, and a detailed knowledge of the reactions that occur when neutrons interact with target nuclei. Brief descriptions of the NAA

Neutron activation analysis takes advantage of the unique relation between photon energy and the emitting nucleus. Neutron activation means that nuclei have been made radioactive by bombardment with neutrons. Analysis refers to the measurement of the energies of the gamma photons released in the radioactive decay process. There are three steps involved in neutron activation analysis.

- (i) A nucleus captures a neutron, forming an unstable isotope.



- (ii) The unstable isotope undergoes beta decay, producing a product nucleus in an excite state.



- (iii) The excited state decays by gamma photon emission. ${}^{76}\text{Se}^* \rightarrow {}^{76}\text{Se} + \gamma$

Materials and Methods**Sample Preparation and Irradiation**

In this experiment, the manganese powder was weighed by digital balance five times and shown in Table (1). The average weight of manganese powder is 5.0005g. Firstly, the was sample put in the small plastic bag and arranged to activate with Am-Be isotopic neutron source in Nuclear Laboratory of Physics Department, Mandalay University. The activity of Am-Be source is 550 mCi. The average neutron energy of the source is about 3 MeV. Irradiation time for the samples is about 72 hour. To activate with thermal neutrons the sample was placed in wax moderator. After irradiation, the gamma ray spectra of the radioactive manganese sample was detected and analyzed by HPGe gamma detector and Gamma Vision 32 Software.

Wax Moderator

Neutrons produced from the isotopic neutron source have broad energy range (1 to 10 MeV)

with the average value around 1-3 MeV. The most preferable nuclear reaction usually occurs by low energy neutron so called "Thermal Neutron" with the energy of 0.025 eV. The energy of neutron produced moderated by colliding with this moderator just like the one billiard ball hit the other ball, the speed of the first ball will slow down. The efficiency to moderate depends on mass of the moderator. In practice, the several research reactors use light water, heavy water, paraffin or hydrogen containing compound as moderator for neutron in nuclear reactor.

In this research, to slow down fast neutrons from the source moderator was required. Therefore, the moderator made by using wax in the form of cylindrical, diameter of 70 cm and 25 cm in height. The centre of core with 6 cm was placed Am-Be isotopic neutron source. The holes made 3.5 cm, 4.5cm, 5.5cm, 6.5cm, 11.5cm etc., from the centre respectively. Each hole was depth by 15 cm. The block diagram of moderator was as shown in Figure (1) and (2).

Experimental Set-Up for Gamma Emission Measurement

In this experiment, the measurement of radioactive manganese sample was made with a gamma-ray spectrometry system. The system consists of HPGe detector ORTEC (model GMX10P4-70-RB-SMN), cooler (model CFG-X-COOL-III-230), preamplifier (model A257N), fast spectroscopy amplifier ORTEC (model-671), high voltage power supply, photomultiplier tube, digital signal processor (DESPEC-LF), a 16k pulse stored Multi-Channel Analyzer together with Gamma Vision-32 software installed in pc and data readout devices. The operation voltage for HPGe detector is negative 1500V dc. The experimental setup of HPGe detection system is as shown in Figure (3). **Energy Calibration**

The energy of radioactive elements in soil samples were unknown. The standard radioactive sources of known energies were used to calibrate the spectrometer. Seven standard sources such as, 14 different energies including all ranges of energy low, medium and high, ^{133}Ba (81 keV, 276.34 keV, 302.85keV, 356.02 keV, 384.85 keV), ^{57}Co (122.06 keV and 136.46 keV), ^{137}Cs (661.66 keV), ^{54}Mn (834.85 keV), ^{22}Na (511 keV and 1274.53 keV), ^{65}Zn (511 keV, 1115.55 keV) and ^{60}Co (1173.24 keV and 1332.50 keV) were used for 10800 seconds placing at 5 cm above the detector cap. The data are as shown in Table (2) and the energy calibration curve is as shown in Figure (4). Establishing a direct relationship between photo peak energy and channel number could do the energy calibration process.

Measurement of samples

Before making the measurement on the samples, energy calibration first made for 600 s by using standard gamma sources. And then background counting was measured for duration of 1800 seconds without sources. Firstly, the sample was irradiated with Am-Be source in the wax moderator about 72 hours. After the irradiation, the sample was measured with various cooling

time placing 3.5 cm from the core. When measuring, the sample was placed on the HPGe detector cap. To calculate the half-life of manganese, the measurement of the sample to examine for activity then carried out. Then the counts as obtained from the spectrum that appear on Multichannel analyzer were analyzed by using Gamma Vision 32 Software. The decay constant (λ) of the sample was obtained by plotting the analyzed data vs cooling time of the sample in MS excel. And then using the following equation, the half-life value was calculated.

$$T_{1/2} = \ln 2 / \lambda$$

(1)

Table (1) Average weight of manganese powder by using digital balance

Sr.no	Weight of manganese sample(g)	Average weight (g)
1	5.0006	5.0005
2	5.0004	
3	5.0007	
4	5.0004	
5	5.0005	

Table (2) Energy calibration data of HPGe detector

Sr. No	Channel	Energy (keV)
1	427.99	81.00
2	644.79	122.06
3	720.81	136.46
4	1460.42	276.34
5	1600.24	302.85
6	1881.39	356.02
7	2028.82	383.85
8	2701.89	511.00
9	3498.53	661.66
10	4414.31	834.85
11	5898.91	1115.55
12	6203.97	1173.24
13	6739.71	1274.53
14	7046.13	1332.50

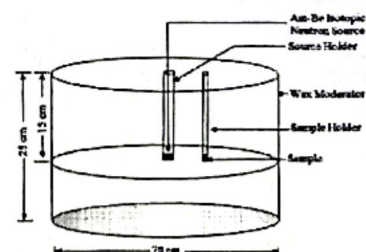


Figure (1) The diagram of moderator (side view).

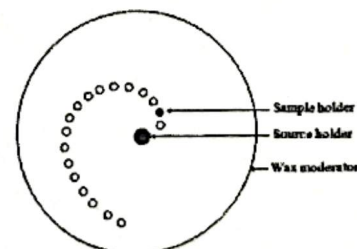


Figure (2) The diagram of moderator (top view)

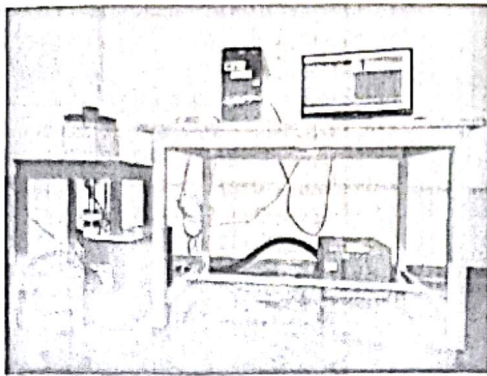


Figure (3) Experimental Setup of HPGe Detection System.

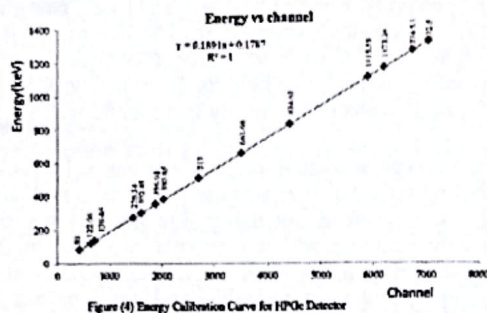


Figure (4) Energy Calibration Curve for HPGe Detector

Results

The natural manganese has 33 isotopes but only one stable isotope, ^{55}Mn . The isotopic abundance of ^{55}Mn is 99%. The possible reactions for stable manganese with neutron absorption are,

- (i) $^{55}\text{Mn}(n,2n)^{54}\text{Mn} \rightarrow ^{55}\text{Mn} + ^1_0\text{n} \rightarrow [^{54}_{25}\text{Mn}] + 2(^1_0\text{n})$
 $[^{54}_{25}\text{Mn}] \rightarrow ^{54}_{24}\text{Cr} + ^0_{-1}\text{e} + \gamma$
 $(E_\gamma = 840.0\text{keV}, E_\alpha = 40\text{MeV}, T_{1/2} = 291\text{days})$
- (ii) $^{54}\text{Mn}(n,\gamma)^{55}\text{Mn} \rightarrow ^{54}\text{Mn} + ^1_0\text{n} \rightarrow [^{55}_{25}\text{Mn}]$
 $[^{55}_{25}\text{Mn}] \rightarrow ^{55}_{24}\text{Mn} + ^0_{-1}\text{e} + \gamma$
 $(E_\gamma = 835.85\text{keV}, T_{1/2} = 312\text{days})$
- (iii) $^{55}\text{Mn}(n,\gamma)^{56}\text{Mn} \rightarrow ^{55}\text{Mn} + ^1_0\text{n} \rightarrow [^{56}_{25}\text{Mn}]$
 $[^{56}_{25}\text{Mn}] \rightarrow ^{56}_{24}\text{Fe} + ^0_{-1}\text{e} + \gamma$
 $(E_\gamma = 847\text{keV}, 1811\text{keV and } 2110\text{keV}, T_{1/2} = 2.57\text{hours})$

The reaction $^{55}\text{Mn}(n,2n)^{54}\text{Mn}$ is needed threshold energy, 40 MeV to 60 MeV. The neutrons produced from the Am-Be source have the energies ranging from 2MeV to 10MeV. The average energy of the isotopic source is only 3-4 MeV. Since the threshold energy of $^{55}\text{Mn}(n,2n)^{54}\text{Mn}$ reactions are higher than the maximum energy of neutrons can get from the Am-Be source, therefore the first reaction is energetically impossible to take place. The second reaction has half-life 312 days, to get saturation we will irradiate nearly for four years, it also can't perform within limited time. So the second reaction can not use in this research. Thus to calculate half-life of manganese decided to be used third reaction. The background spectrum of the HPGe gamma detector was measured before irradiated sample measurement and it was shown is Figure (5).

To investigate the third reaction, $^{55}\text{Mn}(n,\gamma)^{56}\text{Mn}$ yields 847 keV, 1811 keV and 2110 keV gamma emissions which have half-life of 2.57 hours. This reaction can occur only with thermal neutron. Therefore, the manganese sample was placed in the wax moderator with position of 3.5cm from the core for 72 hours. After the irradiation, the sample was measured by using HPGe gamma detector. The energy spectrum was shown in Figure (6). The spectra were analyzed by Gamma Vision 32 Software. By using these spectra analyzed data, the variation of net area counts and cooling time were plotted in MS excel. The decay constants (λ) was obtained from the graph. These measured data were shown in Table (1). The value of decay constants come out from plotting activities vs cooling time using MS excel and half-life values of each energy using Equation (1) are shown in Table (2).

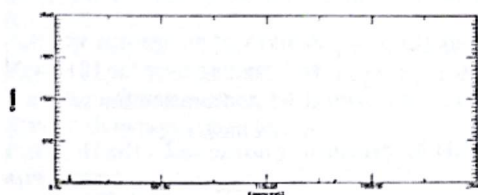


Figure (5) Background Spectrum for counting time 1800s.

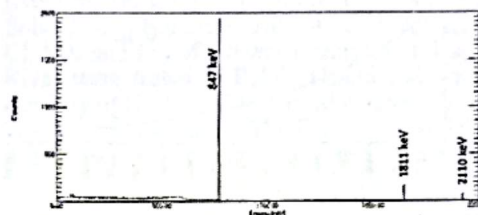


Figure (6) Energy Spectrum for Mn (irradiation time is 72 hour and counting time is 1800s).

Table (3) Measured data of activity and cooling time for Manganese

No.	Cooling Time (t)	Activity(Counts)		
		847 keV	1811 keV	2110 keV
1	1928	20506 ± 133	2268 ± 56	636 ± 41
2	5545	12292 ± 116	1308 ± 43	354 ± 30
3	9333	8589 ± 98	974 ± 38	312 ± 27
4	11466	6794 ± 86	732 ± 31	184 ± 22
5	19863	4353 ± 69	483 ± 28	147 ± 17
6	25612	3088 ± 60	339 ± 22	124 ± 15
7	31902	2134 ± 48	237 ± 18	36 ± 12
8	33733	1296 ± 39	138 ± 15	32 ± 10

Table (4) The value of decay constant and half-life for all energies

No.	Energy (keV)	Decay constant (λ)	Half-life (hours)	TOI Reference (hours)	Discrepancy (%)
1	847	0.0000753	2.557	2.576	0.74
2	1811	0.0000753	2.557		0.74
3	2110	0.0000864	2.276		11.65

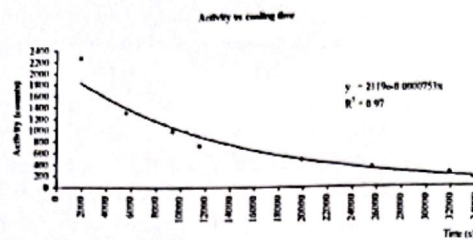


Figure (7) Activity of manganese varies with cooling time for 847 keV at 3.5cm from neutron source in wax moderator.

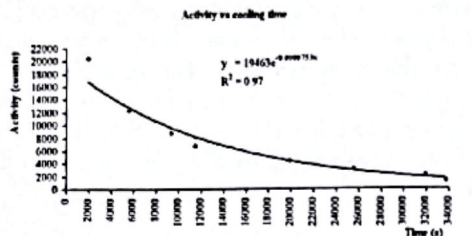


Figure (8) Activity of manganese varies with cooling time for 1811 keV at 3.5cm from neutron source in wax moderator.

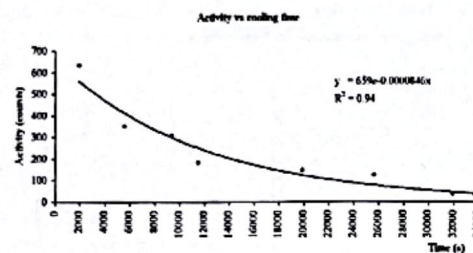


Figure (9) Activity of manganese varies with cooling time for 2110 keV at 3.5cm from neutron source in wax moderator.

Discussions

The $^{55}\text{Mn}(n, 2n)^{54}\text{Mn}$ reaction need 40 MeV to 60 MeV threshold energy. The average energy of that isotopic source is 3-4 MeV. The threshold energy of reaction is greater than the average neutron energy of the source. Therefore, $^{55}\text{Mn}(n, 2n)^{54}\text{Mn}$ reaction is impossible by using Am-Be isotopic neutron source.

The second reaction of manganese, $^{55}\text{Mn}(n, \gamma)^{56}\text{Mn}$ gives half-life 312 days. To be used this reaction, will need at least four years of activation time to get saturation. It is impossible within the limited time period, one year, to perform this research.

The third reaction, $^{55}\text{Mn}(n, \gamma)^{56}\text{Mn}$ gives half-life 2.576 hours is possible with the Am-Be neutron source because they do not need threshold energy and activation time is only a few days. There are three possible energies, 847 keV, 1811 keV and 2110 keV, give from $^{55}\text{Mn}(n, \gamma)^{56}\text{Mn}$ reaction. All have the same half-life but different in gamma emission probability. They are 99% for 847 keV, 29% for 1811 keV and 19% for 2110 keV. It

determined how distinct the photo peak. It is clearly seen in Figure (6), 847 keV photo peak is more distinct than other photo peaks, 1811 keV and 2110 keV. Moreover it is effected how half-life measuring is accurate. From the calculated data, half-life measuring of 847 keV and 1811 keV is very close to the reference value from the Table of Isotope. But for 2110 keV, the half-life value is very far from the reference value from the Table of Isotope. It is due to the fact that gamma emission probability of 2110 keV is very small.

Conclusion

Therefore the calculated half-life value is far from reference point compare with other two energies. According to the Table (4), works out half-life value for all energies are 2.557 hours for 847 keV and 1811 keV and 2.276 hours for 2110 keV, respectively. For 847 keV and 1811 keV energies, the discrepancy values are 0.74%, that means it is lie within the over 95 percent confident limit, meanwhile for 2110 keV its discrepancy is 11.65 %, that means its reliability is under 90%.

Whenever activated on any elements by using NAA method give exact gamma energies and half-lives. Therefore, by using this method we can easily estimate which elements compose in the unknown sample. Thus we can conclude that if sample was very valuable and can't permit to deform, this method becomes very important because properties of this method is non-destructive and only need very little amount of sample, a few microgram, to operate. Moreover it is so sensitive that it can determine traces of elements undetectable by chemical methods.

Acknowledgement

The authors would like to thank Dr Thida Win, Rector, University of Mandalay, for her encouragement. The authors also would like to acknowledge to Professor Dr Lei Lei Win, Head of Department of Physics, University of Mandalay, for her valuable advice and permission.

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Water Chemical Analysis of Taiping River beside Agricultural Farms near Banmaw University

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Abstract

This study was carried out to give the environmental awareness to the residents. River water is commonly used for drinking, bathing, cleaning and cooking purposes. Two water samples at one site (the bank) from Taiping River located adjacent to agricultural farms near Banmaw University, Banmaw Township, Kachin State, Myanmar was examined at Public Health Laboratory, Mandalay, Myanmar to assess the water quality parameters for twelve water quality posts of measurement during the dry season (January) and wet season (July) in 2019. The results are compared with the World Health Organization (WHO) standard values to identify the existence of contaminants above the acceptable levels. The water chemical analysis reports are chemically potable. Taiping River is very suitable for agricultural irrigation and livestock.

Keywords: Taiping River, water quality

Introduction

Water is essential to sustain life, and a satisfactory supply must be available to all. Access to safe water is important as health and development issues at the national, regional and local level. Water is used at homes for consumption such as drinking, cooking, bathing and cleaning. The important way to access to water is either through a municipal water supply from a major city or through wells and water sources. In this research, the water quality of Taiping River beside agricultural farms near Banmaw University in January and July of 2019 was tested for chemical contamination in Public Health laboratory, Mandalay, Myanmar. The main focus of this research is to investigate the water quality of Taiping River at one site located adjacent to agricultural farms near Banmaw University in Banmaw, Myanmar.

Chemical testing of water quality relies on the comparison of the results with WHO drinking water guidelines to identify contaminants. Most of these contaminants are only of concern with chronic exposure (long-term exposure). Some contaminants that occur in water are the matter of concern because of effects arising from acute exposure (short-term exposure). Sewage, garbage and liquid waste of households, agricultural lands and factories are discharged into lakes and rivers. Early types of water pollution were usually due to contamination from human and animal waste, which caused major outbreaks of diseases like cholera. Other hazards may arise intermittently, often associated with seasonal conditions or fluctuations. The toxic elements effect on human health including organs, damage respiratory tract disorder, lung diseases, skin diseases and other illnesses.

Materials and Methods

Description of Research Area

Taiping River, originating in China runs from East to West of Myanmar. It meets Irrawaddy River at Banmaw Township, which flows from North to South of Myanmar. The research area is beside the agricultural farms and situated in Namphar Quarter along Road to Banmaw University, Banmaw, Kachin State, Myanmar.

Sample Location (Sampling Site) and Collection

Sampling site is at approximately 24° 18' 23" north latitude and 97° 15' 14" east longitudes. The sample location is beside kitchen market near white iron bridge along the road to Banmaw University. The sampling site is in Namphar Quarter. Another side of white iron bridge is Namphar Inn. The water in the Namphar Inn flows

into the Taiping River under the white iron bridge. Taiping River beside agricultural farms in Namphar Quarter near Banmaw University is shown in Figure (1). The water sample was collected with one litre bottle each in two times at one site. They were collected first time in 3 January and second time in 13 July 2019 at the same site. Collecting the water sample in Taiping River beside agricultural farms in Namphar Quarter near Banmaw University is shown in Figure (2). Location Map of Taiping River in Namphar Quarter Banmaw Township, Kachin State is shown in Figure (3).

Public Health Laboratory, Ministry of Health and Sports

The twelve water quality parameters (Appearance, Colour, Turbidity, pH value, Total Solids, Total Hardness, Total Alkalinity, Ca, Mg, Cl, SO₄ and Fe) of the water samples of Taiping River were tested at Public Health Laboratory, Ministry of Health and Sports, Mandalay District, Myanmar in two times. The first time was during the dry season (January 2019) and second time was during the wet season (July 2019).

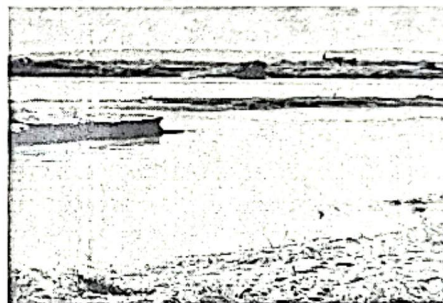


Figure (1) Taiping River beside agricultural farms in Namphar Quarter near Banmaw University



Figure (2) Collecting the water sample in Taiping River beside agricultural farms in Namphar Quarter near Banmaw University

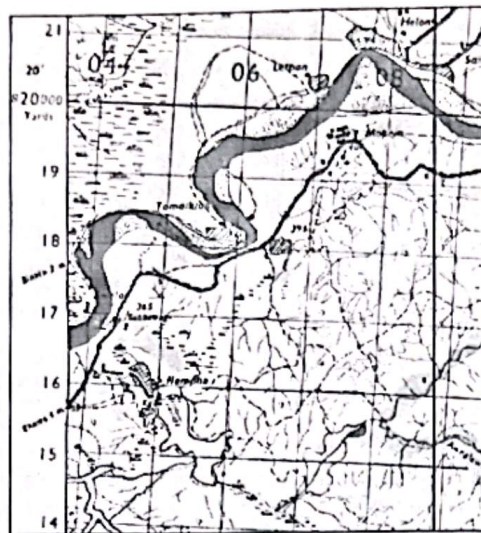


Figure (3) Location Map of Taiping River in Namphar Quarter, Banmaw Township, Kachin State

Results and Discussions

In the research work, the water samples from Taiping River in Namphar Quarter near Banmaw University, Banmaw Township was collected and analyzed in two times after four days in Public Health Laboratory, ministry of Health and Sports. The chemical analysis of the two water samples at one site in Taping River is listed in Table (1).

According to the results, the appearance is clear. Colour, Total Solids, Total Hardness (as CaCO_3), Total Alkalinity (as CaCO_3), Calcium Ca, Magnesium Mg, Chloride Cl and Sulphate SO_4 are under the maximum permissible level in both times. Turbidity is not detectable. PH value is within the standard level. Total iron as Fe was not found. Appearance, Colour, Total Alkalinity (as CaCO_3), Magnesium Mg and Chloride Cl are the same in both results. Therefore, the two remarks of water chemical analysis reports are both chemically potable. The time duration between collecting samples and analyzing them at laboratory in both times is four days. The water from Taiping River in this area are now used for taking bath, washing clothes, agricultural farms and livestock. It is not used for drinking purpose now.

Conclusion

The present research work is carried out to give the environmental awareness to the residents. The results of water samples indicate that water parameter values are safe. The contamination stress of Taiping River was still low at that time when the stress decreases in monsoon period because the volume of water increases and flow rate of water is fast. Water treatment will be needed to describe those processes used to make water more acceptable for a desired end-use. These can use as drinking water, industrial processes, medical and many other uses. The goal of all water treatment process is to remove existing

contaminants in water. This river is favorable to

Table (1) Chemical Analysis of the two water samples at one site in Taping River

No.	Parameter	First Result	Second Result	Maximum Permissible Level (WHO)	Unit
1	Appearance	Clear	Clear	-	-
2	Colour (Platinum, Cobalt Scale)	5	5	50	LCU
3	Turbidity (Secchi Scale Unit)	-	-	25	NTU
4	pH value	7.2	6.8	6.5 to 9.2	-
5	Total Solids	334	342	1500	mg/l
6	Total Hardness (as CaCO_3)	60	80	500	mg/l
7	Total Alkalinity (as CaCO_3)	130	130	950	mg/l
8	Calcium as Ca	18	24	200	mg/l
9	Magnesium as Mg	5	5	150	mg/l
10	Chloride as Cl	40	40	600	mg/l
11	Sulphate as SO_4	78	98	400	mg/l
12	Total Iron as Fe	Nil	Nil	1	mg/l

use as a public water supply. It is very useful for agricultural and livestock. This preliminary work aimed for better control the quality of Taiping River water at Banmaw Township, Kachin State.

Acknowledgements

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PHY 018

Nuclear K^- Bound States in ^8Be Nucleus

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Abstract

Recently " K^-pp " kaonic nuclear bound state was observed in $^3\text{He}(K^-, \Lambda p)n$ reaction at J-PARC E-15 experiment. It has been claimed that a distinct peak was observed in the neutron spectrum, indicating the formation of a bound kaonic system, K^-pp , with the binding energy gives $B_{Kpp} = 47 \pm 3(\text{stat.})$ MeV and a level width $\Gamma_{Kpp} = 115 \pm 7(\text{stat.})$ MeV. This experimental observation stimulates us to study the kaonic nucleus in $^8\text{Be}(\alpha-\alpha)$ system, unbound state which is similar to $p-p$ system. The $K^- \alpha\alpha$ system has been studied within the frame work of three-body coupled rearrangement Gaussian basis treatment. The potentials we employed in our calculations are Akaishi's optical potential, Ali-Bodmer's phenomenological $\alpha-\alpha$ potential and Furutani's $\alpha-\alpha$ folding potential. We predicted a deeply bound kaonic nucleus $^8\text{Be}(K^-)$ with energy -101.0 MeV from the $K^- \alpha-\alpha$ threshold and level width 36 MeV. The narrowness of this state is due to closing of the main decay channel $\pi-\Sigma$. The width is narrow compared to the energy level, and it contradicts to the generally accepted idea that level width of kaonic nuclear states would be very large due to strong absorption of kaon-nucleus interactions.

Keywords: Rearrangement coupled channel method, High density nuclear matter

Introduction

In hadron physics, behavior of hadron interactions in nuclear medium is not well understood yet and it remains an open problem. Since the $I=0$ $\bar{K}N$ interaction is strongly attractive without a hard core of short range, a $\bar{K}$ can form very unusual condensed nuclear systems. Recently a distinct peak in the Λp invariant mass spectrum of $^3\text{He}(K^-, \Lambda p)n$ has been observed. It is well below the mass threshold of the K^- to be bound to two protons. It is found that the simplest fit to the observed peak at $B_{Kpp} = 47 \pm 3(\text{stat.}) +3(-6)(\text{sys.})$ MeV having a width $\Gamma_{Kpp} = 115 \pm 7(\text{stat.}) +10(-20)(\text{sys.})$ MeV (Ajimura *et al.*, 2019). Therefore, we are interested in studying the K^- bound states in ^8Be nuclear systems. The studying of the structure of this system, we expect, would reveal some knowledge about effective antikaon-nucleon and antikaon-nucleus interactions in nuclear medium.

Interactions

Kaon -Nucleon Interaction

To solve the $K^- \alpha-\alpha$ three-body system, it is necessary to know the $K^- \alpha$ and $\alpha-\alpha$ interactions. We constructed the optical potential for $K^- \alpha$ interactions which are derived from a $\bar{K}-N$ phenomenology interaction (Akaishi *et al.*, 2002). The $I=0$ and $I=1$ $\bar{K}-N$ interactions are described as follows;

$$v_{\bar{K}N}^I(r) = v_D^I \exp(-(r/0.66)^2), \quad (1.a)$$

$$v_{\bar{K}N,\pi\Sigma}^I(r) = v_{c_1}^I \exp(-(r/0.66)^2), \quad (1.b)$$

$$v_{\bar{K}N,\pi\Lambda}^I(r) = v_{c_2}^I \exp(-(r/0.66)^2), \quad (1.c)$$

With $v_D^{I=0} = -436\text{MeV}$, $v_{c_1}^{I=0} = -412\text{MeV}$,

$v_{c_2}^{I=0} = \text{none}$,

$$v_D^{I=1} = -62\text{MeV}, v_{c_1}^{I=1} = -285\text{MeV},$$

$$v_{c_2}^{I=1} = -285\text{MeV},$$

where $v_{\pi\Sigma}^I(r) = v_{\pi\Lambda}^I(r) = 0$ is taken to simply reduce the number of parameters.

We calculated the energy level and width of the

$\Lambda(1405)$ resonance state by employing $I=0$, $\bar{K}-N$ interaction. In our coupled-channel two-body computations, complex rotation method (Gyarmati *et al.*, 1985) is incorporated to deal with a resonance state. It is asserted that $\Lambda(1405)$, $I=0$ is a bound state of $K^- - p$ system and it can decay only to $\pi-\Sigma$ state where $\pi-\Lambda$ channel is omitted since its isospin is 1. From our calculations a resonance state is found to be at $E = -27.66$ MeV below the $K^- - p$ threshold and level width $\Gamma = 41.0$ MeV.

 $\bar{K}-\alpha$ Interaction

The optical potential for interaction based on the interaction (Akaishi and Yamazaki, 2002) is constructed by folding 'g' matrices with nuclear density distribution as follows;

$$V_{\bar{K}\alpha}(r) = \int g(\vec{r}-\vec{r}') \rho(\vec{r}') d\vec{r}' \quad (2)$$

The nucleon density distribution of the alpha nuclei is given by

$$\rho(r) = A \left(\frac{A}{A-1} \frac{\beta}{\pi} \right)^{3/2} \exp \left(-\frac{A}{A-1} \beta r^2 \right) \quad (3)$$

where the parameter β is related to the rms nuclear radius as

$$R_{\text{core}} = \sqrt{\frac{3(A-1)}{2A\beta}} \quad (4)$$

The $\bar{K}N$ g matrix in a nuclear medium is defined by

$$g = v + v \frac{Q_N}{E_{st} - Q_N \hat{T} Q_N} g. \quad (5)$$

The binding effects of $\bar{K}$ and N are properly taken into account through the starting energy, E_{st} which is a quantity independent of relative momentum, k . The $Q_N \hat{T} Q_N$ prescription is employed for intermediate states in the g matrix equation (Nagata et al., 1979 and Akaishi et al., 1972).

Interaction between two alphas

Phenomenological l -dependent potentials (Ali and Bodmer, 1966) are used in calculation of $K^- - \alpha - \alpha$ system. In these potentials, an l -independent attractive part has a longer range than the repulsive parts and strongly l -dependent repulsive part becomes weaker as l increases. Thus the attractive part is fitted first from the $l = 4$ phase shift since the large $l = 4$ centrifugal barrier masks the effect of the inner repulsive part. For $l = 4$, only a quite weak repulsive part is permissible.

The nuclear part of the $\alpha - \alpha$ potential is described by following Gaussian forms;

$$V_{\alpha\alpha}(r) = V_r \exp(-(\mu_r r)^2) + V_a \exp(-(\mu_a r)^2), \quad (6)$$

where V_r and V_a the strengths of the repulsive and attractive parts, respectively and the corresponding inverse ranges. These values are

$$V_r = 250.0 \text{ MeV} \quad \text{and} \quad V_a = -87.0 \text{ MeV}$$

$$\mu_r = 0.7 \text{ fm}^{-1} \quad \text{and} \quad \mu_a = 0.475 \text{ fm}^{-1}$$

Alternatively, we use folding potential of Furutani's which has a one range Gaussian form as follows;

$$V_{\alpha\alpha}(r) = -112.0 \exp\{-0.2 r^2\} \quad (7)$$

These potentials reproduce reasonably well the low-lying states and low-energy scattering phase shifts of the $\alpha - \alpha$ systems. We have also employed the OCM-based cluster model study of light nuclei (Hasegawa A. et al., (1971)).

Pauli Suppression Effect in Three-Body System

The Pauli principle between nucleons belonging to α and α clusters is taken into account by the Orthogonality Condition Model; OCM (Saito S., (1969)). The OCM projection operator V_{Pauli} is represented by

$$V_{\text{Pauli}} = \lim_{\lambda \rightarrow \infty} \lambda \sum_f |\phi_f(\vec{r})\rangle \langle \phi_f(\vec{r})|. \quad (8)$$

which rules out the amplitude of the Pauli forbidden $\alpha - \alpha$ relative states from $\phi_f(r_{\alpha\alpha})$ the two-body total wave function. The forbidden states are $f = \{0S, 1S, 0D\}$. In the calculation, the strength λ for V_{Pauli} is taken to be 10^5 MeV, which is large enough to push up away the unphysical forbidden states into the very high energy region

while keeping the physical states unchanged. Harmonic oscillator wave functions are applied for forbidden states.

Complex Coordinate Rotation Method

We use the method of complex coordinate rotation (Gyarmati B. and Kruppa A.T., (1985)) to investigate the resonance states. According to the complex rotation method, the following

coordinate transformation $r \rightarrow r e^{i\theta}$ is carried out, where θ is a real number called rotation angle. Under this transformation, wave function is defined as

$$\Psi(r) \rightarrow \Psi(r e^{i\theta}) = \Psi_\theta(r) = \hat{U}(\theta) \Psi(r). \quad (9)$$

Schrödinger Equation under complex rotation is,

$$H_\theta(r) \Psi_\theta(r) = E \Psi_\theta(r). \quad (10)$$

Then the asymptotic resonance wave function in Gaussian basis expansion is transformed as

$$\Psi_\theta(r) = \sum_j c_j(\theta) e^{-(r/b_j)^2} \quad (11)$$

Schrödinger Equation becomes

$$H(r) \sum_j c_j(\theta) e^{-(r/b_j e^{i\theta})^2} = E \sum_j c_j(\theta) e^{-(r/b_j e^{i\theta})^2} \quad (12)$$

We have to solve the Schrödinger equation which is the same as bound state system except the range parameter b_j becomes $b_j e^{i\theta}$.

Three-Body Schrödinger Equation

Then Schrödinger equation becomes

$$\left[-\frac{\hbar^2}{2\mu_c} \nabla_c^2 - \frac{\hbar^2}{2M_c} \nabla_c^2 + \left\{ V_{23}(r_1) + V_{13}(r_2) + V_{12}(r_3) \right\} + V_{\text{Pauli}} + V_{\text{Coul}} \right] \Psi(\vec{r}, \vec{R}) = E \Psi(\vec{r}, \vec{R}) \quad (13)$$

where c is the channel, $c=1, 2$ and 3 which are described in Fig.1.

The total wave function with angular momentum J and Z component M , Ψ_{JM} may be expanded in terms of basis functions spanned over the three Rearrangement coupled-channels Gaussian basis treatment (Kamimura M. (1988)) as follows;

$$\Psi_{JM} = \sum_{c=1}^3 \sum_{i, l, L_c} D_{i, l, L_c}^{(c)} \phi_{i, l, L_c}^{(c)}(r_c) \chi_{i, l, L_c}^{(c)}(R_c) \times [Y_l(\hat{r}_c) Y_{L_c}(\hat{R}_c)]_{JM} \quad (14)$$

Here l (L_c) stands for the angular momentum of the relative motion associated with the coordinate r_c (R_c), and the bracket $[Y_l(\hat{r}_c) Y_{L_c}(\hat{R}_c)]_{JM}$ represents the vector coupling of the two spherical harmonics.

In Eq. (14), l and L_c are restricted as $0 \leq l \leq l_c^{\text{max}}$, $|J - l_c| \leq L_c \leq J + l_c$, and

$$(-1)^{l+L_c} = (-1)^J. \text{ The numbers } l_c \text{ and } L_c \text{ specify}$$

the radial dependences of $\phi_{i, l, L_c}^{(c)}(r_c)$ and $\chi_{i, l, L_c}^{(c)}(R_c)$, respectively. The form of the radial functions ϕ and χ is taken as

$$\phi_{il}(r) = r^l \exp\{-(r/b_i)^2\},$$

$$b_i = b_1 a^{(i-1)}, (i = 1 - n),$$



$$\chi_{IL}(R) = R^L \exp\{-(R/B_1)^2\},$$

$$B_1 = B_1 A^{(1-1)}, (1 = 1 - N).$$

These basis functions have been verified to be suited for describing both short-range correlations and long-range tail behaviors of few-body systems. The eigen energy E and the coefficients D in Eq.(14) are to be determined by the variational method.

Results and Discussion

Deeply bound $K^- - {}^8\text{Be}$ state

We have carried out three-body calculations to study structure of $K^- - \alpha - \alpha$ system within the frame work of coupled-rearrangement-channel Gaussian-basis variational method (Kamimura, 1988). We have found a nuclear bound state $K^- - \alpha - \alpha$ with energy $E = -101.0$ MeV below the $K^- - \alpha - \alpha$ threshold and level width $\Gamma = 36.0$ MeV. It is generally accepted that such a deeply bound nuclear state would give rise to a larger level width due to strong absorption of kaon-nucleus interaction. However, our calculated bound state becomes lower than $\pi - \Sigma$ threshold which is the major decay channel, and consequently the narrow bound state is obtained. Since the level width is narrow, compared to its energy value, the deeply bound is discrete enough to be experimentally observed.

We also calculate the energy and level width of our bound state with folding potential of Furutani. In this case, we have to incorporate V_{Pauli} to eliminate the Pauli forbidden states between two- α s. It is found that the two potentials, one with phenomenological Ali-Bodmer $\alpha - \alpha$ potential and another one with Furutani $\alpha - \alpha$ folding potential plus orthogonality condition model, give the similar results.

It is also our interest to study the relative motion between the two α s in $K^- - \alpha - \alpha$ system. We carry out calculations to determine distribution of the $\alpha - \alpha$ relative motion where the relative density distribution is defined as

$$\rho(r_3) = |\Psi_{\alpha\alpha}(r_3)|^2 = \frac{1}{4\pi} \int |\Psi_{\alpha\alpha K^-}|^2 d\vec{R}_3 d\vec{r}_3. \quad (15)$$

The distribution of the relative motion between $\alpha - \alpha$ particle is displayed in Fig.1 (b) where Fig. 1(a) is that of Ali-Bodmer without Coulomb. It can be seen from the figures that the maximum peak is found at $\alpha - \alpha$ distance $r = 3.4$ fm in the free-space and in the $K^- - \alpha - \alpha$ system, the maximum is found at $r = 1.4$ fm. Thus the two α -particles are drawn closer by the strong attraction of Kaon-alpha interactions.

Although ${}^8\text{Be}$ (ie. $\alpha - \alpha$ system) is not a bound system, when a π -particle is added to it we found that $K^- - \alpha - \alpha$ becomes strongly bound to give nuclear system. The kaon attracts all nucleons within its interaction range and builds a high-density system. The formation of deeply bound nuclear states in ${}^8\text{Be}$ and other nuclei would

provide a means to obtain high-density nuclear matter at low temperature and a new way to investigate the properties of hadrons in a cold and dense nuclear medium.

Conclusion

It is found that the two α particles are drawn closer by the strong attraction of $K^- - \alpha$ interactions in $K^- - \alpha - \alpha$ system. In the deeply bound state the core nuclei are largely compressed due to the strong attraction of a K^- -nucleus. The antikaon, K^- plays a unique role as a contractor to bind nucleons more tightly, and accommodates a nucleus of much higher density. The studying of the kaonic systems gives some knowledge about effective antikaon-nucleon and antikaon-nucleus interactions in nuclear medium.

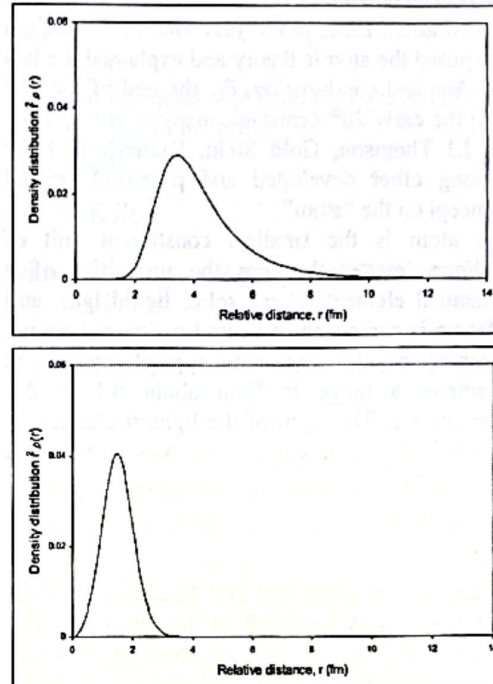


Fig. 1 The density distribution of relative motion between $\alpha - \alpha$ (a) in ${}^8\text{Be}$ and (b) in $K^- - {}^8\text{Be}$ System

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PHY 019

Calculation of The Energy Shift Values of Caesium Atom (Cs) by External Magnetic Fields

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Abstract

The Hydrogen like normal Caesium atom is chosen in this research paper; we studied by the use of non-relativistic quantum mechanical approach and Bohr's atomic model. We studied the energy shift values of a Caesium atom by some external magnetic fields effect and we considered for the two cases; one is the effect of without external magnetic fields and the other is those of with external magnetic fields.

Introduction

Atom is a Greek word which means "indivisible". The Greek believed that matter can be broken down into very small invisible particles called atom. Later in the year 1808, John Dalton proposed the atomic theory and explained the law of chemical combination. By the end of the 18th and the early 20th centuries, many scientists such as J.J Thomson, Gold Stein, Rutherford, Bohr among other developed and proposed several concept on the "atom".

An atom is the smallest constituent unit of ordinary matter that has the properties of a chemical element. Every solid, liquid, gas, and plasma is composed of neutral or ionized atoms. Atoms are extremely small, typical sizes of its diameter a range is from about 0.1 to 0.5 nanometers. The atom of the lightest element in nature hydrogen consists of two particles; a nucleus, whose mass is 1.6724×10^{-24} g and a single electron rotating around it, whose mass is 9.1×10^{-28} g.

Every atom is composed of a nucleus and one or more electrons bounded to the nucleus. The nucleus is made of one or more protons and typically a similar number of neutrons. Protons and neutrons are called nucleons. The protons have a positive electric charge, the electrons have a negative charge and the neutrons have no electric charge. If the number of protons and electrons are equal, that atom is electrically neutral.

If the atom of an element is usually represented by the symbol ${}_Z^AX$, where A is the atomic mass or mass number, Z is the atomic number or the charge number and X the notation of the kind of element.

An atom characterized by an atomic number Z has a nucleus which carries almost the entire mass of the atom and a positive electric charge (Ze) surrounded by Z electrons each of which carries a negative charge (-e). The orbital motion of the electron is characterized by an orbital momentum quantum number (ℓ) and its projection (m_ℓ) which can have $m_\ell = -\ell, -\ell + 1, -\ell + 2, \dots, +\ell$ with reference to the axis of quantization, which is usually chosen as the z-axis. The electron has also an intrinsic spin quantum number $s = 1/2$, its projection $m_s = -1/2, +1/2$ with reference to

the same axis. Thus the total number of electrons with the same angular momentum ' ℓ ' are $2(\ell + 1)$ which are filled, following the Pauli's exclusion principle. The orbital and spin angular momentum of the electron add up quantum mechanically to yield a total angular momentum quantum number 'J' and its projection m_j where $m_j = -J, -J + 1, -J + 2, \dots, +J$ along the z-axis.

When an atom with angular momentum J is in the absence of external fields and when the atom is not interacting with other particles, all the $(2J+1)$ sub-levels are completely degenerate with respect to energy. When the external magnetic field is applied, the energy levels are split into the possible numbers of $(2J+1)$ and this is called the Zeeman Effect.

The ground state energy of hydrogen atom Bohr's Atom Model

In 1913, Bohr proposed his quantized shell model of the atom to explain how electrons can have stable orbits around the nucleus. The motion of the electrons in the Rutherford model was unstable because according to classical mechanics and electromagnetic theory; thus, the electron would lose energy and spiral into the nucleus. The energy of an electron depends on the size of the orbit and is lower for smaller orbits. The atom will be completely stable in the state with smallest orbit, since there is no orbit of lower energy into which the electron can jump. Bohr assumed that an electron in an atom moves in an orbit about the nucleus under the influence of the electrostatic attraction of the nucleus. Circular or elliptical orbits are allowed by classical mechanics, and Bohr selected to consider circular orbits for simplicity. He then, postulated that instead of the infinity of orbits which are possible in classical mechanics, only a certain set of stable orbits, which he called stationary states are allowed. As a result, atom can only exist in certain allowed energy levels with energies $E_a, E_b, E_c, \dots$

If the orbits are quantized, the amount of energy absorbed or emitted is also quantized, producing discrete spectra. Photon absorption and emission are among the primary methods of transferring energy into and out of the atoms. The energies of the photons are quantized, and their energy is explained as being equal to the change in energy of electron when it moves from one orbit to another.

Bohr explained how electrons could jump from one orbit to another only by emitting or absorbing energy. When the electron jumps to a larger orbit, it must absorb a equal in energy to the difference in orbits. There may be only strictly limited number of electrons in each level, 2 in the first innermost shell, 8 in the second and so on these shells are denoted by the symbols K, L, M, N respectively.

Each shell can contain only a fixed number of electrons. The first shell can hold up to two electrons, the second shell can hold up to eight (2+6) electrons, the third shell can hold up to 18 (2+6+10) and so on. The general formula is that the n^{th} shell can in principle hold up to $2n^2$ electrons.

For the case of the one electron atom, Bohr's was able to modify the classical model to obtain the quantization of energy levels by making the additional postulate that the angular momentum of the electron moving in circular orbit can only take

one of the value $L = \frac{nh}{2\pi} = n\hbar$, when n is a

positive integer, $n=1, 2, 3, 4, \dots$ and the common occurring $h/2\pi$ is conventionally denoted by $\hbar$.

Calculation of the Ground State Energy of the Hydrogen Atom

The hydrogen atom is the simplest atom in nature and therefore a good starting point to study atom and atomic structure. The hydrogen atom consists of a single negatively charged electron that moves about a positively charged proton. In Bohr's model, the electron is pulled around the proton in a perfectly circular orbit by an attractive Coulomb force. The proton is approximately 1840 times more massive than the electron, so the proton moves very little in response to the force on the proton by the electron.

A major step forward to understand the spectrum of one-electron atom was taken by N. Bohr's in 1913. Working in Rutherford's laboratory, he was able to combine the concept of Rutherford's nuclear atom, Plank's quanta and Einstein's photons to explain the observed spectrum of atomic hydrogen.

Consider an electron of charge 'e' and mass 'm', it will be taken to be moving with a velocity 'v' in a circular orbit of radius 'r' in an atom.

The Coulomb force between a stationary nucleus with the nucleus of charge +Ze and orbiting electron with charge 'e' is

$$F = K \frac{Ze^2}{r^2} \quad (1)$$

From the Newton's second law of motion, the electron mass m times the centripetal acceleration

$\frac{v^2}{r}$ called centripetal force, $F_c = \frac{mv^2}{r}$. It can be

expressed as follow;

$$K \frac{Ze^2}{r^2} = \frac{mv^2}{r} \quad v = K \frac{Ze^2}{mvr} \quad (2)$$

N. Bohr proposed that the angular momentum (L) of the allowed orbit takes the integral values of

$$L = \frac{h}{2\pi}$$

From Bohr's postulate (3), the angular momentum (m v r) of the allowed orbits takes the integral values of $h/2\pi$. Hence, Bohr's postulate that the angular momentum is given by

$$L = m v r = n \hbar \quad (3)$$

where $n=1, 2, 3, \dots$

By using the above equations (2) and (3), we get the value of v and r as

$$v = \frac{KZe^2}{n\hbar} \quad (4)$$

Substituting equation (4) into the equation (3), we get the radius of the orbit

$$r = \frac{(n\hbar)^2}{mKZe^2}$$

where, $\frac{(\hbar)^2}{mKZe^2} = 0.529 \text{ \AA}$ called Bohr's radius.

$$\text{For } n^{\text{th}} \text{ state, } r_n = \frac{0.529 n^2}{Z} \text{ \AA} \quad (n=1, 2, 3, 4, \dots) \quad (5)$$

The kinetic energy of the electron, T is in the form of

$$T = \frac{1}{2}mv^2 \quad T = \frac{m}{2\hbar^2} \left(\frac{KZe^2}{n} \right)^2 \quad (6)$$

and the potential energy, V is also can be obtained as

$$V = -\frac{KZe^2}{r} \quad V = -\frac{m}{\hbar^2} \left(\frac{KZe^2}{n} \right)^2 \quad (7)$$

From which the total energy E_0 of the electron in the Hydrogen atom is

$$E_0 = T + V \quad (8)$$

$$E_0 = -\frac{m}{2\hbar^2} \left(\frac{KZe^2}{n} \right)^2 \quad (2.8)$$

$$E_0 = -13.6 \frac{Z^2}{n^2} \text{ eV} \quad (9)$$

The ground state energy for the hydrogen atom is obtained $n=1, Z=1$ then

$$E_0 = -13.6 \text{ eV} \quad (10)$$

$$E_n = -13.6 \frac{Z^2}{n^2} \text{ eV for Hydrogen like atom}$$

The above equation (9) is also true for all the simplest one electron hydrogen like atom and so it is very useful to calculate the ground state energy of the chosen hydrogen like Caesium atom.

Basic Concept of Alkali Metals

The group(I) in the periodic table consisting of the chemical elements lithium (Li), sodium (Na), potassium (K), rubidium (Rb), caesium (Cs) and francium (Fr). They are collectively known as the alkali metals. This group lies in the S-block of the periodic table is all alkali. All alkali metals have their outermost electron in an s-orbital. The alkali metals, halogen and noble gases are their important group in the periodic table. The alkali metals are soft, reactive metals.

The outer electron of an atom determines the chemical and optical properties of their atom. The electron in the closed inner orbits do not take part in the emission of spectral lines, and thus atoms are divided into two main categories which are one electron system and many electrons system. The alkali metals (such as lithium, sodium and potassium) have a single electron in the outermost

and as a catalyst in the hydrogenation of certain organic compounds. Caesium has 40 unknown isotopes. The atomic masses of these isotopes range are from 112 to 151. It is a soft, silver-white metallic element belonging to the alkali metal group of chemical elements with a standard atomic weight of 133.9055. Caesium is composed of 37 electrons bounded by the electromagnetic force to a nucleus contains 55 protons along with 78 neutrons, depending on the isotopes held together by the strong force. A Caesium atom has 55 electrons. The electron configuration of the Caesium atom is $(1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^6 4d^{10} 5s^2 5p^6 6s^1)$. The 54th out of the 55th electrons

of the Caesium atom are interlocked in closed shells. We focused considered only the state of 55th optical electron in discussing the spectrum of natural Caesium atom. The electron configuration shows that the outermost shell is (6s). Therefore, the orbital angular momentum is $\ell = 0$ and spin angular momentum is $s = 1/2$ for electron. The total angular momentum J can take

Table. (2) The first excited state and ground state of the ^{55}Cs atom with their corresponding quantum numbers.

State		n	ℓ	s	J	m_j	Lande's g -factor
1 st -excited state	$2F_{7/2}$	4	3	$\frac{1}{2}$	$\frac{7}{2}$	$\frac{7}{2}, \frac{5}{2}, \frac{3}{2}, \frac{1}{2}, -\frac{1}{2}, -\frac{3}{2}, -\frac{5}{2}, -\frac{7}{2}$	$\frac{8}{7}$
	$2F_{5/2}$	4	3	$\frac{1}{2}$	$\frac{5}{2}$	$\frac{5}{2}, \frac{3}{2}, \frac{1}{2}, -\frac{1}{2}, -\frac{3}{2}, -\frac{5}{2}$	$\frac{6}{7}$
Ground state	$2S_{1/2}$	6	0	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}, -\frac{1}{2}$	2

shell. The alkali metals therefore behave much like the hydrogen atom. Hence, the alkali metals have hydrogen-like spectra. The complete electron configurations are written out in Table (1).

Table. (1) The electron configurations of the Alkali metals

St. No	Element	Atomic No	Symbol	Electrons Configuration
1	Lithium	3	Li	$1s^2 2s^1$
2	Sodium	11	Na	$1s^2 2s^2 2p^6 3s^1$
3	Potassium	19	K	$1s^2 2s^2 2p^6 3s^2 3p^4 4s^1$
4	Rubidium	37	Rb	$1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^6 5s^1$
5	Caesium	55	Cs	$1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^6 4d^{10} 5s^2 5p^6 6s^1$
6	Francium	87	Fr	$1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^6 4d^{10} 5s^2 5p^6 6s^2 4f^{14} 5d^{10} 6p^6 7s^1$

Electron Configuration and Energy State of the Caesium Atom

Caesium atom is a chemical element with the symbol Cs. Caesium atom has atomic number of 55 and atomic mass 133 and two naturally occurring isotope ^{133}Cs and ^{134}Cs of which ^{133}Cs is the most abundant at 100% of the mass. Caesium is also used in atomic clocks, in photoelectric cells

$J = (\ell + s), \dots, |\ell - s|$. Then, the total angular momentum of the ground state of Caesium atom will be $J = 1/2$.

If the valence electron in the s-shell can jump to the excited state due to various physical mechanisms and reach to the 4f-state, the orbital angular momentum of the excited electron is $\ell = 3$ and the spin angular momentum is $s = 1/2$. Thus the total angular momentum may be $J = 7/2$ and $J = 5/2$.

The term symbol of the first excited state and ground state of ^{55}Cs with their corresponding quantum numbers are as shown in Table.(2).

The Effective Nuclear Charge (Z_{eff}) and the Screening Constant (σ)

The screening constant describes the attraction between an electron and the nucleus in any atom with more than one electron. It is also referred to as the screening effect or atomic shielding. The shielding effect can be defined as reduction in the attractive nuclear charge on the electron cloud,

due to a difference in the attraction forces on the electrons in the atom. In hydrogen-like atoms (those with only one electron), the net force on the electron is just as large as the electric attraction from the nucleus. However, when more electrons are involved, each electron (in the n -shell) feels not only the electromagnetic attraction from the positive nucleus, but also repulsion forces from other electrons in shells from 1 to n . This causes the net force on electrons in outer shells to be significantly smaller in magnitude; therefore, these electrons are not as strongly bounded to the nucleus as electrons closer to the nucleus. This phenomenon is often referred to as the Orbital Penetration Effect. The shielding theory also explains why valence-shell electrons are more easily removed from the atom.

The values of the screening constant can estimate the effective nuclear charge on each electron. The effective nuclear charge (often symbolized as Z_{eff} or Z^*) is the net positive charge or full experienced by an electron in a multi-electron atom due to the protons in the nucleus. The term "effective" is used because the shielding effect of negatively charged electrons prevents higher orbital electrons from experiencing the full nuclear charge by the repelling effect of inner-layer electrons. The effective nuclear charge experienced by the outer shell electron is also called the core charge. It is possible to determine the strength of the nuclear charge by looking at the oxidation number of the atom.

The shielding effect is observed in an atom having more electrons and particularly more electron shells. The electrons in the valence shell are attracted by the positive charged nucleus. While there is repulsion between the valence electrons and electrons present in the inner shells. Due to this, there is a decrease in the force of attraction between the electrons in the shell and the nucleus. This effect is known as screening effect. The magnitude of the screening effect depends on the number of electron in the inner shells. The decrease in the force of attraction exerted by the nucleus on the valence electron due to the presence of electrons in the inner orbit is called screening effect or shielding effect.

In an atom with one electron, that electron experiences the full charge of the positive nucleus. In this case, the effective nuclear charge can be calculated from Coulomb's law.

However, in an atom with many electrons the outer electrons are simultaneously attracted to the positive nucleus and repelled by the negatively charged electrons. The effective nuclear charge on such an electron is given by the following equation: $Z_{\text{eff}} = Z - \sigma$ (11)

where Z is the number of protons in the nucleus (atomic number), and σ is the average number of

electrons between the nucleus and the electron in question (the number of non-valence electrons) called screening parameter or screening constant.

For 6s electron of the Caesium atom, the parameter of the screening constant is $\sigma = 51.79$ from the Table (3) which is obtained from the reference web page of the www.nuclear-power.net.

Therefore, the effective nuclear charge Z_{eff} of the chosen Caesium atom is $Z_{\text{eff}} = 55 - 51.79 = 3.21$

Table. (3) Alkali Metals Group I (H to Fr) Shielding Constant (σ)

Electron Identity	Lithium Li	Sodium Na	Potassium K	Rubidium Rb	Caesium Cs
1s	0.9377	2.1277	2.7962	4.2963	6.0612
2s	1.7410	6.5954	8.4330	12.5160	14.800
2p		7.8610	9.6577	13.9140	16.603
3s		9.1563	14.0570	22.3510	26.798
3p			15.4200	24.2880	29.098
3d				28.3140	33.028
4s			16.7410	30.8290	38.505
4p				32.5930	41.055
4d					45.412
4f					
5s				34.2300	48.382
5p					50.255
5d					
6s					51.790

Ground State Energy of the Caesium Atom

Next to the Hydrogen the alkali metals Li, Na, K ... have the simplest spectra. Each alkali atom contains in addition to the complete sub-shells of electrons, one single electron in an outer shell. Therefore, the alkali metals are hydrogen-like atoms.

For Caesium atom, a small requires correction term to equation (9) was made by Hertz's formula, with the screening constant, denoted by (σ). Therefore this equation (9) can also be written as in the following form,

$$E_0 = -13.6 \frac{Z_{\text{eff}}^2}{n^2} \quad (12)$$

where Z_{eff} is the effective nuclear charge and which can be obtained by using the following equation, which is in the form of

$$Z_{\text{eff}} = Z - \sigma \quad (13)$$

In equation (12) Z_{eff} is used instead of Z , because of, in an atom with many electrons, the outer electron are simultaneously attracted to the positive nucleus and repelled by the negatively charged electrons. The effective nuclear charge on such electron is given by the above equation (13). For Caesium atom, the screening constant for the 6s state electron is $\sigma = 51.79$, this value is obtained from Table (4). Then, equation (12) can be written as follow;

$$E_0 = -13.6 \frac{(Z - \sigma)^2}{n^2} \quad (14)$$

By using this equation (14), we can calculate the ground state ($n=6$) energy of the Caesium and its energy values is

$$E_0 = -3.8926 \text{ eV} \quad (15)$$

The value which is our calculated for the ground state energy of the Caesium is nearly equal to the the value of references data which is -3.89 eV.

The effect of uniform magnetic field on an atom The Interaction between an Atom and External Magnetic Field

If the atom is placed in the magnetic field, the total angular momentum vector $\mathbf{J}$ precesses about the direction of magnetic field $\mathbf{B}$ as axis. In classical electrodynamics, the interaction energy of an external magnetic field $\mathbf{B}$ with total magnetic moment is given by

$$H_{\text{int}} = -\boldsymbol{\mu}_J \cdot \mathbf{B} \quad (16)$$

The Schrödinger equation for an atom in a uniform magnetic field is

$$H \Psi = E \Psi \quad (17)$$

where H is the total Hamiltonian and in the form of

$$H = H_0 + H_{\text{int}} \quad (18)$$

$$H = H_0 + (\mu_B g \mathbf{J} \cdot \mathbf{B}) \quad (19)$$

where, the magnitude of the total magnetic moment, $\mu_J = -\mu_B g J$

The unperturbed Hamiltonian H_0 satisfies the equation

$$H_0 \Psi = E_0 \Psi \quad (20)$$

where E_0 is the unperturbed energy eigenvalue.

To find the energy value corresponding to the complete Hamiltonian H , the magnetic field is conveniently chosen along the z -axis so that

$$\mathbf{J} \cdot \mathbf{B} = J_z B_z = J_z B \quad (21)$$

The eigenvalue E of the Hamiltonian H_{int} on the $|Jm\rangle$ basis are

$$E = E_0 + (\mu_B g m_J B) \quad (22)$$

where m_J is the projection of vector $\mathbf{J}$ on the direction of the magnetic field and it can take $(2J+1)$ values from $-J$ to $+J$.

The Shifting of Energy Levels by the Presence Magnetic Field

When the external magnetic field is applied, the energy levels are split into the possible numbers of $(2J+1)$ and this is called the Zeeman effect.

When the external magnetic field, the total angular momentum quantum number $J = 7/2$ level splits into eight sub-levels with and the total angular momentum quantum number $J = 5/2$ level into six sub-levels with

$m_J = 5/2, 3/2, 1/2, -1/2, -3/2, -5/2$.

Results and conclusions

The Energy Shift Value for Caesium Atom by External Magnetic Field

In this section, we calculated the energy shift value of the Caesium atom when it is exposed to

magnetic fields and without external magnetic fields.

Atom in magnetic field was a very long history starting from the discovered by Zeeman in 1896 of the splitting spectral lines into components in a magnetic field. All the energy levels of the valence electron in an alkali metal are split into two, one level corresponding to a total angular momentum quantum number $J = \ell + 1/2$ and the other $J = \ell - 1/2$.

The interaction causing this splitting is the spin-orbit interaction, which was discussed in detail, in connection with one electron atom. The energy shift value due to this effect was calculated by details and list in Table.(4) to (5).

The Energy Shift Value for $^2S_{1/2}$ level without External Magnetic Field

By using the equation (22), we calculated the energy value for $^2S_{1/2}$. This equation (22) can also be written as follow;

$$E = E_0 + \Delta E \quad (23)$$

where, $\Delta E = \mu_B g m_J B$ is the energy shift value from the E_0 .

In this level, the external magnetic field is not affected, and thus the energy shift value for this level will be degenerated. The energy shift value, ΔE is zero for the external magnetic field strength is 0 T, therefore the energy value is equal to E_0 and it can be express as,

$$E_0 = -3.8926 \text{ eV} \quad (24)$$

The Energy Shift Value for $^2S_{1/2}$ level with External Magnetic Field Strength of 3.0 T

When the external magnetic field strength of 3.0T is applied on the Caesium atom. The energy shift value between the upper sub-level $m_J = +1/2$ and E_0 can be obtained by the following equation

$$\Delta E = \mu_B g m_J B$$

$$\Delta E = +5.79625 \times 10^{-5} \text{ eV T}^{-1} \times 2 \times \frac{1}{2} \times 3.0 \text{ T}$$

$$\Delta E = +17.388 \times 10^{-5} \text{ eV}$$

where g = Lande's g -factor and its value is 2 for s -state electron taken from Table.(2).

Therefore, the energy value of the upper sub-levels for $m_J = +1/2$ is $E = E_0 + \Delta E$

$$E = -3.8926 \text{ eV} + 17.388 \times 10^{-5} \text{ eV} \quad (25)$$

Similarly, the energy value for the lower sub-level $m_J = -1/2$ is the same amount of the upper shift values and thus we can be express as

$$\Delta E = -17.388 \times 10^{-5} \text{ eV}$$

$$\text{and } E = E_0 + \Delta E$$

$$E = -3.8926 \text{ eV} - 17.388 \times 10^{-5} \text{ eV} \quad (26)$$

The energy values for external magnetic field strength $B=0.0 \text{ T}$, $B=3.0 \text{ T}$, $B=5.0 \text{ T}$ and $B=7.0 \text{ T}$ are calculated, and the detail values are shown in Table.(4) to (5).

Table. (4) The energy shift value for $^2S_{1/2}$ of the Caesium atom without the external magnetic field

External magnetic field (T)	Term symbol	n	J	Energy value (eV) $E = E_0 + \Delta E$	Energy shift value ΔE (eV)
B=0.0	2S_1	6	$\frac{1}{2}$	-3.8926+0.0	0.0

Table. (5) The energy shift values for $^2S_{1/2}$ of the Caesium atom with some external magnetic fields

External magnetic field (T)		n	m_j	Energy value (eV)	Energy shift value
B=3.0	2S_1	6	$+\frac{1}{2}$	$-3.8926 + 17.388 \times 10^{-5}$	$+17.388 \times 10^{-5}$
			$-\frac{1}{2}$	$-3.8926 - 17.388 \times 10^{-5}$	-17.388×10^{-5}
B=5.0	2S_1	6	$+\frac{1}{2}$	$-3.8926 + 28.981 \times 10^{-5}$	$+28.981 \times 10^{-5}$
			$-\frac{1}{2}$	$-3.8926 - 28.981 \times 10^{-5}$	-28.981×10^{-5}
B=7.0	2S_1	6	$+\frac{1}{2}$	$-3.8926 + 40.573 \times 10^{-5}$	$+40.573 \times 10^{-5}$
			$-\frac{1}{2}$	$-3.8926 - 40.573 \times 10^{-5}$	-40.573×10^{-5}

In this paper, the ground state energy and energy shift values of a Caesium atom without the external magnetic field and with the external magnetic field are calculated. From the calculation, the results are tabulated in Table.(4) to Table.(5). These tables show the Caesium atom will not have energy shift value when there is not present external magnetic field strength. When the magnetic field applies to the Caesium atom, the energy shift values are appeared. From the tables, the unperturbed ground state energy level E_0 is split into two sub-levels when the magnetic field is applied and their energy shift values symmetrically around the ground state energy level E_0 with equal amount of magnitude in all applied external magnetic fields. The energy shift values are depends on the strength of the magnetic field B and magnetic quantum number J but it not depends on the principle quantum number 'n' of the valence electron of the considered atom. There will be found that the greater amount of energy shift values is found for the larger magnitude of magnetic field strengths are present.

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The author gratefully acknowledges many useful and enlightening discussions with Dr. Min Swe, who suggested the above research paper.

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PHY 020

Analysis of Some Physical and Chemical Parameters Contained in Tube-Well Water Sample from Aung Chan Thar Quarter in Monywa Township

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Abstract

Many organic and inorganic chemicals effect water quality. In drinking water, these effects may be related to public health. These organic and inorganic chemicals in water can be removed by using distillation process. In this paper, to study the outcome of the distillation process, tube-well water sample from Aung Chan Thar Quarter, Monywa Township, was collected and distilled. And then, physical and chemical parameters (pH, EC, TDS and elements such as Ca, Na, Mg, K, Fe, Cu, Zn, CO₃, CL) in original water and distill water samples were analyzed. The pH values and Electrical Conductivity (EC) value of these water samples were determined by using pH meter and Electrical Conductivity meter. Also total dissolve solid (TDS) value of these water samples were determined by using water bath. The concentration of elements in these samples were determined by using Atomic Absorption Spectrometer (AAS) technique at Yezin, Agricultural University. From the analyzed data, the content of physical and chemical parameters in distilled water were compared with in original water and discussed. It observed that the content of minerals with TDS and EC value is decreased by distillation the original tube-well water. Consuming water of low mineral content can arise the negative effects on the metabolism in the body. Therefore, the distilled water can arise the other negative effects except that it is the more little taste and safe to drink.

Keywords: Tube-well water, AAS method, Physical and Chemical parameters.

Introduction

Water withdrawn directly from river, lakes and reservoirs is rarely clean enough for human consumption if it is not treated to purity. Natural water usually contains chemicals which can be beneficial or harmful to our health. Many chemicals can be found their way into our drinking water supply through different natural processes and human activities. Naturally occurring chemicals such as arsenic, sulphur, calcium and magnesium are generally found in ground water. Human activities can add other chemicals such as phosphorous and pesticides to our ground, surface and rain water. As a result, water sources are increasingly becoming contamination with industrial chemical waste, while microbiological contamination is the target public health threat. Therefore, one way to remove these chemicals and organic from water is to boil it until to changes to steam vapour, a process known as distillation. Distillation is one of many processes that can be used for water purification. Distillation processes can remove not only dissolved minerals but also organic matter in original water. This requires an energy input as heat. In this process, solar radiation is used as the source of energy and water is evaporated. It is separating water vapour from dissolved matter and them is condensed as pure water. Solar water distillation is the most attractive and simple technique. In this research work, tube-well water sample from Aung Chan Thar Quarter, Monywa Township was collected and distilled by using solar water heating system. And then, the content of physical and chemical parameters such as pH, EC, TDS and elements in tube-well water and distilled water were analyzed at Yezin, Agricultural University.

Theory of Atomic Absorption Spectrometer

Atomic Absorption Spectrometer (AAS) determine the presence of metals in liquid samples. It also measures the concentrations of

metals in the samples. In their elemental analysis form, metals will absorb ultraviolet light when they are excited by heat. Each metal has a characteristic wavelength that will be absorbed. The AAS instrument looks for a particular metal by focusing a beam of UV light at a specific wavelength through a flame and into a detector. The sample of interest is aspirated into the flame. If that metal is present in the sample, it will absorb some of the light, thus reducing its intensity. The instrument measures the change in intensity. A computer data system converts the change in intensity into an absorbance. As concentration goes up, absorbance goes up. We can construct a calibration curve by running standards of various concentrations on the AAS and observing the absorbencies. We describe the motion of macroscopic objects using Newton's law of Physics. We can easily measure velocity, acceleration, force, kinetic and potential energies as well as quantify gravitational effects. However, when we look at atomic particles (i.e. protons, electrons, neutrons, etc.), we can no longer describe motion and energy using Newtonian physics. The characteristics of atomic particles are described using the theorems of quantum mechanics. The atomic absorption spectrometer uses the principals of quantum chemistry to detect the presence of certain metals (i.e. iron, aluminum, copper, etc) and determines the concentration of those metals in samples. Although we cannot measure the precise energy state for an atom, we can usually measure changes to its energy relative to its ground state.

The laws of quantum mechanics tell us that atoms do not increase their energy levels gradually. An atom goes directly from one state to another without going through intermediates. We refer to these as transitions. The transition from the ground state (written as E_0) to the first excited state (E_1) requires some form of energy input. This energy is absorbed by the atom. That energy absorption is equal to ΔE_0 to 1. When this energy absorption takes place in the presence of ultraviolet light, some of the light will be absorbed. This uv absorption occurs at a specific wavelength. Each element in the periodic table will have a specific ΔE that will absorb a specific wavelength of uv light. The relationship between the energy transition and the wavelength (λ) can

be described by, $\Delta E = \frac{h}{\lambda}$, $\Delta E = h\nu$.

Atomic absorption uses this relationship to determine the presence of a specific element based on absorption in a specific wavelength.

The Instrument design for Atomic Absorption Spectrometer

The basic components of Atomic Absorption Spectrometer (AAS) instrument is shown in Fig (1). As the figure indicates, there are six primary parts to the system; the light source, light chopper, the flame apparatus, monochromator, the detector and the data system.

- The light source, called a hollow cathode tube, is a lamp that emits exactly the wavelength required for the analysis.
- The light chopper is directed at the flame containing the sample.
- The flame is typically wide (4-6 inches), giving a reasonably long pathlength for detecting small concentrations of atoms in the flame.
- The light beam then enters the monochromator, which is tuned to a wavelength that is absorbed by the sample.
- The detector then measures the intensity of the beam of light. When some of the light is absorbed by a metal, the beam's intensity is reduced. The detector records that reduction as absorption.
- That absorption is shown on a read out by the data system.

Experimental Procedure

Sample Collection

In this research work, tube-well water sample from Aung Chan Thar Quarter, Monywa Township was obtained and distilled by solar water heating system. These water sample was collected with clean bottles. Sample location was determined by using GPS (Global Positioning System) device. It is situated at North latitude -22°08'30", East longitude-95°07'15" and about 72 m from the sea level. The chemical parameters (pH, EC, TDS and elements) in original tube-well

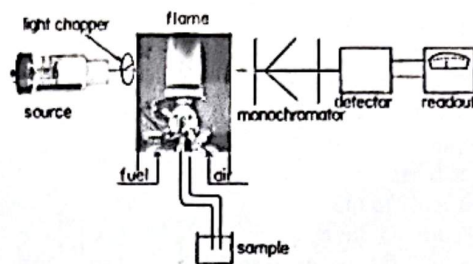


Fig. (1) The Schematic diagram of a Flame Atomic Absorption Spectrometer

water and distilled water samples were determined by using AAS (Atomic Absorption Spectrometer), EC (Electrical Conductivity) meter and pH meter at Yezin, Agricultural University. The list of tube-well water sample is shown in Table (1).

Table (1) The list of Tube-well Water samples.

Code	Sample Name
W ₁	Original tube-well water sample
W ₂	Distill water sample

Construction of Solar Water Heating System

Method of collecting and storing solar energy can vary depending on the uses planned for the solar generator. In general, there are three types of collectors and many forms of storage units. Three types of collectors are flat-plate collectors, focusing collectors, and passive collectors. Of them, we have designed passive collector. Firstly, we built solar collecting box with the length 6ft, breadth 4ft and height 4ft. We made it by 45 degree slant facing to the sun. This box is built by using materials such as glass, wood, cotton as insulator and zinc plates. This box consists of four reflectors, storage cylindrical tank. The storage cylindrical tank which the length is 4ft and the diameter is 1ft, is placed in the box. The horizontal position of the tank is elevated at one end 2 and other end 3 inches from the bottom mirror using two supports as shown in fig (2). The diameter of cold water steel pipe inlet is 1.5 inches and it is coiled in the storage cylindrical tank. The diameter of hot water outlet steel pipe of the tank is 1inche. This pipe is straight line and is connected to the cold water inlet steel pipe. It can be used alone with the understanding that water temperatures will fluctuate with the time of the day. Schematic diagram of beside view of heat storage tank and photograph of Solar Water Heating System are shown in fig (3) and fig(4).

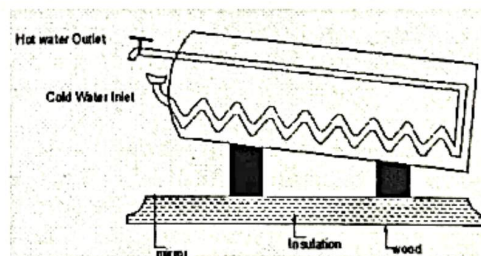


Fig (2) Schematic diagram of the heat storage tank in a box

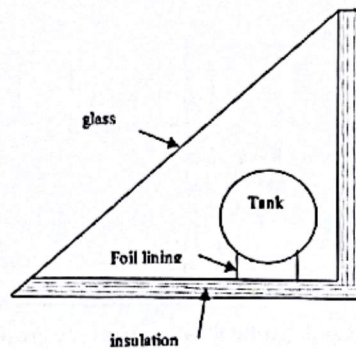


Fig (3) Schematic diagram of beside view of heat storage tank
Operation of Solar Water Heating System

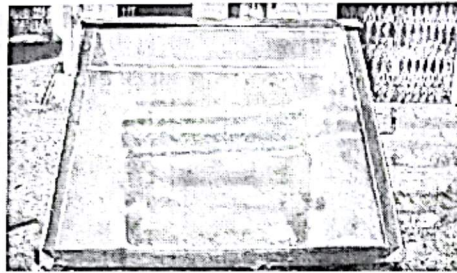


Fig (4) Photograph of Solar Water Heating System

The incoming rays from the sun pass through the glass of the front surface and fall on the reflectors. The reflectors focus to the rays and fall on the storage tank. The storage tank absorbs these solar radiations and convert it to heat naturally. When the storage tank is heated, water in the pipe is boiled. When that water is boiled, any dissolved materials such as salt, bacteria, calcium and iron are remained as solid while the pure water converts to a much lighter steam and is drawn out for condensation.

pH measurements

pH is a measure of how acidic (or) basic water. pH of less than 7 indicate acidity, whereas a pH level of greater than pH 7 indicates a alkaline (basic). pH is really a measure of the relative amount of free hydrogen and hydroxyl ions in the water. pH can be affected by chemicals in the water. So pH is an important indicator of water that is changing chemically. The pH of water determines the solubility and biological availability of chemical constituents such as nutrients (Phosphorus, Nitrogen, and Carbon) and heavy metals (lead, copper, Cadmium, etc). In the case of heavy metals, the degree to which they are soluble determines their toxicity. Metals tend to be more toxic at lower pH because they are more soluble.

The Electrical Conductivity of Water

The measurement of electrical conductivity has many uses. It is also used to determine the purity of water, as water's conductivity changes when it is impure. The electrical conductivity of water estimates the total amount of solids dissolved in water-TDS (Total Dissolved Solids), TDS is measured in ppm (parts

per million) or in mg/L. It is directly related to the concentration of salts dissolved in water. The electrical conductivity of the water depends on the water temperature: the higher the temperature, the higher the electrical conductivity of water increase by 2-3% for an increase of 1 degree Celsius of water temperature. Many EC meters nowadays automatically standardize the reading to 25°C.

Results and Discussion

Results

From the results of the present study, the comparison of the concentration of physical and chemical parameters contained in original tube-well water and distilled water samples with Canadian Recommendation limit is shown in table (2). The comparison of the concentration of each parameter contained in both original tube-well water and distilled water samples are shown in fig (5) to fig (15).

Discussion

In this research work, the content of some physicochemical parameters in tube-well water (W_1) and distilled tube-well water (W_2) were analyzed. These parameters are pH, EC, CO_3 , TDS and eight kinds of elements (Ca, Na, Mg, K, Fe, Cu, Zn and CL).

According to the comparison of pH value in two kinds of water samples, the pH value of original tube-well water (W_1) is lower than that of distilled tube-well water (W_2) and also is in the range of allowable limit of Canadian limit. The pH of water determines the solubility (amount that can be dissolved in the water). Low pH value will more dissolve metals and other substances. But, when pH level is high, the solubility of metals is less. So, it can be seen that the PH value of distilled water sample (W_2) is higher than water sample (W_1) which TDS level is low. In addition, its pH value is also higher than the maximum admissible limit of Canadian. High pH level causes a bitter taste and then water pipes.

From the comparison of the electrical conductivity (EC) value for both water samples (W_1) and (W_2), it is found that EC value of distilled water (W_2) is lower than that of natural tube-water (W_1). But, EC values for both water samples are higher than the admissible limit of Canadian. It is directly related to the concentration of salts dissolved in water. Therefore, people will suffer salty taste, if they drink these tube-well water.

By comparing the results of water samples, TDS value of distilled water (W_2) is less than that of tube-well water. But, TDS value of both water samples are much higher than the Canadian limit. TDS indicate the amount of chemical substances dissolved in water. At increasing levels, palatability decreases. Water that contains too much dissolved mineral matter is not satisfactory for certain uses. If the water contains less than 500 ppm of dissolved solids, it is generally satisfactory for domestic use and for

many industrial purposes. Drinking water with high concentration of TDS can not make people sick. Although there are no direct health concerns, TDS concentrations greater than 1200 mg/L cause a disagreeable taste. Some people can taste salt in drinking water at levels around 500mg/L. But water with extremely low TDS concentrations (eg. Rainwater) may also be unacceptable because of its flat taste.

Atomic Absorption Spectrometer(AAS) was used for the determination of elements such as Ca, Na, Mg, K, Fe, Cu and Zn in both water samples. The concentration amount of calcium and magnesium elements in distilled water are lower than that in original tube-well water. The content of these elements in both water samples is within the admissible limit of Canadian limit. Calcium and magnesium dissolved in water form deposits pipes and boilers as calcium carbonate, magnesium carbonate. Usually, when Ca, Mg elements contain too much, water is hard. This can be avoided with the water softeners. Excessive Ca and Mg may cause problems with laundering, washing and bathing. Calcium element is essential for living thing. But, a lack of Ca is one of the main causes of osteoporosis.

It is found that potassium element in distilled tube-well water (W_2) is also more contained than that in original tube-well water (W_1). For this element, Canadian allowable limit is 20mg/L. According to the analyzed data, the concentration level of this element for both water samples is less than the Canadian limit. It is an essential nutritional element. By comparing the iron content in both water samples, the concentration amount of iron element in water samples W_1 is lower than that in water sample W_2 . Canadian limit of this element is 0.10-0.30mg/L. The content of this element is in a range of Canadian limit. Drinking water with high concentrations of iron will not make people sick. Iron levels above 0.3mg/L can stain water pipes and cloths during washing.

The concentration amount of copper and zinc elements in both water samples are little different. In addition, the content of these elements in both water samples are much smaller than the Canadian limit. These elements are essential for human health. This elements will cause an undesirable taste if its concentrations are above the recommended limit.

From the results, it can be seen that the content of sodium element in both water samples are higher than the Canadian limit. But, the content of this element in distilled water is less than that in natural tube-well water. This element is only found in significant quantities in natural waters, due to the most abundant metallic ion in salt-water. Although there is no apparent hazard to people in good health, high concentration of sodium can suffer hypertension, congestive heart failure or heart disease.

The concentration amount of chlorine element in distill water is higher than that of natural water. But, CL element contained in original water is lower than the Canadian limit and that in W_2 is much higher than the Canadian limit. This element is a chemical that we commonly add to drinking water to kill most pathogens that can make us sick. So, a small amount of chlorine in water is good. High amounts of chlorine can irritate our skin and eyes if we touch it.

Conclusion

According to the comparison of analyzed data of distilled water and natural tube-well water samples, the content of all physical and chemical parameters in distilled water except the pH, Fe and CL are lower than that in natural tube-well water. Although the distilled water with low mineral is safe to drink, it can be negative taste characteristics to the water consumer. Even these are not considered to be health effects, they should be taken into account that consuming water of low mineral content had a negative effect on the water metabolism in the body. Moreover, levels of pH and TDS for both water samples are also higher than maximum admissible limit of the Canadian (pH 8). These water samples are considered to be basic (alkaline). The alkalinity of water is due to the carbonate, bicarbonate and hydroxide content. In spite of not finding CO_3 in original water, CO_3 is contained in distilled water. It may be due to the fact that distilled water does absorb carbon-dioxide when it is exposed to the air. It is observed that the content of mineral with TDS and EC value is decreased by distillation the original tube-well water. In conclusion, this study shows that the distilled water can arise the other negative effects except that it the more little salt taste and safe to drink.

Table (2) The comparison of Physical and chemical parameters contained in original tube-well water and distilled water samples with Canadian limit.

Sr. no	Description	pH	EC (dS/m)	ppm (parts per million)									
				Ca	Na	Mg	K	Fe	Cu	Zn	CO ₃	CL	TDS
1	W ₁	7.47	6.43	26.04	1381.0	62.83	17.11	0.2104	0.0294	0.0743	Nil	210.24	4578.0
2	W ₂	8.44	6.06	1.419	697.1	27.76	16.54	0.2313	0.0241	0.0670	102.48	900.48	3605.0
Allowable limit for drinking water by Canadian limit		6.5-8.0	0.25-0.75	75-250	200.0	50-125	20.0	0.10-0.30	1.00	5.0-10.0	350.0	250.0	Less than 500

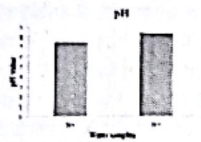


Fig (5) The comparison of pH concentration in tube-well water (W₁) and distilled water (W₂) samples

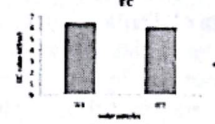


Fig (6) The comparison of electrical conductivity in tube-well water (W₁) and distilled water (W₂) samples

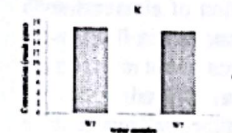


Fig.(11) The comparison of potassium concentration in tube-well water (W₁) and distilled water (W₂) samples

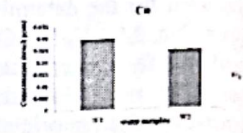


Fig.(12) The comparison of copper concentration in tube-well water (W₁) and distilled water (W₂) samples

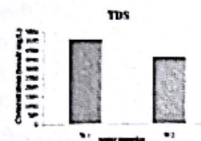


Fig.(7) The comparison of total dissolve solid in tube-well water (W₁) and distilled water (W₂) samples

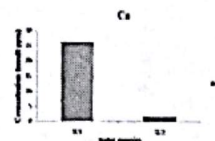


Fig.(8) The comparison of calcium concentration in tube-well water (W₁) and distilled water (W₂) samples

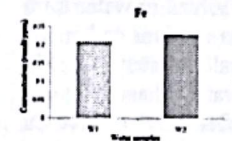


Fig.(13) The comparison of iron concentration in tube-well water (W₁) and distilled water (W₂) samples



Fig.(14) The comparison of zinc concentration in tube-well water (W₁) and distilled water (W₂) samples

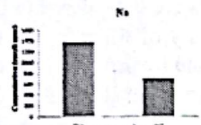


Fig.(9) The comparison of sodium concentration in tube-well water (W₁) and distilled water (W₂) samples

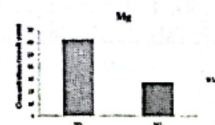


Fig.(10) The comparison of magnesium concentration in tube-well water (W₁) and distilled water (W₂) samples

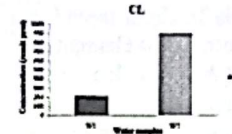


Fig.(15) The comparison of chlorine concentration in tube-well water (W₁) and distilled water (W₂) samples.

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PHY 021

Arduino-based Air Quality Detection System

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Abstract

In this research, the designed and constructed air monitoring system is discussed. Air pollution sensor and carbon dioxide gas sensor are used as the input unit. The Arduino Uno board, the control unit which controls between input sensors and output display. The digital output from air pollution sensor gives the presence of air pollution in the surrounding area. The carbon dioxide gas sensor measures the CO₂ concentration as ppm. The analog to digital converter converts the analog voltage output from carbon dioxide sensor to digital value. The results of carbon dioxide concentration and air pollution status are displayed on liquid crystal display screen. The light emitting diode bar-graph indicates the status of air pollution. The constructed system can be used to monitor the air quality in greenhouse projects, airport, underground car parks, health care center, etc.

Keywords: Carbon dioxide sensor, Air pollution sensor, Arduino, Liquid crystal display

Introduction

Air pollution occurs when gasses particles, and biological molecules are introduced into Earth's atmosphere. It may cause diseases, allergies and death to humans; it may also cause harm to living organisms such as animals and food crops, and may damage the natural environment. Both human activity and natural processes can make air pollution. Increasing the percentage of carbon dioxide gas in the air causes suffocation of living organisms as well as global warming that threaten the existence of life on the planet, very high concentration of carbon dioxide gas causes narcosis.

Air pollution sensors are devices that sensed and monitor the presence of air pollution in the surrounding area. They can be used for environment. These sensors can be put up at home, or bought from certain manufactures. Although there are many types of air pollution sensors, and some are specialized in certain aspects, the majority focuses on five components: ozone, particulate matter, carbon monoxide, sulfur dioxide, and nitrous oxide. The sensors were expensive in the past, but with technological advancements these sensors are becoming more affordable and more widespread throughout the population. These sensors can serve many purposes and help bring attention to environmental issues beyond the scope of the human eye. A carbon dioxide sensor is an instrument for the measurement of carbon dioxide gas. The most common principles for CO₂ sensors are infrared gas sensors (NDIR) and chemical gas sensors. Measuring carbon dioxide is main in monitoring indoor air quality, the function of the lungs, and many industrial processes.

Scope of Work

The air quality monitoring system is constructed by using Arduino Uno board and two sensors, Liquid Crystal Display (LCD) and Light Emitting Diodes (LED). The control unit of the system is Arduino Uno board. The system determines the carbon dioxide gas in air surrounding system and also measured the air pollution. The carbon

dioxide in air is measured as parts-per-million (ppm) unit. The air pollution is determined and displayed as four commands on LCD, that are clean air, slightly pollution, moderate pollution and heavily pollution. And four statuses are also displayed as four LEDs, that are white, green, yellow and red colours.

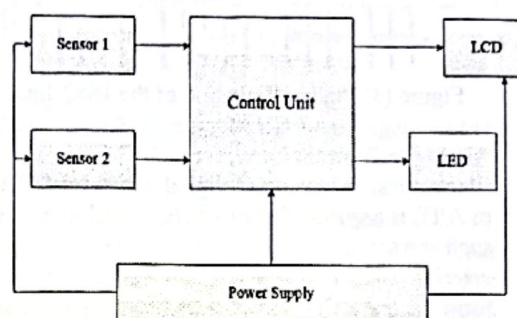


Figure (1) Block diagram of the constructed system

Electronic Devices Used in This Work

Arduino Uno Board

The Arduino Uno is a microcontroller board based on the ATmega328 and it has 14 digital input/output pins (of which 6 can be used as PWM output), 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button. The Arduino contains everything needed to provide the microcontroller; simply connect it to a computer with a USB cable or power it with a AC to DC adapter or battery to get started. The Arduino also has 2 KB of SRAM and 1 KB of EEPROM.

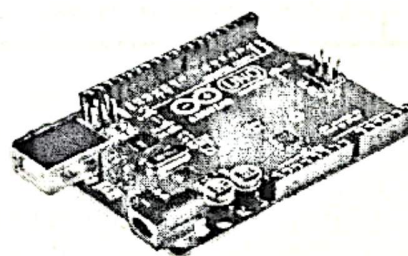


Figure (2) The photograph of Arduino Uno Board

Liquid Crystal Display (LCD)

A Liquid Crystal Display (LCD) is an electronic device that can be used to show numbers, texts, and measurement data. There are two main types of LCD, numeric displays and alphanumeric text displays. The most popular one is 16×2 LCD display module. It has 2 rows and 16 columns. The module has built-in controller, character generator RAM/ROM and driver. LCD module runs 4-bit or 8-bit parallel interface and writes data directly. The LCD (LCD) module conforms to standard eight-data lines, three control lines and five power lines. These connections are laid out a single row of 16 pins.

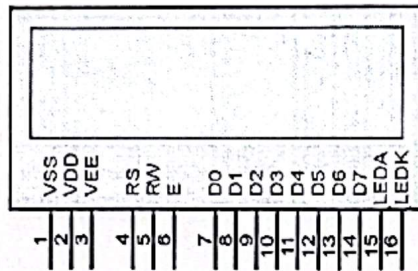


Figure (3) Pin configuration of the 16×2-line LCD Module

Analog to Digital Converter (ADC)

Electronics, an analog-to-digital converter (ADC or A/D) is a system that converts an analog signal, such as a sound picked up by a microphone or light entering a digital camera, into a digital signal form. An ADC may also provide an isolated measurement such as an electronic device that converts an input analog voltage or current to a digital form representing the magnitude of the voltage or current. Typically the digital output is a two's complement binary number, that is proportional to the input, but there are other possibilities, as shown in fig (4), two bits Analog to Digital Converter (ADC).

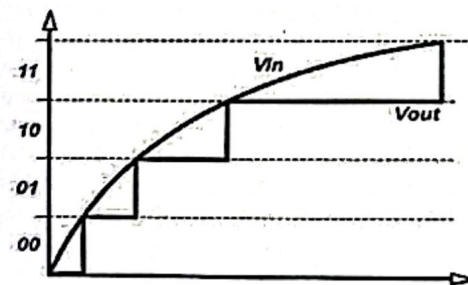


Figure (4) Analog input voltage and digital output voltage

Carbon Dioxide (CO₂) Care Sensor

A carbon dioxide sensor is an instrument for the measurement of carbon dioxide gas. The most common principle for A carbon dioxide sensor (CO₂) sensors are infrared gas sensors (NDIR) and chemical gas sensors. This sensor module has an MG-811 onboard as the sensor component. There is an onboard signal conditioning circuit for

amplifying output signal and an onboard heating circuit for heating the sensor. The MG-811 is highly sensitive to carbon dioxide and less sensitive to alcohol and CO. It could be used in air quality control, ferment process, in-door air monitoring application. The output voltage of the module decreases as the concentration of the CO₂ increases.

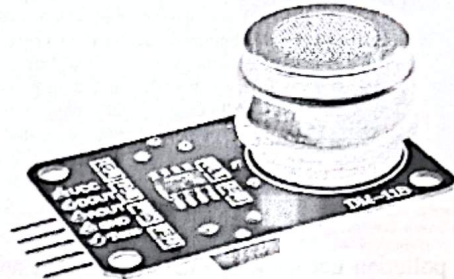


Figure (5) CO₂ gas sensor module

Air Quality Detection Sensor (ZP07-MP503)

Air pollution sensor is a device that detects and monitors the presence of air pollution in the surrounding area. It can be used for both indoor and outdoor environments. These sensors can be built at home or bought from certain manufactures.

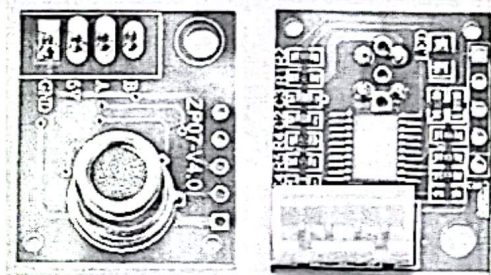


Figure (6) Air quality detection module

Light Emitting Diode (LED)

The light emitting diode (LED) is a p-n junction diode. LED is a specially doped diode and made up of a special type of semiconductors. When the light emits in the forward biased, so it is called as a light emitting diode.

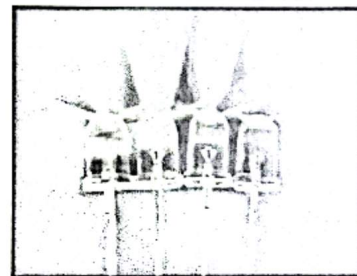


Figure (7) light emitting diode (LED)

Design and Construction of the System

Construction of two Input Sensors with Arduino

The research is going to construct the air quality monitoring system so that the input two sensors are used. One sensor is MG-811 CO₂ care sensor

and the other is ZP07-MP503 air pollution sensor. The control board is Arduino Uno board. Voltage output of CO₂ sensor from Arduino is connected to A0 pin (analog to digital converter) of Arduino. The two digital output pins of air pollution sensors are connected to pin 13 and pin 2 of Arduino. The data from two sensors are received from Arduino and then it performs the calculation for carbon dioxide concentration as ppm. Both LED and the LCD display the state of air pollution. The LCD screen also displays the CO₂ concentration. Fig (8) is the two input sensors with Arduino.

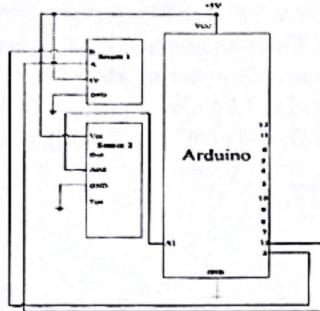


Figure (8) The air quality detection sensor and CO₂ gas sensor with Arduino

Construction of Arduino with Liquid Crystal Display (LCD) and Light Emitting Diodes (LEDs) array

To display the data from the system, 16×2 line LCD is parallel interfacing with Arduino. The LCD can be controlled in two modes: 8 bit and 4 bit. In this research, 4 bit data bus is used via D4 to D7 data line. For write operation to LCD, the R/W pin is grounded. The enable (EN) pin is used to send the enable trigger to LCD. Register select (RS) pin controls where in LCD memory to write the data. The 10k potentiometer is needed to adjust the contrast of the LCD. The backlight of LCD is activated if +5V supply is provided to pin 15, cathode pin and pin 16 is grounded. Then, power is up to the Arduino. The LCD screen provides as a data display screen by interfacing with Arduino. The four LEDs bargraph indicates the air pollution. These LEDs with grounded current limiting resistor are connected to digital output pins of Arduino.

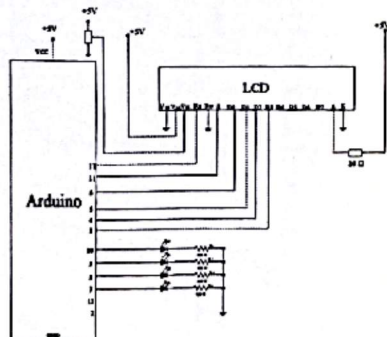


Figure (9) The Arduino with Liquid Crystal Display (LCD) and Light Emitting Diode (LED) bargraph.

Construction of the Whole System

The Arduino Uno is open source microcontroller board and it is equipped with sets of digital and analog pins, various input sensors. To construct the air monitoring system, the two sensors are interfaced with ADC pin and two digital input pins. The CO₂ sensor measures the CO₂ concentration and air pollution sensors monitor the fresh air system. The monitoring datas are displayed on liquid crystal display LCD and so the output section consists both LCD screen with light emitting diode arrays. These four colored LEDs bar graph is connected to the digital output pin of Arduino.

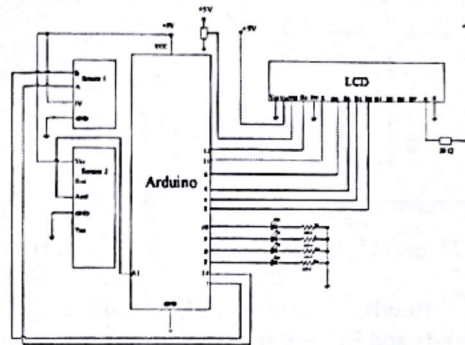


Figure (10) The complete circuit arrangement for constructed system

The Flowchart Section of the System

Firstly, the LCD is initialized. Declare the input and output pin. Then read the carbon dioxide sensor value. The analog voltages from the sensors are converted to digital value from ADC converter. Then calculate the carbon dioxide value as ppm and the result is displayed on LCD screen. Again, read the air pollution data from digital input pins. The program tests which data is arrived. If the data output value of sensor is "Low, Low", then display 'Clear air' on LCD and white LED from pin 7 is ON. If digital values are "Low, High" the words 'Slightly polluted' is appeared on LCD and green LED from pin 8 is ON.

The Yellow LED from pin 9 is ON for 'Moderately polluted' whether the digital value is equal to "High and Low". The data is equal to "High and High" then the red LED from pin 10 is ON and then 'Heavily polluted' message is emerged from LCD screen. The output "High, Low" states of two sensors give the gas pollution concentration shown in table (1).

Table (1) Two output states from air pollution sensor

Pollution grade	Output A	Output B	Pollution Gas concentration
0	0V	0V	Clean air
1	0V	5V	Slightly polluted air
2	5V	0V	Moderately polluted air
3	5V	5V	Heavily polluted air

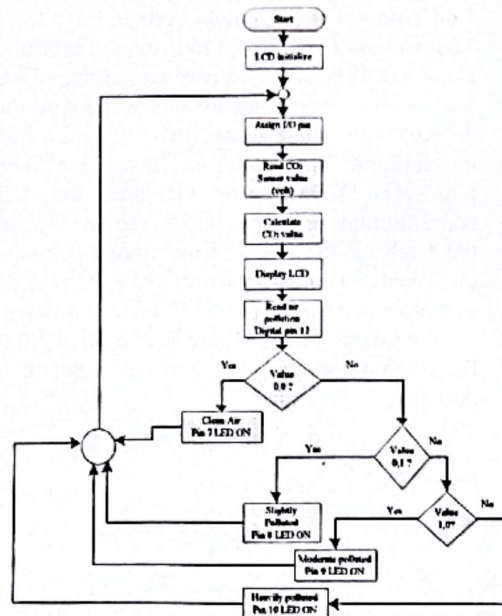


Figure (11) Flowchart of the main program

Results, Discussion and Conclusion

Results and Discussion

The MG-811 CO₂ sensor and ZP07-MP503 air quality detection sensor are used in this research. The control unit is Arduino Uno board. The MG-811 CO₂ sensor module is used to measure the carbon dioxide in air. The output voltage of the module falls as the concentration of carbon dioxide increases. The MG-811 module has highly sensitive to carbon dioxide.

MG-811 sensor gives an output range of 100-600 mV (400 to 10000 ppm CO₂). The output voltage of sensor in clean air (about 400 ppm) is in the range of 500 mV -600 mV. The analog to digital converter A0 pin of Arduino detects the analog output voltage from CO₂ gas sensor and then calculates the carbon dioxide as ppm and display on LCD. Carbon dioxide (CO₂) is lower than 800 ppm is the acceptable indoor air quality. The CO₂ 5000 ppm is the average exposure limit over 8 hours. Concentration of CO₂ between 6000-3000 ppm is a short exposure only. The carbon dioxide (CO₂) concentration is greater than 20 %, its effect is unconsciousness.

In our constructed system, another air quality detection sensor used is ZP07-MP503 air detection module. The sensor is very high sensitivity to organic gases such as formaldehyde, benzene, carbon monoxide, hydrogen, alcohol, ammonia, smoke of cigarette. The sensor is a semiconductor gas sensor and good sensitivity. The output signal pins (A and B) of air quality sensor are inputted to Arduino digital input pins 13 and 2. The four output "1, 0" states of two sensors give the gas pollution concentration shown in table (1).

Fig (12) is the photograph of the front panel of the constructed system with two sensors. Fig (13) is the photograph of circuit connection between

Arduino, sensors, LCD and LED. If the state of the air is clean, the air quality sensor generates the output data (Low, Low) states. In this normal state, the system operates to lighting up the white LED and then appear "clean air" message on LCD. It is shown in Fig (14). Fig (15) shows the photograph of system in which green LED is lighting up and LCD display the words 'CO₂ 553 ppm' and "slightly polluted".

When cigarette smoking, the air is slightly polluted. In this case, the smoke of cigarette is sensed by two sensors. Then the LCD displays the words "moderate polluted" and yellow LED is lit. In this states CO₂ in the air has 770 ppm. More fumes are released from cigarette, red LED lighting up and LCD display the words "CO₂ 838 ppm" and "heavily polluted".

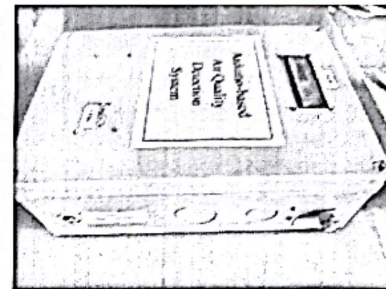


Figure (12) Photograph of front panel of the constructed system with two sensors

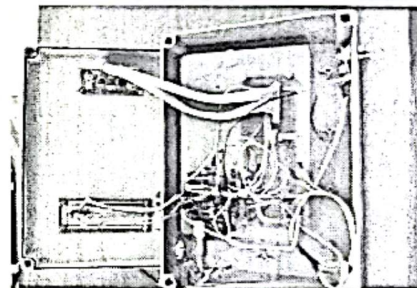
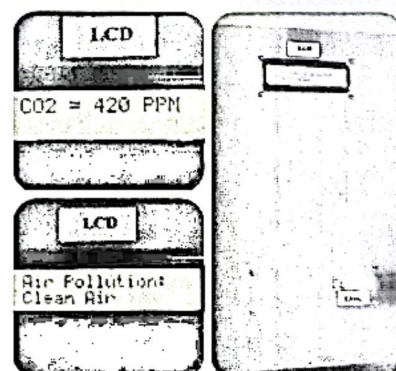


Figure (13) The photograph of circuit connection between Arduino, sensor, LCD,

Figure (14) The photograph of system in which white LED lighting up and LCD display the words 'CO₂ 420 ppm' and clean air.

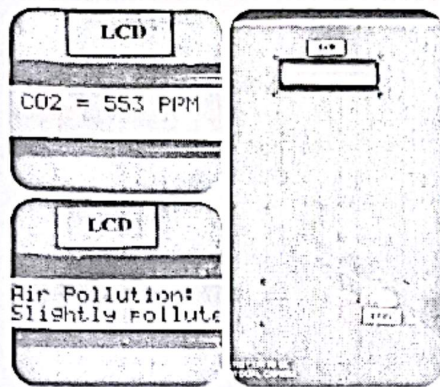


Figure (15) The photograph of system in which green LED lighting up and LCD display the words 'CO₂ 553 ppm' slightly polluted.

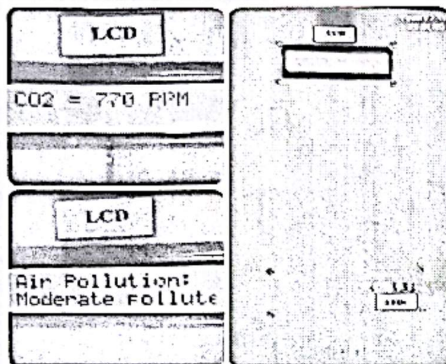


Figure (16) The The photograph of system in which yellow LED lighting up and LCD display the words 'CO₂ 770 ppm' moderately polluted.

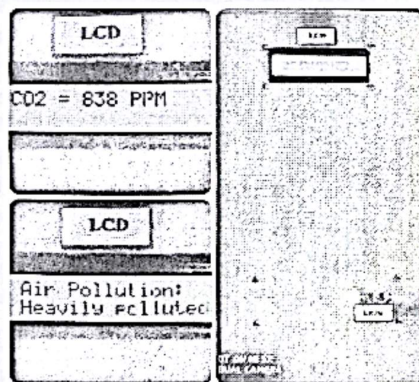


Figure (17) The photograph of system in which red LED lighting up and LCD display the words 'CO₂ 838 ppm' heavily polluted.

Conclusion

The carbon dioxide sensor and air quality sensor can be used to monitor air quality in underground car parks and tunnels, CO₂ measuring instruments for indoor air quality projects, greenhouse projects, CO₂ alarms in restaurants, bio-reactors, etc. The exact amount of CO₂ concentration is known, reducing CO₂ can be made to protect the earth.

Acknowledgements

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PHY 022

Existence of Atomic and Nuclear Hybrid State in $\Sigma^- - \text{Pb}$ System

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Khin Shwe Tint, Lecturer, Department of Physics, Yadanabon University

Khin Swe Myint, Emeritus Professor, Department of Physics, Mandalay University

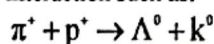
Abstract

The purpose of our research is to calculate the energy of hydrogen-like $\Sigma^- - \text{Pb}$ atom for various states by solving the Schrödinger equation. We assumed as $\Sigma^- - \text{Pb}$ atom is like an ordinary hydrogen atom in which the electron is replaced by a negative sigma hyperon. We also calculated the energy of hydrogen-like Pb^{81+} ionized atom with the above approximation. And then, we determined the radius of hydrogen-like $\Sigma^- - \text{Pb}$ atom to know about their structure. We found that the energy of hydrogen-like $\Sigma^- - \text{Pb}$ atom is greater than Pb^{81+} ionized atom for various orbits and the inclusion of sigma reduces the size of the atom in such a way the smaller radius is obtained. In addition, we observed that the radius of $\Sigma^- - \text{Pb}$ atom is less than nuclear radius for lower orbits. It is found that the existence of atomic state and nuclear state cannot be distinguished in lower orbits. In this way, the existence of atomic and nuclear hybrid state can be found in lower orbits of $\Sigma^- - \text{Pb}$ atom.

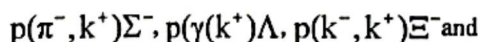
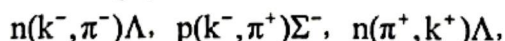
Keywords: energy of hydrogen-like atom, radius of hydrogen-like atom.

Introduction**Strange Particle Σ -hyperons**

The elementary particles are classified into three types. They are leptons, mesons and baryons. The leptons are electrons, photons, neutrino and muon. These particles have spin half. Mesons are the middle weight particles. The rest mass of these particles varies between $250 m_e$ and $1000 m_e$. The mesons are the agents of interaction between particles inside the nucleus. Pion, kaon and eta are mesons. The spin of these particles is zero. The proton and particles heavier than proton are known as baryons. Every baryon has an antiparticle. The baryon number B is +1 for baryons and -1 for antibaryons. In any closed system interaction or decay, the baryon number does not change. This is the law of conservation of baryons. A special class of baryons is hyperons. Hyperons are Λ , Σ , Ξ and Ω . Their masses are between those of the neutron and deuteron. The hyperons have odd half integer spin and have very short life times. Mesons and baryons are called hadrons. Kaon and hyperons have strange behavior. These particles are produced copiously. Their production time is about 10^{-23} sec, but their decay time is about 10^{-10} sec. They are produced by the strong force but they decay with the weak process. These particles are known as the strange particles. Their production in typical of strong interaction such as:

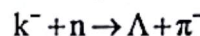


There are many elementary processes, $a + N \rightarrow Y + b$ which produce a hyperon on the nucleon target;



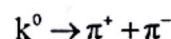
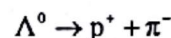
so on.

There are two hyperons production reactions; namely strangeness exchange reaction and associated production reaction. An example for strangeness exchange reaction is

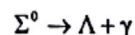


An example for the associated production reaction is $\pi^- + p^+ \rightarrow k^+ + \Sigma^-$

where two strange particles are produced simultaneously. Most of the strange particles decay with the weak process.



But some of these particles decay with the electromagnetic process.



For these particles, the strangeness number is specified by S . The strangeness number $S=+1$ for kaon, $S=-1$ for lambda (Λ), sigma (Σ), antikaon ($\bar{k}$), $S=-2$ for xi (Ξ) and $S=-3$ for omega (Ω). The strangeness number is conserved in strong and electromagnetic interaction. But it is not conserved in weak interaction. Because of the hyperon's different nature from a nucleon, a hyperon can be used as a probe to investigate the low-lying levels of nuclei in which the hyperon is not forbidden by Pauli exclusion principle. The information concerning inner region of nuclei and also nucleon-hyperon interaction can be extracted from hypernuclear study. This field of study has attracted many attentions of scientists among the hyperon, Λ -hypernuclei are studied extensively and there are rich information on ΛN interaction and Λ hypernuclear structure. But it is only an early stage for Σ and Ξ hypernuclear study.

In 1964, sigma baryons were first seen in nuclear emulsions. Their mass is $\sim 1200 \text{ MeV}/c^2$. In decay, single charged particle is seen with unique energy, so only one neutral is involved as follow:

$$\Sigma^+ \rightarrow p\pi^0$$

$$\Sigma^+ \rightarrow n\pi^+$$

$$\Sigma^- \rightarrow n\pi^-$$

While Σ^+ can decay into two channels, Σ^- can decay through only one way. The mass of Σ^+ and Σ^- is not equal. The existence of a Σ^0 hyperon was predicted by Gellmann and Nishijima. Thus Σ particles form in isospin triplet Σ^+ , Σ^0 , Σ^- with $T = 1$, $T_z = 1, 0, -1$ respectively. The means life times of Σ^+ , Σ^0 and Σ^- are $8.02 \times 10^{-11} \text{ s}$, $\sim 10^{-14} \text{ s}$ and $1.49 \times 10^{-10} \text{ s}$ respectively. Spin of sigma is half. Σ hypernuclei are nuclei which contain at least one sigma hyperon.

Hydrogen-Like Atom

The hydrogen atom is a simple mathematical problem in quantum mechanics, but any atom with more than one electron is difficult that an exact solution is impossible. For the two-electron atom, helium, very elaborate approximate solution have been set up by Hylleraas, which gives result agreeing with experimental error. This agreement has convinced physicists that Schrödinger's equation for the many-body problem provides the correct starting point for a study of more complicated atoms. But the method used for helium is too complicated to apply to atoms with more than two electrons and the approximations must be made for many electron atoms. A good starting point is provided by assuming that each electron moves in a central or spherically symmetrical, force field, produced by the nucleus and other electrons.

The alkali atoms are approximately hydrogen like. They all have one valence electron. It will suffice to say that $(Z-1)$ of the electrons are arranged in closed shells. So far as the electric field outside the closed shells is concerned, the nuclear charge $+Ze$, shielded by the $(Z-1)$ electron carrying a charge of $-(Z-1)e$, is equivalent to $+e$, the same as the hydrogen atom. Thus the valence electron is essentially in a hydrogen-like field. However, inside the closed shells the shielding effect of $(Z-1)$ electrons becomes less and less as

we approach the centre and eventually becomes zero in the region just outside the nucleus. For large r the valence electron has an electrostatic potential $-e^2/r$, this expresses the fact that the nuclear charge $+Ze$ is screened by the core of $(Z-1)$ electrons. For small r , potential approaches $-Ze^2/r$ corresponding to an unscreened nucleus. Overall, the electrostatic attraction towards the nucleus is always greater than for hydrogen.

The spectra of all atoms or ions with only one electron should be the same except for the factor Z^2 and the Rydberg number. The spectrum of hydrogen should thus explain those of the ions He^+ , Li^{2+} , Be^{3+} or any other ions which have only one electron. For Li^{2+} , Be^{3+} and still heavier highly ionized atoms, spectral lines have been observed which can be calculated by multiplying the frequencies of the lines of the H atom by Z^2 and insertion of the corresponding Rydberg constant. In 1916, the collected spectroscopic experience concerning the hydrogen-similarity of these spectra was generalized in displacement theorem of Sommerfeld and Kossel, which states: the spectrum of any atom is very similar to the spectrum of the singly charged positive ion which follows it in the periodic table.

Hydrogen-like heavy atoms are the heavy atoms from which all the electrons except one have been removed. Hydrogen-like heavy atoms can be prepared by accelerating the singly-ionized atoms to high energies and passing them through a thin foil; their electrons are "stripped off" on passing through the foil. For example, in order to strip all the electrons from a uranium atom and produce U^{92+} ions, they must be accelerated to energies greater than 10 GeV. By permitting the U^{92+} ions to recapture one electron each, one can then obtain hydrogen-like ion U^{91+} . The corresponding spectral lines are emitted as the captured electron makes transitions from orbits of high n to lower orbits. In present work, we

assumed above approximation, a $\Sigma^- - \text{Pb}$ atom is like an ordinary hydrogen atom in which the electron is replaced by a negative sigma. We calculated the energy of hydrogen-like Pb^{81+} ionized atom and $\Sigma^- - \text{Pb}$ atom for various states by solving the Schrodinger equation. And then, we also calculated the radii of $\Sigma^- - \text{Pb}$ atom to know about their structure.

Solving the Schrödinger Equation for Hydrogen Atom

The Schrödinger equation for the hydrogen atom is

$$-\frac{\hbar^2}{2\mu} \nabla^2 \psi + V\psi = E\psi \quad (1)$$

$$\left[\nabla^2 + \frac{2\mu}{\hbar^2} (E - V) \right] \psi = 0 \quad (2)$$

Where the potential energy V of the electron in the hydrogen atom is

$$V(r) = -\frac{Ze^2}{4\pi\epsilon_0 r} \quad (3)$$

$$\nabla^2 = \left[\frac{1}{r^2} \frac{\partial}{\partial r} \left(r^2 \frac{\partial}{\partial r} \right) + \frac{1}{r^2 \sin\theta} \frac{\partial}{\partial \theta} \left(\sin\theta \frac{\partial}{\partial \theta} \right) + \frac{1}{r^2 \sin^2\theta} \frac{\partial^2}{\partial \phi^2} \right] \quad (4)$$

Substitution equation (4) into equation (2)

$$\frac{1}{r^2} \frac{\partial}{\partial r} \left(r^2 \frac{\partial \psi}{\partial r} \right) + \frac{1}{r^2 \sin\theta} \frac{\partial}{\partial \theta} \left(\sin\theta \frac{\partial \psi}{\partial \theta} \right) + \frac{1}{r^2 \sin^2\theta} \frac{\partial^2 \psi}{\partial \phi^2} + \frac{2\mu}{\hbar^2} [E - V(r)] \psi = 0 \quad (5)$$

The wave function ψ is variable-seperable, i.e, ψ can be written as

$$\psi(r, \theta, \phi) = P(\theta)Q(\phi)R(r) \quad (6)$$

where $P(\theta)$ is a function of θ only, $Q(\phi)$ of ϕ only and $R(r)$ of r only.

Substitution equation (6) into equation (5)

$$\frac{P(\theta)Q(\phi)}{r^2} \frac{\partial}{\partial r} \left(r^2 \frac{\partial R(r)}{\partial r} \right) + \frac{R(r)Q(\phi)}{r^2 \sin\theta} \frac{\partial}{\partial \theta} \left(\sin\theta \frac{\partial P(\theta)}{\partial \theta} \right) + \frac{P(\theta)R(r)}{r^2 \sin^2\theta} \frac{\partial^2 Q(\phi)}{\partial \phi^2} + \frac{2\mu}{\hbar^2} [E - V(r)] P(\theta)Q(\phi)R(r) = 0 \quad (7)$$

Dividing by $P(\theta)Q(\phi)R(r)$ on both sides,

$$\frac{1}{R(r)r^2} \frac{\partial}{\partial r} \left(r^2 \frac{\partial R(r)}{\partial r} \right) + \frac{1}{P(\theta)r^2 \sin\theta} \frac{\partial}{\partial \theta} \left(\sin\theta \frac{\partial P(\theta)}{\partial \theta} \right) + \frac{2\mu}{\hbar^2} [E - V(r)] = -\frac{1}{Q(\phi)r^2 \sin^2\theta} \frac{\partial^2 Q(\phi)}{\partial \phi^2} \quad (8)$$

Multiplying equation (8) by $r^2 \sin^2\theta$, we get

$$\frac{\sin^2\theta}{R(r)} \frac{d}{dr} \left(r^2 \frac{dR(r)}{dr} \right) + \frac{\sin\theta}{P(\theta)} \frac{d}{d\theta} \left(\sin\theta \frac{dP(\theta)}{d\theta} \right) + \frac{2\mu r^2 \sin^2\theta}{\hbar^2} [E - V(r)] = -\frac{1}{Q(\phi)} \frac{d^2 Q(\phi)}{d\phi^2} \quad (9)$$

According to equation (9), the R. H. S and L. H. S should equal to some arbitrary constant and we use m_l^2 .

Therefore R. H. S of equation (9) becomes

$$-\frac{1}{Q(\phi)} \frac{d^2 Q(\phi)}{d\phi^2} = m_l^2 \quad (10)$$

Similarly, L. H. S of equation (9) becomes

$$\frac{\sin^2\theta}{R(r)} \frac{d}{dr} \left(r^2 \frac{dR(r)}{dr} \right) + \frac{\sin\theta}{P(\theta)} \frac{d}{d\theta} \left(\sin\theta \frac{dP(\theta)}{d\theta} \right) + \frac{2\mu r^2 \sin^2\theta}{\hbar^2} [E - V(r)] = m_l^2 \quad (11)$$

Dividing equation (11) by $\sin^2\theta$, we get

$$\frac{1}{R(r)} \frac{d}{dr} \left(r^2 \frac{dR(r)}{dr} \right) + \frac{2\mu r^2}{\hbar^2} [E - V(r)] = \frac{m_l^2}{\sin^2\theta} - \frac{1}{P(\theta) \sin\theta} \frac{d}{d\theta} \left(\sin\theta \frac{dP(\theta)}{d\theta} \right) \quad (12)$$

Similarly, L. H. S and R. H. S should equal to some arbitrary constant.

Therefore, the R. H. S of equation (12) becomes

$$\frac{m_l^2}{\sin^2\theta} - \frac{1}{P(\theta) \sin\theta} \frac{d}{d\theta} \left(\sin\theta \frac{dP(\theta)}{d\theta} \right) = L^2 \quad (13)$$

and L. H. S becomes

$$\frac{1}{R(r)} \frac{d}{dr} \left(r^2 \frac{dR(r)}{dr} \right) + \frac{2\mu r^2}{\hbar^2} [E - V(r)] = L^2 \quad (14)$$

Substitution the potential term

$$V(r) = -\frac{Ze^2}{4\pi\epsilon_0 r} \quad (15)$$

We obtain the equation

$$\frac{1}{R(r)} \frac{d}{dr} \left(r^2 \frac{dR(r)}{dr} \right) + \frac{2\mu r^2}{\hbar^2} \left[\frac{Ze^2}{4\pi\epsilon_0 r} + E \right] = L^2 \quad (16)$$

By multiplying with $\frac{R(r)}{r^2}$, equation (16) becomes

$$\frac{1}{r^2} \frac{d}{dr} \left(r^2 \frac{dR}{dr} \right) + \left[\frac{2\mu}{\hbar^2} \left(\frac{Ze^2}{4\pi\epsilon_0 r} + E \right) - \frac{\ell(\ell+1)}{r^2} \right] R(r) = 0$$

Since the reduce mass $\mu = m$, multiplying with $\frac{\hbar^2}{2m}$, we get

$$\frac{\hbar^2}{2m} \frac{1}{r^2} \frac{d}{dr} \left(r^2 \frac{dR}{dr} \right) + \left(\frac{Ze^2}{r} + E \right) R - \frac{\hbar^2}{2m} \frac{\ell(\ell+1)}{r^2} R = 0 \quad (17)$$

where $4\pi\epsilon_0 = 1$ in atomic unit.

After solving mathematical steps, we obtain the energy of electron for the n^{th} orbit.

$$E_n = -\frac{Z^2 m e^4}{2\hbar^2} \frac{1}{n^2} \quad (18)$$

where, E_n = the total energy of the electron

m = mass of electron

$$\hbar = \frac{h}{2\pi} \quad (h = \text{Planck constant})$$

e = electron charge

$n = 1, 2, 3, \dots$

We calculated the energy levels of hydrogen-like Pb^{81+} ionized atom and $\Sigma^- - \text{Pb}$ atom by using the above equation.

Calculation of the Radius for Hydrogen Atom

The Coulomb force between a stationary nucleus with charge $+Ze$ and an orbiting electron with charge $-e$ is

$$F = -\frac{kZe^2}{r^2} \quad (19)$$

From Newton's second law of motion, the centripetal force

$$F = -\frac{mv^2}{r} \quad (20)$$

From equation (19) and equation (20)

$$mv^2 = \frac{kZe^2}{r} \quad (21)$$

But, from Bohr's postulate

$$mvr = n\hbar$$

$$v^2 = \frac{n^2 \hbar^2}{m^2 r^2} \quad (22)$$

Substituting the equation (22) into equation (21)

we get the radius of electron for the n^{th} orbit.

$$r_n = \frac{n^2 \hbar^2}{mkZe^2} \quad (23)$$

Where, r_n = the radius of the circular orbit

m = mass of electron

v = velocity of electron

k = constant = $9 \times 10^9 \text{ Nm}^2 \text{ C}^{-2}$

$$\hbar = \frac{h}{2\pi} \quad (h = \text{Planck constant})$$

e = electron charge

$n = 1, 2, 3, \dots$

By using the above equation, we calculated the radius of hydrogen-like Pb^{81+} ionized atom and $\Sigma^- - \text{Pb}$ atom for various orbits.

Results and Discussions

The Energy of Hydrogen-Like Pb^{81+} ionized atom and $\Sigma^- - \text{Pb}$ atom

Hydrogen-like heavy atoms are the heavy atoms from which all the electrons except one have been removed. We assumed as $\Sigma^- - \text{Pb}$ atom is like an ordinary hydrogen atom in which the electron is replaced by a negative sigma hyperon. And then we calculated the energy of hydrogen-like Pb^{81+} ionized atom and $\Sigma^- - \text{Pb}$ atom for various states by solving the Schrödinger equation. From these results, we observed that the energy of $\Sigma^- - \text{Pb}$ atom is greater than Pb^{81+} ionized atom for each orbits. The higher the orbit, the greater the energy for these atoms. The calculated energy for these atoms is given in Table (1) and the energy levels of Pb^{81+} ionized atom as shown in Figure (1). Then the energy levels $\Sigma^- - \text{Pb}$ atom as shown in Figure (2).

The Radius of Hydrogen-Like Pb^{81+} ionized atom and $\Sigma^- - \text{Pb}$ atom

And then we also calculated the radius of hydrogen-like Pb^{81+} ionized atom and $\Sigma^- - \text{Pb}$ atom as given in Table (2). In our calculation, the radius of $\Sigma^- - \text{Pb}$ atom is very smaller than Pb^{81+} ionized atom for each orbit. The higher the orbits, the greater the size of these atoms. The inclusion of sigma reduces the size of the atom in such a way the small radius is obtained. Moreover, we found that the radius of $\Sigma^- - \text{Pb}$ atom is less than the nuclear radius for lower orbit. Therefore, the existence of atomic state and nuclear state are mixture. The mixture of the atomic state and

nuclear state is called hybrid state. So we cannot distinguish the existence of the atomic state or the nuclear state of hydrogen-like $\Sigma^- - \text{Pb}$ atom for lower orbits.

Table (1) Comparison between energy of Hydrogen-like Pb^{81+} ionized atom and $\Sigma^- - \text{Pb}$ atom for various orbits

Orbital quantum number	Energy (MeV)	
	Hydrogen-like Pb^{81+} ionized atom	Hydrogen-like $\Sigma^- - \text{Pb}$ atom
1	- 0.0909381	- 212.7120272
2	- 0.0227345	- 53.1780068
3	- 0.0101042	- 23.6346697
4	- 0.0056836	- 13.2519812
5	- 0.0036375	- 8.5084811
6	- 0.0025261	- 5.9086674

Table (2) Comparison between radii of Hydrogen-like Pb^{81+} ionized atom and $\Sigma^- - \text{Pb}$ atom for various orbits

Orbital quantum number	Radius (fm)	
	Hydrogen-like Pb^{81+} ionized atom	Hydrogen-like $\Sigma^- - \text{Pb}$ atom
1	647.5394	0.2768
2	2590.1576	1.1073
3	5827.8546	2.4915
4	10360.6304	4.4293
5	16884.8508	6.9209
6	23311.4185	9.9660

Conclusion

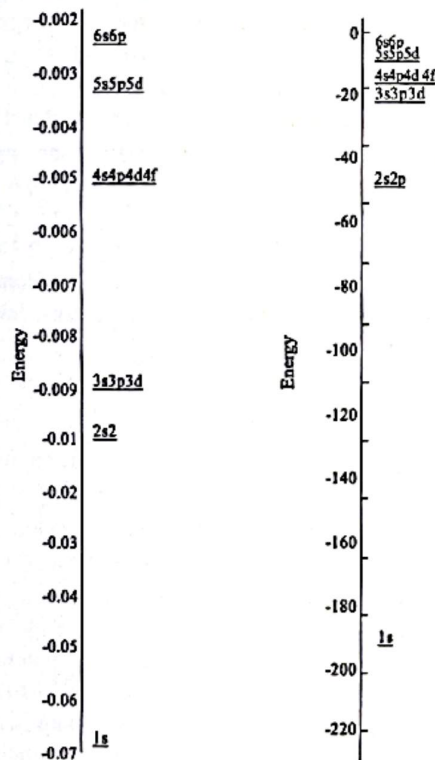
We calculated the energy of hydrogen-like Pb^{81+} ionized atom and $\Sigma^- - \text{Pb}$ atom for various states by solving the Schrödinger equation. And then, we also calculated the radii of hydrogen-like Pb^{81+} ionized atom and $\Sigma^- - \text{Pb}$ atom to know about their structure. In our calculation, we assumed as $\Sigma^- - \text{Pb}$ atom is liked an ordinary hydrogen atom in which the electron is replaced by a negative sigma hyperon. From the calculations, we concluded that the radius of $\Sigma^- - \text{Pb}$ atom is less than nuclear radius and we cannot distinguish the existence of atomic state and nuclear state (hybrid state).

Acknowledgement

I would like to thank all of my friends and member of the Theoretical Nuclear physics Group. I am greatly indebted to Dr Than Than Lwin, Professor, Head of Physics Department, Banmaw University for her encouragement.

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Construction of Concrete Source Holder for Radioactive Sources by Determining the Mass Attenuation Coefficients of Concrete Shield Made of Different Sand Grain Size

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Abstract

Nuclear shielding process is very important in nuclear laboratory. To protect nuclear radiation, concrete and lead and mica are commonly used for shielding purpose. Concrete slabs are made from mixture of sand having different grain size and cement. The ratios of mixture of sand and cement are 2:1, 1:2, 1:1, respectively. And then, the concrete source holder is constructed by determining mass attenuation coefficients of concrete slabs.

1. Introduction

Presently, heavyweight concrete is extensively used as a shield in nuclear plants and radio therapy rooms and for transporting and storing radioactive wastes. For this purpose, concrete must have high strength and high density. Heavyweight and high strength concrete can be used for shielding purposes if it meets the strength and radiation shielding properties. Such concrete that normally utilizes magnetite aggregates can have a density in the range 3.2–4 t/m³, which is significantly higher than the density of concretes made with normal aggregates. Since the aggregates significantly influence the properties of concrete, they also affect its radiation shielding properties. In radiation shielding, the nuclear attenuation properties of the shielding material control its selection. Heavyweight concrete currently used for the construction of radiation shielding properties contains special materials that are expensive and difficult to work with. Hematite and other iron ores are commonly used in the heavyweight and radiation shielding concrete. This paper explained and discussed the optimum mix design for normal concrete used for X-and gamma shielding. In this paper, the physical parameters of mixed concrete are studied. And then, absorption coefficients mixed concrete are investigated with different grain size of sand collected from Myitson, Balaminhin and Waimaw port in Myitkyina. Sample location map of study area is shown in Fig. 1.

2. Materials and Methods

2.1 Development of Concrete Absorber

Concrete is the most important engineering material and the addition or replacement of some of the materials may change the properties of the concrete. In recent years a lot of research work has been carried out in order to obtain more durable and long term performance of concrete structures in the dynamic environment. In this experimental study, concrete mixes of different proportions with sand and cement are prepared and measured the grain size, density and texture of concrete absorbers. Heavy weight and high strength concrete can be used for shielding purposes if it meets the strength and radiation shielding properties. Such concrete that normally utilizes magnetite aggregates can have a density in the range 3.2 - 4 t/m³, which is significantly higher than the density of concretes made with normal aggregates (Gencel et al. 2011) and (Gencel et al. 2012). In this paper, two kinds of materials, sand and cement are mainly used for concrete absorber. The sand samples are collected from Myitson, Bala Min Htin and Waimaw harbor in Myitkyina

Region. Comparison of sand samples seen by optical microscope are shown in Fig. 2.1. (a), (b) and (c). Comparison of Measurement of sand grain size are as shown in Fig. 2.2. (a), (b), (c). In this case, the grain size of sand sample collected from Myitson harbor is 0.33mm, 0.25mm from Bala Min Htin and 0.16mm from Wai Maw, respectively. The sand grain size is measured by Philip Harris optical microscope as shown in Fig. 2.1.1. Experimental setup of sand grain size is 0.33cm. To get concrete absorber, molds for cement paste are constructed with composite material as shown in Fig. 2.1.4 The size of the mold is 6.5 x 5.5 x 1 cm. Sand and cement are mixed thoroughly and then, water is poured on the mixture of sand and cement. The brand of the cement is Crown and conducted by Ngwe Yi Pale Cement Company Ltd, Myanmar. The ratios of mixed cement and water are as shown in Table. 2.1. SC means sand and cement, respectively. The ratios of sand and cement are 1:1, 1:2, 2:1, respectively. Concrete paste and molding of concrete are as shown in Fig. 2.1.5. They are dried for one day under room temperature. And then, they are released from mold after one day as shown in Fig. 2.1.6. Experimental setup of density measurement is shown in Fig. 2.1.7. (a), (b).

Table 2.1 . Sample Site , Sample Code and Number of Samples

Sample Site	Sample Code	SC 1:1 (Slab)	SC 1:2 (slab)	SC 2:1 (slab)	Water(g)
Myit Son	MSC	4	4	4	165.4
Bala Min Htin	BSC	4	4	4	165.4
Wai Maw	WSC	4	4	4	165.4



Fig.2.1.1 Philip Harris

Optical Microscope

Fig.2.1.2 Comparison of Sand Samples Seen by Optical Microscope

Optical Microscope



Fig.2.1.3 Comparison of Grain Size Measurement of Sand Samples

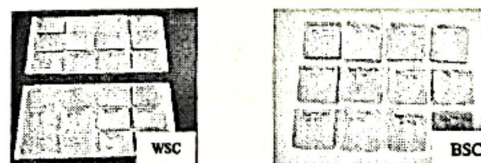


Fig.2.1.6. Concrete Absorbers after Drying Process



Fig. 2.1.4 Molds for Concrete Absorber



Fig. 2.1.5. Concrete Paste and Molding of Concrete Absorber



(a)



(b)

Fig. 2.1.7 Measurement of Concrete Volume (a) and Weight (b) for density

2.2 Experimental Setup and Measurement of Gamma Radiation

Concrete is by far the most widely used material for reactor shielding due to its cheapness and satisfactory mechanical properties. It is usually a mixture of hydrogen and other light nuclei and nuclei of fairly high atomic number (Ikraim et al. 2009). The aggregate component of concrete that contains a mixture of many heavy elements plays an important role in improving concrete shielding properties and therefore has good shielding properties for the attenuation of photons and neutrons (El-Sayed 2002) and (Akkurt et al. 2012). In this paper, absorption coefficients mixed concrete are determined by using GM counter and ^{137}Cs gamma source. Activity of ^{137}Cs is 1μ Curie. In decay process the energy of energetic gamma photon is 0.6662 MeV. Materials for radiation detection are shown in Fig.2.2.1 (a), (b), (c) and (d). Experimental setup is also shown in Fig.2.2.2. Firstly, operating voltage of GM counter is determined by changing the counter voltage. It is found that the operating voltage is 450V. And then, optimization of detector to sample distance, source to sample distance are investigated. It is found that source to sample is 1cm and sample to detector is 1cm. The transmitted gamma photon is measured with the counter.



Fig.2.2.1 . Materials for Radiation detection

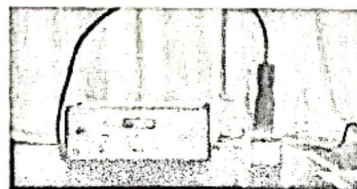


Fig.2.2.2 Experimental Setup of Radiation Detection

2.3 Construction of Radioactive Source Holder After investigation of absorption of concrete slabs

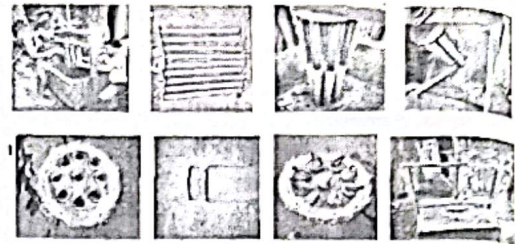


Fig. 2.3.3 Assembly of iron rod holders

Fig. 2.3.6 Source holders

(a)

(b)

Fig. 2.3.7 Complete installation of source holder in concrete shielding

with different sand grain size, concrete source holder is constructed as shown in the following steps:

- (1) Construction of iron box
- (2) Construction of control iron rods
- (3) Mixing sand and cement
- (4) Painting

Firstly, absorption coefficient of concrete slab is investigated and choose the grain size of sand sample with high absorption. In this case MSC is the best absorption compared with the other sample. So, MSC concrete sample is selected to construct the source holder. Secondly, concrete holder is constructed with iron slab (3mm). The size of concrete holder $2 \times 2 \times 2 \text{ ft}^3$. It is shown in figure 2.1.4. And then, source holder is constructed with solid iron rods as shown in figure 2.3.2. The rods are 8 inches in length and 1.5 inches in diameter. In this case, nine iron rods are assembled to hold the radioactive sources as shown in figure 2.3.3. To hold the rods conduit pipes are used and they are embedded in the concrete as shown in figure 2.1.4. Assembly of conduit pipe and source holder is shown in figure 2.3.5. At the tip of the iron rod the source holder is attached as shown in figure 2.3.6. Completion of source holder and concrete shielding is shown in figure 2.3.7 (a) and (b). Red oxide is painted the holder to protect oxidation. Finally, concrete shielding for radioactive source holder is successfully constructed as shown in figure 2.3.8.(a) and (b).

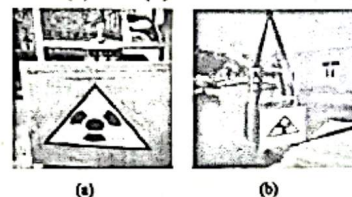


Fig. 2.3.8 Complete installation of source holder in URC, Monywa University.

3. Results and Discussion

Presently, heavyweight concrete is extensively used as a shield in nuclear plants and radio therapy rooms and for transporting and storing radioactive wastes. For this purpose, concrete must have high strength and high density. Heavyweight and high strength concrete can be used for shielding purposes if it meets the strength and radiation shielding properties. Such concrete that normally utilizes magnetite aggregates can have a density in

the range 3.2–4 t/m³, which is significantly higher than the density of concretes made with normal aggregates (Gencel et al., 2012, 2011). The main objective of the current research is to investigate the suitability of some concrete components for producing "high- performance heavy density concrete" by using different types of aggregates that could enhance the shielding efficiency against γ - rays.

3.1 Results of Mixed Concrete Density

To development the mixed concrete , the samples are collected from three places along the Irrawaddy River in Myitkyina Region ,Myanmar. Sample sites are Myitson Harbour , Bala Min Htin Harbour and Wai Maw Harbour. Sample site and sample code are shown in Table.2.1. Comparison of grain size of sand samples is also shown in Fig.2.1.1. In the figure, grain size of Myitson Sample is the biggest among the samples and that of grain size of sand from Wai Maw is the smallest compare with other sample. Densities of mixed concrete are shown in Table. 3.1. In Table 3.1., the density of mixed concrete treated with twice of cement is the highest in all sample. In this case, the sample having more cement absorbs more water rather than the other samples, it makes rise of density.

Table 3.1. Densities of Mixed Concrete

Sample Site	Sample Code	Density (g/cm ³)
Myitson	MSC 11	2.51
	MSC 12	2.56
	MSC 21	2.28
Bala Min Htin	BSC 11	2.3
	BSC 12	2.58
	BSC 21	2.06
Wai Maw	WSC 11	2.2
	WSC 12	2.5
	WSC 21	1.87

3.2 Results of Absorption Coefficients of Mixed Concrete

When gamma particles travel through matter, any interaction that occurs will be with the electrons in the substance. The higher the density of electrons, the more the gamma particles will attenuate. Measured data of count rate per minute for Myitson Concrete(MSC), BalaMin Htin Concrete (BSC) and Wai Maw (WSC) are shown in Table 3.2.1. , Table 3.2.2 and Table 3.2.3. The results of absorption coefficients of Myitson Concrete(MSC) are shown in Fig. 3.2.1 to Fig.3.2.3.

The results of absorption coefficients of Bala Min Htin Concrete(BSC) are shown in Fig.3.2.4 to Fig.3.2.6.. The results of absorption coefficients of Wai Maw Concrete(WSC) are also shown in Fig. 3.2.7 to Fig.3.2.9.

Table 3.2.1 Measured data of count rate per minute for Myitson Concrete(MSC)

Measurement of Count Rate of Gamma Radiation for Concrete Absorber (Myitson)			
Thickness x (cm)	Count rate/ min	Count rate/ min	Count rate/ min
1	SC-11	SC-12	SC-21
	69	74	65.5
	88.5	61	74
2	68	62	81
	56	51	47.5
	55.5	62	51.5
3	49.5	52.5	49
	46	45	39.5
	35.5	39.5	42.5
4	44.5	49.5	39.5
	30	31.5	32
	41	39.5	32.5
	37	42	35

Table 3.2.2 Measured data of count rate per minute for Bala Min Htin Concrete (BSC)

Measurement of Count Rate of Gamma Radiation for Concrete Absorber (Bala Min Htin)			
Thickness x (cm)	Count rate/ min	Count rate/ min	Count rate/ min
1	SC-11	SC-12	SC-21
	70	66	70.5
	77	54	65.5
2	70	76.5	71.5
	58.5	50	55
	53.5	64.5	52.5
3	51.5	53	57.5
	39.5	49.5	50.5
	44.5	45.5	41
4	48.5	46.5	36.5
	38	32	36
	36.5	36.5	45
	35	34	40

Table 3.2.3 Measured data of count rate per minute for Wai Maw (WSC)

Measurement of Count Rate of Gamma Radiation for Concrete Absorber (Wai Maw)			
Thickness x (cm)	Count rate/ min	Count rate/ min	Count rate/ min
1	SC-11	SC-12	SC-21
	70	69	71
	65.5	70.5	87.5
2	66.5	70.5	77.5
	59.5	53.5	66.5
	43.5	58	50.5
3	55	63	50.5
	40.5	43.5	43.5
	37	49.5	40.5
4	45	47	43.5
	37.5	40	31.5
	45.5	38.5	42
	40	31	36

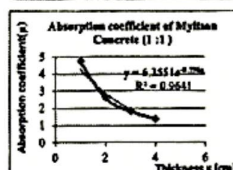


Fig. 3.2.1 Absorption coefficients of Myitson Concrete(MSC11)

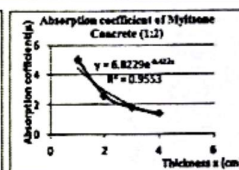


Fig. 3.2.2 Absorption coefficients of Myitson Concrete(MSC12)

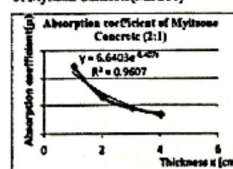


Fig. 3.2.3 Absorption coefficients of Myitson Concrete(MSC21)

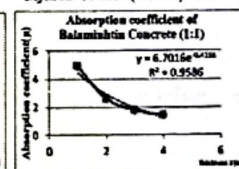


Fig. 3.2.4 Absorption coefficients of Bala Min Htin Concrete(BSC11)

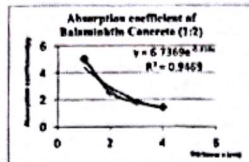


Fig. 4.2.5 Absorption coefficients of Bala Min Itin Concrete (BSC12)

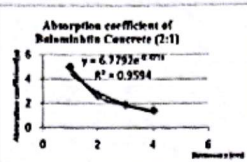


Fig. 4.2.6 Absorption coefficients of Bala Min Itin Concrete (BSC21)

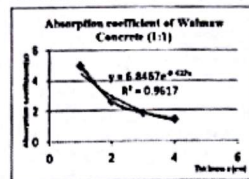


Fig. 4.2.7 Absorption coefficients of Wai Maw Concrete (WSC11)

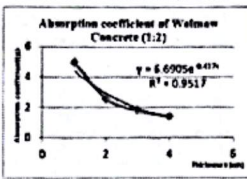


Fig. 4.2.8 Absorption coefficients of Wai Maw Concrete (WSC12)

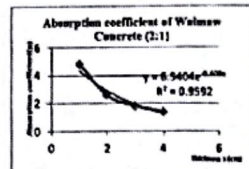


Fig. 4.2.9 Absorption coefficients of Wai Maw Concrete (WSC21)

4.3 Results of Mass Attenuation Coefficients of Mixed Concrete

The most important quantity characterizing the penetration and diffusion of gamma radiation in extended media is the attenuation coefficient μ . This quantity depends on the photo energy E and on atomic number Z of the medium. Comparison of mass attenuation of mention area are described in Fig.4.3.1 to Fig.4.3.3.

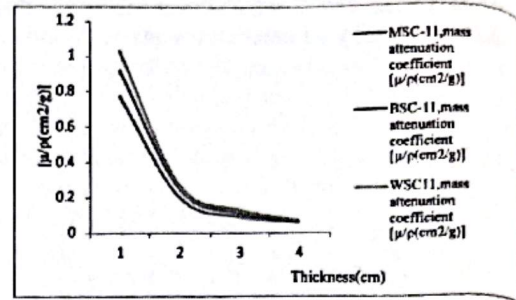


Fig.4.3.1 Comparison of mass attenuation of MSC11, BSC11 and WSC11

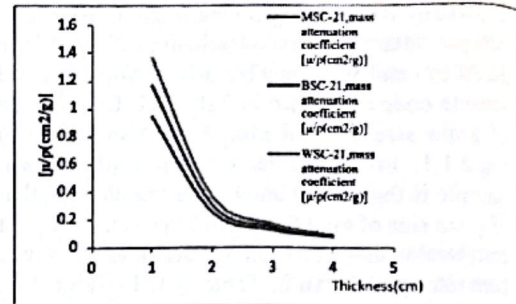


Fig.4.3.2 Comparison of mass attenuation of MSC21, BSC21 and WSC21

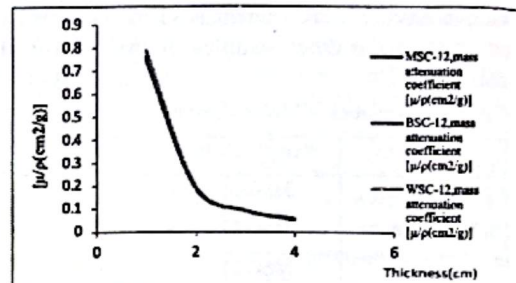


Fig.4.3.3 Comparison of mass attenuation of MSC12, BSC12 and WSC12

Conclusion

In this paper, Sand grain collected from Myitson Site is the biggest in size and it is approximately 0.33mm and that of sample collected from Waimaw Site is the smallest in size and it is 0.16mm. The Density of mixed concrete (BSC) is the highest and it has 2.58g/cm³. Density of mixed concrete (WSC) is the lowest and it has 1.87 g/cm³. From the Figure 4.3.1, Fig.4.3.2 and Fig.4.3.3, mass attenuation coefficients is the best in the mixture of ratio 1:1. So, it is suitable for gamma radiation shielding. By observing the results of sand grain size and mass attenuation coefficients the concrete slab, the source holder for radioactive sources is constructed as shown in figure 2.3.8.

IT 001

Comparative Analysis of Interplanar Spacing and Lattice Strain between Calcium element and Human Hard Tissues

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Abstract

Chemical compounds alloys and crystallizes in a wide variety of structures. The aim of this work is to calculate the lattice interplanar spacing and lattice strain of calcium element and human hard tissues. Some Miller planes of calcium (Ca) structure and human hard tissues obtained by X-ray diffraction method (XRD). XRD analysis give crystal structure, lattice parameters and crystallize size information. The calculated results of interplanar spacing, lattice parameters and lattice strain are indicated shift between Miller planes of calcium structures and human hard tissues. And finally, we concluded to substitute the amount of calcium for human hard tissues.

Keywords: calcium (Ca), human hard tissues, XRD.

Introduction

Human body composed of two types of hard tissues. They are soft tissues and hard tissues. Soft tissues of human body contained blood, cell, tissues, skin etc. Hard tissues of human body contained teeth, bone structure (bone apatite) etc. Bone structure of human body composed of calcium and also called bone apatite, which include both normal bones and the teeth, which have shown are characterized by their high hardness, strength and of course, the elastic modulus.

Nowadays due to the ageing Myanmar population, increased dynamism of people's lives and growing life expectancy, there is an increasing clinical demand for bone replacement and repair. The main mineral component of bone tissue is a nonstoichiometric carbonated multi-substituted apatite with calcium. Calcium is mainly composed of human hard tissues and bone apatite. In human body, about 60wt% of bone is made of calcium apatite and therefore to know calcium structure.

Materials and Method

Raw Material Preparation

The Miller planes of human hard tissues obtained by XRD technique (from Mandalay Medicine University). The raw materials were used in this research calcium (Ca). Calcium (Ca) was collected in the able chemical market. And then, these samples were crushed and cleaned to powder.

The structures of human hard tissues are hexagonal. for hexagonal system $a=b$ not equal c , the interplanar spacing formula is

$$d_{hkl} = \frac{\sqrt{3}}{2} \left(\frac{a}{\sqrt{h^2 + hk + k^2}} \right) + \frac{c}{l}$$

X-Ray Diffraction (XRD)

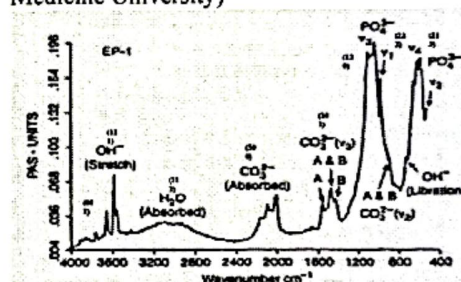
It is a non-destructive analytical technique. It reveals information about the crystallographic structure, crystalline size It preferred orientation in polycrystalline or powdered solid samples. It is used to identify unknown substances, by comparing with a database of Powder Diffraction Files (PDF) maintained by (ICDD). In the present work, it used to verify the phases and crystallinity in the sample Ca-powders. It obtained by using RigakuMultiflex2kW powder XRD with a copper

anode (Cu K α , $\lambda = 1.5406 \text{ \AA}$) as X-Ray source. And fixed from $2\theta = 10^\circ$ to 70° . It given information and the present phases verified by comparing the intensities of the peaks and observed angular position with those of the standard patterns available in the Powder Diffraction File (ICDD file).

In the present work, the diffraction peak at the Miller planes were chosen to calculate the crystallite size (d) since it was isolated any overlapping in calcium structure by following the Debye Scherer's formula,

$$d = \frac{k\lambda}{\beta \cos \theta}$$

Fig (1) The Miller planes of human hard tissues obtained by XRD technique (from Mandalay Medicine University)



Calculation the Interplanar Spacing of Human Hard Tissues

Fig(1) presents the XRD patterns of human hard tissues have mainly eight specific peaks on the XRD pattern, i.e.(002), the overlapping peaks which includes (121), (112), (300) and (202) Miller's plane, (130), (222), and (213).

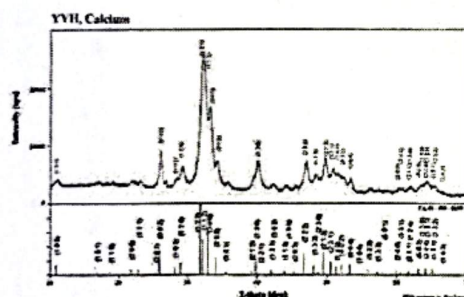
We calculated the interplanar spacing of human hard tissues for Miller planes are shown in table (1).

Table (1) The interplanar spacing of human bone structure from eight Miller planes

No	Miller Planes	Lattice parameters a=b(Å)	Another lattice parameter c(Å)	Interplanar spacing (d_{hkl}) of human bone structure
1	(002)	9.4306	6.8878	3.4439(Å)
2	(121)	9.4306	6.8878	9.9975(Å)
3	(112)	9.4306	6.8878	8.1592(Å)
4	(300)	9.4306	6.8878	2.722(Å)
5	(202)	9.4306	6.8878	7.527(Å)
6	(130)	9.4306	6.8878	2.265(Å)
7	(222)	9.4306	6.8878	5.801(Å)
8	(213)	9.4306	6.8878	5.383(Å)

No	Plane	Crystallite size (Å)
1	(0 0 2)	3.424
2	(1 2 0)	2.168
3	(1 2 1)	1.643
4	(3 0 0)	2.098
5	(1 3 0)	1.678
6	(2 2 2)	2.469
7	(2 1 3)	3.642
8	(0 0 4)	4.780
Average		2.738

Calculation the interplanar spacing of Ca from XRD result

Figure (2) The Miller planes of calcium element obtained by XRD technique
The calcium element is cubic structure. The

No	Miller Planes	Lattice parameters a=b=c(Å)	Interplanar spacing (d_{hkl}) of calcium element
1	(002)	9.4425	4.721(Å)
2	(120)	9.4425	4.223(Å)
3	(121)	9.4425	3.855(Å)
4	(300)	9.4425	3.148(Å)
5	(130)	9.4425	2.986(Å)
6	(222)	9.4425	2.725(Å)
7	(213)	9.4425	2.524(Å)
8	(004)	9.4425	2.361(Å)

interplanar spacing for cubic system is

$$d_{hkl} = \frac{a}{\sqrt{h^2 + k^2 + l^2}} \text{ Å}$$

We calculated for (002) plane, (120) plane, (121) plane, (300) plane, (130) plane, (222) plane, (213) plane, and (004) plane the interplanar spacing are 4.721, 4.223, 3.855, 3.148, 2.96, 2.725, 2.52 and 2.361 Å respectively.

Calculation of Path Different (d) of calcium element

By using Bragg's Law, $n\lambda = 2\sin\theta$, we Calculated for (002) plane, (120) plane, (121) plane, (300) plane, (130) plane and (222) plane, (213) plane, (004) plane, path different are 3.349, 3.081, 2.795, 2.712, 2.252, 1.571, 1.858, and 1.697 Å respectively. The average path different Ca element for all Miller planes is 2.464 Å.

Calculation of Crystallize sizes for Calcium element

By using Debye-Scherrer's formula, Calculated for (002) plane, (120) plane, (121) plane, (300) plane, (130) plane and (222) plane, (213) plane, (004) plane, crystallize sizes are 3.424, 2.168, 1.643, 2.098, 1.678, 2.469, 3.642 and 4.780 Å respectively. The average crystallize sizes Ca element is 2.738 Å.

Results and discussion

Results

The calculated results of interplanar spacing for human hard tissues, eight Miller planes are shown in table (2). And then, the calculated results of interplanar spacing for calcium elements, eight Miller planes are shown in table (3). The calculated values of crystallize sizes of calcium elements are shown in table (4).

Table (2) The interplanar spacing of human bone structure from eight Miller planes

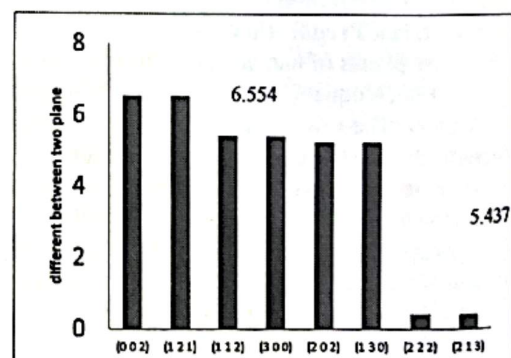
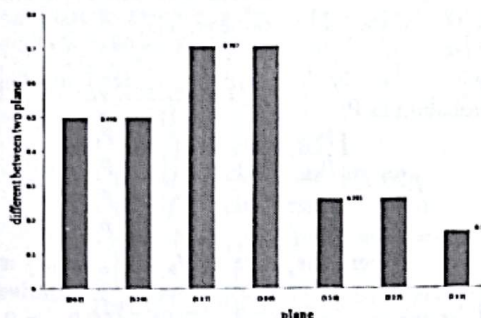


Table (3) The calculated results crystallize sizes for calcium element

No	Miller Planes	Lattice parameters a=b(Å)	Another lattice parameter c(Å)	Interplanar spacing (d_{hkl}) of human bone structure
1	(002)	9.4306	6.8878	3.4439(Å)
2	(121)	9.4306	6.8878	9.9975(Å)
3	(112)	9.4306	6.8878	8.1592(Å)
4	(300)	9.4306	6.8878	2.722(Å)
5	(202)	9.4306	6.8878	7.527(Å)
6	(130)	9.4306	6.8878	2.265(Å)
7	(222)	9.4306	6.8878	5.801(Å)
8	(213)	9.4306	6.8878	5.383(Å)



The calculated results of interplanar spacing of calcium element

Discussion

In this work, we calculated the interplanar spacing of human hard tissues and calcium element. The XRD spectra of human hard tissues for Miller indices contained major mainly sharply eight peaks. The interplanar spacing between (002) and (121) planes is 0.554(Å). And the interplanar spacing between Miller planes (112) and (300) is 5.437(Å). Between the planes (202) and (130), the interplanar spacing is 5.262(Å). Finally, the result of interplanar spacing between planes (222) and (213) is 0.418(Å). The XRD spectra of calcium for Miller indices contained major mainly sharply eight peaks. The interplanar spacing between (002) and (120) planes is 0.498(Å). And the interplanar spacing between Miller planes (121) and (300) is 0.707(Å). Between the planes (130) and (222), the interplanar spacing is 0.261(Å). Finally, the result of interplanar spacing between planes (213) and (004) is 0.163(Å). The results of lattice strain for (002), (120), (121), (300), (130), (222), (213) and (004) planes are 0.008, 0.012, 0.014, 0.011, 0.011, 0.007, 0.004 and 0.003 rad respectively. The average of lattice strain for calcium element is 0.009 rad. The average crystallize sizes of calcium are 156.89(Å).

The average interplanar spacing for eight Miller planes of human hard tissue is 5.662 (Å). The average interplanar spacing for eight Miller planes calcium is 3.318 (Å). The different between the average interplanar spacing of human hard tissues and calcium element (substitution rate) are 1.599(Å).

Conclusion

Applications of these data results are compared and substitution calcium element by using XRD results. All of data results, among sets of all planes, the interplanar spacing decreases as any index increase and it indicates more planes per unit cell mean more closely and shift spaced planes. Comparison of human hard tissues and calcium element is needed to identify 1.172 (Å) among the interplanar spacing.

Acknowledgments

We thank all the people for their help directly and indirectly to complete our study.

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Providing Weather Forecasting in Near Future Based on Markov Chains

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Abstract

Using the stochastic processes called Markov Chains are usually used in modelling many practical problems. In this paper, to predict the immediate future, the data sets in Myitkyina Township are sought. The moving averages for the data are found and grouped them into three different states for the weathers. Then Markov chains calculations are applied to the data to create a 3*3 transitional probability matrix. Using this transition matrix, a system of equations is solved by using Chapman-Kolmogorov Equations and found three steady states that will be the same in every row of the matrix. They are variables that represented the probability that the weather for a given month would fall into one of the three states. When this information is used, the actual data to these equations can be applied and the next weather for the near future can be predicted. Near future weathers using this method are able to be successfully predicted.

Keywords: Chapman – Kolmogorov Equations, Markov Chains, Stochastic process, Steady State Probabilities, Transition Probabilities.

1. Introduction

Weather warnings are important forecasts because they are used to protect life and property. The realization of the importance of weather has increased among the public. People have attempted to predict the weather formally since the 19th century [1]. Weather forecasts are made by collecting quantitative data about the current state. In this paper, future weather forecast for Myitkyina Township is analysed and moving averages are applied to predict the weathers. Firstly, an approximate evaluation of data was created. To find the difference data set to apply Markov Chains was needed. These differences were going to be what Markov Chains was applied too. Using Markovian properties to our data, a system of equations with the unknown variables being the steady states that is aiming to obtain. These equations are sums of probabilities multiplied by unknown variables. Then, to solve the system of equations, to find steady state probabilities is aimed.

2. Methodology

2.1. Markov Chains

Some background concerning the Markov Chains is presented. A Markov Chain is a stochastic process that has the Markovian property. Consider a finite discrete time homogeneous stochastic process with index set $Z^+ = \{0, 1, 2, \dots\}$; that is, a sequence $\{X_n; n \in Z^+\}$ of random variables. As usual the subscript n in X_n stands for the time and X_n denotes the state of the process at time n . If $X_n \in S$, then S is called state space of the stochastic process considered here satisfy the Markov property. Given the present state, the future of the process is independent of the past. That is, for $i, j; x_0, \dots, x_{n-1} \in S, P(X_{n+1} = j | X_0 = x_0, \dots, X_{n-1} = x_{n-1}, X_n = i) = P(X_{n+1} = j | X_n = i) = P_{ij}$

Conditional probabilities for Markov Chains are called transition probabilities. A stochastic process with this property is called a homogeneous Markov chain. The quantity P_{ij} stands for the probability of moving from state i to state j in just one transition and all these

quantities define the matrix of one-step transition probabilities P :

$$P = \begin{bmatrix} P_{11} & P_{12} & P_{13} & \dots & P_{1k} \\ P_{21} & P_{22} & P_{23} & \dots & P_{2k} \\ P_{31} & P_{32} & P_{33} & \dots & P_{3k} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ P_{k1} & P_{k2} & P_{k3} & \dots & P_{kk} \end{bmatrix}$$

Where the finite set $I_k = \{1, 2, \dots, k\}$ is the state space of the Markov chains. The entries P_{ij} of the matrix P must satisfy: (1) $P_{ij} \geq 0$, (2) $\sum_j P_{ij} = 1, i, j \in I_k$. The n -step transition probability $P_{ij}^{(n)}$ is just the conditional probability that the system will be in state j after exactly n steps (time units) given that it starts in state i at any time t . When $n=1$, note that $P_{ij}^{(1)} = P_{ij}$ [2]. Therefore, a Markov Chain is a stochastic process that states that the conditional probability of a future event relies on the present state of the process, rather than any past states or events.

A conventional way to note stationary transition probabilities that will be seen later in this paper is,

$$P_{ij} = P(X_{t+1} = j | X_t = i),$$

$$P_{ij}^{(n)} = P(X_{t+1} = j | X_t = i)$$

2.2. Chapman-Kolmogorov Equations

Chapman-Kolmogorov equations is used to provide a method to compute all of the n -step transition probabilities.

$$P_{ij}^{(n)} = \sum_{k=0}^M P_{ik}^{(m)} P_{kj}^{(n-m)} \text{ for all } i, j = 0, 1, \dots, M$$

$$\text{and any } m = 1, 2, \dots, n-1, n = m+1, m+2, \dots \quad [3]$$

These equations are used to point out that when from steady state to another in n steps is gone, the process will be in some other state after exactly m (m is less than n) states. Thus, the summing up is just the conditional probability that, given a starting point in one state, the process goes to the other state after m steps and then to the next state in $n-m$ steps. Therefore, by summing up these conditional probabilities over all the possible steady states must yield

$$P_{ij}^{(n)} = \sum_{k=0}^M P_{ik} P_{kj}^{(n-1)}$$

$$\text{And } P_{ij}^{(n)} = \sum_{k=0}^M P_{ik}^{(n-1)} P_{kj}$$

This means that these expressions allow to obtain the n steps probabilities from the one step transition probabilities recursively.

2.3. State Transition Diagrams

A convenient and useful method to visualize the state of Markov Chains when they have stationary transition probabilities and a finite number of states is through the use of a state transition diagram. In such diagram, each state of a Markov chain is drawn as a numbered node, and the conditional probability of moving from one state to another is drawn by connecting the nodes with an edge and labelling the edge with the numbered probability. For example, if the stock in a given day is recorded by the following stochastic process where [4]:

$$X_t = \begin{cases} 1 & \text{if stock } t \text{ has gone up} \\ 2 & \text{if stock } t \text{ has gone down} \end{cases}$$

$$\text{and } P(X_{t+1} = 1 | X_t = 1) = 0.7$$

$$P(X_{t+1} = 2 | X_t = 1) = 0.4$$

Then the state transition diagram for this example is:

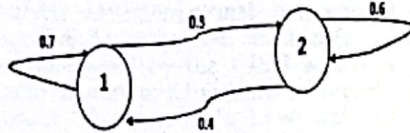


Figure 1. State transition diagram

2.4. Categorizing States of Markov Chains

Since Markov Chains are long run stochastic processes that include transitional probabilities which indicate the likelihood the process will move from one state to another, it is often necessary to categorize, or classify, the varying types of states.

2.5. Properties of Markov Chains in Long-Run

After n -step transition probabilities for a Markov chain have been calculated, the Markov chain will display the characteristic of a steady state. Meaning that, if the value of n is large enough, every row of the matrix will be the same, and such the probability that the process will be in each state k after a certain number of transitions is a limiting probability that exists independently of the initial state. This can be defined as:

For any irreducible ergodic Markov chains, $\lim_{n \rightarrow \infty} P_{ij}^{(n)} = \pi_j > 0$ where, the π_j uniquely satisfy the following steady-state equations

$$\pi_j = \sum_{i=0}^M \pi_i P_{ij}, \text{ for } j = 0, 1, \dots, M$$

$$\sum_{j=0}^M \pi_j = 1$$

The steady state probabilities of the Markov chain, π_j indicate that after a large

number of transition the probability of finding the process in a particular state. $P\{X_n = j\} = \pi_j$

3. Procedural Overview

In this section, the effectiveness of the Markov chain model is demonstrated and it is applied to the weather conditions in Myitkyina Township for prediction near future. The entries of rainfall in Myitkyina for five years are used. The weathers can be classified into three possible states that are rain, clear and tear. The data sets of weather chosen for this paper is five years' worth of weather in Myitkyina Township.

Once the data were found, the first step towards applying Markov chains to the data set began with the calculation of moving averages. Moving averages provide a forecast for future weather and therefore are crucial to work here. Using the difference between the forecasts each year enables to make the predictions for the possibility of where future weather may lie.

3.1 Procedure with Data

In order to better understand the process of using Markov chains and how the data is reached, this section explains the procedure with a corresponding data set so as to better work. Once the data set is got, the corresponding frequencies are calculated [5].

Table 1 displays a (3×3) frequency matrix for weather from January to May in year 2015-2019

Table 1. Frequency transition data from January to May

Weather	Rain	Clear	Tear
Rain	100	50	23
Clear	49	392	48
Tear	28	42	19

Table 2. Frequency transition data from June to September

Weather	Rain	Clear	Tear
Rain	301	51	46
Clear	49	43	15
Tear	48	13	14

Table 3. Frequency transition data from October to December

Weather	Rain	Clear	Tear
Rain	25	15	6
Clear	11	249	22
Tear	8	20	12

(751 days). Another two frequency matrices for weathers from June to September in year 2015-2019 (580 days) and from October to December in year 2015-2018 (368 days) are displayed in Table 2 and Table 3 respectively.

The numbers in the table show how many days moved from one state to another. For example, in the 1st row, 1st column in Table 1, number 100 means the number of days moved from Rain to Rain. For the purpose of computation, the transition matrix of Markov chain is required. The transition matrix, however, works with probabilities and not with frequencies as described in each Table.

3.2 Transition Probabilities

It is necessary to transform the matrix of frequencies into the proper transition matrix [6]. This can be done easily by normalizing each row of the matrix by $P_{ij} = \frac{f_{ij}}{\sum_j f_{ij}}$

where f_{ij} acts as an element of the frequency matrix (Table 1, Table 2, Table 3) and p_{ij} is an element of the transition matrix. After the transitions were labelled with the appropriate intervals, the transition matrix was built and the

ensuring linear system of equations was solved to find the steady states.

Table 4, Table 5 and Table 6 show the probability of transition matrix for the weathers.

Table 4. Transition Probabilities from January to May

Weather	Rain	Clear	Tear
Rain	0.5780	0.2890	0.1339
Clear	0.1002	0.8016	0.0982
Tear	0.3146	0.4719	0.2135

Table 5. Transition Probabilities from June to September

Weather	Rain	Clear	Tear
Rain	0.7563	0.1281	0.1156
Clear	0.4579	0.4019	0.1402
Tear	0.64	0.1733	0.1867

Table 6. Transition Probabilities from October to December

Weather	Rain	Clear	Tear
Rain	0.5435	0.3261	0.1304
Clear	0.0390	0.8830	0.0780
Tear	0.2000	0.5000	0.3000

4. Results

After the probability of transition matrix was built and the ensuring linear system of equations was solved to find the steady states. And then calculate until the steady state probability is reached. And finally, the steady state probabilities are resulted given in Table 7, Table 8 and Table 9 for the respective months.

The steady states provide the probability that the difference will be in any of these months. Accordingly, the percentage of steady state is shown in Table 10. After all, a histogram was created to provide the information got from the calculations.

Conclusion

Table 7. Steady-State Probabilities from January to May

Weather	Rain	Clear	Tear
Rain	0.2414	0.6382	0.1204
Clear	0.2414	0.6382	0.1204
Tear	0.2414	0.6382	0.1204

Table 8. Steady-State Probabilities from June to September

Weather	Rain	Clear	Tear
Rain	0.6862	0.1845	0.1293
Clear	0.6862	0.1845	0.1293
Tear	0.6862	0.1845	0.1293

Table 9. Steady-State Probabilities from October to December

Weather	Rain	Clear	Tear
Rain	0.1138	0.7783	0.1079
Clear	0.1138	0.7783	0.1079
Tear	0.1138	0.7783	0.1079

Table 10. Percentage in Steady-State probabilities from 2015 to 2019

Weather	January to May	June to September	October to December
Rain	24.14%	68.62%	11.38%
Clear	63.82%	18.45%	77.83%
Tear	12.04%	12.93%	10.79%

Weather plays a major role in our daily life. The study of weather phenomenon requires the use of science, math, and different types of equipment and technology and data. The overall analysis of the results can be summarized as follows: The rainfall will be 24.14% from January to May, 68.62% from June to September and 11.38% from October to December. In near future, the rainfall will be around 70% during rainy seasons. Thus, the rain crops can be cultivated in Myitkyina Township during these months to grow planting near future. In the future, weather forecasts will be even more accurate.

Acknowledgements

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LAW 001

Comparison on the application for the right of avoidance contract between the CISG and Myanmar Sale Law

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Abstract

This paper is a comparison on the application for the right of avoidance contract between the United Nations Convention on Contracts for the International Sale of Goods, 1980 (the CISG) and the Myanmar Sale Law, Sale of Goods Act, 1930. The breach of some contractual obligation may be composed into different types of breach and lead to different remedies under the two regimes. An international sale contract, like any other contract, is governed by a particular domestic law relating to. When a contract is concluded, both parties have the certain obligations, and they must perform to fulfill contractual obligations to implement their contract. However, sometimes a breach of contract may arise between concluding parties. Hence, the domestic law provides several remedies for breach to discourage and reduce parties from breach and also entitled to the aggrieved party for any loss. As regarding to the avoidance contract, these two laws adopt different approaches to restrain the right of avoidance. The CISG mainly limits the time for the exercise of right. That is to say, either a party who wants to avoid the contract must declare or notice within a reasonable time. If the notice of avoidance is given beyond a reasonable time, then he or she releases the right to avoid. While the Myanmar Sale Law limits the right by two ways: the own conduct of the aggrieved party and the operation of the rule of law. The own conduct of an aggrieved party concerns with some common law principles like affirmation and waiver. When the aggrieved party knew the breach and his right to terminate and yet still decided to affirm the contract, then he loses the right of termination. The other is by the operation of law through acceptance. This paper will examine which solution is more achievable for making judgments, in practice.

Keywords: avoidance, breach, contract, termination

Introduction

In the international sale of goods,³ the avoidance of contract is regarded as the most serious remedy for breach of contract. The United Nations Conventions on Contracts for International Sale of Goods (CISG) considers the avoidance of contract as a last resort remedy¹ (*ultima ratio*) because of the enormous sums of money involved in international commercial transactions. Consequently, the avoidance of contract is discouraged by the CISG and it is allowed only in the case of a fundamental breach. However, under Myanmar Sale Law; Sale of Goods Act, 1930 terms is simply divided into two kinds; breach of conditions and warranties. If one party has breached the conditions of contract, therefore, the injured party is entitled to avoid the contract. As a general rule, a contract can be ended when the aggrieved party exercises his right of avoidance or termination and subsequently both parties are discharged from further performance of the contract.

Objective

This paper aims to examine on the application for the right of avoidance contract of the CISG and Myanmar Sale Law. In the event of the avoidance of contract, although the Myanmar Sale Law takes certainty in the consequence of breaches into consideration, the CISG takes certainty in justice into account. It aims to explore the primary requirements for application of right for avoidance contract and to determine the similarities and differences regarding for it. And, this paper is intended to suggest that even if the Myanmar does not accede to the CISG, the Myanmar merchants, lawyers and the Government should learn more to understand the current principles of international trade and think over an enter into the CISG.

Research questions and methodologies

This paper will be composed the following research questions-

- What are the primary requirements for application the right of avoidance contract and are they similar or different between the CISG and Myanmar Sale Law?

- Are the same remedies regarding condition breach under Myanmar sale law and fundamental breach under CISG?

- Will these similarities and differences have significant practical consequences for merchants in the event that the Myanmar accedes to the CISG?

In order to explore and answer the above-mentioned questions, this paper will cover the main three research methods. First, the descriptive research method which the providing the provisions of different issues related to the right of the avoidance contract of the CISG and the Myanmar sale law (based on primary and secondary data; published and unpublished analyses on the import and export sectors were used).

Second, the comparative research method which allows for a systematic comparison relating to the provisions the right of avoidance contract under the CISG and Myanmar sale law. In addition to, the Literatures and information concerning the topic will be taken into account. This method may explore the similarities and differences of the avoidance rule when the breach occurred under the two regimes.

Third, case study method that is to examine and evaluate the efficiency of the relating to the remedial rules for breach of contracts under the two regimes. Furthermore, Case Law is an important study or examines in order to discover how the question is solved in practice.

Hypotheses

At the present, the CISG takes into accounts the realities and practicable solution to the harmonization of ASEAN international trade law. Moreover, the CISG is a contemporary uniform regime for the resolution of disputes involving international sale transaction.

Currently, although Myanmar is not a contracting state of the CISG, the CISG's rules may be applied to the Myanmar. For example, it is possible that one of the parties entering into a contract with Myanmar party will be from a contracting state, for instance, China. In such

kind of case whose law will apply by virtue of laws of private international law? This law may be the CISG.

Finding and Result

With the development of the world economy, domestic commercial law fails to satisfy with the needs of international business and solve trade disputes. The avoidance contract is not allow in minor breach of contract under both two system. There may have many advantages considering which to ratify the CISG which legal advantages and trade advantages. In the case of the avoidance of contract, the CISG seeks justice and discourages avoidance. In contrast, the Myanmar Sale Law makes certainty and encourages. In the event of the right of avoidance, the CISG approach is more preferable to having certainty in the consequence of breaches in practice because the expectation of the contracting parties at the time of the conclusion of a contract. Therefore, although it is not assumed that the CISG is comprehensive, Myanmar should not overlook the principles of the CISG because current Myanmar Sale Law is about 90 years old and is not better suited than the CISG for modern commercial contracts. Notwithstanding, even if the Myanmar does not accede to the CISG, the merchants, lawyers and the government of Myanmar should learn and try to understand more knowledgeable about current principles of international trade and think over joining to the CISG. Because of the CISG may be achievable when governing with the international sale of goods transactions.

Problem concerning with termination

At first, it is necessary to describe the concept and the terminology most often used in relation to avoidance. Avoidance is the legal remedy under contract law, which takes effect in situations when an aggrieved party wishes to put an end the further performance of the contract and to put matters into the position, as far as it is possible, in which they were before performance by the other party had begun.²

Regarding to the meaning of avoidance, the buyer's right to 'avoid' the contract under the CISG corresponds to the buyer's right to 'terminate' the contract under the common law and as such 'avoidance' and 'termination' are used interchangeably. Under the CISG, 'speaks of avoidance for non-performance and mixes the language of breach and non-performance, instead of simply referring to breach.' In common law, under the law relating to sale of goods in Myanmar, 'termination' is used to describe the remedy by which the injured party 'is released from his obligation to perform because of the other party's defective performance or non-performance,' i.e., breach of contract.³

Compositions of the breach for the avoidance contract under the two regimes

In both two systems, the main remedies for breach of contract are entitled to by either party or both to put an end from further contractual performances or obligations of a contract or to claim damages. When a contract is fundamentally breached under the CISG or when the condition of a contract is breached under Myanmar Sale Law, the injured party may treat the contract as avoidance and claim damages,⁴ unless the right of avoidance is waived.⁵ When a

contract is not fundamentally breached under the CISG, or when the warranty of a contract is breached under Myanmar Sale Law, the injured party is only entitled to claim damages, he or she has not right to terminate the contract.

The standard for the fundamental breach under the CISG is similar to the breach of condition under Myanmar Sale Law. They all require the impairment of a material interest, i.e., the extent of the breach needs to be serious and substantial enough to deprive what the aggrieved party is entitled to expect on conclusion of the contract, although the expressions in two regimes are slightly different. Article 25 of the CISG provides about the substantial deprivation of expected interests;⁶ and in Myanmar Sale Law requires the breach to deprive the whole benefit of a contract in the essential term breach of the condition of the contract.⁷

However, in the case of the prerequisite for the fundamental breach under the CISG is different from the prerequisite for the breach of the conditions of contract in Myanmar Sale Law. In order to constitute the fundamental breach of the CISG requires the impairment of a material interest substantial to the injured party's expectation on conclusion of the contract.⁸ Whereas, in Myanmar sale law the breach of the condition of contract does not have such kind of requirement. Under Myanmar sale law, the condition of contract can be the terms either expressly agreed or implied by law by the parties in the contract.⁹ The aggrieved party is entitled to terminate the contract in the event of the breach of condition, irrespective of the gravity of the event that has in fact resulted from the breach of contract.¹⁰

In Article 25 of the CISG, the foreseeability of a substantial detriment is an instrument used to ascertain the seriousness of an obligation breached,¹¹ i.e., if the impairment of the injured party's interest was foreseen or would have been foreseen as substantial by the breaching party or by a reasonable person in the same circumstances, then the breach constitutes the fundamental breach of contract.¹² Comparatively, the foreseeability test was not required in the breach of conditions of the contract in Myanmar Sale Law.

Parties' right to declare the contract avoided under the two regimes

The avoidance or the termination of the contract is the hardest word that a party to a sales contract can draw if the other party has breached the contract. The parties' right to declare the contract avoided in the CISG is primarily determined by the existence of the fundamental breach as defined by Article 25. Under the Myanmar Sale Law, the parties' right to terminate the contract is principal based on the breach of condition of the contract.

The important requirement for avoidance of contract, under the CISG, is the fundamental breach of contract. In terms of Article 25 of the CISG, a breach may be the fundamental if it results in such detriment to the other party as substantially to deprive it of what it is entitled to expect under the contract, unless the party in breach did not foresee and a reasonable person of the same kind in the same circumstances would not have foreseen such a result. If the breach is a fundamental nature, an

innocent party has a right to declare the contract is avoided. In that case, there is no required fault or negligence on the part of the breaching party.

The avoidance of contract must be declared by the party who intends to terminate the contract, and that the declaration must be affected by notice to the other party.¹³ The CISG does not provide for an automatic (*ipso facto*) avoidance of contract.¹⁴

Like common law, the termination for breach of contract at Myanmar Sale Law can take place in two cases, the first being where the other party has broken a condition of the contract, and the second where there has been some other breach with very serious consequences.

A contract of sale may contain various stipulations with reference to goods. Some of these stipulations are conditions, and others are warranties¹⁵ which from the very basis of contracts may not be equal importance as they create different obligations.

A condition is so important that it is broken which the opposite party has a right to treat the contract as broken and to move for its remedy. Under the Myanmar Sale Law, the word condition was used as the term a synonym for major term of the contract. Therefore, if the seller breaches a condition which deprives the buyer of substantially the whole benefit of the contract, the buyer can terminate the contract.

The conditions are essential for the objective of the contract. There are two types of conditions, in a contract of sale which express and implied conditions.

Declaration of avoidance

An aggrieved party may declare the contract avoided when the breaching party failure to perform any of his obligations under the contract or the CISG amounts to fundamental breach of the contract.¹⁶ An aggrieved party who wishes to terminate a contract normally gives notice to the defaulting party to become effective declaration of the avoidance.¹⁷

Under the Contract Act, 1872, parties can stipulate expressly or impliedly that one or other or both parties may terminate the contract in certain circumstances, such as: (i) notice at the option of any one or of either party without assigning any reason; (ii) on happening of an event; or (iii) non-performance or breach of a term of the contract.¹⁸ But every case of termination must be communicated between parties. Such notice must be given in the manner and according to the terms provided in the contract. If the contract requires notice of a specified length of time, notice of that length of time must be given.

As a general rule, the contract only comes to an end if an aggrieved party accepts the breach.¹⁹ The primary requirement in effective terminating, a contract is that the behavior of the party 'must unequivocally indicate his intention to exercise the option to terminate the contract'²⁰ as mere silence or inactivity may not be adequate.²¹ Once the party has terminated the contract, he cannot later affirm and demand performance: this follows from the rule that termination released the defaulting party from his primary obligation to perform.²²

Effect of avoidance

Avoidance is a process through which an aggrieved party, by notice to the other side,

terminates the contractual obligations of the parties.²³ Both parties are released from their obligations as a result of the avoidance the contract.

The effects of termination of the contract that the relation on the obligations of the two parties is that the seller comes, as a result of termination, under a secondary obligation to pay damages and that 'his liability in damages may relate both to breaches committed before termination and to losses suffered by the buyer as a result of the non-performance of future obligations brought about by termination.'²⁴

As regard to the different ways to put an end the contract employed by two regimes, i.e., in the CISG used the term 'avoidance' and in the Myanmar Sale Law expressed the word 'termination', both systems are the election of the injured party of such a right has consequence on the contract.

However, The CISG does not deal with the effect of the contract may have on the property in the goods sold; 'in the event of avoidance of the contract, the effect of a reservation of title clause is a matter for the applicable law governing proprietary matters and not for the CISG.'²⁵

In fact, termination affects the legal life of the contract and the contractual relationship of the parties.²⁶ Generally, dispute resolution clauses always remain binding after the contract ceases to exist by way of avoidance or automatic termination.²⁷ All systems now accept that termination will not affect the application of clauses such as arbitration clauses which were intended to apply despite termination.²⁸

Similarities of the avoidance rules under the two regimes

There are three main similarities regarding to the avoidance contract under the two systems which are notice of avoidance, limits within a reasonable time and aspect of it.

(A) Notice of Avoidance

There is no automatic (*ipso facto*) termination of the contract in both systems. According to the avoidance rules of the two regimes, an aggrieved party who wishes to avoid the contract must communicate his decision to the defaulting party. If an aggrieved party fails to do so, he may be held to have lost his right of avoidance. The breaching party may therefore insist upon the performance of contract when the market is suddenly changed tends to favor him again.

(B) Limits on the right within a reasonable time

Both two systems impose a time-limit on the right to avoid the contract. The aggrieved party must make his decision as to whether to exercise his right of avoidance within a reasonable time under certain circumstances.²⁹ The injured party's failure to make a declaration to the effect of avoidance after the excess of a time-limit deprives him of the right to avoid the contract.³⁰ The ascertainment of reasonable time is a matter of fact, depending upon the circumstances of each case.³¹ In Article 49(2) and 64(2) of the CISG, the phrase of 'reasonable time' as a limit on the right of avoidance is used repeatedly. In section 42 of the Myanmar Sale Law, the buyer is deemed to have accepted the goods and lost his right to terminate the contract

'when the expiration of a reasonable time that he retains the goods without intimating to the seller that he has rejected them'.³²

(C) Essence of avoidance

Despite the different expression employed by the two systems; 'avoidance' in the CISG and 'termination' in Myanmar Sale Law, the election of the aggrieved party of such a right has similar effects on the contract. The terms of 'avoidance or termination' under the two systems operate with the prospective effect of the contract only. Both parties are discharged from further performance of the obligations under the contract and the breaching party is liable for any damages suffered by the other party resulting from his breach.³³ If a contract has been wholly or partly performed, the parties are bound to make restitution for any money paid or any goods delivered.³⁴ It should be noted that the injured party is not bound to avoid the contract. The election of avoidance is a right, not an obligation of the injured party.³⁵ Therefore, he has the freedom to waive his right of discharge and treat the contract as continuing, e.g., by accepting the defective performance and consent himself with the remedy of damages only.³⁶

Differences of the avoidance rules under the two regimes

Under these two systems, there have the two differences: the requirements of avoidance and the loss of the right to avoid the contract.

(A) Requirements of avoidance

The avoidance of contract is required in different forms under the two regimes. In the CISG, a notice to avoid the contract to the other party is required for a declaration of avoidance to become effective, the declaration is not subject to any particular formal requirements.³⁷ The notice can be given in writing, oral or even by conduct, as long as it is clear and comprehensible to both parties.³⁸

In contrast, the Myanmar Sale Law holds a flexible approach as to the form of termination for breach of contract. However, in case of mere silence or inactivity may not sufficient to become an effective termination of the contract. The primary requirement in effectively terminating a contract is that the behavior of the aggrieved party must clearly indicate his intention to exercise the option to terminate the contract. It is sufficient that any communication or conduct to the refusing party clearly and unequivocally conveys the intention of an aggrieved party to treat the contract as ended.³⁹ The notification by the aggrieved party or any agent is not necessary. It is sufficient that the fact of election draws the attention of the refusing party.⁴⁰ Occasionally, the aggrieved party's inactivity, e.g., by his mere failure to perform, may also constitute the acceptance of refusing, depending upon 'the particular contractual relationship and the particular circumstances of the case'.⁴¹

(B) Failure the right to avoid

These two regimes adopt the different means to restrain the right of an aggrieved party to avoid the contract. The approach employed by the CISG is the time constrains, i.e., the buyer or seller must declare the contract avoided within a reasonable time, where the goods have been delivered or the price has been paid.⁴² The right of avoidance is lost if the notice of avoidance is

given beyond the limit of reasonable time.⁴³ A failure to give such a notice deprives the buyer of the right to rely on the non-conformity of the goods.⁴⁴ In other words, the buyer not only loses his right to avoid the contract based on a fundamental non-conformity, but also loses his right to recover any damages caused by the delivery of the defective goods.

Likewise, English law, the means of limitation adopted by Myanmar Sale Law for restricting the right of the parties of termination for breach of contract mainly includes two ways: one is the aggrieved party's own conduct and the other is the operation of the rule of law.⁴⁵ The aggrieved party's own conduct refers to the operation of some general common law principles, i.e., affirmation or waiver by estoppel.

The aggrieved party may lose his right to terminate the contract by his own affirmation, that is when he knew both of the breach and his right to terminate and yet still decided to affirm the contract;⁴⁶ or by waiver, that is when he made a clear and unequivocal representation that he would not insist on strict performance of the original contract despite having the knowledge of all the facts and his right of termination.⁴⁷ The other means of limitation for the aggrieved party's right of termination is by the operation of law through acceptance.⁴⁸

When the seller tenders delivery of the goods, the buyer is entitled to a reasonable opportunity for examination of the goods.⁴⁹ The buyer loses his right to terminate the contract when he accepts or is deemed to have accepted the goods by intimating his acceptance to the seller, acting inconsistently with the ownership of the seller, or retaining the goods beyond a reasonable time without rejecting them. It is in contrast to the position of the CISG that where the aggrieved party's right to terminate the contract is lost by affirmation, waiver or acceptance, his right to damages would normally survive under Myanmar Sale Law.⁵⁰

Summary

The primary requirements relating to avoidance of contract are that the breach must be seriousness and the aggrieved party must have suffered the sustainable loss or damage under both two systems. And, although the fundamental breach of contract under the CISG and breach of conditions under the Myanmar Sale Law are the different terms, the most of remedies for these kinds of breach are similarities rather than the differences. Consequently, according to be comparative analysis, it can be concluded that the similarities relating to the right to avoid the contract under the CISG and Myanmar Sale Law outweigh the differences. Nevertheless, the CISG may be achievable when governing with the international sale of goods transactions.

Conclusion

Under both the CISG and Myanmar Sale Law, the parties cannot be entitled the right to terminate for minor breach of the contract. The CISG classifies the nature of the breach (fundamental, non-fundamental), whereas the Myanmar sale law classifies the terms of the contract (conditions and warranties). In the CISG, the avoidance of contract is discouraged by and it is allowed only in the case of a fundamental breach. Under Myanmar Sale Law, the injured party is entitled to avoid the contract when one

party breached the conditions of contract. Generally, in order to allow the parties to avoidance the contract under both systems require that the aggrieved must be suffered the substantial detriment brought upon the breaching party fails to fulfill his obligations under the contract.

In order to avoidance of the contract, it can be noticed that the law relating to sale of goods of Myanmar seeks to achieve the advantage of certainty in commercial transactions by classifying the terms as conditions and warranties, as it is believed that in commercial transactions it is significant that the parties should be able to know their rights and obligations clearly in the case of any breach. Therefore, in the Myanmar sale law makes it clear for the parties that if a party breaches a condition, it enables the innocent party to avoid the contract. Whereas, the CISG seeks justice and discourages avoidance because it believes that, in principle, contracts are made to be performed, not to be avoided. Although the SGA takes certainty in the consequence of breaches into consideration, the CISG takes certainty in justice into account.

Therefore, the most of researcher prefer certainty in justice, because neither the seller nor the buyer knows who is going to breach at the time of the conclusion of the contract, but they know that whoever breaches it will receive fair treatment. To see my view, the CISG resolution is to be preferable to having certainty in the consequence of breach the contract, in practice.

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OS 002

A Study of the Festival of Sand Pagodas

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Abstract

Every nation has its own tradition and Culture and these are valuable things for it. In Myanmar the traditions and Culture are based on the Theravāda Buddhism. Most of twelve monthly festivals are appeared with depend on Theravāda Buddhism. Among the numerous festivals of Myanmar, the festival of sand pagodas is held in the month of Tabauing. It is a Buddhist festival, probably derived from the Buddhist tradition mentioned in the Therapadana. Evidence suggests that the tradition was introduced to Myanmar in King Anawrahta's times of Bagan. This paper aims to encourage people to preserve the festival which otherwise will soon fade away from the rural areas. According to the Pāli texts available to us, we can accrue remarkable merits from this rare practice of erecting sand pagodas.

Keywords : Buddhist traditions, remarkable merits, sand pagodas, Therapadana, twelve monthly festivals

Aim of the Study

The aim of the study is to give awareness of the importance of maintaining a cultural tradition which is meritorious from the perspective of Buddhism. The tradition is found in various forms in different regions, and it indicates the start of the Pagodas' Festival in Tabauing in the country.

Introduction

There are many festivals in Myanmar culture which has maintained uabout1000 years. They are

January (Pyatho) - Equestrian festival
February (Tabodwe) -Harvest festival (Htamanae pwe)
March (Tabauing) -Sand Stupa festival
April (Tagu or Thingyan) -water festival
May (Kason) - Watering the Bodhi Nyaung tree
Jun (Nayon) -Sayetanmae pwe
July (Waso) - The Robe offering
August (Wakhaung) - Offerings Month
September (Tawthalin) - Boat Rowing
October (Thidingyut) -Thidingyut lightening festival
November (Tazaungmon) - Tazaungdaing festival
December (Nadaw) - Sasodaw pwe

With the coming of Tabauing, the Myanmar calendar turns winter into summer when rivers and creeks become thinner and drier with sand dunes appearing in the middle. It is the time when the yearly festival of erecting sand pagodas on these sand dunes. This tradition, deriving from Buddhism, is particularly popular in the delta regions, Rakhine coastal areas and along the Ayeyarwaddy river in Upper Myanmar and it coincides with the lucrative and pleasurable season for Myanmar farmers who have just harvested their croplands, just ready to take some rest from their toils. As a good occasion for doing meritorious deeds, the festival has been accepted in the country since the days of Myanmar kings, when the kings and the chief queens came to the sand dunes with pomp and ceremony to join their



subjects in making sand pagodas in their names' sake. Regrettably, however, the tradition is almost extinct, leaving its traces only in some regions like Mandalay and several villages of Upper Myanmar.

History of Sand Pagodas

According to the Buddhist Chronicles, the tradition of erecting sand pagodas dates back to ages ago when a sage by the name of Narada was living a thousand kalpas before Buddha Gotama. Once, Narada the Sage happened to think himself to be lacking in a source of dependence though he himself was the source of reliance for fourteen thousand follower sages. Then, he remembered the numerous Buddhas who had appeared – as many as sand-grains in the river Amarica – and thus made a sand-pagoda in remembrance of the living Buddhas. Narada the Sage attained jhanic states in that life and was reborn to attain Arahatsip as a seven-year-old Pulinathupiya in the time of Buddha Gotama. Pulinathupiya recalled his past experience of erecting a sand-pagoda and revived the tradition, which served as the start of Sand-Pagodas' Festival in Myanmar.

A Long Tradition of Erecting Sand Pagodas

Together with the advent of Buddhism, the tradition became prevalent in Myanmar, and some sand-pagodas have formed themselves into longlasting monuments. A preminent sand-stone Pagoda called Shwezigon of Bagan still remains

as a good example of such monuments, its name itself being a derivative of 'the-gon' (sandbank) (sizon, segon and thegon are variant linguistic forms meaning sand-dunes. Not only in Bagan Period but also in Nyaungyan Period, sand-pagodas were continually made and mentioned in the famous lutas songs. Again in Innwa Period, the tradition was recorded in the poems; in the Buddhupatti Cantos, the poet Ashin Maha Silavamsa writes these lines (raw translation):

"A variety of fish joyfully play in the rivers; Aquatic birds enjoy the time with their partners – On the sandbanks do people have fun putting up pagodas."

In Myanmar Era 1125-1138, King Sinphyshin of Konbaung Dynasty conquered Ayutthaya and settled a group of artisans from there in Linzinkon, Amarapura Township near Mandalay. These artisans threw the festival so enthusiastically that they received special mention in the revenue inquests of Matai and Pauktaw. In King Botawphaya's time in ME 1155, sand pagodas were erected in a long line along the Shwetachaung creek from 21st Street to Dawna-Chan Quarter. Those devotees of sand pagodas were from Rahai and Minthasu Quarters. Evidence of this festival as a yearly event can be seen in the Thadhina Cantos by Letwe Thondara:

"The whole year has monthly festivals: Water-throwing, Bo-tree watering, Examinations, Ordinations, Lucky draws, Regattas, Lights, Robe-offering, Spirit-dancing, Horse-racing, Bon-firing, and Sandpagodas."

The mural wall-paintings of Mahalokaramsi Pagoda near the Taungthaman Lake also show paintings of a typical scene at the time of the festival in Amarapura Period.

In Yadanapon Period, the festival was held along the Shwetachaung Creek, which can still be seen every year in Montisu Quarter near Rahai Market, in Minthasu Quarter behind Mahumuni Image, in 24th Street, in Dhatan Quarter, in 21st Street (Palei-Ngwayyaung), and so on. The programme practiced in Mandalay is as follows:

1. On the 1st Waxing of Tagu, Minthasu Quarter starts the festival.
2. Monti Quarter starts the festival on the 13th Waxing of Kason; holds the parties on the 14th; consecrates the Buddha images on the 15th and offers alms to the monks.
3. Dhatan Quarter has made its sand-pagoda into a strong building, and holds the yearly pagoda festival on the fullmoon of Tabaung.
4. Palei-Ngwayyaung Quarter holds the festival near Yotaya Market and the No.8 Police Station.
5. Other sand-pagodas in Mandalay which hold the festival include a pagoda near Kyetmway Bridge and another near Daw Thet Shay's School.

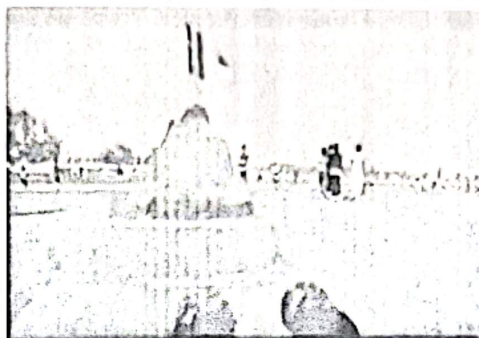


Figure (1) Sand pagoda

Methods of Making Sand-Pagodas

Methods of erecting sand-pagodas differ from region to region. Generally speaking, one must first clear the ground on which a previous sand-pagoda was built the year before. Then, sand taken from the riverbank is soaked with water and made into the form of a 4-foot-high platform. Then, another layer of sand which is again 4 feet high is put on it; then yet another layer of a seven-foot-high platform is added on it. Next, the 7-foot-high bowl-shaped part of the pagoda is made on it with a 8-cubit-tall bamboo standing in the middle. Several layers of sand are added in the form of bell-shaped part and spirals.

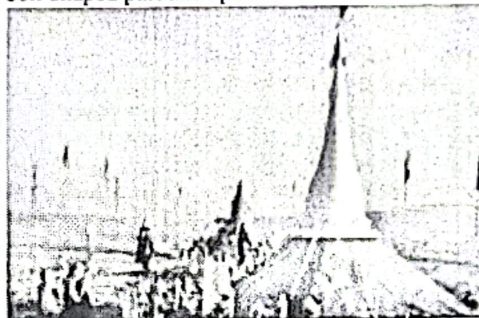


Figure (2) Sand Pagoda at cover with

After having the form of a pagoda like this, the next stage is for white-washing: 10 buckets of quick lime mixed with one viss and a half of cooking oil and one viss of sugar is used together with some indigo to paint on the sand-pagoda. After this, the pagoda is crowned with downturned and upturned lotuses made of wood, which is later gilded.

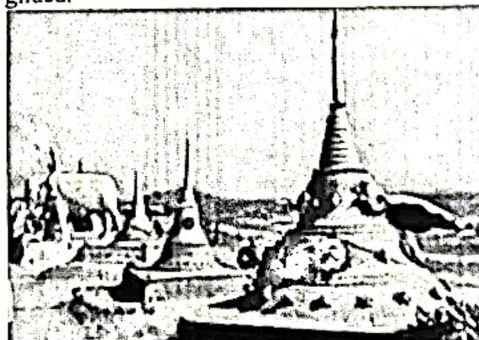


Figure (3) Sand pagoda at Rakhine State

The pagoda is then decorated with paintings of kittimukha and other artistic figures. Finally, a figure of Ananda fish is made in sand and lime at the bottom of the pagoda: the fish surrounding the pagoda and biting its own tail.

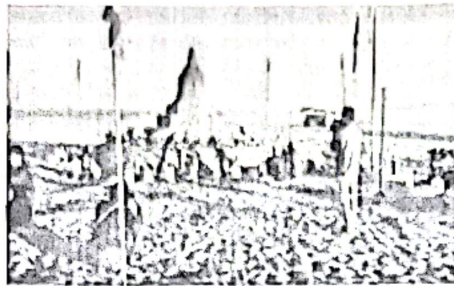


Figure (1) Sand pagoda with five states

About 2 years after the process, the pagoda is tanned and hardened strong enough to bear the currents of winds or rains. The ritual process of consecrating the pagoda follows with the offerings to the Buddha and monks, and festivities are added.

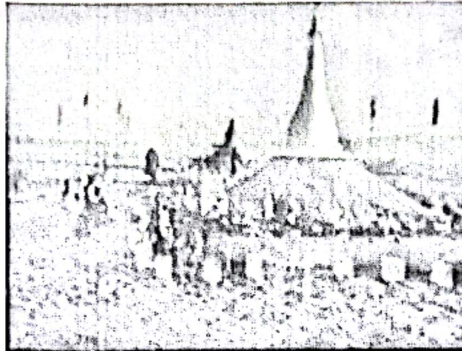


Figure (2) Sand pagoda of Ayeyarwaddy valley

In some regions, a sand pagoda is made by using rolls of mats and built in five layers to signify the five Alinda levels of Mount Meru. Offerings are made to the pagoda, which is encased into a brick pagoda in the course of time.

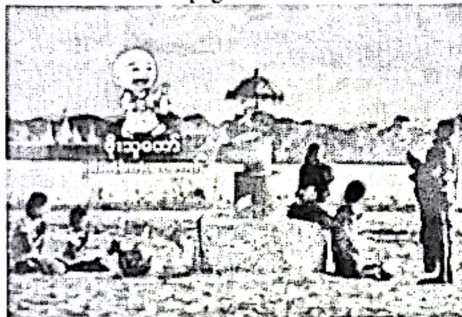


Figure (6) ancient Sand Pagoda

Finding

Narada the Sage enjoyed the benefits of erecting sand-pagodas, which include rebirth in the Brahmas' world, 18 times of rebirths as Sakka in Tavatimsa Heaven, and 36 times of rebirths as universal monarchs. In his last life, he became an Arahant as Pulinathupiya after rebirths only in good existences. The meditation of Buddha's attributes when seeing the erected Sand-Pagoda can give you Arahantship as it did to Pulinathupiya.

Conclusion

Making sand-pagodas can be regarded as the third type of cetiya (object of worship) called Uddissa-Cetiya, and so regarded in Myanmar. Traditionally, the festival has been held in the country especially along the rivers and delta areas as a yearly festival. The tradition was handed down from Bagan Period to now, encouraged by the Myanmar kings and praised in literature by the

famous poets. Buddhist art and architecture is maintained in such an inexpensive way, while organizing different social classes of people at the same time and in the same place. From the perspective of Buddhist philosophy, the tradition brings forth numerous benefits or merits, too. However, in the long course of time, the tradition has almost faded away and called for the preservation of the Buddhist populace in the country.

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- ဦးအေးနိုင် (ဘီအေ) ဆယ်နှစ်လုံးကတည်းက ရေးရာသီဥတုတော်များ စိတ်ကူးချိုးပုံနိပါတ်တိုက်၊ ၁၉၈၈

OS 003

The Great Marble Stone Buddha Images in Sagyin Village

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Abstract

The tradition of idolatry has been in practice in Myanmar for many years. Although the stones such as sand stones, granite stones and marble stones have been used in making images, since the Inwa period. The marble stones from the Sagyin Mountains near the Sagyin Village have widely been used since the reigns of ancient kings. Marble stone is white in color. Statues made of marble stones were idolized by ancient kings. This paper aims to draw the attention of people all over the world to the largest marble images such as Lay-Kyun-Man-Aung pagoda, Loka-Thara-Hpu pagoda, Mahā-That-Kya-Yan-Thi pagoda, Mahā-Loka-Mārajina pagoda, Loka-Chan-Thā-Abhaya-Lābha-Muni pagoda and to the art of stone carving and stone sculpture of the largest marble images and the art of marble stone-carving.

Keywords: idolatry, statues, marble, images

Introduction

Buddhism and idol worshipping co-existed in Myanmar. Although the art of image-sculpture came from India, medium of sculpture were wood, bronze, cement, clay, lead, ivory, emerald, amber, jade, glass, flower powder, palm-leaf powder, bone-ash, bamboo-strips, lacquer and different kinds of stones which are found in Myanmar. Out of them, marble stone was the most popular of all. Since the earliest time of Pyu period, features and *mudrās* were changing through ages into the Myanmar style. During the Amarapura period, images were carved completely in Myanmar style and manner without any trace of foreign influence. Out of various mediums of sculpture different kinds of stones were used regionally. Mostly, way-bu stone, granite stone and sand-stone were used. In the Nyaungyan period, the carvers came to know that marble was the best for sculpture. From that time onwards, marble was used for sculpturing images to these days. Using marble as the medium of image-sculpture had many reasons. First, it was brightly white and it lasted for a long time. In addition to better density and hardness of marble, the stone was weather-beaten. Then it was easy to carve it into any feature. Due to scarcity of marble, the carvers had to put great attention in carving. They had to face many obstacles depending on to *mudrās* and garment. In the Konbaung period, king Mindon had granted the Sagyin-villagers with freedom of quarrying marble in the Royal sacred where forest animals were well-guarded. Sagyin Village still stood as the center of marble-stone mining.

Methods and Materials

In this research paper, facts and figures on *mudrās* of the statues, artifacts and culture of carving are collected periodically by using survey method. The measurement, location *mudrās*, posture and tradition of carving images are described in general. The materials used for the purpose of the research, marble stone industry of Sagyin village, are found to be much useful.

Aim and Objective

This research aims to reveal the importance of stone images made of marble excavated from Sagyin village. Making and enshrining of marble stone images has been an important factor as these Buddha images represent Myanmar arts, skill of sculpture and reflects the strong belief of people in Buddhism. They are also very important for the *Buddhasāsanā*. The uniqueness of while marble found in Sagyin village attracts tourists around the world and this makes Myanmar feel proud of possessing such

fine and highly skilled sculptors and artists, culture and tradition.



Fig. 1 Lay-Kyun-Man-Aung Pagoda

Marble Stone Buddha Images are of different sizes. Among them, the great marble stone Buddha Images are described in this paper.

The first Marble Stone Buddha Image, which was built by King Thiri-Pawara-Mahādamarazadipati (1724) is in Sagaing 'Thaw-ta-ban' pagoda and it is the oldest one among the five marble images described in this paper. The king built it for a good omen and to make his later efforts glorious. It is known as 'Lay-Kyun-Man-Aung' pagoda. To carve this image, a white marble stone of great size was carried on a raft along the Ayeyawaddy River up to 'Thaw-ta-ban', in Sagaing. Stone-carvers were assembled there and were ordered to carve it as soft as newly-polished white conch. The height of the image is (13) feet and (10) inches. It is in an earth touching position or *bhūmiphassa mudrā*. Its length between two knees is (13) feet and (8) inches. This image is situated in Thaw-Ta-Ban, in Sagaing. At the back of the image is a banyan tree to imitate Buddha, enlightened under a bo-tree. In addition, (99) images of orders were carved in attending position to the image of lord Buddha reflecting the traditional story of the post at the place, 'Thaw-ta-ban'. Thus the image is enshrined in the octagonal pagoda. A brass throne was the characteristic of that image and under that brass throne, a copper throne was laid as a prop. The *uṇhāsa* is carved in a lotus-bud type and *urṇā* is painted in gold. The forehead is narrow. The hair-line is studded with jewels. The eyes are like almond seed in shape.

The nose-tip and nostrils are broad. The spread lips are wearing a smile.



Fig 2. Loka-Thara-Hpu Pagoda

Loka-Thara-Hpu image was so far the biggest of all marble images found before Loka-Chan-Thā-Abhaya-Lābha-Muni pagoda. It is in *bhūmiphassa mudrā* i.e. in sitting position. In (1733), Taninganwe king and his son Thiri-Pawara Mahādhammarājā dipati king excavated that royal marble stone reverently from Sagyin hill of Sagyin village. It was carried on a raft along the river. From Ava port, it was carried on the sledges to the new palace-site. That sledges were drawn by elephants. Then a 27-feet deep drain was dug out and the great stone was pulled along it by elephants. The great stone was tied with ropes at three places, top, middle, and base. Then it was pinned down to (27) feet deep. Being the biggest of all marble stone images, it was called 'Loka-Ta-Su or Loka-Thara-Hpu'. The great image is kept in a shrine, east of 'Loka-Thara-Hpu' pagoda. Its estimated weight was (49036) tons. It's high is (29) feet and the length between two knees is (19) feet. The *uṇhōsa* has small lotus-bud type. The forehead is narrow. The small hair-line is gilded and *urna* is "painted" silver color. The eyes are of oats-grain shape. The nose is prominent with pointed tip. The upper lip is thick while the lower lip is thin with a smile. The ears touch the shoulders. It has ear-lobe and the three lucky lines on the neck. The garment is only carved lines. The fingers are all equal in length comparing with those early images. The right hand touches the throne. The characteristic of the images is its left hand. The left hand is not touching on the lap like many other images. It was always found in cross legged in sitting position. The face is slightly turning to the left from the front view. The face was flat wearing a smile.

The other marble image is that of Bagyidaw's Mahā-Thet-Kya-Yan-Thi, popularly known as Taung-Tha-Man Kyauk-Taw-Gyi. This image is (17) feet and (9) inches high and the length between two knees is (11) feet and (8) inches. It is *bhūmiphassa mūdā* in sitting position. Its *uṇhōsa* is a banana bud type, representing rays of Enlightenment. The forehead is narrow and the hair-line is fading and *urna* is painted in gold. The eyebrows and the eyes are not far. The eyes are casting down. The eyes are like

almond seed in shape. The nose is not too prominent. The lips are thin and spread. The ears touch the shoulders. The image has three lucky lines on the neck. 'Du-gou' a fold of garment on the left shoulder is beautiful foldings. The chest is broad and strong. The fingers are of the same length. The right hand touch the throne. The left hand rests on the lap. It is a cross-legged in sitting position. The marble of the image was first class in quality and it is white and soft. The style of the image had departed from that of Ava style. The face is full and serene.

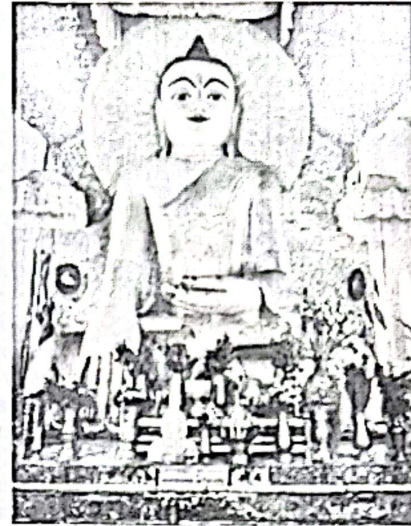


Fig 3. Mahā-Thet-Kya-Yan-Thi Pagoda



Fig 4. Mahā-That-Kya-Māra-Jina Pagoda

The marble image of King Mindon's 'Mahā-That-Kya-Māra-Jina' 'Kyauk-Taw-Gyi' image of (1865) is the third biggest. In June 1864, King Mindon ordered to mine the marble stone of the Sagyin village for carving an image. The great marble stone of U Cho and Daw Khine's quarry at the hill-side of karma hill was quarried. This image was entitled 'Maha-That-Kya-Marrazein Kyauk-Taw-Gyi' pagoda. Its height is (26) feet and (3) inches and the length between two knees is (18) feet. It is in *bhūmiphassa mudrā* in sitting position. The *uṇhōsa* has plantain-bud type rays at the top. These cannot be seen now because the

head was crowned. Eyebrows and eyes are not far. The eyes are casting-down. The nose is big. The upper and lower lips are the same in thickness and wear a smile. The lips are full and the ears are not wide. The ears, with the earrings, are touching the shoulder. The image has three lucky lines on the neck but not distinct. Unlike other images of late Konbaung style, the garment is represented by thick but clear lines. The fingers are of the same length. The torso is slim with thick arms. The right hand touches the throne and left hand spreads over the lap. It is in sitting position with crossed legs. Although the marble is white, it has grey lines. The right hand is not a separate one but touching with the right leg. That is the characteristic of the image. The face is full with a smile.



Fig 5. Loka-Chan-Thā-Abhaya-Lābha-Muni Pagoda

Hundred and thirty five years after the completion of the fourth marble Buddha Image in Mindon's time, there appeared another gigantic monolith in the Kyaung Taw hill of the Sagyin range, in the quarry of U Taw Taw and sons who are the hereditary sculptors in Mandalay, in February 2000. Religiously inspired by the discovery of so large a stone that they decided to make over to the state. It was outlined in the design of a sitting Buddha with *Abhaya mudrā* (no danger gesture). After sixty percent of sculpting had been finished, the colossus measure 37 feet high, 24 feet wide and 10 feet thick, weighing 500 tons!- The largest of its kind. The Image was named "Loka-Chan-Thā-Abhaya-Lābha-Muni". The Image was conveyed with full religious rites and ceremonies by land and water from the Kyaung Taw hill to Yangon from 25 July to 5 August, 2000. During its riverine journey on the Ayeyawaddy River, it made overnight stops at 13 river front towns to receive public devotion and homage-Mandalay, Myin Mu, Pakokku, Bagan Yyaung U, Magwe, Aung Lan, Pyay, Myan Aung, Hinthada, Danubyu, Maubin, Twantay Canal and yangon (Kyo Kon Jetty). From Kyo Kon Jetty it was conveyed by a specially constructed railway to the foot of Min Dhamma Kon hill in Insein Township. On 26 August at 8:20 p.m, the Image was successfully lifted up to the summit of the hill where it would be put onto the already constructed pedestal. When U Taw Taw and party of sculptors and artists finished the remaining forty percent of

their work, possibly by the end of 2000, Loka-Chantha-Abhaya-Lābha Muni would stand under a magnificent pavilion as the largest marble seated Buddha Image in the world. It is in *Abhaya-lābha mudrā* in sitting position. The *Abhaya mudrā*, known as *santida mudrā* or *Abhaya hatta mudrā*, imparts fearlessness and this gesture is made with the hand raised and the palm facing out words, fingers extended pointing up words. The right hand is raised and is bent and the palm faces out words. The left hand is rested on the lap of the crossed-leg with the palm facing up words. The *Abhaya Mudrā* illustrates fearlessness and reveals that there is way to escape from all the worries, sadness, anxiousness that we all have through passion and evil desire. This gesture also represents wealth and prosperity. The *uphōsa* has plantain-bud type rays at the top. These cannot be seen now because the head was crowned. Eyebrows and eyes are not far. The eyes are casting-down. The nose is big. The upper and lower lips are the same in thickness and wear a smile. The lips are full and the ears are not wide. The ears, with the earrings, are touching the shoulder. The image has three lucky lines on the neck but not distinct. The distinct characteristic feature of this statue is that it is made of only pure marble and is not decorated or studded either with gems or jewels like other Buddha images.

Finding and Discussion

Religion developed in the Ava period (1364-1752). In the 17th century Ava, marble stone of Sagyin was regarded as the best for carving Buddhist statues. Since Nyaungyan period, marble stone of Sagyin was used for carving Buddha statues. The stone carving images with marble stone started since the early 18th century. As the kings themselves supervised in carving images, marble stone images became popular more and more. Out of various images, there were four images which the kings themselves supervised in carving and the biggest *Abhaya-Lābha-Muni*, was supervised by U Than Shwe, the former senior general of Myanmar. In spite of following the guide-book on stone carving, form and style of the images became different with the passage of time. The outstanding features of the Ava style images were wide space between the eyes and the eyebrows, the throne and image were separate pieces, thin hair-line, plain garment. Only the early Konbaung style images had 'uphōsa' top-spire, later Konbaung images had none. But the hair line became wider and some were studded with jewels and glass. Later images had carvings and foldings on the garment. Then the eyes and the eyebrows were not distant. It became more natural. The throne and the image were carved in the same piece. The aforementioned facts were the outstanding features of the Konbaung style images. Throughout the Konbaung period, marble stone was widely used in carving images and in carving stone slabs for inscriptions. It meant that the Myanmar king's had a strong interest in the marble stone. Moreover, *Loka-Chantha-Abhaya-Lābha Muni Kyauk-Taw-Gyi* pagoda is one of the largest marble Buddha Images in Myanmar. People around Myanmar come to visit the pagoda with amazing feeling because there are so many different things to catch the visitor's heart. Out of the different mediums of sculpture and carvings, marble is mainly and basically more

avored and used in making Buddha images through different periods of Myanmar Kings as marble stones can stand weather and because of its hardness.

Conclusion

The art of stone-carving in Myanmar reflected the Buddhist art and culture. Stone images were carved to enshrine in temples while metal images were cast for worship at homes or to put in the relic chambers. During the late Bagan period, a more distinctly local style began to develop, which was to become the norm for subsequent images. That style developed during the Ava period. Chronologically the first image is "Lay-Kyun-Man-Aung" sheltered in a temple at Sagaing and King Taninganwe (A.D. 1714-1733) of Nyaung Yan dynasty donated it. The Second Image is located in a big temple at Inwa. It is named **Loka-Thara-Hpu** donated by the same King but finished by his son and successor King **Mahā Dhamma Rājā Dipati**. The Third Sagyin stone image is **Mahā-Thet-Kya-Yanthi** donated by King Bagyidaw (AD. 1819-1837). The fourth image is **Mahā-Thet-Kya-MaraJina** enshrined in a uniquely designed temple located at the foot of Mandalay Hill. King Mindon (AD. 1853-1878) was its donor. Furthermore, the king himself acted as an artist in giving final touches on the face with the royal brushes. In other words, Myanmar kings themselves were enthusiasts in temple-building and carving of Buddha images. The fifth image is **Loka-Chan-Thā-Abhaya-Lābha-Muni**. The Buddha Image was carried from Sagyin Hill Madaya Township in Mandalay region on July 10, 2000 and reached its current location on September 9, 2000. It is also known well as "Loka-Chan-Tha-Abhaya-Labha-Muni" and is the only Marble Buddha Image in Yangon, lower Myanmar. There are four Marble Buddha Images similar to Kyauk Taw Gyi pagoda in upper Myanmar. The peoples believe that "The Marble Stone Images will reflect the history of Buddhism and Buddhist art and culture of Myanmar. It means that the art of carving has national back-up and it is the cause of its flourishing in the Sagyin area up till now.

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The Study of Mudras Found in the Famous Pagodas in Myitkyina

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Abstract

Myanmar is a country where Buddhism is flourishing. Therefore, there are many Buddhist commemorative monuments like pagodas, stupas, and images are found as a symbol of being flourishing of Buddhism all over in Myanmar. Tradition and matters associated with Myanmar culture of arts and handicrafts can be studied in those Buddhist commemorative monuments, such as, pagodas, stupas, and images. Studying the art and handicraft of Buddha images, statues and symbols is called Iconography. In which gesture of hand and foot, bodily gesture, seat or throne, manners of wearing clothes and ornament, style of wearing robes, styles of hair knot, and ornamental back drop of the throne etc are constituted. In this paper the thirteen kinds of Buddha's mudra found in the famous pagodas of the city Myitkyina have been mentioned mainly with the descriptive method.

Purpose

This paper is written with the purpose of knowing the meaning of the essence of hand gestures (mudra) of the Buddha images and statues found in the Buddhist pagodas and stupas when going there either for visit or for reverence.

Advantages

Those who know the Buddha's mudras would venerate beyond the traditional reverence and respect and to be able to pay homage with the most reverentially, respectfully, and fait deeply seated in the heart. Because of this ability abundance of good benefits would be obtained. Moreover, he will be the one who is the foremost person who respect and venerate the Buddha.

Finding

There are 13 kinds of Buddha's hand gestures (mudrās) found in the famous pagodas in Myitkyina. Most of the Buddha images are found with the Abhaya mudra, Civarahattha mudra, Jhāna mudra, Dhammacakka mudra, Bhūmiphassa mudra and Mahākaruṇā mudra.

Meaning of Mudra

The word mudra is a Sanskrit word and in Pāli it is "muddā." The Sanskrit word "mudra" is explained as emblem, seal, and symbol, hand gestures used in the religious ceremonies, art of arithmetic, and calculating with fingers and toes in the Sanskrit English Dictionary of Monea William. The word mudra is explored as emblem, seal, counting, art, calculating with fingers in the Pāli English Dictionary of T. W. Rhys David and William Steve.

The word mudra in Sanskrit and mudda in Pāli is one of the fundamental keys necessary to know in doing research of images, statues, relief sculpture and statues in the round. Those who believed in the dispensation had invented variously the hand gestures of the Buddha's images and venerated these images. Mudra is referencing the very profound, delicate, and hidden meanings and natures. Some mudras are showing style and manner only with one hand and some mudras are showing either with tow hands or four to five hands in order to deliver the view with different styles and manners. Therefore, some experts in the iconography divided into and recognized either as mudra or hattha.

When saying mudra it means not only the hand gestures but being recognized all the different styles and manners showing with hands, feet, and body parts as mudras. However, in general the styles and manners are recognized as mudra and the showing of style and manner with hands is recognized as hattha.

(2) Kinds of Mudra

Mudra denotes the showing the signs of what is wishing to explore by means of various

hand gestures. Mudra are basically divided into two.

1. A kind of mudra showing the Abhidhammā nature of secret ceremonies regarding with tantarāyāna, occult science and art of exercising mystic power without recourse to evil spirit, ceremonies of sorcery, and ceremonies of making to be more potent.

2. A kind of mudra showing either the symbol of a character like divine being, king of devas (Sakka), and Brahmā or events in the stories depicting with images, statues, relief sculpture and statues in the round. In this way mudras are basically divided into two kinds.

The first kind of mudra should be depicted by great Brahmins, sorcerers, counselors, Brahmins conducting the sacrificial ceremony and sectarian heads in the festivals and ceremonies. Tibetan monks and Japanese monks are still using up to now this kind of mudra depicting the ceremonies.

The second type of mudra is usually used in the fields of painting and sculpture like making relief sculpture and statues in the round, carving, and painting.

Period of commencing the invention of mudra

Researchers recorded that the culture of venerating the Buddha by sculpturing as a human being was commencing 2nd century A.D. Before that period instead of the Buddha images a kind of symbol such as throne, banyan tree, circle, flagstaff, and book etc was built to be venerated as the Buddha. Therefore, it should be noted that the images and statues of the Buddha was appeared after the 2nd century A.D.

The Gandhāra and Mathura state situated in the north western of the India are the states started to venerate the Buddha images and statues.

1. Abhaya Mudra¹

Abhaya mudra is found in the *Shvemoetaung* pagoda. It is the symbol of preventing all the dangers. It can be called as the symbol of non-danger. Moreover, it is called differently as Santida mudra and Abhayahattha.

A little bit raising of one hand and bent then with the palm facing outward with the fingers spreading up is called Abhaya mudra, the symbol of non-danger. One seeing this kind of statue sees the palm. Sometime, characteristics marks are explored on the palm. The palm raising should be as high as the chest. The other hand is putting on the thigh either facing upward or downward. Sometimes, both hands are facing upward with the Abhaya mudra.

In the Abhaya mudra there is any trace of anger (dosa). It can be seen as the Buddha is encouraging one who is venerating the Buddha statue with this kind of mudra. The meaning of the Abhaya mudra is depicting that you are protected from any danger and not to be frightened and the attribute of the Buddha having anything to be frightened as he was free from cankers (kilesās).

Researchers said this Abhaya mudra is depicting the Buddha is delivering the *Dhajagga Sutta* stating that not to worry, frightening, goose fleshing, terrified and trembling there is the Buddha to be taken as refuge.

In other words, it portrays in order to get the benefits, such as, unshaken, free of sorrow, free of cankers (kilesā), and free of danger for those confronting with the vicissitudes of the world (lokadhamma). It is noted that this kind of hand gesture, Abhaya mudra is used when an individual of great and noble age, attribute, dignity, and wisdom is greeting the guest and wanting to ask whether the guest is healthy or free of danger or free of any disturbance.

2. Cīvarahattha²

This kind of mudra is found in the *Pyilonechanthar Sutaungpyae* pagoda. It is found that either one hand or two of the Buddha statue and Arahāt is holding any one of the nine kinds of robes. It is called Cīvarahattha.

The statue in which the Buddha is holding any one of nine kinds of robe³; a lower robe wearing from the waist to the knee, an upper robe around the torso and shoulders, an outer robe, a doubled robe, bed robe, robe used for facial tower, waist band robe (parikkhāra), robe laid out for sitting or lying down, bathing robe, and robe used to cover the ulcer is called Cīvarahattha statue. It is generally found as the robe resolution, apportioning of robe (vikappanā).

In other walking and standing Buddha statues are found with this kind of Cīvarahattha. These are illustrating the perfection of morality (sīla pāramī), perfection of patient (khanṭi pāramī), and perfection of resolution (adhiṭṭhāna pāramī).

One who builds and venerates the Buddha statues of Cīvarahattha mudra is said to be beneficial of getting various kinds of clothing and ornaments in abundance, free from destruction of his clothes from rat bite, burning, and stolen by thief which is like the benefits obtained through offering of robes and kathina robe mentioned in the *Āṅuttara Nikāya* and the *Vinaya Piṭaka*. All the wishing that had been answered by offering of clothes made of safflower is mentioned in the *Ummādanṭī Jātaka*.

¹ Buddhist Iconography, P.36-37

² Buddhist Iconography, P.49

³ 227 rules for monks, p. 477.

1. Thin = lower robe, wearing at the waist

2. Ko = upper robe wearing upper part of the body, ekasī

3. du = dukutṭa, double robe

4. eik = bedding robe

5. myaet = robe used as facial tower

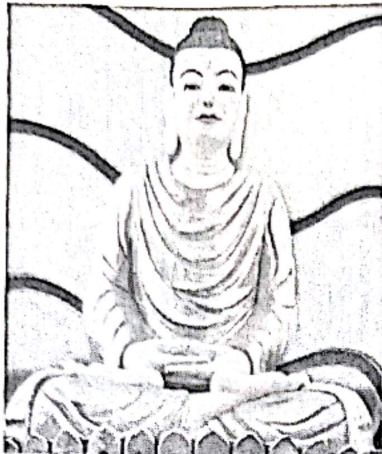
6. parate = (parikkhāracola) handkerchief, water strainer, bag to hold the alms bowl etc of miscellaneous

7. nisidd = robe laid out for sitting

8. moe = bathing robe, robe wearing when bathing in the rain

9. amar = robe covering the ulcer. Robe wearing as underwear when suffering of ulcer in order not to stain the lower robe

3. Jhāna Mudra¹



Jhāna mudra is found in the *Pyilonechanthar Sutaungpyae* pagoda. It is a kind of practicing meditation or entering the Jhāna attainment. Both hands are putting on the lap with palms facing upward. Right palm is placing on the left palm and sitting in relax without any tense. In this kind of mudra it is making to showing the manner of entering the Jhāna attainment and having concentration (*samādhi*). In these mudras it may be found that two thumbs are touching end to end and the rest fingers are spreading.

According to Tibetan and Myanmar culture views this Jhāna mudra is used in making the sculpture of *Amibhāsā Jhāni Buddha*. The mind of individual who is entering the Jhāna attainment is so pure and cleans that he had limitless wisdom illuminating with no ending. In order to depict *Amibhāsā Buddha* having unlimited wisdom this kind of mudra has been used.

It is said that among the *bodhipakkhiya* dhammas it is especially indicating the Jhāna dhamma. It is indicating the *samatha* practice.

4. Dhammacakka Mudra²

Dhammacakka Mudra is found in the *Sutaungpyae* pagoda. It is the style of delivering the very first sermon. In which the Buddha was about to make the turning the wheel of the Dhamma.

It is a kind of style that the right thumb and forefinger are touching the left thumb and forefinger and the right hand is about to turn the wheel of a cart. Both hands are rising up above the sternum. The left hand is usually covering the right hand.



This Dhammacakka mudra depicting Gotama Buddha was delivering the Dhammacakkapavattana Sutta to the group of five ascetics (*pañcavaggi*) in the Isipatana deer park near *Bārāṇasī*. The time of delivering the Dhammacakkapavattana sermon was during the early watch of the full moon night of Waso in 103 Mahā Era, (B.C-588). At the end of the Dhammacakkapavattana Sutta Brahman *Koṇḍañña* had realized the Dhamma and became a stream-enterer (*sotāpanna*). Owing the request of Brahman *Koṇḍañña* to become a monk the noble Buddha had ordained him by saying “*ehi bhikkhu*.”

At the very first night of delivering the Dhamma the first monk of the members of Sangha community of the Buddha was appeared. This Dhammacakkapavattana Sutta is the first sermon as well as the fundamental of the three Piṭakas and the essence of the Piṭaka. The Buddha had being taught this Dhammacakkapavattana Sutta repeatedly to Vappa, Bhaddiya, Mahānāma, and Assaji every day. They all had realized all conditioned things dhammas have the nature of perishing and became stream-enterers (*sotāpannas*). On account of their request the Buddha had ordained them as monks by saying “*ehi bhikkhu*.” People venerate this kind of Buddha statue having this Dhammacakkamudra depicting the Buddha delivering the first sermon that is the beginning of the dispensation as noble and having blessing (*maṅgalā*).

¹ Buddhist Iconography, P.50

² Buddhist Iconography, p-59,60.

5. Bhūmiphassa Mudra¹



Bhūmiphassa mudras are found in the *Shwemoetaung* pagoda, the *Sutaungpyae* pagoda, the *Myamyintzu* pagoda and the *Pyilonechanthar Sutaungpyae* pagoda. It is the style in which the Buddha's hands are touching the earth. It is called the gesture of indicating the *Vasundharī* Earth as the witness.

The right hand of the Buddha is hanging down from the right knee. In this style the palm is facing inward and all the fingers are spreading and pointing directly downward either to the lotus throne or earth or a kind of seat. The left hand is usually placed on the lap with the palm facing upward. The back of the right hand can be seen. Sometimes, in the left hand a certain thing like a bowl is placed.

The word *bhūmiphassa* is the combination of two words, *bhūmi* meaning of the earth and *phassa* with the meaning of touching. Therefore, the *bhūmiphassa* is the style of touching the earth. Reason for the appearance of this mudra is as follows. The future Buddha was entering in the eight kinds of attainment (*samāpatti*) in the grove having the name of *Bhadra* after partaking of *ghaṇā* milk rice gruel offered by *Sujātā*, the rich man's daughter on the full moon day of *Kasone*. In evening the future Buddha went to the *Mahābodhi* maṇḍana and spread the eight handful of grass that was donated by *Sotthiya*. After that he made the solemn resolution: "let my flesh and blood dry up, and let only my skin, nerves, and bones remain! Never shall I unfold this cross legged position until I attain Buddhahood!" and sat on the grass throne.

At that time, *Māra* creating himself with one thousand arms and riding on *Girimekhalā* elephant and leading numerous fighting forces armed with various weapons and coming to the place where the Buddha was sitting and fighting the future Buddha. *Māra* caused the fearful rain to be fallen. That fearful rain, however, changed into the flower rain when it reached close to the future Buddha. At that time King *Māra* approached the future Buddha and said, "Oh! Prince *Siddhattha*, rise up from the throne." The future Buddha had made referencing his meritorious deed done during the life time of *Vessantarā* to the great earth as a witness. At that time the great earth was

shaking with frightening sound. Owing to this happening *Māra* and all his accompanied beings were so frightened and ran away. Ancient saying was present that in order to depicting the event of the Buddha's victory over *Māra*, this mudra was invented. Therefore, Myanmar dramatic art composed as, "the earth shall be known and heard as a witness."

The earth has the nature of unable to run out, being strong, hard, and supporting, and able to be touch and to grasp. The meaning of mudra showing the great earth is this Buddha statue is the image of the Buddha symbolizing the Buddha who is endowed with above attributes.

6. Mahākaruṇā Mudra²



It is found in the *Shwemoetaung* pagoda. In this kind of mudra the statue is sculptured with raising either left hand or right up to the chest or upper part of the breast with the palms facing inwardly and covering and pressing the chest, breast and edge of the shoulder. It is illustrating the compassion (*karuṇā*). If this kind of mudra found in the Buddha statue it indicates the Buddha is a great being with great compassion (*mahākaruṇā*).

The Buddha had fulfilled the perfections for many *asankheyya* worlds for the all sentient being because of having great compassion (*mahākaruṇā*). It is the right and true words. The Buddha statue with this kind of mudra is built for indicating the earth as the witness of this truthful word.

This kind of mudra is mostly found in depicting the events like descending of the Buddha from the *Tāvātimsa* celestial world to human world and delivering the dhamma to those suffering of worry, suffering, sorrow, and lamentation.

By venerating the images of this *Mahākaruṇā* mudra appearance of salvation and rescue persons, free from worry, sorrow, and lamentation, getting compassion and forbearance of even one's enemies, appeasing of grudge, danger, and free from pride, win in the law cases, increase in dignity and power of the king, having much glory, having abundant of people who respect him, and appearance of noble one who support and honor him.

¹ Buddhist Iconography, p-68,69,70.

² Buddhist Iconography, p-70,71.

Conclusion

Thorough understanding of mudra one can say with what purpose these statues were made by seeing the hand gestures of the statues. In general each statue has no sophisticated specification of images and statues of the Gandhāra period as there were very few rules and regulations regarding with mudra. For Sakyamuni Buddha, however, it is difficult to make separate specification for mudra. It is not easy to say this image is either Sakyamuni Buddha or Amibhāsā Buddha or Verocana Buddha by referencing and based on only one kind of mudra. Buddhism and Buddhist arts spreading all over Asia are varied according to the place, meaning, forms and appearances of images and statues. Although the form and appearances are varied due to the decorations the internal nature and essence is the same in the original meaning and the final replicating meaning.

Relief sculpture and statues in the round are found mostly taking the guise of the human appearance. In order not to be likened with human hands, feet and body parts are made many hands, many heads, and many eyes, and making the arising of wings from the body and flying in the sky are sculptured as a special characteristic. However, the style of wearing clothes, decoration, and using weapons are found the same as that used by human beings. Therefore, by studying the decorating materials used in the images and statues and material things the historical tradition, social cultures, and Buddhist philosophical thinking (Abhidhammā) people who were living in those days can be estimated. Unless the origin and source of any image or statue are known it has a little value. It is found that when the origin, source, and historical essence of that image is known and understood it becomes very valuable.

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The Impact of Hand Attitude (Mudra) on Society

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Abstract

This paper explores the symbolic gestures of the hands of the Buddha images (mudra) and the history and the origin of mudra. The meaning of mudra is understood from the point of view of scholars, the hand attitudes in Buddhism and the usage signs of mudra in daily life of humans in society. These signs can be used between humans who are silent and in different countries as a body language and are a good connector of humans communicating with each other. The Buddha shows feelings by using the mudra and similar signs are still being used today for showing people's feelings. The main idea of this paper is to demonstrate that mudra is not only a set of cultural signs but also signs which are essential to our daily life and which are important for human communication and as such, still have an impact on today's society.

Keywords: mudra, connector, different shapes, fingers

Introduction

The background history of mudra

The history of mudra is a mystery. The mudra is also called hand styles that are created using all fingers of both hands to show different ideas and feelings. The mudra uses different hand positions. Some of the mudras use one hand and some mudras use two hands some use more than three. Sometimes the mudra includes not only a hand style, but also a leg style.¹ In Buddhism, the Buddha's images are made using different mudra. The literature suggests that in the later Vedic period, the mudra is used as a sign of seal, in worship. *Aṭṭhakathā* in *pāli* showed that mudra is the art or calculation mention as a noble craft (*ukkaṭṭham nāma sippaṃ muddā gaṇānā lekḥā*).² Generally mudra is the gesture of palm and fingers. Mudra is also known as *hatta* because it refers to the weapon at Hindu's gods hand.

The origin of Mudra

Mudras may have been used from the beginning of time, developing when men started communicating with each other using gestures as a sign language in the absence of any kind of dialogue, language or script. Mudras are not only found in Asia, but they are also used throughout the entire world. In their rituals, European ancestors certainly were familiar with specific gestures, which they used to underline and seal what they thought and wanted to say.³ In India, mudras are an established component of all religious activities. The various mudras and *hattas* (arm poses) are significant in the depiction of Hindu gods.⁴

The word mudra

There are different meanings about the mudra according to scholars. The scholar Hommel said that mudra is derived from *Musaru* of Assyrian language. The scholar Coomaraswamy said that the word mudra mean sign language and Rao said that it is used as a sign of stable and also used in ceremonies. Moreover, scholar Woodward said that mudra is sign of all fingers.⁵ The word mudra is Sanskrit meaning 'gesture', 'mark' or seal'. The Sanskrit for mudra is literally translated to gesture or attitude. Mudra is also commonly translated to

seal. The roots in Sanskrit are *Mud* and *Dru*. *Mud* is delight or pleasure, and *Dru* is to draw forth. The literal translation includes the hand gestures but will also include *dristis* (eye focal points), *asanas* (body positions), and *pranayama* (breathing techniques).⁶

The different shapes of mudra in Buddhism

There are fifty kinds of mudra at the Buddha's images in Myanmar cultures. They are *Añjalimudrā* mudra⁷, *Ardh-Chandra Hatta*, *Abhaya⁸mudrā* mudra, *Āliṅga Hatta*, *Uttarabodhimudrā*, *Katyavalambita mudra*, *Kaṭaka Hatta*, *Kusatriṇahasta*, *Karaṇa mudra*, *Kati Hatta*, *Kusamudrā*, *Kesamassu pahāna mudrā*, *Khepana mudra*, *Gadāmudrā*, *Gaja mudra*, *Caṭeḍāṇamudrā*, *Cinta mudrā*, *Civara Hatta*, *Jānamudra*, *ñānamudrā*, *Tajjanimudrā*, *Tappana mudrā*, *Tiṇakiraṇa mudrā*, *Tripaṭaka Hatta*, *Tilokavijaya mudrā*, *Daṇḍa Hatta*, *Damara Hatta*, *Dāna mudrā*, *Dhammacakrā mudrā*, *Namakkāra mudrā*, *Nidrata Hasta*, *Patta mudrā*, *Padumā Hatta*, *Pāṭihāriya mudrā*, *Pottaka Hatta*, *Buddhasamaṇa mudrā*, *Byāchyāna mudrā*, *Bhūṭadāmara mudrā*, *Bhūmiphassa mudrā*, *Mahākaraṇa mudrā*, *Yoga mudrā*, *Lalitakhepa mudra*, *Lola Hasta*, *Vajirāhukaṇa mudrā*, *Vandani mudrā*, *Vara mudrā*, *Vitakka mudrā*, *Vimhaya Hatta*, *Venāyaki mudrā*, *Santida mudrā*, *Sandassana mudra*, *Sabbarājindya mudrā*, *Samādi mudrā*, *Sīhakaṇṇa mudrā*, *Sūci mudrā*⁹

These are some examples of Buddhist mudras and their meaning.



Figure 3 *Añjalimudrā*

¹ P-30myanmar

² P-194 *aṭṭhakāḍḍinipāṭa*

³ P-4 mudras yoga in your hands

⁴ P-5 mudras yoga in your hands (Gertrud hirschi)

⁵ P-50 culture of Oriental Studies

⁶ P-1 Mudra (Nicole Dunn)

⁷ P-21 Hout sein

⁸ P-104 Hout Sein

⁹ P-12 Aung Khin Soc (the mudra of Buddha), p-34 MCS mudras

Añjalīmudrā means that honouring and celebrating.



Figure 4 Abhaya mudra

Abhaya mudra is protection, peace and dispelling of fear.



Figure 5 bhumiphasa mudrā

Bumiphasa mudrā means that to invoke the earth as witness to the truth of his words



Figure 6 kesamassupahāna mudra

Kesamassupahāna mudra means that renunciation (nekhamma), equanimity (upekkhā), resolution (adhiṭṭhāna), truthfulness (sacca), patience (khanti), loving-kindness (metta).¹

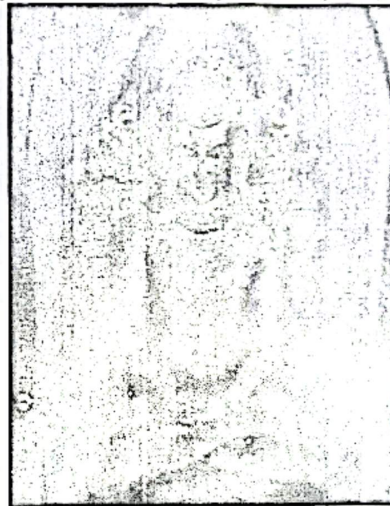


Figure 7 jhāna mudrā

¹ P-27 Aung Khin Soe

Jhāna mudrā means that concentration of mind



Figure 8 Santida mudrā

Santida mudrā means that Peace, Luxury, wealthy and healthy.



Figure 9 Uttarabodhimudrā

Uttarabodhi mudrā means that enlightenment

Material and Methods

The study is based on the primary Buddhist sources. The data have been collected from published sources such as Pāli texts. The data were analyzed by using descriptive method and comparative method.

Findings and discussion

Mudras are the hand gestures that are symbolic in different cultures. Mudras have been used in Buddhist sculptures and in the painting of India and Tibet. Mudras are used in Indian culture and in the traditional classical dancing of Indian. In Buddhism and Hinduism, a symbolic gesture of the hands and fingers is used either in ceremonies, dance or in sculpture and painting. It is used in rituals of sacrifice as the priest makes offerings to the gods. Moreover, mudras are also used in conjunction with pranayama (yogic breathing exercise) in yoga. Mudras have a very deep history and can be found in all cultures including, Ancient Egyptians, Romans, Greeks, Persians, Aborigines in Australia, Ancient Indians, Ancient Chinese and others. It has never been proven that apes will communicate with each other using their hands. Each culture will have their own mudras, and every mudra would have a specific meaning. Hand mudra are used in religious, spiritual, and artistic traditions of many cultures throughout the world. The mudrā (the hand attitude) has been used all religions and cultures to show the feelings and ideas. The mudra can also be identified in use today for showing people's feelings.



Figure 1. OK



Figure 2 .peace



Figure 3. love



Figure 4. call phone



Figure 5.success



Figure 6. Unsuccess



Figure 7. worship

For example, when everything is ok, index bent to the thumb and other fingers are up together has been used. To show the sign for peace, index and middle fingers up together, to show love sign, the ring finger and middle finger bent and the other are up together, to call phone, the thumb finger and the small finger are up and the other fingers bent, to express the success, thumb finger is up, to express fail, thumb finger is down, to say fuck, the middle finger is up and the others bent together, to scold, the index finger is up and the others are bent together. A further examples is to demonstrate a heart symbol by using both hands. Both index fingers are bent and both thumbs are touch, to express the wrong sign, one index finger across

another index finger and to express promise sign, little finger is up and other fingers are bent.

Nowadays, Mudras are used in every action, every moment of the day. Each action is a symbol of our underlying mental and physical condition and the results of various energy pattern forming within our being.¹ The sign of mudra can be used to improve relationships. Mudras are a non-verbal mode of communication and self- expression, consisting of hand gestures and postures. Mudras can grant spiritual bliss and deeper communication of the body and mind. Mudra as mystical hand gestures can be used to focus subtle energy, transmit teachings through symbols and confer psychic protection. The word mudra is gentle and is believed to affect the flow of energy in the body. The mudra is a physical symbol, expressed with the hands. It is highly complex sign language of hand configurations and gestures evoking specific meanings and a whole penumbra of associations. They are used to communicate each other. They are used for the energetic, emotional, and physical effects therefore, the attitude and positioning of the hands is very important for humans. It is a connector with each other and is a sign of body language. By using these signs, the connection is facilitated with each other and communication will flow and work will be easily accomplished. These signs can be used between humans who are silent and unable to verbalize or people from different countries, cultures and different social situations. These hand symbols are therefore very useful as communication signs for all humans. Therefore, hands are a source of tremendous power.

Conclusion

Mudras are more indicate and meaningful. The palms and fingers have been bestowed with enormous power and strength. Everybody is full of deep mysteries and potentials that can be expressed and discovered through the language of mudra. Mudras are a non- verbal mode of communication and self-expression, consisting of hand gestures and finger- postures. They are symbolic signs based finger pattern used to express ideas and feelings. Taking the place of the spoken word they retain the efficacy of verbal communication expressing both ideas and feelings. Mudra indicates to the faithful in a simple way the nature and function of human. So, everyone can use mudras within relationships to facilitate connection between each other. Mudras can be used by all people including those who cannot speak. Hands are very useful for all people. Hands are not only one part of body but provide a means whereby signals can be easily transmitted. Therefore, everybody should be aware of their hands as a valuable way of communicating with others and take care of our hands.

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HIS 001

The Role of Oil Industry- Myanmar Monarch to the Time of Rehabilitation in Yenanchaung Oilfield Area

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Abstract

This paper attempt to examine Myanmar's Oil Production that began from Myanmar monarchs and was run after the country had gained its independence especially in Yenangyaung based on the facts are collected. The purpose of this paper is to know the conditions of oil wells, the conditions of oil production, the types of oilfield rehabilitation and the nature of *Twinyoe-Twinza* who's lived in Yenanchaung. In order to do this research, an examination is focused on primary sources, secondary evidences, and records and noted on oilfield areas. This research work takes two methods: the method of comparing the data mentioned in the local documents: and the method of exposing the contents of primary sources. This attempt results in the establishment of a clear vision concerned with the prominent of town as well as in oil production and flourishing religion at that time. Depending on the findings of such examination, I am going to expose the historical document of the town, Yenanchaung that has possessed the ample historic images of oil wells and the structure of *Twinyoe-Twinza*.

Keywords: *Twinyoe-Twinza*, oil wells, Yenanchaung

Introduction

Oil or petroleum was one of the important mineral products of Myanmar. It is learnt that the extraction of petroleum in Yenanchaung area was begun in the reign of King Tannet (A.D 877-906) of Bagan.²² In the town of Yenanchaung, there was "*Twinyoe-Twinzas*" who had hereditary right by royal grant to work oil wells. During the reign of king Aniruddha (A.D 1044-1077) there were twenty-four *Twinyoe* and their fourteen descendants and were assigned duty to present earth-oil to royal palace.

The demarcated boundary at this area was *Taung-kha-mauk* in the east, *Pya-gyi-taung* in the west, *Yauk-thwa-taung* in the south and *Kyauk-ma-sin* in the north. Of the social status in Myanmar society, one social status is found confined to only a region, which were *Twinyoe Twinzas* or hereditary earth oil diggers and owners of Yenanchaung.

Materials and Methods

The data required for this paper is mainly collected from the families of *Twinyoe-Twinza*, interviews with local oil wells owners and workers and copying from National Archive files and records. In writing this paper, comparing the data mentioned method and the method of exposing the content of local documents and primary sources are mainly used.

Findings

The study of this paper shows that the type of oil production, oil wells and social status and custom of *Twinyoe-Twinza* are distingue in character. Regarding with the oil wells, it is also found that the modern technique have been used and number of oil wells were owned by *Twinyoe-Twinza* before colonial period.

Oil Production in Myanmar Kings

Although there is no convincing evidence that petroleum was found in Myanmar in the Bagan period, it is reported that petroleum was regarded as an article used by the crown in the reign of King Anawrahta of the Bagan period and that it was presented to the crown for preserving palm-leaf manuscripts of Buddhist scriptures.²³

There were twenty-four *Twinyoe-Twinzas* who submitted petroleum to the kings. Though the number of *Twinyoe-Twinzas* families increased. The crown exempted their descendents from crown service and taxation.²⁴ Thus, only the *Twinyoes* and *Twinzas* had the right to extract petroleum freely in the Bagan period. Petroleum became extensively used. Although it was first used only for lighting and for protecting palm-leaf manuscripts of scriptural texts from insects by applying it on them, it was used for other purposes in later times.

From the Nyaungyan period (1600-1752) onwards, petroleum became one of the twelve items (*she-nah-mu min-daing*) the *athis*, *alas* and the *winne kappas* were required to submit to the crown.²⁵

During King Badon's reign, there were more than 520 petroleum wells owned by *Twinyoes* and *Twinzas* and the total petroleum production was 9,287 tons.²⁶ During his reign, the *Myothagyi* (the headman of town) had to collect and submit to the crown one-tenth of the incomes of the people residing in his jurisdiction.²⁷

In the reign of King Mindon (AD 1852-1878) of the Konbaung period, petroleum production became more organized. King Mindon installed Daw Khin, who was a daughter of the *Myowun* (governor) of Yenangyaung and who was serving as a lady-in-waiting in the Glass Palace, as his queen, the title named *Susiripabha*, and granted her *Kyemyin Taik* in fief. King Mindon confiscated 120 oil wells owned by the ancestors of Queen *Kyemyin* and forty-four wells they held as security for debts.²⁸

²² Gazetteer of Yenanchaung Township, Yenanchaung Myone Hmattan Compilation Committee, Yenangyaung, Kawi Mahein Press, 1969, p. 7 (Henceforth: *Hpyitsin Hmattan*, 1969)

²³ U Naing, *The Origins of the Hereditary Twinyoe Twinzas*, Yenanchaung, Tms., 1960, p. 5 (Henceforth: Naing, 1960)

²⁴ Naing, 1960, 5

²⁵ Dr Yi Yi, *Lexicographical Notes for Researchers*, Researches in Burmese History, Yangon, 1974, p. 494 (Henceforth: Yi Yi, 1974)

²⁶ U Aye Kyaw, "Yangon Port during King Badon's Reign", Yangon, *Telkatho Pyinnyapadetha Sazaung*, Vol. IV, part.iii, July 1969, p. 186

²⁷ Yi Yi, 1974, 256

²⁸ Captain Thein Kyaw, *Myanmar's Earth Oil-Myanmar's Molten Gold*, Yangon, Daily Gazette Press, 1959, p. 17 (Henceforth: Thein Kyaw, 1959)

(Photo-1)
Old Myanmar Hang-dug Oil Well in
Yenanchaung



Source: Htar Thet Thet Oo Collections

From 1861 onwards, the petroleum extracted around *Twingon* and *Beme* in the Yenanchaung oilfield was transported to Yangon port and sold to foreign firms.²⁹ On 1 October 1874, the Royal Petroleum Refinery (*Yenanchet-yondaw*) was established. The refined products from this refinery were distributed from April 1875 onwards.³⁰

Oil Production in Colonial Period

Since the British annexation of Upper Myanmar, the rights concerning petroleum production had been changed. The petroleum wells the *Twinyoes* and *Twinzas* owned and the petroleum obtained from them could be sold, mortgaged or leased to anybody; in addition, a *Twinyoe's* right to own petroleum wells could be transferred to anybody. New oil wells were also bored. The people had to pay taxes on the amount of petroleum extracted. As regards the method of

Sl. No.	Name of the Well	Depth (Fathoms)	Production (Barrels per Day)	Owner	Remarks
1	Twinyoe	10	100	British	
2	Twinyoe	12	120	British	
3	Twinyoe	15	150	British	
4	Twinyoe	18	180	British	
5	Twinyoe	20	200	British	
6	Twinyoe	22	220	British	
7	Twinyoe	25	250	British	
8	Twinyoe	28	280	British	
9	Twinyoe	30	300	British	
10	Twinyoe	32	320	British	

extracting petroleum, *lun-tu-zets* (drill rigs) replaced *maung-tu-zets* (steam hammers for driving pipes).³¹

All the petroleum firms that came to Myanmar worked not only in the Yenanchaung oilfield, but also in the new oilfields such as *Chauk*, *Yenan-gyat*, *Minbu*, *Lan-ywa*, *Yenan-ma*, *Badaukpin*, etc.³²

The British government levied taxes on the crude oil produced. The government collected petroleum tax, excise and land tax. To collect petroleum tax, two toll gates (one at *Beme* and the other at *Let-hmat-kon* quaters) were established. The clerks at the oilfields would measure the petroleum and calculate the amount of tax. They would give permits for transport to the cart driver concerned only when the tax had been paid.

The permits had to be submitted to the officers at the toll gate. If the officers thought the amount of petroleum on a cart exceeded the amount mentioned in the documents, they would demand the cart driver to pay the difference before allowing the cart to continue its journey. The permits for transport had to be issued from 6:00 to 10:00 am or from 2:00 pm to 5:00 pm.³³ The way the taxes were collected indicates that the government attached great importance to petroleum industry.

In the reserved wards in *Twingone* and *Beme* villages, the area of each oil well must be one-fourteenth of an acre. The boundaries of each well must form a hexagon circumscribing a 60 feet diameter circle. However, in the plots which were one-fifth of an acre in extent, the circle must be a 100 diameter circle. The well must always be at the centre of the plot.

Reports on the drilling of oil wells had to be submitted to the Minister of Revenues through the commissioner. Heads of departments concerned had to make biannual or quarterly lists of the amounts of petroleum produced in Yenanchaung, *Singu*, *Yenangyat* and *Minbu* towns.³⁴ It seems that the government was trying to keep abreast of the changes in the wards which produced petroleum.

Concerning the refining of petroleum, B.O.C transported the petroleum produced in Yenanchaung to its petroleum refinery in *Thanlyin*. A pipeline to transport petroleum had

²⁹Maung Kyaw Win (M.A.), "Oil Industry in King Mindon's Reign", *Shumawa Yokeson Magazine*, Yangon, February 1974, p. 107.

³⁰U Kyaw, "History of Down River Route", *Sha Sha Hpwe Hpwe Myanmar Thamaing* (Little known Facts on Myanmar History), Vol. II, Yangon, Theintaik Yadana Press, 1999, p. 202

³¹Burma Petroleum Industry, The Burma Research Society, Burma Pamphlets, Longmans Green and Co. Ltd., April 1946, p. 3

³²Thein Kyaw, 1959, 19-27

³³The Burma Oilfields Manual, 1920, Rangoon, Supdt., Govt. Printing and Stationery, 1931, pp. 58-59 (Henceforth: *The Burma Oilfields*, 1931)

³⁴The Burma Oilfields, 1931, 87



Source: Record by U Khin Oo (Refinery Owner)

been constructed since 1907. B.O.C established the *Thanlyin* Petroleum Refinery in 1925. The IBPC (Indo Burma Petroleum Industry) in contrast, used tankers to transport petroleum. There were refineries only in *Thanlyin* and *Pantha* (near *Indaw*).³⁵

N.O.C (Nathigh Oil Company), however, had its refineries in *Sa-daing* ward in *Yenanchaung* and *Ya-tha-ra* in *Minbu*. The petroleum refinery of BBPC (British-Burma Petroleum Company) stood in *Thilawa*.³⁶ It can be assumed that these petroleum companies expanded their business activities and refined petroleum because petroleum and petroleum products became widely used in Myanmar as well as in other countries.

Oil Production under Japanese Administration

During the WWII, Britain was on the brink of losing the war and was compelled to retreat from Myanmar. Therefore, they British forces destroyed the machines for drilling oil wells, petroleum refineries and oil wells in Myanmar so that the enemy would not be able to use them. The British government did not make any preparations to defend Myanmar from Japanese invasion.

The situation deteriorated, and the British forces employed a scorched earth policy and destroyed the oil wells in *Yenanchaung* on 15 April 1942. On 18 April 1942, British and Japanese forces engaged in *Pin-chaung* (Pin creek) area in *Yenanchaung* and, on 19 April 1942, the British forces pulled back from the oilfields of Myanmar.³⁷

The Japanese forces captured *Yenanchaung* on 20 April 1942. The Headquarters of Japan's Southern Asian Army dispatched a group of people to *Yenanchaung* to repair the oil wells and extract petroleum. On 1 May 1942, the Japanese army adopted a stopgap plan for the expansion of petroleum production and began the task of drilling for petroleum.

(Photo-II)



Source: Record by U Win Maung (Yenanchaung Oilfield worker)

The Conditions of Rehabilitation in Yenanchaung

Under the Japanese military rule, small private petroleum refineries sprouted up in *Yenanchaung* oilfield. There were altogether seventy three small petroleum refineries in Myanmar under the Japanese occupation and, of them, forty three stood in *Yenanchaung*.

Under the Japanese occupation, a person who desired to establish a private petroleum refinery had to apply for a license from the *Khayaing wun's* (district officer's) office through the office of the *Wundauk* (officer) concerned.

The *Ne-baing wun-dauk* (sub divisional officer) would check whether there were any objections against the proposal; if there were no objections, he would issue a licence to refine petroleum. Those who applied for licenses were *Maung Hla Maung*, *Maung San Kyu*, *Maung Tu*, *Maung Sit Kunt*, *Maung Aye* and *Maung Hla Pe*. Those who refined petroleum needed to have sand and water in the refineries to prevent fires. They also had to undertake that they would run their refineries safely.³⁸

After World War II, foreign petroleum companies returned to Myanmar oilfields and formed the Burma Oil-Fields Rehabilitation Unit.³⁹ The cost of rehabilitating the oilfields was too high and the task was onerous. B.O.C, I.B.P and B.B.P.C banded together and formed a consortium-the A.O.C (Association of Oil Company)-to work together in producing and refining petroleum. The B.O.C, I.B.P and B.B.P.C held 76.8%, 17% and 6.2% stakes in this consortium.⁴⁰ It is clear that the companies, which formerly had operated separately, joined forces for carrying out the mammoth task of rehabilitating the oilfields.

³⁵ Hpyiwin Hmattan, 1969, 97

³⁶ Myanmar's Petroleum Industry, Burma Socialist Programme Party Central Committee Headquarters, Yangon, Party Press, 1978, pp. 31-32 (Henceforth: Myanmar Yenanchaung, 1978)

³⁷ Khin Maung Gyi, 2006, 126

³⁸ Oilfield, 1942, 1/15 (B), Acc. 839, p. 8, National Archive Department

³⁹ Reports on the conditions of small private petroleum refineries run by the natives in Yenanchaung and suggestions, Yenanchaung, Tms, 1945, p.2

⁴⁰ Myanmar Yenanchaung, 1978, 36

The Report of Twinyoe-Twinzas

The petroleum companies made an offer to the *Twinyoes* and *Twinzas* to operate under the new pooling system which was introduced in 1947. They invited the *Twinyoes* and *Twinzas* to join forces with them to work the oil wells they collectively owned as a joint venture. The B.O.C, however, would be holding the reins.

They explained the *Twinyoes* and *Twinzas* that the implementation of the new pooling system would cut production and storage costs and would enable them to share the costs of boring exploratory wells.⁴¹ However, the *Twinyoes* and *Twinzas* refused to work together with the petroleum companies.

In their report submitted to the Oilfields Enquiry Committee in 1949, the *Twinyoes* and *Twinzas* stated that they could not accept the pooling system and mentioned the problems they would face if they accepted it.⁴² Although the *Twinyoes* and *Twinzas* refused to band together with them, the companies joined together to carry out their business activities. The four companies which formed the consortium extracted petroleum only from the best of the four petroleum wells they owned and shared the profits equally.⁴³ The pooling system led to the downsizing of the workforce; two thousand of the 6900 workers who were working in the companies were made redundant. Thus, the problem of unemployment in the oilfields began.⁴⁴

The firms which desired to drill for petroleum reapplied for licenses from the government in 1947. They had to send their applications to the Department of Revenues through the offices of the *Nebaing Wundauks*. They could drill for petroleum only after they had obtained licenses.

The Program of Joint Venture

Myanmar government and the petroleum companies negotiated to set up a joint venture to produce petroleum. Myanmar government continued their negotiations and the companies agreed that they would reimburse the money if they failed to form the joint venture.⁴⁵

After the matters concerning the joint venture were deliberated by the cabinet, the Minister for Industry and Mining sent a reply to the general manager of B.O.C on 13 December 1948.⁴⁶ After discussing with the petroleum companies for setting up a joint venture, the Myanmar government requested for a loan from the British government. Although the British government seems to have subsidized the rehabilitation programme from March 1949 onwards, it is stated in a report made by the Oilfields Enquiry Committee in 1950 that the British government did not contact the Myanmar government till August 1949.⁴⁷

Insurgencies in Oilfields

Insurgency in Myanmar grew after it regained independence, hampering the establishment of a joint venture and the

rehabilitation of oilfields. Furthermore, the *Ye-baw-byu* captured Yenanchaung oilfield on 23 February 1949. However, the insurgents did not destroy the oilfields because the workers negotiated with them.

Accordingly, they stopped all their activities concerning petroleum production in Yenanchaung oilfield on 13 July 1949, saying that the lives and property of the British nationals in Yenanchaung oilfield were at risk.⁴⁸ B.O.C failed to inform the Myanmar government before stopping petroleum production and firing workers.⁴⁹ It is clear that by firing workers from the petroleum industry while insurgencies were growing, B.O.C was worsening the political situation in the country.

Disputes in Oilfield Area

Disputes over the area in which petroleum wells were bored arose in 1949. The *Twinyoes* and *Twinzas* requested the *Yenan-wun* (Director of Petroleum Industry) to remove the *Beme* village because the land for which they had obtained a lease was situated there. The villagers of *Beme* demanded the cancellation of the lease as the village land was their ancestral land. The *Yenanwun* himself investigated the matter, and granted leases only of land in non-residential areas in *Beme* village. There were altogether 47 *let-twins* owned by *Twinyoes* and *Twinzas* in *Beme* village.

A petition the villagers of *Beme* village sent to the office of the commissioner of Magwe division has been discovered. On 2 September 1949, the office of the *Myobaing* of Yenanchaung issued an order (Revenue case no. 40/49-50) that the people residing near the land leased for prospecting petroleum were to move either to *Kyauk-htayan* or *Kyat-lein-gon*, both in the tract of *Beme*, in accordance with the order of the deputy commissioner.

The Sector of B.O.C (1954- Limited)

On 12 January 1954, Burma Oil Company 1954 Limited, a joint venture between B.O.C (Burma Concession) Limited, a branch of B.O.C, and the government of Myanmar, was formed. The new company, as signed in the agreement, was named *Burmah Oil Company 1954 (Limited)* (final -h in the name *Burmah* was elided in the name of the new company). U Ba Tun, secretary of the Ministry of Mining, representing the President of the Union of Myanmar, and Mr. W.E.V. Abraham, representing B.O.C, I.B.P and B.B.P.C, signed the agreement. The joint venture had five directors: three from B.O.C and two from the Myanmar government's side.

The joint venture formed by this agreement was named B.O.C (1954) Ltd., and it engaged in prospecting, producing and refining petroleum. B.O.C (1954) Ltd. could engage only in less profitable activities of prospecting, producing and refining petroleum. BOC (Burma Trading) Ltd., in contrast, engaged in the lucrative

⁴¹ Ba Pe (Yenanmye), "Myanmar Oilfields Over which the Capitalists had held Sway", *Sarpe Loketha Magazine*, no. 19, Yangon, Win Shwezin Press, 1982, p. 112 (Henceforth: Ba Pe, 1982)

⁴² "1949 Report Submitted by the Twinzayoe Society of Yenanchaung to the Oilfields Enquiry Commission in 1949", *Yenanchaung, Tms.*, 1962, pp.11-12 (Henceforth: *Twinzayoe Asiyinhkanza*, 1949)

⁴³ *Twinzayoe Asiyinhkanza*, 1949, 10

⁴⁴ Ba Pe, 1982, 112

⁴⁵ *Myanma Yenana*, 1978, 45

⁴⁶ Oilfield, 1948, 12/1, Acc. no. 697, p. 21, National Archive Department

⁴⁷ Report of the Ad-hoc Oilfields Enquiry Committee, Rangoon, Supdt. Govt. Printing and Stationery, 1950, p.17 (Henceforth: *Reports*, 1950)

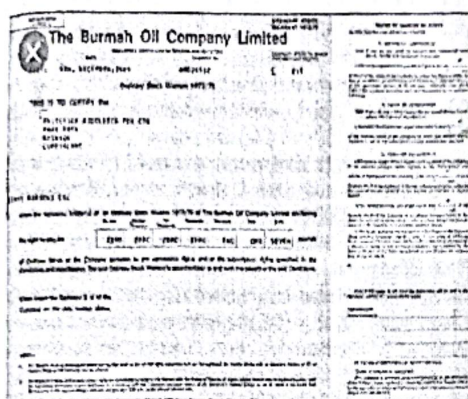
⁴⁸ *Khin Maung Gyi*, 1970, 87

⁴⁹ *Myanma Yenana*, 1978, 47

business of marketing and distribution. Under the contracts, the petroleum products of B.O.C (1954) Ltd. had to be sold to B.O.C (Burma Trading) Ltd. and I.B.P Company. The joint venture company for petroleum production could not control the lucrative business of marketing petroleum products.⁵⁰

The percentages of the stock of the joint venture held by B.O.C, I.B.P and B.B.P.C were 76.8, 17 and 6.2, respectively. They agreed that the construction of a petroleum pipeline was not included in their agreement. B.O.C (Burma Trading) Ltd. and I.B.P Ltd. owned 83% and 17% of the joint venture's stock, and they were to share the profits. B.O.C (Burma Trading) Ltd., if it entered a joint venture with the Union Government, would only have to buy and distribute the products of the joint venture.

(Photo-III)



BUITTENLAND.

BURMAH OIL CO.

al dividend 22½ % (v. j. 20 %) N. 11 Mei (Per tel.) — De B any declareert een slotdividen jede een bonus in contanten van totale uitkeering over het afgel 22½ % (vorige jaar 20 %) beloo ist is gestegen van £ 1.534.6 18. Aan de reserve word: £ 1 00.000) gedeeld, terwijl een l 2.479 (v. j. £ 453.511) als onv op nieuwe rekening overgaat. I jertreff de meest optimistische m en de aandelen met een noi en £ 1 liepen aan de beurs o 192/1½. Andere petroleumw meens willing, hoewel zij niet unt van den dag sloten. stelde het bestuur voor aan l

Source: Record by U Khin Oo (Refinery Owner)

Conclusion

Yenanchaung oilfield was a locality with large deposits of oil and a locality in which petroleum was extracted in the monarchical days, in the colonial period and in the period after Myanmar gained independence. During the colonial period, foreign firms came and drill for petroleum in Myanmar. As regards the expansion of petroleum industry in the colonial period, the Oilfields Manual of 1920 and Burma Oilfields Manual of 1938 were passed to define the boundaries of the areas that produced petroleum and to define the boundaries of petroleum wells, taxes were collected and other tasks concerning petroleum production were carried out. It is therefore clear that the government made

petroleum companies operate in an organized way.

With regard to petroleum production in Myanmar under the Japanese occupation, the British, pursuing scorched earth policy, blew up the petroleum wells and the buildings connected with petroleum production when they withdrew from Myanmar. Therefore, the Japanese had to repair the oil wells and produce and refine petroleum. The people in various localities who engaged in petroleum industry produced petroleum merely to earn their livelihood.

Petroleum companies were confronted with some problems. Therefore, B.O.C, saying that there was no security in Yenanchaung oilfield, relocated its office from Yenanchaung to Chauk and stopped petroleum production. Therefore, oilfield workers became unemployed. To solve the problem of employment and to appraise the situation, the government formed the Oilfields Enquiry Committee. In 1954, the government of Myanmar itself entered into a joint venture with petroleum companies and formed a joint venture company named B.O.C (1954) Ltd. to produce petroleum.

It is learnt that the joint venture company for petroleum production was formed with the suggestions made by various ministries. The country's economy did not grow as it should because it had to rely on imported petroleum products. It is learnt that the joint venture company went on producing petroleum and petroleum products until the government nationalized it in 1962.

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⁵⁰Myanma Yenan, 1978, 53

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- ### Interviews
- Interview with U Tin Pe, Age 87, Refinery owner, 1 August 2006 (Twingone quarter, Yenanchaung)
 - Interview with Daw Mya Kyi, Age 76, Refinery owner, 1 August 2006 (Twingone quarter Yenanchaung.)
 - Interview with Daw Hla Tin, Age 68, Refinery owner, 18, 19, 20 August 2006 (Twingone quarter, Yenanchaung)
 - Interview with Daw Kyi Lwin, Age 82, Refinery owner, 4 August 2006 (Myenikhin quarter, Yenanchaung)

HIS 002

Microcosmic Idea in the Establishment of the Royal Capitals

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Abstract

The Indian concept of universe or microcosmic idea played a crucial role in way of life and thought of traditional Myanmar. During the long course of monarchical rule, Myanmar kings, like those of some other early Southeast Asian kingdoms, built royal capitals and palaces with various aspects and objectives. These capitals stood not only as the hub of power, culture, literature, and arts but also as the center of universe or *mandala* or Mt. Meru. By this way, the king took the role of *devaraja*-or living got on throne. Not only building of capital and palace but also other aspects of palace. This paper discusses how Indian concept of universe influenced the establishment of royal capitals. The examination is also made on the interrelation between this concept and the society. Author of this paper explored firsthand information to yield new interpretation on the royal capitals and concept of *mandala*.

Keywords: culture of building capitals

Introduction

This paper is an attempt to examine the objectives and aspects of the palaces and royal capitals throughout history. Indeed Myanmar kings were found of the title Myo-ti Nan-ti Min-founder of royal capital. As the king who established the royal capital assumed themselves as the *cakkavatim*-or universal monarch, the capital and palace took the form of small universe on earth. This paper aimed to make comparison between the palaces and microcosmic idea of the traditional Buddhist and Brahmanic norms.

Throughout monarchical history, royal capitals and palaces were necessarily built as the center of administration and symbols of power. These capitals stood as with the multi-faceted aspects in precolonial Myanmar. The royal capitals represented the hubs of Myanmar Buddhist religion, culture, literature, art, architecture and even occult science.⁵¹ When traced these capitals were established within the contest of a Buddhist faith and culture. All of these capitals were also founded prophetic utterance of the Buddha.⁵² According to the theory of Myanmar kingship derived from *cakkavatti* and *bodhisatta* ideals,⁵³ the palace established by the king took the form of the abode of universal monarch. The kings usually assumed themselves as the lord supreme or mighty universal monarch. For instance the inscription of 1098 indicated king Kyansittha (1084 – 1113) thus;

*the king of kings, the lord supreme, the mighty universal monarch, who makes his vehicle the white elephant, the omniscient bodhisattva, who shall verily be a Buddha and save from misery all living creatures.*⁵⁴

As a king of kings or universal monarch, the abode of a king should be different from that of ordinary people. Thus the king's palace and capital was built in accordance with the Buddhist cultural pretext and Brahmanical influence. Although Myanmar kings assumed themselves as the defender of Buddhist faith, they accepted

Indian culture and Brahmanic practices to great extent. Since the early days of monarchical rule, Brahmins had great influence in the palace. The advent of Brahmanical priests prevailed since Bagan period. They had access to the sacred texts, law books, Pali and Sanskrit literature. They were appointed as priests, teachers, ministers and counselors of the king and royalty.⁵⁵ As a result, the establishment of the royal capital and palaces since Bagan period was conducted under the supervision of Brahmanic priests who were in favour of Indian cosmological idea. The customary belief of cosmology mentions thus;

*At the center of earth is Mount Meru, above which is Tavatimsa, ruled by Sakka (Indra), who heads the (thirty-three) Nat kings and around which lay four Great Islands (Mahadipa). Of them, the southern one, Jambudipa, is the most important. Sakka of Tavatimsa is placed above all Brahmas, even though the world of devas (celestial nats or deities) is technically inferior to the world of Brahmas.*⁵⁶

Customarily, Myanmar kings claimed themselves as *Loka-tha-mu-di nat*-or living guardian spirit of mundane world even though Myanmar kingship is not wholly depended on *devaraja* kingship of Khmer.⁵⁷ However the role of the king was so revered that the people of old Southeast Asia accepted him as the super human. According to a study,

..... both the territorial and hierarchical political structures common to all the Buddhist and Hindu kingdoms of Southeast Asia were themselves modeled after the Hindu-Buddhist picture of the heavenly realm Based on the magical conception of a microcosm-macrocosm parallelism, the entire kingdom was organized as the cosmos in miniature, with the palace, as its center, representing the mythical Mt. Meru, and the king and his princes representing Indra and devas of the Tavatimsa heaven. The kingdom

⁵¹ Francois Tainturier, *The Foundation of Mandalayby Kin Mindon*, Ph. D Dissertation, Department of Art and Archaeology, School of Oriental and African Studies, University of London, September 2010, P.45 (Henceforth Tainturier 2010)

⁵² Myanmar Shei-haung Myotipon Sanit. (The Plans of the Ancient Capitals of Myanmar), *Parabaik*, M.S, Universities' Central Library, No.(B), 13798 (Henceforth *Parabaik* M.S, 13798)

⁵³ William J. Koenig, *Burmese Polity, 1752-1819*, Ann Arbor, Center of South and Southeast Asian Studies, The University of Michigan, 1999, 73 (Henceforth Koenig 1999)

⁵⁴ After Koenig 1999, 76

⁵⁵ J.G de Casparis and I.W. Mabbett, "Religion and Popular Beliefs of Southeast Asia before C.1500", *The Cambridge History of Southeast Asia* Vol I, part I, Nicholas Tarling (ed), Cambridge, Cambridge University Press, 1999, pp. 286-87 (Henceforth: Casparis and Mabbett, 1999)

⁵⁶ Michael Aung-Thwin, *Pagan: The Origins of Modern Burma*, Honolulu, University of Hawaii Press, 1985, 31 (Henceforth: Aung-Thwin, 1985)

⁵⁷ Kenneth R. Hall, "Economic History of Southeast Asia", *The Cambridge History of Southeast Asia*, Nicholas Tarling (ed), Cambridge, Cambridge University Press, 1999, p.281 (Henceforth: Hall, 1999)

itself was divided into provinces, each ruled by one of the princes.⁵⁸

The idea of Mount Meru is a common acceptance in traditional Myanmar. It was depicted in various forms since Bagan period.⁵⁹ Buddhist philosophy also mentions the existence of Mt. Meru which was believed to stand at the center of universe. Mt. Meru and its surrounding mountains towered up in the center enclosed by a series of eight concentric oceans and seven mountain ranges. The outermost of these called Cakravada Mountain, is located at the very edge of the world, and in the ocean just inside it (i.e. the outermost ocean) islands are depicted to the north, south, east and west of Mount Meru respectively. Mt. Meru is sacred to the Hindus, the Buddhists and the Jains.⁶⁰ The cosmic aspect can be seen in the establishment of Angkor Wat in Cambodia and some pagodas in Myanmar. Angkor Wat was built as a series of concentric courtyards surrounding a central pyramid pile on top of which five towers rose in quincunx to place the Mountain of the Gods (Mahameru) in the center of the Kingdom, and the kingdom in the center of the universe.⁶¹ The remarkable religious monument which was built in accordance with the cosmic ideology is Myatheindan Pagoda in Mingun. The pagoda was built by King Sagaing (Bagyidaw) with seven concentric oceans with four islands and Mahameru.⁶²

The religious edifices and palaces were usually built as a series of concentric courtyards, central spire and surrounding chamber all of which are surrounded by fort wall and moat. The palace took the form of the mountain of Gods (Mahameru) in the centre of the kingdom, and the kingdom in the center of the universe. By this way, the king built the palace as *mandala*-auspicious core.⁶³ All of the palaces of Myanmar were built on the mandala plan.

Myanmar kings were reluctant to establish their capitals in Lower Myanmar. Although they could obtain the opportunity of seaborne trade and productive rice belts of Ayeyawaddy and Sittaung Deltas, Myanmar kings, except from Tabinshwehti to Nanda Bayin, settled their capitals in Upper Myanmar. Of these capitals and palaces, no one can know the location and architectural style of Bagan palace. Although an inscription found near Tharaba Gate indicated the ritual of the establishment of palace by King Kyansittha (1084-1112), no information is yielded on the design of the super structure of palace.⁶⁴ As the auspicious date of digging holes for pillars and other rituals were arranged by Brahmanic priests, it is attributed that the design of the palace was

influenced by Brahmanic concepts to some extent. Whenever a new king ascended the throne the coronation ceremony was presided by eight Brahmans, representing the guardian spirits of Mt. Meru. The king residing at the exact center of the selected square enclosure gained the status of divine.⁶⁵

Not only cosmic idea played an important role in the establishment of royal capital and palace but traditional beliefs, occult, science and following customary phenomena dominated the founding of palaces. Traditionally, the kings believed that the establishment of new palace and city was a symbol of charismatic monarch. They also believed that they would become *bya-deik win-min* -the king to whom a prophecy by the Buddha has been made. By this way they won the support of people.⁶⁶ When traced, the establishment of the palaces of Pinya to Mandalay were made in accordance with these above mentioned phenomena.

The concept of universal monarch who ruled over the whole of Jambudipa was more apparent in the establishment of Kambojasadi Palace by King Bayinnaung on 22 October 1566. The establishment of this palace shed light on the glory and power of King Bayinnaung because he assigned the lords of vassal states and principalities to build the gates of the royal capitals. The king named the gates after the names of chiefs and sawbwas who built the gates.⁶⁷

Following list read;

Gates of the New City of Hantharwaddy and Builders

1. Kalay Min Southernmost gate of Western wall
2. Zimme Min Eastern gate of Southern wall
3. NyaungShwe Min Middle gate of Western wall
4. Taninthayi Min Second West gate of Northern wall
5. Taungoo Min Middle gate of Eastern wall
6. Dala Min Second Southern gate of Eastern wall
7. Dawe Min Western gate of Southern wall
8. Pakhan Min Second Eastern gate of Northern wall
9. Patheingyi Min Eastern gate of Northern wall
10. Pyay Min Northern gate of Eastern wall
11. MoeGaung Min Second Western gate of Southern wall

⁵⁸ Melford E. Spiro, *Burmese Supernaturalism*, Philadelphia, Institute for the Study of Human Issues, 1978, P. 182 (Henceforth: Spiro, 1978)

⁵⁹ (a) See Photograph one and two

(b) U Kala, *Mahayazawingyi* (The Great Chronicle), Vol. III, Yangon, Yabyay Publishing House, 2006 (Third Impression), Plate (A) I to Plate (A) 4, pp 64-65 (Henceforth: U Kala 2006)

⁶⁰ Richard L. Thompson, *Mysteries of the Sacred Universe: An Overview* <http://www.sacreduniverse.com/overview.html>, pp. 1-12

⁶¹ Casparis and Mabbett 1999, 290

⁶² See Photograph Three

⁶³ Mount Meru, *Dharmapala Thangka Center*, <http://www.bremende/infot/nepal/Gallery-3/Misc/12-24/meru-0.htm>, p. 1

⁶⁴ An Inscription Found Near the Tharaba Gate, Bagan, " *Archaeological Survey of Burma: Epigraphica Birmanica Being Lithic and Other Inscriptions of Burma*, Charles Duroiselle (Ed), Mon Inscriptions, No. IX-XI, Vol III, Yangon, Supdt Government Printing 1923, pp 56-57

⁶⁵ John F. Cady, *A History of Modern Burma*, Ithaca, Cornell University Press, 1960 (Second Printing) pp. 4-7 (Henceforth, Cady, 1960)

⁶⁶ Tin Chon, "Konbaungkhit Myanmar Min Do-Ei Myoti-nanti Chin Lokoktaya Htonmya" (Occult and Religious Practices on the Establishment of Palaces and Cities in Konbaung Period: 1752-1885), *Yenangyanug Degree College Annual Magazine*, 2009-2010, pp 48-49 (Henceforth: Tin Chon, 2010)

⁶⁷ Hmannan, 2008, 524-528

12. Mohnyin Min Middle gate of Southern wall
13. Mo-ne Min Second Southern gate of Western wall
14. MoMeik Min Second Eastern gate of Southern wall
15. Mottama Min Middle gate of Northern wall
16. Yodaya Min Western gate of Northern wall
17. Linzin Min Southern gate of Eastern wall
18. Thayawaddy Min Second Northern gate of Western wall
19. Theinni Min Northern gate of Western wall and
20. A-wa Min Second Northern gate of Eastern wall.⁶⁸

As the Indra-Sakka was believed to be living on top of Mt. Meru which was flanking by a bodes of other guardian spirits, King Bayinnaung resided at the golden palace surrounded by the gates of subordinate chiefs. In other words, King Bayinnaung assumed himself "King of Kings" by residing in the new palace.

After the collapse of Taungoo dynasty, Prince Nyaung-yan, son of king Bayinnaung, restored the law and order and established a new dynasty centering at Inwa.⁶⁹ King Nyaung-yan followed the tradition of his father in the establishment of Inwa. He summoned the subordinate chiefs to build the gates of city as follows;

Gates of Inwa built by Nyaung-yan Min in 1598

Name of Gate Built by

- (1) Kyawbon Gate
Awa Shwepyoise
(under expense of the king)
- (2) Yan-aung Gate
Awa Shwepyoise
(under expense of the king)
- (3) Aung-ban Gate
Chief of Mo-gaung
- (4) Thazi Gate
Chief of Nyaung-yan
- (5) Win Mana Gate
Chief of Mo-meik
- (6) San-ya Gate
Chief of Bhamo
- (7) Kalay Gate
Chief of Kalay
- (8) Lei-tha Gate
Chief of Thauing-thut
- (9) Man-aung Gate
Chief of Mong Ne⁷⁰

The king also ordered *myo-thu-gyis* -town headmen to build the city wall. About 25 town headmen were employed to build the wall. Another 16 *myo-thu-gyis* were employed in the building of palace, pavilion, earth palace, shrines for guardian spirits.⁷¹ The list of the chiefs, *myo-*

thu-gyis and *myo-zas* -fief-holders of the town who built the royal capital of Inwa illustrate the areas which fell under the control of Nyaung-yan Min. However the king did not name the city-gates after the name of the chief who built it. Instead he named the city-gates in accordance with the location and horoscope after consulting with learned Brahmins.

When king Mindon founded Mandalay, he took the plan of city on the model of the

Appendix
Hanthawaddy City Gates

Yodara	Tamintayyi	Mottama	Pakhan	Putha
Theradi				Pyay
Tharyawadi				Ava
Nourghwe				Taungoo
Mo-ne				Dala
Kalay				Letwin
Dawei	Moegang	Mochayin	Momeik	Zemae

universe. According to the belief of Buddhist people, Mt. Meru located at the very center of universe. Sakka or Indra's abode known as *Tavasimta* located on top of Mt. Meru which was encircled by seven mountain ranges and seven seas, and four islands. The southern most island known as Jambudipa was a bode of human. All of the universe is circled by a wall. King Mindon took this plan and built Mandalay on square plan. The plan was known as Mandala-set or Mandala plan. The central *pya-that* or earth palace of Myanansankyaw palace complex represent Vejayaanta palace of the city of Indra from Mt. Meru.⁷² In addition all of the buildings of the palace were built on the brick pedestal of 6 feet and 9 inches high. It resembled the MahaThudasana city of Indra on top of Mt. Meru. In addition the city was guarded by four guardian spirits of MahaThudasana city as follows;

Pajapati Nat (Northeast Corner)
Sandana Nat (Southeast Corner)
Keinnuganda Nat (Southwest Corner)
Karmathehta Nat (Northwest Corner)
The above mentioned *nats* or guardian spirits were comprised in the 37 guardian spirits of MahaThudasana city.⁷³ In addition the palace guards known as *win* were organized in accordance with the formation of four major guardian spirits of Mt. Meru as follows;

⁶⁸ (a) Dr. Toe Hla, *Ko-hti Ko-nan Ko-kyu-ngan Hnint* (The Cities and Palaces of the Past: A study on the Centers of Power), Yangon, Lin Yadana Publishing, 2005, pp. 20-21 (Henceforth: Toe Hla 2005)

⁶⁹ Twinthin Taikwun Maha Sithu U Tun Nyo, *Maha Yazawin-thit*, (The New Chronicle) Vol Three, U Thein Hlaing

(ed), Yangon, Miba Myitta Association, 1997 pp 1-3 (Henceforth: Tun Nyo 1997)

⁷⁰ Parabaik M. S 679 NLC, 17-18

⁷¹ Parabaik M. S 679 NLC, 18-19

⁷² Toe Hla, 2005, 118

⁷³ Not related with the 37 Nats comprising Taungbyon, Mane Lay, U Min Kyaw, etc.

Name of the Palace Guard	Emblem
1 She-win (guards of the eastern direction of Mt. Meru)	Terahta Image which put double dagger on right shoulder
2 Taung -Letya -win (guards of southern direction of Mt. Meru)	Viruhtaka Nat who put double edge dagger on right shoulder
3 Nauk -win (guards of western direction of Mt. Meru)	Virupetka Nat who put double edge dagger on right shoulder
4 North-Let -we -win (guards of northern direction of Mt. Meru)	Kuvera Nat who put double edged dagger on the right shoulder

The image of above mentioned *Nats* were tattooed on the necks of respective servicemen. They took responsibility to the security of the king whenever he went out of palace.⁷⁴ When the wall was built, eleven images of chief guardian *nats* and 522 figurines of guardian spirits were buried under the wall of each direction.⁷⁵ By this way the palace of King Mindon represents the Maha Thudasana city and the king himself represents the Sakka or Indra. He was guarded by his servicemen who represents the guards of Mt. Meru. The predecessors of King Mindon followed the idea of *Mandala* and microcosmic belief.

Conclusion

Since the emergence of the Pyu city-states to the end of the monarchical rule, the cities and palaces were built by the kings of successive dynasties. The archaeological and literary evidence reveal that the kings resided in the majestic palaces to make clear distinction between them and subject people. Although Myanmar king did not accept the idea of divine kingship of the west or mandate of heaven of China, the traditional Myanmar accepted that the king and royalty occupied the exalted position of the society. The king was regarded as the arbiter of all existence. His role was the most supreme one and unchallengeable. Thus his palace site was regarded as the sacred one and represent the microcosmic pattern on the ground of mundane world. All palaces were built only with timber, as one- story building, with *pyathat* building with embellished tiered roof, on the rectangular plan and also built in accordance with traditional concept of universe. By this way their status was supposed to be superior than that of ordinary people.

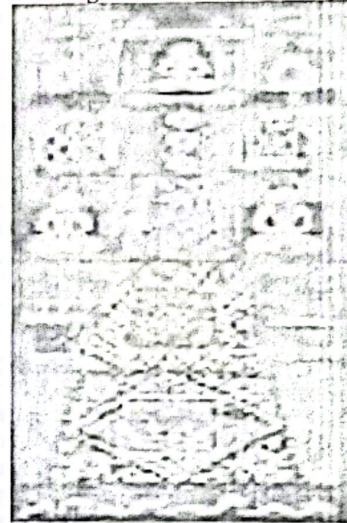
Pageant of King Mindon: Leaving His Palace on Visit to the Kyauktawgyi Pagoda (1865)



Source: Memiors of the Archaeological Survey of India. No.27. New Delhi. 1998 (Reprint)

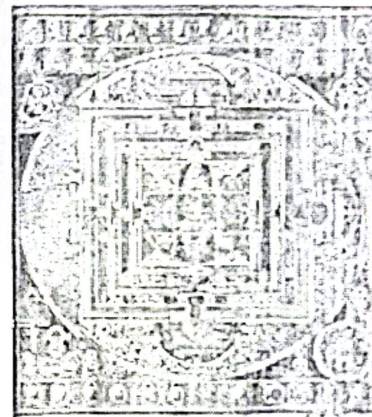
⁷⁴ see photograph Five

Painting of Mount Meru from Jain



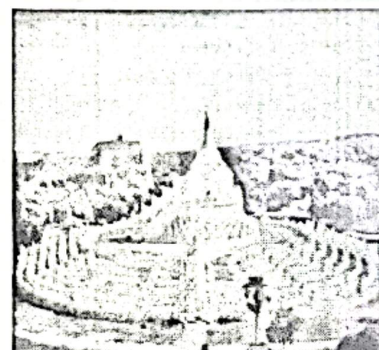
Source: Source: en.m.wikipedia.org/

Mandala



Source: en.m.wikipedia.org/

Mya Theindan Pagoda



Source: en.m.wikipedia.org/

Pageant of King Mindon: Leaving His Palace on Visit to the Kyauktawgyi Pagoda (1865)

⁷⁵ Toe Hla, 2005, 119-23

Kachin *Du-Wa* Ship before the British Rule

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The term "Kachin" is a Myanmar word because Myanmar people refer to all the tribes of northern hills as Kachin.⁷⁶ They were recorded as Kachin or *Theinphaw* in ancient Myanmar records. The word "Kachin" first appeared in English in about 1837. Before that, only the word *Ka-khyen* was used. The word "*Ka-khyen*" was first used by the American Missionary Rev. Kincaid. It was stated that Kincaid reached Mogaung in 1837.⁷⁷ Kachins live in Assam and east of Assam, northern Myanmar and north-eastern mountains of Myanmar, west Yunnan State and at the boundary of Myanmar and China.⁷⁸ They live in Myanmar the northern Shan State and Bhamo, Katha Areas to the south. Kachin *Theinphaws* of Konbaung Era widely lived in the north, north-east, hilly regions of north-east in northern Myanmar, west Hkamti, east of Chindwin River, Uru-se-ywa, surrounding Mogaung, Bhamo Katha, Momeik, Mohlaing, Mansi, Hsenwi Shan state.

In Kachin people, there are the Jinghpaw, Maru, Lashi, Azi, Lisu and Rawang tribes who are different in language and similar in culture and tradition. The concept that all those six tribes are descended from Majoi Shingra Bum Region.⁷⁹ There are four groups in Kachin according to their spoken words. They are 1. Jinghpaw Language Group

2. Maru(Lawngwaw), Lashi, Azi Language Group

3. Nung - Rawang Language Group

4. Lisu Language Group

In Jinghpaw Language Group, there are Jinghpaw (Singhpaw), Gauri, Tsasen, Duleng, Hkahku and Htingnai (lowland). In Maru Language Group, there are Maru, Lashi, Azi, Mainghta (A'chang) and Hpon. There are some different words in Nung Rawang Language Group. In Lisu Language Group, there are differences and discrepancies according to the regions.⁸⁰ Therefore, their political concepts also differ according to their languages' differences.

In a mixed community of Lisu, Azi, Maru and Jinghpaw speakers, the Jinghpaw speakers group will have solidarity among themselves. Politically speaking, the Azi are quite indistinguishable as a group from *Gumsa* Jinghpaw. The empirical fact that in some parts of the Kachin Hills encounter extreme examples of this language factionalism, where as in other areas

the Kachin sub-groups adopted Jinghpaw speech must be seen as an symptom of some contrast in political ideology. This bring us to the topic of *Gumsa and Gumlaw*.⁸¹ Kachin themselves have names for various districts. There are

(1) "Sinpraw Ga", the eastern land, roughly the Bhamo and Sadon Districts;

(2) "Sinli Ga", north Hsenwi State;

(3) "Htingnai Ga", the lowlands, the region between Mogaung and Katha;

(4) "Hkahku Ga", upriver country, the region to the north of the N'mai- Mali Hka confluence and so on.⁸²

In those places mentioned above, Jinghpaw language is the most common among Kachin. Jinghpaws call themselves Jinghpaw, meaning "human". Jinghpaws are called B'ouk by Maru, P'ok by Lashi, Shatung by Azi, An Hpu by Rawang and Ah Hpu Hpa by Lisu.⁸³

Some Kachin Historian stated that Kachin people first lived in the region called Hkawng Wang Ga and settle down at Putao Plain which was also called Malihku Majoi. Jinghpaw entered Myanmar from the north and some Jinghpaw migrated to Assam. At that time, the powerful Shan feudals were still governing the Kachin's territories. The famous towns during Myanmar King's reign in the Kachin State were Mohnyin, Mogaung, Waingmaw, Sinbo, Shwegu and Kaung Ton. Mohnyin and Mogaung were the towns which started the Kachin Shan Myanmar relation.⁸⁴

Kachin had been taken part in the attack launched by the Nan Chao on Hanoi in 863, Jinghpaw, Maru and Lashi must have already been in Bhamo, Myitkyina District and Yunnan province before that time.⁸⁵ Therefore, the naming of Maru, Lashi and Nan Chao are the same, as Nan Chao influential symbol.⁸⁶ P'ok and Mang Zaw were recorded as the first class fighters when Nan Chao attacked Hanoi.⁸⁷ Maru, Lashi and Azi called their elder people as Mang Zaw. Jinghpaw and Azi had the tradition of naming "Zaw" (Chao) to the chiefs or Duwa tribe men. Therefore, according to Fan Cho's record, P'ok is assumed to be Jinghpaw and Mang Zaw to be Maru, Lashi and Azi.

In early Konbaung Era, Kachins through Chyaukan pass and Daru pass, entered into Assam and Hukawng Valley, from between N'maikha and Malikha Rivers. The cause for Kachins' migration

⁷⁶E.R. Leach, *Political Systems of Highland Burma*, Great Britain, Fletch & Son Ltd, 1964, 41 (Henceforth: Leach, 1964)

⁷⁷(a) H.G. Tegenfeldt, *A Century of Growth: The Kachin Baptist Church of Burma*, California, William Carey Library, 1974, p. 80,91 (Henceforth: Tegenfeldt, 1974)

(b) Ola, Hanson, *The Kachins: Their Customs and Tradition*, Rangoon, American Baptist Mission Press, 1913, p.18 (Henceforth: Hanson, 1913)

⁷⁸J. George Scott and Herdman, *Gazetteer of Upper Burma and Shan States*, Part I, Vol.i, Rangoon, Government Printing, 1900, p. 331 (Henceforth: George, 1900)

⁷⁹Natural flat Mountain

⁸⁰Leach, 1964, 44-45

⁸¹Leach, 1964, 50

⁸²Leach, 1964, 55

⁸³Branghpa, "Kachin, Their Tradition and Customs," M.A (Thesis), Department of History, Mandalay University, 1998, p.1 (Henceforth: Branghpa, 1998)

⁸⁴"Kachin-de-tha-yet-swe-thamaing (AD 556-1885)", Collection Research of Kachin Historical Records Myitkyina University, History Department, 2002 (Henceforth: "Yet-swe", 2002)

⁸⁵G.E. Harvey, *History of Burma* (from the earliest time to 10 March 1824), London, Frank Cass and Company Limited, 1967, p.15 (Henceforth: Harvey, 1967)

⁸⁶Lhovo Literature and cultural committee, *Lhovo-Thamaing-Achine-chok (a Brief History of Lhovo)* Waningmaw, type writing, 1967, p.35 (Henceforth: Lhovo, 1967)

⁸⁷Fan Cho, *The Man Chu: the Book of Southern Barbarians*, translated by Gordan H.Luce, edited by G.P. Obey, New York, Department of Far Eastern Studies, 1961, p. 26 (Henceforth: Fan Cho, 1961)

was based on the inter rebellion among themselves because of the difference in administrative policy of *Gumsa*, feudal and *Gumlau*, anti-feudal. Because of that *Gumsa* and *Gumlau* attack, the Kachin *Gumsa* from the triangle region moved again to Assam and Hukawng, avoiding the *Gumlau*'s attack. Those migrated *Gumsa* are (1) Daihpa (2) Pyisa (3) Hkamti Shan Namsun Wa tribes.⁸⁸

There was a war between Ahom Shan and Kachin in 1779.⁸⁹ But there were no confrontations between northern feudals and Myanmar Kings in Konbaung Era. Because there were the invasions of Assam-Manipur-Kahte, national tribes seemed to rely on each other because of the invasions of Assam, Manipur and Chinese. Myanmar made no attempt to control the Kachin directly. On the contrary, the Kachin Duwas were awarded Myanmar honorific titles and treated with the respects due to minor royalty.⁹⁰ The title conferred upon Daihpa Gam by the Myanmar kings.⁹¹ In this way, the Kachin *Gumsa* Duwa Daihpa Gam became the most powerful in Hukawng region and he organized, united and administered the Shans and Kachins all over Hukawng Region. But he was attacked by his relatives, the *Gumlau*.⁹² The exact number of faithful Kachin chiefs or *Taung-sar Saw-bwa* was not known.⁹³

To the east, the story of Hsenwi is very similar. Hsenwi 49 mine was divided into 5 lets as the East, the West, the South, the North and the Middle and were governed by Myanmar officials and army officers. But the problem was not settled and the North of Hsenwi was under the power of Kachin.⁹⁴ During King Thibaw's Reign, the Kachins who lived between Bhamo and Chinese border.⁹⁵ The Mahtang *Taung-sar* who was very powerful with mass weapons and followers.⁹⁶ The British authority made inquiries about Kachin Hilly Region through Myanmar Ministers in 1886, first after the fall of Upper Myanmar and learnt that there were altogether 54 Kachin *Taung-sar Saw-bwa* 35 out of 54 *Taung-sars* were from Mogaung, Mohnyin near Ayeyarwady river and Inndaw region. There were six *Taung-sars* of Jade Mines and eleven of Amber Mines.⁹⁷

In Kachin traditional administrative system, there were altogether three basic types which were *Gumrawng Gumsa*,⁹⁸ *Gumchying Gumsa* or Feudal System and *Gumlau* or anti-Feudal System. By these three systems together with the chiefs of *Du*, *Magam*, *Agyi* and *Salang*'s supervision, Kachins lived. Those traditional administrative systems were practised from 1500 to 1900.⁹⁹ The establishment of those traditional administrative systems related to the structure of

Kachin society. In Kachin society, Htinggaw or family is the smallest and a village was also the narrowest in social affairs. In the south of Kachin State and plain regions, village was called as Kahtawng and Ga, or Yang in northern regions. A town was called 'Mare,' the State 'Mung daw' the country, 'Mung'. Such Mung term was directly borrowed from the Shan Mong.¹⁰⁰

The number of houses in a village called Kahtawng was not limited. The borders between villages were marked by streams, hill tops and big trees. The structures of villages were not the same from one place to another. Mostly in one village dwelled one tribe, for example, Marip Ga, Lahtaw Ga, N'hkum Ga, Maran Ga. As there were villages that followed the name of the tribes, there also were governing chiefs of each tribe such as Marip Du, Lahtaw Du, N'hkum Du and Maran Du.¹⁰¹ Those village groups were combined to be an estate called Mung. Those such villages had three different administrative systems and there also became the chiefs. They were *Duwas* of *Gumchying Gumsa* system, *Magam* in *Gumrawng Gumsa*, and chiefs of *Gumlau* was *Agyi*, *Salang*.

Among the three administrative system, the most ancient was *Gumrawng Gumsa* system in which *Magam* chief was elected by the public. That system was practised upper Putao region of Hpaktha stream, Machanbaw, Nogmon, Khawbode of northern Myanmar by Rawang tribes, Lisu villages and Duleng Jinghpaw villages between Htingnan and Hpaktha stream.¹⁰² There were chiefs in every village that system, the ruling power was not in the hand of a certain person or tribe but in the hands of the public or the villagers. In such villages, a person who could lead in social, peaceful and legal affairs became automatically the chief or *Magam* and he would survive as a *Magam* as long as he got the villagers' trust and respect or else he would be left out. Therefore, when there was a vacancy for a *Magam*, in the case of being left out or death, the villagers found another person with the abilities mentioned above.¹⁰³ The rank of *Magam* was not for the descendants. According to *Gumrawng Gumsa* System, though it was said that the landowner was not concerned with the administration, sometimes in some villages, the landowner is *Magam*.

In later *Gumchying Gumsa* or Feudal System, the powerful men are *Duwa* Chiefs. They made *Mare Agyi* or *Mare Salang* or the village headman and *Ramma-ning-baw* or the youth leader as their attendants and administer the peace and restoration of the village. This system was assumed to have derived from *Gumrawng Gumsa* system. In other words *Magams* became *Duwa*. It was because the *Gumsa* chiefs were named the

⁸⁸Ma Nawng, Kawl, *The History of Kachin of the Hukawng Valley*, translated and noted by J.L.Bombay, Time of India Press, 1944, p.v (Henceforth: Ma Nawng, 1944)

⁸⁹Bunghku, "Jinghpaw-hte Ginra" (Jinghpaw and place), 2009, p. 196 (Henceforth: Bunghku, 2009)

⁹⁰Leach, 1954, 242

⁹¹Ma Nawng, 1944, 50,52

⁹²Leach, 1964, 43

⁹³C.M, Enriquez, *The Races of Burma*, Culcutta, Government of India Publication, 1933, p.32 (Henceforth: Enriquez, 1933)

⁹⁴Kyan, Daw, *The Condition/Situation of Myanmar Naing-gan* (1885-86), Yangon, Sarpay Beikman Press, 1978, p. 171 (Henceforth: Kyan, 1978)

⁹⁵(a) Enriquez, 1933, 32

(b) G.W , Dawson, *Burma Gazetteer Bhamo District*, Rangoon, Government Printing and Stationary, 1960, p.21 (Henceforth: Dawson, 1960)

⁹⁶Kyan, 1978, 173

⁹⁷Kyan, 1978, 172,230,231

⁹⁸*Gumrawng* means liberty and *Gumsa* means one hundred people, *Gumrawng Gumsa* means people who have liberty

⁹⁹Bunghku, 2004, 195

¹⁰⁰Leach, 1964, 121

¹⁰¹Hanson, 1913, 61

¹⁰²Naw Awn, Thing Bai, *Ginru Ginsa* (the origin of Kachin), Maymyo, 1985, p.95 (Henceforth: Naw Awn, 1956)

¹⁰³Leach, 1964, 206

Chinese word 'Zau', and Shan word 'Hkun' from Shan *Saw-bwas* as imitations.¹⁰⁴

Gumsa chiefs classified their estate according to the area and power. They are: 1. N'kawn Sha Duwa - who got the tax from his people.

2. N'kawn N'sha ai Duwa - who did not get tax from his people.¹⁰⁵

The *Gumsa Duwas* accepted themselves as the most powerful masters in their domain and their possessions were inherited by their descendents. In this acceptance, they changed taxation upon their fellow villagers. They chanced to get a leg of any four-legged animal of other tribe villagers, except from the same tribes, killed for propitiating or from hunting. Moreover, the villagers had to volunteer in growing the *Duwa's* fields or *Taung-ya*.¹⁰⁶ That charge was not necessary to be paid by *Duwa* but he had the chance to get the paddy and crops from every household as an annual present. Such *Duwas* were called taxed *Duwas* or a thigh eating *Duwas*. Their possessions, which came from the villages, became plentiful and his house became one like the rice barn.

The Kachin chiefs political authority is based on his ability to preserve the prosperity of his domain by making sacrifices to the sky spirit, *Madai Nat* and to the earth spirit *Shadip Nat*. This ritual power is inherited automatically only by the youngest son of a thigh-eating chief. Chiefs are concerned to establish their legitimacy as members of a 'youngest son lineage'. In the hearth of the Kachin area (the Traingle), the political associations of an important chief can be very numerous, consequently chiefly genealogies in this region are extremely long, in fringe areas such as North Hsenwi and Hukawng Valley, a chief's Jinghpaw political associates are fewer in number and his genealogy correspondingly less extensive.¹⁰⁷

In most matters, *Duwa's* political obligation are towards his domain chief, Mung *Duwa* who is usually of quite different clan to himself. His obligations towards this domain chief are essentially the due of a feudal tenant towards his Manorial System. Where lineage matters are concerned, the village headman owes deference not to his own territorial chief but the '*Uma du*' who is head of the youngest son branch of his own lineage, and through him to one or more further '*Uma du*', geographically even more remote.¹⁰⁸ Such a thigh eating *Duwas* were the inheritances in *Gumsa* system. So, in *Gumsa* system, the *Duwa* and his tribe were governing class. For example, Lahpai tribes were the governors in the estates where Lahpai *Duwa* ruled and the other tribes were ruled by them.

The headman of the village is always a member of the lineage owning it. Usually the name of the village indicates the lineage the owners, e.g. Pasi - ga is owned by the Pasi lineage; 'Laga Kahtawng' is owned by the 'Laga' lineage, etc.¹⁰⁹ In other words, *Gumsa* system could be called a clan administration system. In some small

villages even the *Agyi* was got the *Duwa* title with the background of their tribe. Some senior a thigh eating *Duwas* gave the strangers the free land of their estate the chance to live and set up the village and made them junior *Duwa* or the village headmen. But they did not have the chance to a thigh eating. Though they were acknowledged as junior *Duwas*, they did not have the chance to get annual present of crops and free volunteer ship. They were called *Duwas* who did not get tax or N'kawn N'sha ai *Duwa*.

The *Gumsa Duwas* did not build their houses and live separately from his people, like the Myanmar kings and their palaces and the Shan *Saw-bwas* and their Hawmans. But Kansi or Ginsi *Duwa* of Pharkant region and Sinli *Duwa* of South Bhamo built strong palaces and lived.¹¹⁰ In *Gumsa* administrative system, the *Duwa's* getting authority was concerned with Kachin's traditional beliefs. For the Kachins who grew the shifting *Taung-ya*, *Taung-ya* agriculture was the most important for their living. According to their belief, for the purpose of good fertilization and well production of their *Taung-ya*, it is necessary to propitiate the *Madai Nat* who ruled rain and the *Shadip Nat* who ruled the earth. But the villagers had neither the chance to propitiate by themselves nor the fees to use.

These propitiate were only for *Duwas*, only they had the chance. Even in *Duwas*, A thigh eating *Duwas* only could propitiate these gods and could pay the cost. According to such belief, the villagers had to rely on *Duwas* for the proper production of their *Taung-ya's*, the administrative power of *Duwas* was strong and survived.¹¹¹ *Gumsa Duwas* married within Kachin *Duwas* themselves. They also were in alliance with Shan *Saw-bwas* by giving their daughters. In round about 1800, Mong Maw *Saw-bwa* Hkam Yu Yung gave his widowed mother to Kachin Hkawng Hsung *Duwa* together with a paddy field as a wedding present to alliance with Kachins.¹¹² As a result, the Kachin chief's wore the great oath that he would come to help of her and her children's children for all generations. The Kansi Chiefs who are Kachin overlords of the jade producing area west of Kamaing have for several generation married Shan as well as Kachin wives. The Shan women are members of the family of the former *Saw-bwa* of Mong Hkawng, Maingkwang in Hukawng Valley. These women are therefore Haw Hseng Shan, their ancestors were rulers of Mogaung and overlords of all the Hkamti Shan States of the north-west.¹¹³

It seems that reached one explanation of why the attempts by *Gumsa* Kachin chiefs to turn themselves into Shan princes have always ended in disaster. There are plenty of quite well documented instances, the Pyisa chief in Assam around 1825, the Daihpa *Duwa* in the Hukawng in 1835, the Gauri *Duwas* of Mahtang (Mong Hka) in the period 1855-70, the Mong Si chief around 1885, the Kansi *Duwa* for the years of 1870 or so. The Kansi *Duwa* who are Kachin overlords of the Jade producing area west of Kamaing have

¹⁰⁴ Naw Awn, 1985, 99

¹⁰⁵ Branghpa Collections

¹⁰⁶ Gildhodes, C. *The Kachin Religion and Mythology*, Calcutta, Catholic Orphan Press, 1922, p. 79, 81 (Henceforth: Gildhodes, 1922)

¹⁰⁷ Leach, 1964, 127

¹⁰⁸ Leach, 1964, 130

¹⁰⁹ Leach, 1964, 116

¹¹⁰ Leach, 1964, 122

¹¹¹ Gildhodes, 1922, 79, 81

¹¹² Leach, 1964, 220

¹¹³ Leach, 1964, 220

married Shan as well as Kachin wives. The Shan women are members of the family of the former *Saw-bwa* of Mong Hkawn (Maingkwan, Hukawng Valley).¹¹⁴

When the British took over eastern Assam in 1824, they found that the most influential Kachin chief was Pyisa Gam.¹¹⁵ Daihpä Gam was a distant lineage brother of Pyisa Gam above. The two were feud enemies. When the British supported Pyisa Gam as paramount in Assam, the rest of the Tangai lineage transferred their support to Daihpä. He was extremely successful.¹¹⁶

In the early part of the 19th century much of trade between Myanmar and China. The route passed through the Kachin centre of Loilung which was in the domain of Gauri Lahpai chiefs of the *Aura* lineage. These chiefs flourished exceedingly and gave their domain the Shan title of Mong Hka, assuming the household lineage name of Mung-ga (Mong Hka). In 1868 Loilung was ruled by the Mahtang chief's elder brother. Mahtang and Loilung are described by Anderson as the two most thriving Kachin villages he had seen.¹¹⁷

In the struggle for the control of the large Shan State of Hsenwi which were a prominent feature of the Myanmar history between 1846 and 1887, the rival Shan factions all had their Kachin supporters. The Kachin *Duwa* of Mong Si were consistent supporters of the legitimate *Saw-bwa*, Hseng Naw Hpa. The domain was divided into several sub-territories each of which was ruled by a Kachin *Duwa*.¹¹⁸ The Kansi *Duwa*'s lineage clearly came to power through the fact that they held a recognized title over the land from which jade is obtained westward of Kamaing. Through all the Myanmar history during the past century and a half nothing seems to have seriously damaged the jade trade and the Kansi *Duwa* still draws his royalties.¹¹⁹ These *Duwas* were all *Gumsa Duwas*.

Gumsa Duwas made the governing system as a clan administrative system and made unfair taxation upon their villagers and dealt with the villagers as their slaves, the ordinary villagers became against them and revolted. *Gumlau* or anti-feudal system was the system which was the result of the revolt to traditionally ruled *Duwas* and landowners. The revolt spread from north triangle regions to west Malikka during 18th and 19th centuries. Some *Gumsa Duwas* fled to Hukawng Valley. Some *Duwas* gave in capitulated with the confession that they would never tax again and ask volunteer and set themselves as the same with ordinary class.¹²⁰ *Gumlau* is one of anarchic republicanism. Each man is as good as his neighbours, there are no class differences, no chiefs, a protestant theory. Among the *Gumlau*, factionalism is rife, each little local unit is a political entity on its own.¹²¹

According to Kachins, their administrative system started from Hkin Du Yang of Triangle area. Ting Mai Sha Duwa who ruled the Hkin Du Yang village asked much crops and the villagers in tolerated and planned to assassinate him. But the *Duwa* dodged to Putao plain, to the rise of Malikka river, on the report of a child. His descendents were known as Dureng tribes. This Hkin Du Yang village is still in triangle area and survived as a monument of revolting the administrative systems.¹²² More than half a century ago, a spirit of republicanism manifested in the administration territory known as the Triangle and the west of the Malikka. Kawlu Ma Nawng recorded specifically relates to the *Gumlau* of the Hukawng Valley. The *Gumlau* of the Hukawng Valley area originated in a revolt by the *N'Dup-Dumsa* or blacksmith-priest lineage controls a large area in the northeast of the Hukawng Valley.¹²³

The *Gumlau* area which was regarded as the *Gumlau* movement by the English writers of the 1890s was that of the Triangle which includes the domains of Sagri Bum and N'Gum La. This area supposed to have become *Gumlau* for the first time around 1870, though another authority gives the specific date of 1858.¹²⁴

In all three administrative systems of Kachin, the rulers and rich people bought and owned slaves. Especially, *Du*, *Magam* of *Gumchying Gumsa* used slaves in administration, politics, warfare, economy and agricultural works.¹²⁵ They did slave trade and attacking wars with the force of slaves. Slave system started in Kachin society in about 1500 and the main factors are found out to be as follows:

1. Capturing the losers of the battle as slaves
2. Becoming slave from the debt to pay
3. Capturing the strangers for slaves
4. Making the persons who bewitched
5. Capturing the person who assaulted the wife or children of *Duwa*
6. Slaving the orphans¹²⁶

Six thousand Kachin soldiers were included when Myanmar marched to Assam Manipur in 1818. Those Kachins possessed many slaves and used them in fighting. British seemed to find ways to demolish the strength of *Duwas* and at that time, according to the act of abolishing slaves,¹²⁷ they planned to free the Kachin's slaves.¹²⁸

Standing the slave system of Kachin, the class of people was found and to have been divided basing in the administrative system. They were:

1. *Du Magam* or the ruling class
2. *Darat Daroi* or ordinary class
3. *Su Rawng* or the class born from ordinary class father and slave mother
4. *Mayam*¹²⁹ or slave class

¹¹⁴ Leach, 1964, 220

¹¹⁵ Ma Nawng, 1944, 41-42

¹¹⁶ Ma Nawng, 1944, 43, 52

¹¹⁷ Leach, 1964, 224, 22

¹¹⁸ Leach, 1964, 225-226

¹¹⁹ Hertz, 1960, 136-137

¹²⁰ Ma Nawng, 1977, 26

¹²¹ Tegenfeldt, 1974, 41

¹²² Sumlut Gam, 1982, 220, 222

¹²³ Ma Nawng, 1944, 26, 39

¹²⁴ Ma Nawng, 1944, 26, 39

¹²⁵ (a) Tegenfeldt, 1974, 37

(b) Brang Di, Maran, *Prat Ningnan Wunpawng Ahtik Labau Kadun* (Modern History of Kachin), New Delhi, Pan Kachin Development Society, 1996, p.41 (Henceforth: Brang Di, 1996)

¹²⁶ Naw Awn, 1985, 68

¹²⁷ Slavery Abolition Act, 1833

¹²⁸ Brang Di, 1996, 44

¹²⁹ Kachins call slaves

There were two kinds of slaves Kachin society.¹³⁰ *Ngawng Mayam* and *Timung Mayam*. *Ngawng Mayam* was the slave who did not live together with *Duwas* but had to serve outside works. They possessed their own houses and properties and had to give heavy tax to *Duwas*. *Timung Mayam* lived in the same house with *Duwas* and did necessary household works. They did not need to pay tax like *Ngawng Mayam*.

In conclusion, Kachins, before colonial period, lived in the hilly regions of north, northeast and northwest of Myanmar in small tribal villages. They made their living by shifting *Taung-ya* cultivation. Kachins were guessed to have entered Myanmar about 1st century and lived in Putao plains. From there, they also lived in triangle areas between N'maikha and Malikha rivers, to the south. Nearly all Kachin estates were under the rule of Nan Chao during 8th and 9th century. Under Nan Chao's power, Kachins served in the army, fighting. They settled town at their present estates, Mohnyin, Mogaung, Bhamo, Myitkyina, Sinbo, north Hsenwi, Katha and Yunan of China. Kachins who lived in plains, at that time, made their living as professional soldiers of Shan *Saw-bwas*. Since they had lived in the hilly triangle areas, Kachins lived and ruled according to their own rules within their tribes. According to their tradition, they had practised three kinds of administrative systems. Since the end of 18th century there appeared the system of *Gumlau*, the revolt of ordinary people to the traditionally ruled *Gumsa Duwa*. But only *Gumsa* system was practised for many years. Because of the *Gumlau* revolt, political concepts and administrative systems within Kachins differed. Some *Gumsa Duwa* of triangle area were found to have reached Hukawng and Assam. However, *Gumsa* system only was practised as the most practical Kachin traditional administrative system till 1960. All of Kachins political and administrative policies were based on the *Gumsa's* political concepts and ideas was found out that only *Gumsa Duwas* took the lead in Kachin's socio-politics and economic progress.

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¹³⁰Naw Awn, 1985, 68

The Arrival of Christian Mission in the Kachin Hill Region 1872-1932

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This paper presents that the study of social life and belief of Kachin people who live in the Kachin hill regions. Before the Kachins became Christians, they were animists and illiterates. It also explains the arrival of Christian missionaries from western countries. Due to their endeavour mission works, the social life of Kachins was changed. They became civilized people under the guiding of the missionaries. There were missionaries from five Christian denominations in Kachin hill regions. They were Roman Catholic, American Baptist Mission, Anglican mission, Assembly of God Church of Christ. Roman Catholic missionaries were the first and earliest missionaries in Kachin hill region. And then, the missionaries of Baptists, Anglican, Assembly of God and Church of Christ were arrived respectively. Among the Kachins, the majority of Kachins became Baptists. Some Kachins converted to Roman Catholic, Anglican, Assembly of God and Church of Christ. The Christian had arrived the Kachin hill before the colonial administration period. Therefore, some Kachins had converted into Christians when the British arrived in Kachin land.

The Kachin who live along the northern Myanmar, northern Shan State, Katha District, Assam region in India are Tibeto Burman race and they migrated down together with Burmans. The Kachin has six ethnic groups.¹³¹ They are Jinghpaw, Lachid, Lhaovo, Lisu, Rawang and Zai Wa.¹³² It is accepted unanimously that they were the descendants of the same *Majoi Shingra Bum*. Every inhabited region along the Kachin migration is called *Majoi*.¹³³ The exact location of *Majoi Shingra* were not properly rounded, but it is assumed that *Majoi Shingra* located somewhere eastern Tibet and around the plateau of Sichuan in China high land. Another assumption was Mongolia highland.

The Kachin ethnic to avoid the influence of Chinese Chief and move down to the northern part of Myanmar and around the first century AD, and slowly they settled down somewhere between upstream of Than Lwin and upstream of Mekhong. That area was Dulong Khu plateau highland. The Kachins dwelled together in Dulong khu area. Dulong Khu area was a very high rocky mountain and the snow was too deep that cultivation was not to impossible. While the Kachins were dwelling in Dulong cave, they suffered from famine and they baked the

parchments to satisfy their hunger. Therefore, when the literate old people passed away the younger Kachin generation became illiterate. Oral tradition says that the Kachins became experts in mountain climbing and fighting against each race became they were illiterate and uneducated.¹³⁴

The Kachin ethnic scattered down in the present area in 1850,¹³⁵ and scattered down northeast mountain ranges and northwest hilly region, and northwest Khamti Shan area, Chindwi valley, Kahta, and Theinni.¹³⁶ Thus, until the British occupied the Kachin Mountains the Kachins had migrated, and their migration stopped relatively become of the British rule.

The Kachin migrated down from *Majoi Shingra Bum* to northern Burma the save and sound abundant land. As they migrated down they brought their cultures, tradition, and religion along with them. The religion of the Kachin people was animism. They believed that there were numerous *Nats* in the animism. They believed that there were numerous *Nats* in the animism. Therefore, the spirits were first enquired and propitiated whenever they *taung-ya* paddy field cleaning, paddy plantation, harvesting, wedding ceremonies, for prosperity, for freeing dangers and the like, whenever they begin whole, before they started journey, and whenever they were ask, the spirit were consulted and sacrifices were offered. The animism of the Kachin manly involves the fear of the spirits.¹³⁷

According to the belief of the Kachin, the spirits managed the social culture and their fate. Moreover, the spirits were the ones who managed the good and evil results of the people. Therefore, the propitiation of the Kachin was vital in the religion of the Kachin. The spiritual priest had to manage without mistaken or without fail to do carefully the right place, the right time, and the materials for sacrifice. The Kachin did not think it to be tiresome in satisfying the spirits or to satisfy to make the spirit give favour.¹³⁸ They did not regard it as wasting property. Domestic animals were raised in every home for spiritual sacrifice. Rice beer (*Khawng Ye*) dried beef, smoked fish and eggs were kept in every home for emergency animist sacrifice.¹³⁹ However, when someone did not have the sacrifices for propitiating spirits he would borrow the sacrificial things for him close relatives.

The Kachins were animists before the missionaries arrived in the Kachin hills regions. The Kachins became Christians by the teaching of

¹³¹Zunwa Zau Shan, *Mongolia Mungdan kaw nna yu Hkrat wa ai Jinghpaw Wunpawng shani a ru Pawt Labau* (History of Junghpaw Descendants in Mongolia), Laiza, Woi Chyai, 2015, p.191

¹³²Marip Naw Awn, *wunpawng Labau Ginshi* (Indigenous Knowledge), Myitkyina, Hanson Press, 1983, p.48

¹³³The place where the Kachin's inhabited for a long time, Danya Mawshe, *About the Grand Kachin Manau Dance*, Myitkyina, Hanson press, 1990, p. 3

¹³⁴Wawn Hkan Aung, *Hugawng Tingpho*, Myitkyina, Hason press, 2003, p.8

¹³⁵Tegenfeldt, *A century of Growth; The Kachin Baptist Church of Burma*, South Pasadena, California, William carry library, 1947, p.16 (Henceforth: 1947, Tegenfeldt)

¹³⁶Daw Kyan, *Myanmar Naing-ngan A-che a-ney* (1885-86) (The Situation of Myanmar In 1885-86), Yangon, Sarpebeikman Press, 1978, p.171

¹³⁷Maran Baw La, *Htunghking Ningli laika* (Modernized outlook and Kachin Culture) Yangon, Tenggaha press, 2003 p. 86

¹³⁸Gilhodes, *The Kachin Religion and Custom*, Calcutta, Catholic Orphan Press, 1992, p. 112

¹³⁹Brang Shawng, *Nat Jaw Htunghking laika*, (Nat Worship, Oral Traditions and others of the Kachin), Yangon, Diamond Jubilee Press, 2015, P.38

the missionaries. There were many missionaries, from the Western countries, who were sent from five different Christian denominations. There were Roman Catholic, Baptist, Anglican, assemblies of God and Church of Christ

The first who arrived in the Kachin hills were the Roman Catholic missionaries from France. The first missionary from Roman Catholic was Bishop Paul Bigandet who arrived Yangon in 1856. He established mission head quarter in Yangon and tried to expand the mission field up to the Kachin hills. He organized France missionaries to do mission in the Kachin hills. Thus, Father Biet came to Bhamo in 1872 to do mission works. A few years later, Father Lecomte who worked as missionary in Mandalay for many years in Mandalay also moved to Bhamo. After that Father Biet and Father Lecomte began to do mission works in Bhamo.¹⁴⁰

Father Biet selected Sama village, which was twenty six miles far from Bhamo, as mission field. During that time, another two missionaries, Father Faire and Father Caucoux were arrived Bhamo in 1876 and they tried to expand new mission fields around Bhamo. Thus, Sha-U and Hkanleng villages, eastward of Bhamo became the mission fields of the Roman Catholic in 1876. In addition the Roman Catholic missionaries arrived up to the confluence region, in Myitkyina 1877. They did mission works among Maru (Lhaovo) tribe, but they were not converted into Christians rapidly.¹⁴¹

The Kachins continued to practice the animists' tradition even though the missionaries expanded their mission works. No one was converted into Christian in the Kachin villages, but the Catholic missionaries did to stop their mission works among the Kachins. After nine years of mission works, a Kachin young man, called Maran Ma Naw, converted into Christians in 1881. Some believe that the Roman Catholic mission works seemed to be not successful because they could not open mission schools among the Kachin communities.¹⁴² However, the conversion of the Kachin young man into Christians became the starting point of the Kachins animists who converted into Christians.

The mission works were progressed after 1881. However, the new missionaries could not come to Bhamo because the third English-Myanmar war broken out. In 1887, the missionaries, Father Cacloux and Father Pecot arrived Bhamo. In 1891, the missionaries based at a village called Naingkaba, which was nine miles far from Bhamo. Thus, thirty three Kachin people converted to Christian, as members of Roman Catholic Church. In the end of 1900, Father Gilhodes arrived at Bhamo. He based a Kachin village, called Tunhong to do mission works. After that, Father Faucheux, Father Roche and Father Delot arrived Bhamo within in 1904. These three Fathers helped mission works in Tunhong.

As a result, about two hundred fifty Kachin people became Christians and Tunhong became the Christian village.¹⁴³

Even though the mission works were progressed, the new missionaries could not come to Bhamo because of the broken out of the First World War after 1900. In 1914, some Karen Fathers came and helped for the mission works. After the First World War, women missionaries arrived at Bhamo. The women missionaries and Father Roche established a mission school, an orphanage and a nursing home in Nan Hlaing village, and they tried hard to do mission works. After six years of their works, the new converts were increased into three hundred and fifty in numbers. Thus, the Kachin villages, such as Sinlum, Panghkak and Tingsing from Bhamo district, became the Christian villages in 1934.¹⁴⁴

After sixty years of doing mission works from Roman Catholic, the missionaries noticed that there was not much progress in mission works. Therefore, the missionaries asked Saint Columba Church in Ireland to help them for mission works. Thus, eight missionaries (Father Patric Usher, Reverend Bernard Way, Rev. James Stuart, Rev. Deriel Cooney, Rev. Thomas Walsh, rev. Thomas Murhpy, Rev. William Kehoe, and Denis Maclindon) were sent to Bhamo from St. Columban Church, Ireland. After that the mission works at Bhamo district were led by the Ireland missionaries.¹⁴⁵

Many missionaries from Ireland arrived at Kachin hill regions and did mission works. And they could establish mission center at a Kachin village, Kajihtu between *May hka* and *Mali hka*. When the Ireland missionaries tried to progress the mission works, the Second World War started to break out. The Japanese soldiers arrived at Bhamo in May, 1942 and most missionaries departed to India, but some continued to work in the Kachin hills. The Japanese prohibited the missionaries to do mission works. Some missionaries were arrested by the Japanese soldiers and some were imprisoned in Mandalay. However, all missionaries were released in June, 1942.

After Second World War, some new foreign missionaries arrived in the Kachin hills. At that time, Father Patrick Usher began to open a seminary at Bhamo in 1947 to continue the mission works by the native people. Father Patrick Usher repaired the buildings which were ruined in the Second World War. Again, he built new buildings and continued to do mission works.¹⁴⁶

The American Baptist Mission was the second mission, which entered to the Kachin hills. The Baptist missionary, Eugenio Kincaid was the first Baptist missionary, who came to Kachin hills in 1937 and he planned to do mission works. After forty years of his planning, the American Baptist Mission sent the missionaries, Albet J. Lyon with his family and Jacob A. Freyday to the Kachin

¹⁴⁰M. Kum Hsang, *The Catholic Mission to Kachins*, Bachelor of Divinity, Thesis, Yangon, Myanmar Institute of Theology, 1991, P.18 (Henceforth: Kum Hsang, 1991)

¹⁴¹ Father Leo, *History of Sacred Roman Catholic Mission*, Myitkyina, Jinghpaw Kasa Press, 1961, P.56

¹⁴² G.Tegenfeldt, 1974, 16

¹⁴³Zingtung Grawng and Nawhkum Naw, *The established of Roman Catholic Mission In Kachin State*, Tawngoo, Catholic Press, 1961, P. 36

¹⁴⁴ Jangma Pawlu, *Catholic Mission to Kachin*, Bachelor of Divinity, Thesis, Yangon, Myanmar Institute of Theology, 1972, P. 21

¹⁴⁵ Paul Grawng, *Catholic Mission (Columban Golden Jubilee)*, Myitkyina, Jinghpaw Kasa Press, 1987, P. 5

¹⁴⁶ Edward Fisher, *Mission in Burma*, New York, The Sebury Press, 1980, P. 37

hills for the first time. They were arrived Bhamo on 13th February, 1878. In addition, the Karen missionaries such as Saya Koteh, Saya Naythah and wife of Saya S'Peh were arrived Bhamo along with Albet J. Lyon.¹⁴⁷

One month later, Albet J. Lyon died with malaria disease on 18th March 1878, before he did his mission works in Bhamo. Then, American Baptist Mission sent Rev. William Hennery Roberts and his family to continue mission works in Bhamo. Thus, Rev. William Hennery Roberts and his family arrived at Bhamo on 12th January 1879.¹⁴⁸ Then, Rev. William Hennery Roberts observed the situation of the Kachin villages around Bhamo to do mission works. Later, he based a Kachin village called Bumwa. However, Rev. Roberts and his wife were sick and left for Yangon to cure malaria. Meantime, a Karen Saya, S'Peh remained in Bumwa to do mission works. Rev. Roberts's wife was died with malaria in Yangon and Rev. Roberts went back to America for a while. Then, he returned to Bhamo on 5th January 1882. Rev. Roberts baptized seven villagers at Bumwa. It was said that those who wanted to be baptized were nine villagers, among them two villagers were too young to be baptized.¹⁴⁹

After baptizing seven Kachins, many Kachins began to convert into Christians from the animists. These were the fruits of the American Baptist Mission in Kachin hills. Today, majority of the Kachins are Baptist Christians in the Kachin State. Rev. Roberts anticipated that the Kachin needed to have Bibles in Kachin language to become good Christians. Thus, he tried to invent Kachin scripts with the help of Josiah Cushing. First, he invented the Kachin scripts from Karen scripts but it was not successful. Then, he tested again with Burmese scripts but it did not work again because the sound of the Burmese scripts did not fit with the Kachin language. Since the Kachins were animists and did not have literature before, many missionaries tried to invent the Kachin literature but it did not work to create the Kachin literature. Finally, Rev. Roberts asked the American Baptist Mission to send a specialist who was trained to create scripts.¹⁵⁰

As Rev. Robert requested, the American Baptist Mission sent Dr. Ola Hanson and his family to Bhamo on 22 December 1890. Dr. Ola Hanson had learned English, German, Sweden, Greek and Hebrew languages before he came to Bhamo. As soon as he arrived at Bhamo, he started to collect the Kachin words from the natives.¹⁵¹ After collecting Kachin words, he began to invent the Literature by using Burmese scripts but it was failed. Finally, he decided to create the Kachin scripts with Roman scripts. He used forty Roman alphabet to get the right tone of the Kachin language.¹⁵²

Thus, the British government also allowed registering as Kachin scripts from Roman scripts. After that, Dr. Ola Hanson held a meeting

with Mr. F. Lewison and representative from Anglican Churches, the missionary Father Adrian from Catholic Church and Rev. Roberts from Baptist Churches. Then they decided to use the new invented scripts as the Kachin scripts on 5 May, 1895. Thus, that day (on 5 May, 1895) was the day of the Kachins receiving the literature.¹⁵³

At that time, Rev. George Geis was doing mission works in Myitkyina and his works were progressed. He baptized Lahtaw Shalum Tu, Layang Roi, Hpau Naw Ji and Myin Kyaw in Myitkyina on 20th November 1897. Thus, Rev. George Geis was able to establish a Baptist community in Myitkyina on 24th November 1897.

Rev. George Geis asked the British government the land for a Church and a mission school. The British government provided a place at Shansu quarter, Myitkyina. He built there temporary school building and opened mission school on 1st May 1897. He also built a new two story building and opened extended mission school in May 1902. Some Kachins became literate and participated in doing mission works.

The literate Kachins published a three-page Kachin Newspaper in August, 1914 for the first time with the help of Dr. Ola Hanson. At first, they could publish only religious articles in the paper. However, they were able to include world news, Myanmar news, Health section, social, education, government ruling system, transportation, and so on. They could circulate about 1500 papers monthly. As the circulation of Kachin News Paper, Kachin began to appreciate the Kachin scripts and interest attending mission school.¹⁵⁴

At that time, Dr. Ola Hanson started to translate New Testament Bible into Kachin with the help of his assistances, Labya De, Lahpai Seng Li, Myitung Naw Grawng and Lahpai Seng Li. His Bible translation the whole Bible was completed on the 1st August, 1926. Dr. Ola Hanson passed his Kachin Bible in the hand of Saya Damau Naw in the celebration of 50th golden Jubilee of Kachin Baptist Convention, which was held on 25th-28th March 1927, in Bhamo. Thus, the Kachins received the Kachin Bible on 27th March, 1927. Translation into Kachin bible became a milestone for the Kachins.

Anglican Missionary group would be the third group who came to Kachin hill and did mission works. Rev. A. T. Houghton was the first missionary of Anglican Bible Churchmen Mission Society (BCMS) to Kachin hill regions. He was a military officer who came to the Kachin hill with the British Army. After meeting with the Kachins in Pyin Oo Lwin, Bhamo and some Kachin village, he was interested to do mission works in the Kachin community. Therefore, he retired from British military and work as a missionary in the Kachin community. He and his sister, Miss Eleen arrived Myitkyina in November, 1942. When he had arrived Myitkyina, the American Baptist mission was settled down in Myitkyina and

¹⁴⁷ Tegenfeldt, 1974, 367

¹⁴⁸ Randolph L. Howard, Baptist in Burma, the Judson Press, 1931, P.75

¹⁴⁹ Marip Aung La, The Brief History of Kachin Literature, Myitkyina: Hanson Press, 1995, P. 7

¹⁵⁰ Mading Zung Kyang, the Distribution of Baptist Missionary in Kachin, Myitkyina: Nawng Nang, 1983, p. 9

¹⁵¹ Lahtaw Gam, A Brief History of Dr. Ola Hanson, Yangon: Bahan Press, 1995, p. 45

¹⁵² JHZ Labau Mazing Komiti, *Jinghpaw Wunpawng Hkalup Hpung Ginjaw* (HISTORY of Kachin Baptist Church), 2008, P.27

¹⁵³ Gustaf A. Sword, *Light in the Jungle: Life Story of Dr. Ola Hanson*, Chicago: Baptist Conference Press, 1954, P. 68

¹⁵⁴ The Kachin News Paper (Kachin News Paper), Rangon: the American Baptist Mission Press, 1958, P.27

Bhamo. Therefore, Rev. A. T. Houghton discussed about his mission works with Rev. G. J. Geis from Myitkyina and Dr. Ola Hanson from Bhamo. After that he chose Moegaung regions as his mission fields. Thus, Moegaung regions and Hugaung valley became the mission fields of the Anglican Mission.¹⁵⁵

The Anglican missionaries set up their head-quarter at Mohnyin in December 1924 and started their mission works. In January 1925 they established the first dispensary in Mohnyin. Thus, they did their mission works along with healing ministry. In December, 1927 after two years of their mission, two Kachins, Chying Lup Yaw and Marip Kaw converted into Christian (Anglican). In the same year, Kadu Zau La, Hpauje Tu and Pausa Naw converted into Christian from animists. Thus, they could establish an Anglican Church in Mohnyin.¹⁵⁶

Another new missionary, Rev. Crittle arrived Kamaing in 1929 from England and he extended mission fields. He tried to teach Bible to the Kachins. Kadu Zau La and Kin Raw La were the first students among that community. The Anglican missionaries were able to established Bible school in Mohnyin in 1931. Rev. A. T. Houghton served as the president and Miss V. Falconer and Miss L. Mason helped him in teaching. In Bible school, they taught the Bible as well as health education.

In 1932, Rev. A. T. Houghton and Rev. Crittle visited to Lonekin village with Rev. Woodbury from American Baptist Mission. In 1934, three Kachins and two Shans converted into Anglican in that place, Lonekin village. Thus, they established a dispensary and an Anglican Church in Lonekin and continued to do their mission works there. They also opened a small hospital at Maingkwan, Hugaung regions. First, Dr. Middleton West managed this hospital but Dr. Johnston continued to manage it later. They collected donations from the patients and the natives and opened Bible school with these donations. Later, the Anglican missionaries could do their mission works with full support from England. However, almost all of the Anglican had to leave to India because of the Second World War. Meanwhile, the native leaders continued to do mission works of the Anglican mission.¹⁵⁷

Their mission works were very successful because they taught the Bible as well as health education. However, they could not cover education section. As the Church members request, they started to open mission schools. After the Second World War, the Anglican foreign missionaries returned to Kachin hill regions. In October, 1949, they established another mission head-quarter in Tanaing, on the Ledo Road. After that they went to Naga people for doing their mission works.¹⁵⁸

After Anglican Mission, missionaries of Church of Christ arrived at the Kachin hill regions. They selected their mission fields in the northern part of Kachin State. The leader of the mission was Mr. Justin Russel Morse. Before he came to Kachin hill, he served as a missionary of Yunnan Tibet Christian Mission in 1920. His purpose was to spread gospels in China, but his mission works were moved to the Kachin hill because of the political changes in China. In 1933, Mr. Justin Russel Morse came to Potao and did mission works among Rawang and Lisu tribes.¹⁵⁹ In 1934, Zihtang Solomon and Zihtang Yung Gare converted to Church of Christ. Thus, they started to established Church of Christ in Potao. The missionaries also invented Rawang literature and translated the Bible into Rawang. Then, they started to open Bible school and mission schools in Potao.¹⁶⁰

Mr. Justin Russel Morse brought more than thirty different kinds fruits of seeds from Florida and California, America and grew in the Potao regions. In addition, he taught the natives about farming. The missionaries tried to help Rawang and Lisu tribes for development by doing their mission works.¹⁶¹

Along with the Church of Christ, missionaries of Assemblies of God (A. G) mission also entered to the Kachin hills. The leader was Mr. J. Clifford Morrison. Like Mr. J.R. Morse, he returned from China Inland Mission. Pioneer missionary was a Chinese, Mr. Paul Yang, who was sent by Mr. J. Clifford Morrison to do mission works among Rawang and Lisu tribes in 1931. Mr. Paul Yang arrived at Zihtang, known as Khaw Bude. He preached gospel in Mang Sar, Nang Saing and Ma Rang Dong villages. Ma Ruin Tong Yan from Ma Rang Dong village was the first converted person to Assemblies of God (A.G.) Church. Thus, they established Assemblies of God (A.G.) Church in Potao.¹⁶²

Mr. J. C. Morrison continues to develop mission works in Potao. In 1948, he taught the Bible and preached the Gospel once in three months. Therefore, the numbers of the news converts were increased. The first native Rawang missionary was Nang Hi Hpung. The mission works of Assemblies of God (A.G) were successful, but some new church members were lived in remote areas and they were very poor. The Assemblies of God (A.G) church tried to support the new converts, who were living in the remote areas.¹⁶³ For example, the missionaries opened a few primary schools and they also support the students.

In conclusion, the missionaries who came to the Kachin hill were from different Christian denomination. They were Roman Catholic mission, American Baptist mission, Anglican Mission, The Church of Christ Mission and Assemblies of God Mission. The first mission

¹⁵⁵ Kum Hpag, 1991, 25

¹⁵⁶ A. T. Houghton, *Dense Jungle Green*, Rochester, The Stanhope Press, 1937, P.221

¹⁵⁷ Maran Hkawn Tawng, *Socio-Economic Condition of Kachin State Under Colonial Rule (1886-1948)*, Ph.D, Dissertation, Department of History, University of Mandalay, 2014, P. 56

¹⁵⁸ A Hla Aung, *History of Myitkyina Missionary Diocese, Myitkyina Diocese, Myitkyina*, 1987, P. 20

¹⁵⁹ Khin Hpag Ah Hpung, *The Church of Christ in Myanmar*, B.Th. Thesis, Far Eastern Fundamental School of Theology, 1995, P. 8 (Henceforth: Ah Hpung, 1995)

¹⁶⁰ Kuru La Ring, *A short history of the mission to the Rawang*, Bachelor of Divinity, Thesis, MIT, 1993, P. 82 (Henceforth: La Ring, 1993)

¹⁶¹ Ah Hpung, 1995, 9

¹⁶² La Ring, 1993

¹⁶³ Zau Ba, *Myanmar-pyi A.G. A-tin-daw Yaza-win* (The History of A.G. Church in Myanmar, Myitkyina, Shwe Kya Press, 1997, P.55

to the Kachin hill was Roman Catholic mission. After five years, the American Baptist mission came to the Kachin hill. They invented the Kachin scripts and promoted education sector. Even though the American Baptist mission entered to Kachins after Roman Catholic mission, they were more successful because of their education programs. In addition, Baptists mission also held meeting once in a year or once three year to discuss about social development. Thus, Baptists were more advanced than other Kachin Christians. Roman Catholic Mission said to be not successful in the beginning because they were weak in promoting education. However, their works were progressed after many missionaries arrived at the Kachin hill. The Anglican mission reached out to Kachins after 50 years of Roman Catholic Mission and Baptists Mission. Their mission fields were Mogaung areas, along the rail track and Hugaung Valley. They also promoted health education and other development programs. Later, they included education programs in their mission works. They opened a few mission schools.

Finally, Church of Christ Mission and Assemblies of God Mission entered to northern parts of the Kachin hills. The missionaries of Church of Christ invented Rawang scripts and promoted the situation of Rawang and Lisu tribe. They also tried hard for development of the natives. The Assemblies of God Mission also promoted education section. They opened a few primary schools and they put their energy for development of the natives.

As the Kachins converted to Christians from the animists, their life situations were transformed by the Christian missionaries. The missionaries also invented the Kachin literature and promoted education programs as well as vocational education such as farming and others. In summary, the Kachins were developed under the teaching of the missionaries and they became literates under the education programs of the mission. Thus, the Christian missions played important role which changed the social life of Kachin People.

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HIS 006

Kachin Under British Rule

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This Paper presents the conditions of Kachin people under the British colonial rule. At first, I will present background history of Kachin people and then their participations of the British army, religion and economic conditions. Although the Kachin people were undeveloped under British rule, their conditions were changed especially by the Christian religion. Since 1898 many Kachin men had served in the British military police and military units. It also changed the life style of Kachin people. The act of British government in education sector was too weak. Thus they produced a lot of soldiers they did not produce educated people. But the missionaries invented the Kachin literature and they emphasized educational needs. In economic conditions, the Kachin people earned their living with slash and burnt agriculture system. Under the British administration they continue the same system for their farms. There were no markets, difficult to access the whole kachin hill region. All of their work was intended for family and only for self sufficient. Therefore, economic growths have been only in a small numbers. But the British colonial rule brought about remarkable changes the Kachin society.

The Kachin is comprised with ethnic group Jinghpaw, Rawang, Lisu, Laovo, Lachid and Zaiwa. It is accepted unanimously that they were the descended of the same majoi shingra bum. They also refer to this ancestral home as majoi shingra bum or the highland of Mongolia plateau of which lies far to the north.^{*} Before 1500 BC the Kachin had migrated to Sumprabum and triangle area, while the Shans were living in the plains closed to the Kachin hill. And then, they moved toward south up to that plain where they resided together with Shans. That migration of kachin had taken up till the British annexation to the Kachin hill region.

In the first half of 19th century the Kachin were already established in approximately their present location. They were widely distributed in the Kachin hill region, northern Shan state, Yunan province of China and Assam of India.[†] The warlike Kachins always push their way to southward and were never under the rule of any nations. Before the British administration the Kachin people were independently inhabited their land. Most of Kachins were living under the control of Duwas. They were chief of their domains or territories.

According to the recommendation of Enriquez, the chief characteristic of Kachin tribes are sturdy independence, truthfulness, revengefulness, love of liberty, cruel treachery, incapacity for continuous work hospitality.[‡] Before the colonial administration, village is the most basic social structure by politically,

economically and sociologically. Because of the Kachin people understand their village as a sovereign state and mostly a village belongs to one clan.[§] The Kachin waged wars within their clans and other people all the times. Therefore, they built their village on top of the hills or steep mountains to prevent their enemies. Again when they had built their houses contained with several rooms for families instead of one family. For this reason, some Kachin houses were three hundred feet long in earlier day. The villager settled any problem that arises in the village can be carried out by joining together.

Kachin had preferred living together with the Shans, though they related was little with the Chinese, Burmese and India around them. They had never come into contact and relations with outside world. These made them backward people. By doing so, they almost came to a position to be ruined. By the times, the foreign Christian mission came to the Kachin hills and a little bit later the British had occupied Kachin region because the British wanted to penetrate up to China via Bhamo.^{**}

After Burmese King Thibaw was deported to India in December 1885, the column led by General Prinderghast arrived at Bhamo. After capturing Bhamo Brigder General Norman was charged with maintaining security and Majaor Cook was responsible for civil administration. Thus Major Cook was become as the first Deputy Commissioner.^{††} On first January 1886, Governor-General Lord Dufferin declared that Burma was under the British Empire and incorporates into the British India.^{‡‡} After that declaration, Hpunggan Duwa with a group of Kachin began to attack the British troops at Sawaddi nine miles far away from Bhamo in February 1886. Thus the Kachin started waging against the British. At that time the Kachin controlled the villages around Bhamo.

In Bhamo region the insurgents let by local leaders and Hpunggan Duwa were attacked several times. The British used to observe the activities of Hpunggan Duwa and tried to destroy his possible camps in the areas around Bhamo. At that time, the Kachin and Shan attacked repeatedly Bhamo in 1886. The British had to face difficulties in communicating with the Kachins. They attacked again British troops in November 1887 at Si-in village which was road to China. Therefore the British had to try to win local people's trust while they taking harsh measures against the resistance fighter. The intention of British to occupy the Kachin region was not easy task for them.

In February 1886 British troops arrived at Mogawng for the first time. When they arrive Mogawng, Wara Kachin and Maran Kachin

^{*} Sword, Gustaf A, Light in the Jungle, Illinois, Baptist Conference, 1954, P.31(Henceforth: Sword, 1954)

[†] Tegenfeldt, Herman G., A Century of Growth: The Kachin Baptist Church of Burma, South Pasadena, California, William Carry Library, 1974, p.16 (Henceforth: Tegenfeldt, 1974)

[‡] Enriquez, C.M. Races of Burma, Second Edition, India, Delhi, Manager of Publications, 1933, P. 24 (Henceforth: Enriquez, 1933)

[§] Maran Baw La, Modernized outlook and Kachin Culture, Yangon Thingaha Press, 2003, P.12

^{**} Singhal, D.P. The annexation of Upper Burma, Singapore, Eastern University, Press, 1960, P 11

^{††} Crosthwaite, Sir Charles, The Pacification of Burma, London, Frank Cass and Co. Ltd., 1968, P.235

^{‡‡} Scoot, J. G. Gazetteer of Upper Burma and Shan States, Part 1, vol.1, Yangon, superintendent Government Printing, 1900, p 117

resisted against the British troops therefore the British did not control till the end of 1886. They wanted to occupy Mogawng was mainly to take control of the Jade mines and to gain a foothold in Kachin region. Even though they want occupy Kachin region the British forces did not know everything about land and people.

Thus the British decided to send two columns led by Major Mainwaring and Captain Hasting separately came back for the second time in December 1887 and police expedition to permanently occupy. U pho Saw opposited the British after joining together with Sama Duwa Gum Seng Li and other Kachin Duwas and patriotic Shans on 22nd May 1888. Thus severe fighting broke out Mogawng and many people were fallen both side. Finally, the native insurgent troops retreated from Mogawng. The British brought from India five platoons under Major O' Donnel came to reinforce civil administration.

In Wuntho, the uprising was led by Saw-bwa U Awng Myat with his followers but they were suppressed by the British troops and occupied Saw-bwa's capital Pinlebu on 27th February 1891. In 1892 the British spread two military forces from Bhamo to the east of Ayeyarwady toward Sadung, Sama and another military force from Myitkyina to Sadung and Sama.⁶⁶ Because of intense fighting with the native people in Sama Captain Boyce Morton was fallen thus the Sama fort was named Fort Morton. In Sadung combat the British Captain Harrison and seventy soldiers were fallen. Therefore, the Sadung fort also named Fort Harrison after the dead of Harrison. However, In 1923 Triangle area, north of Kachin hill region was still unadministered area which means that so far it had no roads, government, politics and no taxes. In 1924 there was only sub-divisional office and military post of 50 rifles of Putao.

In the pacification of Kachin region British employed various tactics. They used either military means of negotiation or politics. They opened permanent military post in strategic location. At first the British recognized the hereditary rights of Duwas. Because they understood if they were able to persuade the Kachin chief these Duwas to accept the British over lordship there would be no difficulty to pacify the region. Under British rule the Gumlau administrative system gradually faded away. The British authorities issued orders appointing the village chiefs in Gumlau administrative areas as agyi or village headman. He was expected to execute without question all instructions received from the British District Officer Tawng-ok. The British had one system of administration used in all areas, formerly under the administrative system of Gumlau and Gumsa.

Under the British colonial period they governed the Kachin hills separately from Burma proper since it had annexed the whole Burma. The Kachin settlement in Myitkyina, Bhamo, Putao District were governed by deputy Commissioners. At the same time, the British also concerned to keep the frontier areas relatively undisturbed and

quiet. They saw the Kachins were war like races thus they look to the Kachins for recruits for native military police and army unites. From 1897, the British began to make the recruitment of kachins for the military police and civil officer. These officers were permanently posted to the hills with the headquarters at Sinlumbaka. In the army they took well to military discipline and in many cases develop both respect and affection for the British officer.⁶⁷ These services had tremendous influence upon their development.

The British army started to form a coy for the Kachin in Bhamo on 1907. The British commended this coy to fight against the Shans and Chinese armed insurgents. In this combat, the Kachin soldiers fought bravely and won over the rebels. After that the British began to notice and recorded that the Kachins were skillful in combats. The consequently British formed again new coy in 1909 and another coy was formed in 1914. When the 1st World War broke out in 1914 Kachin soldiers about 1589 from Bhamo sent to India. And then were sent to France, Gallipoli, Egypt, Persia, Aden, Africa and Baghdad. Later the British collected more Kachin new soldiers and sent them to Middle East and they reached Mesopotamia on 15th August 1917

According to the group of veteran's record the Kachin soldiers were brave and skillful in combats in Mesopotamia and Turkey battle fields. Thus some Kachins soldiers received many honorary awards but some soldiers were suffered injury and died. Among them, Subedar Jing Hpaw Gam was promoted to Subedar-Major position and he also received 2nd class golden medal award (Order of British Empire). But total sixty soldiers died and 113 were injuries in the war.

Moreover, the soldiers who were under British colonial countries served faithfully and excellently to the British, the Emperor invited to England and offered a position as King's bodyguard. Among the Kachin soldiers Panghkum Zau Tu, Myihtoi Naw, Lasang Gam received king's bodyguard position. The first person Subedar Major and Honorary Letanuen Panghkum Zau Tu was invited by king George V to England in 1931 and offered apposition as bodyguard. He served six month in the palace a position of king orderly officer. In the 1st world war Subedar-Major Myihtoi Naw was also awarded gold medals and a high position called "Naik Agyi". He served faithfully to the British government. Therefore, the King Gedorge VI invited him to England and offered a position as a bodyguard in 1935. He served six months in the King's palace and a position of King Orderly Officer. He received uniform of King's body guard and gold medals. Like the previous solders Subedar Major Lasang Gam was awarded the King Victoria Medal and served four months as king's bodyguard and a position of king orderly officer.⁶⁸

But it can be seen that the Kachin soldiers were not offered higher position and it can be concluded that the Kachin soldiers were uneducated people. However, during the First

⁶⁶ Lawang Li, *The city of Kachin State History*, Myitkyina, Hanson Press, 1995, P.4

⁶⁷ Dawson, G.W, *Burma Gazetteer*, Bhamo District, Reprint, Yangon, Government Printing and Stationary, 1960, P.29 (Henceforth: Dawson, 1960)

⁶⁸ Walaw Bum Zau Hkawng, *The history of Kachin of Hukawng*, Myitkyina, Queen computer, p 80

World War many Kachin were recruited in army and they served in abroad. Before this experience, they never knew about hygienic living and nutrition and daily diet. Turning of these situations could also catch their intention. When the German was destructed by the allied and the 1st world war ended they returned to Burma. However, some soldiers served, again the Army which the British formed in Burma.

When the 2nd World War broke out the Japanese began to bomb Myitkyina of 8th May 1942. The Japan air force and infantry troops reached Myitkyina, Northern Part of Burma. Thus the British retreat from Sumprabum on 15th May 1942 to India. On the way to India, one British officer, Mr. Stevenson told the Kachin elders that if the Kachin wanted to establish the Kachin country. Kachin should help the British and rebelled against the Japanese.^{***} Thus the Kachin tried the best during the resistance against the Japanese. In the early days of Japanese occupation, the Veterans from Burma frontier Army, Burma Rifles and some leaders of armed groups of the Kachin hill led the Kachin villagers and against the Japanese. In August 1942 the British came back to Putao under the leadership of Lt. Col. Cambell and Captain Leeches by air force. They started to organize and form Kachin Levis. They brought arm, food, medicine and other military supplies by air force. The purpose of organizing levies was to resist against Japanese strategically. The British could organize six coy and each was composed of more than a hundred soldiers. The Kachin Levis gave Japan many difficulties in Kachin areas.^{***}

Similarly, Bhamo fell into Japanese hands in May 1942, Sinlum region became Allied's headquarters and American Kachin Rangers Regiments were organized by Major Pete Joost and Captain Lazum Tang Ji. New recruits from surrounding villages and former veterans were combined into five regiments. The five battalions were able to organize more than one thousand new soldiers within three months. Many ration and military equipments were delivered U.S Army to Sinlum Area by air lift. In this way, Sinlum headquarters stoutly defended Japanese attack under heavy assault.^{***}

During 1942 to 1945, anti-Japanese resistance movements in Kachin State arose as a remarkable resistance movement. From 12 years to 70 years persons were participated in this resistance movement. Though they were not involved in fighting, these children's were very useful guide for the route for the allied forces. We can see that, during war time period, some U.S officers form Kachin Levies and Kachin Ranger lived together with Kachin soldiers and even they eat opium and drunk rice Beer. On 24th to 26th March 1945, one great Padang Manau festival was held at Sinlum in which American military officers granted military medals and guns for gift to Kachin soldiers. Thus on 29th March, discharge

certificate for Kachin soldiers were issued and all military units were withdrew back from this area.^{****}

In religion the Christianity penetrated to Kachin region as a new religion during colonial period. Before the colonial rule most of Kachin professed animism. The Christian mission had arrived there a little bit earlier than the British colonial administration and when the British arrived in 1886, the Kachin people stated converting to Christianity.^{****}

The French Roman Catholic Missions was the first and earliest mission in Kachin hills. And the first priest Father Biet reached Bhamo In 1872. As the second mission the American Baptist Mission came to Kachin. Although a pioneer Baptist mission came to Kachin. Although a pioneer Baptist missionary man Mrs. Albert J. Lyon arrived at Bhamo on 13th February 1878, he died on March 15th 1878. Thus another missionary couple Rev. H. Roberts and wife arrived at Bhamo on January 1879. After the First World War, the third Anglican mission reached in 1924 and the last mission was Assemblies of God, Church of Christ mission arrived in 1930s.

Until 1895, the Kachin people had no their own literature. Their oral history, legends, stories, and mythology had recorded by animist priest Jaiwa, Dumsa they transmitted to one another by word of mouth and told it to the people on great feast days. Accordingly, in order to solve the problem of lack of literature Rev. Dr. Ola Hanson the Baptist missionary tried to invent the Kachin literature. The inventor Rev. Dr. Ola Hanson with his knowledge of Swedish, English, German, Greek and Hebrew was sent out specifically to do linguistic and literary work for the Kachins.

The invention was put up for recognition by Mr. F. Lewishon, the District Commissioner, as Governor, to represent the Anglican diocese all the assistant residents, Father Accarian of Francis Roman Catholic Mission, Rev. William H. Roberts and Rev. Dr. Ola Hanson of Baptist Mission on 5th May 1895.^{****} At first the lack of emphasis upon the opening of schools especially in the hill region was the factor in the slow growth of the Roman Catholic Mission. Thus the first Roman Catholic Mission School was opened at Hkudung in 1907. Due to scarcity of good teachers, lack of interest in education on the part of Kachin people, the missionaries face many troubles.

The first American Baptist mission enter the Kachin hill region found there was already interest in having schools. Thus, the centers schools in Bhamo, Myitkyina, Namhkam and Sumprabum were opened shortly after the beginning of Baptist mission. Scores of little village school in every part of Kachin Hills were also opened. During those years Government aids were limited and often delaying assistance and some schools were run under grant in aid

^{***} Roi Nau, M, The Role of Kachin Race in Struggle for Myanmar Independence, M.A. Thesis, University of Yangon, 1992, P.44

^{***} Hpauwung Tang Gun and Chyauchyi Naw Ja, Heritage Warriors Ancestors Era, Vol.I, Myitkyina, 2001, P.73-74

^{****} The Army and Military Pensioners Ex-Servicemen's Association, Jinghpaw Hpyen dap labau laida,

The Kachin Military History, Bhamo, Ex-Servicemns's Association, 1954, P.58

^{****} Gordon, Ian MC Fellows, The history of the Kachin Guerrillas of North Burma, London, Robert Hale Limited, 1950, P.1

^{****} Tegenfeldt, 1974, P.119

^{****} Awng La, M. K.B.C. Labau (The History of Kachin Baptist Convention), Myitkyina, Hanson Memorial Press, 1984, P.5

system.^{*****} The Anglican mission emphasized more health care than education. Thus when they arrived and set up headquarters at Mohnyin in December 1924 they established the first dispensary.^{††††} The Church of Christ and Assemblies God mission these two were return from China Inland mission. They emphasized rural development so, the missionary M.J. Russel Morse brought thirty various kinds of seeds from Florida and California and planted in Putao regions.^{‡‡‡‡} There were Grape Fruits, King Fruits, Washington, American lime and etc. are still growing well exported to every part of the country.

Due to the endeavor of missionary most Kachin people converted to Christianity. Although the Kachin were animist traditionally they also have the concept of creation theory. It was one of the facts that they converted into Christian. One missionary strategy was that if they want to organize the whole community through the chief Duwa or influential person could easily be converted.^{§§§§} The schools were another and even more effective means of evangelism. The teacher-preachers were importance in both educational factors and religious realms made him a key figure in the conversion and general advancement of Kachin people. Moreover they intended to develop not only religion but also secular sector. The majority of Kachin had converted into Christianity after that the living standard of Kachin people absolutely change.

Kachin hill region is covered with forest and mountain and native people earn living with agriculture. The native people cultivate many kinds of paddy and vegetables of the hillside region however these were not for the economic purpose. They raised animals more emphasize for sacrifice nats worship purpose as well. Beside the cultivation the native people made home utensils which are handicraft and made hand woven cloth as well. However these utensils are also not for sale and not for economic purpose. They mainly worked to be self sufficient for one's families.

The economic conditions of the ancient Kachin had been influenced by the culture of offering nat and outdated views. They accepted wrong concepts that they could be richer that the relevant nats give blessings to them only. Therefore, the economic condition was, too weak to improve in the Kachin hills.

Prior to the British rule the Chinese merchants came by taking mule and started trading since the Kachin settlement in the Kachin hill region. Kachin brought silver, cotton cloth, Chinese silk, utensil, and fancy goods from the Chinese merchants. They sold coffee seeds, leather, ivory, deer horn, tiger's skeleton, gold, jade, and herbs to Chinese merchants.^{*****} But the economic system of Kachin region was not developed and less of prosperous, because they were able to produce only for self sufficient.

Actually, the British wanted to penetrate into China rather than occupying economic profits of the Kachin hill region. The economic power of the Kachin hill was not very much important for the British. But the British wanted to get through from the behind door to China. And they wanted to export the product of India and England and import the product of China. The British government tried to make commerce with China through Bhamo since before they occupy the Kachin hill region. Therefore the British government went up stream to Bhamo from Mandalay without delay on 28th December 1885 after occupied Mandalay. It was to be able to control the Bhamo town rapidly by the British because it is situated in the central point of commercial place. Therefore, to develop agriculture the British government carried out the activities of setting up the experimental gardens, celebrating the agricultural demonstration and sending the Kachin agricultural trainees to agricultural training. By this way the British government carried out modern farming methods for developments of cultivation and their advantages. However there was not seen any agricultural development distinctively. Because there was a small number of people and only few people wanted to initiate the method of examining cultivation.^{†††††}

Although the British government did not succeed in cultivation, they could collect opium taxes. Before the colonial period it was grown the opium plant for eating in Hukawng valley and China border area. They did not intend to export to other regions and only cultivate it for the consumption purpose. The poppy plantation was especially prevailed in some Kachin hills which are 400 feet above sea level and cold dry places. According to the geographical situation, climate and form of the Kachi hillside region is particularly appropriate to grow opium. Therefore opium plants are particularly grown in Sadung, Sama, Hukawng region and China border area before the colonial period.

Under the British rule it was important to get opium tax for them. As a result the British government allowed the Kachin hillside region Katha, Bhamo and upper Chindwin regions to grow the opium plant legally. After that they collected opium tax from those opium plantations. The opium trade was prohibited except for the people who paid tax to the government according to the rule of 1895 Kachin Hill Tribes Regulations item 31. On the other hand the prohibited growth of opium in any other regions but they levy tax of opium importing from India and China. Although the British government had prohibited from opium smuggling and cultivating they had less intention to help the native people to free from eating opium by living in good character and opium smuggling.^{‡‡‡‡‡} They only tried to have a profit from the opium tender sale that was caught.

^{*****} Sword, 1954, 66

^{††††} Kum Hsang, M, The Anglican Mission to the Kachins, Bachelor of Divinity, Thesis, Yangon, Insein, 1991, P.25

^{‡‡‡‡} Hkin Hsang, Ah Hsang, The Church of Christ in Myanmar, Bachelor of Divinity, Thesis, Far Eastern Fundamental School of Theology, Insein, 1995, P.9

^{§§§§} Sword, 1954, 66

^{*****} Hertz, W. A. Burma Gazetteer, Myitkyina District, Vol. A, Reprint, Yangon, Government Printing and Stationary, 1960, P.104

^{†††††} Report on the administration of Burma for the year 1915-1916, Yangon, Superintendent Government Printing and Stationary, 1916, P.54

^{‡‡‡‡‡} Dawson, 1960, 82

The best teak is available in Indawgyi region and the British government gave permission to private business. British Government had contracted with steel Brother Company and other Companies had also run timber production since 1905. Ayeawaddy Flotilla Company get permit to produce wood and other forest products from Bhamo. However, the British Government tried to preserve deforestation so they made a survey to fix the forest reserve since 1891. By this way they started to recognize the forest reserve in Bhamo and Myitkyina District from 1893 onwards.

Jade, gold, amber and other mineral resources were abundantly found in Kachin region. Especially Myitkyina District produces the precious Jade. Prior to the British rule Jade business had been famous and Chinese jade merchant tried to get jade all the time. Under the British Government, Mogawng came to be a jade city, which mainly did buying and selling jade. Kachin people themselves brought jade from jade mines to Mogawng. Kachin Duwa Kansi Nawng had been a ruler of Jade mining area while the British arrived to Bhamo in 1885. Therefore, Major Adamson, the first Deputy Commissioner of Bhamo with a group arrived and met with Duwa Kansi Nawng and they agreed that the chiefs of Kachin ethnic to collect jade mine tax the same as former period.

By this way it came to be flourishing and developed with jade cutting, buying and selling in Bhamo, Mogawng and Mandalay cities. All the jade trading was monopolize the foreign people. The British Government gave their attention more on collecting tax than doing jade business in jade mines. All the forest and mineral production were in the hand of foreign companies. Economic had been a little bit changed. However, it can be seen that there was no distinctive development in Kachin region.

In conclusion, before the colonial rule Kachin lived freely and independently in their region under the leadership of Duwas. When the British confiscated their land they tried to resist against the British. But they did not enough and modernized weapons did not form military operation systematically, thus the British gradually suppress the resistance movement. And the whole Kachin hilly region was gradually under the British administration. While the Kachin men served the British army they could contact the western people and had many experiences it was changed their way of thinking. The impact of Christian mission was considerable on the Kachin people. The missionaries tried to uplift of Kachin people through education, health care, and rural development. Under the colonial period the kachin people continue earn living with agriculture. Owing to the lack of market, knowledge, technology, capital of Kachin people and without producing industrial product economic growths had been only in a small number even though it has many natural resources. But the British Colonial rule brought about the remarkable changes in the Kachin Society.

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ENG 001

Artistic Bamboo Handicrafts

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Abstract

This paper focuses on the art of producing bamboo handmade materials. However, it aims at analyzing the contribution of artistic bamboo handicrafts such as bamboo bracelets, earrings, clocks, rice bowl, cups, phone stands, etc. produced by the owner "Y Garden Restaurant." In analyzing the contribution of artistic bamboo handmade products, the 6 ways to measure small business success stated by Kappel (2017) are applied as a methodology. After doing the analysis of the contribution of bamboo products, the findings show that making artistic bamboo handmade products is on a better way to generate bamboo handmade things with high quality and will certainly enhance the image of native people as a sustainable development. The findings also show that due to knowing the art of producing bamboo handmade products, native people have the opportunity to earn. Finally, this research suggests that from the environmental point of view, bamboo planting should be done to conserve the forest and to promote artistic bamboo handmade products.

Keywords: artistic bamboo handicraft, handmade, sustainable development, contribution

1. Introduction

"The art" is defined as "the use of imagination to express ideas or feelings, particularly in painting, drawing, or sculpture" in the Oxford Advanced Learners Dictionary (2019). It also states that 'artistic' means 'done with skills and imagination; attractive and beautiful'. Cambridge Dictionary defines 'artistic' means skillfully and attractively made'. When we say 'handicraft', most imagine the things made from stone, wood, bone, clay, or cloth. However, this research focuses on artistic handicrafts, made from bamboo, which is still plentifully grown and seen in Kachin State. Particularly, it aims at analyzing the contribution of artistic bamboo handicrafts such as bamboo bracelets, earrings, clocks, rice bowl, cups, phone stands, etc. produced by the owner "Y Garden Restaurant." The aim of their production is to make fine products from raw materials, to encourage local people learn the skills of creating handmade things, and to give up buying expensive things made from bamboo which is available too much in own country and to be able to produce artistic bamboo handicrafts. Their vision is to promote the life of local people from the life of hardship and toil through producing bamboo handicrafts.

2. Literature Review

"Bamboo crafts are not only a traditional artwork of Myanmar but also of its neighbor to the west, India" said The Myanmar Times (2017). It also stated that in both India and Myanmar, bamboo is used for not only crafts but housing, fencing and sometimes in clothing. Moreover, it mentioned that Manipuri people use bamboo-based items in their everyday life for a variety of purposes from lining their house to inside the kitchen. According to the above statements, bamboo is very important and dominant in people's life. The advisor to the National Museum (2017) stated that Bamboo art and crafts are prominent in Myanmar. Myanmar ethnic groups are skilled in traditional bamboo craft-making. However, in the article "Bamboo craft losing its appeal" (2016), it was said that forest depletion, a shortage of high-quality materials and skilled artisans and a lack of government support are some of the main worries of their craft. In the article, one craftsman stated that bamboo is becoming rare and has to be protected from mildew and worms. They have to make up samples to the customers' demands to encourage sales. Lacquer ware is based on bamboo, but the market for bamboo products is weaker and the products are not so durable. It can be hard to estimate how long an article will last.

Therefore, the production of artistic bamboo handicrafts nowadays are interesting to estimate whether successful or not. This is the main reason to focus on such a small business success.

3. Methodology

As this research focuses on contribution of artistic bamboo handicrafts, it is, therefore, measured by 6 ways of Kappel (2017). Kappel's 6 ways to measure business success are as follows:

- (1) Look at your business financial statement
- (2) Check customer satisfaction
- (3) Average how many new customers you get
- (4) Conduct performance reviews
- (5) Stay current on the market
- (6) Assess your own expectation

In surveying the contribution of artistic bamboo handicrafts, following the 6 ways of Kappel (2017) mentioned above, the owner "Y Garden Restaurant" gives responses on them. In analyzing her answer for their financial statement, they don't have stable income from their bamboo products because of some reasons. The first reason is that their products are starting to be launched among the customers and their business is running as a small one. Secondly, they could sell to a few customers who love handicrafts and to only natural lovers. However, their bamboo products are all sold out to people who bought them as souvenirs. She has also told that even if their products are widely used, they think they could run their business well as they could invest well and bamboos are available in their own yard. At present, they could hardly say about their monthly income rates through bamboo handicrafts.

In checking the customers' satisfaction, she gives the message that the customers are fond of their bamboo products, especially the bracelets which are painted with different designs such as flowers, or birds on them. Moreover, the bracelets are very artistic and the paints on them are done by the artists from Min Goon, a famous village in central Myanmar. Myanmar people who are settling in abroad bought the bamboo handicrafts, especially bamboo bracelets or earrings or cups as souvenirs for the foreigners. The guests are satisfied with what they have bought because the artistic bamboo handicrafts are so cheap and cute that everyone can afford them. She said that they will try as much as they can to make the customers satisfied themselves and they always request feedback from their customers.

In surveying how many customers they get, it is found that they have sold out whatever they have produced. As the owner opens Y Garden Restaurant, not only local people but the foreigners don't miss to visit there. Therefore,

they have new customers every day. She said that people from US are fond of the bamboo bracelets and have ordered them once. Some people are fond of rice bowls or watches.

For conducting performance reviews, she said that the majority of people are fond of artistic bamboo handicrafts. Therefore, their business will be extensively broad soon. They are also still searching new technology to create new items. They don't need to worry about financial cases, and they can handle their business very well. They don't hear the customers are not happy with their products and they don't still have bad reputation for their products.

In marketing, they had a deal with a great businessman and needed to build the 10 bamboo bungalows. At present, they have built only three bamboo bungalows and they could sell each bungalow for 20 or 25 lakhs.

In assessing their own expectation, she said that their environmental friendly business goal is to make a positive change in their community by promoting the life of local people who can earn at home comfortably and make everyone proud of it. According to the owner, it is very surprising that the whole bamboo pole is very useful indeed. There is no waste as bamboo pieces from carving are burnt and it generates the steam to liquid which appears the toner for skin care. Therefore, the owner has to hire the beauty technician for their business. In future, they will be able to run with stable capacity and make a lot of beneficial things for community.

4. Findings and Discussion

After analyzing the contribution of artistic bamboo handicrafts, following Keppel (2017)'s 6 ways to measure business success, it becomes impressive at the present situation. According to the owner, they don't have stable income from bamboo crafts and not many people know well about the products. However, in making artistic bamboo handicrafts, bamboo is not expensive. A pole of bamboo costs only 500 kyats. If a product is finished, it will cost 5000 kyats or 10,000 kyats. To get the high price, methodology is very important in processing raw material to fine products. Moreover, the artist needs too much creativity and skills, interest and new ideas. In this business, although raw materials are easily available, it requires fine artists, and skillful workers. Keppel (2017) states that money is very important in running a business and in making it grow. He also states that even if a small business, to measure business performance everyone needs to check out the financial statements to see how profitable the business is.

In exploring the customers' satisfaction, it was found that 90% of people who bought their products are happy to have them. Up till now, it is obvious that they could do to please their customers.

The owner as well as the artists should see what they need to improve and be happy under the workload. At present, the business does not have a lot of employees to create bamboo handmade materials and they can manage their work well. However, when their technological skills are perfect and when the products are in demand, the business will need a lot of employees and the owner needs to conduct performance review very often whether the employees are happy or not in the workplace and whether the customers are

happy or not to buy their products. Up till now, the business does not have bad reputation as well as financial issues and they often listen to the suggestions of the customers.

Despite the production of artistic bamboo handicrafts is emerging as a small business, they could create several types of people's taste. They are trying to upgrade the required skills. The reasons why people bought the bamboo handicrafts are that they cherish the nature as well as they appreciate unique Myanmar products. Another reason is that a bamboo handmade is enchanting to possess because of premium sense while using it. The business is not very popular in these days though, they can contribute well for their products. As they have a deal

with the great businessman and needed to build the banglos totally as much as they could and so, the demand is still increasing. Moreover, if they have a way to solve the bamboo fungus in the rainy season, or if they can replace the bamboo handicrafts instead of plastic utensils in the market and it will be widely used.

5. Conclusion

In analysing the contribution of artistic bamboo handicrafts in Myitkyina, Kachin State, the findings show that this business is a very promising one for Northern Myanmar and it will be sustainable development for the community. As their goal is aiming at to support the local people in Kachin State and to make them earn comfortably just staying at home, this business, as they claimed, could be a great business which can distribute their products to within local areas as well as to abroad whose people would love to possess their bamboo handicrafts. In the near future, their technical education is also to be developed by the artists, who will distribute to new members in the business to be highly performing artists as well as to the community to make bamboo handicrafts as one of the icons of Myanmar. However, from the environmental point of view, the depletion of bamboo can damage the weather and cause a great loss. Therefore, as bamboo is the type of grass which can grow fast, bamboo planting should be done to conserve the forest. This research also suggests that another researcher can extend studying bamboo handicrafts produced by people from IDPs in Kachin State and make comparisons between their products, skills, and contribution.

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ARC 001

The Study on Ethnohistory and Culture Tradition of Kanan Nationals in Nanzar village, Bamouk Township, Katha District, Upper Sagaing Division, Myanmar

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Abstract

This paper mentions the study on definition of Ethnohistory and cultural tradition of Kanan National in Nanzar village, Bamouk Township, Katha District, Upper Sagaing Division, in Myanmar. Kanan village are total of 24 villages in the Bamouk Township, Katha District. The total of Kanan area are about 34 mile wide. There are over 10000 people in the 24 villages. Nanzar village is the largest of the Kanan villages. There are 275 houses. Farming and agriculture are their economy. Kanan villages are located 26 mile far from in the north of Pinleebu and 40 mile far from in the west of Bamouk. Kanan national who live in the top end of Mu river at which Mu river begins to flow. Gold is found in Kanans area. The Kanan national believe in Buddhism. They worship the native traditional spirit. The ethnic of Kanna are a small minority of ethnic group in Myanmar. But they preserved their traditions and customs. Kanans nationals have simple traditional culture. They are very simple ancient ethnic people. They have still kept their traditional culture. Kanan have not had their own alphabets and use Myanmar writing for written language. For spoken language, they use Kanan language. Before the young boys go to school, they attend the class in Buddhist monasteries in their villages. Benefits: the study on Kanan national who their custom, belief, socio-economic and regional concerns. We can maintain their culture and encourage of Kanan nationals to preserve of their heritage.

Methods

To survey

Field trip to Bamouk Township, Katha District, Upper Sagaing Division

To meet the native people of Kanan nationals at Bamouk Township, Katha District, Upper Sagaing Division

Aim and Objective

In this paper, the study of Kanan national who their custom, belief, tradition, socio-economic, ICH (Intangible Culture Heritage), CBT (Community Based Tourism) of ethnic. We need to promote education, health and regional concerns. We can maintain their culture and encourage of Kanan national of preserve of their heritage. Besides several young men use drugs much. It is urgently necessary to have law and orders and to take care of the characters of the local people. Therefore, the government need to support education, health and basic needings to promote social life of Kadu and Kanan and to take care of keeping the traditional cultures of Kadu and Kanan.

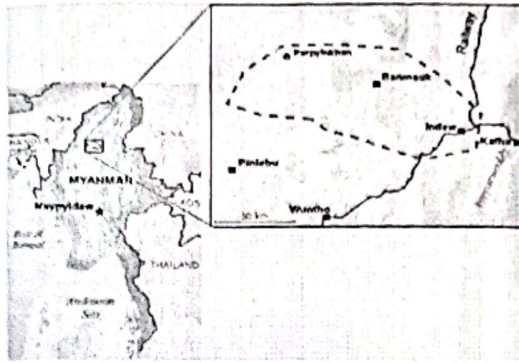
Introduction

Kadu and Kanan lived together in the areas of Indaw, Bamouk, Hteechaing, Katha, Pinleebu, Cawlin and Wintho at Katha district, Sagaing division, Upper Myanmar. But Kadu language and Kanan language are different. Kadu language is very similar with Kachin language. Some words of Kanan language is similar with Kachin language and other words of Kanan language is similar with Shan language. The chronicle which mention that Tagaung city was the central town of Kadu in Man-Shu of Chinese (A book on South wildnen) who the Kadus were originally remains uncertain, but now they are

little more than Myanmar and Shan half-breeds with trace of Chin and possibly Kachin blood. There are another tribes whom live with them. They are Kanan nationals. Kadu and Kanan nationals live in the same area of Katha district. But, the name of the Kanan become popular just after the Bagan period. A small number of population of Kanan people live in Moechnyin township in Kachin state, that area is northeast of Bamouk township of Sagaing division. Kanan people left their native region of Moechnyin township, Kachin state. Moechnyin city is border line of Sagaing division and Kachin state. Kadu and Kanan who stay at the top end of Mu river. They are deserted from Pyu. (Kyaw Shin, The beauty of Kanan, 2012). Kanan are very simple and ancient ethnic people. They have still kept their traditional culture. Kanans have not their own alphabets and own writing. They use Myanmar alphabets and Myanmar writing for written language. For spoken, they use Kanan language. Kanan people Buddhist and they pay worshipping to "They lord Budddha". They belief traditional spirit or gods or nat. There is a description about the Kanan people inhabitants living in the Nanzar village of Bamouk township, Katha district, Upper Sagaing division in Myanmar.

1. Location

Nanzar Village of Kanan region is situated in Bamouk Township from about 40 miles. Mu river started at Kanan Village which native people called Shwekyauung. There is a saying " Kanan begins at Shwekyauung village and ends at Leepitone village". Gold is found in Kanan area. The area at which Kanan dug gold and sent gold to the Myanmar King in previous time. (Mg Kyaw Shin- Kadu and Kanan Ahla, 2012). Nanzar village is the biggest village in the total of 24 villages.(Map 1)



Map 1: Location of Kadu & Kanan region, Katha district, Upper Sagaing Division Source from Kadu Media



2. Definition of Ethnohistory and beginning the Myanmar tribes of Kadu and Kanan nationals

Ethnohistory is the study of cultures and indigenous peoples' customs by examining historical records as well as other sources of information on their lives and history. It is also the study of the history of various ethnic groups that may or may not still exist. Ethnology is the branch of anthropology that compares and analyzes the characteristics of different people and the relationships between the compare cultural, social, or sociocultural anthropology. Early man was a hunter and he travelled far. A Burmese expression that the people moved about in quest of places "where water is clear and grass tender" alluded to this nomadic past. (Than Tun, Myanmar history of Burma) Later men formed into groups and each group became quite different from all other groups. Climate, food, daily activity, etc., all combined to widen this difference as time went on. Then agriculture tied them down to certain regions from where they loathed to move out again.

The Proto-Myanmar had once lived at the Tao valley of Kansu province in northwest China 4,000 years ago. We have no direct evidence either to refute or affirm this statement. The Chinese however told about some Tibeto Myanmar who came to live at the Myanmar Chinese border by the 7th century A.D. (Man Shu, A book on South Wildmen, A.D.863).

Mongolians formed another major race in Burma. Tibeto-Burma was divided into many groups and one big group is named the Tibeto-Chinese language family. From this family there sprung a sub-family called the Tibeto-Burmans who were in Myanmar from about the first millennium B.C. This sub family branched out into many more group and the earliest of them who came to settle in Myanmar were the Chin, Kadu, Pyu and Thet. Chin lived along a river which later came to be known after them as the Chindwin river. They were probably driven up the Chin hills later by the Kadu. Kadu occupied northern Myanmar with Tagaung or Thindwepyi as centre. Thet settled in Rakhine and in some parts of Central Myanmar. Pyu lived along the Irrawaddy from about Thit-saint in the north to Pyay in the south. Some were also to be found at Santwe. They built cities and grew into a kingdom by the 4th

century A.D. (GH luce Pre-Began Burma language & History, Oxford University, 198D.

Borrowing the South Indian scripts of the 4th century A.D., they made a system of their own to write their language. They became Buddhist converts. They were on the decline from about the 7th century and their last capital (probably Hanlin in Shwebo district) was destroyed by the Nanchao army in A.D. 832. Another group of Tibeto-Burmans built a kingdom at Arakan. "They left inscriptions in Sanskrit dating back to the middle of the 6th century AD. Unlike the Pyus and Mons who had cultural contacts with South India, the Tibeto-Burmans of Arakan had a closer relationship with north eastern India. Their capital was Vesali near Myauk-U. A Chandra dynasty ruled there from 4th century A.D.

Karens belonged to the Tibeto-Chinese family. They came into Burma from the north along the Salween, passed the southern Shan States and entered the southern plains of Burma by about the 7th century A.D. The decline of the Pyus was partly due to them. Burmans followed the same route very much taken by the Karens to enter Burma. They appeared only in the 9th century A.D. They preferred to live only in the hot, dry regions and so they took central Burma. Kyaukse area was their "first home" in Burma. Then they occupied the Minbu area. With centre at Pagan, they consolidated their power in central Burma and built a kingdom which they called "Naing-ngam"-the land of conquest, in the 10th century A.D. When the Proto-Myanmar came in Myanmar they probably came a long the crossed the northern Shan State and Kyaukse area from the southeast. According to Man Shu (A book on South Wildmen) when the Nanchao army came to rob and destroy the people in the plains of Southeast Asia, these they looted Myanmar between A.D.832. The wide range of places in Southeast Asia with which they were quite familiar, they had chosen the plains of central Myanmar as their new home. They preferred to live in a hot dry land than in a hot wet area infected with malaria. (Than Tun, The history of Myanmar)

Since they knew about the land as well as the peoples of Myanmar, they marched into Myanmar along the line of least resistance. They crossed the Northern Shan states and invaded the Kyaukse area from the south east. They seized the rich lands of Kuaukse and Minbu areas where food supply was plentiful. They mounted guards near Mandalay in the south. This was a sort of military occupation. The people like Mon, Kadu, Pyu, Thet, Paunglaung and Sakyaw from whom they seized Central Myanmar were not strong enough to put up any real opposition to their activites. (Than Tun, Where did Pyu disappear it?) (Map-2)



Map:2 Location the Katha district of ancient Myanmar
Source from U Hla Tun (Bamouk)

3. Background History of Kanan region and Kanan National

Nowadays, Kanan people of Nanzar village live in Bamouk township and Pinleebu area in Bamouk Katha district in the Upper Sagaing Division. They are the ethnic who live in the top end of Mu river at which Mu river begins to flow. The top end of Mu river is 26 miles far from in the north Pinleebu town and is 40 miles far from in the west of Bamouk town. There are 24 villages of Kanan. There is a saying "Kanan" begins at Shwekyauung and kana ends at Leepitone. According to the saying, Kanan's area begins at Shwekyauung village and ends at Lee-pi-tone village. Gold was found in Kanan's area and so Kanan's area was called Kanan shweasuwinneemyei (the area at which Kanan dug gold and sent gold to the Myanmar King in previous time). We can found the pillar with gold painting of monastery at Nanzar village. (Map-3). It is said that Kanan were the members or the service men of digging gold and sending gold to Myanmar Kings and were governed by Shwe Hmu (the term for the chiefs who were appointed by Myanmar royal palace.) Only after Bagan era, the name "Kanan" became to be called among the people of Myanmar. Kanan's area was under Moekaung Shan. Moekaung was subject to Myanmar King and Kanan were also subject to Myanmar Kings. It is thought that Chin people also lived in the area of Kanan because Chin traditional instrument were found in digging in the area of Kanan. In the book of "Myanmar before Anawrahtar" by Bo Hmu Ba Shin, mented that the ancient Pyu came into Myanmar from the northeast, and founded ancient Beikthano city and they were the ancestors of Kadu-Kanan in Katha district. Kadu and Kanan who stay at the top end of Mu river are the people who desented from Pyu. The history researchers say in various thought how they came to the top end of Mu river. It seems to be that they ran away along Mu river to the north of Ayeyawaddy river through Halin after Sriekstra fell down. Finding Pyu ornaments and Pyu's funeral urns are the evidences which show that Pyu lived along Mu river. So Kanan seem to be the descendants of Pyu. (Ba Shin, Myanmar before Anawrahtar)

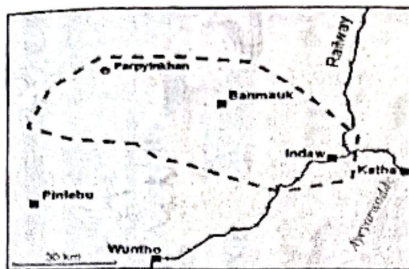
Another story of hear say that it was a myth the origin of Kanan ethnic people live in Beikthano

city. Kanan people was ancestor of Beikthano Queen. The defeat Queen of Beikthano was running along the Chindwin river. So, Kanan people ran away from Chindwin river after defection. Kanan left their city and they found a new city called Monestate in Mahamyang forest. Later, it seems to be going to Mu river through the Mahamyang forest. So, Kanan ethnic are the descend of the Pyu. (Kyaw Shin, The beauty of Kanan, 2012). The most people of Kachin and Chin are Christians. Although, they are close to the Kachin and Chin, they didn't worship any Christian. They worship only the Buddhist.

Kanan people is generations of Pyu people because they both have the same behavior, five prominent behaviors are observed. Kanan people

- say politely and have good manners
- are strong devotees in Buddhism
- keep good characters being afraid of acting wrong and feeling shameful doing evils, Hiri and Auttapap in Pali language
- have neither argument nor attack within the reciprocal, or pay mutual respect between individuals.
- take a seat with knees folded before elders

Their speaking language is observed to be slightly similar to that of Pyu people. Some of tools and utensil which they used when they were alive were buried together with bodies after dead. Excavation of Pyu people's cemeteries reported that the custody of burial dead bodies of people is as similar as that of Kanan people. (fig-1, fig-2)



Map 3: Location of Kadu and Kanan region,
Katha district Upper Sagaing Division
Source from Kadu media

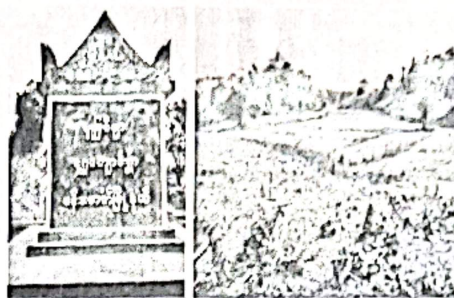


Fig-1

Source of The Mu River
Photo by researcher

Kanan
man

4. The social life of Kanan National at Nanzar village

Nanzar village is the largest of Kanan village. The research area is Nanzar village, Bamouk township, Katha district, Upper Sagaing division. Nanzar village was 40 miles from Bamouk township. Kanan villages are 24 villages in total. There are Shwekaung, Paytar, w, Zayane, Nanhim, Hahone, Kyunetaw, Muethar, Mulee, Mahasaung, Kasaphar, Pehenn, Leepatone, Pinhline, Magyikone, Nattle, Nantaw and Lakinmun. Nanzar village is the largest of Kanan villages. There are more than 270 houses in total.

According to the survey in 2018, there is only one Hight Tonepope, Nanzar, Hekee, Tazone, Mahaw, Leiksaw, Hawya School. In the Nanzar village, there are a total of 1519 people living in the village. There are 275 families in the village. At present, Kanan's complexion is white and smooth. Kanan face are the form of circle and their hair design of sanritwine. (Fig-5,6). Kanan are the same tribe of Shan. A few words of Kanan resemble with Kachin' words. In wearing clothes,

Village	Dwelling house	Total Family	Male	Female	Total
Nanzar	275	275	719	800	1519

wears longyi on which the design of square are made and black shirt with line which looks like Shan jacket. They put turban on head (Fig-3,4). Kanan women wear the black shirt and the black longyi on both of which crossing stripes are made. The young woman put flowers on Sanyitsan. Sanritsanhtone (a design of hair style) as an ornament. (Fig-5,6). They weaves clothes themselves. Their economic are agriculture, both at the plains and the slopes and digging gold at Shwehmaw (local name of the areas which are productive with gold). There are jungles because the district gets 80 inches of rainfall pre year. There are famous Tamalan trees in the jungles. They man furniture with tamalan wood. They get honey and kanyin oil from the jungles. Kanan are very simple and ancient ethnic people. They have still kept their traditional at culture. Kanan have not had their own alphabets and own writing. They use Myanmar alphabets and Myanmar writing for written language. For spoken language they use Kanan language. Before the young boys go to school, they attend the class in Buddhist monasteries in their village. Their traditional food is hinpaung which is cooked with rice powder and monehyine and the other vegetables being mixed and put in earthened pot. There is traditional food



Fig-3

Kanan Man



Fig-4

Kanan Man and Women



Fig-5

Kanan lady and their hair style of Sanritwine
& Sanritsanhtone



Fig-6

Photo by researcher



Fig-7



Fig-8



Fig-9



Fig-10

Kanan children and their hair style

Photo by researcher
monhyine pound.

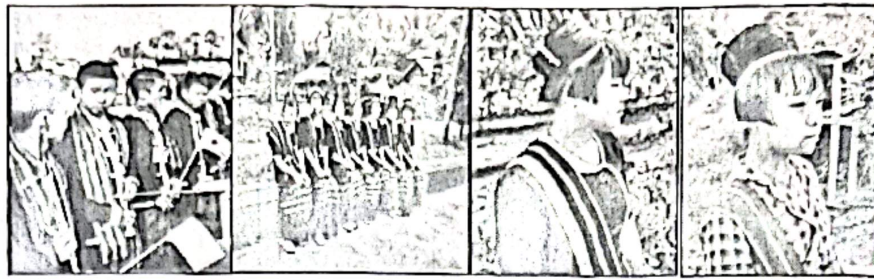


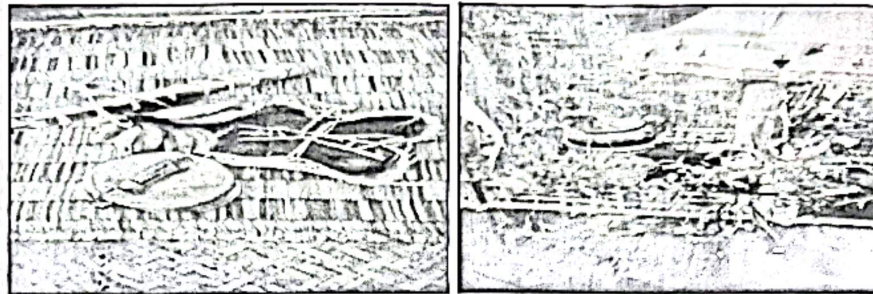
Fig-11

Fig-12

Fig-13

Fig-14

Adolescent of Kanan Photo



4.1 Belief, custom and tradition of Kanan

Kanan are Buddhists and they pay worshipping to Buddha. They have traditional spirit. They worship to "Ashingyi Phihaw nat" the name of Kanan's traditional spirit in every Kanan village. In addition, they worship of another nat were "Sumone" and "Sukut" who are brothers of spirit. They hold celebration of worshipping to the spirits two times every growing paddy period and the other in harvesting period. They pay worshipping to spirit in every year. One in growing paddy period and the other in harvesting period. They pay worshipping to spirit in every house. An altar for spirit is put on the middle wooden pole (Alekhaungtaing). In the time of marriage, they have to pay worshipping to Aleekhaungtaing Spirit (Nat in Myanmar). At first, they pay worshipping to Aleekhaungtaing spirit or nat) with greentae, meat and fish which are packed with green leaves and then bride and bridesness are allowed to be married. But, there is no statue of spirit. (Fig-15,16)

Their traditional food is Hinpaung which is cooked with rice-powder and monehngin and the other vegetables being mixed and put in earthened-pot. There is another traditional food Monehnginpound.

Traditional house

The designs of Kanan's houses are circular in shaped. (Fig-17) The house are built with wooden poles. The roofs are thatch. (Fig-18) In building the interior part of the house, they do not use any iron nails. (Fig-19) They used cain to tie. The wooden beams are joined each other by making holes at the beams. There are no partition or walls in the houses and so there are no rooms in Kanan's house. There are only two room for paying worship to the Buddha and a room for sleeping. Kanan house are like pavilions. Some look like long ellipses. The structures are rised



Fig-17

Kanan traditionalat houseNanzar village
Photo by researcher

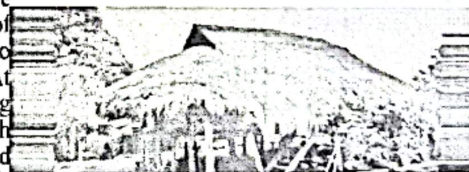


Fig-18

The roofs are thatch of Kanantraditional house



Fig-19

No use anynails and use cain to tie of Kanan
traditional House Photo by researcher

: only

Ancient Monastery

Ancient monastery was built in 1140 ME (Myanmar Era). The pillar with gold painting,

ceiling and wall with painting were found in this monastery at Nanzar village. (Fig-20)

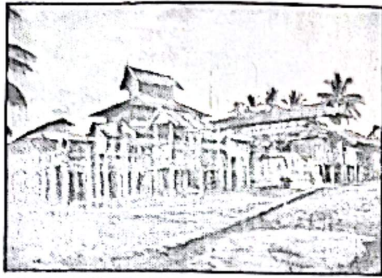


Fig-20

Ancient Monastery at NaThe roofs are thatch of Kanan traditional house nzar village



Fig-21

The pillar with gold painting of ancient monastery at Nanzar village



Fig-22

Fig-23

Fig-24

Fig-25

Traditional bamboo craft

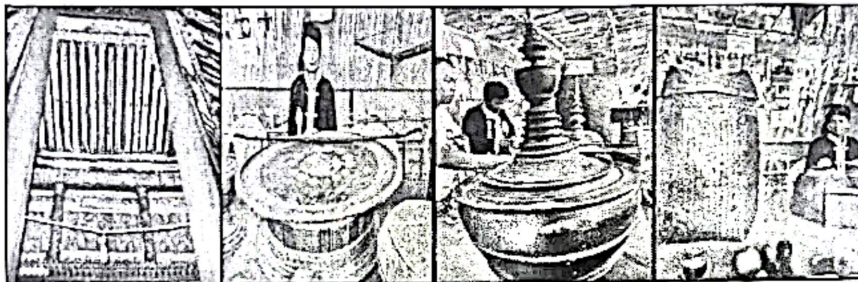


Fig-26

Celling painting & wall painting at ancient monastery

Fig-27

Traditional dining table (Daunglan)

Fig-28

Bamboo offering bowl

Fig-29

Bamboo basket (for storage clothes)

Photo by researcher



Fig-30

Fig-31

Fig-32

Fig-33

Traditional dinning table (daunglan) of bamboo with cover

Various types of bamboo baskets
Photo by researcher

To preserve the natural beauty of environment

The Kanan region was very famous for Zalone Mountain.(Fig-34) There are jun because districte 80 inches of rainfall pre year. Thereare famous Tamalan trees in the jungles. (Fig-35) They get honey and kanyin from the jungles Myanm species of orchid where found in this area.(Fig-36)

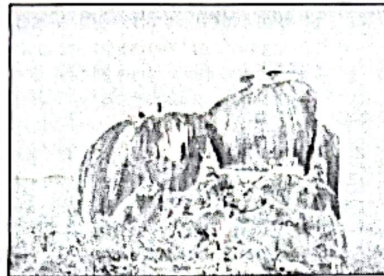


Fig-34
Zalone Mountain



Fig-35
Thick jungle



Fig-36
Myanmar species of orchid

Finding and Discussion

Among 135 ethnics in Myanmar, Kanans a few population and they live in remote areas which are difficult to go and come from the other districts. However, they are the ethnic groups who have still been able to keep their traditional culture. Although Kadu have had their own literature since 30 years ago, Kanan have not have their own literature yet. Though the twoethnic groups of Kadu and Kanan are different in languages. Now, there are more and more tourist who visit there because of very famous Zalone mountain. The area is a deep jungle many of oukchin bird. Which is a rare species are seen in the jungle. Some of the hunters catch oukchin bird and they sell the barks of oukchin bird as ornament. It is known that there is a great demanding for the barks of oukchin bird to buy in market. And so, it is urgently necessary to give knowledge to the villages and the hunters to able to keep the rare birds alive. Because, there are gold mine and a lot of valuable tamalan trees and fairly good economics, there are a number of

greedy business men and a number of gamblers. Besides several young men use drugs much. It is urgently necessary to have law and orders and to take care of the characters of the local people. Therefore, the government need to support education, health and basic needings to promote social life of Kadu and Kanan and to take care of keeping the traditional cultures of Kadu and Kanan.

Conclusion

This paper present the ethnohistory and culture tradition of Kanan nationals in Nanzar village of Katha district. Kanan people are ancient ethnic people. The Kanan were originally remains uncertain, but they are little more than Myanmar and Shan half breeds with trace of Chin and possible Kachin blood.

They people mostly depend on farming for a living and they are also involved in salt production a manageable scale of gold business in Pinleebu and Bamouk. They are Buddhist. In this paper, the study of Kanan national who their custom, belief, tradition, socio-economic, ICH (Intangible Culture Heritage), CBT (Community Based Tourism) of ethnic. We need to promote education, health and regional concerns. We can maintain their culture and encourage of Kanan national of preserve of their heritage.

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ZOL 009

Occurrence of Butterfly Species in Mandalay University Campus

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Abstract

A total of 1923 butterflies representing 44 species, confined to 33 genera and five families were recorded and identified during the study period from October 2017 to July 2018 in Mandalay University Campus. Three species in Papilionidae, 12 species in Pieridae, 18 species in Nymphalidae, six species in Lycaenidae and five species in Hesperidae were recorded. The highest number of species composition was recorded in Nymphalidae (41.86%) followed by Pieridae (27.9%), Lycaenidae (11.62%), Hesperidae (11.62%) and the lowest was Papilionidae (6.97%) were respectively. The highest population species in *Papilio demoleus* and the lowest population species in *Euthalia lubentina* were observed in study area. Mandalay University Campus with a variety of vegetation is environmentally friendly for the butterflies to thrive.

Keywords: Occurrence, five families, butterfly species

Materials and Methods

Introduction

All butterflies are found in diverse habitats ranging from woody plains to moist deciduous patches. Most of these are beautiful, flying insects with large scaly wings. They have a pair of antennae and exoskeleton. Butterflies are classified into two super families, Hesperioidea and Papilionoidea. Of which Hesperioidea has all the skippers, while Papilionoidea includes the rest, the true butterflies. Hesperioidea consists of a single family of Hesperidae (Skippers), whereas Papilionoidea has four families: Papilionidae (Swallowtails), Pieridae (Whites and yellows), Nymphalidae (Brush-footed butterflies) and Lycaenidae (Blues). Among various groups of butterflies, the Papilionids are very important since they contain some of the largest and colourful butterflies (Mathew and Revatty, 2014).

The threatening process of butterfly have been caused by habitat destruction, impacts of land management, agricultural and forestry practices, clearing and leveling hilltops, pesticides, weeds, introduced arthropods, climate change and over collecting. Butterflies are sensitive to change in temperature, humidity and light levels that are caused by habitat changes. Changes in butterfly composition and abundance can point to suitable changes in the forest habitat because larvae have specialized host plants requirements and adults are important for studies that can several the stabilization or decline of butterfly species population due to habitat destruction or less of forest ecosystem (Addai and Baidoo, 2013).

Butterflies are strongly influenced by local weather and highly sensitive to environmental changes. They react rapidly to environmental changes due to their short generation time, high mobility, and specific habitat preferences. Urbanization is usually considered to impact biodiversity. Increased urban features, including busy roads, buildings, and anthropogenic activities correspond with decreases in butterfly species richness, diversity and abundance (Ghosh and Dey, 2016).

Mandalay University Campus was chosen as the study area since it harbours a variety of vegetation, flowers and large trees which attract a number of butterfly species. Moreover, there is still a need to study, the occurrence of butterflies. Therefore, with this in mind, the present study has been undertaken with the following objectives to study and identify butterfly species and to investigate the occurrence of butterfly species in Mandalay University Campus.

Study area

The study area is located in Mandalay University Campus lying between 21° 57' 00" N and 21° 57' 45" N and 96° 05' 15" E and 96° 06' 15" E, Mahar Aung Myay Township, Mandalay Region.

Study period

The study period was conducted from November 2017 to July 2018.

Collection of the specimens

Butterfly collection was made twice a month. Butterflies were captured by using butterfly net, during daytime because they are diurnal and sun lovers. Butterflies were collected during 9:00 - 11:00 am and 3:00 - 5:30 pm. Monitoring butterfly populations were counted by fix route transects (Pollard, 1977). The butterflies were observed on 5 m on both side of the transect and were captured by using the butterfly nets.

Preparation of the specimens

After catching, the butterflies were killed by a sharp nip on the thorax between the thumb and fore finger on the thorax of the butterflies while still in the net. Then butterflies were put into a triangular tracing paper envelopes with wings folded back and flat. Dates of collection, time, locality were noted down.

Dead specimens were mounted on the setting board. Forewings of butterfly were spread with right angles to the body and hind-wings for enough forward so there was no gap between fore and hind-wings. It was kept inside the insect box with naphthalene balls to ward off ants for future study.

Identification and classification of collected specimens

Identification was made by Talbot (1939 and 1940), Pinratana (1988), Wynter Blyth (1957) and Bingham (1905 and 1907). Classification was followed after Corbet and Pendlebury (1992).

Analysis of the data

The relative abundance was calculated using by Krebs (1989).

$$\text{Relative abundance} = \frac{\text{Total number of individuals of the species}}{\text{Total number of individuals of all the species in particular site}}$$

uC = uncommon (having relative abundance less than 0.01)

C = common (having relative abundance of 0.01 and above but less than 0.05)

vC = very common (having relative abundance of 0.05 and above)

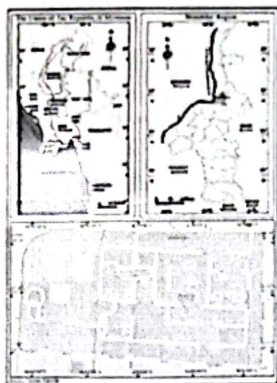


Figure 1. Location of Mandalay University Campus
Results

In the present study, a total of 43 species belonging to 33 genera, nine subfamilies and five families were recorded in the Mandalay University Campus. A total of 1923 individuals comprise 43 species from five families were recorded in the present study. Papilionidae (6.97%), Pieridae (27.90%), Nymphalidae (41.86%), Lycaenidae (11.62%) and Hesperidae (11.62%) (Fig 1).

In family Papilionidae including three species and 86 individuals the highest population percentage species of *Papilio demoleus* (46.51%) and the lowest population percentage species of *Pachliopta aristolochiae* (10.46%) was recorded in the present study. Papilionidae was found to the highest number of individuals in February and the lowest numbers in June in the present study period (Table 2).

In family Pieridae consisting of 12 species and 686 individuals. The highest population percentage was recorded *Ixias pyrene* (19.53%) and the lowest population percentage of *Pareronia anias* (1.02%). In the month of December was a highest of individual and in the month of November was lowest number of individual (Table 3).

In family Nymphalidae composed of 18 species and 661 individuals in this study. The highest population was *Danaus genutia* (19.96%) and the lowest population was *Euthalia lubentina* (0.15%). In the month of January and February were highest number of individual and the month of November in least number of individual (Table 4).

In the family Lycaenidae was represented with five species and 391 individuals. The highest population and lowest population were *Tarucus callinara* (32.99%) and *Prosotas dubiosa* (9.97%). In the month of highest and lowest

population were June and November within study

Table 1 List of butterfly species collected from Mandalay University Campus

Family	Scientific Name	Common Name
Papilionidae	<i>Pachliopta aristolochiae</i>	Common Rose
	<i>Papilio demoleus</i>	Line Butterfly
	<i>Papilio polytes</i>	Common Marmon
Pieridae	<i>Delias parithoe</i>	Red Banded Jezebel
	<i>Delias descombesi</i>	Red Spotted Jezebel
	<i>Pareronia valeria</i>	Common Wanderer
	<i>Pareronia anias</i>	Wanderer
	<i>Cepora nerissa</i>	Common Gull
	<i>Hebomola glaucippe</i>	Great Orange Tip
	<i>Ixias pyrene</i>	Yellow Orange Tip
	<i>Appias libythea</i>	Striped Albatross
	<i>Leptotia nina</i>	Prythe
	<i>Catopsilia pyranthe</i>	Mottled Emigrant
	<i>Catopsilia pomona</i>	Lemon Emigrant
	<i>Eurema andersonii</i>	One-Spot Grass
Nymphalidae	<i>Danaus genutia</i>	Common Tiger
	<i>Danaus chrysippus</i>	Plain Tiger
	<i>Tirumala limniace</i>	Blue Tiger
	<i>Melanitis loda</i>	Common Evening Brown
	<i>Melanitis zitenius</i>	Evening Brown
	<i>Elymnias hypermnestra</i>	Common Palmfly
	<i>Mycalopsis perseoides</i>	Common Bush Brown
	<i>Ypthima humel</i>	Common Five Ring
	<i>Acraea terpsicore</i>	Tawny Coster
	<i>Phalanta phalantha</i>	Common Leopard
	<i>Cethorix cyane</i>	Leopard Lacewing
	<i>Euthalia lubentina</i>	Green Baron
	<i>Junonia hierta</i>	Blue Pansy
	<i>Junonia almana</i>	Peacock Pansy
	<i>Junonia lemonias</i>	Lemon Pansy
Lycaenidae	<i>Junonia orithya</i>	Blue Pansy
	<i>Hypolimnas bolina</i>	Great Eggfly
	<i>Neptis hylas</i>	Common Sailor
	<i>Tarucus callinara</i>	Spotted Pierrot
	<i>Syntarucus plinius</i>	Zebra Blue
Hesperidae	<i>Chilades pandava</i>	Cycadad Blue
	<i>Lampides boeticus</i>	Long-tailed Blue
	<i>Prosotas dubiosa</i>	Tailless Lineblue
	<i>Ampittia dioscorides</i>	Bush Hopper
	<i>Telipotia colon</i>	Palm Dart
	<i>Parnara apostate</i>	Swift
	<i>Pelopidas mathias</i>	Small Branded Swift
	<i>Pelopidas conjunctus</i>	Conjoined Swift

Table 2 Species composition, relative abundance and status of butterfly species from family Papilionidae

No.	Species	Nov	Dec	Jan	Feb	Mar	April	May	June	July	Total no. of individual	Species composition	Relative abundance	Status
1	<i>Pachliopta aristolochiae</i>	0	3	3	2	0	0	0	0	2	9	10.46	0.1046	vC
2	<i>Papilio demoleus</i>	3	5	5	8	6	5	1	2	3	40	46.51	0.4651	vC
3	<i>Papilio polytes</i>	2	6	8	7	5	4	1	1	3	37	41.82	0.4182	vC
Total no. of individual		5	14	15	17	11	9	2	3	10	86	100		

Table 3 Species composition, relative abundance and status of butterfly species from family Pieridae

No.	Species	Nov	Dec	Jan	Feb	Mar	April	May	June	July	Total no. of individual	Species composition	Relative abundance	Status
1	<i>Delias parithoe</i>	0	15	7	4	1	0	0	0	0	27	5.93	0.0293	C
2	<i>Delias descombesi</i>	0	18	10	5	2	0	0	0	0	35	5.19	0.0519	vC
3	<i>Pareronia valeria</i>	0	2	4	2	0	0	0	0	0	8	1.16	0.0116	C
4	<i>Pareronia anias</i>	0	2	3	1	0	0	0	0	0	7	1.02	0.0102	C
5	<i>Cepora nerissa</i>	2	5	3	1	0	1	3	10	8	32	4.66	0.0466	C
6	<i>Hebomola glaucippe</i>	3	2	2	0	1	0	0	0	0	8	1.16	0.0116	C
7	<i>Ixias pyrene</i>	12	25	20	18	15	18	9	11	8	134	19.53	0.1953	vC
8	<i>Appias libythea</i>	10	11	8	6	4	4	3	6	12	64	9.32	0.0932	vC
9	<i>Lepidoptera</i>	7	38	25	15	10	12	10	0	13	118	17.20	0.1720	vC
10	<i>Catopsilia pyranthe</i>	0	5	5	7	1	2	4	3	7	34	5.26	0.0526	vC
11	<i>Catopsilia pomona</i>	0	8	9	7	5	17	13	15	10	84	12.24	0.1224	vC
12	<i>Eurema andersonii</i>	0	25	21	15	13	16	15	18	9	133	19.38	0.1938	vC
Total no. of individual		43	137	115	81	54	70	56	63	67	686	100		

period (Table 5).

In family Hesperidae five species and 99 individuals were recorded. The highest population was *Ampittia dioscorides* (42.42%) and lowest population was *Pelopidas conjunctus* (5.05%).

The highest population was recorded in the month of July and the lowest population in January (Table 6).

Monthly total number of individual and species composition of five families are individual 86 (4.47%) in Papilionidae, individual 686 (35.67%) in Pieridae, individual 661 (34.39%) in Nymphalidae, individual 391 (20.33%) in Lycaenidae and individual 99 (5.14%) in Hesperidae were observed in study area.

Relative abundance of butterfly species recorded

The highest relative abundance was 27 species recorded in *Pachliopta aristolochiae* (0.1046), *Papilio demoleus* (0.4651) and *P. polytes* (0.4302) in Papilionidae; *Delias*

callinara (0.3299), *Syntarucus plinius* (0.2941), *Chilades pandava* (0.1150), *Lampides boeticus* (0.1611) and *Prosotas dubiosa* (0.0997) in Lycaenidae; *Ampittia dioscorides* (0.4242), *Telicota colon* (0.2020), *Parnara apostata* (0.2121), *Pelopidas mathias* (0.1111) and *P. conjunctus* (0.0505) in Hesperidae were very common species in study area (Table 2, 3, 4, 5 and 6).

The higher relative abundance was 10 species in *Delias pasithoe* (0.0393), *Parerona valeria* (0.0116), *P. anais* (0.0102), *Cepora nerissa* (0.0466) and *Hebomoia glaucippe* (0.0116) in Pieridae; *Melanitis leda* (0.0438), *M. zitenius* (0.0302), *Phalanta phalantha* (0.0105), *Junonia almana* (0.0468) and *Neptis hylas* (0.0287) in Nymphalidae were common species (Table 4).

The lowest relative abundance was 6 species in *Ypthima humei* (0.0090), *Acraea terpsicore* (0.0075), *Euthalia lubentina* (0.0015), *Junonia hierta* (0.0090), *J. orithya* (0.0045) and *Hypolimnas bolina* (0.0090) were uncommon species recorded (Table 4).

A totally 43 species from five families of butterflies, 27 species as very common, 10 species as common and six species as uncommon species were recorded in study area.

Discussion

Totally 43 butterfly species under 33 genera were collected at Mandalay University Campus. Among the five families of butterflies, Papilionidae comprise (6.97%), Pieridae (27.9%), Nymphalidae (41.86%), Lycaenidae (11.62%) and Hesperidae (11.62%) were collected in Mandalay University Campus. In the present study, three species of Papilionidae, 12 species of Pieridae, 18 species of Nymphalidae, five species of Lycaenidae and Hesperidae were collected on the study area.

In the present study, three species of Papilionidae were *Papilio polytes*, *P. demoleus* and *Pachliopta aristolochiae* were observed in the study area. In family Papilionidae was considered *Papilio polytes* and *P. demoleus* were collected as the number of abundance species in the throughout year. *P. demoleus* was the most abundance species. It may be due to their host plants were abundant occurred in human environs all around the year. *P. aristolochiae* was lowest population because of their host plants were cleared for cultivation of other crops. Su Su Tun (2010), Ei Ei Ko (2015) and Phyu Zar Kyaw (2017) were reported *P. polytes* and *P. demoleus* were highest population. So, present result was agree with their finding.

According to Corbet and Pendlebury (1992) reported that Pieridae are mostly white, yellow or orange and are divided into four subfamilies Pierinae, Coliadinae, Dismorhiinae and Pseudopontiinae. They also stated that only the first two occurred in Oriented Region. Kinyon (2004) stated that 58 species of Pieridae in Myanmar.

In the present study, 12 species of family Pieridae were recorded in the study area. The most occurred species were *Ixias pyrene*, *Leptosia nina* and *Eurema andersonii* were usually found

Table 2 Species composition, relative abundance and status of butterfly species from family Nymphalidae

No	Species	Nov	Dec	Jan	Feb	Mar	April	May	June	July	Total no. of individual	Species composition	Relative abundance	Status
1	<i>Danaus genutia</i>	5	18	20	23	28	18	6	11	8	132	13.27	0.1527	VC
2	<i>D. chrysippus</i>	3	10	10	25	18	13	7	9	6	101	10.1	0.1227	VC
3	<i>Tirumala borealis</i>	2	8	3	7	8	8	0	1	5	44	4.4	0.0545	VC
4	<i>Hebomoia glaucippe</i>	3	3	4	2	0	3	0	4	4	29	2.9	0.0358	C
5	<i>Hebomoia glaucippe</i>	4	4	3	3	2	2	0	0	0	20	2.0	0.0247	C
6	<i>Cybele</i>	3	13	10	12	5	6	0	0	0	53	5.3	0.0646	VC
7	<i>Mycalesis perseoides</i>	2	8	8	6	7	5	2	4	3	45	4.5	0.0545	VC
8	<i>Ypthima humei</i>	0	2	1	0	0	0	1	3	0	6	0.6	0.0075	VC
9	<i>Acraea terpsicore</i>	0	3	1	0	0	0	0	0	1	5	0.5	0.0062	VC
10	<i>Phalanta phalantha</i>	0	2	1	1	0	0	2	0	1	7	0.7	0.0086	C
11	<i>Cethosia cyane</i>	0	3	12	10	8	4	0	2	0	41	4.1	0.0505	VC
12	<i>Delias callinara</i>	0	0	1	8	0	0	0	0	0	1	0.1	0.0012	VC
13	<i>Junonia hierta</i>	0	2	1	1	1	0	1	0	0	6	0.6	0.0075	VC
14	<i>Junonia almana</i>	0	2	6	7	8	3	0	3	1	31	3.1	0.0383	C
15	<i>Junonia leucosticta</i>	5	19	24	15	10	13	6	8	11	113	11.3	0.1395	VC
16	<i>Junonia orithya</i>	0	0	0	0	0	0	3	1	0	4	0.4	0.0049	VC
17	<i>Euphaedra bolina</i>	0	0	0	0	4	2	0	0	0	6	0.6	0.0075	VC
18	<i>Neptis hylas</i>	0	4	8	5	2	0	0	0	0	19	1.9	0.0233	C
Total no. of individuals		29	105	117	96	79	32	46	40	661	100			

Table 3 Species composition, relative abundance and status of butterfly species from family Lycaenidae

No	Species	Nov	Dec	Jan	Feb	Mar	April	May	June	July	Total no. of individual	Species composition	Relative abundance	Status
1	<i>Eurema andersonii</i>	0	10	13	5	7	7	20	58	23	133	13.3	0.3299	VC
2	<i>Syntarucus plinius</i>	0	12	17	0	0	5	17	30	23	115	11.5	0.2941	VC
3	<i>Chilades pandava</i>	0	0	0	0	7	5	10	15	10	45	4.5	0.1150	VC
4	<i>Lampides boeticus</i>	2	10	12	10	8	8	7	4	3	65	6.5	0.1611	VC
5	<i>Prosotas dubiosa</i>	0	0	0	0	0	30	12	12	3	59	5.9	0.0997	VC
Total no. of individuals		2	22	42	10	20	55	66	97	45	391	100		

Table 4 Species composition, relative abundance and status of butterfly species from family Pieridae

No	Species	Nov	Dec	Jan	Feb	Mar	April	May	June	July	Total no. of individual	Species composition	Relative abundance	Status
1	<i>Appias libythea</i>	1	0	0	1	2	4	4	11	15	42	4.2	0.0510	VC
2	<i>Leptosia nina</i>	1	1	0	2	0	3	3	3	6	20	2.0	0.0247	VC
3	<i>Eurema andersonii</i>	0	0	1	0	1	0	3	3	9	23	2.3	0.2875	VC
4	<i>Delias callinara</i>	2	4	0	0	2	0	0	0	3	11	1.1	0.1395	VC
5	<i>Delias callinara</i>	0	0	0	1	0	3	0	1	0	5	0.5	0.0625	VC
Total no. of individuals		4	5	1	4	6	10	10	17	33	99	100		

descombesi (0.0510), *Ixias pyrene* (0.1953), *Appias libythea* (0.0932), *Leptosia nina* (0.1720), *Catopsilia pyranthe* (0.0524), *C. pomona* (0.1224) and *Eurema andersonii* (0.1938) in Pieridae; *Danaus genutia* (0.1996), *D. chrysippus* (0.1527), *Tirumala limniace* (0.0665), *Elymnias hypermnestra* (0.0786), *Mycalesis perseoides* (0.0860), *Cethosia cyane* (0.0620) and *Junonia lemonias* (0.1709) in Nymphalidae; *Tarucus*

in colonies from the major host plants such as were very abundant found although *Pareronia valeria*, *P. anias* and *Hebomoia glacucippe* were not abundance in the study area. According to Ei Ei Ko (2015) reported very dominant species in *Delias pasithoe*, *D. acalia*, *D. descombesi*, *P. valeria* and *P. anias* were under family Pieridae usually found sucking nectar of flowering plants in the months of December and January from Nyaung Shwe Environs. Therefore, it may be considered that abundant of butterfly species in the area may be due to the abundance of their host plant.

According to Mail, *et al.* (2014) family Nymphalidae are a large and most diverse of robust bodies butterflies that come in almost various shape and colour. Some do visit flowers but they are generally visit and suck partial to overripe fruits, tree sap and even animals and urine. Kinyon (2004) mentioned 384 species of Nymphalidae in Myanmar.

In the present study, 18 butterfly species family Nymphalidae were collected in the study area. *D. genutia* and *D. chrysippus* and *J. lemonias* were observed as abundant species throughout the whole year. May Zin Oo (2014) and Cho Thet Oo (2015) were butterflies found to be the most abundant. Perveen (2014) was described *D. genutia* and *D. chrysippus* are toxic butterflies which have a tough, leathery skin to survive occasional attacks. When attacked it fakes death and nauseating liquid, which makes it smell and taste terrible. These butterflies are release nauseating liquid and then inedible for protected predator. Therefore, it may be possible the very abundance species.

In the present study, five species of family Lycaenidae; *Tarucus callinara*, *Syntarucus plinius*, *Chilades pandava*, *Lampides boeticus* and *Protoparce dubiosa* were recorded in study area. According to Aye Aye Thin (2016) and Pa Pa Phy (2016) were reported that *L. boeticus* were very abundant species. In the present study, *Tarucus callinara*, *Syntarucus plinius* and *Lampides boeticus* were mostly observed because of the species very common butterfly around human habitations along the shrubs, small trees, pond and green plants. Aye Aye Thin (2016) and Pa Pa Phy (2016) were not reported. Therefore, it may be assumed that difference location and habitat type.

According to Wynter-Blyth (1957), Hesperidae are exclusively confirmed to grassland, large numbers of them are crepuscular in habit. In the present study, five species in Hesperidae, *Ampittia dioscorides*, *Telicota colon*, *Parnara apostata*, *Pelopidas mathias* and *P. conjunctus* were mostly found in the morning, sitting low on the grass blade and bushes. Thus, present result was similar with their finding.

In the present study, the occurrence of highest number of species and individuals revealed. *P. demoleus* (46.51%) 40 individuals in Papilionidae; *Ixias pyrene* (19.53%) 134 individuals in Pieridae; *Danaus genutia* (19.96%) 132 individuals in Nymphalidae; *Tarucus callinara* (32.99%) 129 individuals in Lycaenidae and *Ampittia dioscorides* (42.4%) 42 individuals in Hesperidae. *Euthalia lubentina* (0.15%) one individual in the lowest number of species.

Species composition of butterfly species in different families were recorded the highest percentage (41.86%) in Nymphalidae, followed by (27.90%) in Pieridae, the lowest percentages in Lycaenidae and Hesperidae.

The different relative abundances of butterfly species were observed in study area. The very highest relative abundance (0.4651) and the species composition (46.5%) in *P. demoleus*. The lowest relative abundance (0.0015) and the species composition (0.15%) in *Euthalia lubentina* were recorded.

A major threat to butterflies includes changes in their environment and habitat destruction which may affect the food plants of the caterpillars or nectar plants for adult. Natural enemies of butterflies include birds and lizards. The largest numbers of butterflies appear when there has been an abundance of larval food stuff, when such at plenty of young green leaves and shoots and when the weather condition are suitable.

Conclusion

It may be concluded that the results of present study indicate that Mandalay University Campus, with a large number of trees, flowering plants and a variety of shrubs and herbs offered a friendly environment for the butterflies to thrive. And also indicated that taxonomically import features for the information of the species.

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Morphological Study of Some Pest Species from Saylonegyi Village, Thanlyin Township

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Abstract

Weekly fields were made in Saylonegyi Village, Thanlyin Township to collect some rice butterflies. The infested rice plants with these pests were taken to the laboratory of Zoology Department, East Yangon University. A total of 18 insect pest species belonging to 16 genera, 13 families of four orders were recorded and identified from the paddy field of study sites, during December 2014 to July 2015. Both larva and adult stages were examined. Investigation on the major and minor of the insect pests of paddy was conducted in the field of study site. The most dominant species and major pest was *Nephotettix virescens* order Hemiptera. Five species were recorded as minor pests. Collected pest species were taxonomically identified and classified according to Borror *et al.* (1976), Heinrichs *et al.* (1994) and Heinrichs and Barrión (2004). Types of damage were also recorded according to respective insect pests.

Keywords: rice butterfly, major pests, minor pests, rice plants

Introduction

Rice has been cultivated as a major source of food in 114 countries and all the continents. Although paddy fields were originally wetlands and artificially constructed devices for rice production, they have worked as a nursery of biodiversity and cultural diversity (Kinet *et al.*, 2011).

The majority of rice production is located within the tropics and subtropics of the world total; some 90% is within Asia, 4% in Latin America and less than 2% in sub-Saharan Africa (Heinrichs *et al.*, 1994). Rice, the staple diet of over half of the world's population, is grown on over 145 million hectares in more than 110 countries, and occupies almost one-fifth of the total world cropland under cereals (Pathak and Khan, 1994).

Rice is the staple food for the people of Myanmar. Therefore, these plants need to be protected. Control measures should then be considered. However, basic knowledge on the pests should be sought before control measures are put into practice. Myanmar has many both marine and freshwater resources. Many rivers, lakes, ponds, streams, creeks, dams and 'ins' paddy fields scattered throughout the country. The rice plant is an ideal host for many insect species. All of the plants are vulnerable to insect feeding from the time of sowing till harvest. There are over 800 insect species damaging rice in one way or another, although the majority of them do very little damage. In tropical Asia about 20 species are of major importance and cause economic damage and of regular occurrence. In addition to direct damage, many insects also act as vector of dreaded disease of rice (Cited by Moe Thidar, 2007).

In Myanmar, since rice is the staple food, rice production is to be increased proportionately with the annual increase of population. Production is aimed at two directions: area extension and intensification cultivation of high yielding varieties for feeding livestock annual increasing population and cultivation of high quality rice varieties to compete in the international market. To achieve the target requirement, all rice production constraints must be solved through the use of high yielding and quality seeds, modern techniques and pest management (Shepard *et al.*, 1990).

Insects are air breathing mostly terrestrial and rarely aquatic arthropods. Sexes are separated.

Development is sometime direct. Many harmful insects damage growing farms crops, fruits and stored grains. Some insects bring about cross-pollination of many fruits and flowers (Richards and Davies, 1977).

The rice plant is subject to attack by more than 100 species of insects; 20 of them can cause economic damage. Together they infest all parts of the plant at all growth stages, and a few transmit viral disease. The major insect pest that causes significant yield losses are leafhoppers and planthoppers, which cause direct damage as well as transmit viruses, stem borers; and a group of defoliator species (Cramer, 1967).

Insect pests attack the rice crop from the time the nursery bed is prepared until harvest. The rice plant passes through 10 stages during its growth cycle, (1) germination and emergence, (2) seedling (3) tillering (4) stem elongation (5) panicle initiation (6) panicle development (7) flowering (8) milk grain (9) dough grain and (10) mature grain stage (Reissinger *et al.*, 1986). The actual species complex varies in abundance and distribution from locality to locality and from year to year.

Rice (*Oryza sativa* L.) originated in China, but spread very early to India, and is now grown extensively throughout the Asia. The most important production areas for export purposes are Thailand, Myanmar, China, and the USA (Hill, 1983). This crop is abundantly cultivated for traditional and commercial uses of rice in Thanlyin Township, Yangon Region, Myanmar.

Successful pest control anywhere is not easy. Most of the time has to use insecticides and there are problems with chemical formulation, method of application, precise timing, hitting the target area, and retention on the target (Hill, 1983).

Therefore, it is very urgent time need to be protected and control measures should then be considered. However, basic knowledge on the pests should be sought before control measures are put into practice. Therefore, we have chosen to study the rice pest of Saylonegyi village rice fields in Thanlyin Township.

The present study focused on the following objectives:

- to examine the occurrence of rice insect pests in study site
- to access the mode of damage caused by insect pests on rice

Materials and methods

Study Site

The investigation of insect pests on rice field was conducted in Saylonegyivillage in Thanlyin Township, between 16°42'0" to 16°44'24" N and 96°20'6" to 96°22'30" E (Fig. 1).

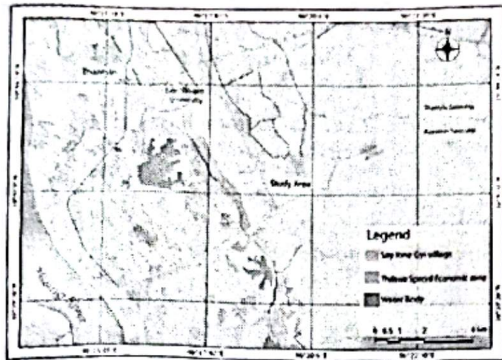


Figure 1 Location map and satellite image of study area (Source: Google Earth, 2015)

Study Period

The study period was lasted from December 2014 to July 2015.

Collection of Specimens

The materials used in the present study were hand net, light traps, plastic bottles, dissecting microscope, and digital camera.

The insect pests were searched on paddy field for visually and collected. Arthropods were collected either by picking up with hands or by using insect net in day time and light traps were set up at night time. The study was carried out twice per month from the beginning of the growing season till the time of harvest. In the field each square plot (1'x1') were made at four different places and marked with bamboo poles.

Preservation of the Specimens

Collections were conducted twice per month during the times of early morning and late evening before the application of pesticides. Some captured insects were anesthetized with chloroform and mounted into the insect box using with insect pins for further study. Moreover, damaged or infested parts of the plant were also noted down and photographed with digital camera.

Identification and Classification

Collected insects were classified according to Borror *et al.*, (1976), Bland and Jaques (1978), Heinrich *et al.*, (1994) and Heinrichs and Barrion (2004).

Results and Discussion

A total of 18 species belonging to 16 genera, 13 families of four orders were recorded from the study area (Table 1). A total of 18 species of rice field insect pests belonging to four orders 13

families were recorded from study site during the study period. On the occurrence records of the rice field insect pests, the rank of the family was Alydidae>Pyralidae>Noctuidae>Pentatomidae>Satyridae>Hesperiidae>Amatidae>Scarabaeidae>Acrididae>Cicadellidae>Pantatomidae>Pyrrhocoridae>Scutelleridae.

Ei Thet Nwe (2015) recorded that a total of twelve species of rice field insect pests belonging to four orders under nine families were recorded from three different sites during the study period. On the numerical records of the rice field insect pests, the rank of the family was Cicadellidae>Pyralidae>Noctuidae>Acrididae>Alydidae>Coccinellidae>Hesperiidae>Satyridae>Pantatomidae.

Several short-horned grasshoppers in the genus *Oxya* occur on rice throughout the world. *Oxyahyla*, *O. chinensis* occur in both Africa and Asia. *O. japonica japonica* is additional *Oxya* species that occur in Asia (Pathak and Khan, 1994). In the present study, the population was highest in the study fields, *Oxya* spp. are general feeder consuming foliage of grass species in addition to rice. Therefore, the present study was also agreed with the statement of Pathak and Khan, 1994.

In the present study, Arthropod pests attacked and damaged four different parts such as stem, leave, root and panicle of the rice plants from the sowing time to harvesting time. Thus, it should be controlled throughout the growing period. Rice insect communities occurring in West Africa are very similar to those in Asia (Heinrichs *et al.*, 1994).

The green leafhopper, *Nephotettix virescens* are severe pests of rice in Asia where *N. virescens*, *N. cinction* and *N. nigropictus* are vectors of the virus diseases tungro, rice transitory yellowing, rice dwarf virus, rice gall dwarf, and yellow dwarf (Heinrichs and Barrion, 2004). According to the native farmers, high populations of this pest occurred all year round when two or more rice crops were grown within the study period. In the present study, *N. virescens* were recorded in irrigated rice at study site throughout the study period.

Pentatomid bugs or stink bugs are also important rice pests in Asia. It is a polyphagous pest and often causes serious damage to rice (Pathak and Khan, 1994). But, in the present study, *Nezaraviridula* can be considered as a minor rice plant in Thanlyin environs because *N. viridula* has many host plants and is especially common on cotton and tomato plants.

Reissing *et al.*, 1986 stated that the rice bug of *Leptocoris aoratorius* (Alydidae) is a major pest of rice and found in the environment of rice field; but more prevalent on rainfed wetland or upland of rice. Therefore, this pest is an important pest was found in the rice fields. These findings were also agreed with the above author records.

WaiWai Tin (2011) recorded that among several insects which attack the cotton plant, *Dysdercus* perhaps the best known on account of vivid red colour with peculiar markings.

In the present study, *Dysdercus cingulatus*, cotton stainer bug is belonging to family

Pyrrhocoridae was found insect species of rice crop. Therefore, this pest is a moderate important pest in the rice field.

In order Hemiptera, two families are recorded namely Pentatomidae and Scutelleridae. *Eurygastera austriaca* and *Chrysocoris stolliae* are destroyed by sucking the juice of physic nut plants (Rijssenbeek, 2006).

In the present study, hemipterous bug belonging to the family Pentatomidae, *Eurygastera austriaca* and *Chrysocoris stolliae* that feed by sucking the sap of the rice plant and causing serious loss of rice crop.

Green-horned caterpillar, *Melanitis leda* is among a number of defoliating insects that are minor feeders on rice in Asia (Dale, 1994). In the present study, these insects occurred in all rice field environments but were most prevalent in rainfed lowland rice field and not serious for paddy plant. These findings were also agreed with Day, 1994.

The skipper belongs to the family Hesperidae of the order Lepidoptera. They are the pests of sugarcane, rice, sorghum, *Paspalum* and various species of grasses (Anonymous, 1976). The morphology and charotaxy of the last larva of *Pelopidas mathias* which are important pests of rice in India. The adult *P. mathias* is distinctly differentiated from other members of the butterflies. *Pelopidas mathias* is also one of the pests of rice plants. Boll of these species cause mechanical injuries to young transplanted plants.

Mainly Lepidopterus insects infests on rice plants and other grasses in the rice fields (Banerjee, 1956). *Euchromia* spp. of order Lepidoptera feeds on rice leaves in our studied.

The case worm occurred only in rice fields of standing water. It was found in irrigated and rainfed wetland environments and was more prevalent in the raining season. A number of related species occur in Asia, but among them *Nymphula depunctalis* is the most widely distributed (Reissing et al., 1986). In the present study, *N. depunctalis* was also recorded in the study site. The damaging state in the larvae was found that larvae lives in sections of young rice plants was left and rolled into tubes called cases. This record agreed with the statement of Reissing et al., 1986.

Scripophaga spp. is among the minor rice stem borers in West Africa (Heinrichs and Barrion, 2004). In Asia, the most destructive and widely distributed are yellow stem borer, white stem borer, dark headed stem borer, striped stem borer and pink borer (Pathak and Khan, 1994). In the study period, *Scripophaga incertulas* and *S. innotata* were major pests of rice and occasionally economic losses to the rice crop. These findings were also agreed with the above author records.

Insects noted as causing severe or moderate injuries were as follows: *Mythimna separata* (Napompeth, 2001). Crop damage is caused by the larvae or caterpillars. Partly grown larvae feed on the young leaves, producing skeletonized leaf blades. They feed rapidly and consume large amounts of foliage in a short time as well as detach into rice panicles.

The family Noctuidae of order Lepidoptera, the larvae of *Spodoptera litura* eats the leaves of the young and mature plants, often left the leaves bitter. If attack is heavy, only petiole of the leaves of the host plants will leave, and plants become bold (Herbison-Evans and Crossley, 2008).

Spodoptera litura also known as army worm that destroys tender leaves of rice plant in nursery period were found in large group in this study. Reissing et al., 1986 stated that many species of army worms and cut worms attack into rice plants; their larvae can become highly abundant and move with large groups in the field.

Ghosh (1940) reported that *Anomala antiqua*, the sesamum black beetle (Scarabaeidae); this beetle and its grubs (Chafer grub) are pests causing damage to several crops in Upper Burma. The beetles appear in swarms after the first showers of rain and congregate on early sesame in the evening and eat off the leaves. In the present study, *Anomala antiqua* (Coleoptera) were found low to medium number causing moderate damage.

Ei Thet Nwe (2015) recorded 12 insect pest species contributing 12 genera nine families and four orders, from paddy fields, Thanlyin Township. These species are the one Orthoteran, three Hemipterans, one Coleopteran, and seven Lepidopterans.

Table 1 Recorded pest species from paddy fields in study site

Order	Family	No.	Scientific Name	Common Name
Orthoptera	Acrisidae	1	<i>Oryza japonica</i>	Short-horned grasshopper
Hemiptera	Cicadellidae	2	<i>Nephotettix virescens</i>	Green Leafhopper
	Pentatomidae	3	<i>Nezara viridula</i>	Green stink bug
	Alydidae	4	<i>Leptocoris acuticornis</i>	Rice ear bug, Paddy bug
		5	<i>L. acuta</i>	Slender rice bug
		6	<i>Cletus trigonus</i>	Leaf footed bug
	Pyrrhocoridae	7	<i>Dysdercus cingulatus</i>	Cotton Stainer/Red Cotton bug
	Scutelleridae	8	<i>Eurygastera austriaca</i>	Wheat shield bug
	Pyrrhocoridae	9	<i>Chrysocoris stoll</i>	Jewel bug
Lepidoptera	Satyridae	10	<i>Melanitis leda</i>	Green horned caterpillar
	Hesperidae	11	<i>Pelopidas mathias</i>	Dark small-branded swift
	Amorphae	12	<i>Euchromia</i> spp.	Wasp-like moth
	Pyralidae	13	<i>Nymphula depunctalis</i>	Caseworm
		14	<i>Scripophaga gajacanthus</i>	Yellow stem borer
		15	<i>S. innotata</i>	White rice stem borer
	Noctuidae	16	<i>Mythimna separata</i>	Rice ear cutting caterpillar
		17	<i>Spodoptera litura</i>	Tropical armyworm
Coleoptera	Scarabaeidae	18	<i>Anomala antiqua</i>	Rice black beetle

Table 2 Pest status of insect pest species on rice, *Oryza sativa* L., in the study site

No.	Scientific Name	Common name	Pest status
1	<i>Oryza japonica</i>	Rice field small grasshopper, short-horned grasshopper	Minor
2	<i>Nephotettix virescens</i>	Green leafhopper	Major
3	<i>Nezara viridula</i>	Green stink bug, Green vegetable bug	Minor
4	<i>Leptocoris acuticornis</i>	Rice earbug, paddy bug	Major
5	<i>L. acuta</i>	Slender rice bug	Major
6	<i>Cletus trigonus</i>	Leaf footed bug	Major
7	<i>Dysdercus cingulatus</i>	Cotton stainer (Red cotton bug)	Minor
8	<i>Eurygastera austriaca</i>	Wheat shield bug	Major
9	<i>Chrysocoris stoll</i>	Jewel bug	Major
10	<i>Melanitis leda</i>	Green horned caterpillar	Minor
11	<i>Pelopidas mathias</i>	Dark small-branded swift	Major
12	<i>Euchromia</i> spp.	Wasp-like moth	Minor
13	<i>Nymphula depunctalis</i>	Rice case worm	Major
14	<i>Scripophaga gajacanthus</i>	Yellow rice stem borer	Major
15	<i>S. innotata</i>	White rice stem borer	Major
16	<i>Mythimna separata</i>	Rice ear cutting caterpillar	Major
17	<i>Spodoptera litura</i>	Tropical armyworm	Major
18	<i>Anomala antiqua</i>	Rice black beetle	Major

Table 3 Recorded rice pest species with affected stages on plant parts

Recorded species	Affected rice plant parts	Affected plant parts	Damage stages of pest
<i>Oryza japonica</i>	Leaves	Flowering stage, seedling stage and vegetative growing stage	Stem and seedling
<i>Nephotettix virescens</i>	Leaf and seedling	Seedling stage and vegetative growing stage	Stem and seedling
<i>Nezara viridula</i>	Stem and seedling	Flowering stage	Stem and seedling
<i>Leptocoris acuticornis</i>	Inflorescence and seed	Flowering stage, seedling stage	Stem and seedling
<i>L. acuta</i>	Inflorescence and seed	Flowering stage and grain	Stem and seedling
<i>Cletus trigonus</i>	Leaves	Flowering stage and grain	Stem and seedling
<i>Dysdercus cingulatus</i>	Leaves and seed	Flowering stage and grain	Stem and seedling
<i>Eurygastera austriaca</i>	Grain	Flowering stage	Stem and seedling
<i>Chrysocoris stoll</i>	Inflorescence and seed	Flowering stage, seedling stage	Stem and seedling
<i>Melanitis leda</i>	Leaves	Flowering stage, seedling stage and vegetative growing stage	Caterpillar
<i>Pelopidas mathias</i>	Leaves	Flowering stage, seedling stage and vegetative growing stage	Caterpillar
<i>Euchromia</i> spp.	Leaves	Flowering stage	Caterpillar
<i>Nymphula depunctalis</i>	Leaves	Flowering stage, seedling stage and vegetative growing stage	Caterpillar
<i>Scripophaga gajacanthus</i>	Leaves and stem	Flowering stage, seedling stage and vegetative growing stage	Caterpillar
<i>S. innotata</i>	Leaves and stem	Flowering stage, seedling stage and vegetative growing stage	Caterpillar
<i>Mythimna separata</i>	Leaves, panicle	Flowering stage, seedling stage and vegetative growing stage	Caterpillar
<i>Spodoptera litura</i>	Leaf, stem and root	Flowering stage, seedling stage	Caterpillar
<i>Anomala antiqua</i>	Leaves	Grain stage	Stem and seedling

which is not usually eaten, the other is the trying of the two edges of the same leaf together to form such tubes in which the caterpillars live. Sometimes the tips of the leaves are rolled backwards and borer tried the portion to form the tube. Damage is severe in young transplanted seedling and may last up to the time of ear emergence. In cases of severe infestation, the plants are sickly and often fail.

During the study period, it was also noted that every farmer in the study sites used one or more strategy to protect or reduce of damage by insects such as use of pesticide with fertilizer or soak in salt water before sowing the seeds. The predators in paddy field may investigate to help and reduce insect pest population because the number of specimen of pest species. In the present study, among the 18 species, 13 species were found as major pests and five species were observed as minor pest species. Therefore, the most of pest species were infested on *Oryza* sp.

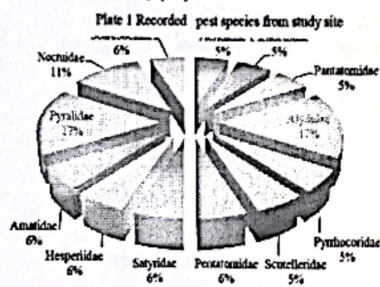


Figure 2 Occurrence of recorded pests in each family

Conclusion

During the study period, 18 pest species were recorded 13 major pests and five minor pests. This result may need to share the knowledge of farmers about different insects which attack on the rice in Thanlyin Township and also provide to other

researchers, and interested people in entomology and agriculture sectors.

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Isolation and Identification of some soil bacteria from rice field of Hmawbi Township, Yangon Region

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Abstract

The present work was conducted to isolate and identify the phosphate solubilizing bacteria of the rice cultivated soil from Hmawbi Township, Yangon Region. The research was conducted from September 2017 to March 2018. *Bacillus megaterium*, *B. circular* and *B. subtilis*, *Pseudomonas striata* and *P. putida* were isolated from rice field soil. Total viable bacterial counts (CFU/L) in soil were 1.3×10^6 in site I, 7.4×10^6 in site II, 4.8×10^7 in site III, 8.5×10^7 in site IV and 4.1×10^7 in site V, *Bacillus* species and *Pseudomonas* species were found to grow well.

Keywords: Soil bacteria, *Bacillus*, *Pseudomonas*, CFU/L.

Introduction

Rice is the only major grain crop grown almost exclusively as human food (De Datta and Brady, 1987). It is expected that in the year 2020 an additional 300 million tonnes will be needed to feed the rapidly expanding human population. To meet demand, its production must increase by 65% within 30 years and must be achieved with only minimal expansion of the cultivated area (Saito and Watanabe, 1978).

Research on rice nutrition has shown that even when high amounts of inorganic nitrogen (N) fertilizer are applied, rice plants obtain only 60% of their N from soil (Reddy *et al.*, 2002).

Rice is a staple food for nearly half of the world's population, most of who live in developing countries. The crop occupies one-third of the world's total area planted with cereals and provides 35-63% of the calories consumed by 2.7 billion people (IRRI, 1993).

In Asia as a whole, much of the population consumes rice in every meal. In many countries, rice accounts for more than 70% of human caloric intake. The total consumption of rice varies widely between different regions. In Asia as a whole, just over 30% of all calories come from rice (Buresh *et al.*, 2005).

Phosphorus (P) is a major growth – limiting nutrient, and unlike nitrogen, there is no large atmospheric source that can be made biologically available (Ezawa *et al.*, 2002). Efficient of P fertilizer throughout the world is around 10% - 25% (Isherwood, 1998), and concentration of bioavailable P in soil is very low reaching the level of 1.0 mg kg⁻¹ soil (Goldstein, 1994).

Phosphate solubilizers belonging to diverse taxonomic groups of micro-organisms, especially bacteria, are known. However, many PSB species remained unknown and more studies are needed to reveal the high biodiversity of these bacteria (Hilda and Fraga, 1999).

The main objectives of the present study were;

- to isolates bacteria associated with soil near rice plant roots and
- to identify the isolated bacteria to species level.

Materials and Methods

Study site

The soil sample were collected from rice field in Hmawbi Township in Yangon region.

Study period

The research was done during the period from June 2017 to March 2018.

Collection of samples

Each sample of soil were collected at a depth of from top to 15.1cm (6 inches) depth.

Sample preparation for isolation and identification of bacteria

Soil samples were ground to powder and sieved through a 0.01mm x 0.01mm square mesh steel filter. Sieved soil samples were put in a sterile polyethylene bag, labeled and used for soil bacteria isolation and identification.

Isolation

To isolate the species of *Bacillus*, ten fold serial dilutions (down to 10⁻¹² level) of soil sample were spread on the surface of soil extract agar plates and the plates were incubated at 37 °C for 2 days. After incubation period, the plate was checked and the different kinds of bacterial colonies were sub-cultured again to get pure cultures for identification. To isolate the species of *Azotobacter*, ten fold dilution of the soil samples were streaked on the surface of nitrogen free agar plates and the plates were incubated at 30 °C for 7 days (Thompson and Skerman 1970). Different colonies growing on the plates were selected and sub-cultured to identify.

Isolation of Pure Culture

Isolation of pure cultures is essential for identification of bacteria and this is normally achieved by plating out on a solid culture medium in a petri dish. Streak plate technique (Gilliest and Dodds, 1968) was used in this work. Firstly, a well is spread over the one quarter of the surface using a wire loop loaded with semi-solid culture previously inoculated from the root pieces. The loop is then sterilized in a Bunsen flame and after cooling is recharged from the well and drawn in three parallel lines across the fresh part of the medium this procedure strokes. Thus the inoculum density is successively reduced, so that isolated organisms are deposited ultimately and on incubation these give rise to individual colonies.

Each separate colony is a pure culture of a single kind of bacterium since it consists exclusively of the progeny of a single bacterial cell.

Staining Methods

Gram Staining .The method described by Collins (1964) was employed in Gram's stain reaction of the isolated microorganisms.

Biochemical Tests (i) Indole Test, Methyl-Red test (MR test), Voges-Proskauer test (VP test),

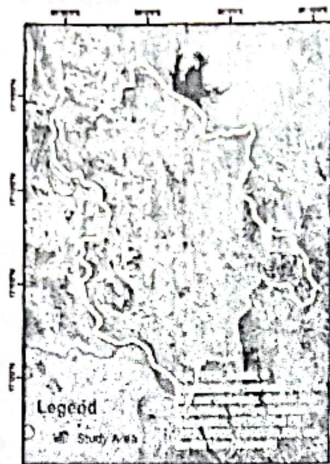


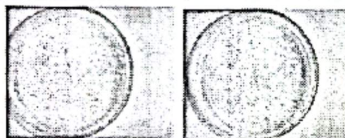
Fig. Map of collection sites of Hmawbi rice field.

Simmon's Citrate Test, Triple Sugar Iron test (TSI test), the method of Cruickshank (1975) was followed.

(ii) Catalase Test -Catalase test was made by using the method of Salle (1948).
Finding and Discussion

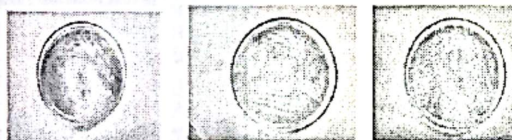


A. *Bacillus megaterium* B. *Bacillus circulans* D. *Bacillus subtilis*

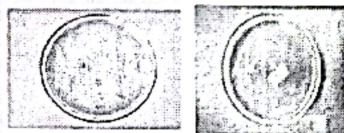


E. *Pseudomonas striata* F. *Pseudomonas putida*

Plate 1. Bacteria growth on nutrient agar



A. *Bacillus megaterium* B. *Bacillus circulans* C. *Bacillus subtilis*



D. *Pseudomonas striata* E. *Pseudomonas putida*

Plate 2. Isolated bacteria growth on MacConkey agar

Preservation of Bacteria. The purified isolates were transferred into the nutrient broths covered with sterile mineral oil and then the test tube were stocked at 4 °C in the Refrigerator (ElbaER 059). The date and the time recorded were to be used for the next experiment in the future.

Table 1 Data, time, weather condition of sample of soil collection and pH and species composition at the sampling area.

		Site	pH	Species
Date	15.9.2018	I	7.49	<i>Bacillus megaterium</i>
Time	11:30 am	II	8.48	<i>Bacillus circulans</i>
Weather	Fine	III	7.76	<i>Bacillus subtilis</i>
Temperature	82°C	IV	8.51	<i>Pseudomonas striata</i>
		V	8.28	<i>Pseudomonas putida</i>

Table 2. Morphological characteristics of isolated bacteria

Bacteria samples	Colony Morphology	Cell shape	Gram stain	Agar growth	
				EMB	MacConkey
<i>Bacillus megaterium</i>	Spreading, clear large colony, that splatters across the agar surface, 0.5 cm to 1 cm (diameter)	small rod or oval	+	-	+
<i>Bacillus circulans</i>	Spreading, clear large colony, that splatters across the agar surface, 0.5 cm to 1 cm (diameter)	small rod or oval	+	-	+
<i>Bacillus subtilis</i>	Spreading, clear large colony, that splatters across the agar surface, 0.5 cm to 1 cm (diameter)	small rod or oval	+	-	+
<i>Pseudomonas striata</i>	Circular raised, smooth surface, 2mm to 2.5 mm (diameter)	rod	-	-	+
<i>Pseudomonas putida</i>	Circular raised, smooth surface, 2mm to 2.5 mm (diameter)	rod	-	-	+

Table 3 Biochemical characteristics of identified isolates

Samples	Catalase	MR	VP	Indole	Simon Citrate	Urease test	TSI		
							Butt	Slant	Gas
<i>Bacillus megaterium</i>	+	-	-	-	+	-	K	A	+
<i>Bacillus circulans</i>	+	+	+	+	+	-	K	A	+
<i>Bacillus subtilis</i>	+	+	-	-	+	-	K	K	+
<i>Pseudomonas striata</i>	+	-	-	-	+	+	K	K	+
<i>Pseudomonas putida</i>	+	-	-	-	+	+	K	K	+

Result

Five species of soil bacteria, namely *Bacillus megaterium*, *B.circulans*, *B.subtilis* *Pseudomonas striata* and *P. putida* (Table-1) were investigated from the rice soil of Hmawbi Township Yangon Region. All of these species were firstly cultivated on the Nutrient Medium and then incubated onto the *Bacillus* and *Pseudomonas* medium for the test of wanted species.

Discussion

Soil samples were analysis for isolation, identification and viable cell count. Rice field soil samples were analysis for isolation, identification, total viable cell count and physicochemical parameters of soil.

Five species of soil bacteria, namely *Bacillus megaterium*, *B.circulans*, *B.subtilis* *Pseudomonas striata* and *P. putida*. The maximum permitted value of cultivated soil pH was 6.0-7.5 (Washington State University 2004). The soil pH were 7.49, 8.48, 7.76, 8.51 and 8.52 in site I, II, III, IV and V respectively. Therefore the present study of pH were greater than the maximum permitted value of cultivated soil.

In this work, three species of *Bacillus*, were same colony morphology after isolation and same their cell shape and gram stain and then same their growth on EMB and Macon Key agar. Two species of *Pseudomonas* were same colony morphology, cell shape, gram stain and same their growth on EMB and Macon Key agar.

Analysis of the elements of phosphate indicated that 2.90 ppm in site I, 2.50 ppm in Site II, 3.20 ppm in site III, 1.60 ppm in site IV and 3.10 ppm in site V.

Analysis of the elements of nitrogen indicated that 0.46 ppm in site I, 0.42 ppm in site II, 0.49 ppm in site III, 0.29 ppm in site IV and 0.47 in site V.

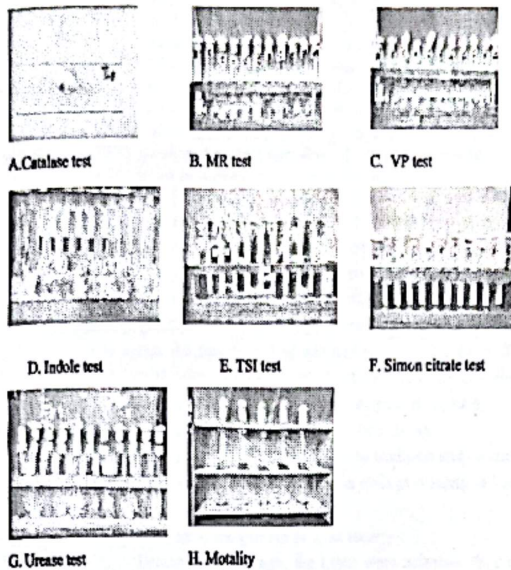


Plate 3 Biochemical test of isolated bacteria

Table 4. Physicochemical parameters of soil samples (ppm)

Study site	Site I	Site II	Site III	Site IV	Site V
Phosphorus	2.90	2.50	3.20	1.60	3.10
Nitrite	0.300	0.260	0.350	0.160	0.330
Nitrate	0.680	0.605	0.765	0.363	0.725
Nitrogen	0.46	0.42	0.49	0.29	0.46
potassium	5.5	5.0	6.0	4.0	5.8
Calcium	Low	Low	Low	80	Low
Copper	4.40	3.40	5.20	2.40	4.50
Iron	high	0.96	high	0.59	high

Table 5. Bacteria Viable account of five study site

Study Site	CFU/g
I	1.3×10^6
II	7.4×10^6
III	4.8×10^6
IV	8.5×10^7
V	4.1×10^7

Analysis of the elements of potassium indicated that 5.5 ppm in Site I, 5.0 ppm in Site II, 6.0 ppm in Site III, 4.00 ppm in Site IV and 5.8 ppm in Site V.

According to the Washington State University Home, 2004, the normal ranges were 10-20 ppm of phosphate and 120-200 ppm of potassium.

According to the Washington State University Home, 2004, the normal ranges were 1.01-1.50 mg/L of nitrogen, 4.00-6.00 mg/L of nitrate and 4.00-6.00 mg/L of nitrite.

In the present study, all sampling period of analyze elements and physicochemical parameters were normal ranges values.

Although the actual number in existence in the environment has not been determined, bacteria occur at population levels of 10^4 to 10^7 per gram of soil (Alexander, 1977).

Viable bacteria count (CFU/g) in collected soil samples were 1.3×10^6 in site I, 7.4×10^6 in site II, 4.8×10^6 in site III, 8.5×10^7 in site IV and 4.1×10^7 in site V.

Conclusions

In this study all species showed, the colony morphology of the isolates was in agreement with the description of *Bacillus* and *Pseudomonas* given by Bergey *et al* (1923) and Cruickshank (1975). All sampling period of analyze elements and physicochemical parameters were normal ranges values. It is concluded that the isolated and identified *Bacillus* and *Pseudomonas* bacteria presented in this work

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HIS 003

History of Lisu in Kachin State

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Abstract

This paper is the study of the History of Lisu in Kachin State. Lisu, one of the 136 Myanmar national races and then one of the transitional minority groups in Southeast Asia, particularly live in four different nations: China, Myanmar, Thailand and a few in India. According to the record, it is known that the *Yawya* who would become Lisu, inhabited the rugged area on both sides of the present Myanmar-China border. Many Lisu in the past never settled permanently in one particular place. They were always looking for new and better places. In writing this paper, as the primary sources are rare, it is based on oral history and on field research. In brief, this paper tries to give the images of Lisu tribe.

Introduction

This paper focuses on the interview of Lisu people though particularly, the writer of this paper would like to focus books, oral history, periodicals and interviews. Hence, the scope of this paper is to assess the maintained of life and traditional culture of Lisu. And then, the objectives of the study of this thesis are as follows:

- to know the genealogy as the source of the race.
- to find out the background of their living.
- to understand and maintain their tradition and custom.
- to denote the removal of gross evils prevailing in Lisu society.
- to denote the growth of Lisu society.

Before a century ago, the Lisus were animists; they do not care any socio-economic, religion and so forth. Nowadays, Lisus gradually came to know, how maintain their life and tradition. Therefore, this paper, I would like to present about the History of Lisu in Kachin State: which are included:

- meaning of Lisu,
- the origin of Lisu,
- the migration
- the kinds of Lisu,
- the different name of Lisu
- distribution of Lisu,
- Language and other theme etc....

Meaning of Lisu

The word "Lisu" denotes the "race" or the "people" who migrated from higher land. It also means that it is the race that, after living in a dale at the foot of a great mountain by doing cultivation, migrated and passed through that mountain under the leadership of a thousand heroes and settled in the new place, where they lived by cultivation, controlling water and fish. Thus in essence, it means "Lisu" are the ones who moved down to the lowland. The word "Li" means "binding". Among the trappings of their costume are "long belt" and "long girdle", in addition to long turban with which they usually wrapped their head. These acts of "girdling", "wrapping", "swathing" or "bandaging" are all described in the language of Lisu as "Li". Although the meaning of "Li" is bandage in English, there are sacred meanings in "Li", which are unity, solidarity and the power which can grasp everything to be oneness and to be firm. "Su" means song or sound. It can conclude that the meaning of Lisu is "the joyful people" in unity and solidarity.¹

We can find that Anthony R. Walker gives several definitions of Lisu:

Lisu: the term Lisu according to James O. Fraser is *Lisu People who have comedown*. Ta'o claims that, Lisu in Nakhi language means, *Born from the stone, or People of mountain*. Some of the Lisu informants in Thailand said that the name Lisu is a combination of *Yili* meaning custom, law, *Yisu* one who runs from and therefore, outlaw, rebel or loser of rules and regulations or the rolling one.²

Two Lisu elites, Zo Yo Se and Sa daw, defined Lisu as follows:

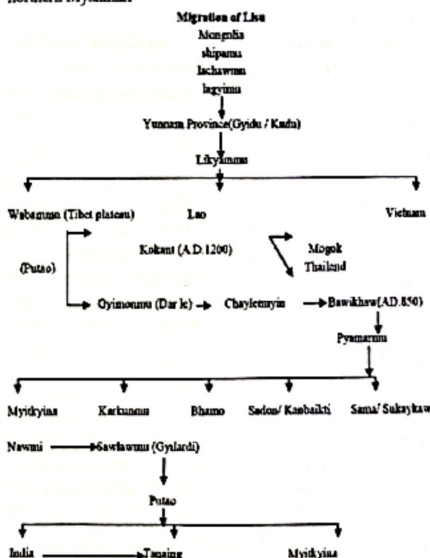
Lisu: A race that conquers the hills, the mountain ranges the forests, rivers and fertile lands for the benefit of the people.³

Origin of Lisu

Most of Lisu say they came from the upper reaches of Thanlwin River, but some claims they came from the place called Hsaing Hsaing near Hpimaw, and yet another said that they came from Waba (Snow White / Upper Mekong) district in the upper reaches of Mekong River. At best, Lisu people might come from eastern Tibet, going down far wise to Putao, from where followed along the courses of Maykha River, Thanlwin River and Mekong River, and thence to Yangtze Valley and finally to Yunnanfu. Majority of Lisu are now found lived in Yunnan, west of Yunnanfu, China.⁴ But, Lisu in Myanmar believed that they came from eastern Tibet. According to Manshu treatise, written by Fanchi in 685 A.D, Lisu of Nankin region went down along the Yangtze River and Lisu from Tibet plateau followed along the Thanlwin, Mekong and Yangtze Rivers and settled along the border of Yunnan Province, Kwekyo Province and Zichuan Province.⁵ Between 16 and 20 centuries, Lisu peoples entered Myanmar through Yunnan.⁶

Migration of Lisu

According to the Lisu traditional legend, Lisu are originated from BABILEI (Babylonia) to MUKUYA (Mongolia) where they cloud descend and rests. From MUKUYA, they migrated to the Eastern part of the Tibet Plateau known to them as KWADZU, a dry land and PATAW. Pataw is at the headwaters of the Salween River, Mekong River and Yangtze River. It is almost impossible to trace the first Lisu immigrants or when and where they first settled in Myanmar. Some Lisu were found reached even to Peking in the northeast and lived with Chinese people in juxtaposition.⁷ Nevertheless, among the three groups of Tibet-Myanmar, Lisu consists of the easternmost group of Lolo-Moso who migrated towards south from Mongolian plateau. Lolo peoples followed Mekong River and Lisu along Thanlwin River. In general, Lisu people live in the region between 25 and 28 degrees North Latitude, which is locally known as Numland. By distribution, they can be divided into three groups: the one migrated from Mongolian plateau to Wabanyei in Mekong Valley, the other moved to Nawmineyi in Thanlwin Valley, where established the city of Bali, and another group scattered in Lashio, Kengtung, Loilin, Taunggyi, Putao, Myitkyina and Mogok, in northern Myanmar.⁸



Kinds of Lisu

Lisu are classified into four main groups and this classification seems to be based on the differences in their

traditional dress and dialect variations. Lisus are called white Lisu (Pe Lisu or Lowu), Black Lisu (He Lisu or Hucha Lisu), floral Lisu (Hwa Lisu or Yeime or Shasha Lisu) and Hkolo Lisu (small Chinese Lisu).⁹ White Lisu lives Amelo in Putao, Luda, Tibet and the region between Mekong and Thanlwin Rivers, while Black Lisu resides in areas of Htaikaw, Hpyamar, Hpinaw and Ganhpun. Floral Lisu are also known as *Yimay* or Shasha Lisu, who settled in areas of Sadon, Sama, Myitkyina, Bhamo, Shan state, Mogoke and Thailand. Hkolo Lisu lives in juxtaposition with Kachin, Shan and Chinese. Though Hkolo Lisu wears traditional Lisu dress, they speak Yunnan Language, instead of Lisu. They settled in Namkhan and Kukhine regions and at present speak the language of Floral Lisu.¹⁰

There were about 55 clans in the Lisu tribe, which were ascribed by the name of fauna and flora. Clans known by the fauna name were:

Ngwahpa (the fish race)
Lahpa (the tiger race)
Wawhpa (the bear race)
Byahpa (the bee race)
Hehpa (the rat race)
Lahpa (the musk deer race)
Kyikya (the chicken race)
Yan (the goat race)
Guhpa (the owl race)
Yinnhpa (the swallow race) and
Zalihpa (the insects' race)

Clans known by the flora name were:

Gwahpa (the barley race)
Zihpa (the fibre plant race)
Sihpa (the hollow trunk)
Gyukya (the bamboo race)
Nawhpa (the soy-bean race)
Zippa (the fire wood race)
Lihpa (the tree race)
Chahpa (the tea race)
Lemehpa (the tasteless race)
Thaunghpa (the non-material race)
Zawhpa (the non-material race)
Khawhpa (the non-material race)
Dipha (the non-material race)
Lamyahpa (the non-material race)
Tunhpa (the material race)

Lisu peoples called "Waw" for vegetables, "hawky" for fire, "saw" for the ones who built kitchen and *Likyur* for the people who made the boats.¹¹ The people who arrived earlier were called "Zawky" and "Hpihya" for the ones who arrived later. As the livelihood of Lisu peoples are mostly agriculture and hunting, there might appear the tradition naming them and kinfolks after the object and materials frequently found around their environment. Therefore, it is learnt that there are nearly sixty other names, ascribed to Lisu peoples. Major sub-tribal group of Lisu are *Town Kya*, *Ngwa Hpa*, *Ngawhpa*, *Zawky*, *Gu Hpa*, *Lai Mair*, *Bya hpa*, *Dzi Hpa*, *La Hpa*, and *Waw Hpa*. The word "Kya" means "Family" and that of "Hpa" "man". By the study of these names, it comes to understand that these sub-tribal groups are in fact not sub-tribal groups, but instead are the clan names, differed from the principal clans, due to their differing localities.

Distribution of Lisu

The distribution of Lisu people can be found stretching from Putao in the north to Shan State in the south, especially in the Arkyan Valley¹², arrived there by passing Watershed Mountains of Thanlwin and Ayeyarwady River in mass migration. No one knows exactly, when did occur this mass migration. According to the British administrative officer J.T.O. Bernand, Lisu people arrived in mass migration in about 1920. It was thought that mass migration occurred due to decreasing fertility in agriculture and

insufficient agriculture Lands, in addition to the incoming of Chinese people into their land.

According to the 1954 census, got from the office of Hill Tract Administration, there was a total population of 11573 persons of Lisu people in Putao region. Lisu peoples, spread out from Arkyan Valley towards west, can be found in Ridam (NT 9274) in Myakha Valley, in Shankha Valley (NT 5143), west of the watershed mountain of Malikha and Myakha and in lowland around Khanti.¹³

Major C.M. Enriquez, the British recruiting officer, in his book of Race of Myanmar, described that Lisu peoples came through the Shin Khaung Pass, east of Arkyan Stream, and settled in villages of Chiladi, Mikaw, Hpada, Adula, region of Nyiwahtan Stream, Dilawaswe and Jayzakha.¹⁴ Lisu from the Shilandam region, east of Khaunglamphu, near the upper border of Amat Stream, moved to Khawbude region, which is known as Air deity, where they built Mikaw Village. At the time of the establishment of Mikaw Village, it was said that there was no administration at all. In about 1935, the people began to live in Marmule Village and built new village in this order, Malidi, Namsabum, Mulashidi, Namhtonkhu, Par Ein, Makyawwar and Makatmon. Since then, Lisu people settled widespread throughout Putao Plain.¹⁵ At present, Lisus can be found in Myanmar, China and Thailand. In China, they can be found in regions of Lijiang, Baoshan, Nujiang and Dehong. The number of Lisu people is about 730000 persons. The Peoples' Republic of China recognizes Lisu as the national race, among the 56 national races of the country. In Myanmar, the number of Lisu is about 350000 persons, living in Kachin and Shan States. In Thailand, they number about 55000 people.¹⁶

According to Paul and Elaine Lawis, there were about 7500 Lisu in Thailand in 1958, and it grew to about 18000 people in 1983. The population growth rate was about 3.6% per annum. In the same year, Lisu population in Myanmar was about 250000 persons and in China it was about 500000 peoples. The distribution of Lisu in Thailand by region was 47% in Chiang Mai, 23% in Gyamrai, 19% in Mae Hong Son and 11% in Prachuab, Tak, Kamphimpit, Hplachabam and Sukhotai.¹⁷

Language of Lisu

Diversity of different languages among the people of Lisu was so great to the extent that Lisus themselves could not understand what one said. Lisus in the western and eastern Yunnan speak the Chinese in communicating themselves. According to Mr Fraser, the China Inland Mission, only 60 percent of Lisu language is stationary and unchanged and the rest of 40% is found always changing. Lisu language is difficult with 6 high and low tones, in addition to 250 separate sounds. None of these words does end in alphabetical sound. Therefore, when Lisu people speak Chinese, their pronunciation becomes so bad. Lisu language is full of borrowed or modified Chinese words.¹⁸ At present, depending on the location and dialects, Lisu language can be divided into three groups, namely,

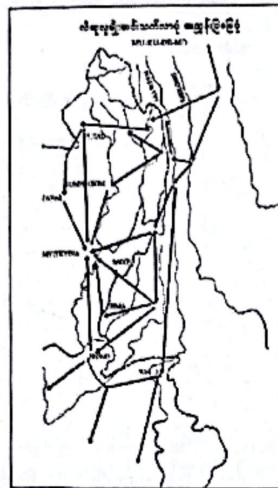
- (a) *Hucha*
- (b) *Law Wu* and
- (c) *Yimu*.¹⁹

Nawmi Lisus from Putao and Thanlwin Valley speak Hucha and Lawwu, while Lisus from Myitkyina, Bhamo, Mogoke and Shan States speak Yimu some of Lisu language resembles to that of Lo Lo in Yunnan, China and some to the Myanmar language. As some of current Lisu language resemble to some Chinese words, some people have wrongly thought that Lisu language resembles to Yunnan Chinese. Chinese words found in Lisu language were found adopted as they represented modern cultural theme which do not exist before.

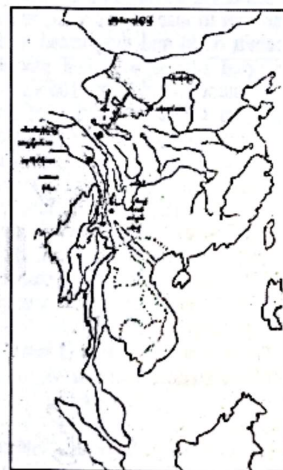
Linguists said that Lisu language is difficult to speak and study. It has six high and low tonal sounds; there also are 250 independent sounds ending with vowel sounds only. As Lisu speakers could not speak Chinese words clearly, words borrowed from Chinese became corrupted. Some said that the adoption of borrowed Chinese words into Lisu language happened only sometimes ago.²⁰

Conclusion

In conclusion, Lisu are part of Lolo-Moso group, which is inclusive of Tibet-Myanmar major group. Lisu is more akin to Lolo people, linguistically and racially. It is hard to expose or conjecture the birth place of Lisu peoples. Most probably, these people may originate somewhere in Tibet, as they themselves have accepted that they came down from the eastern part of the plateau in northern Tibet. This paper comes into being, by the migratory line of the people and by their legends and traditional oral history. The genealogy of Lisu also is legendary. Whenever attempts have been made to trace back the distribution and descendants of these peoples, it is found that one cannot be traced back, not more than five generations. Different households with different family names are reflection of different location and different livelihood in different domain. The legend said that Lisu peoples emerged Burma since about 9 century A.D. Nevertheless, these peoples are found able to create a literature for them, a reflection of initiative and innovative ideas and opinions. Likewise, their clothing's and costume undergo changes through the tide of time.²¹



(Source: U Li Hpu Ja and U Yo Li, *Record on the Origin and Genealogy of Lisu People*, Computer typescript, Myitkyina, Lisu Literature and Culture Committee, 18 December 2001)



(Source: U Li Hpu Ja and U Yo Li, *Record on the Origin and Genealogy of Lisu People*, Computer typescript, Myitkyina, Lisu Literature and Culture Committee, 18 December 2001)



hasakhaw (HteinChone District, China)

5-2-2011 New Year Festival



Myitkyina

15-2-2011 New Year Festival



Putao

15-2-2011 New Year Festival



Bamaw / Moegoke

15-2-2011 New Year Festival

(Photo by Dr. Kyaw Swe Nyunt, History Department)

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- ⁵ Anthony, 1975, 158
- ⁶ Anthony, 1975, 158
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- ¹⁰ Interview with Rev. Bya Yaw Han, born in 1942, at Mankhein village, Myitkyina, on 18-6-2011
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- ¹² Located in Khawng Lan Hpu Township, referred to the rising region of Maykha River
- ¹³ Yeiin Nwe Pa, I, 1957, 66-67
- ¹⁴ Enriquez, 1933, 62
- ¹⁵ U Li Hpu Ja and U Yo Li, *Record on the Origin and Genealogy of Lisu People*, Computer typescript, Myitkyina, Lisu Literature and Culture Committee, 18 December 2001, P.9-12
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CHEM 054

Investigation of Antioxidant Capacity of Phenolic Phytochemicals from *Valeriana officinalis* L. (Kantbalu)

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Abstract

There is currently an upsurge of interest in phytochemicals as new sources of natural antioxidants. The aim is to use them in foods and pharmaceutical preparations in order to replace synthetic antioxidants, which are being restricted due to their potential health risks and toxicity. The relative levels of antioxidant activity, phenolic content and total flavonoid content of aqueous and ethanolic extracts have been determined by using the DPPH, the Folin-Ciocalteu and Aluminum chloride colorimetric methods. *Valeriana officinalis* L. (Kantbalu) is a popular and widely available herbal supplement, primarily used to treat insomnia and anxiety. Since the root of Kantbalu has an invaluable medicinal purpose, it was chosen for this research work. The total phenolic content of ethanolic extract (90.40 ± 0.007 mg GAE/g) possessed higher phenolic content than that of aqueous extract (86.95 ± 0.002 mg GAE/g) and the total flavonoid content of ethanolic extract (9.63 ± 0.001) was also higher than that of aqueous extract (0.88 ± 0.002) mg QE/g. Moreover, antioxidant activity of ethanolic extract ($IC_{50} = 15.2 \mu\text{g/mL}$) was found to be more potent than that of aqueous extract ($IC_{50} = 49.11 \mu\text{g/mL}$). Therefore there was a good correlation between total phenolic or total flavonoid and antioxidant capacity.

Keywords: *Valeriana officinalis* L.; total phenol content; total flavonoid content; antioxidant activity

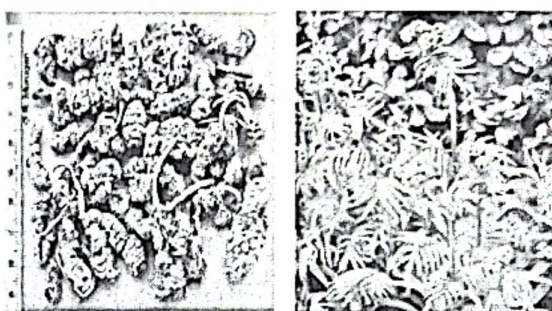
Introduction

Valeriana officinalis L. is a well-known and frequently used medicinal plant, which has a long-proven history of efficacy. It was absolutely first used as a treatment for brain disorder within the late 16th century [1]. It is light grayish brown and about the size of a finger joint, bearing many rootlets. The fresh root has no odor, while the dried root smells distinctly unpleasant, due to isovaleric acid [2]. Its many active components coordinate an ideal release of hormones and balance the body's cycles to stimulate restful, thorough, undisturbed sleep. This has been one of the main uses of valerian root since ancient times. This is related to the previous point about sleep disorders, but valerian essential oil is also widely used to improve mood and reduce anxiety [3]. Phenolic compounds are ubiquitously distributed phytochemicals found in most plant tissues, including fruits and vegetables. Although they are not nutrients, dietary intake provides health-protective effects. Phenolic compounds are a group of small molecules characterized by their structures having at least one phenol unit [4]. Flavonoids are a group of natural compounds with variable phenolic structures. These compounds are able to bring about various biological and pharmacological activities in animal cells [5]. Antioxidants are substances which can safely interact with free radicals and terminate the chain reaction before vital molecules are damaged [6]. Antioxidants are widely used as ingredients in dietary supplements in the hope of maintaining health and preventing diseases such as cancer and coronary heart disease [7]. It is well known that phenolic compounds are mainly responsible for antioxidant activities and antioxidant activity is an integrated parameter of antioxidants present in a complex. A correlation between these two activities could help in identifying the contributing factors for both the activities [8].

Materials and Methods

Selected plant used in this study was Myanmar medicinal plant, root of *Valeriana officinalis* L. (Kantbalu). The dried sample was purchased from Theingi market. The dried pieces were made into powder by using grinding machine. The powder sample was stored in air tight container to prevent moisture changes and other contaminations. The dried powdered sample was used for chemical and biological investigations.

Fig. 1. Plant and roots of *Valeriana officinalis* L. (Kantbalu)



100g of dried powdered sample was placed in two different conical flasks. The 500 mL of ethanol and distilled water was added into each flask and stopped with a cork. The sample was allowed to macerate and placed in a shaker, shaken continuously for about 6 hour and the suspension was allowed to stand for 18 hr. The extract was filtered rapidly taking care not to lose any solvent, and transferred to weighed porcelain basin and evaporated to dryness on water bath. The dried filtrate was then placed in oven, maintained till constant weight, at 105°C. The crude extracts were used for the determination of total phenol content, total flavonoid content and antioxidant activity.

One of the oxidative factors, total phenolic contents (TPC) was measured spectrophotometrically according to the Folin-Ciocalteu method [9]. The total flavonoid content (TFC) of the samples was determined UV spectrometrically according to the Aluminium chloride colorimetric assay and the free radical scavenging activity of crude extracts of *Valeriana officinalis* L. (Kantbalu) was measured by using DPPH free radical scavenging assay [10].

Result and Discussion

Total Phenol Contents

The total phenol content of ethanolic and aqueous extracts of root of Kantbalu are shown in Table 1. According to the results, the higher TPC (mg GAE/g) was detected in ethanol extract (90.40 mg GAE/g) than aqueous extract (86.95 mg GAE/g). This means that phenolic compounds were more soluble in ethanol. Comparison of total phenol contents in watery and

ethanolic extracts is represented by table I and a bar graph, Fig. 2.

TABLE I Total Phenolic Contents of Ethanol and Aqueous Extracts of Roots of *Valeriana officinalis* L.(Kantbalu)

Tested samples	Total Phenolic Contents (mg of GAE/g of extract)
Aqueous	86.95± 0.002
Ethanol	90.40 ± 0.007

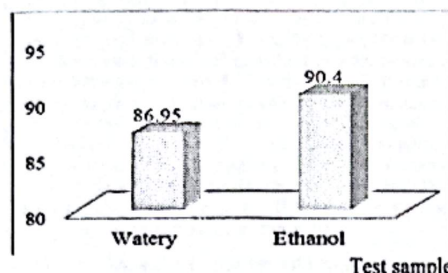


Fig. 2. Total phenolic contents of ethanol and aqueous extracts of roots of *Valeriana officinalis* L. (Kantbalu)

Total Flavonoid contents

In this study, high phenol contents have been found to exert high antioxidant potential. The total flavonoid content of aqueous and ethanolic extracts of root of Kantbalu are shown in Table 2. According to the results, the higher TFC (mg QE /g) was detected in ethanolic extract (9.63mg QE/g) than that of aqueous extract (0.88mg QE/g). This means that flavonoid compounds were more soluble in ethanol. Comparison of total flavonoid contents in aqueous and ethanolic extracts of root of Kantbalu is represented by table II and a bar graph, Fig. 3.

TABLE II Total Flavonoid Contents of Aqueous and Ethanolic Extracts of Root of *Valeriana officinalis* L. (Kantbalu)

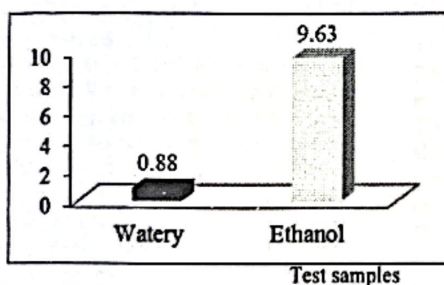


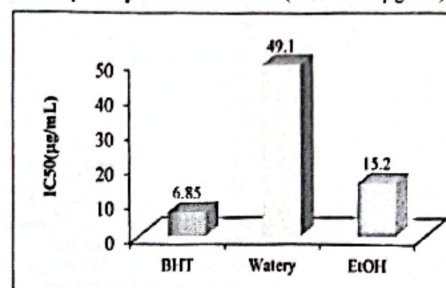
Fig. 3. Total flavonoid contents of watery and ethanolic extracts of root of *Valeriana officinalis* L. (Kantbalu)

Antioxidant Activity

Acknowledgment

The authors feel indebted to Dr. Ni Ni Than, Professor and Head, University of Yangon, Yangon, Myanmar, for her stimulating suggestions.

The antioxidant activity of watery and ethanolic extracts of root of Kantbalu was evaluated by DPPH (2,2-diphenyl 1-picrylhydrazyl) radical scavenging assay. BHT was used as standard. The absorbance of different concentrations (6.25, 12.5, 25, 50, 100 and 200 µg/mL) of tested sample was measured at 517 nm by using UV- 7504 spectrophotometer. From the experimental results, IC₅₀ values of ethanolic and watery extracts are 15.2 and 49.1 µg/mL respectively. Antioxidant potency of ethanol and water extracts were concluded to be very weak if compare with the potency of standard BHT (IC₅₀ = 6.85µg/mL). The



IC₅₀ values of ethanolic and watery extracts and standard BHT are shown in Fig. 4.

Fig. 4. IC₅₀ values of crude extracts and standard BHT

Conclusion

In this study, investigation of phytochemical constituents, total phenol contents, total flavonoid contents and antioxidant activity of the root of *Valeriana officinalis* L. (Kantbalu) were reported. The results of preliminary phytochemical screening of different crude extracts of *V.officinalis*L. revealed the presence of alkaloids, carbohydrates, α-amino acid, glycosides, phenolic compounds, reducing sugar, saponins, tannins, steroids, terpenoids and flavonoids. However cyanogenic glycoside, organic acid and starch were absent. Total phenol contents in ethanolic extract (90.40±0.007 mg GAE/g) is higher than in the watery extract (86.95±0.002mg GAE/g) as well as the total flavonoid contents in ethanolic extract (9.63±0.001 mg QE/g) is higher than in the watery extract (0.88±0.002 mg QE/g). Moreover, the antioxidant potential of ethanol extract

TABLE II Total Flavonoid Contents of Aqueous and Ethanolic Extracts of Root of *Valeriana officinalis* L. (Kantbalu)

Tested samples	Total Flavonoid Contents (mg of QE/g of extract)
Watery	0.88± 0.002
Ethanol	9.63± 0.001

(IC₅₀=15.2µg/mL) is more potent than the watery extract (IC₅₀=49.1µg/mL). There was a good correlation between total phenolics, total flavonoids and antioxidant capacity. The phenolic compounds from *Valeriana officinalis* L. may supply substantial antioxidants which may provide health-promoting advantages to the consumer. From the overall assessment of this research, root of *Valeriana officinalis* L. has a good source of many constituents with different pharmacological activities and can be used as a source of alternative medicine.

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CHEM 059

Antioxidant and Anticancer Potentiality of *Aegle marmelos* L. (Okshit) bark and *Psidium guajava* L. (Guava) Leaf Extracts

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Abstract

Aegle marmelos L. (Okshit, OS) bark and *Psidium guajava* L. (Guava, GV) leaf were explored chemically and followed by antioxidant and antiproliferation activities determination. The samples were collected from Taunggyi University Campus, Taunggyi Township, Shan State in 2018. The preliminary phytochemical results showed that the presence of carbohydrate, flavonoids, glycosides, phenolic compound, reducing sugars, saponins, steroids, tannins, terpenoids, and organic acids are present in both samples. The samples (OS and GV) were observed to compose by protein (12.65 and 1.78%), moisture (10.23 and 12.11%), fat (11.6 and 1.81%), and fiber (14.08 and 16.13%), and carbohydrate (46.45 and 53.36 %) were found to be determined by using the AOAC method. In addition, the elements such as K, Cl, Fe, P and S are found as major elements in OS whereas Fe, K, Ca, Na, Si, Al, Mg in GV were found using ED XRF method. The total phenol contents were determined by Folin-Ciocalteu reagent (FCR) method. The total phenolic contents of MeOH and water extracts were 4.12, and 8.26 µg GAE/mg for OS and 2.13 and 1.04 µg GAE/mg for GV respectively. As pharmacological activities, the order of anti-proliferative effect against HepG2 cell line was observed to be methanol extract of GV ($IC_{50}=150.8$ µg/ml) > OS ($IC_{50}=169.8$ µg/ml) by MTT assay. The antioxidant activity of GV ethanol extract ($IC_{50}=3.62$ µg/ml) was found to be most potent and followed by GV methanol extract ($IC_{50}=3.75$ µg/ml), GV aqueous extract ($IC_{50}=4.48$ µg/ml), OS methanol extract ($IC_{50}=5.81$ µg/ml), OS aqueous extract ($IC_{50}=7.24$ µg/ml), and OS ethanol extract ($IC_{50}=12.21$ µg/ml) determined by DPPH radical scavenging assay. Both samples possess significant pharmacological activities and potentially could be applied as herbal medicine.

Keywords: *Aegle marmelos* L. (Okshit, OS) bark, *Psidium guajava* L. (Guava, GV) leaf, Phytochemical constituents, pharmacological activities, herbal medicine

Introduction

In Myanmar, a high proportion of the rural and urban population rely on herbal medicinal plants. According to Myanmar traditional medical belief there are 96 diseases which afflict humankind using fresh or dried roots, stems, barks, leaves, buds and flowers of medicinal plant and the hair, fat, bones and organs of certain insects, reptiles and mammals. Myanmar indigenous medicine is able to heal and cure all 96 maladies. Indigenous medicines are administered as powder, mixtures, decoctions, infusions, percolates, pastes, extracts, preserves, pills or tablets (Phyu Phyu Myint *et al.*, 2017). Herbs and medicinal plants are found in abundance in the country, and serve as highly affordable remedies for diseases. *Aegle marmelos* is a smooth and dark green. It has a leaf with three leaflets. It is a medium sized, slender, aromatic, armed, deciduous tree, gum bearing tree growing up to 18 meters tall and its local name is Okshit. The plant contains flavonoids, glycosides, steroids, alkaloids, cuscatalin, cuscutin, and amarvelinodoroside, neritaloside, stropeside, tyramine, ursolic acid, β -sitosterol glucoside, gitoxeginin, methyl cinnamate, dihydroajugapitin, ferulic acid. Traditionally, it is used in treatment of protracted fever, diaphoretic, and as demulcent and as purgative. Various studies on *Aegle marmelos* showed that the plant has anticonvulsant, antimicrobial, antioxidant, anti-steroidal, anti-inflammatory, antitumour, diuretic, anti-HIV, hypotensive, and hypoglycaemic activity. (Benni *et al.*, 2011) *Psidium guajava* L. (Guava) is abundant in the warm temperate regions of the northern Hemisphere. It is native to Europe and Asia and its local name is Guava. Phytosterols, sesquiterpene lactones, flavonoids, and phenolic acids of *Psidium guajava* L. (Guava) are responsible for anti-diabetes actions. This herbaceous plant is traditionally used to treat hepatic disease, diabetes mellitus, rheumatoid arthritis, cancer and jaundice. It exerts anti-

hyperglycemic, anti-oxidant, anti-inflammatory, anti-allergic and anti-coagulant activities. (Seo *et al.*, 2005)

Both these two plants contain varieties of natural chemicals that are capable of fighting some infections and healing the human body. This research highlights the current practice and recommended improvement of herbal medicines in the treatment of liver cancer *in vitro* using HepG2 cell lines as well as antioxidant property related to total phenol content.

Materials and Methods

Preparation of the samples

The plant materials were collected from Taunggyi Township, Myanmar in December, 2018. The samples were identified the specimens at Department of Botany, Taunggyi University. The samples were cleaned, carefully dried in shadow and powdered. About 2 g each of ground powder was soaked in 20 ml of different solvent (water, methanol and ethanol) and shaken for 8 h at 180 rpm, 37° C. The soaked substance was filtered throughout Hyundai micro filter paper (110 mm). The solvent was evaporated with rotary evaporator (SB-1200, EYELA, China) at 60 °C. The crude extract was stored in a well-closed container, protected from light and kept in a refrigerator at 4° C.

Determination of nutritional values, phytoconstituents and elementary analysis

The amount of nutrients such as moisture, ash, fat, carbohydrate, fiber, protein, and calories in the samples were determined by recommended analytical methods. Preliminary phytochemical investigation was carried out according to the standard procedures. In dry powder samples for the standardization and quality control were also determined by EDXRF spectrophotometer, at Taunggyi University.



Determination of antioxidant activity

In vitro screening of antioxidant activity the radical scavenging activity of the ethanol, methanol and watery extracts were investigated by using DPPH assay according to the spectrophotometric method. In this experiment, five different concentration (0.625, 1.25, 2.5, 5 and 10 µg/ml) of each crude extract in ethanol solvent were used. Ascorbic acid was also used as standard and ethanol without crude extract was employed as control. Determination of absorbance was carried out at wavelength 517 nm using UV visible spectrophotometer. Each experiment was done triplicate. (Hataro *et al.*, 1989)

Determination of total phenol content

The total phenolic content of the extracts was determined by using Folin-Ciocalteu reagent following a slightly modified method of Ainsworth. Gallic acid was used as a reference standard for plotting calibration curve. A volume of 0.5 mL of the plant extract (100 µg/mL) was mixed with 2 mL of the Folin-Ciocalteu reagent (diluted 1:10 with de-ionized water) and were neutralized with 4 mL of sodium carbonate solution (7.5%, w/v). The reaction mixture was incubated at room temperature for 30 min with intermittent shaking for color development. The absorbance of the resulting blue color was measured at 765 nm using double beam UV-VIS spectrophotometer (UV Analyst-CT 8200). The total phenolic contents were determined from the linear equation of a standard curve prepared with gallic acid. The content of total phenolic compounds expressed as mg/g gallic acid equivalent (GAE) of dry extract.

Determination of antiproliferation activity

The experiment was performed in triplicate. 400 mg of the methanol extract were dissolved in 1 ml of dimethyl sulfoxide (DMSO) and then serially diluted to 200, 100 and 50 µg/ml for *in vitro* cytotoxic assay (antiproliferation activity).

Cell lines and culture medium

HepG2 cell lines were obtained from American Type Culture Collection (ATCC). HepG2 cells were cultured in Dulbecco's Modified Eagle Medium (DMEM) media supplemented with 10 % (v/v) fetal bovine serum and 1% (v/v) of a penicillin/streptomycin solution. Antibiotics (the final concentration to be 100 U/ml penicillin and 100 µg/ml streptomycin) were added to the medium to eliminate potential interference from microbial contamination that may be present on the test material and control samples. Cells were cultured at 37° C and 5% CO₂ humidified atmosphere; complete medium was changed every 2 to 3 days.

Cytotoxic Assay

The cellular toxicity of the methanol extracts of all samples on cultured cells were measured using 3- (4, 5-dimethylthiazol-2-yl) -2, 5- diphenyl tetrazolium bromide (MTT) assay. The cells were grown in 24-well plates at a density of 5×10^4 cells per well. The cells are

allowed to grow overnight in a cell culture incubator. The cells were treated with different concentrations of samples (0, 50, 100, and 200 µg/ml) and incubated for 24 h. Later, 50 µl of the MTT solution (5 mg/ml) was added to each well (final concentration of MTT 0.5 mg/ml), and the plate was reincubated for 2 h. Finally, the medium was removed and 1000 µl of DMSO was added to solubilize the water insoluble formazan crystals which were a metabolite of a tetrazolium salt. The amount of formazan crystal was determined by measuring the absorbance at 595 nm by using a micro plate spectrophotometer (Spectra Max 190). The cell viability curves of the cell line were established based on extract concentration by triplicate experiment after the specified period. (Fesola *et al.*, 2011)

Results and Discussion

The preliminary phytochemical test on the dry powder samples (OS and GV) revealed the presence of alkaloid, glycosides, steroid, α-amino acids, carbohydrates, organic acid, phenolic compounds, and terpenoid. Some nutritional values in OS and GV were found to contain protein (12.65 and 1.78 %), moisture (10.23 and 12.11%), fat (11.6 and 1.81%), Ash (7.53 and 5.85 %), Carbohydrate (46.45 and 53.36%) and fiber (14.08 and 16.13%). The nutritional values for the samples were found to be good source of fiber and carbohydrate. The results are shown in Table 1.

Table 1 Some Nutritional Values of OS and GV

No.	Parameters	Content (%)	
		OS	GV
1	Moisture	10.23	12.11
2	Ash	7.53	5.85
3	Fat	11.6	1.81
4	Crude Fiber	14.08	16.13
5	Proteins	12.65	1.78
6	Carbohydrate	46.45	53.36

EDXRF elemental analysis show that OS was found to possess K, Cl, Fe, P, and S as well as GV contained K, Ca, Na, Si, Al, Mg. It can be seen that essential minerals for human health such as calcium and potassium in sample were the most predominant. Ca is key for the health of bones and teeth, but it also affects muscles, hormones and nerve function. The primary functions of potassium in the body include regulating fluid balance and controlling the electrical activity of the heart and other muscles. Potassium supports blood pressure, cardiovascular health, bone strength and muscle strength. According to ED XRF, no toxic element was found in leaf sample. The results were reported in Table 2.

Table 2 Relative Abundance of Some Elements in OS and GV by (EDXRF)

No.	Elements	Relative Abundance (%)	
		OS	GV

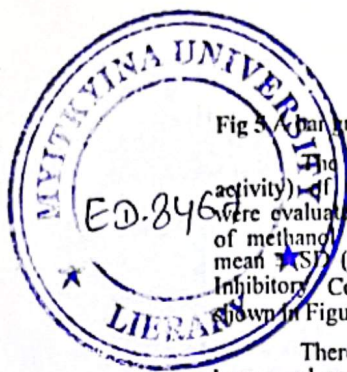


Fig 5 Bar graph of total phenol content

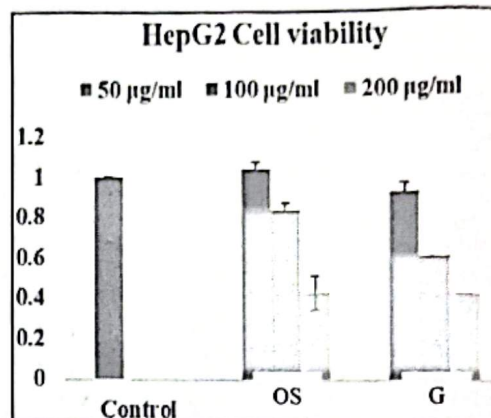
The cytotoxicity (anti-proliferative activity) of methanol extract of OS and GV were evaluated by MTT assay. The cytotoxicity of methanol extract was expressed in term of mean $\pm$ SD (standard deviation) and IC_{50} (50% Inhibitory Concentration) and the results are shown in Figure 6.

There are many plants extracts have been used as anticancer agents even vegetables and fruits may help reduce the risk of cancer in humans. Some tropical plants, namely *Glochidion daltonii*, *Cladogynos orientalis*, *Catimbium speciosum*, *Acorus tatarinowii*, *Amomum villosum* and *Pinus kesiya* were also reported against the human hepatocarcinoma (HepG2) cell line. The cell lines were growth inhibited in a dose- dependent manner after exposure to the plant extracts. The results presented by the optical density (OD) and they indicated that all the different plants methanol extract which mentioned above have a cytotoxic effect in cell lines. IC_{50} values obtained in both cell lines using MTT assay showed that GV was more effective in inducing cytotoxicity in HepG2 cell line, IC_{50} ($150.8 \pm 2.13 \mu\text{g/ml}$) and followed by the plant extracts of OS, IC_{50} ($169.8 \pm 4.01 \mu\text{g/ml}$).

Fig 6 A bar graph of cell viability for 24 h treated by MeOH extracts of OS and GV

Conclusion

The results of the study suggest that *Aegle marmelos* L. (Okshit; OS) bark and *Psidium*



guajava L. (Guava; GV) leaf are rich in phenolic compounds and have a good antioxidant activity. It can be used as a natural source of antioxidants to prevent the progression of many diseases. The methanolic extract of both samples also produced marked *in-vitro* anti-liver cancer activity that justifies its use in traditional system of medicine in Myanmar and other Asian countries. However, further detailed investigations are needed to ascertain the mechanisms and constituents behind its anti-liver cancer actions.

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1	Potassium (K)	90.0	3.65
2	Calcium (Ca)	9.36	3.64
3	Sulphur (S)	0.0978	-
4	Iron (Fe)	0.134	82.8
5	Phosphorus (P)	0.114	0.431
6	Chlorine (Cl)	0.0375	0.806
7	Sodium (Na)	-	3.13
8	Aluminum (Al)	-	1.23

The percent oxidative inhibition values of crude extracts measured at different concentration and the results are summarized in Table 3 and Figure 4. From these experimental results, it was found that as the concentrations increased, the absorbance values decreased i.e. increase in radical scavenging activity of crude extracts usually expressed in term of % inhibition. From the average values of % inhibition, IC_{50} (50% inhibition concentration) values in $\mu\text{g/mL}$ were calculated by linear regressive excel program.

From these results, it can be clearly seen that both samples possess significant activity (Figure 1 and 2). Among these extracts, since the lower the IC_{50} showed the higher the free radical scavenging activity.

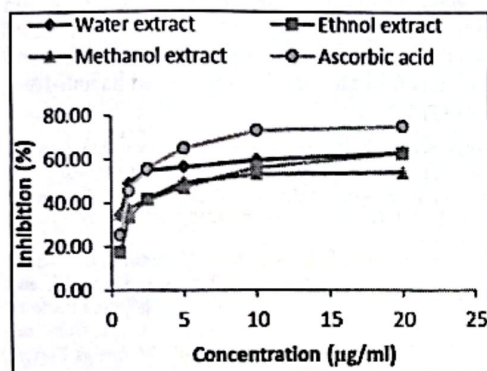


Fig 1 Plot of % oxidative inhibition Vs concentrations ($\mu\text{g/ml}$) of OS extracts

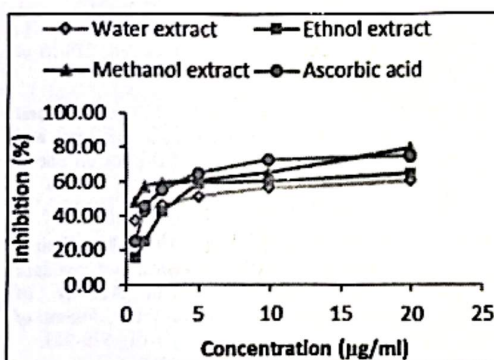


Fig 2 Plot of % oxidative inhibition Vs concentrations ($\mu\text{g/ml}$) of GV extracts

The antioxidant activity of GV ethanol extract ($IC_{50} = 3.62 \mu\text{g/ml}$) was found to be most potent and followed by GV methanol extract ($IC_{50} = 3.75 \mu\text{g/ml}$), GV aqueous extract ($IC_{50} = 4.48 \mu\text{g/ml}$), OS methanol extract ($IC_{50} = 5.81 \mu\text{g/ml}$), OS aqueous extract ($IC_{50} = 7.24$

$\mu\text{g/ml}$), and OS ethanol extract ($IC_{50} = 12.21 \mu\text{g/ml}$) (Figure 3 and 4).

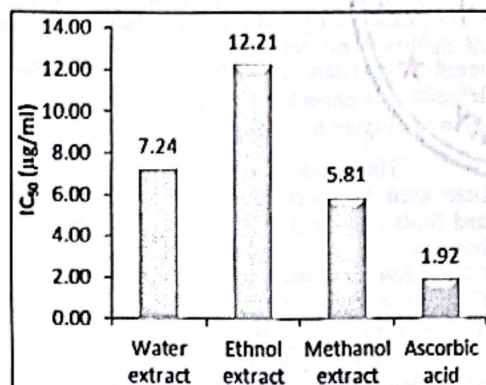


Fig 3 A bar graph of IC_{50} values of OS extracts

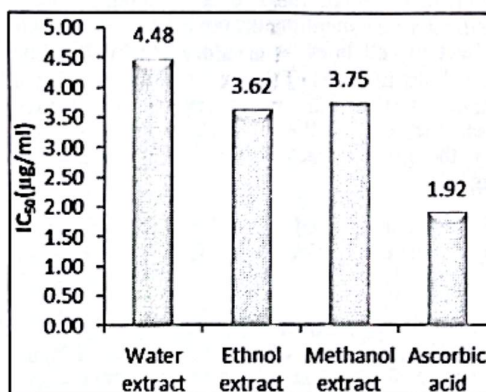
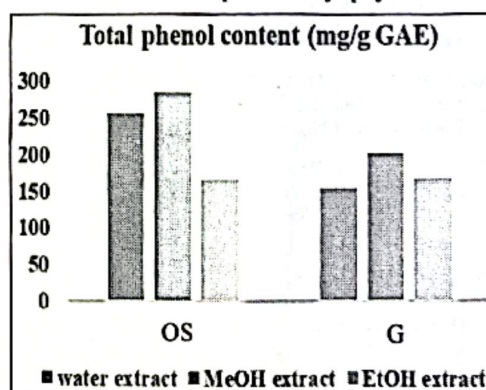


Fig.4 A bar graph of IC_{50} values of GV extracts

The total phenolic content expressed in terms of GAE and yield (%) of OS extract (water, methanol and ethanol) was found to be $(257.2 \pm 1.79; 284.4 \pm 2.88$ and 165.4 ± 1.56 mg of GAE/g). For GV sample, total phenol contents are calculated as $(154.8 \pm 3.91; 201.64 \pm 4.32$ and 167.6 ± 2.23 mg of GAE/g using the linear equation based on the calibration curve of gallic acid. The results of preliminary phytochemical



screening confirmed the presence of various classes of secondary metabolites in the sample including poly phenols (tannins and flavonoids). Plant polyphenols, produced either from phenylalanine or from its precursor shikmic acid, are important dietary antioxidants because they possess an ideal structural chemistry for free radical scavenging activity (Figure 5).