၂၀၁၈ ခုနှစ်၊ မြန်မာနိုင်ငံ ဝိဇ္ဇာနှင့်သိပ္ပံပညာရှင်အဖွဲ့ဆုရ

ပါရဂူကျမ်း

oawoevyie; tp&icpmrsm;

2018 Calendar Year, Myanmar Academy of Arts and Science Award Winning

Doctoral Dissertation

Research Reports

၂၀၂၀ ပြည့်နှစ်၊ အောက်တိုဘာလ

2020 October

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မာတိကာ

t rmpm

ပညာရေးသည် ပုဂ္ဂိုလ် တစ်ဦးချင်းနှင့် မိသားစု တစ်စုလုံး၏ ကျန်းမာရေးကို မြှင့်တင်ပေးရုံသာမက၊ ဝင်ငွေကို တိုးပွားစေသည့်အပြင်၊ လူမှုအစုအဖွဲ့များအကြားခွဲလည်း လူမှုဆက်ဆံရေး၊ ပြည်တွင်း ငြိမ်းချမ်းရေး၊ နိုင်ငံတော်၏ စီးပွားရေးနှင့် အမျိုးသား စည်းလုံးညီညွတ်ရေး အစရှိသည့် လုပ်ငန်းတို့ကို ဖွံ့ဖြိုးတိုးတက်စေရာတွင် အဓိက အခန်းကဏ္ဍမှ ပါဝင်နေပါသည်။

နိုင်ငံတော်က မြန်မာနိုင်ငံ၏ ပညာရေးအဆင့်အတန်းကို အာဆီယံ အဖွဲ့ဝင် နိုင်ငံများ၏ အဆင့်အတန်းမှသည် ကမ္ဘာ့ဖွံ့ဖြိုးပြီးနိုင်ငံကြီးများ၏ အဆင့်အတန်း မီသည်အထိ မြှင့်တင်ပေးသွားရန် ရည်မှန်းထားပါသည်။ ပညာရေးဝန်ကြီးဌာနအနေဖြင့် ဤရည်မှန်းချက် အထမြောက်စေရေးအတွက် အမျိုးသားပညာရေး မဟာဗျူဟာစီမံကိန်း (၂၀၁၆–၂၀၂၁)ကို ရေးဆွဲချမှတ်၍ အကောင်အထည်ဖော်ဆောင်ရွက်လျက်ရှိပါသည်။

အမျိုးသားပညာရေးဥပဒေကို ပြင်ဆင် သည့်ဥပဒေ (၂၀၁၅)၊ စာမျက်နှာ (၁၃)၊ ပုဒ်မ (၂၈) တွင် သုတေသန ဆောင်ရွက်မှုနှင့်စပ်လျဉ်း၍ အဆင့်မြင့်ပညာ သင်ကြားပို့ချနေသော တက္ကသိုလ် ကောလိပ်များအား သုတေသနနှင့် ပညာရပ်ဖွံ့ဖြိုးမှုကို ဦးစားပေး ဆောင်ရွက်ရမည်ဟု ပြဋ္ဌာန်းထားပါသည်။

နိုင်ငံတော်အစိုးရက မြန်မာနိုင်ငံ ဝိဇ္ဇာနှင့်သိပ္ပံပညာရှင်အဖွဲ့ကို ၁၉၉၉ ခုနှစ်၊ ဩဂုတ်လ (၁၆)ရက်နေ့တွင် ဖွဲ့စည်းပေးခဲ့ပါသည်။ ဤပညာရှင်အဖွဲ့အနေဖြင့် ပညာရေးနှင့် နီးနွယ်သော လုပ်ငန်းများကို–

(က) သင်ကြားရေးနှင့်သင်ယူရေး၊

(ခ) သုတေသန လုပ်ငန်းလမ်းညွှန်မှု ပေးရေး၊

(ဂ) ပညာပြန့်ပွားရေးနှင့်ပညာဖြန့်ဖြူးရေး၊

(ဃ) ပညာရှင်များ ပြုစုပျိုးထောင်ရေးဟူ၍ လုပ်ငန်းကြီးလေးမျိုး ခွဲခြားကာ၊

ပညာရေးကဏ္ဍ၏ လိုအပ်ချက်များအရ ဦးစားပေးအစီအစဉ်အတိုင်း ပြည်တွင်းပြည်ပ ပညာရှင် များနှင့် ပူးပေါင်းဆောင်ရွက်လျက်ရှိပါသည်။

၂၀၁၉ ခုနှစ်အထိ နှစ်ပေါင်းနှစ်ဆယ်အတွင်း၌ သုတေသနစာတမ်းဖတ်ပွဲများကို ပညာရှင်အဖွဲ့စတင်ဖွဲ့စည်းချိန် ၁၉၉၉ ခုနှစ်မှစတင်၍ နှစ်စဉ် ကျင်းပ ပေးလျက်ရှိပါသည်။ ၂၀၀၅ ခုနှစ် ပဉ္စမအကြိမ် သုတေသန စာတမ်းဖတ်ပွဲမှ အစပြု၍ taumi;q; oawoepmwr;q(Best Paper Award)ကို ချီးမြှင့်ခဲ့ရာ၊ တစ်နှစ်ထက်တစ်နှစ် ဆုရစာတမ်းများ၏ အရေအတွက် ပိုမို၍ တိုးပွားလာခဲ့ပါသည်။ ၂၀၁၉ ခုနှစ် သုတေသန ညီလာခံ၌ အကောင်းဆုံး သုတေသနစာတမ်းဆုရ စာတမ်းရှင် စုစုပေါင်း (၃၂)ဦး အား ဆုများ ချီးမြှင့်နိုင်ခဲ့ပါသည်။

သုတေသနလုပ်ငန်းများပေါ် အခြေခံ၍ ပါရဂူကျမ်းပြုစုခဲ့သော ပညာရှင်များအနက် ထူးချွန်သူများအား ရွေးချယ်၍ jrermEii 0ZmEioyynm&itzdq ချီးမြှင့်ရန် ပညာရှင်အဖွဲ့ အနေဖြင့် ကြိုးပမ်းခဲ့ပါသည်။ ၂၀၁၈ ခုနှစ်အတွင်း၌ ပါရဂူဘွဲ့ ရရှိခဲ့သူများအား ပြိုင်ပွဲဝင်ရန် ပညာရှင် အဖွဲ့မှ ဖိတ်ခေါ်ခဲ့ရာ၊ ပါရဂူဘွဲ့ရ ပညာရှင် စုစုပေါင်း (၄၆)ဦး ယှဉ်ပြိုင်ခဲ့ကြပါသည်။ ဘာသာရပ်တိုင်း၌ ပညာရှင်အဖွဲ့ဆု၏ အရေအတွက်နှင့်အတူ ဆုငွေ၏ ပမာဏကိုလည်း တိုးမြှင့်ပေးအပ်သွားရန် အဖွဲ့က

ကြိုးစားနေပါသည်။ ပညာရှင်အဖွဲ့ဆု အစပျိုးချိန်တွင် ပညာရှင်အဖွဲ့၊ ထွန်းဖောင်ဒေးရှင်း၊ သီရိမွန်ဖောင်ဒေးရှင်းတို့၏ လှူဒါန်းငွေဖြင့် ဆုများကိုချီးမြှင့်ခဲ့ပါသည်။ ယခုအခါ

(က) မြန်မာနိုင်ငံစာစစ်အဖွဲ့ ဥက္ကဋ္ဌ(ငြိမ်း) ဦးမောင်မောင်စိန် နှင့်ဇနီး ဒေါ်ခင်မာမာတို့က ရန်ကုန်တက္ကသိုလ် ပါမောက္ခချုပ် ဆရာကြီး ဒေါက်တာ ထင်အောင် အထိမ်းအမှတ်အဖြစ် လှူဒါန်းငွေ၊

(ခ) ရန်ကုန်စီးပွားရေးတက္ကသိုလ်မှ ဆရာကြီး ဦးဝီလျံပေါ အထိမ်းအမှတ်အဖြစ် လှူဒါန်းငွေ၊

(ဂ) ရန်ကုန်တက္ကသိုလ် မြန်မာစာဌာနမှ မြန်မာစာဌာန တည်ထောင်ခဲ့သည့် (၇၅)နှစ်ပြည့် အထိမ်းအမှတ်အဖြစ် လှူဒါန်းငွေနှင့်

(ဃ) ဆရာမကြီး ဒေါ်ခင်သိန်း၊ ပါမောက္ခ(ငြိမ်း)၊ အရှေ့တိုင်းပညာဌာနမှ ရန်ကုန်တက္ကသိုလ် ပါမောက္ခချုပ် ဆရာကြီး ဦးဖေမောင်တင် အထိမ်းအမှတ် အဖြစ် လှူဒါန်းငွေ

များကို ဘဏ်တွင် ပဒေသာပင်အဖြစ် အပ်နှံကာတိုးပွားလာသည့် ဘဏ်အတိုးငွေများဖြင့် ဆုငွေကို ချီးမြှင့်လျက် ရှိပါသည်။

ထိုလှူဒါန်းငွေများအပြင် သုတေသနစာတမ်းဆုနှင့် ပညာရှင်အဖွဲ့ဆု အတွက် ၂၀၁၆ ခုနှစ်၊ (၁၆)ကြိမ်မြောက် သုတေသနစာတမ်းဖတ်ပွဲမှ အစပြု၍ ပညာရေးဝန်ကြီးဌာနမှ ဆုငွေများကို ထုတ်ပေးနေပါသည်။

တက္ကသိုလ်၊ ကောလိပ်များမှ ဆရာ၊ ဆရာမများ၏ စွမ်းဆောင်ရည်သည် တစ်ဦးချင်း၏ ပညာအရည်အချင်းနှင့်အတူ မိမိတတ်ကျွမ်းသော ဘာသာရပ်၌ မိမိဆောင်ရွက်ခဲ့သော သုတေသနလုပ်ငန်းများမှ ရရှိထားသည့် အတွေ့အကြုံများ အပေါ်တွင်လည်း အများအပြား မူတည်နေပါသည်။

(၁၉)ကြိမ်မြောက် သုတေသနညီလာခံတွင် ၂၀၁၈ ခုနှစ် အတွက် မြန်မာနိုင်ငံ ဝိဇ္ဇာနှင့်သိပ္ပံပညာရှင်အဖွဲ့ဆု ရရှိခဲ့သည့် သုတေသနလုပ်ငန်း အစီရင်ခံစာများမှာ အောက်ပါအတိုင်း ဖြစ်ပါသည် –

(u) 0Zmynm&y

- သမိုင်း ဘာသာရပ်

  Royal Boatman Groups in Lower Myanmar (1752-1852)

- ပထဝီဝင် ဘာသာရပ်
  Geographical Analysis of Land Cover and Land Use Changes in Chaungzon Township
- မြန်မာစာ ဘာသာရပ်(ဘာသာဗေဒ)
  မြန်မာဘာသာစကားရှိ အပြောစကားပုံစံများ လေ့လာချက် (လူမှုဘာသာဗေဒ)

(ခ) oyynm&y

- ဓာတုဗေဒ ဘာသာရပ်

  Hydroxyapatite and Hydroxyapatite Magnesium Oxide Nanocomposites from Waste Cow Bone

- ရူပဗေဒ ဘာသာရပ်

  Implementation of Analog Signal Synthesizing System to Generate Digital Sound of Myanmar Gong

- သတ္တဗေဒ ဘာသာရပ်

  Applicability of Fish Scale Based Biomaterials in Hard Tissue Implantation

- ကုန်ထုတ်ဓာတုဗေဒ ဘာသာရပ်

  Process Development on the Production of Dry Cat Food from Fish Factory Wastes

(ဂ) vra&;yn&m&y

- ပညာရေး ဘာသာရပ်

  An Assessment of Reasoning Skills Enhancing Problem Solving Ability Among Student Teachers from Universities of Education in Myanmar

- စီးပွားရေးပညာ ဘာသာရပ်

  The Incidence of Non-Tariff Measures on Market Access for Myanmar Fishery Exports

မြန်မာနိုင်ငံဝိဇ္ဇာနှင့်သိပ္ပံပညာရှင်အဖွဲ့ဆု (၉)ဆုကို သုတေသီများအား ချီးမြှင့်နိုင်ခဲ့ပါသည်။ ပြိုင်ပွဲဝင်ခဲ့ကြသော ပါရဂူကျမ်းဆိုင်ရာ သုတေသနပြုစုသူများ အပါအဝင် တက္ကသိုလ် ဆရာ၊ ဆရာမများ နှင့် အများပြည်သူတို့ လေ့လာခွင့် ရရှိစေရန် ရည်ရွယ်၍ ဤစာအုပ်ကို ပုံနှိပ်ထုတ်ဝေ ဖြန့်ချိခြင်း ဖြစ်ပါသည်။

ဒေါက်တာသက်လွင်

ဥက္ကဋ္ဌ

မြန်မာနိုင်ငံ ဝိဇ္ဇာနှင့်သိပ္ပံပညာရှင်အဖွဲ့

FOREWORD

It cannot be denied that education plays a vital role in increasing the family income, promoting the general well-being of an individual as well as that of his family, invigorating the cooperative spirit of communities, developing the country's economy, and last but not least, contributing positively to all endeavours for national unity and peace.

Our country has been engaged vigorously in the task of enhancing the quality of education with a view to raising it from the current ASEAN standard to that of the developed countries. In order to achieve that objective, the Ministry of Education drew up the National Education Strategic Plan 2016-2021 and has since been implementing the projects under that plan.

Section 28 on page 13 of The Republic of the Union of Myanmar National Education Law (2014) stipulates that all colleges and universities under the Department of Higher Education give priority to carrying out research programmes and education development.

The Myanmar Academy of Arts and Science, instituded in 1999, is fully committed to:

1) The dissemination of modern methods and techniques of teaching and learning,
2) The promotion of research and providing guidelines for research programmes and projects,
3) The dissemination and propagation of knowledge and expertise among the general public, and
4) The promotion of measures aimed at the generation and proliferation of competent researchers, academicians and Technocrats.

Ever since its institution, the Academy has endeavoured to meet those commitments through national and international networks.

From the year 2000, a year after its inception, the Academy has been holding Annual Research Conferences, and from the Fifth Annual Research Conference onwards, the Academy commenced bestowing the Best Paper Award. The number of quality research papers has increased from year to year; it is most gratifying to find that a total of 32 researchers won the Best Paper Award at the 2019 Research Conference.

In 2006, the Academy initiated a nationwide Contest of Research Reports of doctoral theses in various fields of study, with a view to bestow the Myanmar Academy of Arts and Science Award to the best researcher of the year; there was a total of 120 contestants. Currently, the Academy is making an all-out effort to raise the prize money in order that there would be more and more research aspirants in every field of study. The initial Academy of Arts and Science Awards were borne by the Academy, the Tun Foundation and the Thiri-mon Foundation. Today, donations made by:

a) Retired President of the Board of Examinations U Maung Maung Sein and his spouse in commemoration of Sayagyi Dr Htin Aung, Rector of Rangoon University
b) Yangon University of Economics in commemoration of Sayagyi Saw William Paw
c) Department of Myanmar, University of Yangon, in commemoration of its 75th anniversary, and
d) Sayamagyi Daw Khin Thein, Retired Professor of the Department of Oriental Studies, University of Yangon in commemoration of Sayagyi U Pe Maung Tin

have been established as a Foundation and the bank interest accrued upon it is used as the means to meet the expenses of the awards.

In addition, since 2017, the Ministry of Education has been sponsoring the Best Paper Award as well as the Myanmar Academy of Arts and Science Award.

The ability of an academician is commensurate not only with his or her educational accomplishments but also with the knowledge he or she gains from the research projects he or she carries out.

The best research report of doctoral theses for the year 2018 are:

(a) Arts

- **History**
  Royal Boatman Groups in Lower Myanmar (1752-1852)
- **Geography**
  Geographical Analysis of Land Cover and Land Use Changes in Chaungzon Township
- **Myanmar (Language)**
  မြန်မာဘာသာစကားရှိ အပြောစကားပုံစံများ လေ့လာချက် (လူမှုဘာသာဗေဒ)

(b) Physical Sciences

- **Chemistry**
  Hydroxyapatite and Hydroxyapatite Magnesium Oxide Nanocomposites from Waste Cow Bone
- **Physics**
  Implementation of Analog Signal Synthesizing System to Generate Digital Sound of Myanmar Gong
- **Zoology**
  Applicability of Fish Scale Based Biomaterials in Hard Tissue Implantation
- **Industrial Chemistry**

  Process Development on the Production of Dry Cat Food from Fish Factory Wastes

(c) Social Science

- **Educational Psychology**

  An Assessment of Reasoning Skills Enhancing Problem Solving Ability Among Student Teachers from Universities of Education in Myanmar

- **Economics**

  The Incidence of Non-Tariff Measures on Market Access for Myanmar Fishery Exports

All the Nine authors of those Research Reports of doctoral theses were awarded the Myanmar Academy of Arts and Science Award. The Myanmar Academy of Arts and Science is delighted to publish this book for the benefit of the Contestants concerned, the academicians in the universities and colleges as well as the general public.

President

Myanmar Academy of Arts and Science

1/ / 2018 cEp? jrermEi 0ZmEi oyyn m½i t z l q Ei E;E , aom y&*u s r; oawoe vyie; t p&icpm a&;c s , r

&n& , c u

၁။ မြန်မာနိုင်ငံ ဝိဇ္ဇာနှင့်သိပ္ပံပညာရှင်အဖွဲ့၊ အခြေခံစည်းမျဉ်းများ အခန်း(၂)၊ အပိုဒ် (၃) တွင် ပါရှိသည့် ရည်ရွယ်ချက် (၅)ရပ်အနက် –

(၁) နိုင်ငံတော်ကို အကျိုးပြုမည့် သုတေသနလုပ်ငန်းများ ဆောင်ရွက်ရန်နှင့်

(၂) နိုင်ငံတော်ကိုအကျိုးပြုမည့် ဝိဇ္ဇာသိပ္ပံပညာရှင်များ မွေးထုတ်နိုင်ရေးအတွက် စီမံဆောင်ရွက်ရန်၊

တို့ပါရှိပါသည်။

qay; t yc s ;j r i r

၂။ မြန်မာနိုင်ငံ ဝိဇ္ဇာနှင့်သိပ္ပံပညာရှင်အမှုဆောင်အဖွဲ့၏ စတုတ္ထလုပ်ငန်းအဖွဲ့ဖြစ်သော **ပညာရှင်ပြုစု ပျိုးထောင်ရေးအဖွဲ့**က ချမှတ်ထားသည့် လုပ်ငန်းစဉ် (၁၄)ရပ်အနက်၊ လုပ်ငန်းစဉ် (၆)တွင် ဝိဇ္ဇာနှင့်သိပ္ပံပညာရပ်ဆိုင်ရာ ကျမ်းများ၊ စာအုပ်များအနက်မှ အကောင်းဆုံးကို "ဝိဇ္ဇာနှင့်သိပ္ပံဘာသာ စာပေဆု" ချီးမြှင့်ရန် ပါရှိပါသည်။ အဆိုပါဆုကို **မြန်မာနိုင်ငံ ဝိဇ္ဇာနှင့်သိပ္ပံပညာရှင်အဖွဲ့ဆု** အနေဖြင့် ထိုက်လျောက်စွာ ပေးအပ်ချီးမြှင့်ရန် ရည်ရွယ်ခြင်း ဖြစ်ပါသည်။

p owrwc s u

၃။ "မြန်မာနိုင်ငံ ဝိဇ္ဇာနှင့်သိပ္ပံပညာရှင်အဖွဲ့ဆု" ရွေးချယ်ရေးအတွက် ယေဘုယျ သတ်မှတ်ထားသော စံများမှာ အောက်ပါအတိုင်းဖြစ်ပါသည်–

(က) ပြည်ထောင်စုသမ္မတ မြန်မာနိုင်ငံတော်၊ ပညာရေးဝန်ကြီးဌာနအောက်ရှိ တက္ကသိုလ်များတွင် **သတ်မှတ်ထားသည့်ခုနှစ်အတွင်း** တင်သွင်း လက်ခံခဲ့သော **ပါရဂူကျမ်း** ဖြစ်ရမည်။

(ခ) နိုင်ငံတော်နှင့်လူမျိုးအတွက် အသိညာဏ် တိုးတက်စေရန်(သို့မဟုတ်) အသိညာဏ်ကို အသုံးချနိုင်စေရန် (သို့မဟုတ်) သက်ဆိုင်ရာ ဘာသာရပ် ဖွံ့ဖြိုးတိုးတက်စေရန် ထူးခြားစွာ အကျိုးပြုစေနိုင်သည့် ပါရဂူကျမ်းဖြစ်ရမည်။

(ဂ) "မြန်မာနိုင်ငံ ဝိဇ္ဇာနှင့်သိပ္ပံပညာရှင် အဖွဲ့ဆု" အတွက် မိမိ၏ပါရဂူကျမ်းကို အခြေခံ၍ စာမျက်နှာ(၂၀–၃၀)ခန့်ရှိ သုတေသနလုပ်ငန်း အစီရင်ခံစာ (Research Report) ပြုစု ရေးသား တင်သွင်းရမည်။

(ဃ) မူပိုင်ကိစ္စနှင့်စပ်လျဉ်း၍ ရှင်းရှင်းလင်းလင်း ရှိစေရမည်။

(င) ၂၀၁၈ ခုနှစ် အတွင်း ပညာရေးဝန်ကြီးဌာန အောက်ရှိ တက္ကသိုလ်များတွင် ထုတ်ပြန်သော **ပါရဂူကျမ်း အောင်စာရင်းတွင်** ပါရှိကြောင်း **သက်ဆိုင်ရာ ပါရဂူဘွဲ့ ရယူခဲ့သည့် တက္ကသိုလ်၏ မော်ကွန်းထိန်းထံမှ** ထောက်ခံချက် ပါရှိရမည်။

a&;cs , a&; t z| zlpn;jci;

၄။ "မြန်မာနိုင်ငံ ဝိဇ္ဇာနှင့်သိပ္ပံပညာရှင်အဖွဲ့.ဆု" ရွေးချယ်ရေးအဖွဲ့.များကို အကဲဖြတ်နိုင်မည့် ပညာရှင်များဖြင့် ဖွဲ့.စည်း၍ ရွေးချယ်ခြင်းဖြစ်ပါသည်။

၅။ သုတေသနလုပ်ငန်းအစီရင်ခံစာကို အောက်ဖော်ပြပါ မူ (၅)ရပ်အပေါ်တွင် အခြေခံ၍ အကဲဖြတ် ရွေးချယ်ပါသည်–

(က) သုတေသနလုပ်ငန်းသည် နိုင်ငံတော်အတွက် မည်၍ မည်မျှအကျိုးပြုခြင်း (Contribution to the National Interest)

(ခ) သုတေသနလုပ်ငန်းသည် ပင်ကို ဖြစ်ခြင်း (Originality)

(ဂ) သုတေသနလုပ်ငန်းကို စနစ်တကျ/သိပ္ပံနည်းကျ ဆောင်ရွက်ထားခြင်း (Systematic/ Scientific Approach)

(ဃ) သုတေသနလုပ်ငန်းသည် ဘာသာရပ်အတွက် မည်သည့်အတိုင်းအတာအထိ အကျိုးပြုနိုင်ခြင်း (Contribution to the Subject)

(င) သုတေသနအစီရင်ခံစာ ဖတ်ကြား တင်ပြပုံ စနစ်ကျခြင်း (Presentation, Format and Style)

qcs;jrijci;

၆။ "မြန်မာနိုင်ငံ ဝိဇ္ဇာနှင့်သိပ္ပံပညာရှင်အဖွဲ့.ဆု" ချီးမြှင့်ပေးအပ်ရာတွင် –

(က) အဆိုပြုလာသော ဝိဇ္ဇာဘာသာရပ်ဆိုင်ရာ ပါရဂူကျမ်းများအနက်၊ အကောင်းဆုံး ဝိဇ္ဇာပညာရပ် ပါရဂူကျမ်းနှင့် သုတေသနလုပ်ငန်းအစီရင်ခံစာ ပြုစုသောပုဂ္ဂိုလ်အား ပညာရှင်အဖွဲ့.၏ဆုကို **ဝိဇ္ဇာနှင့်သိပ္ပံပညာရှင်အဖွဲ့.ဆု (ဝိဇ္ဇာပညာရပ်)** ဟူ၍ လည်းကောင်း၊

(ခ) အဆိုပြုလာသော သိပ္ပံဘာသာရပ်ဆိုင်ရာ ပါရဂူကျမ်းများအနက်၊ အကောင်းဆုံး သိပ္ပံပညာရပ်ပါရဂူကျမ်းနှင့် သုတေသနလုပ်ငန်းအစီရင်ခံစာ ပြုစုသော ပုဂ္ဂိုလ်အား ပညာရှင်အဖွဲ့.၏ဆုကို **ဝိဇ္ဇာနှင့်သိပ္ပံပညာရှင်အဖွဲ့.ဆု (သိပ္ပံပညာရပ်)**ဟူ၍ လည်းကောင်း၊

(ဂ) အဆိုပြုလာသော လူမှုရေး (စီးပွါးရေးပညာ၊ သင်ပြမှု/သင်ယူမှုပညာ၊ ဥပဒေပညာ၊ ဘာသာစကားစသည့်) ဘာသာရပ်ဆိုင်ရာ ပါရဂူကျမ်းများ အနက်၊ အကောင်းဆုံး လူမှုရေးပညာရပ်ပါရဂူကျမ်းနှင့် သုတေသနလုပ်ငန်းအစီရင်ခံစာ ပြုစုသောပုဂ္ဂိုလ်အား ပညာရှင်အဖွဲ့.၏ဆုကို **ဝိဇ္ဇာနှင့်သိပ္ပံပညာရှင်အဖွဲ့.ဆု (လူမှုရေးပညာရပ်)**ဟူ၍ လည်းကောင်း

ဆု (၃)မျိုး ခွဲခြား၍ ချီးမြှင့် ပေးအပ်ခြင်း ဖြစ်ပါသည်။

rwcsl ။ ဆု တစ်ဆုစီအတွက် အကောင်းဆုံးဟု ယူဆထားသော ပါရဂူကျမ်း အကယ်၍ မရှိပါက ထိုဆုအတွက် ချီးမြှင့်မည် မဟုတ်ပါ။

၇။ ၂၀၁၈ ခုနှစ်၊ (၁၃)ကြိမ်မြောက် "မြန်မာနိုင်ငံဝိဇ္ဇာနှင့်သိပ္ပံပညာရှင် အဖွဲ့.ဆု"အတွက် ပြိုင်ပွဲဝင်သည့် ပါရဂူဘွဲ့.ရပညာရှင် စုစုပေါင်း (၄၆)ဦး ရှိခဲ့.ရာ၊ အောက်ဖော်ပြပါ (၉) ဦးတို့သည် "မြန်မာနိုင်ငံ ဝိဇ္ဇာနှင့်သိပ္ပံပညာရှင် အဖွဲ့.ဆု" ကို –

(၁) **ဝိဇ္ဇာပညာရပ်**မှ သမိုင်း ဘာသာရပ်တွင် ဒေါက်တာ မြဖြူမိုး၊ ပထဝီဝင် ဘာသာရပ်တွင် ဒေါက်တာ ခင်တိုးတိုးလွင်၊ မြန်မာစာ ဘာသာရပ်တွင် ဒေါက်တာ စိုင်းမောင်မောင်မြင့်တို့က လည်းကောင်း၊

(၂) **သိပ္ပံပညာရပ်**မှ ဓာတုဗေဒ ဘာသာရပ်တွင် ဒေါက်တာ ချိုလွင်လွင်ခိုင်၊ ရူပဗေဒဘာသာရပ်တွင် ဒေါက်တာ သိန်းထွန်းဦး၊ သတ္တဗေဒ ဘာသာရပ်တွင် ဒေါက်တာ လဲ့လဲ့အေး၊ နှင့် ကုန်ထုတ်ဓာတုဗေဒ ဘာသာရပ်တွင် ဒေါက်တာ ကြိုင်သူဇာမွန်တို့က လည်းကောင်း၊

(၃) **လူမှုရေးပညာရပ်**မှ ပညာရေးစိတ်ပညာ ဘာသာရပ်တွင် ဒေါက်တာ ရာဇာချစ်နှင့် စီးပွားရေး ဘာသာရပ်တွင် ဒေါက်တာ ဇင်ဇင်နိုင်က လည်းကောင်း၊

အသီးသီး ရရှိကြပါသည်။

၈။ အဆိုပါ "မြန်မာနိုင်ငံ ဝိဇ္ဇာနှင့်သိပ္ပံပညာရှင်အဖွဲ့ဆု" ချီးမြှင့်ရာ၌ ပါရဂူကျမ်းနှင့် သုတေသနလုပ်ငန်းအစီရင်ခံစာများအပေါ်တွင် အခြေပြု၍ အရွေးချယ်ခံရသည့်အကြောင်းရင်း တို့ကို အောက်တွင် အကျဉ်းချုပ်၍ ဖော်ပြထားပါသည်–

(၈–၁) 0Zm ynm&y (1) - သမိုင်း ဘာသာရပ်
ဒေါက်တာ မြဖြူမိုး
လက်ထောက်ကထိက၊
သမိုင်းဌာန၊ ရန်ကုန်နိုင်ငံခြားဘာသာ တက္ကသိုလ်

ကျမ်းခေါင်းစဉ် – **Royal Boatman Groups in Lower Myanmar (1752-1852)**

(က) **ဝိဇ္ဇာပညာရပ်**တွင်ပညာရှင်အဖွဲ့ ဆုရသူသုံးဦးအနက် ဒေါက်တာ မြဖြူမိုးသည် ၂၀၁၈ ခုနှစ်တွင် ရန်ကုန်တက္ကသိုလ်မှ **သမိုင်းဘာသာရပ်** ဖြင့် ပါရဂူဘွဲ့ ရရှိခဲ့သူ ဖြစ်ပါသည်။

(ခ) ဒေါက်တာ မြဖြူမိုးသည် –

- ဤပါရဂူကျမ်း သုတေသနသည် Social History အတွက် အထောက်အကူပြုခြင်း၊ ပင်ကိုယ် သုတေသနဖြစ်ခြင်း၊ တွေ့ရှိချက် အသစ်များကို တင်ပြရာတွင် ရေးသားတင်ပြချက်များ ရှင်းလင်းခြင်း၊ ခြုံငုံသုံးသပ်ချက်များလည်း ပါဝင်သဖြင့် ပညာရပ်ကို အထောက်အကူပြုကြောင်း တွေ့ရှိရခြင်း

တို့ကြောင့် **ဝိဇ္ဇာပညာရပ်ဆိုင်ရာ** မြန်မာနိုင်ငံ ဝိဇ္ဇာနှင့်သိပ္ပံပညာရှင် အဖွဲ့ဆုအတွက် ရွေးချယ်ခဲ့ခြင်း ဖြစ်ပါသည်။

(၈–၂) 0Zm ynm&y(2) - ပထဝီဝင် ဘာသာရပ်
ဒေါက်တာခင်တိုးတိုးလွင်
ကထိက၊ ပထဝီဝင်ဌာန၊
ဘားအံတက္ကသိုလ်

ကျမ်းခေါင်းစဉ် – **Geographical Analysis of Land Cover and Land Use Changes in Chaungzon Township**

(က) **ဝိဇ္ဇာပညာရပ်**တွင် ပညာရှင်အဖွဲ့.ဆုရသူ သုံးဦးအနက် ဒေါက်တာ ခင်တိုးတိုးလွင် သည် ၂၀၁၈ ခုနှစ်တွင် ရန်ကုန်တက္ကသိုလ်မှ **ပထဝီဝင် ဘာသာရပ်** ဖြင့် ပါရဂူဘွဲ့ ရရှိခဲ့သူဖြစ်ပါသည်။

(ခ) ဒေါက်တာ ခင်တိုးတိုးလွင်သည် –

- ဤပါရဂူကျမ်းသည် ၁၉၉၀ မှ ၂၀၁၅ နှစ်များအတွင်း Land Use and Land Cover ပြောင်းလဲမှုကို GIS and RS နည်းဖြင့် စနစ်တကျ တင်ပြထားပါသဖြင့် နိုင်ငံ၏ လူမှုစီးပွားဘဝကို အကျိုးပြုသည့် စာတမ်းဖြစ်သည်။
- Land Use and Land Cover Changes ကိုဖြစ်ပေါ်စေသည့် အကြောင်းရင်းများနှင့် အကျိုးဆက်များကို အသေးစိတ် ပြုစုတွက်ချက် ဖော်ထုတ်ပေးထားသည်ကို တွေ့.ရှိရပါသည်။
- ကမ်းရိုးတန်း တိုက်စားမှု၊ ပို့ချမှုများကို တွက်ချက်ပြီး၊ ကမ်းရိုးတန်းပုံသဏ္ဌာန် ပြောင်းလဲမှုများကို မြေပုံနှင့်တကွ ရှင်းလင်းတင်ပြထားသောကြောင့် နောင်အနာဂတ်တွင် ဖြစ်ပေါ်လာနိုင်သည့် အနေအထားကို သိပ္ပံနည်းကျ ထားသည့်ကို တွေ့.ရပါသည်။ ထို့အပြင် ဒေသဆိုင်ရာ ဖွံ့ဖြိုးမှု လုပ်ငန်းရပ်များတွင်များစွာ အထောက်အကူပြုမည့် ကျမ်းဖြစ်သည်ကိုလည်း တွေ့.ရှိရခြင်း၊

တို့.ကြောင့် **ဝိဇ္ဇာပညာရပ်ဆိုင်ရာ** မြန်မာနိုင်ငံ ဝိဇ္ဇာနှင့်သိပ္ပံပညာရှင်အဖွဲ့.ဆု အတွက် ရွေးချယ်ခဲ့ခြင်း ဖြစ်ပါသည်။

(၈–၃) 0Zm ynm&y(3) - မြန်မာစာ(ဘာသာဗေဒ)ဘာသာရပ်
ဒေါက်တာ စိုင်းမောင်မောင်မြင့်
လက်ထောက်ကထိက၊
မြန်မာစာဌာန၊ စစ်တက္ကသိုလ်

ကျမ်းခေါင်းစဉ် – jrermbmom pum;& tajympum;yprsm; avvmcsu

(က) **ဝိဇ္ဇာပညာရပ်**တွင် ပညာရှင်အဖွဲ့.ဆုရသူ သုံးဦးအနက် ဒေါက်တာ စိုင်းမောင်မောင်မြင့် သည် ၂၀၁၈ ခုနှစ်တွင် မန္တလေးတက္ကသိုလ်မှ **မြန်မာစာ ဘာသာရပ်** ဖြင့် ပါရဂူဘွဲ့ ရရှိခဲ့သူဖြစ်ပါသည်။

(ခ) ဒေါက်တာ စိုင်းမောင်မောင်မြင့်၏ သုတေသနသည် –

- မြန်မာဘာသာစကားတွင် လူမှုဆက်ဆံရေးခွဲသုံးသည့် အပြောစကားပုံစံများ အကြောင်းကို ကိုယ်ပိုင် သုတေသန အဖြစ် ပြုစုထားသည့် အတွက် နိုင်ငံအကျိုးပြုပါသည်။
- မျက်မှောက်ခေတ် မြန်မာ့လူမှုနယ်ပယ်အတွင်း အသုံးပြုနေသည့် မြန်မာစကား အပြောပုံစံကို ကွင်းဆင်းလေ့လာထားသောကြောင့် အသစ်တီထွင်မှု ဖြစ်သည်။
- သိပ္ပံနည်းကျ စံနစ်တကျ လေ့လာထားသဖြင့် အထောက်အထားခိုင်မာပြီး စနစ်တကျသော ကျမ်းတစ်ဆောင်ဟု ဆိုနိုင်ပါသည်။ ထို့အပြင် မြန်မာဘာသာ

စကားလေ့လာမှုအတွက် အထောက်အပံ့ဖြစ်ခြင်းနှင့် အရေးအသား တင်ပြပုံ ကောင်းမွန်စနစ်ကျသဖြင့် မြန်မာဘာသာစကား လေ့လာသူတို့အတွက် အကျိုးပြုသော ကျမ်းဖြစ်ခြင်း၊

တို့ကြောင့် **ဝိဇ္ဇာပညာရပ်ဆိုင်ရာ** မြန်မာနိုင်ငံ ဝိဇ္ဇာနှင့်သိပ္ပံပညာရှင်အဖွဲ့ဆု အတွက် ရွေးချယ်ခဲ့ခြင်း ဖြစ်ပါသည်။

(၈-၄) oy yn&y(1) - ဓာတုဗေဒ ဘာသာရပ်
ဒေါက်တာ ချိုလွင်လွင်ခိုင်
လက်ထောက်ကထိက၊ ဓာတုဗေဒဌာန
ရန်ကုန်တက္ကသိုလ်

ကျမ်းခေါင်းစဉ် – **Hydroxyapatite and Hydroxyapatite-Magnesium Oxide Nanocomposites from Waste Cow Bone**

(က) **သိပ္ပံ ပညာရပ်**တွင် ပညာရှင်အဖွဲ့ဆု ရသူ လေးဦးအနက် ဒေါက်တာ ချိုလွင်လွင်ခိုင်

သည် ၂၀၁၈ ခုနှစ်တွင် ရန်ကုန်တက္ကသိုလ်မှ **ဓာတုဗေဒ ဘာသာရပ်** ဖြင့် ပါရဂူဘွဲ့ ရရှိခဲ့သူ ဖြစ်ပါသည်။

(ခ) ဒေါက်တာ ချိုလွင်လွင်ခိုင် ၏ သုတေသနသည် –

- ဤပါရဂူကျမ်းသည် စွန့်ပစ်နွားရိုးမှ၊ အရိုးအက်ခြင်း၊ အရိုးကျိုးသည်တို့ကို ကုစားရာတွင် အသုံးပြုနိုင်မည် Hydroxyapetite -Hydroxyapetite-Magnesium oxide တို့ကို ဓာတ်ခွဲခန်းတွင်း၌ ထုတ်လုပ်ကာ၊ လေ့လာထားသည့် သုတေသနဖြစ်သည်။ ကနဦးရရှိသည့် နွားရိုးကို ဓာတုဗေဒ နည်းစဉ်များဖြင့် အပူချိန် အနိမ့်အမြင့်တွင် အဆင့်ဆင့် သန့်စင်ခြင်း၊ နောက်ဆုံးအဆင့်၌ အဆင့်မြင့်နည်းများဖြင့် ဓာတ်ခွဲစမ်းသပ်ခြင်းတို့ကို ပြုလုပ်ထားကြောင်း၊ ဒုတိယအဆင့်တွင် Magnesium Oxide နာနိုအမှုန့်များ ထုတ်လုပ်ခြင်း၊ သန့်စင်ပြီး Hydroxyapetites နှင့် ရောစပ်ခြင်း၊ အပူချိန် အမျိုးမျိုး၌ hydroxyapetite-Magnesium Oxide နာနိုပေါင်းစပ် (nanocomposite) များကို ပြုလုပ်ထားကြောင်း တွေ့ရှိရပါသည်။ ထိုသို့ပြုလုပ်ထားသည့် Hydroyapetite- MgO ကို Microorganism ၆ မျိုးဖြင့် စမ်းသပ်ခြင်း၊ Protein Adsorption test နှင့် Homolysis test များဖြင့် စမ်းသပ်ရာတွင်၊ ဇီဝသဘောအရ သဟဇာတဖြစ်ကြောင်းကိုလည်း တွေ့ရှိရပါသည်။ Wistar ကြွက်များဖြင့် သမ်းသပ်ရာတွင် အရိုးဆက်နိုင်သည့် ဂုဏ်သတ္တိရှိကြောင်း၊ ထို့ကြောင့် Hydroxyapetite-MgO နာနိုပေါင်းစပ် ပစ္စည်းကို အရိုးကျိုး အရိုးဆက်သည့် ဒဏ်ရာ ကုစားမှုတွင် အဖြည့်ခံပစ္စည်း အဖြစ် အသုံးပြုနိုင်ကြောင်း ခြုံငုံ သုံးသပ်ထားသည်ကို တွေ့ရှိရခြင်း၊

တို့ကြောင့် **သိပ္ပံပညာရပ်ဆိုင်ရာ** မြန်မာနိုင်ငံ ဝိဇ္ဇာနှင့်သိပ္ပံပညာရှင်အဖွဲ့ဆု အတွက် ရွေးချယ်ခဲ့ခြင်း ဖြစ်ပါသည်။

(၈–၅) oy yn&y(2) - ရူပဗေဒဘာသာရပ်
ဒေါက်တာ သိန်းထွန်းဦး
ကထိက၊ ရူပဗေဒဌာန၊
ကလေးတက္ကသိုလ်

ကျမ်းခေါင်းစဉ် – **Implementation of Analog Signal Synthesizing System to Generate Digital Sound of Myanmar Gong**

(က) **သိပ္ပံပညာရပ်**တွင် ပညာရှင်အဖွဲ့ဆုရသူ လေးဦးအနက် ဒေါက်တာ သိန်းထွန်ဦး သည် ၂၀၁၈ ခုနှစ်တွင် မန္တလေးတက္ကသိုလ်မှ **ရူပဗေဒ ဘာသာရပ်** ဖြင့် ပါရဂူဘွဲ့ရရှိခဲ့သူ ဖြစ်ပါသည်။

(ခ) ဒေါက်တာ သိန်းထွန်းဦး ၏ သုတေသနသည် –

- ဤပါရဂူကျမ်း သုတေသနသည် မြန်မာ့မောင်း၏ (c-note) စီသံစဉ်ကို ဒီဂျစ်တယ်စနစ် (Digital System)ဖြင့် တည်ဆောက်ရန် ရည်ရွယ်သည့် စမ်းသပ်ချက် သုတေသနဖြစ်ပါသည်။ အသံလှိုင်းတို့၏ ရူပဗေဒ သဘော တရားကို အခြေပြုကာ အရည်အသွေး စံချိန်မီသည့် သံစဉ်ရရန် Digital Signal Processing ကို အသုံးပြုထားကြောင်း၊ ထိန်းချုပ် ပရိဂရမ်ကုဒ်(Control Program Code) ကို တီထွင်ဖန်တီးရေးသား အသုံးပြုထားသည်ကို တွေ့ရကြောင်း၊ ထို့ကြောင့် မြန်မာ့ တူရိယာအတွက် ဆန်းသစ်တီထွင်မှုပါသော ရှေ့ပြေး ဤသုတေသနကျမ်းသည်၊ မြန်မာ့ တူရိယာအတွက် တစ်ခေတ် ဆန်းစေမည့် သုတေသနဟု သတ်မှတ်နိုင်ခြင်း၊

တို့ကြောင့် **သိပ္ပံပညာရပ်ဆိုင်ရာ** မြန်မာနိုင်ငံ ဝိဇ္ဇာနှင့်သိပ္ပံပညာရှင်အဖွဲ့ဆု အတွက် ရွေးချယ်ခဲ့ခြင်း ဖြစ်ပါသည်။

(၈–၆) oy yn&y(3) - သတ္တဗေဒ ဘာသာရပ်
ဒေါက်တာ လဲ့လဲ့အေး
ကထိက၊ ဌာနမှူး
ဆေးတက္ကသိုလ်–၁၊ ရန်ကုန်

ကျမ်းခေါင်းစဉ် – **Applicability of Fish Scale Based Biomaterials in Hard Tissue Implantation**

(က) **သိပ္ပံပညာရပ်**တွင်ပညာရှင်အဖွဲ့ဆုရသူလေးဦးအနက် ဒေါက်တာ လဲ့လဲ့အေး သည် ၂၀၁၈ ခုနှစ်တွင် ရန်ကုန်တက္ကသိုလ်မှ **သတ္တဗေဒ ဘာသာရပ်** ဖြင့် ပါရဂူဘွဲ့ ရရှိခဲ့သူ ဖြစ်ပါသည်။

(ခ) ဒေါက်တာ လဲ့လဲ့အေး ၏ သုတေသနသည် –

- ဤပါရဂူကျမ်း သုတေသနသည် (Notopterus notopterus) ငါးအမျိုးအစား တို့၏ အရေခွံမှ သန့်စင်သည့် Hydroxyapetite ကို ပြုလုပ်ရာတွင် အပူချိန်

၈၀၀ ဒီဂရီ စင်တီဂရိတ်၌ နာနိုအရွယ်အစားရှိ အမှုန်ပွ(Porous particles) များ ရရှိကြောင်း၊ TGA ဖြင့် အတည်ပြုထားသည့် လေ့လာမှုဖြစ် သည်။ ထုတ်လုပ်ထားသည့် Hydroxyapetite တွင် အဆိပ်သင့်စေသည့် သတ္တုဓာတ်များ (Heavy metals) ပါဝင်မှုမှာ စံချိန် စံညွှန်းထက် လျော့နည်း ကြောင်းကိုလည်း စမ်းသပ်ပြ ထားပါသည်။ Albino ကြွက်များဖြင့် စမ်းသပ် ရာတွင် ၁၄ ရက်ကြာပြီးသည့်တိုင်၊ အဆိပ်လက္ခဏာကို မတွေ့ရ ကြောင်း၊ သွားနှင့် (Tooth and Bone) အရိုးကဲ့သို့ အမာစား အသားမျင် (Hard tissue) တည်ဆောက်မှုတွင် Hydroxyapetite ကို အစားထိုးသုံးနိုင်ကြောင်း ဖော်ညွှန်းသည့် သုတေသနဖြစ်သည်။ Wistor ကြွက်များ၏ ဦးခွံ(Skull) များ ကွဲအက် ချို့ယွင်းသည့်အခါ Hydroxyapetite ကို သဘာဝပစ္စည်းကဲ့သို့ အစားထိုး စမ်းသပ်ခဲ့သည့် လေ့လာမှုများတွင် ဇီဝသဘောအရ သဟဇာတ ဖြစ်ကြောင်း ဖော်ထုတ်သည့် သုတေသဖြစ်ကြောင်း တွေ့ရှိရခြင်း၊

တို့ကြောင့် **သိပ္ပံပညာရပ်ဆိုင်ရာ** မြန်မာနိုင်ငံ ဝိဇ္ဇာနှင့်သိပ္ပံပညာရှင်အဖွဲ့ဆု အတွက် ရွေးချယ်ခဲ့ခြင်း ဖြစ်ပါသည်။

(၈–၇) oy ynm&y(4) - ကုန်ထုတ်ဓာတုဗေဒ ဘာသာရပ်
ဒေါက်တာ ကြိုင်သူဇာမွန်
ကထိက၊ ကုန်ထုတ်ဓာတုဗေဒဌာန
ရန်ကုန်အနောက်ပိုင်း တက္ကသိုလ်

ကျမ်းခေါင်းစဉ် – **Process Development on the Production of Dry Cat Food from Fish Factory Wastes**

(က) **သိပ္ပံပညာရပ်**တွင် ပညာရှင်အဖွဲ့ဆုရသူ လေးဦးအနက် ဒေါက်တာ ကြိုင်သူဇာမွန်သည် ၂၀၁၈ ခုနှစ်တွင် ရန်ကုန်တက္ကသိုလ်မှ **ကုန်ထုတ်ဓာတုဗေဒ ဘာသာရပ်** ဖြင့် ပါရဂူဘွဲ့ ရရှိခဲ့သူဖြစ်ပါသည်။

(ခ) ဒေါက်တာ ကြိုင်သူဇာမွန် ၏ သုတေသနသည် –

- ဤပါရဂူကျမ်းသည် အိမ်မွေးကြောင်များအတွက် ကြောင်စာ ထုတ်လုပ်ရာတွင် အရည်အသွေးနိမ့် စံချိန်မမှီသည့် ငါးများရယူကာ ၎င်းတို့၏ အဟာရဓာတ် (Nutritive Values)ကို ဓာတ်ခွဲခြင်း၊ ဂျုံပြောင်းတို့၏ ဖွဲ၊ ပဲပိစပ်တို့နှင့် အချိုး အမျိုးမျိုးဖြင့် ရောစပ်ပေါင်းတင်ခြင်းဆက်လက်စမ်းသပ်သည့် သုတေသန ဖြစ်ကြောင်း၊ ထို့ပြင် ချေဖရုံသီး၊ မုံလာဥနီနှင့် ကြောင်ရိုးသေးအရွက်တို့ကို ဖြည့်စွက်၍လည်း ဖော်ထုတ်စမ်းသပ်ရာ– အိမ်မွေးကြောင်များ အတွက် ပရိတင်း အဟာရဓာတ် ယိုယွင်းပြောင်းလဲမှု မရှိကြောင်း၊ ထုတ်လုပ်မှု ကုန်ကျ စရိတ် နည်းကြောင်းကိုလည်း တွေ့ရှိရခြင်း၊

တို့ကြောင့် **သိပ္ပံပညာရပ်ဆိုင်ရာ** မြန်မာနိုင်ငံ ဝိဇ္ဇာနှင့်သိပ္ပံပညာရှင်အဖွဲ့ဆုအတွက် ရွေးချယ်ခဲ့ခြင်း ဖြစ်ပါသည်။

(၈–၈) v ra&;yn ㎜&y(1) - ပညာရေးစိတ်ပညာ ဘာသာရပ်
ဒေါက်တာ ရာဇာချစ်
လက်ထောက်ကထိက၊ ပညာရေးစိတ်ပညာဌာန၊
စစ်ကိုင်းပညာရေးတက္ကသိုလ်

ကျမ်းခေါင်းစဉ် – **An Assessment of Reasoning Skills Enhancing Problem Solving Ability Among Student Teachers from Universities of Education in Myanmar**

(က) **လူမှုရေးပညာရပ်**တွင် ပညာရှင်အဖွဲ့ဆုရသူ နှစ်ဦးအနက် ဒေါက်တာ ရာဇာချစ်သည် ၂၀၁၈ ခုနှစ်တွင် ရန်ကုန်ပညာရေးတက္ကသိုလ်မှ **ပညာရေးစိတ်ပညာ ဘာသာရပ်** ဖြင့် ပါရဂူဘွဲ့ ရရှိခဲ့သူဖြစ်ပါသည်။

(ခ) ဒေါက်တာ ရာဇာချစ်၏ သုတေသနသည် –

- ပညာရေးကဏ္ဍတွင် တာဝန်ယူမည့် ဆရာ ဆရာမများ ပညာရေးတက္ကသိုလ်များ၌ ပညာသင် ယူနေသည့် ဆရာ ဆရာမများ၏ High Thinking skill ကို မြှင့်တင်ရေးအတွက် ရည်မှန်းချက်ဖြင့် ဆောင်ရွက်သော သုတေသနဖြစ်ပါသည့် အတွက် Problem Solving Skills Ability ကို အကဲဖြတ် သုတေသနပြုလုပ်သည့် ကျောင်းတစ်ခုဖြစ်သည့် အတွက် နိုင်ငံတော်၏ အကျိုးစီးပွားအတွက် အထောက်အကူပြုကျမ်းတစ်ခု ဖြစ်ပါသည်။
- ဆရာ ဆရာမကောင်းများဖြစ်ထွန်းလာရေးအတွက် Reasoning Skills Test နှင့် Problem Solving Ability Test များကို ကိုယ်ပိုင် အသစ်တည်ထောင်ထားခြင်း၊ Regression Model of Reasoning Skill for Problem Solving Ability ကို ဖော်ထုတ်ခြင်း၊ ဆရာ ဆရာမကောင်းများ အတွက် Reasoning Skills ကို မြင့်တက်စေသည်။ ပင်ကိုယ် သုတေသနဖြစ်သည်ကို တွေ့ရှိရပါသည်။
- သုတေသနလုပ်ငန်းစဉ် အဆင့်ဆင့်ကို ဆောင်ရွက်ရာတွင် မှန်ကန်မှု၊ ယုံကြည်မှု၊ လက်ခံနိုင်မှုရှိပါသည်။
- ဤသုတေသနသည် ပညာရေးစိတ်ပညာဘာသာရပ်အတွက် စနစ်တကျဖြင့် အသစ်ဖော်ထုတ် နိုင်သည်ကို တွေ့ရှိရပါသည်။
- အထူးသဖြင့် ဘာသာရပ်အကျိုးအတွက် လက်တွေ့အသုံးချနိုင်သည့် ချဉ်းကပ်မှုများ၊ Model များဖြင့် ဖော်ထုတ် ပြုစုထားသော ကျမ်းတစ်ခု ဖြစ်ကြောင်း တွေ့ရှိရခြင်း

တို့ကြောင့် **လူမှုရေးပညာရပ်ဆိုင်ရာ** မြန်မာနိုင်ငံ ဝိဇ္ဇာနှင့်သိပ္ပံပညာရှင်အဖွဲ့ဆု အတွက် ရွေးချယ်ခဲ့ခြင်း ဖြစ်ပါသည်။

(၈–၉) v ra&;yn m&y(2) – စီးပွားရေးပညာဘာသာရပ်
ဒေါက်တာ ဇင်ဇင်နိုင်
တွဲဖက်ပါမောက္ခ၊ အသုံးချဘောဂဗေဒဌာန
ရန်ကုန်စီးပွားရေးတက္ကသိုလ်

ကျမ်းခေါင်းစဉ် – **The Incidence of Non-tariff Measures on Market Access for Myanmar Fishery Exports**

(က) **လူမှုရေးပညာရပ်** တွင် ပညာရှင်အဖွဲ့.ဆုရသူ နှစ်ဦးအနက် ဒေါက်တာ ဇင်ဇင်နိုင် သည် ၂၀၁၈ ခုနှစ်တွင် ရန်ကုန်စီးပွားရေးတက္ကသိုလ်မှ **စီးပွားရေးပညာ ဘာသာရပ်** ဖြင့် ပါရဂူဘွဲ့.ရရှိခဲ့သူ ဖြစ်ပါသည်။

(ခ) ဒေါက်တာ ဇင်ဇင်နိုင်၏ သုတေသနသည် –

- Trade Facilitation အတွက် အထောက်အကူဖြစ်စေ၍ နိုင်ငံတော်အတွက် အကျိုးပြုကျမ်း ရှားပါးသုတေသနဖြစ်ပြီး ပင်ကိုယ်ဖြစ်သည်ကို တွေ့.ရှိရ ပါသည်။
- Problem identification မှ စ၍ Literature review ကို ပြည့်ပြည့်စုံစုံဖြင့် စနစ်တကျ ချဉ်းကပ် လေ့လာထားခြင်း၊ တင်ပြသည့်ပုံစံ၊ တင်ပြနည်း တို့မှာလည်း ကောင်းမွန်ကြောင်း တွေ့.ရှိပါသည်။
- ဘောဂဗေဒ ဘာသာရပ် ဖွံ့.ဖြိုးမှုအတွက် အထောက်အကူ ဖြစ်ပါသည်။
- အထူးသဖြင့် ဤသုတေသနပြုလုပ်ရာတွင် ဘာသာရပ်နှင့် နိုင်ငံတော်အတွက် ထဲထဲဝင်ဝင် အားထည့် ဆောင်ရွက်ထားသည်ကိုလည်း တွေ့.ရှိရခြင်း၊

တို့.ကြောင့် **လူမှုရေးပညာရပ်ဆိုင်ရာ** မြန်မာနိုင်ငံ ဝိဇ္ဇာနှင့်သိပ္ပံပညာရှင်အဖွဲ့.ဆု အတွက် ရွေးချယ်ခဲ့ခြင်း ဖြစ်ပါသည်။

ROYAL BOATMAN GROUPS IN LOWER MYANMAR (1752-1852)

၂၂-၁၁ ROYAL BOATMAN GROUPS IN LOWER MYANMAR (1752-1852)

Mya Phyu Moe[♣]

Summary of the Report

An attempt has been made to study the types of boats and barges, formation of boatman groups and functions and remuneration of boatman groups in the Konbaung Period. It aimed to share the knowledge of the naval strength, the types of boats which they used in those days and the social status of the boatmen. This research was made by the descriptive methods and critical method. Complete facts and figures about the types of watercraft and its construction method were found by studying Parabikes and personal interviews. The formation of boatman groups and their functions remunerations were collected from the Parabikes Palm-leaf Manuscripts and books. Under the period of surveying, it was found the technology of the construction of the watercraft and their skill of navigation. This study unveiled the discrimination among the court officials while they were using the boats or watercrafts.

Keywords: boatman, boat, barge, Konbaung

Introduction

This research fills the gap to about the evaluating study of the royal boatman groups in Lower Myanmar during Konbaung Period from 1752 to 1852. It had to emphasize about the significance role of the boatmen of Konbaung Kings in Lower Myanmar. In this research, firstly types of boats and barges; secondly formation of boatman groups and finally functions and remuneration of boatman groups were presented.

Aims and Objectives

The research was submitted for the Ph. D degree and aimed to reveal the naval strength of Myanmar kings and its significance role in the local wars and battles for Thailand campaigns. And it counted the types of boat with respect to the usage of boat, according to match with the geographical condition and users' status etc. And also it aimed to investigate and evaluate how they formed the boatman groups, what are their functions or duties, their responsibilities and remunerations.

Outcome

By doing this research, it could share the knowledge of the technology of the construction of watercraft and skill of navigation in the inland waterways and off shore or coastal waterways in those days. Moreover, the social status of the boatmen and discriminations among the royal family and among the court officials while they were using the boats or watercraft, were understandable. And also how the boatmen were formed, the ranks among them, their responsibilities, their duties, and remuneration were realized.

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Research Methodology

Data and figures were collected from the Parabaike and photographs, but some figures (i.e. Figures 1 and 2) were drawn by author to explain the measurements and location of the point marked on the drawings. Descriptive method and critical method were used, field survey researches were collected and photographs were taken. Besides, personal interviews with the seamen, boatmen and boat- builders from Dala, Thanlyin, Kyauktan, Khayan and Thonegwa Townships during survey trips and discussions also made with knowledgeable persons. The Palm-leaf Manuscript, Parabaik, and documents were obtained from the National Library, Yangon; International Theravada Buddhist Missionary University Library, Kaba Aye, Yangon; Universities' Central Library, Yangon and National Museum, Yangon.

Findings

This research described an assumption on the prevailing of the use of watercrafts (raft, boats and etc.) in Myanmar. In the prehistoric ages men used dugout for the waterway trips. In the coastal regions and deltas of Myanmar sea-gypsies Salon (Mawken or Nigritos) introduced boats probably to Mon and natives of Taninthayi coast. Gradually the skill of navigation and techniques of the construction of boats were improved and boats were widely used in the Pagan Period. It was witnessed on the mural painting of that period. In the reign of Myanmar kings, even though the navy is not included in the four kinds of combat arms (i.e. elephant corps, the cavalry, the chariots and the infantry), boats were crucial and necessary for the transportation not only for the troops but also to convey arms and food supply. Moreover, the king's army conveyed boats on land and they transforms as sailors to use the boats when they met the rivers or creeks; therefore they were amphibious soldiers. They were well experience infantry soldiers as well as the weathered naval soldiers. If they could not carry boats by land route, they constructed the boats whenever they arrived as in the Bayinnaung's Thailand campaign. British envoy, Michael Symes who went along the River Ayeyarwady from Yangon for Innwa, recorded about the boats of Myanmar. The British envoy well impressed the naval strength of Myanmar king.

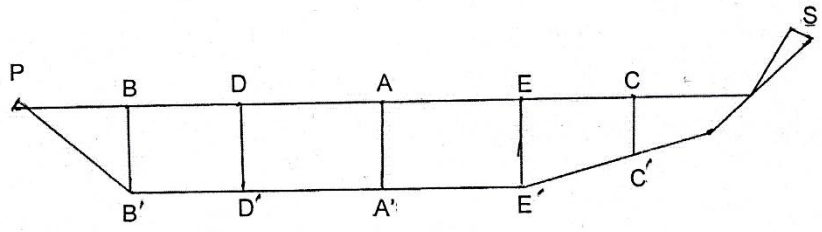
Boats were invented according to suit the geographical conditions of the respective region and for the purpose of use. Therefore, the types of the boats could be roughly classified as: (a) Ye hlay (war boat), (b) Taikhlay (attack boat), (c) Hkathlay (boat rowed by fixed oar or oars), (d) Hlayyan (attending or reserved boat), (e) Raikkha tin konhlay (supply boat), (f) Konhlay (cargo boat) and (g) Hsweihlay, Nginhlay (tow boat). Another type of boat, Hlawka, which prow and stern were higher than the deck used for the court and its official by the king's permission. Barges or Phaung were used by the king, queen and royal family. Pyigyimon Phaung in Mandalay and Karaweik hall at Kandawgyi lake in Yangon are the typical barges of the olden days. Boats and barges were built by obeying the rules of occult science and gave the names of boats according to the legends or auspicious omens. Myanmar kings strongly believe upon the supernatural power and they were superstitious that they liked to use lucky numbers and lucky figures of animal on the prow and stern of the boats. On the façade of the rafts were created with strange and glorious forms of imaginary animals by mixture of five, seven, nine, ten or twelve parts of different animal.

The construction systems of the boats were found in a Parabaike and it is well impressed for the accuracy and exact Myanmar measurement system which care up to a fraction of an inch. The Construction plan shows in the following table.

Table 1 Construction plan

Portion	Beam	Depth	Girth	Floor thickness	Hull thickness	Balance block	Remarks
2nd point Oo-ka-wun	6 feet	4.2 feet	12.2 feet	7.3 inches	6.4 inches	-	-
4th point Oo-chain- doun	9.5 feet	4 feet	16- feet	5.6 inches	6.4 inches	1.6 feet	-
1st point, Wun-hlaing-chain- doun or Pet-ain	12 feet	4 feet	18.4 feet	5.3 inches	6.4 inches	1.9 feet	5.2 Inches lower
5th point, Pe – chain-doun	8.85 feet	4.174 feet	17.3 feet	5.3 inches	6.4 inches	1.6 feet	-
3rd point, Pe-ka-wun	4.7 feet	3.3 feet	13.1 feet	7.3 inches	6.4 inches	-	-

Sa-kyin or the length between perpendiculars was 101 feet. The length between Oo-ka-wun and Oo-chain-doun was twenty feet. The length between Oo-chain-doun and Wun-hlaing-chain-doun was 30.35 feet. The length between Wun-hlaing-chain-doun and Pe-chain-doun was 30.35 feet. The length between Pe-chain-doun and Pe-ka-wun was twenty feet. The length of prow was eighteen feet and the length of stern was 30.73 feet. Therefore the total length of the boat was 150 feet.



P=prow

S=stern

A=1st point, Wun hlaing chain doun (or) pet ain

B=2nd point, Oo ka wun

C=3rd point, Pe ka wun

D=4th point, Oo chain doun

E=5th point, Pe chain doun

PS=Overall length= 150 ft

BC=Sa kyin=101 ft (length)

BD=20.0 ft (length)

DA=30.35 ft (length)

AE=30.35 ft (length)

EC=20.0 ft (length)

PB=18 ft (length of prow)

CS=30.73 ft (length of stern)

AA'=4.0 ft (depth)

BB'=4.2 ft (depth)

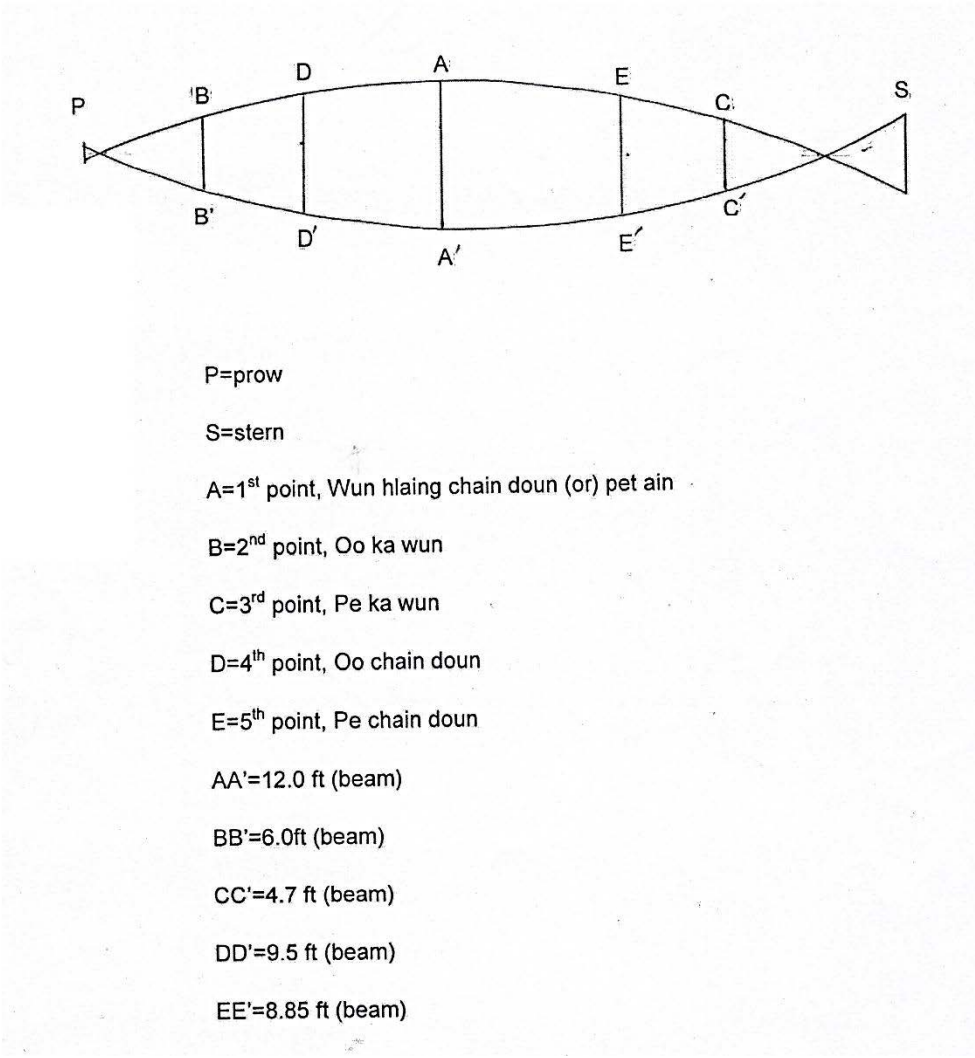
CC'=3.3 ft (depth)

DD'=4.0 ft (depth)

EE'=4.174 ft (depth)

Source: Drawing adopted from NL. Pu- No.727

Figure 1 Construction Plan of a Boat



Source: Drawing adopted from NL. Pu – No. 727

Figure 2 Construction Plan of a Boat

Boat building industries thrived in thaose days. In Lower Myanmar, Mottama (Madama or Matarban), Thanlyin, Pathein, Dala, Lunse (Myanaung), Kyangin and Pyay were once famous places for boat building. Because of cheap price for quality Teak timber and labour, foreigner especially Arab, Portuguese, Dutch, French and English started trade and shipyards since 1500s. About 25 out of 125 vessels arriving at and departing from port of Yangon annually were European ships, the rest were Chinese or Malay junks and Kattu or native crafts. In Mawlamyaing 123 vessels were launched during 1830 and 1855.Some ships built in Yangon (Dagon) between 1790 and 1820 were as follows.

Table 2 List of ships launched at Yangon dockyard

Sr.No.	Name of Vessel	Year	Tonnage
1.	Mysore	1795	777
2.	Adamant	1801	1000
3.	Marquess Wellesley	1802	1050
4.	Sha- Hpari	1805	1000
5.	Peelumcanza	1808	550
6.	Shwe- doung	1811	620
7.	Four Sisters	1815	670
8.	Britannia	1817	750
9.	Perthshire	1820	800

The formation of boatman groups was also exposed in this research. The evolution of boats and boatmen's formation, duties, responsibilities and rights rooted since former kings before Konbaung Period. But, the navy in the reign of Bagan kings was found tremendous and it would hard to believe. In the reign of king Bayinnaung, there found a formidable naval strength. In the reign of king Thalun (1629-1648), king aimed to extend the navy with the strength of 5,000 war- boats, 1,000 Kattu boats and 5,000 Kin Laung boats (scout boat). Though it was emphasized the formation of boatman groups during the Konbaung Period, former kings' formation of naval forces were also described as for example.

Infantry, cavalry, elephant troops, boat fleets or navy were organized in the reign of Myanmar kings as for the purposes to defend their country or to extend their territory. Those forces were formed systematically. Generally, those were formed on the basic of five men in one unit which was called Oza, and two Oza was controlled by an Akyat or lance corporal, but in the reign of King Alaungmintaya, formed his forces as a unit (Oza) with ten men.

Boatmen, musicians and executioners were included in Sugyan or tough groups. The men who patched the barges (Phaung Parapat) and who built the boats (Hlay Khuk Letthamar) were inserted in the Sunu or Suthay (fine group or small group). The formation of Navy was found as follows;

(1) Hlaythin Wun (Officer of Boats)
(2) Phaung Wun (Officer of Barges)
(3) Hlaythin Bo (Captain of Boat)
(4) Hlaythin Sayaygyi (Senior Clerk of Boats)
(5) Htaungke (Chief of One Thousand men)
(6) Penin (Helmsman)
(7) Pechade (Assistant Helmsman)
(8) Khagyi (Cook)
(9) Oozi (Prowman)
(10) Tet Hswel Ahmuhtan (Oarsmen)

In general, boatman groups were included in the type of tough group or Sugyan. That group was divided into sub- groups, boats crew or oarsmen, Hlawka boats crew, barges crew, boat builders or carpenters and Parapat or Tharapat men whose duty was to patch the boats.

The names of the groups were called with respect to the names of boats or barges where they were appointed, i.e. Ywaygyi boatman, Shwe Pan Tan boatman. Similarly, boatman groups were organized with respect to the type or name of Hlwaka boats.

The man who supervised one thousand men was called Htaungke but later his men were even less than one thousand, he was called as usual Htaungke. The chief who governed 3,000 boatmen was called Hlawka Thone Daung Hmu in the reign of Myanmar kings. Poet Shin Htwe Naga Thein was conferred the titles by the King of Taungoo, Minkyinyo (1486 – 1531). One of the poet's titles was Hlawka Thone Daung Hmu which is famous nowadays as his pseudonym. He got that title because the King assigned him to govern 3,000 boatmen when the King founded a Navy himself.

Penin was a key person while the boat or barge was on a voyage and any important decision should made for the navigation himself. Pechade was the second in command as assistant to Penin. Another man called Yar Kyaw Kaing controlled the oarsmen and other boatmen whose duty was to ply the pole, to tie the ropes, to unfurl and furl the sails. Comparing to the modern day crew, Penin is identical to a master of a ship, Pechade is to a chief officer and Yar Kyaw Kaing is to a boatswain.

In Konbaung Period, headmen of towns and villages along the River Ayeyarwady contributed when the King conscripted to organize a Navy. Almost about 500 boats and commoner boatmen could collect within a few days. Those were boatmen's villages. Big war-boats and boatmen could be collected especially from the towns like Pyay, Hinthada, Tharawaw and Thanlyin of Lower Myanmar.

In the time of King Thayarwady (1837 – 1846), a new ship named Shwehintha was built at Capital City and bought a steam ship which was given a name Yay nan yin tha in July 1844. King Pagan also built a steam ship at Hantharwady and named Yadana yin mon. The formation of boatman groups had to be made some changes and new names for the new posts were invented to match with the new type of propelling system.

In the reign of King Alaungmintaya, foreigner crews were organized in Myanmar Navy. Manipuris captives consisting boatmen, blacksmiths, goldsmiths, wavers and dancers were collected when Myanmar occupied Manipura in 1758 and 1764. A prominent foreign soldier in that King was an Armenian named Antonio who fought English company on Haigyikyun (Nagris) in 6 October 1759. Antonio alias Min Ye Kong Pon and Kalan Pwa Myin Si Thein Kha Nara had led over 100 soldiers and occupied the company successfully. When the King went down river for Yangon in July that year, foreigner crew followed in their traditional costumes and also they marched abreast with Myanmar boatmen from Yangon for Ayuddaya via Dawei (Tavoy) in December the same year with five ships.

Foreigners also serviced in the King's Army, as gunners, sailors or ship builders. Among them some were appointed in embassy as interpreter or member of the envoy like Gibson who was sent to Vietnam in 1822. Gibson, originally, was a sailor and an expert in variety of

languages, whose father was an Englishman and his mother was a Telegu. Another foreigner servant of that King was Simon de Vergas, the ship builder.

Boat builders were also included in the boatmen group, among them the foreigners were consisted in certain number more than natives at Capital City. In the reign of King Badon, there were twenty foreigners and ten native carpenters and 133 sawyers in the boat construction works. At that time, a boat builder called NgaTun was a prominent one. He constructed a boat to carry Mingun big bell from work site to Mingun and the King ordered to issue nails and iron whatever he needed. Another clever leader of boat builder was a foreigner. He was titled Thaiddi Harat who built Pyilone Ant Hlawka boat and two other boats at Myede in 1791 with the labour of native boat builders.

Tharapat or Parapat (the men who patch the boat) also contained in the boatmen group, but they might be lower in rank as to the ordinary boatmen because they got about 10 kyats per month while the boat builder carpenter got about 22 kyats per month. At that time, six units of boatmen (i.e. boats, barges, ships, sampans, punts and boat makers) were altogether in 6,238 men.

In this research, the functions and remunerations of boatmen groups were also described. The functions of boatman groups can be found clearly in the appointment orders of Letya Bi Nanthu as Phaung Wun and Satu Yin Ga as Ye hlay Wun. The King's boatman groups took duties and responsibilities in the religious affairs, diplomatic affairs, palace affairs, public works and cultivation on their own land besides their main duty of participating in the naval battles. And also they performed as the traders and transporters of revenue paddy and household goods in the peaceful times.

King's boatmen received titles, ranks, insignias, rewards in money and Nay-mye (land for living) and Loke-mye (land for cultivation) as for their remunerations. On the other hand, boatmen compensated for their lack of duty by paying back their title, rank or insignia, sometimes their life. Commoner boatmen received their remunerations from the King in cash or in kind as wages for their job.

In war times, the naval soldiers or boatmen participated not only as the fighting men but also as boatmen to convey the soldiers, arms, equipments and supplies for the army. It was distinguishably found in the battles of Innwa King Minkhaung and Mon King Rajadarit

Similarly, Alaungmintaya's occupation of Pyay in February 1755 and victory over Thanlyin in July 1755 proved the bravery, loyalty, fulfillment of duties and responsibilities of the boatmen. Moreover, while King Alaungmintaya's army was living in Yangon, Mon army blocked the creeks and rivulets not to supply provisions for Myanmar army. Myanmar boatmen patrolled and broke the blockade of Mon by the following troops. In September 1756, Shwe Daung U Dain Kyaw, Letya Kyaw Htin, Shwe Daung Raza and Min Htin Ye Htut were given fifty more boats each, totally two hundred more boats to displace and capture Mon war- boats at each and every mouth of creeks and rivulets. Other groups Shwe Daung Raza Kyaw, Min Kyaw Theikdi and Letwe Sanda were also given fifty boats each and assigned to capture Mon naval fleets at Danubyu, Hinthada and etc. On 9 December 1759, the king ordered commanders to

make all boats in the creeks ready for use when his troops passed through Mottama. That event showed that the boatmen had the duties and responsibilities to make smooth the supply routes.

Sometimes, the boatmen took extra duty as infantry soldiers if the King wished. In 1808 cargo boat boatmen were extracted from the towns and villages headmen to march for the Northern Shan State. Also in November 1808, boatmen were organized in the main army like the men attending the Royal White Umbrella and Royal Fan with Long Handle and they should serve their duties under Letywaygyi Hmu (Chief of Big Selected Groups).

The construction works at pagodas and religious buildings were very often and boatmen were assigned by the King in those works. Moreover, religious affairs for the reverend monks, Royal families' journey for homage to the famous pagodas were also very frequent. In those times, if the travel was convenient by waterway, boats were used. Therefore, it became the duties of boatmen for the safety and speedy of the journey. At the time of King Alaungmintaya, the King, Royal family and entourage went down in July 1759 along the Ayeyarwady River to make libation for His Majesty's meritorious deed, a golden rest- house on the platform of Shwedagon (Dagon San Daw Shin) Pagoda at Yangon. Entourage organized with forty-four fleets of over 1,000 boats of armed forces and over 500 provision boats. That journey took time thirteen stages from capital city (Shwebo) to Pyay and nine stages from Pyay to Yangon by waterway.

King Badon ordered the boatmen to do the works which were not connecting with their main job. King's boatman groups also took duties in making raw material for construction works. On 11 November 1807, the King ordered the boatmen from Lower Myanmar to bring back clay for bricks making.

Another side job of the boatmen was to render their work for the King's elephants. Myanmar Kings were very fond of elephants which were useful in the military campaign, so the strength of elephant troops showed how powerful the king was. Moreover, to own a white elephant was the pride of a King and its subjects thought that the King was excellent and justice. Myanmar Kings collected the elephants and always searched for white elephant. Especially King Badon collected the elephants and got white elephants. Boatmen were assigned to collect and move the elephants whenever necessary because they were big, heavy and wild and move by waterway was more convenient than any other way.

Myanmar Kings used to celebrate annual regatta festival in Tawthalin (September-October) every year. In the reign of King Badon, the King held a regatta between 30 August and 4 September, six months after his coronation. He held the annual regatta festival according to the advice of learned persons on 3 September 1787. He ordered to build temporary palace, to prepare and arrange for regatta and also ordered boats of Ministers and Officers should participate in the competition by appointing commoners as the oarsmen. It was held for joy and aimed to promote the skill and abilities the boatmen. Villages of Poe Kayin tribes which were near the banks of creeks were found scattered along the coast from Myeik up to and within the deltas of the Thanlwin (Salween), Sittaung and Ayeyarwady Rivers. They were very muscular and powerful boatmen by birth and tradition. Under their different Penin, they often carried off the first prizes at the royal boat races of the capital.

Former kings conferred titles as well as insignias, towns or villages in fief and permission to use certain kind of boat with suitable decorations as remunerations. Some examples are as follows:

(1) Htaungke of Yan Naing Boatman Group from Pyay, Nga Su Pyae was conferred Thiri Gingar title and five Pe (8.75 acreas) in fief by King Thalun on 7 November 1637 for attacking Dawei.

(2) Chief of Pho Khaung boat was conferred Turin Yawda title and a village in fief by King Pyay (1661 – 1672) in August 1661.

(3) Chief of Shwe Hlay boat was conferred Letwe Yawda title and a village in fief by King Narawara (1672 – 1673) in April 1673.

(4) Chief of ShweHlay boat was granted Myinkhondaing village in fief by the King Minyekyawhtin (1673 – 1698) of Nyaungyan Period (1597 – 1752) in February 1691.

(5) King Minyekyawhtin conferred Thiri Yawda title for the Chief of Shwe Hlay boat in January 1698.

(6) King Sane (King Saturday) (1698 – 1714) of Nyaungyan Period conferred the title Raza Dewa to the Chief of Shwe Hlay Boat in November 1701.

(7) King Alaungmintaya conferred the Daippa We Thaw title to a Boat Clerk called Nga Myat Tha in 1757.

The remunerations given by the kings for the boatmen for the boatmen were mainly the lands to live and lands for cultivation. Besides chiefs of boatman groups were allowed to attend Hluttaw at Taw seats and suitable titles and appropriate insignias were given to them. Sometimes kings rewarded money (silver) and permissions to trade without paying fees or taxes and allowed to carry arms on board for their safety. In return, the boatmen submitted their loyalty, materials for the construction works, provisions for the palace and kings' arsenal (viz. jaggery, silver or gold, muskets, lead, gunpowder and etc.).

Steam ships were used in the mid and late Konbaung Period, therefore new posts and terms were materialised, such as Captain or Ka-pi-tan, Ye-kyaung-pya (navigator), Tet-ma-kaing (helmsman), Mi-htoe (boiler- man), Set-saya (engineer), Kha-ya-thi or Kha-la-thi (sailor), Sa-lin (serang or chief of sailors). Captain was commonly called the name as Thin-baw-daw-zee at that time. They all were Myanmar national and according to the changes of the propelling system the functions and remuneration.

The following salary bill was found in the book of B.R. Pearn's "A History of Rangoon" as follows:

The following is the monthly salary bill of a King's ship, the Thunendah, in the year 1785 -

Captain Rs. 320.

First Officer Rs. 80.

Second Officer Rs. 60.

Gunner Rs.25.

Five Succanys (i.e. steermen) Rs. 12 each

JJ

Syrang (i.e. boatswain) Rs. 16.

First Tondall (i.e. assistant boatswain) Rs. 24.

Second Tondall Rs. 20.

Caulker Rs. 18.

Two Casabs (i.e. storekeepers) Rs. 8 each.

Forty-five Lascars Rs. 7 each

Supercargo Rs. 300.

Source: Imperial Record Department, Public Consultation, 13th March, 1789, No. D 95

Which described above were the remunerations gave by the King but also the boatmen should be punishable for their lack of duty which deserved capital punishment recognizing as a criminal case. For example; during the Royal waterway journey, Hman Si Phaung (Glass Mosaic Royal Barge) was towed by the four boats of Boatman Groups and other six boats included with Kyauk Myet Si Boat, Yauk Thwa Si Boat and Wun Bo Tha Si Kyay Thanda Boat. Pyigyi Mon Royal Barge was towed by the four boats of Boatman Groups and six boats which were rowed by the boatmen of Pyaw Bwe Group and Royal 150 Group. Local headman should mark and show with signs where the shallow water, and under water rocks situated.

Once, Hman Si Phaung was grounded and ordered to execute the Htaungke of Taung Yan Boat, Yan Lin Boat, Hswel Ma Naing Boat and Pyan Hlwar Boat, but in the same order (11 November 1806) he excused them. The Ministers and Officials should come when the Royal Barge was grounded, but they did not come. Therefore the King ordered on 26 November 1806 to crucify them, but for the first time he excused by the same order.

Discussion

Mawken or Salon tribes might be the first user of watercrafts (boat and raft) in Myanmar, in the olden days. Mon or who dwelled in the southern part of Myanmar adopted the technology of building boats and navigational skill from the Salon. This is an assumption of which arguments may be appeared.

However, Myanmar used boats or watercrafts before Pagan Period and it was much more advanced in the Pagan Period which proved by the mural paintings of that time. Gradually boat-building technologies and navigational skills promoted by the ages especially in inland waterways and coastal voyages. Myanmar boats, barges and ships which were doubtful for the endurance in the open sea even though made with good timber woods, the designs and construction techniques were not much modernized like the British and France. Myanmar kings built boats and barges mostly for the inland waterways and for the domestic battles. They built barges to show their honour and glory by decorating with strange figures like Pyinsarupa, Thattarupaetc, and figures of legendary animals and constructing a big and grand pasada with tiered roofs and elaborate decorations on it. As for the war boats were mostly designed for the speed and easy manouvering in the river or creeks, so it must be light and provided good space for the rowers. As for the cargo boats, for the space of the cargo they needed to reduce the

number of boatmen, so depended upon the force of current for the downstream and force of wind for sailing for upstream.

Boatmen who worked for the boats and barges must be strong and healthy to match their nature of work. They had the high capacity to endure the weather and hardship on the waterways. Therefore, in the king's service they were categorized as Su gyan (Tough or Rough group). They were organized in a certain form for each boat or barge under the Hlay thin Wun and Phaung Wun, Ye hlay Wun, Yay kin wun, Yay Wun and Akauk Wun supervised accordingly. For each boat or barge Htaungke or Penin closely commanded the boatmen. The officers of the boatman groups had the hereditary rights for the successions but Hlay thin Wun, Phaung Wun and Ye hlay Wun were appointed especially to the king's favourable and trustworthy or his by- laws. The Strength of Myanmar king's navy was rather difficult to count because the villages along the River Ayeyarwady were the villages of boatmen, they had to serve the king whenever His Majesty summoned. Moreover, those villages had to submit the battle boats whenever the king demanded. Towns and villages of Lower-Myanmar such as Hinthada, Tharawaw, Thanlyin and Dala were the sources of fair boats and good boatmen.

Without the king's permission a man from a group could not transfer to another group, likewise boatman could not change from one boat to another as they wish. The lands which were allotted by a king were approved by the later king and those were permanent in successions and not transferable to another group. Sometimes they were transferred to the infantry group for their special performance or temporarily for the need of fighting. Sometimes they had to do corvee works which were not relating to their skill or main job, for example, making bricks with Young male group in 1807.

In peaceful times they were allowed to do trade with their boats along the rivers carrying their arms on board by submitting muskets for the king's arsenal or supplying jaggery for the construction works. The traders' boatmen who conveyed revenue paddy from Lower Myanmar granted special favour to pass the toll stations freely. The kings favoured some Htaunke and Pen in to attend the Hluttaw and gave permissions to take seats at Taw sitting places and some were allowed to use suitable titles and insignias. Besides, some were rewarded money (silver), for example, King Bagyidaw rewarded 150 ticals of silver each to the Htaungke of Ywaygyi Royal boat and two others. A notable salary bill for the crew of King's ship named Thunendah, in 1785 was found, but it was not the custom for the Myanmar king, the possibility is the crew may be the foreigners. Besides, estimation could be made for the wages of boatmen in those days by the review of a British merchant, Henry Gouger's payments for the boatmen in August 1822. He gave fourteen ticals flowered silver each for the oarsmen and double (i.e. 28 ticals) for the Penin for the trip of Yangon to Amarapura.

Annual regattas were held in Tawthalin (6^{th} month in Myanmar calendar) every year in the times of Myanmar kings. It was celebrated colourfully and joyfully to promote the efficiency of the boatmen and to make fun for the people. The boat races were compulsory in the regattas. Po Karen tribes from Lower Myanmar were strong men and expert rowers who achieved first prizes in the boat races at the Capital City.

The boatmen were praised and rewarded according to their performances but they had to take responsibilities for their failure of duty and recklessness. For example, once in 1806, a royal

barge, Hmansiphaung was grounded in a waterway trip, the responsible persons, Htaungkes of Taungyan boat, Yan lin boat, Swe ma naing boat and Pyanhlwar boat were ordered to execute. Later they were excused by the King.

Boatman groups Myanmar kings were brave and skilful in naval battles, but the construction and structures of boats and ships were much lagged behind the British or the other Western countries. After the first Anglo Myanmar war Mawlamyaing was a ship- building centre in Southeast Asia. Between the years 1830 and 1855, 123 sea going vessels were built and launched at Mawlamyaing dockyards. Myanmar kings used first steam ship in 1844 and there were a few worthy ships or boats to confront the British naval forces in the second Anglo Myanmar war which concluded the occupation of Lower-Myanmar by the British.

Myanmar Navy which was a formidable force in the eyes of the foreigners in the reign of King Badon and mid-Konbaung Period. It became weaker and weaker in the Yadanabon Period. They were incompatible with the fleet of steam ships of the British who invaded Myanmar. It was probable that boatmen in the late Konbaung Period were lack of efficiency in the battle fields because they accumulated more experience in the ceremonial displays of the fleets in the Royal entourage than combat trainings and practices. Therefore, the British easily occupied the whole country in 1885.

Conclusion

This research evaluates about the Myanmar traditional boats and watercrafts which were used not only by the kings' navy but also by the commoner for their daily use in the old days. The formation of boatman groups, their functions and duty remuneration and responsibilities are described in it. However, it could contribute to fulfil the knowledge about the significance role of boatmen in Myanmar society and how and why the types of boat were improved to suit along the waterways of Myanmar in the reign of Myanmar kings. The social conditions of the boatmen including the boat builders, boat repairers and controllers of the waterways were revealed in it and contributed much more to assist the social history of Myanmar. The impressive skill of the navigation was unveiled along the inland waterways and coastal voyages by this dissertation. Moreover, it gives the abundant knowledge of the construction and designs of the boats and traditional custom and believing which concern with the boat building.

References

Parabaik and Palm-leaf Manuscripts

(Appointment Order for Phaung Wun) Parabaik No. 623,Yangon,National Library.

(Appointment Order for Yehlay Wun) Parabike No. 623.Yangon, National Library.

Collection of the Illustrations of Assorted Boats and Collection of Rhymns for the Method of Peddling, My Lord.) Parabike (Copy). Yangon. Historical Research and National Library Department, 2017.

Construction plans of Royal Barges, Royal Hlaw- kaBoats , Royal Sampans, Royal Boats) Parabaik No. 727. Yangon National Library.

(List of the King's Boat) Parabike, No.7520, Yangon, Universities' Central Library.

(The King's Order passed on the 1st Waxing day of Tagu ME 1187 (8th March 1826) at Hluttaw.) Parabike No.609. Yangon, National Library.

The King's Order passed on the 4th Waxing day of Tasaungmon ME 1146 (16th October 1784) and received by the Crown Prince at Hluttaw.) Parabike No. 356. Yangon, National Library.

(The King's Order passed on the 4th Waxing day of Tawthalin ME 960 (24th August 1598) and received by the Caduceus Bearer at Hluttaw.) Parabike No. 45235, Yangon, Universities' Central Library.

The King's Order passed on the 5th Wanning day of Natdaw ME 1121 (9th December 1759) and received by the port guards who were posted by Banya Dala.) Orders of Alaungmintaya, Manuscript, No. 34, p.123. Yangon, Universities' Central Library.

(The King's Order passed on the 5th Wanning day of Pyatho ME 1121 (9th December 1759). Orders of Alaungmintaya, Manuscript, No. 48, p.160. Yangon, Universities' Central Library.

The King's Order passed on the 8th Waxing day of Nayon ME 1163 and send by Nga Myat Tha, clerk of Wundauk Nay Myo Thiri Sithu.) Plamleaf Manuscript No.81981/5. (Eight Line Palmleaf Manuscript: Ku- reverse K ū- obverse Line No. 7,8 and 1 - 3) Yangon, National Library.

(The King's Order passed on the 10th Waxing day of Wagaung ME 1000 (9th July 1638) and received by the Chief of Heralds at Hlluttaw.),Parabike,No. 1944, Yangon, National Library.

The King's Order passed on the 12th Waxing day of Tabotwe ME 1101(3rd January 1650). Plam-leaf Manuscript No.98-171- 7 Pe. Yangon, National Library.

Books (in Myanmar)

Anthology of Myanmar Literature, Vol. 1 (1991) Yangon, SarpayBiman Press.

Chronology of Myanmar History.Vol. 1.(2009) Yangon Historical Researc Department, Naypyidaw.

Furnival J.S.F and PeMaung Tin (ed.) (1960) *Sambudipa U- hsaungKyan (Survey of Jambudipa).*

Yangon, Burma Research Society.

Glass Palace Chronicle.Vol. 1 (1992) Yangon, News and Periodical Enterprise.

Glass Palace Chronicle.Vol. 2 (1992) Yangon, News and Periodical Enterprise.

Glass Palace Chronicle.Vol. 3 (1992) Yangon, News and Periodical Enterprise.

Kala, U. (2006 a) *Great Chronicle Vol. 1* Yangon, Yarpyae Press.

Kala, U. (2006 b) *Great Chronicle Vol. 2* Yangon, Yarpyae Press.

Kala, U. (2006 c) *Great Chronicle Vol. 3* Yangon, Yarpyae Press.

KhinKhinLay, Dagon (1979). *Biography and Literary Works of WutmasutWundauk,* Yangon, Dagon

KhinKhinLay Book House.

Kyan. Ma (2006) *Myanmar Soldiers in the Konbaung Period,* Yangon, MyanmaYadanaSarpay.

KyawSweOo (ed.) (2012) *History of King Sinphyushin's Campaign by LetweNawyahta.* Yangon,Literature Committee of Tun Foundation Bank.

Kyaw Win, Dr. (2006) *Introduction to Konbaung,*YarpyaePresss.

Lin Yon ThitLwin, (1981), *The Boat.* Yangon, SarpayBiman.

Maung Muang Tin, U (2005). Terminological Dictionary of Golden Palace, Yangon, Yarpyae Press.

Maung Muang Tin, U (2003 a).*Great Royal Chronicle of the Konbaung Dynasty. Vol. 1,* Yangon, YarpyaePress.

Maung Muang Tin, U (2003 b).*Great Royal Chronicle of the Konbaung Dynasty. Vol. 2,* Yangon, Yarpyae Press.

Maung Muang Tin, U (2003 c).*Great Royal Chronicle of the Konbaung Dynasty. Vol. 3,* Yangon, YarpyaePress.

Maung Naing (2016) *A Study on the Royal Vessels and Maritine Technology of Ancient Myanmar*, Yangon, Kanyeikmon Press.

Myaketu (January, 1972) The Mythical Karaweik Bird and the Hall, Ngwetayee Magazine.

Myanmar Encyclopedia Volume. XIV, Yangon, SarpayBiman.

*Myanmar- English Dictionary (1993).*Yangon, Myanmar Language commission, Ministry of Education.

Naing Pan Hla (1997). *Treatise on the Campaign of Yarzardirit,* Yangon, Myawaddy Press.

Ne Win, Tetkatho (tr) (2004) *Narrative of the Mission of the Mission to the Court of Ava in 1853,* Yangon, Ta-gaung Publishing House.

Nyo Mya (1997) *The Quest of Konbaung,* Yangon, Myawaddy Press.

Pe Maung Tin, U (2003) *History of Myanmar Literature,* Yangon, Sabioo Sarpay.

Taw Sein Ko (1977) *Records of the Hluttaw,* Yangon, Printing and Publishing Corporation.

Than Tun (2002), *Ancient History of Myanmar,* Yangon, Innwa Book House.

TheinHlaing, U. (2002) *Research Dictionary for Ancient History of Myanmar,* Yangon, University Historical Research Centre.

Tin, U. (2012) *Documents Relating to the Administration of the Myanmar Kings and Penal Law or Royal Orders of Bodawpaya (Five Volumes in One)* Yangon, Seikkuchocho Press.

Toe Hla. Dr. (2004) *Social and Economic Life of Rural in Konbaung Period 1752- 1885.*Yangon, Myanmar Historical Commission, University press.

Toe Hla. Dr. (2014) *History among Land Contractual Thetkayit.* Yangon, Department of Historical Research and National Library.

Tun Yi (2015) *Anthology of Foreign Affairs in the Konbaung Period,* Yangon, MibaGon Press.

Yi Yi, Dr. (1970) *Notes on Research Dictionary,* Yangon, Myanmar Research Society.

Zeya Thinkhayar (2009) *Treatise on the Royal Terminology,* Yangon Yarpyae Press.

Books (in English)

Bentley, Jerry H. et al (2006) *Tradition and Encounters" A Brief Global History,* New York, McGraw-Hill.

Fytch, Albert (1878) *Burma Past and Present, In Two Volumes, Vol. 1,* London, C. Kegon Paul and Co.

Gouger, Henry (2002) "*Two Years Imprisonment In Burma" (1824 – 1826),* Bangkok, White Lotus Co. Ltd.

Harvey, G.E (1967) "*History of Burma*" (New impression), London, Frank Cass & Co. Ltd.

Maung Htin Aung, (1967), "*A History of Burma*", New York & London, Columbia University Press.

Naing Pan Hla, Dr. (2011), "Archaeological Aspects of Pyu, Mon, Myanmar," Yangon, Thin Sarpay.

Nisbet, John, (1901), *"Burma under British Rule- and before", in two volume, Vol.1,* Westminster, Archibald Constable & CO. Ltd.

Pearn, B.R., (1939), *"A History of Rangoon",* Rangoon, American Baptist Mission Press.

Searle, H.F (1928), *"Burma Gazetteer: The Mandalay District", Vol.A,* Rangoon, Government Printing and Stationery, Burma.

Symes, Michael. (1800), *"An Account of an Embassy to the Kingdom of Ava",* London, Necol and Wright.

Than, Charlie (2006) *ASEAN COCI's Symposium & Publication on Maritime & Waterways MYANMAR PEPORT.* Yangon, Myanmar Maritime University.

Than Tun (2010) *A Modern History Of Myanmar (1752- 1948)* , Yangon LokaAhlin Publishing House

Than Tun, Dr. (ed.) (1983) *The Royal Orders of Burma (A.D. 1598-1885) Part.I. (A.D. 1598-1648),* Kyoto, The centre for Southeast Asian Studies, Kyoto.

Than Tun, Dr. (ed.) (1986) *The Royal Orders of Burma (A.D. 1598-1885) Part.II. (A.D. 1649-1750),* Kyoto, The centre for Southeast Asian Studies, Kyoto.

Than Tun, Dr. (ed.) (1986) *The Royal Orders of Burma (A.D. 1598-1885) Part.III. (A.D. 1751-1781),*Kyoto, The centre for Southeast Asian Studies, Kyoto.

Than Tun, Dr. (ed.) (1986) The Royal Orders of Burma (A.D. 1598-1885) *Part.IV. (A.D. 1782-1787),*Kyoto, The centre for Southeast Asian Studies, Kyoto.

Than Tun, Dr. (ed.) (1986) *The Royal Orders of Burma (A.D. 1598-1885) Part.V. (A.D. 1788-1806),* Kyoto, The centre for Southeast Asian Studies, Kyoto.

Than Tun, Dr. (ed.) (1988) *The Royal Orders of Burma (A.D. 1598-1885) Part.VI. (A.D. 1807-1810),* Kyoto, The centre for Southeast Asian Studies, Kyoto.

Than Tun, Dr. (ed.) (1988) *The Royal Orders of Burma (A.D. 1598-1885) Part.VII. (A.D. 1811-1819),*Kyoto, The centre for Southeast Asian Studies, Kyoto.

Than Tun, Dr. (ed.) (1988) *The Royal Orders of Burma (A.D. 1598-1885) Part.VIII. (A.D. 1819-1853),*Kyoto, The centre for Southeast Asian Studies, Kyoto.

Than Tun, Dr. (ed.) (1990) *The Royal Orders of Burma (A.D. 1598-1885) Part.X. Epilogue, Glossary and Index.*Kyoto, The centre for Southeast Asian Studies, Kyoto.

Thant Myint – U (2001) *The Making of Modern Burma.* Cambridge, Cambridge University Press.

The British Burma Gazetteer,(1879), in two Volumes. Vol. 2. Rangoon, Government Pres.s

The Chambers Dictionary (Reprint) (1996), New Delhi, Allied Chambers (India) Limited.

TunAung Chain (2013), *Flowing Waters: Dipping into Myanmar History,* Yangon, Myanmar Knowledge Society (MKS).

Personal Interview

U Hla Win (62 yr.), (Owner of Country Boats) *Ngabyaema* Village, *Thanlyin* Township. (30.8.2015)

U MaungNgwe (54 yr.), (Boat Builder) *Anauk* Village, *Thonegwa* Township. (25.9.2015)

U Win Aung (48 yr.), (Foreman at Dockyard, *Dala*.) *Aungmingalar* Street, Dockyard Quarter, *Dala*. (18.9.2015)

GEOGRAPHICAL ANALYSIS OF LAND COVER AND LAND USE CHANGES IN CHAUNGZON TOWNSHIP

၂-၂၊ GEOGRAPHICAL ANALYSIS OF LAND COVER AND LAND USE CHANGES IN CHAUNGZON TOWNSHIP

Khin Toe Toe Lwin

Abstract

This research work is an attempt to identify and analyze the land cover and land use changes during the 25-year period from 1990 to 2015 in Chaungzon Township (Belugyun). The township is located at the mouth of the Thanlwin River as an island, fronted by the Mawlamyine River, Dayebauk River and the Gulf of Mottama. Therefore it is constantly modified by bank erosional impact of the Thanlwin River and tidal waves and sediment deposition of the Gulf of Mottama, gradually changing the land cover of the township. The identification of land cover change is based on the satellite images taken in 1990, 2000 and 2015, land cover classification and land cover maps using RS and GIS techniques. To identify the spatial variation of land use types and their changes, GPS is used during field surveys. The changes in socio-economic conditions due to land cover and land use changes are based on the responses to the questionnaires and semi-structured interviews with the locals.

Keywords: Land cover and land use, classification, erosion, deposition, GIS, RS

Introduction

The changes in land cover and land use pattern in any given area may affect the socio-economic conditions of the people concerned. For the best use of land, it is impossible without detailed information relating to the land cover and land use types. Therefore it is necessary to constantly study the land cover and land use pattern that witness changes because of natural processes and human actions. The study of the temporal and spatial changes of land cover and land use in Chaungzon Township, Mon State and its findings, may somehow, be helpful in drawing systematic regional development plans and in the best use of the land.

The main aim of this study is to examine the factors causing the temporal and spatial changes of land cover and land use and to provide certain information in drawing plans for the regional development and systematic land use. The objectives are

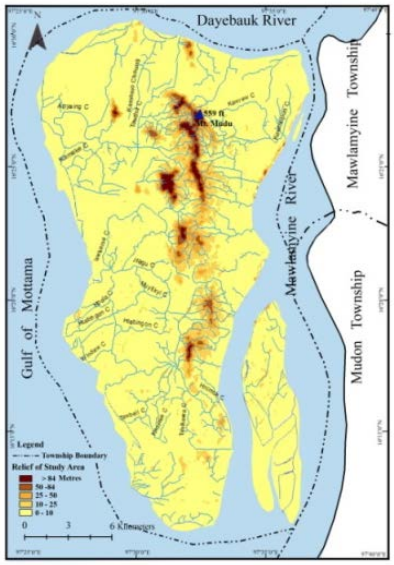
- To examine the extent of land cover and land use changes (1990, 2000 and 2015)
- To assess the driving forces of land cover and land use changes
- To explain the impacts of land cover and land use changes
- To present the relationship between the changes of land cover and land use and human activities.

Study Area

Chaungzon Township is one of the ten townships of Mon State and it is located at the mouth of Thanlwin River. Being an island it is flanked by the Mawlamyine River in the east and Gulf of Mottama in the west which is affected by the impact of the waves and boisterous seawater, constantly changing the shore line and the shape. On the other hand, deposition is dominant in the western and southern part, gradually extending the young alluvial plain.

Therefore, the shoreline of Chaungzon Township is ever changing, sometimes less obviously and at other times conspicuously.

The areal extent of Chaungzon Township is 658.13 sq km (65813.53 hectares or 162623 acres), comprising 3 wards in urban area and 43 village tracts in the rural area. A mountain range with a general elevation of about 150 m (500 feet) runs from north to south. On both sides of the range is low alluvial plain favourable for growing field crops, particularly paddy. In 2014 census, the total population of the township was 121150 persons of which 6.12 per cent were urban dwellers and the majority (93.88%) rural inhabitants. Agriculture is the chief economic activity, covering about half the area of the township. About two-thirds of the agricultural land is paddy land and monsoon paddy is the main crop. Fishery is the second most important economic activity, next to agriculture. Manufacturing industry is very limited with a few small-scale cottage industries.



Source: MIMU (Myanmar Information Management Unit)

Figure 1 Reliefs and Drainage of Chaungzon Township

Materials and Methods

This dissertation essentially presents land cover and land use changes during the past 25 years from 1990 to 2015. First, the relevant facts and data are collected from books, articles, research papers and theses. To know the real situation of the study area, field surveys were conducted particularly on land use types and the changes in the topographic features.

The maps required for this research work are obtained from Myanmar Information Management Unit (MIMU), the soil types and their qualities with map from the Soil Department of Mawlamyine, geological rock units and map from the Department of Geology, Mawlamyine University, the climate data from the Meteorology and Hydrology Department, Mawlamyine and population data from the Population and National Registration Department, Chaungzon and Mawlamyine.

For the assessment of land cover and land use change, causes and impacts of changes, both quantitative and qualitative methods are used.

In classifying land cover and analyzing changes, the satellite images of three different periods (1990, 2000 and 2015) are based on. The images for 1990 and 2000 are obtained from Landsat 7 ETM+ (131- 49) and the image for 2015 from Landsat 8. And then RS and GIS methods are used for analysis. For land cover classification, maximum likelihood algorithm in supervise classification method is used by ENVI 4.7 software in Remote Sensing method. Land cover maps are taken out from Arc GIS 10.1 software with GIS method. Change matrices are calculated to analyze the changes from one type of land to another.

The reclassification of land use is mainly based on the land use types classified by Department of Agricultural Land Management and Statistics, landform characteristics with Google Earth, land difficult for classification by field survey and locating the places by GPS as well as photo evidences and discussion with the locals.

Primary data are collected for land cover and land use changes, causes and impacts of changes and that are related to human- induced activities, using qualitative method. During field surveys, relevant information is collected by engaging with the locals. Questionnaires are distributed to the heads of wards and village tracts. The use of questionnaires is to know the land use types and changing conditions, to have the knowledge of settlements and economic activities, to identify the impact of natural hazard and to learn the natural change of landforms and the changing land use type due to anthropogenic pressure.

Findings and Discussions

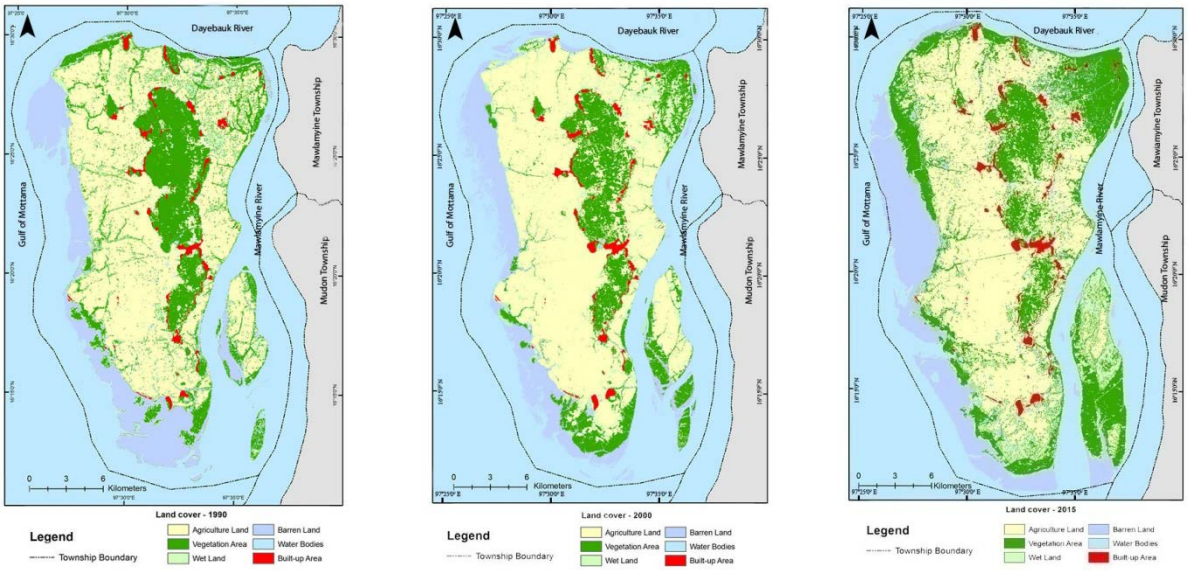
The characterization of land cover and land use is important for understanding the earth's surface and its relationship to human activities. For land cover analysis satellite imagery for Landsat ETM+ and Landsat 8 (131-49) for the three time periods in 1990, 2000 and 2015 were used.

Areas and Rate of Change in Land Cover Types

Table 1 Brief Description of Land Cover Types defined in Chaungzon Township

No.	LC Types	Description	Code	Color
1	Vegetation Area	an area covered with community forest, tidal forest, dhani (nipa) land, cultivating hard wood, rubber, mixed garden and smallholder tree crops	VA	green
2	Agriculture Land	crop cultivated area which determined by inundating field	AL	yellow
3	Barren Land	rocks, beaches and dunes, swamp land, degraded land, newly deposited land that cannot utilized	BL	purple
4	Wetland	a land area includes brackish water and marshes, tidal and non tidal fresh with bush, tall grass and aquatic plants	WL	turquoise
5	Water Bodies	an area covered by open water such as sea, river, stream and lake	WB	blue
6	Built-up Area	settlement area including town and village lands and their related infrastructure	BA	red

Source: Based on Landsat 8 (131-49) imagery, (2015)



(A) 1990 (B) 2000 (C) 2015

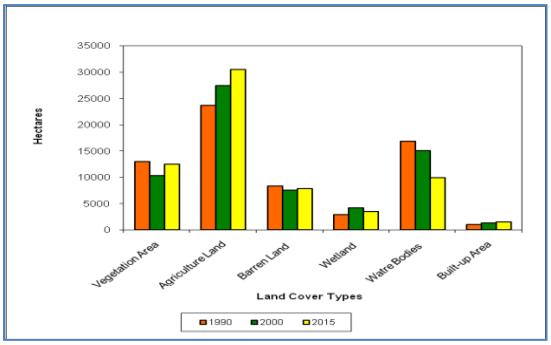
Source: Landsat 7 ETM+ (1990, 2000), Landsat 8 (2015) (131-49)

Figure 2 (A), (B), (C) Land Cover Types of Chaungzon Township (1990, 2000 and 2015)

Table 2 Land Cover Areas in Chaungzon Township for 1990, 2000 and 2015

Land Cover Types	1990		2000		2015	
	Hectare	Per cent	Hectare	Per cent	Hectare	Per cent
Vegetation Area	13028.49	19.80	10267.15	15.60	12542.10	19.06
Agriculture Land	23741.86	36.07	27503.67	41.79	30580.53	46.46
Barren Land	8362.79	12.71	7541.40	11.46	7863.30	11.95
Wetland	2839.24	4.31	4130.81	6.28	3468.93	5.27
Water Bodies	16870.29	25.63	15084.99	22.92	9890.10	15.03
Built-up Area	970.86	1.48	1285.51	1.95	1468.57	2.23
Total	65813.53	100	65813.53	100	65813.53	100

Source: Based on Landsat Images (131-49) 1900, 2000 & 2015



Source: Based on Table 2

Figure 3 Land Cover Areas of Chaungzon Township

During the whole study period, the agriculture land was the most dominant and it increased gradually. In 1990 agriculture land area was 23741.86 hectares (36.07%) and it increased to 30580.53 hectares (46.46%) in 2015. The increased area in 25-year period was 6838.67 hectares with +1.01 per cent annual rate of change.

Water body area in 1990 was 16870.29 hectares (25.63%) the second most dominant land cover type in the study area. The area decreased to 15084.99 hectares (22.92%) in 2000 and further contracted to 9890.10 hectares (15.03%) in 2015. The average annual rate of decline was -2.14 per cent in the study period.

The built-up area occupied 970.86 hectares (1.48%) in 1990, 1285.51 hectares (1.95%) in 2000 and 1468.57 hectares (2.23%) in 2015. The average annual change increase rate was +1.66 per cent in 1990- 2015 period.

The other land cover types, i.e., vegetation area, barren land and wetland also witnessed changes, but not under the same trends. The areas increased in certain period and decreased in another period. The vegetation land area in 1990 was 13028.49 hectares (19.80%) and it dropped to 10267.15 hectares (15.60%) in 2000 with an average annual decreased rate of -2.38 per cent. However, the area increased to 12542.10 hectares (19.06%) in 2015. Therefore, the annual rate of change with increasing trend was +1.33 per cent. For 25-year period from 1990 to 2015, the vegetation area decreased slightly with -0.15 per cent annual rate of change.

Likewise, barren land decreased from 8362.79 hectares (12.71%) in 1990 to 7541.40 hectares (11.46%) in 2000, wetland area increased from 2839.24 hectares (4.31%) in 1990 to 4130.81 hectares (6.28%) in 2000. In 2015, barren land area increased to 7863.30 hectares (11.95%), but wetland area decreased to 3468.93 hectares (5.27%). The annual rates of change of barren land and wetland in 1990-2000 periods were -1.03 per cent and +3.75 per cent respectively. From 2000 to 2015, the annual rates of change were +0.28 per cent and -1.16 per cent.

Land cover change processes were then detected through classification comparison method. The data obtained from change matrices was further used to calculate the rate of change in each land cover class using the following formula devised by Puyravaud (2003), (requoted by Schulz, J. J, et.al., 2010).

$$\boxed{r = [1/(t_2 - t_1)] \times [\ln (A_2/A_1)]}$$

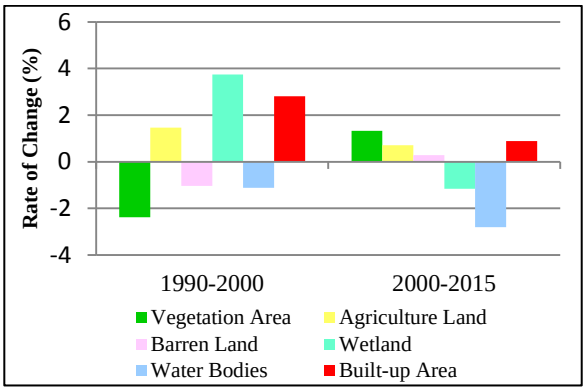
Where, r = rate of change

A_2 & A_1 = the areas covered by a given land cover at time 1 and time 2 respectively

Table 3 Rate of Land Cover Change in Chaungzon Township

No	LC Types	Rate of Change (%)		
		1990-2000	2000-2015	1990-2015
1	VA	-2.38	1.33	-0.15
2	AL	1.47	0.71	1.01
3	BL	-1.03	0.28	-0.25
4	WL	3.75	-1.16	0.80
5	WB	-1.12	-2.81	-2.14
6	BA	2.81	0.89	1.66

Source: Based on Land Cover Area (1990, 2000 and 2015)



Source: Based on Table 3

Figure 4 Rate of Land Cover Change in Chaungzon Township

Change Pattern of Land Cover

Change matrix shows the change area from one land cover class to another. The diagonal cells of the matrix represent the area that has remained same in both the time period. Other cell values represent the area that has changed from one class to another class.

Table 4 Land Cover Change Matrix in Chaungzon Township (1990 to 2000)

Year	2000							
1990	Area in Hectares	V A	AL	BL	WL	WB	BA	Grand Total
	VA	7769.88	3733.20	0.00	941.45	339.88	244.08	13028.49
	AL	263.96	21663.58	0.00	1755.19	14.41	44.72	23741.86
	BL	1496.89	700.54	4448.93	558.43	1148.56	9.44	8362.79
	WL	311.76	1343.94	305.70	794.46	69.57	13.81	2839.24
	WB	424.66	62.41	2786.77	81.28	13512.57	2.60	16870.29
	BA	0.00	0.00	0.00	0.00	0.00	970.86	970.86
	Grand Total	10267.15	27503.67	7541.40	4130.81	15084.99	1285.51	65813.53

Source: Landsat 7 ETM+, 131-49

Table 5 Land Cover Change Matrix in Chaungzon Township (2000 to 2015)

Year	2015							
2000	Area in Hectares	V A	AL	BL	WL	WB	BA	Grand Total
	VA	6798.82	2533.94	0.00	752.72	109.22	72.45	10267.15
	AL	705.61	25396.68	0.00	1299.42	26.53	75.43	27503.67
	BL	2606.09	190.91	3257.84	572.14	899.31	15.11	7541.40
	WL	1022.24	2446.29	87.75	485.28	75.63	13.62	4130.81
	WB	1409.34	12.71	4517.71	359.37	8779.41	6.45	15084.99
	BA	0.00	0.00	0.00	0.00	0.00	1285.51	1285.51
	Grand Total	12542.10	30580.53	7863.30	3468.93	9890.10	1468.57	65813.53

Source: Landsat 7 ETM+ & Landsat 8, 131-49

Table 6 Land Cover Change Matrix in Chaungzon Township (1990 to 2015)

Year	2015							
1990	Area in Hectares	V A	AL	BL	WL	WB	BA	Grand Total
	VA	6601.04	5130.91	90.34	588.15	271.51	346.54	13028.49
	AL	206.72	22439.85	0.00	991.43	14.41	89.45	23741.86
	BL	2530.26	1282.02	2553.72	1056.43	916.70	23.66	8362.79
	WL	609.51	1636.92	109.02	387.69	71.56	24.54	2839.24
	WB	2594.57	90.83	5110.22	445.23	8615.92	13.52	16870.29
	BA	0.00	0.00	0.00	0.00	0.00	970.86	970.86
	Grand Total	12542.10	30580.53	7863.30	3468.93	9890.10	1468.57	65813.53

Source: Landsat 7 ETM+ & Landsat 8, 131-49

Vegetation area was decreased by 487.39 hectares from 1990 to 2015. The vegetation area that remained unchanged in 25-year period was 6601.04 hectares or 50.7 per cent. From vegetation area 39.4 per cent were changed to agriculture land, 0.7 per cent to barren land, 4.5 per cent to wetland, 2.1 per cent to water bodies and 2.7 per cent to built-up area, changing 49.3 per cent in total.

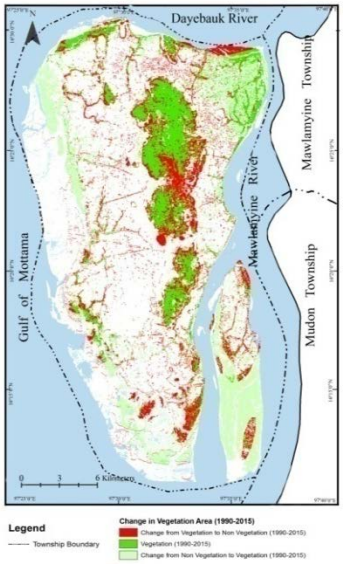
In the same period, some land types also changed to vegetation land, 0.9 per cent from agriculture land, 30.3 per cent from barren land, 21.5 per cent from wetland and 15.4 per cent

from water bodies. The decrease in the vegetation area is mainly due to the extension of agriculture land.

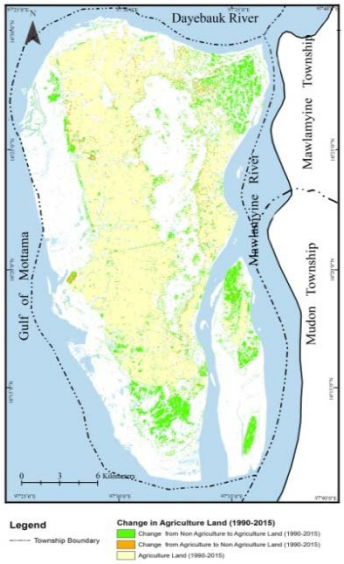
Agriculture land gained the largest area (6838.67 hectares) among six types of land cover in the past 25 years. During that period the area of agriculture land that remained unchanged was 94.5 per cent, while 0.9 per cent was changed to vegetation land, 4.2 per cent to wetland, 0.1 per cent to water bodies and 0.4 per cent to built-up area, totaling 5.5 per cent.

The land types that changed to agriculture land were 39.4 per cent from vegetation area, 15.3 per cent from barren land, 57.7 per cent from wetland the highest among the different land types, and 0.5 per cent from water bodies.

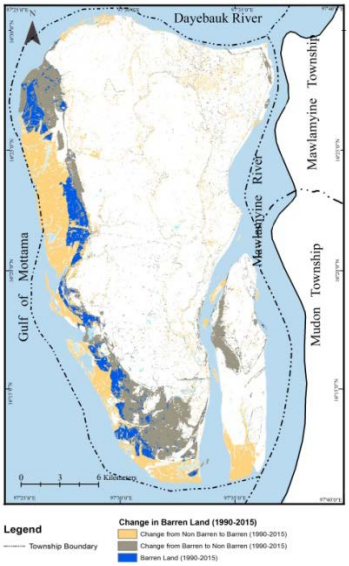
During the 25-year period, the change in the barren land area was less obvious with 499.49 hectares, while 2553.72 hectares (30.5%) remained unchanged. From barren land 30.3 per cent changed to vegetation land, 15.3 per cent to agriculture land, 12.6 per cent to wetland, 11.0 per cent to water bodies and 0.3 per cent to built-up area.



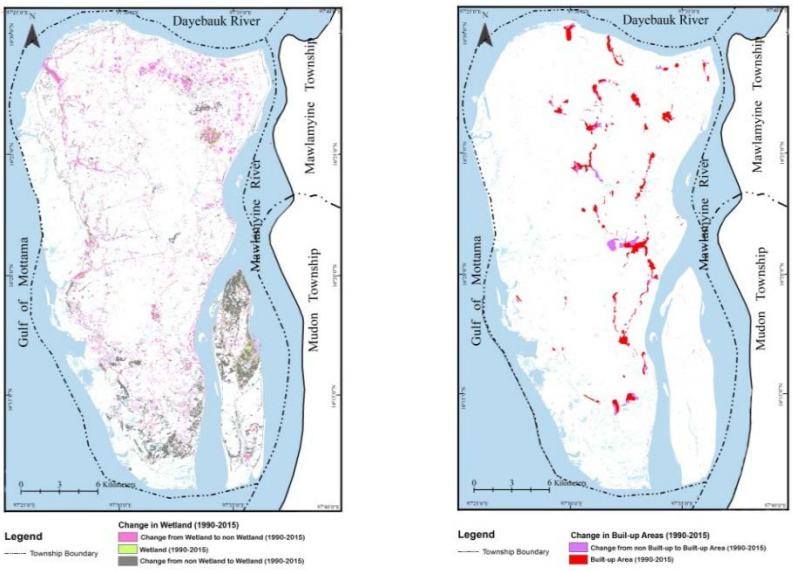
(A) Change in Vegetation Area



(B) Change in Agriculture Land



(C) Change in Barren Land



(D) Change in Wetland **(E) Change in Built-up Area**

Source: Based on Landsat Satellite Imagery

Figure 5 (**A, B, C, D, E**) Changes from one area to another in Chaungzon Township (1990-2015)

On the other hand, 0.7 per cent of vegetation land, 3.8 per cent of wetland, and 30.3 per cent of water bodies changed to barren land. Barren lands are mostly found along the western part and in the extreme south, including mainly newly deposited alluvial plain and sand banks.

The wetland area of Chaungzon Township was increased by 1291.57 hectares in the 1990-2000 period and it decreased by 661.88 hectares in the 2000-2015 period. The wetland area that remained unchanged in that period was 387.69 hectares (13.7%), but of the remaining area 21.5 per cent were changed to vegetation area, 57.7 per cent to agriculture land, 3.8 per cent to barren land, 2.5 per cent to water bodies and 0.9 per cent to built-up area changing (86.3%) in total.

In the same period, wetland area changed 4.5 per cent from vegetation land, 4.2 per cent from agriculture land, 12.6 per cent from barren land and 2.6 per cent from water bodies.

Chaungzon is an island township surrounded by water and therefore it has relatively large area of water bodies. Based on the satellite images, the area of water bodies was 16870.29 hectares (25.63%) in 1990 and 9890.10 hectares (15.03%) in 2015, decreasing 6980.19 hectares in the 25-year period.

The water body area that remained unchanged was 8615.92 hectares (51.1%). The loss of water body area was 15.4 per cent to vegetation area, 0.5 per cent to agriculture land, 30.3 per cent to barren land, 2.6 per cent to wetland and 0.1 per cent to built-up area, totaling 48.9 per cent. At the same period, it gained 2.1 per cent from vegetation area, 0.1 per cent from agriculture land, 11.0 per cent from barren land and 2.5 per cent from wetland.

The built-up area is lowest among the six land cover types. However, it has been increasing gradually. The net increased area in the 1990-2015 periods was 497.71 hectares. During the study period, there has been no change from built-up area to the other land types, but

it gained 2.7 per cent from vegetation cover, 0.4 per cent from agriculture land, 0.3 per cent from barren land, 0.9 per cent from wetland and 0.1 per cent from water bodies.

Accuracy Assessment

Accuracy assessment is an important step in image classification and change detection. A classified image needs to be compared against reference data, assume to be true, in order to assess its performance and quantify its accuracy. Accuracy assessments were conducted on the 2015 classified image based on 150 ground truth points corresponding to six main land cover classes. Being much closer to the date of ground-truth points were collected, it was obtained overall classification accuracy of 83% for the 2015.

Table 7 Accuracy Assessment of 2015 Land Cover Classification

Ground Truth Data								
Land Cover	**VA**	**AL**	**BL**	**WL**	**WB**	**BA**	**Total**	**Producer Accuracy (%)**
VA	6912	725	134	170	0	322	8263	83.65
AL	828	4654	67	129	5	210	5893	79.54
BL	195	201	9039	436	558	0	10429	86.67
WL	279	86	1085	5597	52	318	7417	75.46
WB	17	0	9	168	2616	0	2810	93.27
BA	322	185	0	343	0	5161	6011	85.85
Total	8553	5851	10334	6843	3231	6011	40823	
User Accuracy (%)	80.81	79.54	87.46	81.79	80.96	85.85		83.23%

Overall Accuracy 83%

Source: Based on Landsat 8, 131-49 Imagery 2015 and Field Observation 2016

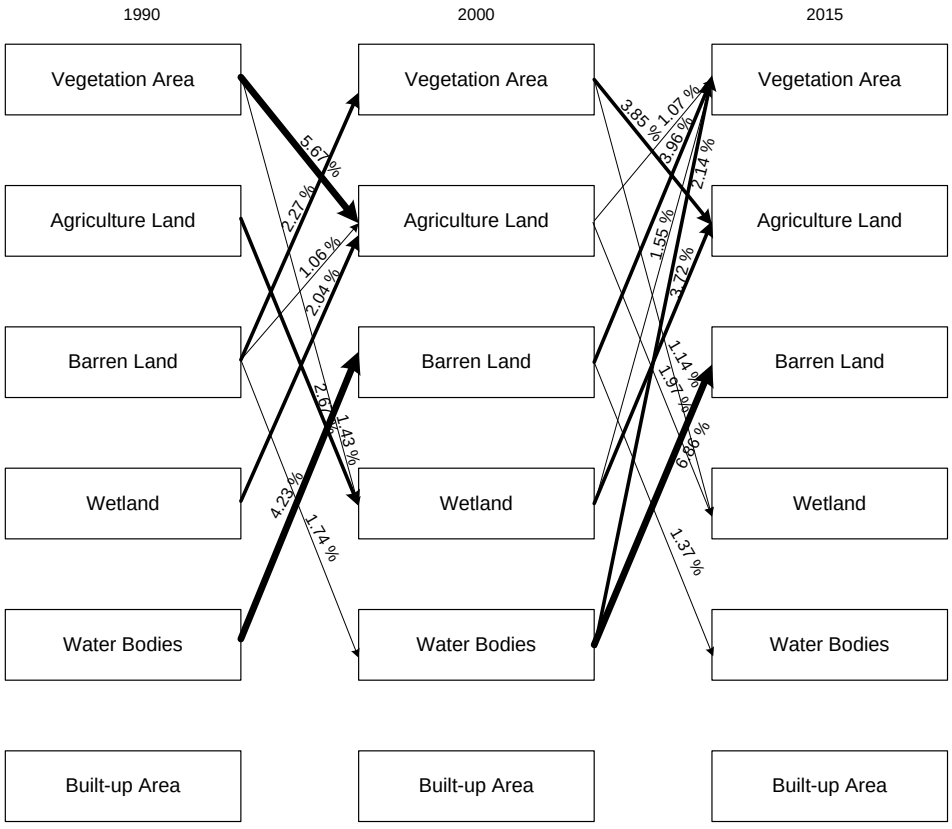
Overall Accuracy is essentially tells us out of all of the reference sites what proportion were mapped correctly. The overall accuracy is usually expressed as a percent, with 100% accuracy being a perfect classification where all reference sites were classified correctly.

Analysis of Land Cover Changes

The changes of land cover from one type to another in the period from 1990 to 2015 were not under the same trend. During the 1990-2000 periods, 3733.2 hectares (5.67%) of the vegetation area changed to agriculture land. The cutting of hardwoods and bamboos for local use and clearing of vegetation for rubber plantations depleted and reduced the natural vegetation cover over the central upland. The reclamation of tidal forest area for ‘le’ (paddy) land also decreased the vegetation area.

In the same period water bodies witnessed the second largest area of change among the six land cover types, particularly to barren land with 2786.77 hectares (4.23%) due to sediment deposition. The third most change was the change of agriculture land to wetland with 1755.19 hectares (2.67%). The change was due to invasion of seawater and flooding along the river banks and tidal creeks. In the same period the change of barren land to vegetation area was 1496.89 hectares (2.27%). The newly formed barren land over time was occupied by dhani (nipa) and tidal forest. The change of wetland to agriculture land was 1343.49 hectares (2.04%). Some wetlands of inland area were also converted to agriculture land.

In the period from 2000 to 2015, the change of water bodies to barren land was largest in area with 4517.71 hectares (6.86%). Such changes occurred mostly along the western and southern coastal areas and southern extreme of Hintharkyun. Barren land emerged due to deposition of sediments on the areas occupied by water bodies and the emerged land remains barren without vegetated cover. The second largest land cover change was witnessed by barren land changing into vegetation area with 2606.09 hectares (3.96%). The barren land with young alluvium became stable over time turning to vegetation area.



Source: Based on Table 4, 5

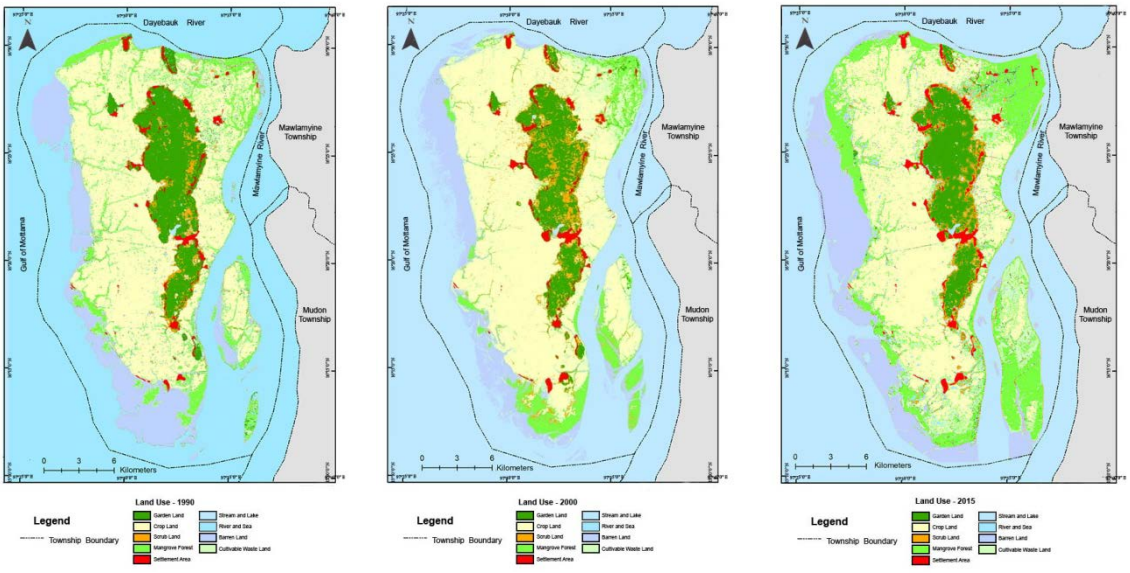
net change > 4 %
between 2 % and 4 %
between 1 % and 2 %

Figure 6 Major land cover change trajectories and their contributions to net change in percentage of the study area

Changes of Land Use

Changes in land use are much more difficult to quantify. The study of land cover and land use changes of an area can identify the physical and socio-economic conditions as well as the spatial and temporal use of land by the local inhabitants. Based on these facts and information the authority concerned can lay out plan for the best use of the land. Also, the important facts for the satisfaction of basic requirements of the increasing population are available from the study.

Level.1(Land Cover)	Level.2 (Land Use)
1. Vegetation Area	1. Scrub Land
	2. Mangrove Forest
2. Agriculture Land	3. Garden Land
	4. Crop Land
3. Barren Land	5. Bare land (Sandy beach, exposed rocks, degraded land, newly deposited alluvial flat)
4. Wetland	6. Cultivable Waste Land
5. Water Bodies	7. Stream and Lake
	8. River and Sea
6. Built-up Area	9.Settlement Area (transportation land, industrial land, other settlement lands)



(A) 1990 (B) 2000 (C) 2015

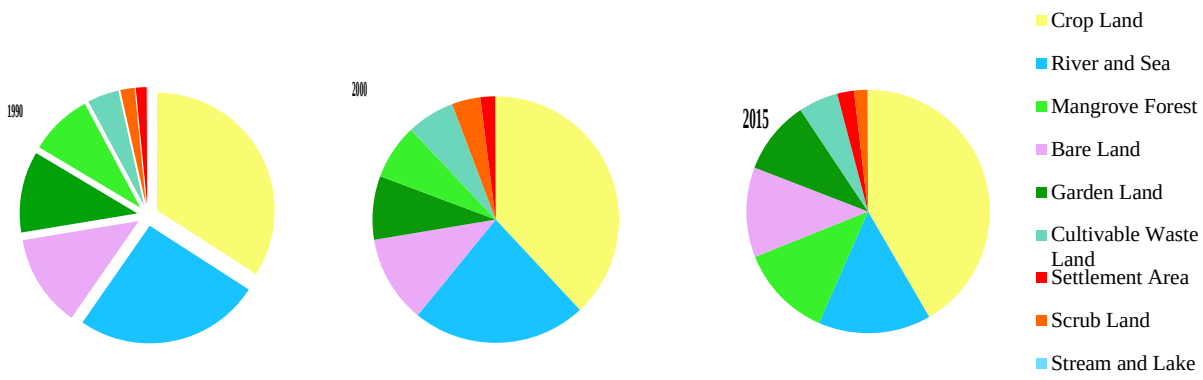
Source: Land Cover Maps and Field Survey

Figure 7 (A), (B), (C) Land Use Types of Chaungzon Township (1990, 2000 and 2015)

Table 8 Land Use Areas in Chaungzon Township (1990, 2000 and 2015)

No.	Land Use Types	1990		2000		2015	
		Hectares	%	Hectares	%	Hectares	%
1	Garden Land	7357.55	11.18	5491.95	8.34	6429.65	9.77
2	Crop Land	22450.89	34.11	25042.67	38.05	27401.20	41.63
3	Scrub Land	1290.97	1.96	2461.00	3.74	1179.33	1.79
4	Mangrove Forest	5670.94	8.62	4775.20	7.26	8112.45	12.33
5	Settlement Area	970.86	1.48	1285.51	1.95	1468.57	2.23
6	Stream and Lake	47.75	0.07	42.90	0.07	40.90	0.06
7	River and Sea	16822.54	25.56	15042.09	22.86	9849.20	14.97
8	Cultivable Waste land	2839.24	4.31	4130.81	6.28	3468.93	5.27
9	Bare Land	8362.79	12.71	7541.40	11.46	7863.30	11.95
	Total	65813.53	100.00	65813.53	100.00	65813.53	100.00

Source: Based on Land Cover Maps 1990, 2000 and 2015 and Field Survey



Source: based on Table 8

Figure 8 Land Use Areas of Chaungzon Township

There are nine land use types in Chaungzon Township of which crop land is the most dominant. In 1990, the crop land area was 22450.89 hectares (34.11%) it increased to 25042.67 hectares (38.05%) in the year 2000 and then to 27401.20 hectares (41.63%) in 2015. The crop land area has been continuously increasing during the 25-year period.

The secondmost dominant type is river and sea water. However, river and sea water has been declining from 16822.54 hectares (25.56%) in 1990 to 15042.09 hectares (22,86%) in 2000 and to 9849.20 hectares (14.97%) in 2015, due to the emergence of wide alluvial flats in the western and southern coastal areas.

Bare land occupied the third largest area in 1990 with 8362.79 hectares (12.71%), and in 2000with 7541.40 hectares (11.46 %). But it declined to the fourth place in 2015 with 7863.30 hectares (11.95%), although the area was slightly increased.

The mangrove forest area was 5670.94 hectares (8.62%) in 1990, but it slightly decreased to 4775.20 hectares (7.26%) in 2000. However, it increased sharply to 8112.45 hectares (12.33%) in 2015, taking the third place in area among the nine types of land use.

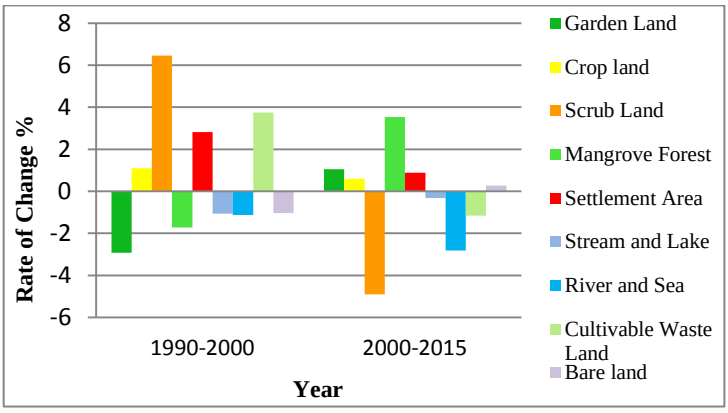
Stream and lake area is lowest among the land use types and the change was less pronounce in 25- year period. The second lowest type is settlement area. The occupied area of settlement land was 970.86 hectares (1.48%) in 1990, 1285.51 hectares (1.95%) in 2000 and 1468.57 hectares (2.23%) in 2015. With the increasing number population, the settlement area has been gradually increasing in the 25- year period.

Other types of land use including garden land, scrub land and cultivable waste land witnessed less changes in the 25- year period.

Table 9 Rate of Land Use Change in Chaungzon Township

No	Land Use Types	Rate of Change (%)		
		1990-2000	2000-2015	1990-2015
1	Garden Land	-2.92	1.05	-0.54
2	Crop Land	1.09	0.60	0.80
3	Scrub Land	6.45	-4.90	-0.36
4	Mangrove Forest	-1.72	3.53	1.43
5	Settlement Area	2.81	0.89	1.66
6	Stream and Lake	-1.07	-0.32	-0.62
7	River and Sea	-1.12	-2.82	-2.14
8	Cultivable Waste Land	3.75	-1.16	0.80
9	Bare Land	-1.03	0.28	-0.25

Source: Based on Land Use Areas (1990, 2000 and 2015)



Source: Based on Table 3.3

Figure 9 Rate of land Use Changes

During the study period, garden land area was decreased by 927.90 hectares with an average annual decreased rate of -0.54 per cent. The decrease in areas of garden land was due to the cutting of hardwoods and bamboos for construction and firewoods. In 2015, garden lands are being occupied by rubber and teak plantation and the area of scrub land in the upland area is replaced by plantation areas.

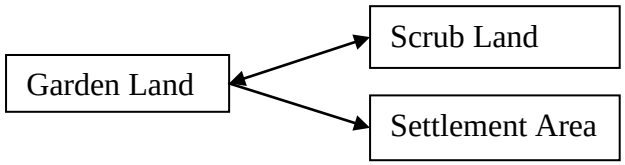


Figure 10 Change Pattern of Garden Land

The increase in crop land area is more conspicuous in southern newly formed alluvial flat. The newly emerged land is seem as bare land in the image taken in 1990, and in 2000 it has changed into crop land and vegetation cover. In 2015, much of the land has been reclaimed as crop land.

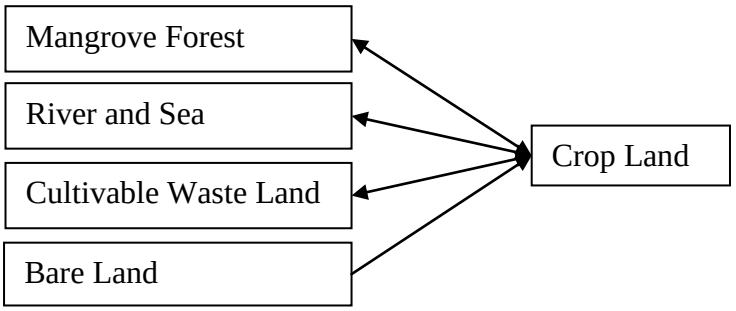


Figure 11 Change Pattern of Crop Land

Scrub lands are found on the upland region of the study area. From 1990 to 2015, scrub land area was decreased by 111.64 hectares with an average decreased rate of -0.36 per cent in the study area.

As the present scrub lands are being occupied by rubber and teak plantation, the area of scrub land is likely to disappear in the next decade and the entire upland area would turn green (Plate 4).

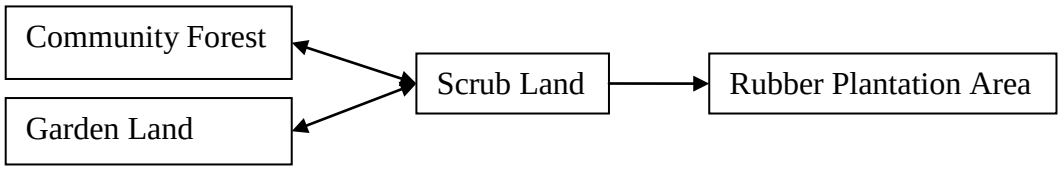


Figure 12 Change Pattern of Scrub Land

Plate 1 Much of the scrub land has been replaced by young rubber trees, teak and hardwood plantations. (Muyitkalay Village Tract) 16º 18' 28.25" N, 97º 32'13.82"E (23.4.16)

Mangrove forest thrives particularly on the coastal area around the township, along the tidal creeks and in the young alluvial flat of the south. Mangroves are sharply increased in the 1990-2015 period. The increased area of mangrove forest in 25-year period was 2441.51 hectares with +1.43 per cent annual rate of change..

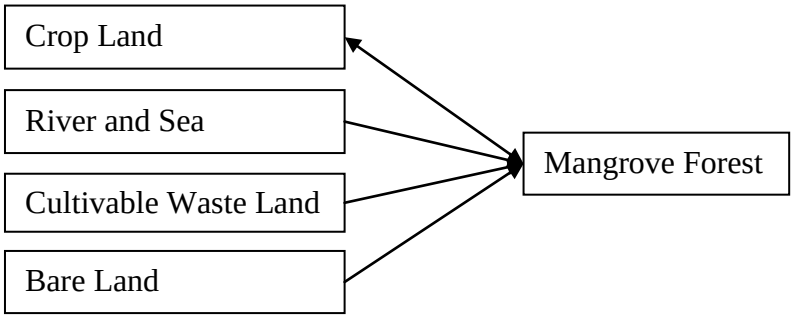


Figure 13 Change Pattern of Mangrove Forest

Plate 2 The alluvial flat formed by newly deposited sediments has become firm enough to be colonized by the mangrove species.(Sebalar Village Tract) 16º 16' 38.26"N, 97º 29' 06.11" E (23.4.2016)

Settlement areas includes town, villages and related infrastructures. Being unable to reclassified the remote sensing data received from satellite images, reclassification is based on the facts and information obtained from field surveys and data available from Department of Agricultural Land Management and Statistics. Settlement area of Chaungzon township is classified into four types as: (a) residential land (town and villages), (b) transportation land, (c) industrial land and (d) other areas.During the 25-year period, settlement area was increased by 497.71 hectares with +1.66 per cent annual rate of change.

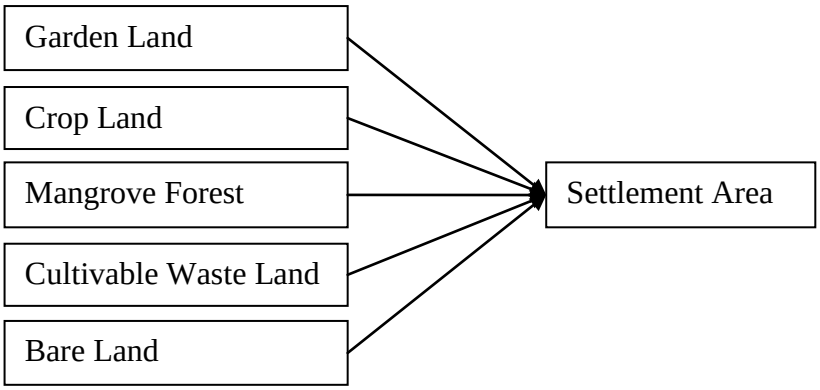


Figure 14 Change Pattern of Settlement Area

Plate 3 Due to the construction of the approach road for the new bridge across the Mawlamyine River, turning crop land into road land (Kawmupon Village Tracts) 16º 26' 39.81" N, 97º 35'36.35" E (29.11.2016)

Stream and Lake includes tidal streams, natural lakes, dug ponds and creeks. All the streams are affected by the tidal action. The next 15 years in 2015, the area further decreased to 40.90 hectares (0.06%). Therefore, the decreased area of stream and lake during the study period was 6.85 hectares with -0.62 % annual rate of change.

Some inland lakes and parts of the streams were filled with sediments, reducing the water body area. On the other hand, certain parts of crop land have changed into inland water bodies due to extraction of clay for making bricks and digging of fish ponds.

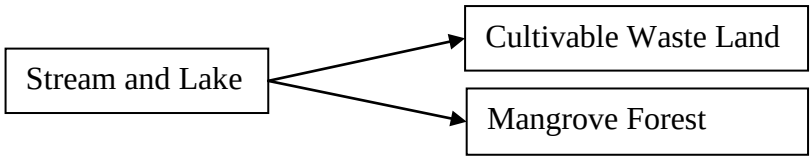


Figure 15 Change Pattern of Stream and Lake

Plate 4 Crop land changed into water body area due to extraction of clay for making bricks and digging of fish ponds (Muyitkalay Village Tract) 16º 17'23.08" N, 97º 32'24.91" E (23.4.2016)

Generally the area of river and sea water has gradually declined from 1990 to 2015 in Chaungzon Township. Therefore, the decreased area of river and sea water in 25-year period was 6973.34 hectares with an average decreased rate of -2.14%. River and sea water along the northwest, west and the south have changed into bare land and mangrove forest due to sediment deposition.

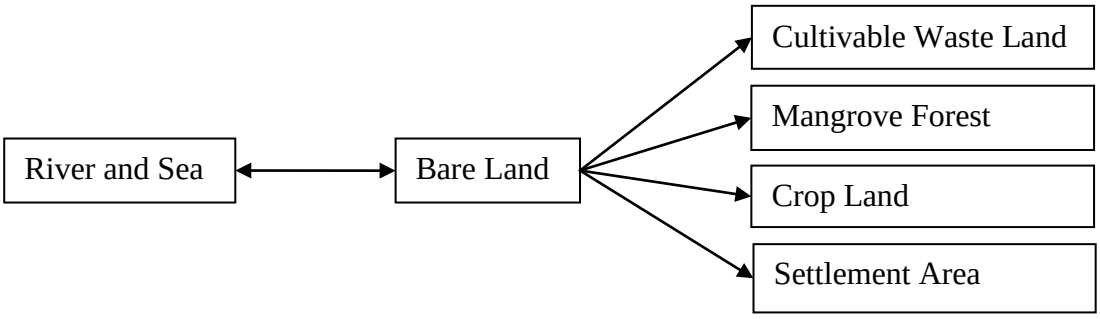


Figure 16 Change Pattern of River and Sea

Cultivable waste land in Chaungzon Township includes fallow 'le' land being inundated, water-logged lands, shallow depressions neartidal creeks and the lakes. The net increased area in the study period was 629.69 hectares with an average annual rate of change was +0.80%.

Figure 17 Change Pattern of Cultivable Waste Land

Bare land remains as unused land by the local people.From 1990 to 2015, the decreased area of bare land was 499.49 hectares with - 0.25 % annual rate of change.Although bare land cannot be used now, it is likely to be changed into crop and or mangrove forest in the near future.

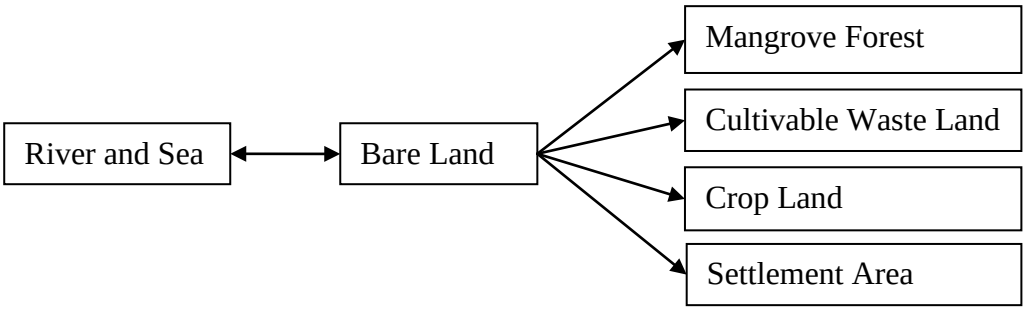


Figure 18 Change Pattern of Bare Land

The process of land use and land cover change is pervasive and continuous in responses to natural process and anthropogenic pressure. Such changes affect the ecosystems of the respective areas.

The problem of inventorying and classifying multiple-uses occurring on a single parcel of land will not be easily solved. Such use is observed in the upland area of the township.

In Chaungzon Township, bank collapse is not uncommon along the northeastern and eastern coastal areas mainly due to bank erosion. Bank collapse turns some agriculture land and built-up areas into water bodies.According to image taken in 2015, most bare lands along western coast has changed into mangrove forest area. However, new bare land has emerged due to deposition process. The new bare lands are likely to become agriculture land in the near future.

Plate 5 Settlement area changed into water body under bank erosion (Mayan Village) 16º 19' 40.77" N, 97º 33' 55.83" E (27.4.2015)

Plate 6 The newly emerged bare land located at the extreme northwest of the township have been used as settlement area (Daye VillageTract) 16º 30' 30.03"N, 97 º29'45.82"E (29.11 2016)

Plate 7 Newly deposited areas have been also used as crop land (Daye VillageTract) 16º 30'36.24"N, 97 º29'47.50"E (29.11 2016)

Causes of Land Cover and Land Use Changes

The land cover and land use changes in Chaungzon Township are attributable to both natural processes and man-induced activities. The former includes coastal bank collapse, erosion and deposition. However, it is difficult to identify the exact extent of changes by such natural processes. Therefore, this study on land cover and land use changes and its impacts is based on the data and information acquired from field surveys, responses to questionnaires and interviews with the relevant locals.

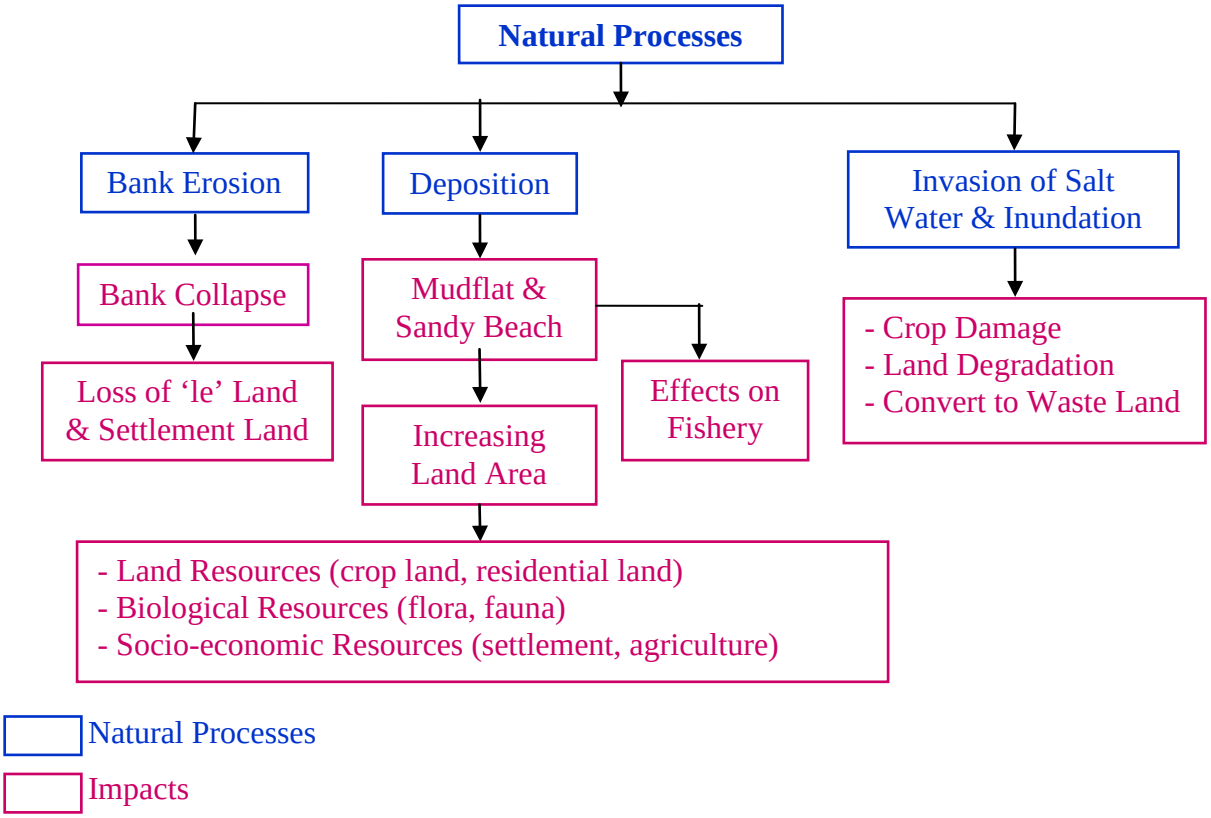
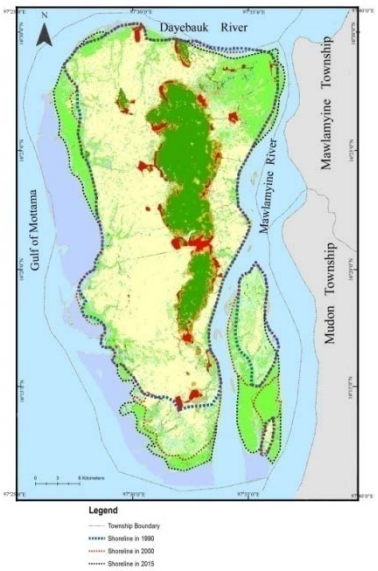


Figure 19 Natural Processes and Impacts of Land Cover and Land Use Changes

The bank erosion has affected mostly along the northeastern and eastern coasts of the island by the Thanlwin River. It is leant from field surveys that 11 out of 43 village tracts of the township witnessed bank erosion. Bank erosion and bank collapse took away farmland and parts of the residential areas.



Source: Land Cover Map 1990, 2000 and 2015

Figure 20 Shoreline Changes in Chaungzon Township

The process of sediment deposition is more pronounced in the study area. The western and southern parts of the island are adjoined with the open sea and deposition process is pronounced by the work of wave action. Excepting the northeastern and eastern coastlines, the remaining parts the coastline have been changed notably by depositional process during the study period.

Being an island township, the existing creeks are affected by tidal action, especially in the spring-tide period and inundation of 'le' (paddy) land usually occurs when the spring tide coincides with heavy rain.

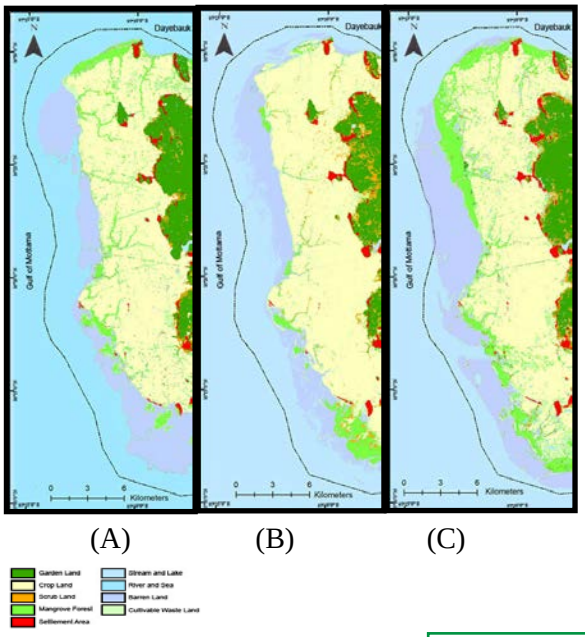


Figure 21 (A), (B) and (C) show the Changes along the Western and Southern Coasts of the Study Area

Source: Land Use Map 1990, 2000 and 2015

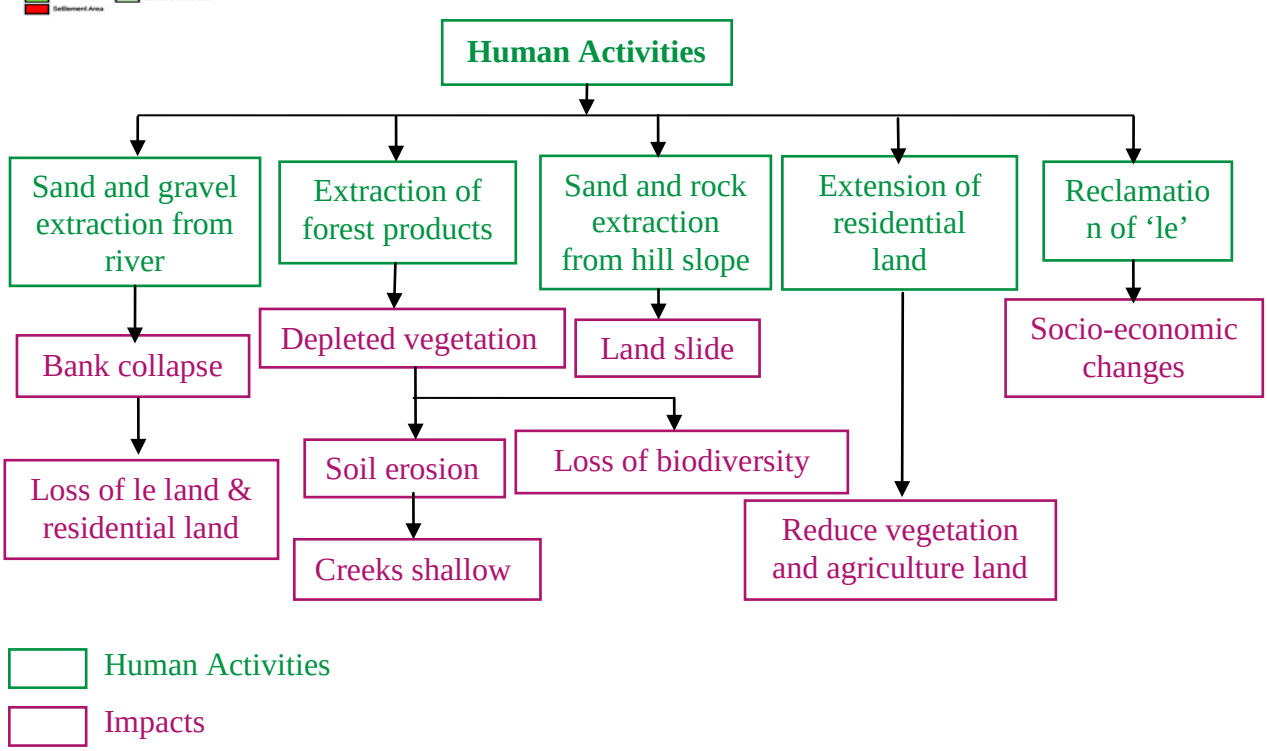


Figure 22 Human Activities and Impacts of Land Cover and Land Use Changes

Human activities that affect the land cover and land use in Chaungzon Township are as follows:

(a) Extraction of river sands and gravels and dredging

(b) Extraction of hardwoods and firewood and the extension of rubber land

(c) Extension of residential area

(d) Reclamation of 'le' (paddy)land and

(e) Other activities

Impacts of Land Cover and Land Use Changes

In Chaungzon Township, both bank erosion and deposition processes are dominant along the coastline. Bank collapse occurs due to erosion, resulting in shorter width in some places of the Main Island, but depositional landform characterized by mudflat and young alluvium are more pronounced, increasing the land area of the township. According to local records the extreme width of Belugyun was 16.49 km (10.25 miles) and the extreme length from north to south measured 31.38 km (19.5 miles). Based on the image of Google Earth in 2015, it had an extreme width of 18.63 km (11.58 miles) and an extreme length of 34.96 km (21.73 miles). Likewise, Hintharkyun has become more elongated in shape with greater length from north to south. Generally, the change in configuration of the eastern shoreline is less obvious on the map, but the western shoreline has greatly changed. The shape has notably extended towards the west and south.

Biological impact here means the impact of land cover and land use changes over the flora and fauna within the study area. During the past 25 years, the favorable habitats for wild animals have been cleaned for the cultivation of rubber and such undertaking sharply decreased the number of wildlife, destroying the richness of biodiversity.

On the other hand, the natural processes in Chaungzon Township enhance the formation of habitats for aquatic animals and birds. Such natural enhancement is found in the coastal area. During the study periods, the sediments, essentially sand and mud have been widely deposited on the northwestern, western and southern coastal areas. Such deposition sets the stage for the growth of mangrove forest which is expanding rapidly. In such areas covered with newly deposited fertile sediments serve as the habitats for several mangrove species and increase the number different semi-marine fauna.

Such changes have direct impact on settlement land, 'le' (paddy)cultivation and fishery both positively and negatively.

The extension of settlement areas have been carried out in nearly all the village tracts. Among the 43 village tracts in Chaungzon Township 22 village tracts are fronted by coastline. The villages fronted by the river or sea witnessed serious bank erosion and bank collapse.

Generally, the settlement area of the coastal region has witnessed either decrease or increase due to natural processes, while parts of garden land, fallow land and virgin and vacant land in the middle section of the township have been converted to settlement land.

The main economic activity of Chaungzon Township is agriculture, particularly growing of monsoon paddy. In Chaungzon Township, the 3 wards of the town and all village tracts have

more or less ‘le’ (paddy) land.26 out of 43 village tracts have suffered the negative impact of the invasion of saline water, to some extent destroying the planted crop, paddy.

Being located at the mouth of Thanlwin River both marine fishery and freshwater fishery can be carried out. Among the 43 village tracts fishing industry is carried out in 19 village tracts. Fishery has been sharply declining and at present it is not an important economic activity of these villages. The declining fishing activity is largely due to the emergence of new alluvial land which increases the distance between these villages and the sea, partly because of shallow tidal creeks.

Prediction

Transitional probability matrix reveals the change potential of one type of land into another type. The rows in the matrix table represent the old land cover types and the columns the newer categories. The value matrix in the row mentioned in transitional probability matrix Table 5.1 represent land cover types in 2015 and column refers to matrix value of land cover in 2030. Diagonal cell values indicate the land cover types that remain unchanged in the 2015-2030 periods, and other cell values represent the land cover types that may change from one to another type.

Table 10 Transitional Probability Matrix in Chaungzon Township (2015 to 2030)

Year	2030							
	L C	**V A**	**AL**	**BL**	**WL**	**WB**	**BA**	**Total**
2015	VA	6354.61	4939.36	86.97	566.19	261.37	333.60	12542.10
	AL	266.26	28903.49	0.00	1277.00	18.56	115.22	30580.53
	BL	2379.13	1205.45	2401.19	993.33	861.95	22.25	7863.30
	WL	744.69	1999.96	133.20	473.67	87.43	29.98	3468.93
	WB	1521.05	53.25	2995.83	261.01	5051.03	7.93	9890.10
	BA	0.00	0.00	0.00	0.00	0.00	1468.57	1468.57
	Total	**11265.74**	**37101.51**	**5617.19**	**3571.20**	**6280.34**	**1977.55**	**65813.53**

Source: Derived From Land Cover Change Matrix

Table 11 Land Cover Areas and Change Per cent in Chaungzon Township for 2015 and 2030

No.	Land Cover Types	2015		2030		2015-2030
		Hectare	**%**	**Hectare**	**%**	**Change %**
1	Vegetation Area	12542.1	19.06	11265.74	17.12	1.94
2	Agriculture Land	30580.53	46.46	37101.51	56.37	-9.91
3	Barren Land	7863.3	11.95	5617.19	8.54	3.41
4	Wetland	3468.93	5.27	3571.20	5.43	-0.16
5	Water Bodies	9890.1	15.03	6280.34	9.54	5.49
6	Built-up Area	1468.57	2.23	1977.55	3.00	-0.77
	Total	65813.53	100	65813.53	100.00	

Source: Derived From Land Cover Change Matrix

Conclusion

This paper focuses on two aspects: investigation of the physical characteristics of land cover changes using satellite image classification; and questionnaires, interviews and field observations at the local level on the ground changes. Changes in land cover are quantified using satellite remote sensing imagery, however driving forces of the changes in land use are harder to measure through quantitative analysis such as physical experiment. The qualitative analysis helps not only at understanding changes on the ground, but also the possible reasons behind such changes. By combining quantitative and qualitative methods a more comprehensive understanding of changes at different spatial locations and temporal periods are gained.

In Chaungzon Township, agriculture is the chief economic activity and nearly half the township area is agriculture land. Owing to bank erosion and invasion of saline seawater, thousand acres of 'le' (paddy)land are destroyed annually, causing economic hardship to the farmers of the coastal areas. Therefore, more embankments should be constructed and the existing ones should be strengthened.

Although natural bank erosion process cannot be stopped, the authority concerned should take necessary measures to minimize the negative impact of the natural process.

Some parts of the newly emerged land are not stable and liable to disappear. They should be somehow managed to become stable with relevant modern techniques. Usually, the newly emerged lands are used only for cultivation of crops. Instead, some parts of the land should be used for tourism sites for the local development.

The coastline of the study area is constantly changing as a result of bank collapse and deposition of sediments. There has been no record of such changes. The responsible persons should record the changes to be able to carry out the best use of land along the coastal areas in the future.

The agriculture land area has notably increased in the 25-year period. At the same time, some parts of agriculture land were taken away by the bank erosive action of the tidal waves and others converted to wetland due to invasion of saline seawater.

During the study period, the change of barren land was most obvious. The colonization of mangroves over barren land resulted in the formation of the new vegetation area, and some parts have also changed to agriculture land and wetland. The newly emerged barren land plays an important role in the land cover and land use change and also change the natural ecosystem of the area.

Generally the land cover and land use changes in the 25- years period were manifested by increase of land area in agriculture land, built-up area and wetland area, while that of water bodies, barren land and vegetation area have been decreasing.

The presence of mangrove forests in the coastal area can prevent the invasion of tidal water into the 'le' (paddy)l and and villages and helps reduce the negative impact of tidal waves and strong surge. To effectively maintain the mangrove forests, the authority concerned strictly forbid the cutting of mangrove for firewood or agricultural implements.

The coastal area has changed markedly due to the bank erosion of the Thanlwin River and the wave action of the Gulf of Mottama which have led serious bank collapse along the coast,

and the deposition of sediments has formed new alluvial plain particularly in the west and south. The deposition process outpaces erosion process, thus resulting in the increase of land area of the study area which can be considered as positive land cover changes.

References

Agricultural Atlas of the Union of Myanmar (2001-2002)

Anderson, J.R., Hardy, E.E., Roach, J.T., Witmer, R.E., (2001): *A Land Use and Land Cover Classification System for Use with Remote Sensor Data.* **U.S Geological Survey Circular 671, Geological Survey Professional Paper 964.**

Areendran, G., Rao, P., Raj, K., Mazumdar, S., Puri, K., (2013): *Land use/land cover change dynamics analysis in mining areas of Singrauli district in Madhya Pradesh, India*. **International Society for Tropical Ecology 54(2)**: 239-250.

Congalton, R.G., Green, K., (1999): *Assessing the Accuracy of Remotely Sensed Data*: **Principles and Practices. Lewis Publishers, Boca Raton.**

Elias, P., Dekolo, S., Babatola, O., (2011): *Land Use Change Modeling in Developing Countries*: **Issue and prospects. International Journal of Geography and Geology1(1)**: 23-41.

Ellis, E. A., Baerenklau, K. A., Marcos-Martinez, R., Chavez, E., (2010): *Land use/Land Cover Change Dynamic and Drivers in a low-grade Marginal coffee Growing Region of Veracruz, Mexico*. **Agroforest System (2010) 80:** 61-84.

Enger, E and Smith, B., (2006): *Environmental Science, A Study of Interrelationships*. (Tenth Edition) The McGraw-Hill Companies

Kay Thi Aung (2009): **Agricultural Land Use in Chaungzon Township**. (Unpublished M.A. Thesis, Department of Geography, Mawlamyine University)

Khine Khine Shein (1996): **Land Utilization of Chaungzon Township**. (Unpublished M.A. Thesis, Department of Geography, Mawlamyine University)

Khin Moe Phyu (2012): **Role of Cottage Industries in Chaungzon Township**. (Unpublished M.A. Thesis, Department of Geography, Mawlamyine University)

Khin Su Kyaw (2016): **Fishing Industry of Chaungzon Township: Case Study of Kamarkay, Sebalar and Zeegone Village Tracts**. (Unpublished M.A. Thesis, Department of Geography, Mawlamyine University)

Loveland, T.R., (1999): *Land Cover Trends: Rates, Causes, and Consequences of Late- Twentieth Century U.S. Land Cover Change*. **U.S. Environmental Protection Agency.**

Mas, J.F., Velazquez, A., Diaz-Gallegos, J.R., Mayorga-Saucedo, R., Alcantara, C., Bocco, G., Castro, R., Fernandez, T., Perez-Vega, A.,(2004): *Assessing land use/cover changes: a nationwide multidate spatial database for Mexico.* **International Journal of Applied Earth Observation and Geoinformation**(5) 249-261.

Maung Maung Aye, Myint Myint Thein, Khine Khine Shein (1999): *A Geographical Analysis of Human Environment in Chaungzon Township*, **research Paper Reading Session in Hailing A.D 2000 and the New Millennium**, Department of Geography, University of Mawlamyine.

Min Min Aye Than (2011): **Geographical Analysis on Land Cover and Land Use Changes in Padaung Township**. (Unpublished PhD Dissertation, Department of Geography, University of Yangon)

Morshed Anwar, Sk., (2002); **Land Use Change Dynamics: A Dynamic Spatial Simulation**. (Unpublished M.Sc Thesis, Asia Institute of Technology, School of Advanced Technologies, Thailand).

Nan Tin Zar Oo (2012): **Geology and Petrology of Chaungzon Area**, **Chaungzon Township, Mon State**. M.Sc Thesis, Department of Geology, Mawlamyine University.

Opeyemi, Z.A., (2006): **Change Detection in Land Use and Land Cover Using Remote sensing Data and GIS, (A case study of Ilorian and its environs in Kwara State**. (Unpublished M.Sc. Thesis, Department of Geography, University of Ibadan, Nigeria).

Phyo Ngwe Zin (2014): **Petrology of the Northern part of Bilugyun Area, Chaungzon Township, Mon State**. M.Sc Thesis, Department of Geology, Mawlamyine University.

Pickard, G. L., Emery,W. j., (1990): **Descriptive Physical Oceanography** (5, illustrated ed.) Elsevier. pp. 7-8.

Rawat, J.S., Kumar, M., (2015**):** *Monitoring Land Use/Cover Change using Remote Sensing and GIS Techniques: A Case Study of Hawalbagh block, distirict Almora, Uttarakhand, India*. **The Egyptian Journal of Remote Sensing and Space Sciences (2015) 18,** 77-84.

Schulz, J.J, Cayuela, L., Echeverria, C., Salas, J., (2010): *Monitoring Land Cover Change of the Dryland Forest Landscape of Central Chile (1975- 2008)*. **Applied Geography 30 (2010)** 436-447.

Sopheak, C., Wales, N., Frewer, T., (2011): *An Investigation of Land Cover and Land Use Change in Stung Chrey Bak Catchment, Cambodia*. **Working Paper Series No. 53.**

Thwe Thwe Aye (2015): A **Geographical Analysis on Land Use and Land Cover Changes in Kyaukse Township**. (Unpublished PhD Dissertation, Department of Geography, University of Mandalay).

Tint Tint Tun (2014): **Petrology of the Southern Part of Bilugyun Area, Chaungzon Township, Mon State.** M.Sc Thesis, Department of Geology, Mawlamyine University.

Win Pa Pa Myo (2006): **A Spatial Analysis of Land Use and Land Cover Change in Hlegu Township**. (Unpublished PhD Dissertation, Department of Geography, University of Yangon).

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အစီရင်ခံစာအကျဉ်း

"မြန်မာဘာသာစကားရှိ အပြောစကားပုံစံများလေ့လာချက်" သုတေသနကျမ်းကို ပြုစုရခြင်းမှာ မြန်မာလူမျိုးတို့သည် လူမှုနယ်ပယ်အသီးသီး၌ စကားကိုမည်ကဲ့သို့သောပုံစံဖြင့် ပြောဆိုအသုံးပြုနေကြပြီး ထိုကဲ့သို့ ပြောဆိုအသုံးပြုကြခြင်းဖြင့် ပြောသူနှင့်နာသူတို့၏ လူမှုဆက်ဆံရေး၊ လူမှု အဆင့်အတန်းကို မည်ကဲ့သို့ထင်ဟပ်နေကြောင်း၊ မြန်မာဘာသာစကားနှင့်မြန်မာ့လူ့အဖွဲ့အစည်းအကြား မည်ကဲ့သို့ အပြန်အလှန် အကျိုးသက်ရောက်မှုကို ဖြစ်ပေါ်စေကြောင်းတို့ကို စနစ်တကျ လေ့လာဖော်ထုတ်ရန်နှင့် မြန်မာဘာသာစကားဖွဲ့ဖြိုးတိုးတက်အောင် ဆောင်ရွက်ရာ၌ အထောက်အကူဖြစ်စေရန် ရည်ရွယ်ပြုစုခဲ့ပါသည်။ မျက်မှောက်ခေတ်အပြောစကားများ၊ မြန်မာနိုင်ငံအတွင်း ထုတ်ဝေဖြန့်ချိလျက်ရှိသော စာနယ်ဇင်းများ၊ မြန်မာနိုင်ငံအတွင်း ထုတ်လွှင့်ပြသလျက်ရှိသော ဖျော်ဖြေရေးအစီအစဉ်များကို အလေ့လာခံအဖြစ်သတ်မှတ်ပြီး ခေတ်မီလူမှုဘာသာဗေဒနည်းနာများဖြင့် လေ့လာသုတေသနပြုခဲ့ပါသည်။ ထိုကဲ့သို့ သုတေသနပြုရာတွင် ညွှန်းခေါ်စကားပုံစံများ၊ စကား သင်္ကေတရောသုံးခြင်းပုံစံများ၊ စကားလုပ်ဆောင်ချက်ပုံစံများနှင့် စကားပြောပုံစံများဟူ၍ ပိုင်းခြားကာ လေ့လာဆန်းစစ်ခဲ့ပါသည်။ အပြောစကားပုံစံများကို ပိုမိုပေါ်လွင်စေရန် သရုပ်ဖော်ပုံ များ၊ အသံလှိုင်းရုပ်ပုံများကို အသုံးပြုခဲ့ပါသည်။ အရေးအတွက်ဆိုင်ရာလေ့လာဆန်းစစ်ချက်များ ကိုလည်း အသုံးပြုထားပါသည်။ အပြောစကားပုံစံများသည် လိင်၊ အသက်အရွယ်၊ လူမှုဂုဏ် အဆင့်အတန်းတို့အပေါ် အခြေခံ၍ ပြောဆိုနေကြသကဲ့သို့ တစ်ဦးအပေါ်တစ်ဦး အပြန်အလှန် လေးစားမှု၊ ဂါရဝတရားထားရှိမှု၊ ယဉ်ကျေးပျူငှာမှု၊ ကိုးကွယ်ယုံကြည်မှုနှင့်ယဉ်ကျေးမှု ဓလေ့ထုံးစံတို့ အပေါ်အခြေခံ၍လည်း ပြောဆိုနေကြကြောင်း တွေ့ရပါသည်။ အဖွင့်စကားမှ အဆုံးသတ်စကားအထိ စကားပြောပုံစံ (တစ်နည်းအားဖြင့်) စကားပြောဖြစ်စဉ်(၁၀)မျိုးကို ဖော်ထုတ်မှတ်တမ်းတင်နိုင် ခဲ့ပါသည်။ ထို့ကြောင့် ဤလေ့လာသုတေသနပြုချက်များသည် မြန်မာဘာသာစကားလေ့လာမှုနှင့် မြန်မာဘာသာစကားဖွံ့ဖြိုးတိုးတက်ရေးတို့အတွက် များစွာအထောက်အကူပြုနိုင်လိမ့်မည်ဟု ယုံကြည်ပါသည်။

သော့ချက်ဝေါဟာရများ– လူမှုဘာသာဗေဒ၊ ညွှန်းခေါ်စကား၊ စကားသင်္ကေတရောသုံးခြင်း၊ စကားလုပ်ဆောင်ချက်၊ စကားပြောစိစစ်မှု၊

နိဒါန်း

ဘာသာစကားတွင် ပြောသူနှင့်နာသူတို့၏လူမှုစရိုက်လက္ခဏာများကို တွေ့မြင်နိုင်သကဲ့သို့ ပြောသူနှင့် နာသူတို့အကြားရှိ လူမှုဆက်ဆံရေးအခြေအနေ၊ လူမှုအဆင့်အတန်းကိုလည်း သိရှိနိုင်ပါသည်။ ဤ အစီရင်ခံစာသည် "မြန်မာဘာသာစကားရှိ အပြောစကားပုံစံ" များကို လူမှုဘာသာဗေဒရှုထောင့်မှ လေ့လာထားချက်ကျမ်းအား အစီရင်ခံတင်ပြခြင်း ဖြစ်ပါသည်။ ကျမ်းပြုသူသည် လူမှုဘာသာဗေဒ ပညာရပ်ကို ၂၀၀၇ခုနှစ်၊ မဟာဝိဇ္ဇာတန်းမှစတင်၍လေ့လာသင်ယူခဲ့ရာမှ စတင်စိတ်ဝင်စားခဲ့ပါသည်။ ထို့ကြောင့် ပါရဂူကျမ်းခေါင်းစဉ် တင်သွင်းရသောအခါ လူမှုဘာသာဗေဒ ပညာရပ်ဖြင့် သုတေသန ပြုလုပ်ရန် စိတ်ကူးရပြီး တင်သွင်းခဲ့ခြင်းဖြစ်ပါသည်။

ရည်ရွယ်ချက်

လူမှုဘာသာဗေဒ၏သဘောမှာ ဘာသာစကားနှင့်လူ့အဖွဲ့အစည်းကြားရှိ အပြန်အလှန် ဆက်စပ်မှုကို လေ့လာသောပညာရပ်ဖြစ်ပါသည်။ မြန်မာလူမျိုးတို့သည် လူမှုနယ်ပယ်အသီးသီးတွင် စကားကို မည်ကဲ့သို့သောပုံစံဖြင့် ပြောဆိုအသုံးပြုနေကြပြီး ထိုကဲ့သို့ ပြောဆိုအသုံးပြုကြခြင်းဖြင့် ပြောသူနှင့် နာသူတို့၏လူမှုဆက်ဆံရေး၊ လူမှုအဆင့်အတန်းကို မည်ကဲ့သို့ထင်ဟပ်နေကြောင်း၊ မြန်မာဘာသာ စကားနှင့် မြန်မာ့လူ့အဖွဲ့အစည်းအကြား မည်ကဲ့သို့ အပြန်အလှန် အကျိုးသက်ရောက်မှု ဖြစ်ပေါ်စေ ကြောင်းကို စနစ်တကျ လေ့လာဖော်ထုတ်ရန်နှင့် မြန်မာဘာသာစကားဖွံ့ဖြိုးတိုးတက်အောင် ဆောင်ရွက် ရာတွင် အထောက်အကူဖြစ်စေရန် ရည်ရွယ်ပြုစုခဲ့ပါသည်။

ဦးတည်ချက်

ယနေ့ခေတ်တွင် လူမှုဘာသာဗေဒပညာရပ်သည် အကြောင်းအရာ အလွန်ကျယ်ပြန့်ပြီး လူအများ စိတ်ဝင်တစားလေ့လာကြသည့်ပညာရပ်ဖြစ်ပါသည်။ လူတို့သည်အမျိုးမျိုးသော လူမှုအဆက်အစပ် အတွင်း ဘာသာစကားကို ကွဲပြားစွာပြောဆိုလျက်ရှိပြီး ဘာသာစကားသည် လူမှုဆက်ဆံရေးကို နားလည်သဘောပေါက်ရန်ကူညီနိုင်ကြောင်းသိရှိလာကြသည်။ လူတစ်ယောက်သည် စကားပြောဆိုသည့် အခါ မိသားစုကို ပြောသောစကား၊ သူစိမ်းတစ်ရံကိုပြောသောစကား၊ လုပ်ငန်းခွင်တွင် မိမိ လုပ်ဖော် ကိုင်ဖက်များနှင့် အထက်လူကြီးများကို ပြောသောစကားတို့သတူညည် မည်သို့မျှမီနိုင်ကြပေ။ ထိုသို့ ကွဲပြားသောလူမှုအခြေအနေတွင် ဘာသာစကားကို မတူကွဲပြားစွာ အသုံးပြုကြခြင်းသည် လူမှုဘာသာ ဗေဒလေ့လာမှု၏ ဦးတည်ချက်ဖြစ်လာခဲ့ပါသည်။

အပြောစကားပုံစံများကို လေ့လာရာ၌ မြန်မာလူမျိုးတို့သည် လူမှုနယ်ပယ်အသီးသီးတွင် စကားကို မည်ကဲ့သို့သောပုံစံဖြင့်ပြောဆိုအသုံးပြုနေကြသနည်း။ ထိုကဲ့သို့ ပြောဆိုအသုံးပြုခြင်းဖြင့် ပြောသူနှင့် နာသူတို့၏ လူမှုဆက်ဆံရေး၊ လူမှုအဆင့်အတန်းကို မည်ကဲ့သို့ ထင်ဟပ်နေသနည်း။ ပြောသူနှင့်နာသူတို့ မည်ကဲ့သို့သောအကျိုးသက်ရောက်မှုကို ဖြစ်ပေါ်စေသနည်းဟူသော အချက်များသည် မြန်မာဘာသာ စကားဖွံ့ဖြိုးရေးနှင့် ထိန်းသိမ်းရေးတို့အတွက် အရေးပါသော သုတေသနပြဿနာ ဖြစ်လာပါသည်။ ထိုပြဿနာကို ဦးတည်ဖော်ထုတ်နိုင်ရန်အတွက် သုတေသနမေးခွန်းများ ထုတ်ကြည့်ခဲ့ပါသည်။ ထိုသုတေသနမေးခွန်းများမှာ–

(က) မြန်မာလူမျိုးတို့သည် တစ်ဦးနှင့်တစ်ဦးတွေ့ဆုံစဉ် မည်ကဲ့သို့သောပုံစံဖြင့် ညွှန်းခေါ် ပြောဆို ကြသနည်း။

(ခ) မြန်မာဘာသာစကားအတွင်း အများအပြားဝင်ရောက်လျက်ရှိသော အင်္ဂလိပ်ဘာသာ စကားများကို မည်ကဲ့သို့သောပုံစံဖြင့် ထည့်သွင်းအသုံးပြုကြသနည်း။

(ဂ) လူတစ်ဦးနှင့်တစ်ဦး ပြောဆိုကြသော စကားများသည် ပြောသူက နာသူအပေါ် မည်ကဲ့သို့သော စကားလုပ်ဆောင်ချက်ပုံစံများကို ဖြစ်ပေါ်စေသနည်း။

(ဃ) မြန်မာလူမျိုးတို့သည် စကားပြောဆိုရာတွင် အဖွင့်စကားမှ အဆုံးသတ်စကားအထိ မည်ကဲ့သို့သောပုံစံများဖြင့် ပြောဆိုနေကြသနည်း။

ဟူ၍ ဖြစ်ပါသည်။ ထိုသုတေသနမေးခွန်းများကို အခြေခံပြီး မြန်မာဘာသာစကားရှိ အပြောစကား ပုံစံများကို လေ့လာဆန်းစစ်ရန် ဆုံးဖြတ်ခဲ့ပါသည်။

၁။ လေ့လာမှုနယ်ပယ်သတ်မှတ်ခြင်း

၁၊ ၁။ အသုံးခံအချက်အလက်များ

အပြောစကားပုံစံများအတွက် လိုအပ်သောအသုံးခံအချက်အလက်များထုတ်ယူပြီး စနစ်တကျ လေ့လာသုတေသနပြုနိုင်ရန် မျက်မှောက်ခေတ်ကို ၂၀၀၈ ခုနှစ်မှ ၂၀၁၇ ခုနှစ်အတွင်း သတ်မှတ်ခဲ့ပါသည်။ ယခင်က မြန်မာဘာသာစကားကို လူမှုဘာသာဗေဒပညာရပ်ဖြင့် လေ့လာသုတေသနပြု ဖော်ထုတ်ခဲ့ကြသော်လည်း မြန်မာဘာသာစကားရှိ အပြောစကားပုံစံတစ်ခုလုံးကို ပေါ်လွင်အောင် ကျယ်ကျယ်ပြန့်ပြန့် လေ့လာသုတေသနပြုခဲ့ခြင်း မရှိသေးပေ။ အပြောစကားပုံစံများဟုဆိုရာတွင် အပြောဟန်စကားပြေနှင့် စကားပြောနှစ်မျိုးစလုံးကို ဆိုလိုပါသည်။ အပြောဟန်စကားပြေသည် ကြိုတင်စီစဉ် ထားပြီး ဝါကျဖွဲ့ထုံးစည်းကမ်းများနှင့်အညီ စီစဉ်ရေးသားထားသော စကားပြေမျိုး ဖြစ်ပါသည်။ 'အင်း၊ အဲ၊ ဟိုဒင်း၊ ဒါနဲ့၊ အော်' စသည့် မပြေပြစ်သောစကားများ မပါပေ။ စကားပြောသည် ကြိုတင် စီစဉ်မထားဘဲ ပါးစပ်ထဲက ရုတ်တရက်ပြောလိုက်သော စကားဖြစ်၍ 'အင်း၊ အဲ၊ ဟိုဒင်း၊ ဒါနဲ့၊ အော်' စသည့် အထစ်အငေါ့များ ပါဝင်သည့်စကားများဖြစ်သည်။ အလေ့လာခံ အပြောဟန်စကားပြေများအတွက် နေ့စဉ်သုံးအပြောစကားများ၊ မြန်မာနိုင်ငံအတွင်းပုံနှိပ်ထုတ်ဝေလျက်ရှိသောစာအုပ်၊ စာစောင်များ၊ စကားပြောများအတွက် မြန်မာနိုင်ငံအတွင်းထုတ်လွှင့်ပြသလျက်ရှိသော ဖျော်ဖြေရေး

အစီအစဉ်များ၊ သတင်းအစီအစဉ်များ၊ ဗွီဒီယိုဇာတ်လမ်းများကို အသုံးပြုထားပါသည်။

၁၊ ၂။ အသုံးပြုသည့်ဘာသာဗေဒနယ်ပယ်

ဘာသာစကားကို လေ့လာသည့်အခါ ဘာသာဗေဒနှင့် လူမှုဘာသာဗေဒတို့သည် လေ့လာပုံလေ့လာ နည်းကွဲပြားကြပါသည်။ ဘာသာဗေဒသည် ဘာသာစကားကို လူ့အဖွဲ့အစည်းအတွင်းမှ ခွဲထုတ်ပြီး ထိုဘာသာစကား မည်ကဲ့သို့ဖွဲ့စည်းတည်ဆောက်ထားသည်ကို လေ့လာခြင်းဖြစ်သည်။ လူမှုဘာသာဗေဒသည် လူ့အဖွဲ့အစည်းအတွင်း၌ ဘာသာစကားကို မည်ကဲ့သို့ အသုံးပြုပြီး ဘာသာစကားနှင့် လူ့အဖွဲ့အစည်းကြားရှိ အပြန်အလှန်ဆက်စပ်မှု၏ သွင်ပြင်လက္ခဏာများကို လေ့လာခြင်းဖြစ်သည်။ ထို့ကြောင့် မြန်မာဘာသာစကားရှိ အပြောစကားပုံစံများကို ဖော်ထုတ်ရန်အတွက် ဘာသာဗေဒ၏ ပညာရပ်ခွဲဖြစ်သော လူမှုဘာသာဗေဒနယ်ပယ်ကို အသုံးပြုထားပါသည်။

၂။ သုတေသနပြုရာ၌ အသုံးပြုခဲ့သည့် လူမှုဘာသာဗေဒနည်းနာများ

မျက်မှောက်ခေတ် မြန်မာဘာသာစကားရှိ အပြောစကားပုံစံများကို လေ့လာနိုင်ရန်အတွက် လူမှုဘာသာဗေဒနည်းနာနှင့် သဘောတရားများကိုအသုံးပြုခဲ့ပါသည်။ မြန်မာဘာသာစကားကို လေ့လာခြင်းဖြစ်၍ ရှေးဦးစွာ မြန်မာဘာသာစကား၏ သဘောသဘာဝကို ဖော်ထုတ်ခဲ့ပါသည်။ ထို့နောက် ကျမ်းတွင် အဓိကအခြေခံမည့် လူမှုဘာသာဗေဒနည်းနာများကို သတ်မှတ်လေ့လာခဲ့ပါသည်။

၂၊ ၁။ တွေးဆချက်များ

မြန်မာဘာသာစကားရှိ အပြောစကားပုံစံများကို လေ့လာခြင်းဖြစ်၍ ဦးစွာ မြန်မာဘာသာစကား၏ သဘောသဘာဝကို ဖော်ထုတ်ရန်လိုအပ်မည်ဟု တွေးဆမိပါသည်။ ထို့နောက် သုတေသနပြုသနာ

အတွက် အဓိကအခြေခံမည့် နည်းနာများကို ဘာသာစိတ်နယ်ပယ်များအဖြစ် သတ်မှတ်လေ့လာရန် လိုအပ်မည်ဟု တွေးဆမိသည်။အပြောစကားပုံစံများသည် အလွန်ကျယ်ပြန့်၍ သုတေသန ပြဿနာကို ဦးတည်လေ့လာနိုင်ရန် သုတေသနမေးခွန်းထုတ်ပြီး ထိုသုတေသနမေးခွန်းများအတွက် အခြေခံ လေ့လာမည့် နည်းနာများကိုလည်း တင်ပြရန်လိုအပ်မည်ဟု တွေးဆမိပါသည်။

မြန်မာလူမျိုးတို့သည် တစ်ဦးနှင့်တစ်ဦး တွေ့ဆုံစကားပြောဆိုရာ၌ မည်ကဲ့သို့ညွှန်းခေါ်ပြောဆို ကြသည်ကိုသိရှိနိုင်ရန် ညွှန်းခေါ်စကားကို လေ့လာရန်လိုအပ်မည်ဟု တွေးဆမိပါသည်။ ညွှန်းခေါ် စကားများကို စတင်လေ့လာရခြင်းမှာ လူတစ်ဦးနှင့်တစ်ဦးတွေ့ဆုံစဉ် ညွှန်းခေါ်စကားဖြင့် အဖွင့်စကား ပြောဆိုရသောကြောင့်ဖြစ်ပါသည်။ ထိုညွှန်းခေါ်စကားများသည် လူမှုဆက်ဆံရေးနယ်ပယ်တွင် အရေးကြီးသော စကားပြောပုံစံတစ်ခုဖြစ်မည်ဟု တွေးထင်ခဲ့ပါသည်။

မြန်မာဘာသာစကားအတွင်း အများအပြားဝင်ရောက်လျက်ရှိသော အင်္ဂလိပ်ဘာသာစကားကို မည်ကဲ့သို့ ထည့်သွင်းအသုံးပြုကြသည်ကို သိရှိနိုင်ရန် စကားသင်္ကေတရောသုံးခြင်းကို လေ့လာရန် လိုအပ်မည်ဟု တွေးဆမိပါသည်။ ထိုသို့ရောသုံးပုံများကို အပြောဟန်စကားပြေဖြင့် ရေးသားထား သောအချက်အလက်များဖြင့် တင်ပြပါက ပိုမိုထိရောက်မည်ဟုတွေးဆမိပါသည်။ ထိုသို့ရောသုံးခြင်း သည် မြန်မာဘာသာစကားဖွံ့ဖြိုးမှုအတွက် အကျိုး/အပြစ်တို့ကို ဖော်ထုတ်နိုင်လိမ့်မည်ဟု ထင်ပါသည်။ လေ့လာရာတွင် စကားလုံးအဆင့်၊ ပုဒ်အဆင့်နှင့် ဝါကျခွဲအဆင့်ဟူ၍ ခွဲခြားဖော်ထုတ်နိုင် လိမ့်မည်ဟုလည်း တွေးဆထားပါသည်။

တစ်ဖန် လူတစ်ဦးနှင့်တစ်ဦးပြောဆိုသောစကားများသည် ပြောသူကနာသူအပေါ် မည်ကဲ့သို့ လုပ်ဆောင်ချက်များကို ဖြစ်ပေါ်စေကြောင်းသိရှိနိုင်ရန် စကားလုပ်ဆောင်ချက်ကို လေ့လာရန်လိုအပ် မည်ဟု တွေးဆမိပါသည်။ စကားပြောတစ်ခုအတွင်း စကားခွန်းဖြင့်လုပ်ဆောင်ရာတွင် အမျိုးအစား မည်မျှပါဝင်ကြောင်းနှင့် ပြောသူနှင့်နာသူတို့၏ စကားလုပ်ဆောင်ချက်ပုံစံကို သရုပ်ဖော်ပုံနှင့်တကွ ဖော်ထုတ်လျှင် ပိုမိုရှင်းလင်းစွာတင်ပြနိုင်မည်ဟုထင်ပါသည်။ စကားလုပ်ဆောင်ချက်၏ ကျယ်ပြန့် နက်နဲ့ပုံနှင့် အကျိုးကျေးဇူးများကို ဖော်ထုတ်နိုင်လိမ့်မည်ဟု တွေးဆခဲ့ပါသည်။

ထို့နောက် မြန်မာလူမျိုးတို့သည် စကားပြောဆိုရာတွင် အဖွင့်စကားမှ အဆုံးသတ်စကား အထိ မည်ကဲ့သို့ပြောဆိုကြသည်ကို သိရှိနိုင်ရန်အတွက် စကားပြောပုံစံများကို ဖော်ထုတ်ရန်လိုအပ် မည်ဖြစ်ပါသည်။ ယခင်က မြန်မာဘာသာစကားကို လေ့လာရာတွင် ခေတ်မီနည်းပညာ စက်ပစ္စည်းကို အသုံးပြုပြီး လေ့လာမှုမှာ နည်းပါးပါသည်။ ထို့ကြောင့် တိတိကျကျ လေ့လာမှတ်တမ်းတင်နိုင်ရန် အလေ့လာခံများကို ခေတ်မီနည်းပညာဆော့ဖဝဲနှင့် ကွန်ပျူတာနည်းပညာပေါင်းစပ်ပြီး စနစ်တကျ လေ့လာလျှင် ပိုမိုထိရောက်သော သုတေသနအဖြေထွက်လာနိုင်မည်ဟု တွေးဆမျှော်မှန်းခဲ့ပါသည်။

၂၊ ၂။ လုပ်ဆောင်ချက်များ

မြန်မာဘာသာစကား၏ သဘောသဘာဝကို ပညာရှင်များ၏အယူအဆများအပေါ်အခြေခံပြီး ဦးစွာ ဆန်းစစ်ခဲ့ပါသည်။ သုတေသနပြဿနာအတွက် နည်းနာများကို ဘာသာစိတ်နယ်ပယ်အဖြစ် သတ်မှတ်လေ့လာရန် လုပ်ဆောင်ခဲ့ပါသည်။ ထို့နောက် သုတေသနမေးခွန်းများအတွက် အခြေခံ လေ့လာမည့် နည်းနာများကိုလည်း မြန်မာဘာသာစကား၏ သဘောသဘာဝနှင့်အညီ ဖော်ထုတ်ခဲ့ ပါသည်။

ညွှန်းခေါ်စကားပုံစံများကို ဖော်ထုတ်ရာတွင် **ညွှန်းခေါ်စကား**[၁]နှင့် **တိုက်ရိုက်အညွှန်းစကား**[၂]တို့၏ အထူးပြုလေ့လာသည့်နယ်ပယ်များ ကွဲပြားပုံကို ဆန်းစစ်ခဲ့ပါသည်။ ညွှန်းခေါ်စကားသည် လူမှုဆက်ဆံရေးနယ်ပယ်တွင် အရေးကြီးပုံကိုလည်း ဖော်ထုတ်ခဲ့ပါသည်။

စကားသင်္ကေတရောသုံးခြင်းပုံစံများကို ဆန်းစစ်ရာတွင် **စကားသင်္ကေတရောသုံးခြင်း**[၃] နှင့် **စကားသင်္ကေတကူးပြောင်းခြင်း**[၄] တို့၏ သဘောသဘာဝကို လေ့လာခဲ့ပါသည်။ မြန်မာဘာသာ စကားအတွင်း အင်္ဂလိပ်စကားရောသုံးရာခြင်းပုံစံ(၃)မျိုးကို ဖော်ထုတ်ခဲ့ပါသည်။ ပိုမိုရှင်းလင်းစွာ နားလည်နိုင်ရန် နိုင်ငံခြားဘာသာစကား၏ သာဓကများဖြင့်ပါ နိုင်းယှဉ်လေ့လာခဲ့ပါသည်။ စကား သင်္ကေတရောသုံးခြင်းပုံစံများတွင် စကားလုံးအဆင့်၊ ပုဒ်အဆင့်နှင့် ဝါကျခွဲအဆင့်ဟူ၍ ခွဲခြား ဖော်ထုတ်ပြီး ထူးခြားချက်များကိုလည်း ဖော်ထုတ်နိုင်ခဲ့ပါသည်။

စကားလုပ်ဆောင်ချက်[၅]ပုံစံများကို လေ့လာရာတွင် မြန်မာဘာသာစကားတွင်တွေ့ရသော စကားလုပ်ဆောင်ချက်ပုံစံကို ဆန်းစစ်ခဲ့ပါသည်။ **စကားခွန်းများ**[၆]ပုံစံကိုလည်းကောင်း၊စကားပြော တစ်ခုအတွင်း စကားခွန်းအားဖြင့်လုပ်ဆောင်ရာတွင် ပြောသူနှင့်နာသူတို့၏ စကားလုပ်ဆောင်ချက် ပုံစံကိုလည်းကောင်း ဖော်ထုတ်ခဲ့ပါသည်။ စကားလုပ်ဆောင်ချက်ပုံစံများကို သုတေသနပြုရာ၌ သဒ္ဒါအရ ပြောသူရည်ရွယ်သည့် စကားလုပ်ဆောင်ချက်ကို ဖော်ပြနိုင်ခဲ့ပြီး စကားလုပ်ဆောင်ချက်၏ ကျယ်ပြန့်နက်နဲ့ပုံနှင့် အကျိုးကျေးဇူးများကို ဖော်ထုတ်ခဲ့ပါသည်။

စကားပြော[၇]ပုံစံများကို ဖော်ထုတ်ရာတွင် **စကားပြောစိစစ်မှု**[၈] သဘောတရားကို အသုံးပြုပြီး **အဖွင့်စကား**[၉]မှ **အဆုံးသတ်စကား**[၁၀]အထိ ပြောဆိုပုံများကိုဆန်းစစ်ခဲ့ပါသည်။ တိတိကျကျ လေ့လာ မှတ်တမ်းတင်နိုင်ရန် အလေ့လာခံရုပ်သံများကို ခေတ်မီနည်းပညာဆော့ဖဝဲနှင့်ကွန်ပျူတာနည်းပညာ ပေါင်းစပ်အသုံးပြုပြီး အသံလှိုင်းရုပ်ပုံများဖြင့်ပါ စနစ်တကျ လေ့လာသုတေသနပြုခဲ့ပါသည်။

အလေ့လာခံ အပြောဟန်စကားပြေများအတွက် ပထမအဆင့်အနေဖြင့် မြန်မာနိုင်ငံအတွင်း ပုံနှိပ်ထုတ်ဝေလျက်ရှိသော စာအုပ်၊ စာစောင်များကို စုဆောင်းခဲ့ပါသည်။ စကားပြောများအတွက် ဖျော်ဖြေရေးအစီအစဉ်များ၊ သတင်းအစီအစဉ်များ၊ ဗွီဒီယိုဇာတ်လမ်းများနှင့်အသံမှတ်တမ်းများကို စုဆောင်းခဲ့ပါသည်။ ဒုတိယအဆင့်အနေဖြင့် ထိုစုဆောင်းထားသော အချက်အလက်များကို ခွဲခြမ်း စိတ်ဖြာ၍ သက်ဆိုင်ရာ လူမှုဘာသာဗေဒ၏ ပညာစိတ်နယ်ပယ်များဖြင့် သုတေသန ပြုခဲ့ပါသည်။ ပညာရပ်ဆိုင်ရာသီအိုရီများကို နားလည်အောင် အကြိမ်ကြိမ်ဖတ်ရှုခဲ့ရပါသည်။ ဝေါဟာရသစ်များ ကိုလည်း မိမိဘာသာစကားနှင့်ဆီလျော်အောင်ဘာသာပြန်ဆိုခဲ့ပါသည်။ ပညာရှင်များ၊ ဝက်ဗ်ဆိုက်

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[၁] address term
[၂] deixis
[၃] code-mixing
[၄] code-switching
[၅] speech act
[၆] utterances
[၇] conversation
[၈] conversation ananysis
[၉] opening sequence
[၁၀] closing sequence

များ၏ အမည်တို့ကို How To Pronounce (https://www. howtopronounce.com)ဝက်ဗ်ဆိုက်မှ မြန်မာ အာလျှာနဲ့ရွတ်ရ လွယ်ကူသော အင်္ဂလိပ်အသံထွက်ကိုယူ၍ အနီးစပ်ဆုံးတူအောင် မြန်မာ အက္ခရာဖြင့် အသံဖလှယ်ထားသည်။ စကားပြောများအတွက် နိုင်ငံခြားပညာရှင်များ၏ စကားပြောကို စာသားအဖြစ် ရေးကူးရာတွင် အသုံးပြုသည့်သင်္ကေတအချို့ကို အခြေခံပြီး စကားပြောများကို စာသားများ အဖြစ် ပြန်လည်ကူးယူ တင်ပြခဲ့ပါသည်။ ထိုသို့ ပြန်လည်ကူးယူရာတွင် Sony ၏ Sound Forg Pro 10.0 အသံ တည်းဖြတ်သည့် Software ကို အသုံးပြုခဲ့ပါသည်။ အပြောစကားများကိုသာ အဓိက လေ့လာခြင်း ဖြစ်သော်လည်း အပြောစကားနှင့်အတူတွဲဖက်နေသော အမူအရာနှင့် သင်္ကေတတို့ကိုလည်း အမြွက်မှု ဖော်ထုတ်ခဲ့ပါသည်။ ပိုမိုပေါ်လွင်စေရန် သရုပ်ဖော်ပုံများ၊ အသံလှိုင်းရုပ်ပုံများနှင့် အခြားဘာသာ စကားမှ သာဓကများဖြင့်ပါ သုတေသနပြဿနာကို လေ့လာဆန်းစစ်ခဲ့ပါသည်။

၃။ မြန်မာဘာသာစကားရှိ အပြောစကားပုံစံများ၏ သုတေသနရလဒ်များ

မျက်မှောက်ခေတ် မြန်မာဘာသာစကားရှိ အပြောစကားပုံစံများကိုလေ့လာရာတွင် ညွှန်းခေါ် စကားပုံစံ၊ စကားသင်္ကေတရောသုံးခြင်းပုံစံ၊ စကားလုပ်ဆောင်ချက်ပုံစံနှင့် စကားပြောပုံစံတို့ကို အခန်းများခွဲ၍ လူမှုဘာသာဗေဒရှုထောင့်မှ လေ့လာတင်ပြခဲ့ပါသည်။

၃၊ ၁။ ညွှန်းခေါ်စကားပုံစံများ

ညွှန်းခေါ်စကားပုံစံများတွင် လူပုဂ္ဂိုလ်အမည်ဆိုင်ရာ၊ ဓလေ့ထုံးစံဆိုင်ရာ၊ ဘာသာရေးဆိုင်ရာ၊ အသက်မွေးဝမ်းကျောင်းဆိုင်ရာ၊ ဆွေမျိုးတော်စပ်မှုဆိုင်ရာ၊ ရင်းနှီးကျွမ်းဝင်မှုဆိုင်ရာ၊ ပုဂ္ဂလနာမ်စား ဆိုင်ရာ၊ အမည်မခေါ်သည့် ညွှန်းခေါ်စကား/သုညညွှန်းခေါ်စကားဆိုင်ရာနှင့် ယေဘုယျညွှန်းခေါ် စကားဆိုင်ရာတို့ကို ဖော်ထုတ်တင်ပြထားပါသည်။

၃၊ ၁၊ ၁။ တွေ့ရှိချက်များ

လူပုဂ္ဂိုလ်အမည်ဆိုင်ရာ ညွှန်းခေါ်ခြင်းတွင်–

(၁) အမည်တစ်လုံးတည်းကို ပိုင်းဖြတ်ညွှန်းခေါ်သည့် အပြောစကားပုံစံ

(၂) အမည်နှစ်လုံးတွဲနှင့်အထက် ပိုင်းဖြတ်ညွှန်းခေါ်သည့် အပြောစကားပုံစံ

(၃) **အမည်အပြည့်အစုံ**[၁] ကို ညွှန်းခေါ်သည့် အပြောစကားပုံစံ

(၄) အဖွဲ့အစည်းလိုက်အမည်ကို ညွှန်းခေါ်သည့် အပြောစကားပုံစံ

(၅) အမည်တစ်လုံးတည်းကို **နှစ်ထပ်ပြု**[၂] ညွှန်းခေါ်သည့် အပြောစကားပုံစံ

(၆) **နောက်ဆက်**[၃] 'ကြီး၊ လေး'ထည့်၍ ညွှန်းခေါ်သည့် အပြောစကားပုံစံ

တို့ကို တွေ့ရပါသည်။

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[၁] full name

[၂] reduplication

[၃] suffix

ဓလေ့ထုံးစံဆိုင်ရာ ညွှန်းခေါ်ခြင်းတွင်–

(၁) ဓလေ့ထုံးစံဆိုင်ရာ ဂုဏ်ပုဒ်သက်သက်ကို ညွှန်းခေါ်သည့် အပြောစကားပုံစံ

(၂) ဓလေ့ထုံးစံဆိုင်ရာဂုဏ်ပုဒ်နှင့် အမည်ပေါင်းစပ်ညွှန်းခေါ်သည့် အပြောစကားပုံစံ

တို့ကို တွေ့ရပါသည်။

ဘာသာရေးဆိုင်ရာ ညွှန်းခေါ်ခြင်းတွင်–

(က) ဘာသာရေးဆိုင်ရာ ဂုဏ်ပုဒ်သက်သက်ကို ညွှန်းခေါ်သည့် အပြောစကားပုံစံ

(ခ) ဘာသာရေးဆိုင်ရာဂုဏ်ပုဒ်နှင့် အမည်ပေါင်းစပ်ညွှန်းခေါ်သည့် အပြောစကားပုံစံ

တို့ကို တွေ့ရပါသည်။

အသက်မွေးဝမ်းကျောင်းဆိုင်ရာ ညွှန်းခေါ်ခြင်းတွင်–

(၁) အလုပ်အကိုင်ဆိုင်ရာဂုဏ်ပုဒ်သက်သက်ကို ညွှန်းခေါ်သည့် အပြောစကားပုံစံ

(၂) အလုပ်အကိုင်ဆိုင်ရာ ဂုဏ်ပုဒ်နှင့်အမည်ပေါင်းစပ်ညွှန်းခေါ်သည့် အပြောစကားပုံစံ

(၃) ရာထူး/အဆင့်ဆိုင်ရာ ဂုဏ်ပုဒ်သက်သက်ကို ညွှန်းခေါ်သည့်အပြောစကားပုံစံ

(၄) ရာထူး/အဆင့်ဆိုင်ရာ ဂုဏ်ပုဒ်နှင့်အမည်ပေါင်းစပ်ညွှန်းခေါ်သည့် အပြောစကားပုံစံ

တို့ကို တွေ့ရပါသည်။

ဆွေမျိုးတော်စပ်မှုဆိုင်ရာ ညွှန်းခေါ်စကားတွင် ညွှန်းခေါ်သူကိုဗဟိုပြု၍–

(၁) ညွှန်းခေါ်သူနှင့်တိုက်ရိုက်ဆွေမျိုးတော်စပ်မှုဆိုင်ရာ ညွှန်းခေါ်စကားပုံစံ

(၂) ညွှန်းခေါ်သူနှင့်ကြားခံ၍ ဆွေမျိုးတော်စပ်မှုဆိုင်ရာ ညွှန်းခေါ်စကားပုံစံ

ဟူ၍ လေ့လာတွေ့ရှိရပါသည်။

ရင်းနှီးကျွမ်းဝင်မှုဆိုင်ရာ ညွှန်းခေါ်ခြင်းတွင်–

(၁) **အမည်ပြောင်များ**[၁] ကို ညွှန်းခေါ်သည့် အပြောစကားပုံစံ

(၂) **ချစ်စနိုးအမည်များ**[၂] ကို ညွှန်းခေါ်သည့် အပြောစကားပုံစံ

(၃) **ဗန်းစကားအမည်များ**[၃] ကို ညွှန်းခေါ်သည့် အပြောစကားပုံစံ

တို့ကို တွေ့ရပါသည်။

ပုဂ္ဂလနာမ်စားများတွင် အစဉ်လာသဒ္ဒါအရ ပြောသူနာမ်စား၊ ကြားနာသူနာမ်စား၊ အပြောခံ နာမ်စားဟူ၍ ၃ မျိုးရှိပါသည်။ ယင်းတို့အနက် ကြားနာသူနာမ်စားသည်သာလျှင် ညွှန်းခေါ်စကားနှင့်

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[၁] nick names

[၂] pen names

[၃] slang names

သက်ဆိုင်ပါသည်။ မြန်မာဘာသာစကားတွင် လူမှုဆက်ဆံရေးအရ ကြားနာသူကို ညွှန်းခေါ်သည့် နာမ်စားများလည်း ကွဲပြားပါသည်။ လူပုဂ္ဂိုလ်ဆိုင်ရာ ကြားနာသူနာမ်စားများအဖြစ် 'မင်း၊ နင်၊ ခင်ဗျား၊ ညည်း၊ တော်၊ ရှင်၊သင်၊ သင်း(ဒင်း)၊ သူ' တို့ကို တွေ့ရပါသည်။

အမည်မခေါ်သည့်ညွှန်းခေါ်စကားပုံစံသည် ပြောဆိုသူကနာသူကို မည်သို့ညွှန်းခေါ်ရမည်ကို မဝေခွဲနိုင်လျှင် အမည်ကိုမသုံးဘဲ နှုတ်ခွန်းဆက်စကား၊ လောကဝတ်စကားတို့ဖြင့်အစားထိုး ညွှန်းခေါ်ခြင်းဖြစ်သည်။ အင်္ဂလိပ်ဘာသာစကားတွင် 'excuse me,hello, how are you?' စသည့်ဖြင့် တွေ့နိုင်ပါသည်။ တစ်ခါတစ်ရံ မိမိညွှန်းခေါ်မည့်သူ၏ အမည်၊ ရာထူးဂုဏ်ပုဒ်ကို သိလျှင်သော်လည်းကောင်း၊ မသိလျှင်သော်လည်းကောင်း၊ ထိုအမည်၊ ရာထူးဂုဏ်ပုဒ်ကို မညွှန်းခေါ်တော့ဘဲ နှုတ်ခွန်းဆက်စကား၊ လောကဝတ်စကားဖြင့် စကားခွန်းကိုပြောဆိုတတ်ကြကြောင်း တွေ့ရပါသည်။

ယေဘုယျညွှန်းခေါ်စကားသည် အမည်၏တာဝန်ကို ထမ်းဆောင်နိုင်ပြီး ဘာသာစကားတိုင်း တွင် အနည်းနှင့်အများရှိပါသည်။ အင်္ဂလိပ်ဘာသာစကားတွင် မိဘကို 'Hey Dad' (ဟေ့ အဖေ) ဟု ညွှန်းခေါ်လျှင် မရိုင်းသော်လည်း မြန်မာဘာသာစကားတွင် 'ဟေ့ အဖေ'ဟု ညွှန်းခေါ်လျှင် ရိုင်းပြရာ ကျပါသည်။ ယင်းအသုံးကို မြန်မာတို့က မယဉ်ကျေးသောစကားအဖြစ် မှတ်ယူထားပါသည်။ 'ဟေ့' နှင့် 'ဟိတ်' သည် အသက်ကြီးသူ၊ ဂုဏ်ကြီးသူတို့က အသက်ငယ်သူ၊ လူမှုအဆင့်နိမ့်သူတို့ကို ညွှန်းခေါ်လျှင် မရိုင်းသော်လည်း အသက်ငယ်သူ၊ လူမှုအဆင့်နိမ့်သူတို့က အသက်ကြီးသူ၊ ဂုဏ်ကြီးသူတို့ကို ညွှန်းခေါ်လျှင် ရိုင်းပြရာကျကြောင်း တွေ့ရပါသည်။

၃၊ ၁၊ ၂။ စိစစ်ချက်များ

မြန်မာဘာသာစကားတွင် လူပုဂ္ဂိုလ်အမည်ဆိုင်ရာ ညွှန်းခေါ်စကားပုံစံ ၆ မျိုးကို ဖော်ထုတ်ရရှိပါသည်။ အမည်တစ်လုံးတည်း ပိုင်းဖြတ်ညွှန်းခေါ်ခြင်းသည် ချစ်သူသမီးရည်းစားများအကြားတွင် အသုံးများသည်။ ယင်းသည် အကြင်နာခံစားမှုပါသော ညွှန်းခေါ်စကားများသာ ဖြစ်နေခြင်းမှာလည်း မြန်မာညွှန်းခေါ်စကား၏ ထူးခြားချက်တစ်ခုပင်ဖြစ်သည်။ အမည်နှစ်လုံးတွဲနှင့်အထက် ပိုင်းဖြတ်ညွှန်းခေါ်စကားပုံစံတွင် အသက်ကြီးသူက အသက်ငယ်သူနှင့် ရွယ်တူအချင်းချင်းတွင် လိုင်မရွေးဘဲ ညွှန်းခေါ်နိုင်ပါသည်။ အမည်အပြည့်အစုံ ညွှန်းခေါ်ခြင်းပုံစံတွင် ညွှန်းခေါ်သူနှင့် ညွှန်းခေါ်ခံရသူ တို့အကြား သာမန်ဆက်ဆံရေးမျိုးဟုဆိုနိုင်ပါသည်။ အဖွဲ့အစည်းအလိုက် ညွှန်းခေါ်စကားပုံစံတွင် အဖွဲ့အလိုက် ယှဉ်ပြိုင်ပွဲများ၊ အခမ်းအနားပွဲများတွင်သာ လူပုဂ္ဂိုလ်အမည်များကိုယ်စား အဖွဲ့အစည်းအမည်ကို ညွှန်းခေါ်လေ့ရှိကြပါသည်။ အမည်တစ်လုံးတည်းကို နှစ်ထပ်ပြုညွှန်းခေါ်စကားပုံစံနှင့် နောက်ဆက် 'ကြီး၊ လေး' ထည့်၍ ညွှန်းခေါ်စကားပုံစံတို့တွင် ညွှန်းခေါ်သူနှင့်ညွှန်းခေါ်ခံရသူအကြား နွေးထွေးသောဆက်ဆံမှု သဘောဖြစ်ပါသည်။

ဓလေ့ထုံးစံဂုဏ်ပုဒ်ဆိုင်ရာတွင် ညွှန်းခေါ်စကားပုံစံ ၂ မျိုးကို ဖော်ထုတ်ရရှိပါသည်။ ဂုဏ်ပုဒ်နှင့် အမည်ပေါင်းစပ်ညွှန်းခေါ်သည့် အပြောစကားပုံစံများတွင် ညွှန်းခေါ်စကားပုံစံ ၄ မျိုး ရှိပါသည်။ ဓလေ့ထုံးစံဆိုင်ရာဂုဏ်ပုဒ်နှင့်အမည် ပေါင်းစပ်ညွှန်းခေါ်သည့် အပြောစကားပုံစံများတွင် 'ဦး/ဒေါ်' ဂုဏ်ပုဒ်နှင့်အမည်တစ်မျိုးမျိုး ပေါင်းစပ်ညွှန်းခေါ်ခြင်းသည် မြန်မာ့ယဉ်ကျေးမှုဓလေ့ထုံးစံအရ အသက်ငယ်သူက အသက်အရွယ်ကြီးသူ လူကြီးပိုင်းကို ညွှန်းခေါ်ခြင်းဖြစ်ပါသည်။ အချို့ဒေသများတွင် အမျိုးသား

များကို ‘ငါ၊ ဖိုး၊ ကိုရင်၊ မောင်ရင်’ စသည်ဖြင့်လည်းကောင်း၊ အမျိုးသမီးများကို ‘မိ၊ မယ်’ စသည်ဖြင့်လည်းကောင်း အမည်၏ရှေ့တွင်တပ်၍ ညွှန်းခေါ်ကြပါသည်။ ထို့ကြောင့် ဓလေ့ထုံးစံဆိုင်ရာ ညွှန်းခေါ်စကားပုံစံများသည် ပြောသူနှင့်နာသူတို့၏ လိင်၊ အသက် အရွယ်၊ လူမှုဂုဏ်အဆင့် အတန်းကို လိုက်ပြီး အမည်တစ်မျိုးမျိုး ပေါင်းစပ်ညွှန်းခေါ်နိုင်ပါသည်။

ဘာသာရေးဆိုင်ရာတွင်ညွှန်းခေါ်စကားပုံစံ ၂ မျိုးကို ဖော်ထုတ်ရရှိပါသည်။ မြန်မာတို့သည် သံဃာတော်များနှင့်သီလရှင်များကို မြင့်မြတ်သောပုဂ္ဂိုလ်များအဖြစ် ယဉ်ကျေးသည့် အသုံးအနှုန်းတို့ ဖြင့်သာ ရိုသေလေးစားစွာ ညွှန်းခေါ်လေ့ရှိပါသည်။ ဘာသာရေးပုဂ္ဂိုလ်များကလည်း လူပုဂ္ဂိုလ်များကို ဘာသာရေးဆိုင်ရာအသုံးများဖြင့်သာ ညွှန်းခေါ်ကြပါသည်။ လူပုဂ္ဂိုလ်များသည် ဘာသာရေးပုဂ္ဂိုလ်တို့ကို ဘွဲ့အမည်ထက် ဘာသာရေးဂုဏ်ပုဒ်ကိုသာ အများဆုံးညွှန်းခေါ်ကြပါသည်။ အခမ်းအနားပွဲများတွင်သာ ဘွဲ့အမည်နှင့်ဘာသာရေးဆိုင်ရာဂုဏ်ပုဒ်ကို ပေါင်းစပ်ညွှန်းခေါ်လေ့ရှိကြပါသည်။ ဘာသာရေးဆိုင်ရာ ညွှန်းခေါ်စကားပုံစံများတွင် ယဉ်ကျေးသောပုံစံအဖြစ် ညွှန်းခေါ်ရာ၌ စကားခွန်း ၏ အဆုံးတွင် ‘ဘုရား’ ထည့်၍ တလေးတစား ညွှန်းခေါ်ကြပါသည်။

အသက်မွေးဝမ်းကျောင်းဆိုင်ရာတွင် ညွှန်းခေါ်စကားပုံစံ ၄ မျိုးကို ဖော်ထုတ်ရရှိပါသည်။ ညွှန်းခေါ်ရာတွင် အလုပ်အကိုင်၏နောက်တွင် ‘ဆရာ၊ သမား၊ သည်(သယ်)၊ ရှင်’ သင့်တော်ရာ ဂုဏ်ပုဒ်တစ်မျိုးမျိုးဖြင့် ပေါင်းစပ်ညွှန်းခေါ်သကဲ့သို့ အလုပ်အကိုင်ဂုဏ်ပုဒ်နှင့် အမည်တစ်မျိုးမျိုးကိုလည်း ပေါင်းစပ်ညွှန်းခေါ်ကြသည်။ ရာထူး/အဆင့်ရှိသောသူများကိုလည်း ယင်းတို့၏ရာထူး/အဆင့်အပြင် အမည်ကိုပါ ပေါင်းစပ်ညွှန်းခေါ်ကြသည်။ ဌာနဆိုင်ရာ အကြီးအကဲများ၏ဇနီးများကို ညွှန်ခေါ်ရာ၌ ခင်ပွန်းသည်၏ ဂုဏ်ပုဒ်နှင့်အမည်ကို ဇနီးသည်၏ အမည်ရှေ့တွင်တပ်ကာ အခမ်း အနားပွဲများတွင် ညွှန်းခေါ်လေ့ရှိပါသည်။ ထို့ကြောင့် အသက်မွေးဝမ်းကျောင်းဆိုင်ရာ ညွှန်းခေါ် စကားပုံစံများတွင် ဂုဏ်ပုဒ်သက်သက် ညွှန်းခေါ်ခြင်းကို အသုံးများပြီး ဂုဏ်ပုဒ်နှင့်အမည် ပေါင်းစပ် ညွှန်းခေါ်ခြင်းကို ပုံစံတကျညွှန်းခေါ်သောအခမ်းအနားပွဲများတွင်သာ အသုံးပြုကြကြောင်း လေ့လာ သိရှိရပါသည်။

ဆွေမျိုးတော်စပ်မှုဆိုင်ရာညွှန်းခေါ်စကားပုံစံများတွင် ဆွေမျိုးတော်စပ်မှု ၂ မျိုးကို ဖော်ထုတ်ရရှိပါသည်။ မိဘနှစ်ပါးနှင့်ဆိုင်သော ဝေါဟာရများတွင် အားပါးတရညွှန်းခေါ်သည့်ပုံစံအဖြစ် ‘ကြီး’ နောက်ဆက်ထည့်ပြီးညွှန်းခေါ်ခြင်းကို မျက်မှောက်ခေတ် ကလေးငယ်များ၏ ညွှန်းခေါ်စကားတွင် အများဆုံးတွေ့ရသည်။ သား၊ သမီးတို့က မိဘနှစ်ပါးကို ညွှန်းခေါ်ရာတွင် ဆွေမျိုးစပ်ဝေါဟာရ ဂုဏ်ပုဒ်သက်သက်ကိုသာ ညွှန်းခေါ်ကြသော်လည်း မိဘနှစ်ပါးက သား၊ သမီးတို့ကို ညွှန်းခေါ်ရာတွင် ဆွေမျိုးစပ်ဝေါဟာရအပြင် အမည်တစ်မျိုးမျိုးဖြင့်လည်း ပေါင်းစပ်၍ ညွှန်းခေါ်ကြပါသည်။ ‘ဘိုးဘိုး၊ ဘွားဘွား’ ဟူ၍ နှစ်ကြိမ်ထပ် ညွှန်းခေါ်မှုကို ကလေးငယ်များ၏ ညွှန်းခေါ်စကားတွင် အများဆုံးတွေ့ရသည်။ ထူးခြားချက်မှာ အဘိုးနှင့်အဘွား ညွှန်းခေါ်စကားတို့တွင် ‘ကြီး’ နောက်ဆက်ထည့်ပြီး ‘အဘိုးကြီး၊ အဘွားကြီး’ ဟု ညွှန်းခေါ်လျှင် ရိုင်းပျသည့်စကားဖြစ်သွားပါသည်။ ထို့ကြောင့် ဆွေမျိုးတော်စပ်မှုဆိုင်ရာ ညွှန်းခေါ်စကားပုံစံများသည် မြန်မာလူမျိုးတို့၏ တစ်ဦးအပေါ်တစ်ဦး အပြန်အလှန်လေးစားမှု၊ ဂါရဝတရားထားရှိမှု၊ ယဉ်ကျေးပျူငှာမှုတို့ကို ပြသခြင်းလည်း ဖြစ်ပါသည်။

ရင်းနှီးကျွမ်းဝင်မှုဆိုင်ရာတွင် ညွှန်းခေါ်စကားပုံစံ ၃ မျိုးကို ဖော်ထုတ်ရရှိပါသည်။ အမည်ပြောင်များကို သူငယ်ချင်းများ၊ အလွန်ရင်းနှီးသူများကြားတွင် ညွှန်းခေါ်ကြပြီး ချစ်စနိုးအမည်များကို ဇနီးမောင်နှံ၊ သမီးရည်းစား၊ မိဘနှင့်သားသမီး၊ သူငယ်ချင်းများအကြားတွင် ညွှန်းခေါ်ကြသည်။

ဗန်းစကားအမည်များကို သူငယ်ချင်းများကြား၌ ညွှန်းခေါ်ခြင်းဖြင့် အလွန်ရင်းနှီးသူများအဖြစ် အကဲခတ်နိုင်ပါသည်။ ထို့ကြောင့် ရင်းနှီးကျွမ်းဝင်မှုဆိုင်ရာ ညွှန်းခေါ်စကားပုံစံများသည် အလွန်ရင်းနှီးသူများအကြား၌ ညွှန်းခေါ်ကြခြင်းဖြစ်ပါသည်။ ထိုသို့ ညွှန်းခေါ်ကြခြင်းမှာ တစ်ဦးနှင့်တစ်ဦး ရင်းနှီးကျွမ်းဝင်သူများဖြစ်ကြောင်း ပြသရာလည်းရောက်ပါသည်။

ပုဂ္ဂလနာမ်စားဆိုင်ရာတွင် ညွှန်းခေါ်စကားပုံစံ ၉ မျိုးကို ဖော်ထုတ်ရရှိပါသည်။ ယင်းတို့အနက် တစ်မျိုးမျိုးကို ညွှန်းခေါ်သူနှင့်ညွှန်းခေါ်ခံရသူတို့၏ လိင်၊ အသက်အရွယ်၊ ရင်းနှီးမှု၊ လူမှုအဆင့်တို့အပေါ်မူတည်ပြီး သင့်တော်ရာ နာမ်စားတစ်မျိုးမျိုးဖြင့် ညွှန်းခေါ်လေ့ရှိကြပါသည်။ ထူးခြားသည်မှာ အင်္ဂလိပ်ဘာသာစကားတွင် မိဘနှစ်ပါးကို 'you' ဟု ကြားနာသူ နာမ်စားသုံး၍ ညွှန်းခေါ်လျှင် မရိုင်းသော်လည်း မြန်မာဘာသာစကားတွင်မူ မိဘနှစ်ပါးအပြင် လူကြီးသူမများကို ပုဂ္ဂလနာမ်စားညွှန်းခေါ်စကားပုံစံတစ်မျိုးမျိုးဖြင့် ညွှန်းခေါ်လျှင် ရိုင်းပျသောကြောင့် မညွှန်းခေါ်သင့်ပေ။

အမည်မခေါ်သည့် ညွှန်းခေါ်စကားပုံစံသည် နှုတ်ခွန်းဆက်စကား၊ လောကဝတ်စကားတို့ဖြင့် စကားခွန်းကို စတင်ခြင်းဖြစ်သည်။ ထိုသို့ စတင်ခြင်းဖြင့် ပြောသူနှင့်နာသူတို့၏ လူမှုဆက်ဆံရေးကို မထိခိုက်နိုင်ပေ။ သို့သော် မြန်မာလူမျိုးတို့၏ ယဉ်ကျေးမှုဓလေ့ထုံးစံအရ အသက်အရွယ်အလိုက် ဂါရဝထားသော လူမျိုးများဖြစ်၍ ဦးအရွယ် 'ဦး'၊ အဒေါ်အရွယ် 'အဒေါ်'၊ အစ်ကိုအရွယ် 'အစ်ကို'၊ အစ်မအရွယ် 'အစ်မ'၊ ညီအရွယ် 'ညီ'၊ ညီမအရွယ် 'ညီမ' စသည့် ဆွေမျိုးစပ်ဝေါဟာရ တစ်မျိုးမျိုးဖြင့် ညွှန်းခေါ်နိုင်ပြီး လူမှုဆက်သွယ်ရေးလမ်းကြောင်းကို ဖွင့်နိုင်ပါသည်။

ယေဘုယျညွှန်းခေါ်စကားပုံစံများတွင် အမျိုးသားတို့၏ ယေဘုယျညွှန်းခေါ်စကား 'ကောင်' နှင့် အမျိုးသမီးတို့၏ ယေဘုယျညွှန်းခေါ်စကား 'ကောင်မ' သည် မယဉ်ကျေးသော အသုံးဖြစ်၍ ပြောသူနှင့်နာသူအကြား မရင်းနှီးလျှင်မညွှန်းခေါ်သင့်ပေ။ အချို့လည်းအာမေဠိတ်ပြု၍ 'ဟိတ်ဟိတ်၊ ဟေ့ဟေ့၊ ဟဲ့ဟဲ့' စသည်ဖြင့် ညွှန်းခေါ်တတ်ကြသည်။ ထို့ကြောင့် ယေဘုယျညွှန်းခေါ်စကားကို ရွယ်တူအချင်းချင်းနှင့် အသက်ကြီး၊ ဂုဏ်ကြီးသူတို့က အသက်ငယ်သူတို့ကို ညွှန်းခေါ်နိုင်ပြီး အသက် ငယ်သူတို့က အသက်ကြီးသူတို့ကိုပြန်လည်ညွှန်းခေါ်လျှင် ရိုင်းပျသည့်ညွှန်းခေါ်စကား ဖြစ်သွားသည်။

၃၊ ၂။ စကားသင်္ကေတရောသုံးခြင်းပုံစံများ

စကားသင်္ကေတရောသုံးခြင်းပုံစံတွင်–

(၁) ထည့်သွင်းခြင်း[၁]

(၂) တစ်လှည့်စီဖြစ်ပေါ်ခြင်း[၂]

(၃) သင့်လျော်သောဝေါဟာရပြုခြင်း/တူညီမှုပြုခြင်း[၃]

ဟူ၍တွေ့ရပါသည်။ မိုက်စကန်၏ တူညီမှုပြုခြင်းပုံစံသည် စံစကားနှင့်ဒေသိယစကားလေ့လာမှုကို အဓိကထား လေ့လာခြင်းဖြစ်၍ ထည့်သွင်းခြင်းနှင့်တစ်လှည့်စီဖြစ်ပေါ်ခြင်းကိုသာ လေ့လာထားပါ သည်။ မိမိကျမ်းသည် ဒေသိယစကားကိုလေ့လာသည့် ကျမ်းမဟုတ်၍ စံစကားနှင့်ဒေသိယစကား

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[၁] insertation

[၂] alternation

[၃] congruent lexicalization

လေ့လာမှုများကို ချန်လှပ်ခဲ့ပါသည်။ ထိုသို့ လေ့လာရာတွင် စကားသင်္ကေတရောသုံးခြင်းပုံစံများကို စကားလုံးအဆင့်၊ ပုဒ်အဆင့်နှင့် ဝါကျခွဲအဆင့်ဟူ၍ ခွဲခြားပြီး ဖော်ထုတ်တင်ပြထားပါသည်။

၃၊ ၂၊ ၁။ တွေ့ရှိချက်များ

ထည့်သွင်းခြင်းပုံစံတွင်–

(၁) စကားလုံးအဆင့်ထည့်သွင်းခြင်းပုံစံ

(၂) ပုဒ်အဆင့်ထည့်သွင်းခြင်းပုံစံ

(၃) စကားလုံးအဆင့်နှင့် ပုဒ်အဆင့် တွဲဖက်ထည့်သွင်းခြင်းပုံစံ

(၄) ဝါကျခွဲအဆင့်ထည့်သွင်းခြင်းပုံစံ

(၅) စကားလုံးအဆင့်၊ ပုဒ်အဆင့်နှင့် ဝါကျခွဲအဆင့်တွဲဖက်ထည့်သွင်းခြင်းပုံစံ

တို့ကို တွေ့ရပါသည်။

စကားလုံးအဆင့် ထည့်သွင်းခြင်းပုံစံတွင် မူရင်းစကားလုံးထည့်သွင်းခြင်း၊ အတိုကောက်စကားလုံးထည့်သွင်းခြင်း၊ အတိုကောက်နှင့်သီးခြားစကားလုံးတွဲဖက်ထည့်သွင်းခြင်း၊ မြန်မာဘာသာပြန်နှင့်မူရင်းစကားလုံးတွဲဖက်ထည့်သွင်းခြင်း၊ မြန်မာဘာသာပြန်နှင့်အတိုကောက်စကားလုံး တွဲဖက်ထည့်သွင်းခြင်း၊ မြန်မာအသံဖလှယ်ခြင်းနှင့်မူရင်းစကားလုံးတွဲဖက်ခြင်းပုံစံဟူ၍ တွေ့ရပါသည်။

ပုဒ်အဆင့်ထည့်သွင်းခြင်းပုံစံတွင် မူရင်းပုဒ်ထည့်သွင်းခြင်း၊ အတိုကောက်နှင့် မူရင်းပုဒ် တွဲဖက်ထည့်သွင်းခြင်း၊ အတိုကောက်နှင့်သီးခြားပုဒ် တွဲဖက်ထည့်သွင်းခြင်း၊ မြန်မာဘာသာပြန်နှင့် မူရင်းပုဒ် တွဲဖက်ထည့်သွင်းခြင်း၊ မြန်မာအသံဖလှယ်ခြင်းနှင့်မူရင်းပုဒ် တွဲဖက်ခြင်းပုံစံဟူ၍ တွေ့ရပါ သည်။

အင်္ဂလိပ်စကားလုံးအဆင့်နှင့်ပုဒ်အဆင့် တွဲဖက်ထည့်သွင်းခြင်းပုံစံတွင် စကားလုံးနှင့်ပုဒ်တွဲဖက်ထည့်သွင်းခြင်းပုံစံ၊ အတိုကောက်၊ စကားလုံးနှင့်ပုဒ် တွဲဖက်ထည့်သွင်းခြင်းပုံစံဟူ၍ ခွဲခြားလေ့လာတွေ့ရှိရပါသည်။

ဝါကျခွဲအဆင့်ထည့်သွင်းခြင်းဟုဆိုရခြင်းမှာ အင်္ဂလိပ်ဝါကျ သို့မဟုတ် ဝါကျခွဲတို့သည် မြန်မာဝါကျဖွဲ့စည်းပုံအတွင်း ထည့်သွင်းရောသုံးလိုက်သောအခါ ဝါကျခွဲအဆင့်နေရာတွင်သာ ရောသုံးခံရခြင်းဖြစ်ပါသည်။ အင်္ဂလိပ်ဝါကျခွဲအဆင့်ထည့်သွင်းခြင်းပုံစံများတွင် အင်္ဂလိပ်ဝါကျခွဲ တိုက်ရိုက် ထည့်သွင်းခြင်းပုံစံ၊ မြန်မာဘာသာပြန်နှင့်မူရင်းအင်္ဂလိပ်ဝါကျခွဲတွဲဖက်ခြင်းပုံစံဟူ၍ တွေ့ရပါသည်။

ဝါကျတစ်ကြောင်းအတွင်း စကားလုံးအဆင့်၊ ပုဒ်အဆင့်နှင့်ဝါကျခွဲအဆင့်တို့ကိုပါ တွဲဖက်ထည့်သွင်းခြင်းပုံစံတွင် ဝါကျတစ်ကြောင်းအတွင်း စကားလုံးနှင့်ဝါကျခွဲ တွဲဖက်ထည့်သွင်းခြင်းပုံစံ၊ ပုဒ်နှင့်ဝါကျခွဲတွဲဖက်ထည့်သွင်းခြင်းပုံစံနှင့်စကားလုံး၊ ပုဒ်နှင့်ဝါကျခွဲ တွဲဖက်ထည့်သွင်းခြင်းပုံစံဟူ၍ လေ့လာတွေ့ရှိရပါသည်။

တစ်လှည့်စီဖြစ်ပေါ်ခြင်းပုံစံများတွင်–

(၁) အမှီဝါကျခွဲအဆင့် တစ်လှည့်စီဖြစ်ပေါ်ခြင်းပုံစံ

(၂) အမှီခံဝါကျခွဲအဆင့် တစ်လှည့်စီဖြစ်ပေါ်ခြင်းပုံစံ

တို့ကိုတွေ့ရပါသည်။ တစ်လှည့်စီဖြစ်ပေါ်ရာတွင် ဝါကျတစ်ကြောင်းအတွင်း အမှီဝါကျခွဲသက်သက် တစ်လှည့်စီဖြစ်ပေါ်ခြင်းပုံစံ၊ အမှီဝါကျခွဲနှင့်မြန်မာဘာသာပြန်တွဲဖက်၍ တစ်လှည့်စီဖြစ်ပေါ်ခြင်းပုံစံဟူ၍ လေ့လာတွေ့ရှိရပါသည်။

၃၊ ၂၊ ၂။ စိစစ်ချက်များ

မြန်မာဘာသာစကားတွင် ဝါကျအတွင်း၌ စကားလုံးအဆင့် စကားသင်္ကေတထည့်သွင်းရောသုံးခြင်း ပုံစံ ၆ မျိုးကို ဖော်ထုတ်ရပါသည်။ မူရင်းစကားလုံးထည့်သွင်းခြင်းသည် မြန်မာဘာသာစကားအတွက် စကားလုံးလိုအပ်ချက်ကို အင်္ဂလိပ်စကားမှ တိုက်ရိုက်ရောသုံးခြင်း ဖြစ်ပါသည်။ အတိုကောက် စကားလုံးထည့်သွင်းခြင်း၊ အတိုကောက်နှင့် သီးခြားစကားလုံး တွဲဖက်ထည့်သွင်းခြင်းပုံစံတို့သည် မူရင်းအင်္ဂလိပ်စကားလုံးကို အတိုကောက်ပြု၍ စကားလုံးအသစ်ဖန်တီးရောသုံးခြင်း ဖြစ်ပါသည်။ ထိုသို့ဖန်တီးရောသုံးခြင်းသည် မူရင်းစကားလုံးကို အတိုကောက်ပြုကာ အမည်နာမများအနေဖြင့် ထည့်သွင်းရောသုံးလိုက်ခြင်းဖြစ်ပါသည်။ ထို့ပြင် အတိုကောက်စကားလုံးနှင့်မြန်မာနာမ်စကားလုံး၊ အတိုကောက် စကားလုံးနှင့် အင်္ဂလိပ်သီးခြားစကားလုံးတို့ကို ပေါင်းစပ်ထည့်သွင်းရောသုံးလိုက်သောအခါ အတိုကောက်စကားလုံးများသည် နာမ်အထူးပြုစကားလုံး ဖြစ်သွားပါသည်။ “ARSA အကြမ်းဖက်သမား၊ KNU ဥက္ကဋ္ဌစောဘဦးကြီး၊ NLD အစိုးရ၊ AFC Cup, HTC Smartphone” စသော သာဓကများတွင် တွေ့နိုင်ပါသည်။ အတိုကောက်စကားလုံး တိုက်ရိုက်ထည့်သွင်းခြင်းတွင် များသောအားဖြင့် နိုင်ငံရေးဆိုင်ရာ၊ စီးပွားရေးဆိုင်ရာနှင့် နည်းပညာဆိုင်ရာအသုံးများကို အတိုကောက်ပြုရောသုံးလေ့ရှိသည်။ မြန်မာဘာသာပြန်နှင့် အတိုကောက်စကားလုံး တွဲဖက်ထည့်သွင်းခြင်းပုံစံသည် အတိုကောက်စကားလုံးများကို အမည်နာမစကားလုံးအဖြစ် အသုံးပြုရောသုံးထားခြင်း ဖြစ်ပါသည်။ မြန်မာအသံဖလှယ် ခြင်းနှင့်မူရင်းစကားလုံး တွဲဖက်ထည့်သွင်းခြင်းပုံစံသည် မြန်မာဘာသာစကားတွင်မရှိသည့် ဝေါဟာရများကို အသံဖလှယ်ချေးငှား၍ မွေးစားစကားလုံးအဖြစ် အသုံးပြုလိုက်ခြင်းဖြစ်ပါသည်။ စကားလုံးအများစုမှာ အသုံးပြုမှု အသားမကျသေး၍ မူရင်းစကားလုံးနှင့်အသံဖလှယ်ထားသော စကားလုံးတို့ကို တွဲဖက်ထည့်သွင်းခြင်းဖြစ်ပါသည်။ အသားကျပြီး အသုံးတွင်ကျယ်လာသည်နှင့်အမျှ မြန်မာအက္ခရာ ဖလှယ်ထားသော စကားလုံးကိုသာ မွေးစားစကားလုံးအဖြစ် အသုံးပြုလာမည်ဖြစ်ပါသည်။ ထူးခြားချက်မှာ မြန်မာဘာသာစကား၌ အပြောစကားပုံစံများတွင် စကားသင်္ကေတထည့်သွင်းရာ၌ အင်္ဂလိပ်စကားလုံးကို မြန်မာဝါကျ၏ အဆုံးသတ်နေရာ၌ထားပြီး ဝါကျကို အဆုံးသတ်လေ့မရှိပေ။ စကားလုံးအဆင့်တွင် မြန်မာဘာသာပြန်နှင့် မူရင်းစကားလုံး တွဲဖက်ထည့်သွင်းခြင်း၊ မြန်မာအသံ ဖလှယ်ခြင်းနှင့် မူရင်းစကားလုံး တွဲဖက်ထည့်သွင်းခြင်းပုံစံတို့သည် မြန်မာဘာသာစကားတွင် ဝေါဟာရ သစ်ဖြစ်ပေါ်တိုးတက်မှုအတွက် အစပြုခြင်း ဖြစ်သည်။ ယင်းသည် မြန်မာဝေါဟာရ ဖွံ့ဖြိုးတိုးတက်ရန် အပေါင်းလက္ခဏာဆောင်ပြီး မြန်မာဝေါဟာရသစ်ဖွံ့ဖြိုးရန်များစွာအထောက်အကူ ပြုပါသည်။

ပုဒ်အဆင့်တွင် စကားသင်္ကေတထည့်သွင်းရောသုံးခြင်းပုံစံ ၅ မျိုးကို ဖော်ထုတ်ရရှိပါသည်။ မူရင်းပုဒ်ထည့်သွင်းခြင်းပုံစံသည် မြန်မာဘာသာစကား၏ ဝေါဟာရလိုအပ်ချက်များကို အင်္ဂလိပ်ပုဒ်များဖြင့်တိုက်ရိုက်ထည့်သွင်းခြင်းဖြစ်ပါသည်။ အတိုကောက်နှင့်မူရင်းပုဒ် တွဲဖက်ထည့်သွင်းခြင်းပုံစံသည် အတိုကောက်စကားလုံးများကို အမည်နာမများအဖြစ် အစပြုဖန်တီးပြီး မူရင်းအင်္ဂလိပ်ပုဒ်နှင့် တွဲဖက်အသုံးပြုထားခြင်း ဖြစ်ပါသည်။ အတိုကောက်နှင့်သီးခြားစကားလုံး တွဲဖက်ထည့်သွင်းခြင်း၌ အတိုကောက်စကားလုံးကို စကားလုံးအသစ်ဖန်တီးခြင်းဖြစ်ပြီး အမည်နာမအဖြစ် တွဲဖက်ရောသုံး

ခြင်းဖြစ်ကြောင်း တွေ့ရပါသည်။ မြန်မာဘာသာပြန်နှင့်မူရင်းပုဒ် တွဲဖက်ထည့်သွင်းခြင်းပုံစံသည် မူရင်း အဓိပ္ပာယ်ကို ပိုမိုလေးနက်စေလိုခြင်း၊ ဘာသာပြန် အသားမကျသေးခြင်းတို့ကြောင့် တွဲဖက် ရောသုံးခြင်း ဖြစ်ကြောင်း ယူဆရပါသည်။ အသံဖလှယ်လိုက်သည့်စကားလုံး အသားကျပြီး အသုံးတွင် ကျယ်လာလျှင် မြန်မာဘာသာစကားဖွံ့ဖြိုးရေးနှင့် စကားလုံးသစ်များပေါ်ပေါက်ရေးတို့အတွက် များစွာ အထောက်အကူ ပြုပါသည်။ ထို့ကြောင့် ဘာသာပြန်နှင့်မူရင်းပုဒ် တွဲဖက်ထည့်သွင်းခြင်း၊ အသံဖလှယ်ခြင်းနှင့် မူရင်းပုဒ်တွဲဖက်ထည့်သွင်းခြင်းပုံစံတို့သည် မြန်မာဘာသာစကားတွင် ဝေါဟာရသစ်ဖြစ်ပေါ် တိုးတက်မှု အတွက် အစပြုခြင်းဖြစ်သည်။ မြန်မာဝေါဟာရ ဖွံ့ဖြိုးတိုးတက်ရန်အတွက် အပေါင်းလက္ခဏာဆောင်သော ပုံစံဖြစ်ပြီး အသုံးပြုမှုမတွင်ကျယ်သေးခြင်း၊ အသားမကျသေးခြင်းတို့ကြောင့် တွဲဖက်ထည့်သွင်းရခြင်း ဖြစ်ပါသည်။ ကျန်ပုံစံများသည် မြန်မာဝေါဟာရ ဖွံ့ဖြိုးရန်အတွက် အနုတ်လက္ခဏာဆောင်သောပုံစံများ ဖြစ်ပါသည်။

စကားလုံးနှင့်ပုဒ် တွဲဖက်ထည့်သွင်းခြင်းတွင် ပုံစံ ၂ မျိုးကို ဖော်ထုတ်ရပါသည်။ စကားလုံးနှင့် ပုဒ်တွဲဖက်ထည့်သွင်းခြင်းပုံစံများတွင် သင်္ကေတ၊ မြန်မာဘာသာပြန်နှင့် မြန်မာအသံဖလှယ်ထားသော စကားလုံးတို့ကိုပါ တွဲဖက်၍ လိုအပ်သလို တစ်ပြိုင်နက်တည်း ရောသုံးနိုင်ပါသည်။ ယင်းတို့ကိုလည်း အခြားဘာသာစကားများကဲ့သို့ မြန်မာဝါကျ၏ အဆုံးသတ်နေရာ၌ထားပြီး ဝါကျကို အဆုံးသတ်လေ့မရှိပေ။ ထို့ကြောင့် မြန်မာဘာသာစကားတွင် စကားလုံးအဆင့်နှင့် ပုဒ်အဆင့် စကားလုံးများကို တွဲဖက်၍ စကားသင်္ကေတများရောသုံးနိုင်သကဲ့သို့ သင်္ကေတ၊ အတိုကောက်စကားလုံး၊ မြန်မာအက္ခရာဖြင့် အသံဖလှယ်သောစကားလုံး၊ ဘာသာပြန်စကားလုံးတို့နှင့်ပါ ဝါကျတစ်ကြောင်းအတွင်း တစ်ပြိုင်တည်း တွဲဖက်ထည့်သွင်း၍ ရောသုံးနိုင်သည်။ မြန်မာဝါကျအတွင်း 'သင်္ကေတ၊ အတိုကောက်၊ စကားလုံးနှင့်ပုဒ်' တို့ကို တစ်ပြိုင်တည်း တိုက်ရိုက်ထည့်သွင်းရောသုံးခြင်းသည် မြန်မာဝေါဟာရသစ်ဖွံ့ဖြိုးတိုးတက်ရန် အတွက် အနုတ်လက္ခဏာဆောင်သော ထည့်သွင်းခြင်းပုံစံများ ဖြစ်ပါသည်။

အင်္ဂလိပ်ဝါကျခွဲအဆင့်ထည့်သွင်းခြင်းတွင် ပုံစံ ၂ မျိုးကို ဖော်ထုတ်ရရှိပါသည်။ အင်္ဂလိပ်ဝါကျခွဲ တိုက်ရိုက်ထည့်သွင်းခြင်းပုံစံသည် မြန်မာဘာသာစကားအတွက် လိုအပ်သောဝေါဟာရများကို မူရင်း အင်္ဂလိပ်ဝါကျများမှ ဝါကျခွဲအနေဖြင့် မြန်မာဝါကျအတွင်း တိုက်ရိုက်ထည့်သွင်းရောသုံးလိုက်ခြင်း ဖြစ်ပါသည်။ မြန်မာဘာသာပြန်နှင့်အင်္ဂလိပ်ဝါကျခွဲ တွဲဖက်ထည့်သွင်းခြင်းပုံစံသည် မူရင်းအဓိပ္ပာယ် ပိုမိုလေးနက်စေလို၍လည်းကောင်း၊ ဘာသာပြန်အဓိပ္ပာယ် အသားမကျသေး၍လည်းကောင်း တွဲဖက်ရော သုံးခြင်းဖြစ်နိုင်ကြောင့် ယူဆမိပါသည်။ ထို့ကြောင့် ဝါကျခွဲ တိုက်ရိုက်ထည့်သွင်းခြင်းပုံစံသည် မြန်မာဘာသာစကားအတွက် လိုအပ်သော အကြောင်းအရာများကို မြန်မာဝါကျအတွင်း အင်္ဂလိပ် ဝါကျခွဲ အဆင့်အနေဖြင့် တိုက်ရိုက်ထည့်သွင်းရောသုံးလိုက်ခြင်း ဖြစ်နိုင်ပါသည်။ စကားသင်္ကေတ ထည့်သွင်း အသုံးပြုသူများ၏ မြန်မာဘာသာပြန်အားနည်းခြင်း၊ ကြိုးစားအားထုတ်မှု အားနည်းခြင်းကြောင့်ဟု ဆိုနိုင်ပါသည်။ ဝါကျခွဲအဆင့် တိုက်ရိုက်ရောသုံးခြင်းသည် မြန်မာဘာသာစကားဖွံ့ဖြိုးမှု အတွက် အနုတ်လက္ခဏာဆောင်သောပုံစံ ဖြစ်ပါသည်။ မြန်မာဘာသာပြန်နှင့်မူရင်းဝါကျခွဲ တွဲဖက် ထည့်သွင်းခြင်းသည် မူရင်းအဓိပ္ပာယ်ကို ပိုမိုလေးနက်စေလို၍လည်းကောင်း၊ မူရင်းအသုံးအနှုန်းနှင့် အကျွမ်းတဝင်ရှိစေလို၍ လည်းကောင်း၊ ဘာသာပြန်အဓိပ္ပာယ် အသားမကျသေး၍လည်းကောင်း တွဲဖက်ရောသုံးခြင်းဖြစ်ကြောင်း ယူဆရပါသည်။

စကားလုံးအဆင့်၊ ပုဒ်အဆင့်နှင့်ဝါကျခွဲအဆင့် တွဲဖက်ထည့်သွင်းခြင်းတွင် ပုံစံ ၃ မျိုးကို ဖော်ထုတ်ရရှိပါသည်။ မြန်မာဘာသာစကားတွင် သင်္ကေတ၊ အတိုကောက်စကားလုံးတို့နှင့်ပါ တစ်ပြိုင်နက်တည်း တွဲဖက်ထည့်သွင်း၍ စကားသင်္ကေတရောသုံးနိုင်ပါသည်။ ထို့ကြောင့် မြန်မာဘာသာ စကားတွင် စကားလုံးအဆင့်၊ ပုဒ်အဆင့်နှင့် ဝါကျခွဲအဆင့် တွဲဖက်၍ စကားသင်္ကေတများ ရောသုံးနိုင်သကဲ့သို့ သင်္ကေတ၊ အတိုကောက်စကားလုံးနှင့်ပါ တွဲဖက်၍ ဝါကျတစ်ကြောင်းအတွင်း တွဲဖက်ရောသုံးနိုင်ပါသည်။ ထိုသို့ တွဲဖက်ထည့်သွင်းရာတွင် မြန်မာဝါကျရော ဖွဲ့စည်းတည်ဆောက်ပုံအတွင်း အဆုံးသတ်နေရာမှလွဲ၍ မြန်မာဝါကျဖွဲ့ပုံအတိုင်း မည်သည့်နေရာတွင်မဆို တွဲဖက်ထည့်သွင်းရောသုံးနိုင်ပါသည်။

ဝါကျခွဲအဆင့် တစ်လှည့်စီဖြစ်ပေါ်ခြင်းတွင် ပုံစံ ၂ မျိုးကို ဖော်ထုတ်ရရှိပါသည်။ အင်္ဂလိပ်ဝါကျများသည် မိမိတို့ဘာသာ သီးခြားရပ်တည်ပါက ဝါကျများအဖြစ် ရပ်တည်နိုင်သော်လည်း မြန်မာဝါကျဖွဲ့စည်းတည်ဆောက်ပုံအတွင်း တစ်လှည့်စီရောသုံးလိုက်သောအခါ ဝါကျခွဲနေရာ၊ ပုဒ်နေရာ တို့တွင် မြန်မာသဒ္ဒါတည်ဆောက်ပုံနှင့် အင်္ဂလိပ်သဒ္ဒါတည်ဆောက်ပုံတို့ တစ်လှည့်စီရောသုံးနိုင်ပါသည်။ ထိုဝါကျခွဲများသည် မြန်မာဝါကျဖွဲ့စည်းတည်ဆောက်ပုံအတွင်း အများအားဖြင့် အမှီဝါကျခွဲများသာ အသုံးများပါသည်။ မြန်မာဝါကျ ဖွဲ့စည်းတည်ဆောက်ပုံအတွင်း အင်္ဂလိပ်အမှီဝါကျခွဲနှင့် အမှီခံဝါကျခွဲ တို့ကို ထည့်သွင်း၍ မြန်မာသဒ္ဒါတည်ဆောက်ပုံနှင့် အင်္ဂလိပ်သဒ္ဒါတည်ဆောက်ပုံတို့ တစ်လှည့်စီ ရောသုံးနိုင်ကြောင်းတွေ့ရပါသည်။ ထူးခြားချက်မှာ နိုင်ငံခြားဘာသာစကားများတွင် သက်ဆိုင်ရာ နိုင်ငံခြားဘာသာစကားများ၏ ဝါကျတည်ဆောက်ပုံတွင် အင်္ဂလိပ်ဝါကျခွဲဖြင့် ထည့်သွင်း၍ ဝါကျကို အဆုံးသတ်နိုင်သော်လည်း မြန်မာဘာသာစကားတွင်မူ 'ပါပဲ၊ ပဲ၊ ပါ' စသည့် မြန်မာဘာသာစကား၏ ဝါကျအဆုံးသတ် တစ်ခုခုဖြစ်သာ ဝါကျကို အဆုံးသတ်လေ့ ရှိပါသည်။ ထို့ကြောင့် တစ်လှည့်စီ ဖြစ်ပေါ်ခြင်းပုံစံသည် ဝါကျခွဲအဆင့်တွင်ဖြစ်ပြီး ဘာသာပြန်အားနည်းခြင်းကြောင့်ဟု ဆိုနိုင်ပါသည်။ အခြားတစ်ဖက်တွင် မိမိတို့၏ အင်္ဂလိပ်စာတတ်မြောက်မှုဂုဏ်ကို ဖော်ပြလိုခြင်းကြောင့်လည်း ဖြစ်နိုင်သည်။ မူရင်းအာဘော်နှင့် လွဲမှားတိမ်းစောင်းမှုမရှိရန်၊ မူရင်းအသုံးအနှုန်းနှင့် အကျွမ်းတဝင်ရှိစေရန်တို့အတွက် မူရင်းအင်္ဂလိပ်ဝါကျခွဲအတိုင်း တိုက်ရိုက်ထည့်သွင်းခြင်းဖြစ်နိုင်ကြောင်း ယူဆရပါသည်။

၃၊ ၃။ စကားလုပ်ဆောင်ချက်ပုံစံများ

စကားလုပ်ဆောင်ချက်များကို ဖော်ပြရာတွင် **ဆောင်ရွက်ချက်ပြကြိယာများ**[၁] ဖြင့် ဖော်ပြသည့် နည်းသည် အထင်ရှားဆုံးနည်း ဖြစ်ပါသည်။ စကားခွန်းအားဖြင့်လုပ်ဆောင်ရာတွင်–

(၁) **စကားအသုံးအနှုန်း**[၂]

(၂) **ပြောသူ၏ဆန္ဒ**[၃]

(၃) **ပြောစကား၏သက်ရောက်မှု**[၄]

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[၁] performative verbs

[၂] locution

[၃] illocution

[၄] perlocution

ဟူ၍ တွေ့ရပါသည်။ စကားလုပ်ဆောင်ချက်ပုံစံကို–

(၁) ဆုံးဖြတ်မှုဆိုင်ရာများ[၁]

(၂) အသုံးချမှုဆိုင်ရာများ[၂]

(၃) တာဝန်ယူမှုဆိုင်ရာများ[၃]

(၄) အပြုအမူဆိုင်ရာများ[၄]

(၅) ရှင်းလင်းတင်ပြမှုဆိုင်ရာများ[၅]

ဟူ၍ လေ့လာထားသည်။

၂၊ ၃၊ ၁။ တွေ့ရှိချက်များ

ဆုံးဖြတ်ချက်ဆိုင်ရာများတွင် **ဆုံးဖြတ်စကား**[၆]၊ **ထင်မြင်စကား**[၇]၊ **ခန့်မှန်းစကား**[၈]၊ **တန်ဖိုးဖြတ်စကား**[၉] စသည်တို့နှင့်သက်ဆိုင်ကြောင်း တွေ့ရပါသည်။ ဆုံးဖြတ်ချက်ပေးသူသည် အခွင့်အာဏာရှိသူက ပေးနိုင်သကဲ့သို့ ပြောသူသည် သူ့ကိုယ်သူလည်း ဆုံးဖြတ်ချက်ချနိုင်ပါသည်။ ထိုအပြောစကားတွင် ပြောသူသည် နာသူအား တစ်စုံတစ်ခုကို မဖြစ်မနေပြုလုပ်ရန် သက်ရောက်မှု ဖြစ်ပေါ်စေသည်။ ထင်မြင်စကားတွင် ပြောသူသည်နာသူကို တစ်စုံတစ်ခုပြုလုပ်ရန် သက်ရောက်မှုမရှိဘဲ ပြောသူက သူ၏အမြင်ကို ပြောပြခြင်းသာ ဖြစ်သည်။ ခန့်မှန်းစကားသည် မှန်းဆမှုများသာဖြစ်ပြီး တိကျမှုမရှိပေ။ နာသူအပေါ် ပြောသူ၏ခန့်မှန်းမှုကို ပြောပြခြင်းသာဖြစ်သည်။ တန်ဖိုးဖြတ်စကားတွင် ပြောသူသည် တစ်စုံတစ်ခုအတွက် ငွေကြေး သို့မဟုတ် လုပ်ရည်ကိုင်ရည်ဖြင့် တန်ဖိုးဖြတ်နိုင်ကြောင်း တွေ့ရသည်။

အသုံးချမှုဆိုင်ရာစကားများတွင် **အသုံးချစကား**[၁၀]၊ **ချိန်းဆိုစကား**[၁၁]၊ **အမိန့်ပေးစကား**[၁၂]၊ **သတိပေးစကား**[၁၃]၊ **တိုက်တွန်းစကား**[၁၄]စသည့်ဖြင့် လွှမ်းမိုးမှုတစ်ခုခုကို အသုံးချခြင်းနှင့် သက်ဆိုင်ပါသည်။ အသုံးချမှုစကားတွင် ပြောသူသည် သူတစ်ပါးကို မိမိအကျိုးအတွက် အခွင့်အရေးဖြင့် အသုံးချခြင်းဖြစ်ပါသည်။ အသက်အရွယ်အဆင့်အတန်းမရွေး အသုံးချပိုင်ခွင့်ရှိပါသည်။ သို့သော် မြန်မာ့လူ

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[၁] verdictives
[၂] exercitives
[၃] commissives
[၄] behabitives
[၅] expositives
[၆] verdict
[၇] opinion
[၈] estimation
[၉] appraisal
[၁၀] exercise
[၁၁] appointment
[၁၂] order
[၁၃] warning
[၁၄] urge

အဖွဲ့အစည်းတွင် တပည့်ဖြစ်သူကဆရာကိုလည်းကောင်း၊ ရာထူးငယ်သူကရာထူးကြီးသူကို လည်းကောင်း၊ အသုံးချသည့်အပြောစကားကို ပြောဆိုမှုနည်းပါသည်။ အကြောင်းမှာ မြန်မာတို့က မယဉ်ကျေးသည့် လုပ်ရပ်အဖြစ် ယူဆကြခြင်းကြောင့်ဖြစ်ပါသည်။ ချိန်းဆိုစကားတွင် ပြောသူသည် အကြောင်းကိစ္စ တစ်ခုခုပြီးမြောက်ရန်အတွက် အချိန်၊ နေရာ စသည့်ဖြင့် တစ်ခုခုကို အသုံးပြု၍ ချိန်းဆိုခြင်းဖြစ်သည်။ ထိုအပြောစကားတွင် ပြောသူနှင့်နာသူတို့၏ရင်းနှီးမှု၊ ပတ်သက်မှု အတိုင်းအတာကို အကဲခတ်နိုင်ပါသည်။ အမိန့်ပေးစကားတွင် ပြောသူသည် နာသူကို လိုက်နာဆောင်ရွက်ရန် အမိန့်ပေးနိုင်သော အာဏာနှင့်အရှိန်အဝါတို့ကို အသုံးပြုခြင်းဖြစ်သည်။ သတိပေးစကားတွင် ပြောသူသည် နာသူ၏အကျိုး၊ မိမိ၏အကျိုးကို ရှေ့ရှုပြီး လွှမ်းမိုးမှုတစ်ခုခုကို အသုံးချကာ သတိပေး ပြောဆိုနိုင်သည်အပြင် အချို့ သတိပေးစကားများတွင် ခင်မင်မှု၊ စေတနာ၊ မေတ္တာတို့ အပေါ် အခြေခံ၍လည်း ပြောဆိုခြင်းဖြစ်ပါသည်။ တိုက်တွန်းစကားတွင် ပြောသူသည် နာသူ၏ ကိုယ်ကျိုး အတွက် တစ်စုံတစ်ခုကိုဆောင်ရွက်ရန် အရှိန်အဝါနှင့်အခွင့်အရေးကို အသုံးချသော်လည်း အချို့ တိုက်တွန်းစကားများသည် စေတနာ၊ မေတ္တာတို့အပေါ်တွင်လည်း အရင်းခံ၍ တိုက်တွန်းပြောဆိုခြင်း ဖြစ်ကြောင်း တွေ့ရသည်။

တာဝန်ယူမှုဆိုင်ရာစကားများတွင် **တာဝန်ယူစကား**[၁]၊ **ကတိပေးစကား**[၂]၊ **အာမခံစကား**[၃]၊ **အလုပ်လက်ခံစကား**[၄]၊ **သဘောတူစကား**[၅]၊ **ထောက်ခံစကား**[၆] စသည့်တို့နှင့် သက်ဆိုင်ပါသည်။ တာဝန်ယူစကားတွင် ပြောသူသည် ဆောင်ရွက်ရန်အမှုကိစ္စများကို ကိုယ်တိုင်တာဝန်ယူ ပြောဆိုခြင်းဖြစ်သည်။ ထိုစကားတွင် ပြောသူသည် နာသူအား အညွှန်းခံအတွက် တာဝန်ယူခြင်းဖြင့် ပြောသူနှင့် နာသူတို့ အပြန်အလှန်နားလည်မှု ရရှိစေသည်။ ကတိပေးစကား၊ အာမခံစကားတွင် ပြောသူသည် နှစ်ဦးစလုံး၏ အကျိုးအတွက် သို့မဟုတ် သူတစ်ပါးအကျိုးအတွက် တစ်စုံတစ်ခုကို ကတိပေးခြင်း၊ အာမခံပေးခြင်း ဖြစ်ပါသည်။ အလုပ်လက်ခံစကားတွင် ပြောသူသည်တစ်စုံတစ်ခုကို တာဝန်ယူပြီး လက်ခံဆောင်ရွက်ခြင်းဖြစ်ပါသည်။ ထောက်ခံစကားတွင် ပြောသူသည် တစ်စုံတစ်ခုအတွက် ဘက်လိုက်ပြောခြင်းဖြစ်သည်။ သဘောတူစကားတွင် ပြောသူသည် တစ်စုံတစ်ခု၏ ဆန္ဒအတိုင်းလိုက်လျောခြင်းဖြစ်သည်။ ယင်းသို့ ပြောဆိုခြင်းဖြင့် နှစ်ဦးစလုံး၏ ဆက်ဆံရေး တိုးတက်ကောင်းမွန်စေပြီး လုပ်ငန်းအဆင်ပြေအောင်မြင်စေနိုင်ကြောင်း တွေ့ရပါသည်။

အပြုအမူဆိုင်ရာစကားများတွင် **တောင်းပန်စကား**[၇]၊ **ဂုဏ်ယူဝမ်းမြောက်စကား**[၈]၊ **ဝမ်းနည်းစကား**[၉]၊ **ကျိန်ဆဲစကား**[၁၀]၊ **စိန်ခေါ်စကား**[၁၁] စသည်တို့နှင့် သက်ဆိုင်ပါသည်။ တောင်းပန်စကားတွင် ပြောသူသည် အပြစ်မှခွင့်လွှတ်ရန်၊ တစ်စုံတစ်ရာပြုလုပ်ပေးရန်နှင့် တစ်စုံတစ်ရာမပြုလုပ်ရန် တောင်းပန်

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[၁] commitment
[၂] promise
[၃] guarantee
[၄] acceptance
[၅] agreement
[၆] espousal
[၇] apology
[၈] congratulation
[၉] condolence
[၁၀] curse
[၁၁] challege

ခြင်းဖြစ်သည်။ ဂုဏ်ယူဝမ်းမြောက်စကားတွင် ပြောသူသည် တစ်စုံတစ်ယောက်အတွက် မိမိရင်တွင်း ခံစားမှုကိုပြောခြင်း ဖြစ်သည်။ ဝမ်းနည်းစကားတွင် ပြောသူသည် မိမိကိုယ်တိုင် သို့မဟုတ် တစ်စုံ တစ်ယောက်အတွက် စိတ်ထိခိုက်ရခြင်းဖြစ်ကြောင်း တွေ့ရသည်။ ထိုသို့ ပြောဆိုခြင်းဖြင့် လူမှုရေး နားလည်သော၊ ကိုယ်ချင်းစာနာတတ်သော ပြောသူ၏ စိတ်နေသဘောထားကို တွေ့ရှိရပါသည်။ ကျိန်ဆဲ စကားတွင် ပြောသူသည် တစ်စုံတစ်ယောက်ကို ဘေးတွေ့ရန် ကျိန်ဆဲခြင်းဖြစ်ပြီး စိန်ခေါ် စကားတွင် တစ်စုံတစ်ယောက်ကို ယှဉ်ပြိုင်ရန်စိန်ခေါ်ခြင်းဖြစ်ကြောင်း တွေ့ရသည်။

ရှင်းလင်းတင်ပြမှုဆိုင်ရာစကားများတွင် **ရှင်းလင်းတင်ပြစကား**[၁]၊ **ငြင်းဆိုစကား**[၂]၊ **ဝန်ခံစကား**[၃]၊ **အမှန်လက်ခံစကား**[၄] စသည်တို့ပါဝင်ပြီး အကျိုးသင့်အကြောင်းသင့် ဆွေးနွေးခြင်း သို့မဟုတ် ရှင်းပြခြင်း ဖြစ်သည်။ ရှင်းလင်းတင်ပြခြင်းတွင် ပြောသူသည် တစ်စုံတစ်ရာကို အကြောင်းကိစ္စတစ်ခု အတွက် အကျိုးသင့်အကြောင်းသင့်ပြောဆိုခြင်း ဖြစ်ပါသည်။ ငြင်းဆိုစကားတွင် ပြောသူသည် တစ်စုံတစ်ယောက် ကို ဖြစ်ရပ်တစ်ခုနှင့်ပတ်သက်၍ ငြင်းဆိုခြင်း သို့မဟုတ် မိမိနှင့်မသက်ဆိုင်ကြောင်း ပြန်လည် တုန့်ပြန်ပြောခြင်းဖြစ်သည်။ ဝန်ခံစကားတွင် ပြောသူသည် တစ်စုံတစ်ယောက်ကို မိမိလုပ်ရပ်နှင့် ပတ်သက်၍ ဟုတ်မှန်သည်ဟု ပြောခြင်းဖြစ်သော်လည်း အကြောင်းပြချက်ပေးကာ ဝန်ခံသည့်သဘောကို တွေ့ရှိရပါသည်။ အမှန်လက်ခံစကားတွင် ပြောသူသည် မိမိကိုယ်တိုင် အမှန်ကို လက်ခံသော်လည်း အကြောင်းပြချက်ပေးကာ လက်ခံသည့်သဘောကို တွေ့ရှိရသည်။

၂၊ ၃၊ ၂။ စိစစ်ချက်များ

ဆုံးဖြတ်ချက်ဆိုင်ရာ စကားပုံစံတွင် ပြောသူကနာသူကို တစ်စုံတစ်ခုအတွက် ဆုံးဖြတ်ချက် ပေးခြင်း၊ တန်းဖိုးသတ်မှတ်ခြင်း၊ အမြင်သဘောထားကိုချပြခြင်းဖြင့် ပြောသူ၏ရည်ရွယ်ချက်ကို ပြီးမြောက်စေသည်။ ထို့ပြင် အချို့အပြောစကားများသည် နာသူကို မဖြစ်မနေ လိုက်နာလုပ်ဆောင်ရန် အတွက် သက်ရောက်မှုကို ဖြစ်စေသော်လည်း အချို့အပြော စကားများသည် နာသူကို မဖြစ်မနေ လုပ်ဆောင်ရမည်ဟူသော သဘောမျိုးကို မတွေ့ရပေ။ နာသူ၏ဆန္ဒအပေါ်မူတည်ပြီး သက်ရောက်မှု ဖြစ်ပေါ်စေပါသည်။ တစ်ချို့ အပြောစကားများသည် နာသူနှင့်အညွှန်းခံကိုပါ စကား တစ်ခွန်းတည်းဖြင့် သက်ရောက်မှုနှစ်မျိုးကို ဖြစ်ပေါ်စေသည်။ ထိုစကားလုပ်ဆောင်ချက်များကြောင့် ပြောသူနှင့်နာသူ တို့၏ လုပ်ငန်းခွင်ဗဟုသုတကိုရရှိစေပြီး လုပ်ငန်းဆောင်တာများပါ ပြီးမြောက်စေသော အကျိုးကျေးဇူးကို ရရှိစေပါသည်။

အသုံးချမှုဆိုင်ရာစကားပုံစံတွင် ပြောသူကအခွင့်အရေးကို မိမိအကျိုးအတွက် အသုံးချခြင်း၊ အကြောင်းကိစ္စတစ်ခုခုအတွက် လိုက်ပါလုပ်ဆောင်ရန် အခွင့်အာဏာကိုသုံးခြင်း၊ နာသူ၏အကျိုးကို ရှေ့ရှုပြီး တစ်စုံတစ်ခုဆောင်ရွက်ရန် လွှမ်းမိုးမှုတစ်ခုခု၊ အရှိန်အဝါနှင့် ခင်မင်မှုစေတနာတို့ကို အသုံးပြုခြင်းဖြင့် ပြောသူ၏ရည်ရွယ်ချက်ပြီးမြောက်အောင် လုပ်ဆောင်ခြင်းဖြစ်ပါသည်။ ထိုစကား ကြောင့် ပြောသူ၏ဆန္ဒပြီးမြောက်စေသကဲ့သို့ နာသူက လိုက်နာလုပ်ဆောင်ခြင်းဖြင့် နှစ်ဦးနှစ်ဖက်စလုံး အပြန်အလှန် အကျိုးကျေးဇူးကိုရရှိစေပြီး လူမှုဆက်ဆံရေးကို ပိုမိုချောမွေ့စေနိုင်သည်။

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[၁] exposition

[၂] argument

[၃] confession

[၄] assumption

တာဝန်ယူမှုဆိုင်ရာစကားပုံစံတွင် ပြောသူကဆောင်ရွက်ရန်ကိစ္စများကို ကိုယ်တိုင်တာဝန်ယူ ခြင်း၊ ပြောသူနှာသူ နှစ်ဦးစလုံးအကျိုးအတွက် တာဝန်ယူခြင်း၊ အညွှန်းခံအကျိုးအတွက် တာဝန်ယူ ခြင်း၊ တစ်စုံတစ်ခုအတွက် ကတိပေးခြင်း၊ အာမခံခြင်း၊ ထောက်ခံခြင်း၊ သဘောတူခြင်းတို့ကို တွေ့ရသည်။ ယင်းတွင် ပြောသူ၏ရည်ရွယ်ချက် ဆန္ဒပြီးမြောက်အောင် မိမိအကျိုးသာမက သူတစ်ပါးအကျိုးကိုပါ လိုလိုလားလားဆောင်ရွက်ပါသည်။ ထိုစကားကြောင့် ပြောသူကနာသူကို မိမိဘက်ပါအောင်စည်းရုံးနိုင်ပြီး လူမှုဆက်ဆံရေးအတွက် ကောင်းမွန်သော အကျိုးကျေးဇူးကိုရရှိစေပါသည်။ ထို့ပြင် သူတစ်ပါး၏ အကျိုးကို လိုလားခြင်းဖြင့် လူအများ၏ အားကိုးယုံကြည်မှုကို ရရှိစေပါသည်။

အပြုအမူဆိုင်ရာစကားပုံစံတွင် ပြောသူကမိမိကို အပြစ်မှခွင့်လွှတ်ရန်၊ အလုပ်ကိစ္စပြီးမြောက် စေရန်နှင့် မကောင်းမှုကိုမလုပ်ရန် တောင်းပန်ခြင်း၊ တစ်စုံတစ်ယောက်နှင့် ထပ်တူဝမ်းမြောက် ဝမ်းသာခြင်း၊ စိတ်ထိခိုက်ခြင်း၊ တစ်စုံတစ်ယောက်ကို ဘေးတွေ့စေခြင်း၊ စိန်ခေါ်ခြင်းဖြင့် ပြောသူ၏ ဆန္ဒကို ထုတ်ဖော်ခြင်းဖြစ်ကြောင်း တွေ့ရပါသည်။ ယင်းတွင် အချို့ အပြောစကားများသည် အညွှန်းခံ အတွက် ပြောသူ၏ခံစားချက်ကို ထုတ်ဖော်ကြောင်းတွေ့ရသည်။ ထိုစကားအပြုအမူများကြောင့် ပြောသူ နှင့်နာသူတို့၏ လူမှုဆက်ဆံရေးချောမွေ့စေသကဲ့သို့ အချို့စကားအပြုအမူများသည် ပြောသူနှင့် နာသူတို့၏ ဆက်ဆံရေးကို ပျက်ပြားစေပါသည်။

ရှင်းလင်းတင်ပြမှုဆိုင်ရာစကားပုံစံတွင် ပြောသူကတစ်စုံတစ်ယောက်ကို အကြောင်းကိစ္စ၊ အဖြစ်အပျက်၊ ပြဿနာတစ်ရပ်နှင့်ပတ်သက်ပြီး အကျိုးသင့်အကြောင်းသင့် ပြောဆိုကြသကဲ့သို့ အချို့အပြောစကားများသည် အကြောင်းပြချက်ပေးကာ ပြောဆိုခြင်းလည်းဖြစ်သည်။ ထိုစကားများကြောင့် ပြောသူနှင့်နာသူတို့၏ အဖုအထစ်ပြဿနာများကို ပြေလည်မှုရရှိစေပြီး လူမှုဆက်ဆံရေးမှာ ကောင်းမွန် နိုင်စေပါသည်။ ပြောသူနှင့်နာသူတို့၏ သံသယကိုလည်း ပြေပျောက်စေနိုင်သည်။

၃၊ ၄။ စကားပြောပုံစံများ

စကားပြောပုံစံများကိုဖော်ထုတ်ရာတွင် အဖွင့်စကား၊ စကားအလှည့်ယူခြင်း၊ ကြားလပ်၊ စကားထပ်မှု၊ အချက်ပြစကား၊ စကားအတွဲအဖက်စုံတွဲ၊ ဘေးတိုက်ဖြစ်စဉ်၊ ကြားထိုးဖြစ်စဉ်၊ စကားပြင် ပြောခြင်းနှင့် အဆုံးသတ်စကားဟူ၍ ဖော်ထုတ်ထားပါသည်။

၂၊ ၄၊ ၁။ တွေ့ရှိချက်များ

မြန်မာဘာသာစကားရှိ အဖွင့်စကားပုံစံများတွင် မြန်မာလူမျိုးတို့သည် တစ်ဦးနှင့်တစ်ဦးတွေ့ဆုံစဉ် အဖွင့်စကားများကို နှုတ်ခွန်းဆက်စကား၊ ဆုတောင်းစကား၊ ကြိုဆိုစကား၊ ဝမ်းမြောက်စကား၊ လောကဝတ်စကား စသည်တို့ဖြင့် ယဉ်ကျေးပျူငှာစွာ စတင်ပြောဆိုကြကြောင်း တွေ့ရပါသည်။ အထူးသဖြင့် အဖွင့်စကားပုံစံတွင် ယနေ့ခေတ် အသုံးတွင်ကျယ်နေသော အဖွင့်စကားမှာ “မင်္ဂလာပါ” ဟူသော နှုတ်ခွန်းဆက်စကား ဖြစ်ပါသည်။ ယင်းကို အဖွင့်စကားအဖြစ် နေရာကဏ္ဍမျိုးစုံ၌ တွင်ကျယ်စွာ အသုံးပြုလျက်ရှိပါသည်။ သာမန် လူနှစ်ဦးတွေ့ဆုံချိန် သို့မဟုတ် လူနှစ်ဦး ဖုန်းပြော ချိန်တို့တွင် “မင်္ဂလာပါ” ဟူသည့် နှုတ်ခွန်းဆက်စကားကို အဖွင့်စကားအဖြစ် ပြောဆိုမှုမှာ နည်းပါးပါသည်။ သို့သော်လည်း အခမ်းအနား အစီအစဉ်ဖြင့် ပုံစံတကျ တင်ဆက်ရသော စကားပြောတို့တွင် “မင်္ဂလာပါ” ဟူသော နှုတ်ခွန်းဆက်စကားကို ကျယ်ကျယ်ပြန့်ပြန့် အသုံးပြုပြောဆိုကြသည်။ သာမန်အားဖြင့် ပုံစံတကျမဟုတ်သော တွေ့ဆုံမှုများတွင် လောကဝတ်စကားကိုသာ အသုံးပြုပြောဆိုကြပါသည်။

ဖုန်းစကားပြောတွင် အများအားဖြင့် ဖုန်းခေါ်သူက အဖွင့်စကားကို အမေးစကားနှင့်စတင်ပြီး ဖုန်းလက်ခံသူက လက်ခံစကားတို့ဖြင့် စတင်ပြောဆိုကြကြောင်း တွေ့ရပါသည်။ ဖုန်းခေါ်သူနှင့်ဖုန်း လက်ခံသူတို့၏ရင်းနှီးမှု၊ သူစိမ်းဆန်မှု၊ ဖုန်းခေါ်သူ၏ ဖုန်းနံပါတ်ကို ဖုန်းလက်ခံသူကမည်သူဖြစ်ကြောင်း ကြိုတင်သိရှိထားမှုတို့အပေါ်မူတည်ပြီး အမျိုးမျိုးကွဲပြားစွာ ပြောဆိုလေ့ရှိကြကြောင်း တွေ့ရပါသည်။

စကားပြောစိစစ်မှုအရ စကားအလှည့်ယူခြင်းတွင်–

(၁) အလှည့်ဖွဲ့စည်းမှုဆိုင်ရာ ပေါင်းစပ်မှု[၁]

(၂) အလှည့်ခွဲဝေမှုဆိုင်ရာ ပေါင်းစပ်မှု[၂]

တို့ကို တွေ့ရပါသည်။ စကားအလှည့်ယူခြင်းစနစ်၏ အလှည့်ဖွဲ့စည်းမှုဆိုင်ရာနှင့် အလှည့်ခွဲဝေမှု ဆိုင်ရာပေါင်းစပ်မှုတို့တွင်–

(က) လက်ရှိပြောသူသည် နောက်ပြောမည့်သူကို ရွေးချယ်ပေးခြင်း[၃]

(ခ) နောက်ပြောမည့်သူက မိမိဘာသာ ရွေးချယ်ပြောဆိုခြင်း[၄]

(ဂ) လက်ရှိပြောသူက ဆက်လက်ပြောဆိုနေခြင်း[၅]

တို့ကို တွေ့ရသည်။

အလှည့်ဖွဲ့စည်းမှုဆိုင်ရာနှင့် အလှည့်ခွဲဝေမှုဆိုင်ရာ နည်းလမ်းအရ စကားအလှည့်ယူရာတွင် မတူညီသည့်လုပ်ဆောင်ချက်များကြောင့် စကားတစ်ခွန်းနှင့်တစ်ခွန်းကြားတွင် တိုတောင်းသော **ကြားလပ်များ**[၆] ဖြစ်ပေါ်နိုင်သည်။ ပြောဆိုသူနှစ်ဦးကြားတွင် တိုတောင်းသော ကြားလပ်များအဖြစ် **အနုစိတ်ခေတ္တရပ်နားမှုများ**[၇]၊ **တိတ်ဆိတ်မှုများ**[၈] ဖြစ်နိုင်သကဲ့သို့ တစ်ဦးချင်းစကားဥ်လည်း အနုစိတ် ခေတ္တရပ်နားမှုများ၊ တိတ်ဆိတ်မှုများ တွေ့ရသည်။

စကားပြောဖြစ်စဉ်တစ်ခုတွင် ပြောဆိုသူနှစ်ဦးကြားဥ် မတူညီသော စကားလုပ်ဆောင်မှုများ ကြောင့် တိုတောင်းသော **စကားထပ်မှုများ**[၉] ဖြစ်နိုင်ပါသည်။ စကားအလှည့်ပြောင်းယူရာဥ် ပြောသူ နှစ်ဦး စကားထပ်မှုဖြစ်ပွားနိုင်ပြီး ထိုသို့ စကားထပ်ရခြင်းမှာ တူသောအကြောင်းအရာတစ်ခုအပေါ် စကားပြိုင်တူ ပြောရင်း စကားထပ်မှု၊ မတူသောအကြောင်းအရာတစ်ခုအပေါ် စကားလုပြောရင်း စကားထပ်မှု နှင့်ရှေ့ပြောသူ၏စကားမှ အကြောင်းအရာအချို့ကို နောက်ပြောသူက စကားထပ်ကာ အလှည့်ယူလိုက် သဖြင့် **ပူးပေါင်းဆောင်ရွက်သောစကားထပ်မှု**[၁၀] ဟူ၍ ၃ မျိုး တွေ့ရပါသည်။

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[၁] turn-constructional component

[၂] turn-allocational component

[၃] current speaker selects next speaker

[၄] next speaker self-selects

[၅] current speaker continue

[၆] gaps

[၇] micropause

[၈] silence

[၉] overlaps

[၁၀] cooperative overlapping

စကားပြောတွင် လူအချင်းချင်း အပြန်အလှန်ဆက်ဆံရာ၌ အဆင်ပြေချောမွေ့စေရန်ပြုလုပ်ရသည့် အင်္ဂါတစ်ရပ်မှာ **အချက်ပြစကားများ**[၁]ကို အသုံးပြုကြခြင်းဖြစ်ပါသည်။ ယင်းကို **အသေးစား တုံ့ပြန်မှုများ**[၂] ဟုလည်းခေါ်သည်။ အင်္ဂလိပ်စကားပြောတွင် oh yes, yeah, ok, right, no စသည်ဖြင့် တွေ့နိုင်ပါသည်။ မြန်မာစကားပြောတွင် စကားပြောနေစဉ်အတွင်း တစ်ဦးက "အော် အင်၊ အင်း အင်း၊ ဖြစ်မှာပေါ့၊ ဒါပေါ့၊ အမ်၊ ဟုတ်လား" စသည်ဖြင့် အသုံးပြုတုံ့ပြန်ကြခြင်းမျိုးဖြစ်ကြောင်း တွေ့ရသည်။ စကားတုံ့လှယ်ပြောဆိုမှုများတွင် ပြောသူနှင့်နာသူတို့ တစ်လှည့်စီ အသုံးပြုပြောဆိုရသော **စကားအတွဲအဖက်စုံတွဲများ**[၃] ရှိပါသည်။ စကားအတွဲအဖက်စုံတွဲများမှာ နှုတ်ခွန်းဆက်စကားနှင့် ပြန်လည်နှုတ်ခွန်းဆက်စကား၊ အမေးစကားနှင့်အဖြေစကား၊ တောင်းဆိုစကားနှင့်လက်ခံစကား/ ငင်းပယ်စကား စသည်တို့ကဲ့သို့သော အတွဲလိုက်ဖြစ်နေသောပုံစံမျိုး ဖြစ်ပါသည်။

စကားဝိုင်းတစ်ခု၏ **ဘေးတိုက်ဖြစ်စဉ်**[၄]သည် အဓိကအကြောင်းအရာ မဆုံးမီ ထိုအကြောင်းအရာနှင့်ဆက်စပ်ပြီး သွယ်ဝိုက်၍ဝင်ရောက်လာသော ဖြစ်စဉ်မျိုးဖြစ်သည်။ စကားဝိုင်း၏ **ကြားထိုးဖြစ်စဉ်**[၅]သည် လက်ရှိစကားပြောတွင် အဓိကအကြောင်းအရာ မပြီးဆုံးမီ ထိုအကြောင်းအရာနှင့် မပတ်သက်သော သီးခြားဖြစ်စဉ်တစ်ခုဖြစ်ကြောင်း တွေ့ရသည်။

စကားပြင်ပြောခြင်းတွင်–

(က) မိမိကိုယ်တိုင်စကားပြင်ပြောခြင်း[၆]

(ခ) အခြားသူက စကားပြင်ပြောခြင်း[၇]

တို့ကို တွေ့ရသည်။

အဆုံးသတ်စကား[၈]ကို သာမန်တွေ့ဆုံရာတွင် အပြန်အလှန်နှုတ်ဆက်စကားဖြင့် အဆုံးသတ်လေ့ရှိသည်။ အဆုံးသတ်ရာ၌ လူမှုအခြေအနေအလိုက် **အကြိုအဆုံးသတ်စကားများ**[၉]ကို အသုံးပြုပြီး အဆင့်ဆင့် အဆုံးသတ်လေ့ရှိသည်ကိုလည်း တွေ့ရပါသည်။ အင်္ဂလိပ်စကားတွင် အကြိုအဆုံးသတ်စကားအနေဖြင့် okay, all right, thank you, တို့ကို ပြောဆိုကြပြီး မြန်မာတို့ကလည်း "အိုကေ၊ ကောင်းပြီ၊ ကျေးဇူးပါ" ဟူ၍ ပြောဆိုကြကြောင်းလည်း တွေ့ရသည်။

၃၊ ၄၊ ၂။ စိစစ်ချက်များ

မြန်မာ့လူ့အဖွဲ့အစည်းတွင် လူတစ်ဦးနှင့်တစ်ဦး အဖွင့်စကားကို နှုတ်ခွန်းဆက်စကားဖြင့် စတင်ပြောဆိုကြခြင်းမှာ အပြန်အလှန်လေးစားကြောင်းပြသခြင်း၊ တစ်ဦးအပေါ်တစ်ဦး အလေးထားဂရုပြု

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၁ back channel
၂ minimal responses
၃ adjacency pairs
၄ side sequence
၅ Insertion sequence
၆ self-repair
၇ other-repair
၈ closing sequence
၉ pre-closings

ကြောင်းပြသခြင်းနှင့် မြန်မာတို့၏စိတ်ရင်းကိုပြသခြင်းလည်း ဖြစ်ပါသည်။ ယင်းသည် မြန်မာလူမျိုးတို့၏ ဂုဏ်ယူဖွယ်ရာကောင်းမြတ်သော အစဉ်အလာ ယဉ်ကျေးမှုဓလေ့တစ်ရပ်လည်းဖြစ်၍ ထိုကောင်းမြတ်သော အစဉ်အလာကောင်းကို ဆက်လက်ထိန်းသိမ်းသင့်ပါသည်။

စကားအလှည့်ယူခြင်းပုံစံများတွင် ပေါင်းစပ်မှု ၂ခုဖြင့် ပါဝင်ဖွဲ့စည်းနေကြောင်း ဖော်ထုတ် ရရှိပါသည်။ ထို့ပြင် အခြေခံစည်းမျဉ်း ၃ ရပ်စလုံးတွင် ကြားလပ်နှင့် ပူးပေါင်းဆောင်ရွက်သော စကားထပ်မှုများ ဖြစ်ပွားနိုင်ပါသည်။ စည်းမျဉ်း(ခ)တွင်မှု ကြားလပ်အပြင် တစ်ချိန်တည်း တစ်ပြိုင်တည်း စကားထပ်မှုပါ ဖြစ်နိုင်သည်။ စည်းမျဉ်း(က)အရ လက်ရှိပြောသူသည် နောက်ပြောမည့်သူကို ရွေးချယ်ပေးရာတွင် မြန်မာတို့၏အစဉ်အလာ ယဉ်ကျေးမှုအရ အသက်ကြီးသူ သို့မဟုတ် ဂုဏ်ကြီးသူကို အရင်ဦးဆုံး အလှည့်ပေးပြောဆိုစေပါသည်။ ထိုသို့ နောက်ပြောမည့်သူကို ရွေးချယ်အလှည့်ပေးရာတွင် ညွှန်းခေါ်ခြင်း၊ မေးခွန်းမေးခြင်း၊ တောင်းဆိုခြင်း၊ နှုတ်ခွန်းဆက်စကား ပြောဆိုစေခြင်း စသည်တို့ဖြင့် အလှည့်ပေးကြပါသည်။ စည်းမျဉ်း(ခ)အရ နောက်ပြောမည့်သူက မိမိဘာသာရွေးချယ်ပြောဆိုရာတွင် တစ်ဦးပြီးမှတစ်ဦး ဝင်ရောက်ပြောဆိုလျှင် တစ်ချိန်တည်း တစ်ပြိုင်တည်း စကားထပ်မှုကို ရှောင်ရှားနိုင်သည်။ နောက်ပြောမည့်သူက လက်ရှိပြောသူ၏ စကားမဆုံးမီ အတင်းဝင်ပြောလျှင် လက်ရှိပြောသူက သူ့စကားကို ပြီးဆုံးသည်အထိ ဆုပ်ကိုင်ထားနိုင်ပြီး မိမိစကားဆုံးမှပြောရန် ဟန့်တားနိုင်ပါသည်။ စည်းမျဉ်း(ဂ)အရ လက်ရှိပြောသူက ဆက်လက်ပြောဆိုနေရာတွင် ကြိုတင်လမ်းခင်းသည့်ပုံစံနှင့် စကားဆက်များ အသုံးပြုသည့်ပုံစံ ၂ မျိုးကို ဖော်ထုတ်ရပါသည်။ ကြိုတင်လမ်းခင်းခြင်းဖြင့် ပါဝင် ဆွေးနွေးသူတို့၏ သိလိုစိတ်ကို ပိုမိုဖြစ်ပေါ်စေနိုင်ပါသည်။ ထို့ပြင် စကားဆက်များ အသုံးပြုခြင်းဖြင့် နောက်လူဝင် မပြောနိုင်ရန် စကားကို အမျှင်မပြတ်အောင် ပြုလုပ်ထားနိုင်သည်။ ထိုသို့ ပြုလုပ်ခြင်းဖြင့် လက်ရှိပြောသူသည် သူသိသောအကြောင်းအရာကို အချိန်တော်တော်ကြာ အကျယ်တဝင့် အလှည့်ယူပြီး ပြောဆိုနေမည်ဟု ကျန်လူများကလည်း နားလည်သွားစေသည့် အကျိုးကျေးဇူးကို ရရှိစေနိုင်ပါသည်။ ထို့ကြောင့် စကားအလှည့်ယူခြင်းပုံစံတွင် လက်ရှိပြောသူသည် နောက်ပြောမည့်သူကို ရွေးချယ်နိုင် သကဲ့သို့ နောက်ပြောမည့်သူကို အလှည့်မပေးဘဲမိမိစကားကို ဆက်လက်ပြောဆိုနိုင်ပါသည်။ နောက်ပြောဆိုမည့်သူသည် အလှည့်ကိုမိမိဘာသာ အလှည့်ဝင်ယူပြောဆိုနိုင်သကဲ့သို့ အခြားသူပေးသော အလှည့်ကိုလည်း ရယူနိုင်ပါသည်။

ကြားလပ်ပုံစံများတွင် တိုတောင်းသောကြားလပ်အဖြစ် အနုစိတ်ခေတ္တရပ်နားမှုနှင့် တိတ်ဆိတ်မှု ၂ မျိုးကို ဖော်ထုတ်ရရှိပါသည်။ ယင်းတို့သည် အများအားဖြင့် မီလီစက္ကန့်မျှသာ ကြာမြင့်သည့် စကားပြောပုံစံတစ်ခု ဖြစ်ပါသည်။ ကြားလပ်များသည် လူတစ်ဦးချင်းစီ၏ စကားတစ်ခွန်းနှင့် တစ်ခွန်း ကြားကာလတွင်လည်းကောင်း၊ ပြောသူနှစ်ဦးကြားရှိ ပထမပြောသူ၏ စကားအဆုံးနှင့် ဒုတိယပြောသူ၏ စကားအစ ကြားကာလတို့တွင်လည်းကောင်း ဖြစ်ပွားပါသည်။ ထိုသို့ဖြစ်ပွားရခြင်းမှာ ပါဝင်ပြောဆိုသူတို့၏ လူမှုအခြေအနေအပေါ်မူတည်၍ စကားလုံးရွေးချယ်သုံးနှုန်းလိုမှု၊ လေးနက်စေလိုမှု၊ စကားကို အဖြတ်အရပ်ဖြင့်ပြောဆိုမှု၊ မသိသောအကြောင်းအရာအပေါ် စဉ်းစားနေမှု စသည်တို့ကြောင့် ကြားလပ်များဖြစ်ပွားရကြောင်း ဖော်ထုတ်ရရှိပါသည်။

စကားထပ်မှုပုံစံများတွင် စကားအလှည့်အပြောင်းယူရာ၌ စကားထပ်မှုပုံစံ ၃မျိုးကို ဖော်ထုတ်ရရှိပါသည်။ ပူးပေါင်းဆောင်ရွက်သော စကားထပ်ခြင်းတွင် ရှေ့စကားခွန်းနှင့် နောက်စကားခွန်း တို့၏ ချိတ်ဆက်မှုကို အားကောင်းစေသည့်အပြင် ရှေ့စကားခွန်းကို ထောက်ခံလက်ခံသည့်သဘောလည်း

ဆောင်ပါသည်။ စကားထပ်ခြင်းများသည် အသက်တူရွယ်တူများ၊ ရင်းနှီးသူတို့၏ စကားဝိုင်းတို့တွင် ပိုမိုဖြစ်ပွားပါသည်။ အသက်ကြီးသူနှင့်ငယ်သူ၊ ရာထူးကြီးသူနှင့်ငယ်သူ၊ လူမှုအဆင့်ကွာခြားသူများကြားတွင် တစ်ချိန်တည်းတစ်ပြိုင်တည်း စကားထပ်မှု အလွန်နည်းပါးပါသည်။ အကြောင်းမှာ မြန်မာတို့က အသက်ကြီးသူ၊ ရာထူးကြီးသူ၊ လူမှုအဆင့်မြင့်သူများကို စကားပြောရာ၌ ဦးစားပေးတတ်သူများဖြစ်ခြင်းကြောင့် ဖြစ်သည်။ ထို့ကြောင့် လူကြီးသူမများနှင့် စကားလုံ့ပြောဆိုခြင်း၊ စကားဖြတ်၍ ဝင်ပြောခြင်းကို ရှောင်ရှားတတ်ကြပါသည်။

စကားဝိုင်းတစ်ခုတွင် အချက်ပြစကားပုံစံများသည် မရှိမဖြစ်လိုအပ်ပါသည်။ ယေဘုယျ အားဖြင့် ကြည့်လျှင် အမျိုးသားတို့ပြောဆိုသော စကားဝိုင်းထက် အမျိုးသမီးတို့ ပြောဆိုသော စကားဝိုင်းက အချက်ပြစကားများကို ပိုမိုတုံ့ပြန် ပြောဆိုတတ်ကြပါသည်။ တစ်ဦးပြောသည့်စကားကို တစ်ဦးက မည်သို့မျှမတုံ့ပြန်ပါက လက်ရှိပြောနေသူ၏စကားကို သဘောမတူကြောင်း၊ လက်မခံကြောင်း၊ စိတ်မဝင်စားကြောင်း စသည့်သဘောမျိုး သက်ရောက်သွားနိုင်သည်။ ထို့ကြောင့် တစ်ဦးပြောသည့်စကားကို တစ်ဦးက ဂရုတစိုက်နားထောင်နေကြောင်း အချက်ပြသည့်စကားများကို အသုံးပြု၍ ထောက်ပင့်ပေးခြင်းဖြင့် စကားပြောဆိုမှုလမ်းကြောင်းကို ပိုမိုဖြောင့်ဖြူးကာ သွက်လက် သွားစေနိုင်သည်။

စကားအတွဲအဖက်စုံတွဲပုံစံများတွင် ဖြစ်စဉ်နှစ်ခုပါဝင်နေပြီး ဒုတိယစကားခွန်းသည် ပထမစကားခွန်းကို အစဉ်အမြဲပြန်ကြားသည့် စကားပြောဖြစ်စဉ်များဖြစ်နေသည်။ ထို့ပြင် တစ်ဦးနှင့်တစ်ဦး အပြန်အလှန် ပြောဆိုဆက်ဆံရသော လောကဝတ်စကားအတွဲအဖက် စုံတွဲပုံစံများတွင် လက်ရှိ ပြောသူ၏ ပထမစကားခွန်းအပေါ် နောက်လူက ဒုတိယစကားခွန်းဖြင့် မတုံ့ပြန်လျှင် ပြောသူက နာသူအပေါ် သံသယဝင်နိုင်သည်။ “မိမိစကားအပေါ် မကြားချင်ဟန်ဆောင်တာလား၊ မိမိကို မတူမတန်သလို ပြုမူတာလား၊ မာနကြီးသွားတာလား၊ ဘဝင်မြင့်သွားတာလား” စသည့် အဓိပ္ပာယ်အမျိုးမျိုး ကောက်ချက်ချသွားနိုင်ပြီး ပြောသူနှင့်နာသူတို့၏ လူမှုဆက်ဆံရေးမှာလည်း အဖုအထစ် ဖြစ်ပေါ်စေနိုင်ပါသည်။

ဘေးတိုက်ဖြစ်စဉ်ပုံစံများတွင် လက်ရှိပြောနေသော မူလအကြောင်းအရာနှင့် ဆက်စပ်ပြီး သွယ်ဝိုက်၍ ဝင်ရောက်လာသော အခြားစကားပြောဖြစ်စဉ် ဖြစ်သည်။ ယင်းကို ပါဝင်ဆွေးနွေး သူများက အချိတ်အဆက်မိမိ တုံ့လှယ်ပြောဆိုခြင်းဖြင့် စိုပြည်သောစကားဝိုင်းဖြစ်လာနိုင်ပါသည်။ ပါဝင်ပြောဆိုကြသည့် ဘေးတိုက်ဖြစ်စဉ်အပေါ်မူတည်ပြီး ပါဝင်ဆွေးနွေးသူများနှင့်ပရိသတ်ကို ရယ်ရွှင်ဖွယ် ဟာသရသကိုပါ ပေးစွမ်းစေနိုင်ပါသည်။

ကြားထိုးဖြစ်စဉ်ပုံစံသည် မူလအကြောင်းအရာနှင့် ဆက်စပ်မှုမရှိဘဲ သီးခြားဝင်ရောက်လာသောအခြားအကြောင်းအရာ ဖြစ်ပါသည်။ လက်ရှိစကားပြောဖြစ်စဉ်တွင် အနည်းငယ် စိတ်အနှောင့်အယှက်ဖြစ်သော်လည်း မူလစကားပြောဖြစ်စဉ်ကို ပျက်ယွင်းမှုမရှိပေ။ ကြားထိုးဖြစ်စဉ်များသည်ပုံစံတကျသတ်မှတ်ပြီး အလှည့်ယူပြောဆိုခြင်းမျိုးမဟုတ်ဘဲ သက်ဆိုင်ရာ စကားဝိုင်းများအလိုက် ပါဝင်သူတို့ကြားရှိ လူမှုနောက်ခံ အဆက်အစပ်အပေါ်မူတည်၍ လိုအပ်သလိုစကားကို အလွတ်သဘောကြားထိုးကာ ထိန်းညှိပြောဆိုရပါသည်။

စကားပြင်ပြောခြင်းတွင် ပုံစံ ၂ မျိုးဖော်ထုတ်ရရှိပါသည်။ မြန်မာ့လူမှုဝန်းကျင်တွင် မိမိကိုယ်တိုင် စကားပြင်ပြောခြင်းမှာ လက်ရှိပြောသူသည် မိမိကိုယ်တိုင်အစပြုသော စကားနှင့်ပတ်သက်၍ မိမိဘာသာ သင့်လျော်သောစကားလုံးကို ရွေးချယ်သုံးနှုန်းလိုခြင်း၊ အမှားပြင်လိုခြင်းတို့ကြောင့် ဖြစ်ပါသည်။

အခြားသူက စကားပြင်ပြောခြင်းမှာ လက်ရှိပြောသူ၏ စကားကိုနောက်လူက အမှားပြင်လိုခြင်း၊ လက်ရှိပြောသူ၏အယူအဆကို လက်မခံဘဲ နောက်လူက မိမိ၏အယူအဆကို ပြန်လည်ပြင်ဆင် ပြောဆိုလိုခြင်းတို့ကြောင့်ဖြစ်ပါသည်။ ထို့ကြောင့် မိမိကိုယ်တိုင် စကားပြင်ပြောခြင်းသည် စကားပြောဖြစ်စဉ်တွင် အခြားသူများအတွက် အနည်းငယ်စိတ်အနှောင့်အယှက်ဖြစ်သော်လည်း မိမိ၏ အမှားကို အချိန်မီ မိမိကိုယ်တိုင်ပြန်လည်ပြင်ဆင်ခြင်း၊ သင့်လျော်လိုက်ဖက်သော စကားလုံးကို ပြန်လည်ရွေးချယ်ခြင်းဖြင့် အခြားသူများ၏အထင်သေးမှုကို ရှောင်ရှားနိုင်သည့် အကျိုးကျေးဇူးကို ရရှိစေနိုင်ပါသည်။ အခြားသူက စကားပြင်ပြောခြင်းသည် အရင်ပြောသူကို စိတ်အနှောင့်အယှက် ဖြစ်ပေါ်နိုင်သဖြင့် အခြေအနေပေါ်မူတည်ပြီးတစ်ဖက်သူကိုငဲ့ကွက်ကာ ပြင်ဆင်သင့်ပါသည်။

အဆုံးသတ်စကားများသည် သာမန်အားဖြင့် အပြန်အလှန် ခွဲခွာနှုတ်ဆက်စကားတို့ဖြင့်သာ အဆုံးသတ်လေ့ရှိပါသည်။ ထိုသို့အဆုံးသတ်ရာတွင် အကြောင်းပြချက်ပေးသည့်ပုံစံဖြင့် အကြို့အဆုံးသတ်စကား ပြောဆိုကြပါသည်။ ပုံစံတကျတင်ဆက်ရသောစကားပြောတို့တွင် အများအားဖြင့် အကြိုအဆုံးသတ်စကားကို အသုံးပြုပြီးအဆင့်ဆင့်အဆုံးသတ်လေ့ရှိပါသည်။ တစ်ခါတစ်ရံ အဆုံးသတ်စကားနှင့်အတူ လက်ပြနှုတ်ဆက်ခြင်း အမူအရာကိုပါ အသုံးပြုတတ်ကြသည်။ သတင်းအစီအစဉ်ကြေညာရာတွင် အကြိုအဆုံးသတ်စကားပြောပြီး ဆုတောင်းနှုတ်ဆက်စကားဖြင့် အဆုံးသတ်လေ့ရှိပါသည်။ တယ်လီဖုန်းစကားပြောတွင် ပြောသူနှင့်နာသူတို့၏ လူမှုအခြေအနေအလိုက် အကြို့အဆုံးသတ်စကားပြောပြီးမှ အဆုံးသတ်စကားပြောဆိုသင့်သို့ အဆုံးသတ်စကားသာ တစ်ခါတည်းပြောဆိုပြီး ဖုန်းချနိုင်သင့်သို့ အဆုံးသတ် စကားမပြောဘဲ ပြောဆိုနေသော အကြောင်းအရာကို သဘောတူညီချက်ယူပြီး ဖုန်းချနိုင်ပါသည်။ တစ်ခါတစ်ရံ အကြိုအဆုံးသတ်စကားပြောဆိုပြီးမှ ပြောရန်ကျန်သေးသည့်စကားကို ပြန်လည်ပြောဆိုနိုင်သည်။ ထို့ကြောင့် စကားပြောကို အဆုံးသတ်ရာတွင် မြန်မာလူမျိုးတို့သည် လူမှုအခြေအနေအလိုက်၊ အသက်အရွယ်အလိုက်၊ လူမှုဂုဏ်အဆင့် အတန်းအလိုက်၊ ရင်းနှီးမှု အတိုင်းအတာအလိုက် တစ်ဦးချင်းအမူအကျင့်အလိုက် အဆုံးသတ်စကားကို အမျိုးမျိုး ပြောဆိုအဆုံးသတ်လေ့ရှိပါကြသည်။

ခြုံငုံသုံးသပ်ချက်

မျက်မှောက်ခေတ် မြန်မာဘာသာစကားရှိ အပြောစကားပုံစံများကို လူမှုဘာသာဗေဒရှုထောင့်မှ လေ့လာထားပါသည်။ မြန်မာဘာသာစကားရှိ ညွှန်ခေါ်စကားပုံစံများကို လေ့လာကြည့်သောအခါ ညွှန်ခေါ်စကားပုံစံ ၉ မျိုးကို ဖော်ထုတ်ရရှိပါသည်။ မြန်မာတို့သည် မိမိညွှန်ခေါ်မည့်သူကို စကားခွန်း၏အစနှင့် နောက်ဆုံးတွင်ထား၍ ညွှန်ခေါ်ကြပါသည်။ အထူးသဖြင့် စကားခွန်း၏ အစတွင်ထား၍ အများဆုံး အသုံးပြုညွှန်ခေါ်ကြပါသည်။ တစ်ဦးနှင့်တစ်ဦးတွေ့ဆုံစဉ် ပြောသူနှင့် နာသူတို့၏ လိင်၊ အသက်အရွယ်၊ လူမှုဆက်ဆံရေးအခြေအနေ၊ လူမှုအဆင့်အတန်း စသည် တို့ကိုလိုက်၍ ညွှန်ခေါ်စကားပုံစံ ၉ မျိုးအနက် တစ်မျိုးမျိုးဖြင့် ညွှန်ခေါ်နေကြကြောင်း စိစစ်တွေ့ရှိရပါသည်။ ညွှန်ခေါ်ခံရသူတစ်ဦးတည်းကို ညွှန်ခေါ်သူများက ပုံစံအမျိုးမျိုးဖြင့် ညွှန်ခေါ်နိုင်ကြခြင်းမှာလည်း မြန်မာလူမျိုးတို့၏အတွေးအမြင်၊ ဗဟုသုတနှင့် စိတ်ကူးစိတ်သန်းကောင်းမွန်ပုံတို့ကို ဖော်ပြနေပါသည်။ မြန်မာညွှန်ခေါ်စကားများသည် ပြောသူနှင့်နာသူတို့၏ လိင်အလိုက်၊ အသက်အရွယ်အလိုက်၊ လူမှုဂုဏ်အဆင့်အတန်းကွာဟမှုအလိုက်၊ အသုံးပြုပြောဆိုသည့် နေရာအလိုက်၊ တစ်ဦးချင်း၏ အမူအကျင့်နှင့်စိတ်ခံစားမှုအလိုက်

ညွှန်းခေါ်ရခြင်းဖြစ်၍ ညွှန်းခေါ်စကားပုံစံများကွဲပြားရကြောင်း တွေ့ရှိရသည်။ တစ်ဦးနှင့်တစ်ဦး ညွှန်းခေါ်စကားကို မှန်မှန်ကန်ကန် ညွှန်းခေါ်နိုင်ခြင်းဖြင့် ပြောသူနှင့်နာသူတို့၏ လူမှုဆက်ဆံရေးကို အဆင်ပြေချောမွေ့စေခြင်း၊ ညွှန်း ခေါ်စကားကွဲပြားမှုများကိုသိရှိစေခြင်း၊ နိုင်ငံခြားသားများအတွက် မြန်မာတို့၏ ညွှန်းခေါ်စကား ဝေါဟာရများကို သိရှိစေခြင်းဖြင့် ယင်းတို့က မြန်မာလူမျိုးတို့ကို ပိုင်နိုင်စွာ ညွှန်းခေါ်လာနိုင်ခြင်း ဟူသော အကျိုးကျေးဇူးများကိုရရှိစေသည်။ ထို့ကြောင့် လူမှုဆက်ဆံရေးနယ်ပယ် တွင် လူပုဂ္ဂိုလ်တစ်ဦးနှင့်တစ်ဦး တွေ့ဆုံစဉ် ညွှန်းခေါ်စကားများဖြင့် လူမှုဆက်သွယ်ရေးလမ်းကြောင်းကို ဖွင့်ရသဖြင့် မိမိညွှန်းခေါ်မည့်သူ၏ အမည်သာမက အသက်အရွယ်၊ လူမှုဂုဏ်အဆင့်အတန်းနှင့် အမူအကျင့်တို့ကိုပါသိရှိထားရန် လိုအပ်ပါသည်။ သို့မှသာ မှန်မှန်ကန်ကန်နှင့်ချေချေငံငံညွှန်းခေါ်နိုင်မည် ဖြစ်ပါသည်။ ညွှန်းခေါ်စကား ဆီလျော်မှုကြောင့် ဆက်ဆံရေးပြေလည်နိုင်ပြီး မဆီလျော်မှုကြောင့် ဆက်ဆံရေး မပြေလည်မှုများလည်း ရှိလာနိုင်ပါသည်။ သို့ဖြစ်ရာ လူမှုကိစ္စရပ်များနှင့် လုပ်ငန်းဆောင်တာများ အဆင်ပြေစေရန်အတွက် ညွှန်းခေါ်စကားပုံစံများကို သူနေရာနှင့်သူ အံဝင်အောင် ရွေးချယ်ညွှန်းခေါ်တတ်ရန် အလွန်အရေးကြီးကြောင်း သုံးသပ်ရပေသည်။

အင်္ဂလိပ်ဘာသာစကား သင်္ကေတရောသုံးခြင်းပုံစံများကို လေ့လာကြည့်သောအခါ ထည့်သွင်းခြင်းပုံစံနှင့် တစ်လှည့်စီဖြစ်ပေါ်ခြင်းပုံစံဟူ၍ ၂ မျိုးကို ဖော်ထုတ်ရပါသည်။ ထည့်သွင်းခြင်းပုံစံတွင် စကားသင်္ကေတ ထည့်သွင်းရောသုံးခြင်းပုံစံ ၅ မျိုးရှိပြီး တစ်လှည့်စီဖြစ်ပေါ်ခြင်းပုံစံတွင် ဝါကျခွဲအဆင့် စကားသင်္ကေတ တစ်လှည့်စီဖြစ်ပေါ်ခြင်းပုံစံ ၂ မျိုးကို တွေ့ရှိရပါသည်။ မြန်မာဘာသာစကားတွင် စကားသင်္ကေတ ရောသုံးခြင်းသည် မွေးစားထားပြီး အသားကျနေသော အင်္ဂလိပ်စကားလုံးထက် ဝေါဟာရအသစ်များကို ပိုမိုရောသုံးလေ့ရှိကြောင်း တွေ့ရသည်။

ထည့်သွင်းခြင်းပုံစံတွင် စကားလုံးအဆင့်ထည့်သွင်းခြင်းကို အများဆုံးတွေ့ရသည်။ ပုဒ်အဆင့်ထည့်သွင်းခြင်းကို ဒုတိယအများဆုံး တွေ့ရသည်။ စကားလုံးအဆင့်နှင့်ပုဒ်အဆင့် တွဲဖက်ထည့်သွင်းခြင်းကို တတိယအများဆုံး တွေ့ရသည်။ ဝါကျခွဲအဆင့်ထည့်သွင်းခြင်းနှင့် စကားလုံး အဆင့်၊ ပုဒ်အဆင့်၊ ဝါကျခွဲအဆင့် တွဲဖက်ထည့်သွင်းခြင်းတို့မှာ အသုံးနည်းကြောင်း တွေ့ရပါသည်။ စကားလုံးအဆင့် ဝေါဟာရများကို အများဆုံးရောသုံးကြခြင်းမှာ အသစ်သစ်သော လူမှုကိစ္စရပ်များအတွက် ဝေါဟာရအသစ်များ နေ့စဉ်နှင့်အမျှ မြန်မာ့လူမှုနယ်ပယ်အသီးသီးသို့ အများအပြား ဝင်ရောက်လာခြင်းကြောင့် ဖြစ်ပါသည်။ စကားလုံးအဆင့်၊ ပုဒ်အဆင့်နှင့် ဝါကျခွဲအဆင့် တိုက်ရိုက်ထည့်သွင်းခြင်း၊ ဝါကျခွဲအဆင့် တစ်လှည့်စီ တိုက်ရိုက်ထည့်သွင်းခြင်းတို့သည် ဝေါဟာရအသစ်၊ အကြောင်းအရာအသစ်ဖြစ်၍ မူရင်းအဓိပ္ပာယ်ကို ပိုမိုလေးနက်စေရန်၊ မူရင်းအခေါ်အဝေါ်နှင့်အကျွမ်းတဝင်ရှိလာစေရန်၊ မူရင်းအသုံးအတိုင်း တိုက်ရိုက်ထည့်သွင်းခြင်းဖြစ်သည်။ တစ်လှည့်စီ ဖြစ်ပေါ်ခြင်းပုံစံ၌ အမှီဝါကျခွဲအဆင့်နှင့် အမှီခံဝါကျခွဲအဆင့်ဟူ၍ တွေ့ရသည်။ သို့သော် တစ်လှည့်စီဖြစ်ပေါ်ခြင်းပုံစံသည် မြန်မာဘာသာစကားရှိ အပြောစကားပုံစံတွင် အသုံးနည်းကြောင်း တွေ့ရပါသည်။ အကြောင်းမှာ ဝါကျခွဲအဆင့် အင်္ဂလိပ်ဝါကျများသည် စကားလုံးအဆင့်နှင့်ပုဒ်အဆင့်လောက် မြန်မာလူမှုနယ်ပယ်အသီးသီးသို့ ဝင်ရောက်မှုနည်းပါးခြင်းကြောင့် ဖြစ်ပါသည်။ မိုက်စကန်၏သီအိုရီအရ ထည့်သွင်းခြင်းပုံစံသည် ဝေါဟာရဆိုင်ရာ အဆင့်ထည့်သွင်းခြင်းဖြစ်သော်လည်း မြန်မာဘာသာစကားတွင် သဒ္ဒါဆိုင်ရာ ဝါကျခွဲဖွဲ့စည်းပုံအဆင့်အထိ ထည့်သွင်းရောသုံးကြကြောင်း တွေ့ရပါသည်။ ယနေ့ခေတ်တွင် နိုင်ငံရေး၊ လူမှုရေး၊ စီးပွားရေးစသော အခြေအနေများကြောင့် မြန်မာ့လူ့အဖွဲ့အစည်းတွင် ဝေါဟာရအသစ်များ

ဝင်ရောက်လျက်ရှိပါသည်။ ထိုဝေါဟာရများ မြန်မာတို့နှင့် ယဉ်ပါးမှုမရှိသေး၍ မြန်မာဘာသာစကားတွင် တနည်းနည်းဖြင့် ထည့်သွင်းအသုံးပြုကြရာမှ စကားသင်္ကေတရောသုံးခြင်း ဖြစ်လာရပါသည်။ အထူးသဖြင့် နည်းပညာဆိုင်ရာ လူအသုံးအဆောင်ပစ္စည်း များနှင့်ပတ်သက်သော စကားသင်္ကေတ ရောသုံးခြင်းများကို မျက်မှောက်ခေတ်တွင် အများဆုံးတွေ့ရပါသည်။

ထူးခြားချက်မှာ နိုင်ငံခြားဘာသာစကားများတွင် ယင်းတို့၏ ဝါကျဖွဲ့စည်းတည်ဆောက်ပုံအတွင်း အင်္ဂလိပ်စကားလုံး သို့မဟုတ် ပုဒ် သို့မဟုတ် ဝါကျခွဲ တစ်ခုခုကိုထည့်သွင်း၍ ဝါကျကို အဆုံးသတ်နိုင်ပါသည်။ မြန်မာဘာသာစကားတွင်မူ အင်္ဂလိပ်ဘာသာစကားတစ်ခုခုဖြစ် မြန်မာဝါကျကို အဆုံးသတ်လေ့မရှိဘဲ မြန်မာဝါကျအဆုံးသတ် တစ်ခုခုဖြင့်သာ အဆုံးသတ်လေ့ရှိကြောင်း တွေ့ရပါသည်။ အကြောင်းမှာ မြန်မာဝါကျဖွဲ့စည်းတည်ဆောက်ပုံအရ မြန်မာဝါကျ၏သဘောမှာ ဝါကျအဆုံးသတ် စကားလုံး တစ်ခုခုဖြင့်သာ အဆုံးသတ်ရခြင်းကြောင့် ဖြစ်ပါသည်။ ထို့ကြောင့် မြန်မာဘာသာစကားရှိ အပြော စကားပုံစံများမှ စကားသင်္ကေတရောသုံးခြင်းပုံစံများကို ခွဲခြမ်းစိတ်ဖြာ၍ မှတ်တမ်းတင်ခြင်းဖြင့် မြန်မာဘာသာစကားတွင် ဝေါဟာရအသစ်များ ဝင်ရောက်တိုးပွားလာပုံကို သိရှိစေနိုင်ခြင်း၊ မြန်မာဘာသာ စကား လေ့လာသူများနှင့် စိတ်ဝင်စားသူများအတွက် အထောက်အကူပြုနိုင်ခြင်းဟူသော အကျိုးကျေးဇူး များရစေပါသည်။ စကားသင်္ကေတရောသုံးခြင်းကို လိုသည်ထက်ပို၍ အများအပြား အသုံးပြုပါက မြန်မာ့လူ့အဖွဲ့အစည်းတွင် နောက်လာနောက်သားများအတွက် မြန်မာဘာသာစကား၊ မြန်မာဝေါဟာရများ ရှားပါးလာနိုင်သည်။ ထို့ကြောင့် ခေတ်ပညာတတ်ပုဂ္ဂိုလ်များက မိခင်ဘာသာစကား ဆက်လက်ရှင်သန် ဖွံ့ဖြိုးတိုးတက်နေစေရန်အတွက် မြန်မာဘာသာစကားတွင် မရှိသေးသည့် ဝေါဟာရအသုံးအနှုန်းများကို အင်္ဂလိပ်မူရင်းအသုံးအတိုင်း တိုက်ရိုက်အသုံးပြုမည့်အစား မြန်မာအက္ခရာဖြင့် အသံဖလှယ်ခြင်း၊ မြန်မာဘာသာ ပြန်ခြင်းများကို ယခုထက်ပိုမို ကြိုးပမ်းအားထုတ်သင့်ပါသည်။ သို့မှသာ ရှင်သန်နေသော မြန်မာဘာသာ စကားအဖြစ် ကမ္ဘာ့အလယ်တွင် ခေတ်အဆက်ဆက်တိုင်အောင် ဆက်လက်ရှင်သန် ဖွံ့ဖြိုးတိုးတက်နေမည် ဖြစ်ပါကြောင်း သုံးသပ်ရပါသည်။

စကားလုပ်ဆောင်ချက်ပုံစံများကို လေ့လာကြည့်သောအခါ စကားလုပ်ဆောင်ချက်တစ်ရပ်တွင် တိုက်ရိုက် စကားလုပ်ဆောင်ချက်နှင့် သွင်ဝိုက်စကားလုပ်ဆောင်ချက်ဟူ၍ စကားလုပ်ဆောင် ချက်ပုံစံ ၂ မျိုးကို တွေ့ရပါသည်။ ထို့ပြင် စကားလုပ်ဆောင်ချက်တစ်ခုတွင် အမျိုးအစား ၃ မျိုးပါဝင်သည်။ စကားအသုံးအနှုန်းသည် မြန်မာ့လူ့အဖွဲ့အစည်းက သတ်မှတ်ထားသည့် အဓိပ္ပာယ်ရှိသော စကားခွန်းများဖြစ်ပါသည်။ ပြောသူသည် စကားခွန်းတစ်ခွန်းကို ပြောဆိုရာတွင် ရည်ရွယ်သည့်ဆန္ဒ အနည်းဆုံးတစ်ခုပါရှိပြီး နာသူသည် ပြောစကားပေါ်မူတည်၍ သက်ရောက်မှုတစ်ခုခုကို လုပ်ဆောင်ရကြောင်း စိစစ်တွေ့ရှိရပါသည်။ စကားလုပ်ဆောင်ချက်ပုံစံများသည် ပြောသူ၏ဆန္ဒကို ရည်ရွယ်ပြောဆိုသော်လည်း နာသူ၏ လိုင်၊ အသက်အရွယ်၊ အလုပ်အကိုင်၊ လူမှုအဆင့်အတန်း စသည်တို့ကိုလိုက်ပြီး စကားပြောဆိုရာ၌ သူ့နေရာနှင့် သူအံဝင်အောင် စကားလုံးများကို ရွေးချယ်အသုံးပြု ပြောဆိုကြကြောင်း တွေ့ရပါသည်။ စကားလုပ်ဆောင်ချက်ပုံစံများသည် ပြောသူနှင့်နာသူတို့၏ မပြီးပြတ်သေးသည့် လုပ်ငန်းဆောင်တာများကို ပြီးပြတ်စေခြင်း၊ ပြောသူ၏ဆန္ဒသဘောထားကို သူ၏အပြောစကား၌ တွေ့မြင်နိုင်ခြင်း၊ ပြောသူ၊ နာသူနှင့်အညွှန်းခံ သုံးယောက်အနက် တစ်ယောက်ယောက်တို့၏ လုပ်ငန်းဆောင်တာများ ပြီးပြတ်စေခြင်း၊ အချို့ အပြောစကားများသည် စကားတစ်ခွန်းတည်းဖြင့် နာသူနှင့်အညွှန်းခံကို တစ်ပြိုင်နက်တည်း သက်ရောက်မှုနှစ်မျိုးဖြစ်ပေါ်စေခြင်း၊ မြန်မာ့လူ့အဖွဲ့အစည်း၏ နေ့စဉ်ရင်ဆိုင်

နေရသော လုပ်ငန်းဆောင်တာများ ပြီးပြတ်စေခြင်းဟူသော အကျိုးကျေးဇူးများကို ရရှိစေပါသည်။ ထို့ကြောင့် စကားလုပ်ဆောင်ချက်များသည် မြန်မာလူမျိုးတို့၏ လူမှုကိစ္စရပ်များ ကိုသာမက နိုင်ငံအတွက် ကိုယ်စားပြုပြောဆိုရသည့် နိုင်ငံခြားဆက်ဆံရေးနှင့်ဆိုင်သော စကားများအထိပါ ကျယ်ပြန့်နက်နဲ့လျက်ရှိသဖြင့် သူနေရာနှင့်သူ အံဝင်အောင်ပြောဆိုရပေမည်။ သို့မှသာ အောင်မြင်သော လူမှုဆက်ဆံရေးနှင့်သံတမန်ဆက်ဆံရေးကိုပါ တည်ဆောက်နိုင်မည်ဖြစ်ကြောင်း သုံးသပ်ရပါသည်။

စကားပြောပုံစံများကို လေ့လာကြည့်သောအခါ မြန်မာဘာသာစကားတွင် စကားပြောပုံစံ ၁၀ မျိုးကို ဖော်ထုတ်တွေ့ရှိရပါသည်။ယေဘုယျအားဖြင့် စကားပြောဖြစ်စဉ်တစ်ခုတွင် စကားစတင်ရန် အဖွင့်စကားကို မည်ကဲ့သို့စတင်ပြောဆိုကြပုံ၊ စကားအပေးအယူပြုလုပ်၍ တစ်ဦးနှင့်တစ်ဦး မည်ကဲ့သို့ ထိန်းသိမ်းပြောဆိုကြပုံနှင့် အဆုံးသတ်စကားကို မည်ကဲ့သို့ပြောဆို အဆုံးသတ်ကြပုံ ဟူ၍ ကဏ္ဍ(၃) ရပ်ပါဝင်ကြောင်း တွေ့ရပါသည်။ ထို့ပြင် စကားပြောပုံစံများသည် စကားပြော ဖြစ်စဉ်တစ်ခုတွင် ပါဝင်ပြောဆိုသူများက စကားအလှည့်ယူ၍ အပြန်အလှန် တုံ့လှယ်ပြောဆိုကြသည့်ပုံစံများလည်း ဖြစ်ကြပါသည်။ စကားပြောဆိုခြင်းသည် ပါဝင်သူများအကြားတွင် အပြန်အလှန် အပေးအယူရှိမှသာ စိတ်ဝင်စားဖွယ်ကောင်းမည်ဖြစ်၍ မိမိပြောသော အကြောင်းအရာနှင့်ပတ်သက်၍ အခြားသူ၏အမြင်ကိုပါ ဝင်ရောက်ဆွေးနွေးနိုင်အောင် အလှည့်ပေးသင့်ပေသည်။ လက်ရှိပြောသူက မိမိအယူအဆချည်း မပြောဘဲ တစ်ဖက်လူ၏ စကားကိုလည်း အလှည့်ပေးခြင်းဖြင့် စိုပြည်သည့် စကားပြောဖြစ်စဉ်တစ်ခု ဖြစ်လာနိုင်ကြောင်း စိစစ်တွေ့ရှိရပါသည်။

စကားပြောပုံစံများသည် မြန်မာလူမျိုးတို့၏ တစ်ဦးအပေါ်တစ်ဦး တလေးတစားဆက်ဆံ တတ်မှု၊ ဂါရဝတရား၊ နိဝါတတရားထားရှိမှု၊ ယဉ်ကျေးပျူငှာမှုတို့သည် ထိုအပြောစကားပုံစံများတွင် ထင်ဟပ်နေကြောင်းလည်း တွေ့ရှိရပါသည်။ ဤသို့ လေ့လာခြင်းဖြင့် မြန်မာ့လူ့အဖွဲ့အစည်း၌ စကားကို မည်သည့်အခြေအနေတွင် မည်ကဲ့သို့ ပြောဆိုကြပုံကို သိရှိရပါသည်။ မြန်မာတို့၏ အပြောစကားပုံစံများကို ခွဲခြမ်းစိတ်ဖြာ၍ မှတ်တမ်းတင်ခြင်းဖြင့် ဘာသာစကားလေ့လာနေသူများအတွက် အထောက်အကူပြုနိုင်သည့် အကျိုးကျေးဇူးကိုပါ ရရှိစေနိုင်သည်။ ယင်းပုံစံများသည် လူတစ်ဦးနှင့်တစ်ဦး စကားပြောဆိုရာတွင် အခြေခံကျပြီး ကျယ်ပြန့်နက်ရှိုင်းကာ မြန်မာလူမျိုးတို့၏ သွင်ပြင်လက္ခဏာများကို ဖော်ပြနိုင်သော စကားပြောပုံစံများပင် ဖြစ်ပါသည်။ ထို့ကြောင့် မြန်မာ့ လူ့အဖွဲ့အစည်း၌ လူမှုဆက်ဆံရေးအောင်မြင်နိုင်စေရန်အတွက် မြန်မာဘာသာစကားရှိ အပြော စကားပုံစံများ၏ အခန်းကဏ္ဍသည် လွန်စွာပင် အရေးပါလှကြောင်း သုံးသပ်ရပေသည်။

အချုပ်အားဖြင့်ဆိုရလျှင် မျက်မှောက်ခေတ် မြန်မာဘာသာစကားရှိ အပြောစကားပုံစံများ သည် မြန်မာလူမျိုးတို့၏ လိင်၊ အသက်အရွယ်၊ လူမှုဂုဏ်အဆင့်အတန်းတို့အပေါ် အခြေခံ၍ ပြောဆိုကြသကဲ့သို့ တစ်ဦးအပေါ်တစ်ဦး အပြန်အလှန်လေးစားမှု၊ ဂါရဝတရားထားရှိမှု၊ ယဉ်ကျေးပျူငှာမှု၊ ကိုးကွယ်ယုံကြည်မှုနှင့် ယဉ်ကျေးမှုဓလေ့ထုံးစံတို့အပေါ်အခြေခံ၍လည်း ပြောဆိုနေကြကြောင်း စိစစ်တွေ့ရှိရပါသည်။ ထို့ကြောင့် မြန်မာ့လူမှုဆက်ဆံရေးနယ်ပယ်တွင် ဘာသာစကား အဆောက်အဦနှင့် လူမှုအဆောက်အဦတို့၏ အပြန်အလှန်ဆက်စပ်မှုရှိပုံ၊ အပြန်အလှန်အကျိုးပြုပုံတို့ကို မြန်မာဘာသာစကားရှိ အပြောစကားပုံစံများအရ သိရှိရပါသည်။ ထို့ပြင် အဖွင့်စကားမှ အဆုံးသတ်စကားအထိ စကားပြောပုံစံ တစ်နည်းအားဖြင့် စကားပြောဖြစ်စဉ် ၁၀ မျိုး ပါဝင်ဖွဲ့စည်းလျက်ရှိကြောင်း ဖော်ထုတ်တွေ့ရှိရပါသည်။ ထိုအပြော

စကားပုံစံများသည် မြန်မာလူမျိုးတို့အတွက် အလွန်ထိရောက်သော လူမှုဆက်သွယ်ရေးပုံစံများအဖြစ် မြန်မာလူမျိုးတို့ကို အကျိုးပြုလျက်ရှိနေပါကြောင်း သုံးသပ်ရပေသည်။

နိဂုံး

မြန်မာလူမျိုးတို့သည် နွေးထွေးပျူငှာတတ်သော လူမျိုးဖြစ်ပြီး စကားပြောဆိုရာတွင် ယဉ်ကျေးသိမ်မွေ့စွာ ပြောဆိုဆက်ဆံတတ်သူများလည်း ဖြစ်ကြပါသည်။ ထိုမြန်မာလူမျိုးတို့၏ အပြောစကားပုံစံများကို လေ့လာဖော်ထုတ် သုတေသနပြုခွင့်ရသည့်အတွက် အလွန်ဝမ်းမြောက်မိပါသည်။ ကျမ်းကို ခေါင်းစဉ်အတည်ပြုခဲ့သည် ၂၀၁၄ ခုနှစ်မှ ကျမ်းပြုစုပြီးစီးသည့် ၂၀၁၈ ခုနှစ်အထိ ၄ နှစ် တိုင်အောင် ကြိုးစားအားထုတ် ပြုစုခဲ့ရပါသည်။ ကျမ်းပြုစုရာတွင် အထောက်အကူဖြစ်စေရန် ပြည်တွင်း၊ ပြည်ပ တက္ကသိုလ်များမှ ပါရဂူဘွဲ့ယူကျမ်းများကိုလည်း လေ့လာဖတ်ရှုခဲ့ပါသည်။ လိုအပ်သော သီအိုရီများအတွက် နိဒါန်းခြားစာအုပ်၊ စာတမ်းများကို အင်တာနက်ပေါ်တွင် ရှာဖွေစုဆောင်းခဲ့ပြီး ထိုစာအုပ်၊ စာတမ်းများကိုနားလည်အောင် အကြိမ်ကြိမ်ဖတ်ရှုခဲ့ပါသည်။ ထိုကြိုးစားမှု၏ရလဒ်အဖြစ် ယခုကျမ်း ပေါ်ထွက်လာခဲ့ခြင်းဖြစ်ပါသည်။ ဆက်လက်၍လည်း တိုင်းရင်းသားဘာသာစကားများ၏ အပြော စကားပုံစံများကိုလည်း လေ့လာသုတေသနပြုနိုင်ပါသေးသည်။ မြန်မာဘာသာစကားကို လေ့လာနေကြသော နိုင်ငံခြားသားများ အတွက်လည်း မြန်မာလူမျိုးတို့၏ အပြောစကားပုံစံများကိုသိရှိပြီး ယင်းတို့က မြန်မာလူမျိုးတို့နှင့်စကားပြောဆိုရာတွင် မှန်ကန်စွာ ပြောဆိုသုံးနှုန်းတတ်လာစေမည် ဖြစ်ပါသည်။ ထို့ပြင် မြန်မာဘာသာစကားလေ့လာမှုနှင့် မြန်မာဘာသာစကားဖွဲ့ဖြိုးတိုးတက်ရေးတို့အတွက် အထောက်အကူပြုနိုင်မည်ဟု ယုံကြည်လျက် ဤအစီရင်ခံစာကို နိဂုံးချုပ်ပါသည်။

ကျမ်းကိုးစာရင်း

မြန်မာဘာသာ

ကိုလေး၊ **ဒေါက်တာ**။ (၂၀၀၈)။ ***လူမှုဘာသာဗေဒ ဝေါဟာရများအဖွင့်***။ ရန်ကုန်၊ ရန်ကုန်တက္ကသိုလ်၊မြန်မာစာဌာန။

ခင်မင်၊ **မောင်**(ဓနုဖြူ)။ (၂၀၀၄)။ ***မြန်မာစကား မြန်မာစာရုပ်ပုံလွှာ*** (ဒု–ကြိမ်)။ ရန်ကုန်၊ ရူဝဏ်စာအုပ်တိုက်။

ခင်မင်၊ **မောင်**(ဓနုဖြူ)။ (၂၀၁၀)။ ***လက်တွေ့အတ္ထဗေဒနိဒါန်း***။ ရန်ကုန်၊ ဆန်းသဇင်ပုံနှိပ်တိုက်။

ခင်မင်၊ **မောင်**(ဓနုဖြူ)။ (၂၀၁၁)။ ***သက်တံရောင်စုံဘာသာစကား***။ ရန်ကုန်၊ သုခပုံနှိပ်တိုက်။

ခင်မင်၊ **မောင်**(ဓနုဖြူ)။ (၂၀၁၆)။ ***မြန်မာစကားအကြောင်း တစေ့တစောင်း***။ ရန်ကုန်၊ ခိုင်ရဝေ ပုံနှိပ်တိုက်။

တေဇနိယာဘိဝံသ၊ **အရှင်**။ (၁၃၄၈)။ ***စနစ်သစ်ပါဠိ သဒ္ဒါကျမ်း***။ မန္တလေး၊ သုခဝတီစာပုံနှိပ်တိုက်။

ထွန်းမြင့်၊ **ဦး**။ (၂၀၀၇)။ ***ဘာသာဗေဒ*** (တ–ကြိမ်)။ ရန်ကုန်၊ ရာပြည့်စာအုပ်တိုက်။

ဖေမောင်တင်၊ **ဦး**။ (၁၉၅၈)။ ***ဘာသာလောကကျမ်း***။ ရန်ကုန်၊ စာပေဗိမာန်ပုံနှိပ်တိုက်။

မြန်မာစာအဖွဲ့။ (၂၀၀၈)။ ***မြန်မာအဘိဓာန်*** (ဒု–ကြိမ်)။ ရန်ကုန်၊ မြန်မာစာအဖွဲ့ ဦးစီးဌာန။

ဝေဝေတင်၊ **မ**။ (၂၀၁၄)။ ***ပခုက္ကူမြို့နယ်ဒေသိယစကားများလေ့လာချက်***။ မြန်မာစာပါရဂူဘွဲ့ကျမ်း၊မန္တလေးတက္ကသိုလ်။

သောင်းလွင်၊ **ဆရာ**။ (၁၉၇၂)။ ***မြန်မာအက္ခရာဗေဒ***။ ရန်ကုန်၊ ဒေးလီးဂေဇင်ပုံနှိပ်တိုက်။

သန်းဆွေ၊ **ဒေါ်**။ (၁၉၈၀)။ ***မြန်မာဘာသာစကား မြန်မာကျောက်စာ စာတမ်းဆောင်းပါး***။ ရန်ကုန်၊ ဘာသာပြန်နှင့် စာအုပ်ထုတ်ဝေရေးဌာန။

ဩဘာသာဘိဝံသ၊ **အရှင်**။ (၂၀၀၉)။ ***သုတေသနသရုပ်ပြအဘိဓာန်***။ ရန်ကုန်၊ ဖျာပုံတိုက်သစ်၊ သရက်တော ကျောင်းတိုက်။

အောင်မြင့်ဦး၊ **ဒေါက်တာ**။ (၂၀၀၃)။ ***လူမှုဘာသာဗေဒမိတ်ဆက်***။ ရန်ကုန်၊ ရန်ကုန်တက္ကသိုလ်၊မြန်မာစာဌာန။

အောင်မြင့်ဦး၊ **ဒေါက်တာ**။ (၂၀၀၅)။ ***လူမှုဘာသာဗေဒသဘောတရား***။ရန်ကုန်၊ ရန်ကုန်တက္ကသိုလ်၊မြန်မာစာဌာန။

အောင်မြင့်ဦး၊ **ဒေါက်တာ**။ (၂၀၁၀)။ ***ဘာသာစကားသုတေသန***။ ရန်ကုန်၊ ဓူဝံစာအုပ်တိုက်။

အင်္ဂလိပ်ဘာသာ

Ahire, M.M.(2015, July). ***Form and Function of Code Mixing in Marathi.***Language in India,Vol-15, No-7.

Ahyani, Drs. H. M. Natsir and Setya Ariani, M. Pd. (2016).Code mixing Used in Bondan Prakoso and Fade Two Black Songs.***Direktori Journal, Department of English Literature***, Mulawarman University.

Austin, John L. (1962). ***How to Do Things with words***. Cambridge: Harvard University Press.

Ayeomoni,M.O. (2006). Code - Switching and Code - Mixing: Style of Language Use in Childhood in Yoruba Speech Community.***Nordic Journal of African Studies. Vol-15, No-1***, 90-99.

Baker,A.E and Bogaerde, B. van den. (2006). ***Code mixing in mother-child interaction in deaf families***. Hogeschool van Utrecht & Universiteit van Amsterdam.

Bruce,S. and Yearley,S. (2006). ***The Sage Dictionary of Sociology***.London: SAGE Publications Ltd.

Coulmas,f. (2002). ***The handbook of sociolinguistics.***United Kingdom: Blackwell Publishing Ltd.

Crystal, D. (2008). ***A Dictionary of Linguistics and Phonetics*** (6th ed). Oxford: Blackwell Publishing Ltd.

Denes, P. and Pinson, E. (1993).***The Speech Chain****: The physics and biology of spoken language*, New York, W.H. Freeman.

Deuchar,M. (2005). ***Minority Language Survival: Code - mixing in Welsh***. University of Wales, Bangor. Proceedings of the 4th International Symposium on Bilingualism, ed. James Cohen, Kara T. McAlister, Kellie Rolstad, and Jeff MacSwan, 608-620.

Eckert, P and Rickford, J. R. (2002). ***Style and Sociolinguistic Variation***. New York: Cambridge University Press.

Ekalaya,Y and Dewi C. (2015 ,January)**.** an analysis of outer code switching and code mixing in indonesia lawyers club. ***Literary Criticism Journal Vol-2, No-1***, 49-63.

Georgieva,M. (2014). ***Introducing Sociolinguistics***. E-reader: St. Kliment Ohridski University of Sofia.

Halliday, M.K. (2004). ***An Introduction to Function Geammar*** (3rd ed). New York, Oxford University press Inc.

Holmes, J and Meyerhoff, M. (2003). ***The Handbook of Language and Gender***.Oxford: Blackwell Publishers Ltd.

Holmes, J. (2013). ***An Introduction to Sociolinguistics*** (4th ed). London and New York: Routledge ,Taylor& Francis Group.

Hornberger, N.H and McKay, S. (2010). ***Sociolinguistics and Language Education.***UK: Short Run Press Ltd.

Hurford,J.R,Heasley, B and Smith.M.B. (2007). ***Semantics a coursebook*** (2nded)**.** New York: Cambridge University Press.

Ingram,J.J. (2012). ***Whole class interaction in the mathematics classroom*:** A conversation analytic approach. Ph.D Dissertation, University of Warwick.

Isharyanti,N and Cardenas-Claros.M.S. (2009). Code Switch and Code Mixing In Internet chatting**:** between 'yes', 'ya' and 'si' a case study. ***the jalt call journal, vol-5, No- 3***, 67-78.

Kubayi,J.S. (2013). ***Address Forms In Xitsonga: A Socio-Pragmatic Perspective***. Ph.D Dissertation, University of South Africa.

Lerner G,H(Ed). (2004). ***Conversation analysis: studies from the first generation***. Santa Barbara :University of California, John Benjamins Publishing Company.

Likhitphongsathorn T and Sappapan P. (2013).***Study of English Code-mixing and Code-switching in Thai Pop Songs.*** Publisher, Language Institute, Thammasat University, Thailand.

Llamas,C.et.al.(Ed). (2007). ***The Routledge Companion to Sociolinguistics***. New York: Routledge, Taylor & Francis Group.

Lyons, J. (1969). ***Introduction to Theoretical Linguistics*** (2nd ed). London: Cambridge University Press.

Meyerhoff, M. (2006).***Introducing Sociolinguistics***. New York: Blackwell Publishers Ltd.

Moghaddam, A.S.et al. (2013). The Analysis of Persian Address Terms Based on the Theory of Politeness. ***In SKASE Journal of Theoretical Linguistics, Vol-10, No-3***, 55-71.

Moseley,C. (Ed). (2007). ***Encyclopedia of the World'sEndangered Languages.*** Landon and New York: Routledge, Simultaneously published in the USA and Canada.

Muysken, P. (2000). ***BILINGUAL APEECH A TYPOLOGY OF CODE-MIXING***. Cambridge, Cambridge University press.

Osoba,G,A and Osoba,B,K.(2014, September). Code-Mixing in Selected Plays of the New Generation Yorùbá Playwrights.***International Journal of Language and Literature,Vol-2, No-3***, 57-68.

Ouma,M.D. (2014).***CODE-MIXING AND THE LEARNING OF ENGLISH AS A SECOND LANGUAGE:*** a study of selected primary schools in migori county-kenya.University of Nairobi, Department of linguistics and Languages.

Paul Gee, J. (1999). ***An Introduction to Discourse Analysis***. New York, Routledge.

Richards, Jack C and other.(1992). ***Longman Dictionary of Language Teaching and Applied Linguistics*** (2nd ed).Longman Group UK Ltd.

Richards,Jack C and Schmidt,R. (2010). ***Longman Dictionary of Language Teaching and Applied Linguistics*** (4nd ed). Longman Group UK Ltd.

Salako, O.Y. (2015). ***SOCIOLINGUISTIC ANALYSIS OF NIGERIAN PIDGIN ENGLISH IN NIGERIAN FILM.*** Ph.D Dissertation, Indiana University of Pennsylvania.

Salihu,H.H. (2014, *January*).The Sociolinguistics Study of Gender Address Patterns in the Hausa Society. ***International Journal of Social Science and Humanity, Vol-4***, *No-1*.

Sanjaya, D. et al. (2014). ***Code Switching and Code Mixing in Indonesia***: ***Study in Sociolinguistics***. English Language and Literature Studies; Published by Canadian Center of Science and Education .Vol-4, No-1.

Schiffrin, A. (2005). ***MODELLING SPEECH ACTS IN CONVERSATIONAL DIS -COURSE.***Ph.D Dissertation, The University of Leeds.

Searle,J R. (1979). ***expression and meaning: Studies in the theory of speech acts***. New York: cambridge University Press.

Senaratne,C.D. (2009). ***Sinhala-English code-mixing in Sri Lanka: A sociolinguistic study.***Published by LOT, http://www.lotschool.nl.

Sidnell,J. (2010).***Conversation Analysis: An Introduction.***United Kingdom: Blackwell Publishers Ltd.

Siregar, Bahren Umar. (1996). ***Code Alternation in Bilingual Speech Behavior.***Medan :Universitas Sumatera Utara.

Spolky, B. (1998). ***Sociolinguistics***. New York: Oxford University Press.

Sumarsih and Daulay.(2012, April).***An Analysis of Code-Mixing in Talk-show Bukan Empat Mata Program***. Journal of Linguistics of FBS UNIMED,Vol-1, No-1, 10-14.

Takami, T. (2002, September).***A Study on Closing Sections of Japanese Telephone Conversation***. Working Papers in Educational Linguistics, Vol -18, No -1, 66-85.

Thurgood G and Lapolla R. (2003).***The Sino-Tibetan languages***. London and New York, Routledge.

Trauth,G and Kazzazi, K.(Ed). (2006).***Dictionary of Language and Linguistics.***London, Taylor & Francis e-Library.

Verawaty Y and Elfrida R.(2014, Agustus). An Analysis Of Code Mixing In Aneka Yess Magazine. ***The Episteme Journal of Language and Literature,Vol-1, No-1***, 1-13.

Wardhaugh, R. (2006). ***An Introduction to Sociolinguistics***. (5th ed). Oxford: Blackwell Publishers Ltd.

Wiebe,E.et al. (2010). ***Encyclopedia of Case Study Research***: ***Conversation Analysis***. Thousand Oaks: SAGE Publications, Inc.

Ying Chen K H. (2005). ***The Social Distinctiveness of Two Code - mixing Styles in HongKong.*** University of Michigan. Proceedings of the 4th International Symposium on Bilingualism, ed. James Cohen, Kara T. McAlister, Kellie Rolstad, and Jeff Mac Swan, 527-541.

Yule,G. (2010). The study of language (4th ed). New York: Cambridge University Press.

အင်တာနက်အကိုးအကား

Aboutworldlanguages. (2014). ***About worl dlanguages: sino-tibetan-language-family.*** Retrieved December 13,2014, from http://aboutworldlanguages.com/sino-tibetan-language-family.

Abouteducation. (2016). ***about education: conversationterm.*** Retrieved May,4,2016, from https://grammar.about.com/od/c/g/conversationterm. htm.

Abouteducation. (2016). ***about education: conversation analysisterm.*** Retrieved May,4, 2016, from http://grammar.about.com/od/c/g/conversationanalysisterm. htm.

Britannica. (2014). Britannica: ***sino-tibetan-languages.*** Retrieved November 10,2014, from http://www.Britannica.com /topic-browse/society/ languages/sino-tibetan-languages.

Ethnologue. (2014). ***Ethnologue: how many languages are there in the world?*** Retrieved November 10,2014, from http:// www.ethnologue.com/guides/how many lan- guages are there in the world?

go-myanmar. (2014). ***go-myanmar: about-myanmar.*** Retrieved December 13,2014, from http:// www.go-myanmar.com/about-myanmar(burma).

Krystal. (2014). ***Krystal: the 30 most spoken languages in the world.*** Retrieved December 13,2014, from http:// Krystal.com/the 30 most spoken languages in the world.

Sociolinguistics dictionary. (2014). ***Sociolinguistics dictionary: sociolinguistics***. Retrieved September 25,2014, from http:// dictionary. reference.com/ browse/ socio linguistics.

Stedt.(2014). ***Stedt.berkekey. edu:TheSino-Tibetan-language Family.*** Retrieved December 13,2014, from http://stedt.berkeley.edu/about-st.

Translationdirectory. (2014). ***Translationdirectory: Sino-Tibetan-languages***. Retrieved De 13,2014, from http://www.Translationdirectory.com/articles/article2300.php.

Vistawide. (2014). ***Vistawide: language-families.*** Retrieved De 13,2014, from https:// www.vistawide.com/languages/language-families-statistics1htm.

Wikipedia. (2014).***Wikipedia: Burmese-language***. Retrieved December 13,2014, from https://en.m.wikipedia.org/wiki/ Burmese-language.

Wikipedia. (2014).***Wikipedia: Sino-Tibetan-languages***. Retrieved December 13,2014, from https://en.m.wikipedia.org/wiki/Sino-Tibetan-languages.

Wikipedia. (2014).***Wikipedia: Linguistics***. Retrieved December 13,2014, from http://en. m.wikipedia.org/ wiki/Linguistics.

Wikipedia.(2016).***Wikipedia:Conversation***. Retrieved May,4,2016, from https://en.wikipedia.org/wiki/Conversation.

Wikipedia. (2016).***Wikipedia: Conversation_analysis***. Retrieved May,4,2016, from https:// en.wikipedia.org/wiki/ Conversation_analysis.

HYDROXYAPATITE AND HYDROXYAPATITE-MAGNESIUM OXIDE NANOCOMPOSITES FROMWASTE COW BONE

J-၄၊ HYDROXYAPATITE AND HYDROXYAPATITE MAGNESIUM OXIDE NANOCOMPOSITES FROM WASTE COW BONE

Cho Lwin Lwin Khine*

Abstract

Hydroxyapatite (HAp) materials are very popular for bone restoration. The applications of pure HAp are restricted to non load-bearing implants due to the poor mechanical properties of HAp. To improve the mechanical properties of HAp derived from cow bone, incorporation of magnesium oxide was conducted in this research. HAp was prepared by calcination of deproteinised cow bone waste using HCl and NaOH solutions. Effect of calcination temperature on the morphological, structural and thermal properties of HAp was investigated at different temperatures ranging from 800°C to 1200 °C. The prepared HAp samples were characterized by XRD, TG-DTA, FT IR, SEM and EDXRF. In all HAp samples, HAp was the only crystalline phase indicated by X-ray diffraction analysis. Broad peaks were observed in X-ray diffractogram of uncalcined HAp. The well-resolved, sharp and intense peaks were noted after calcination. FT IR spectra of calcined HAp showed the absence of the absorption bands originated by the collagen (1634 cm^{-1} and 1548 cm^{-1}) due to the removal of organic component in HAp. Carbonate peak around 871 cm^{-1} disappeared after calcination at 1000 °C to 1200 °C. SEM images showed the dense and packed structure for uncalcined HAp whereas porous structure for calcined HAp at 800 °C and 900 °C. At 1000 °C and 1100 °C neck formation was observed. MgO nanoparticles was prepared by wet chemical method and a single phase of magnesium oxide with face-centered cubic structure and space group of Fm3m was observed from XRD analysis. Crystallite sizes of prepared magnesium oxide calcined at 400 °C, 500 °C and 600 °C was found to be 13.79 nm, 21.28 nm and 21.71 nm respectively. At higher temperature, it was found to have greater tendency for agglomeration due to higher crystallinity. Crystal structures of all HAp-MgO nanocomposites and HAp were indexed as hexagonal with equal length of a and b and shorter length c. FT IR spectral data revealed the characteristics peaks of both HAp and MgO in the prepared nanocomposites. In the composites highest amount of CaO, P_2O_5 and MgO were observed with small amount of metal oxides. MgO percents increased in the composites with more addition of MgO. Hardness of HAp prepared from cow bone increased from 12 N to 19 N - 53 N after addition of MgO nanoparticles and it increased as the amount of MgO increased. HAp-10 % MgO nanocomposites calcined at 1100 °C was found to have the highest hardness value of 53 N. HAp and HAp-MgO nanocomposites showed mild antimicrobial activities on all tested microorganisms such as *Bacillus subtilis, Staphylococcus aureus, Pseudomonas aeruginosa, Bacillus pumilus, Candida albicans* and *Escherichia coli. In vivo* acute toxicity test on albino mice showed no mortality and no toxicity throughout the dosing schedule of 14 days in all dose levels in all groups. HAp and HAp-MgO nanocomposites prepared at 1000 °C and 1100 °C showed no cytotoxic effect according to brine shrimp lethality bioassay. *In vitro* protein adsorption test and *in vitro* hemolysis test indicated that the prepared HAp and HAp-MgO nanocomposites were biocompatible. Orthopaedic application of HAp and HAp-MgO nanocomposites were conducted by *in vivo* study using Wistar rats. X-ray diagnosis showed that HAp-MgO nanocomposites were suitable for treatment of bone defect. *In vitro* study for repairing the non-living broken bones by HAp-MgO nanocomposites was also conducted using chicken femur bone and it was found that the composites could be used as bioglue. The present study shows that cow femur bone can be effectively utilized for the preparation of HAp-MgO nanocomposites as potential filler to bone defects.

Keywords: cow bone, hydroxyapatite, HAp-MgO nanocomposites, acute toxicity test, protein adsorption test, hemolysis test, orthopaedic application

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Introduction

Hydroxyapatite is a significant biomaterial in the health care industry. Its chemical and mineral phases are analogous to those of natural bone and hence, its usage in the field of dentistry and orthopaedics has been explored (Hornez *et al.*, 2007). Properties like osteoconductivity and osteoinductivity enhance bone regeneration and make hydroxyapatite an important material in tissue engineering (Burg *et al*., 2000), and its biocompatibility leads to its use as bioactive coating over implants (Ye and Wang, 2007).However, the brittleness and poor performance of mechanical stability of pure hydroxyapatite limit its use for the regeneration of non-load-bearing bone defects and tissue engineering applications (Rajkumar *et al*., 2010). Composite biomaterials like metal and polymer matrix are used to improve the mechanical compatibility of nano hydroxyapatite. Generally, composite biomaterials are prepared by using biocompatible/ biodegradable and synthetic/natural polymers (Wang *et al.,* 2007). Inorganic minerals such as hydroxyapatite, bioactive glasses metal oxides and carbon nanotube are incorporated into polymer matrixes to impart bioactivity (Dhanalakshmi *et al.,* 2012). The addition of nanosized particles is desirable to develop composite with a good mechanical strength similar to the natural bone which contains mineral crystals at the nanometer scale and embedded in the collagen matrix (Joseph and Tanner, 2005).

The natural-biological origin hydroxyapatite has several important advantages: worldwide availability in almost unlimited supply, very low cost of raw materials, utilization of very simple and inexpensive apparatus, rapid, uncomplicated and very efficient transformation from raw materials into hydroxyapatite. Therefore, it seems to be an alternative for numerous products based on synthetic hydroxyapatite.

MgO is one of the most successful candidates of reinforcement oxides. The mechanical and biodegradable properties of MgO added composites and alloys are especially attractive for bone and teeth implant applications due to its excellent biocompatibility, high degradability, low weight and density similar to natural bones.

This research is aimed to prepare and characterize HAp and HAp-MgO nanocomposites and to study their structural, morphological and thermal properties for biomedical application. To fulfill the aim the objectives include:

To collect waste cow bone from Mingalar Taung Nyunt retail market, Yangon Region

To prepare and characterize HAp from waste cow bone sample by XRD, TG-DTA, FT IR, SEM and EDXRF techniques

To calcine HAp prepared from cow boneat 800 °C, 900°C, 1000°C, 1100 °C and 1200 °C and to characterize the calcined samples by XRD, TG-DTA, FT IR, SEM and EDXRF techniques

To synthesize MgO nanoparticles by wet chemical method and to characterize the prepared MgO by XRD, TG-DTA, FT IR and SEM techniques

To prepare HAp-MgO nanocomposites with different weight ratios of MgO at different temperatures and to characterize the nanocomposites by XRD, TG-DTA, FT IR, SEM and EDXRF techniques

To investigate the physicochemical properties (pH, bulk density, porosity and hardness) for HAp and HAp-MgO nanocomposites

To study the biocompatibility tests (protein adsorption and hemolysis) and toxicity tests (acute toxicity and cytotoxicity)

To conduct the *in vivo* and *in vitro* biomedical application of prepared HAp and HAp-MgO nanocomposites

Materials and Methods

The experimental works were conducted at the Department of Chemistry, University of Yangon (UY). Hydroxyapatite (HAp) was prepared from readily affordable biowaste cow bone employing simple unit operations and acid-alkali processes.

2.1 Sample Collection

Cow bone samples were collected from Mingalar Taung Nyunt retail market in Yangon Region.

2.2 Sample Preparation

Distilled water washed raw cow bone sample (1kg) was crushed into splintered bone pieces. It was boiled in a steel pot immersed in 2L of hot distilled water contained in a steel pot for 4-5 hours. Boiling was repeated 3 more times. The boiled sample (800 g) was then pressure cooked in 2L of distilled water, under pressure of 5-7.5 psi. Pressure cooking was repeated 3 more times with fresh distilled water. Washing, boiling and pressure cooking removed any adhering oil, fat, meaty things plus some contaminated dirt and microorganisms. Dried bone pieces were then treated with 1M HCl (2 L) in a glass tank for about 24 hours accompanied by occasional stirring. After the acidified bone pieces were washed with distilled water to a nearly neutral state (pH 6.5-7.3) the bone pieces were then immersed in 2 L of 1M NaOH for about 24 hours. The alkali treated bone pieces were repeatedly washed with distilled water to a neutral state. It was air dried and pulverized to a powder form (44 µm). The acid-alkali treatment removed any remaining tissue, fatty matter and making the splintered bones more porous and brittle. It aided the splintered bones to be ground to the powder form. The hydroxyapatite powder was calcined at 800 °C, 900 °C, 1000 °C,1100 °C and 1200 °C in a muffle furnace.

2.3 Synthesis of Magnesium Oxide Nanoparticles

Magnesium oxide nanoparticles were prepared by wet chemical method using magnesium nitrate hexahydrate and sodium hydroxide as precursors and soluble starch as stabilizing agent. Starch act as a stabilizing agent and also prevents the agglomeration of nanoparticles (Agrawal *et al*., 2015). Starch (0.1 %concentration) solution was prepared in 100 mL of distilled water and magnesium nitrate 0.4 mol was added to the above solution. Then the solution was kept under constant stirring using magnetic stirrer for complete dissolution of contents. After complete dissolution, 0.8 mol of sodium hydroxide solution was added in drops along the sides of the container under constant stirring for 2 hours and allowed to settle for 24 hours. The supernatant liquid was then discarded carefully and the remaining solution was centrifuged (3000 rpm at 25°C) for 30 minutes. Centrifugate was washed three times using distilled water and ethanol to remove the by-products and the excessive starch that bound with the nanoparticles. The nanoparticles of magnesium hydroxide were dried in an oven at 100 °C for 4 hours and annealed in a muffle furnace at 600 °C for 4 hours to obtain magnesium oxide. During this process, conversion of magnesium hydroxide into magnesium oxide took place.

2.4 Synthesis of HAp-MgO Nanocomposites

MgO (5 g) was dispersed in 20 mL of distilled water with the help of a magnetic stirrer for 1 hour. The hydroxyapatite suspension was also prepared using the ratio of 1:1 for powder (100 g) and water (100 mL) by means of magnetic stirring for 1 hour to get homogeneity of the dispersion. In order to prepare HAp-MgO nanocomposites, the weight percentages (wt %) of 5 and 10 were chosen. The prepared MgO suspension was poured into the HAp suspension and then was thoroughly mixed using stirrer at 80-90°C for 1 hour. The obtained suspension was cooled to room temperature for 12 hours. In addition, it was filtered using a funnel through filter paper. The residues were washed 2 to 3 times with distilled water. Then, it was transferred into porcelain basin and placed in an oven at 120 °C for 4 hours to obtain dried sample. Moreover, the resulting products were annealed at 1000°C and 1100°C for 4 hours.

2.5 Characterization Techniques

Phase analysis and purity of prepared magnesium oxide, hydroxyapatite and HAp-MgO nanocomposites obtained were investigated by X-ray analysis. X-ray diffraction patterns of the samples were recorded on X-ray diffractometer (Rigaku, Tokyo, Japan), using CuK_{α} radiation (λ= 1.54 Å) at 40 kV and 40 mA. The diffraction angle ranged from 10^{o} to 70^{o} of 2θ.The crystallite size was calculated by Scherrer method. The crystallinity percent was obtained by dividing total area of crystalline peaks by total area of all peaks.

TG-DTA (DTG-60H) Thermal Analyzer, Shimadzu, Japan was employed for investigation of the thermal property of prepared magnesium oxide and cow bone hydroxyapatite. The sample was scanned from 40°C to 600°C under nitrogen atmosphere with a flow rate of 50 mL min^{-1}.

Fourier transform infrared (FT IR) spectra of the samples was recorded on a FT IR spectrometer (FT IR-8400 SHIMADZU, Japan) in a range of wavenumber from 4000 to 440cm^{-1}.

The morphology of the samples were examined by scanning electron microscopy (JEOL-JSM 5610 LV, Japan).

Relative abundance of elements in hydroxyapatite was qualitatively determined by EDXRF analysis using EDX-702 spectrometer (Shimadzu Co.Ltd., Japan).

2.6 Physicochemical Properties of HAp and HAp-MgONanocomposites

pH values of HAp and HAp-MgO nanocomposites were determined by pH meter (Jenway 4330, England) and the hardness of prepared HAp and HAp-MgO nanocomposites were determined by hardness tester (PHAMA Test, PTB 302). Bulk density and porosity of the samples were determined by tapping method and liquid displacement method respectively.

2.7 *In Vitro* Investigation of Antimicrobial Activities of HAp and HAp-MgO Nanocomposites

In vitro screening of antimicrobial activities of HAp and HAp-MgO nanocomposites were carried out against six kinds of bacteria by agar well diffusion method at Pharmaceutical Research Department (PRD), Ministry of Industry, Yangon, Myanmar. The microorganisms

selected were *Bacillus subtilis* (N.C.T.C-8236),*Staphylococcus aureus* (N.C.P.C-6371), *Pseudomonas aeruginosa* (6749),*Bacillus pumilus* (N.C.I.P-8982),*Candida albicans* and *Escherichia coli* (N.C.I.B-8134).

2.8 *In Vivo* Acute Toxicity Test of HAp-MgO Nanocomposites

Acute toxicity of HAp-MgO nanocomposites was tested according to the methods of OECD Guidelines for the Testing of Chemicals 423 at Laboratory Animal Services Division, Department of Medical Research (DMR), Yangon.

According to the test description, total number of 54 adult albino mice, weighing (25-30g) were selected and divided into 9 groups. Each group contained six animals. They were fasted for 18 hours before giving the HAp-MgO nanocomposites. Groups (A 1 to D 2) mice were orally administered with HAp-MgO nanocomposites(2000 mg/kg dose and 5000 mg/kg dose). Group (E) mice performed as a control group and they were treated with clean water and normal animal food. All groups of mice were kept in the standard aluminium mouse cages and allowed to access food and water in the separate room at the room temperature of 26±1 ºC. After administration, mortality and behaviour changes were continuously observed. Then the animals were checked each 24 hours for fourteen days. The mortality during this period was noted (Nil or percent death).

2.9 Cytotoxicity Test

The brine shrimp (*Artemiasalina*, fairy shrimp or sea monkeys)was used in this study for cytotoxicity bioassay of the prepared HAp and HAp-MgO nanocomposites (Ali *et al*., 2013). The toxicity of samples were tested at various concentrations *viz.* 1,10, 100 and 1000 µg/mL in artificial seawater. Ten nauplii were used in each test. Three replications were used for each concentration. A parallel series of tests with the standard potassium dichromate solution and caffeine were conducted. After 24 hours, the number of dead brine shrimps was counted and 50 % lethality dose (LD_{50}) was calculated (Sahgal *et al*., 2010).

2.10 Biocompatibility Tests

2.10.1 *In vitro* protein adsorption test

Protein adsorption test was conducted according to Mishra (2013) with some modifications. Adsorbate used was Bovine Serum Albumin (BSA) from Sigma. Firstly,1 mL each of HAp and HAp-MgO nanocomposites samples with concentrations of 10 mg/mL was added to 1mL of aqueous solution of BSA (1200 µg/mL) in respective test tubes. The mixtures were then shaken and incubated at the physiological temperature (37^oC) for 24 hours. After 24 hours of incubation, the samples were centrifuged at 3000 rpm for 10 minutes. The supernatants were removed and the residual protein concentration was determined using Biuret assay at 550 nm (Holme and Peck, 1998). Sample solution (1 mL) and 4 mL of Biuret reagent were thoroughly mixed and kept at room temperature for 30 minutes. After that, the absorbance value was measured at 550 nm. Hence, by difference the residual protein amount from the total protein amount, the protein adsorbed (µg) was determined.

2.10.2 *In vitro* hemolysis test

Hemolysis test was conducted according to Mishra (2013) with some modifications. Blood was collected from central ear artery of two white rabbits by needle. The rabbits were provided by Laboratory Animal Services, Department of Medical Research, Yangon. Trisodium citrate as anticoagulant was immediately added.The noncoagulant blood was diluted with normal saline(10 mL of normal saline per 8 mL of blood) and stored at 4 °C till use.Following this, thetest specimens (10 mg each) were placed in test tubes with phosphate buffered saline (1 mL each) and agitated and incubated for 24 hours at 37°Cbefore being exposed to blood. After that, 0.5 mL of blood was added to each test tube and the volume made up to 10 mL with saline.Hydrochloric acid was used as positive control and phosphate buffer saline (PBS) solution was used as negative control.The samples and controls were placed in contact with blood for 1 hour in incubator at 37 °C. After centrifugation at 4000 rpm for 10 minutes,the absorbance of the supernatant was measured at 545 nm.The percentage of hemolysis was determined by the following formula.

$$\text{Percent hemolysis} = \frac{\left(A_{\text{sample}} - A_{\text{negative control}}\right)}{\left(A_{\text{positive control}} - A_{\text{negative control}}\right)} \times 100$$

2.11 *In Vivo* Test for Orthopaedic Application of HAp and HAp-MgO Nanocomposites

HAp and HAp-MgO nanocomposites were conducted for orthopaedic application employing Wistar rats (male with 250-300 g body weight).The animals were obtained from Laboratory Animal Services Division, Department of Medical Research, Yangon. All of the rats were kept in standard rat cages.The animals were facilitated with standard environmental condition of photoperiod (12:12 hours dark: light cycle) and temperature (24 °C). They were provided with standard laboratory pellets and water was given *adlibitum*. Animals were divided into two individual groups in this experiment as follows:

Group I, after surgery procedure, left side of skull defect was not filled any materials. Group I, after surgery procedure, right side of skull defect was filled with HAp. Group II, after surgery procedure, left side of skull defect was filled with HAp-5 % MgO nanocomposite(1100 ºC). Group II, after surgery procedure, right side of skull defect was filled with HAp-10 % MgO nanocomposite (1100 ºC).

Wistar rats were injected with Ketamine hydrochloride (50 mg/kg) before the surgery. The dorsal area of each rats skull was shaved before the surgery, and the surgical field was prepared with septidine solution. A 3 cm midline scalp incision was made, and underlying musculature and periosteum were elevated, exposing the parietal bones. Identical 0.3 cm diameter (left side and right side) round bony defect was then created in the parietal bone using stainless steel hand drill carefully. Care was then taken to avoid injury to the dura or midsagittal sinus. The sample powder was taken in a watch glass and distilled water added drop wise till the powder got fully wet and got paste. The paste was molded in the skull bone cavity before suturing. Defects were gently packed with HAp paste for right side of test (I) animal and left side was left unfilled (control) and HAp-10 % MgO nanocomposite (1100 ºC) paste for right side of

test (II) animal and HAp-5 % MgO nanocomposite (1100 ºC) paste for left side of test (II) animal. External examination of the skull bone defects was conducted after 15 days and 30 days surgery by taking photos of the skull bone. Test animals of groups (I) and (II) were post-tested by X-ray radiography. The Wistar rats were observed (a) immediately on operation day (b) 15 days after surgery and (c) 30 days after surgery at Crown Veterinary Resources, Yankin Township, Yangon. Skull bone lesion samples were used for histological examination in Pathology Research Division, Department of Medical Research (Lower Myanmar).

2.12 *In Vitro* Test for Orthopaedic Application of HAp-MgO Nanocomposites as Bone Glue

Chicken femur bones were also used *in vitro* bone glue experiment. With a manual bone saw shaft, femur bones of some of the chicken were horizontally and completely cut and some were almost completely. Bone glue made of HAp-MgO nanocomposites and polyethylene glycol (1:1) were then applied to stick the broken dried chicken femur bones and kept for 24 hours.

Results and Discussion

3.1 Effect of Calcination on Colour Tone of Hydroxyapatite

The observed colour toneof prepared hydroxyapatite was yellowish white. After calcination at 800°C, the colour tone has still tinged yellowish white. The yellowish colour or the tinge tone may be due to organic matrix (collagen). However, above 800°C that is from 900°C to the range of 1200°C the hydroxyapatite was observed to be clear white (Venkatesan and Kim, 2010).

3.2 Characterization of Hydroxyapatite

3.2.1 XRD analysis

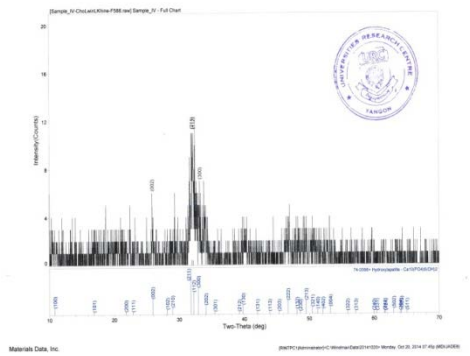
Figure 3.1 presents the XRD analysis of HAp prepared from cow bone samples of uncalcined and calcined at 800 °C, 900 °C, 1000 °C, 1100 °C and1200 °C. XRD analysis of uncalcined HAp prepared from cow bone shows a broad peak pattern with poor crystalline intensity of HAp phase. From the results, not all the standard peaks were found because of the presence of organic compounds (collagen) which disperses the X-ray radiation. As the temperature increased from 800 °C to 1200 °C, sharp and narrow peaks with high intensity of crystalline pattern were observed as reported by Figueiredo *et al.* (2010). All the XRD peaks match with the standard peaks of pure hydroxyapatite and no impurity other than hydroxyapatite was detected. The results indicated that all organic substances were completely eliminated. It was confirmed by phase analysis by X-ray method which showed the formation of single phase of hydroxyapatite. The principal characteristics diffraction peaks of HAp appeared at 2-Theta values of 31.848°, 32.060° and 32.908° which correspond to Miller indices of (211) (112) and (300) respectively. The well-resolved XRD of hydroxyapatite could be easily indexed on the basis of hexagonal crystal system with equal length of a and b axes and shorter length of c axis (Table 3.1). The crystallite size and percent crystallinity of hydroxyapatite are shown in Table 3.2. As the temperature increased the crystallite size was found to become larger. This may be

due to the fact that particles coalesced at higher temperature. Furthermore it was found that crystallinity percent also increased as the calcination temperature increased.

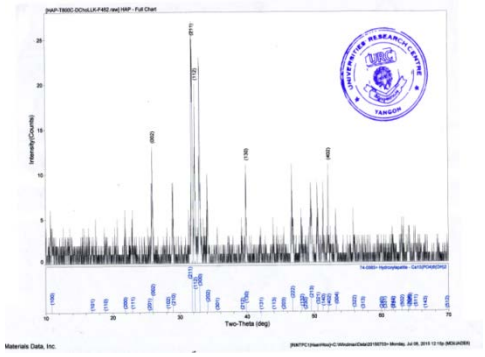
3.2.2 TG-DTA analysis

Thermal analysis data of uncalcined hydroxyapatite prepared from cow bone are shown in Table 3.3. It was noted that the weight loss in the temperature range of 39.79 to 60 ^{o}C was 1.22%due to evaporation of residual water. Within the temperature range of 60 to 288^{o}C, the weight loss was 8.42% due to the combustion of organic residue. An exothermic peak was observed at 275.70 ^{o}C.A higher weight loss of35.51% was noted in the temperature range of 288 to 436 ^{o}C. The weight loss was also due to combustion of organic residue. An exothermic peak was also observed at 387.84^{o}C. Between the temperature range of 436 to 599.26 ^{o}C the prepared uncalcined hydroxyapatite was found to be thermally stable.

TG-DTA thermogram of calcined samples show negligible weight loss with further increase of temperature (Table 3.4). It can be deduced that hydroxyapatite is thermally stable and this indicates that complete formation of hydroxyapatite crystals at 900 °C.



(a)



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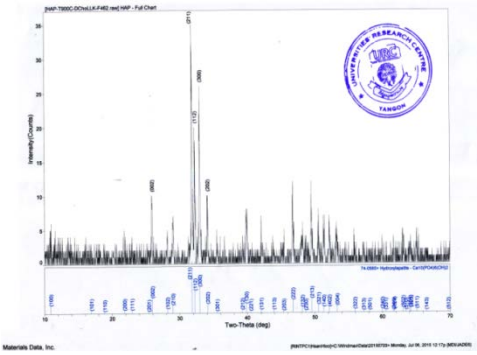

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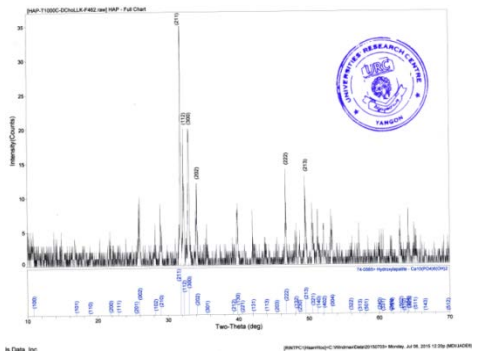

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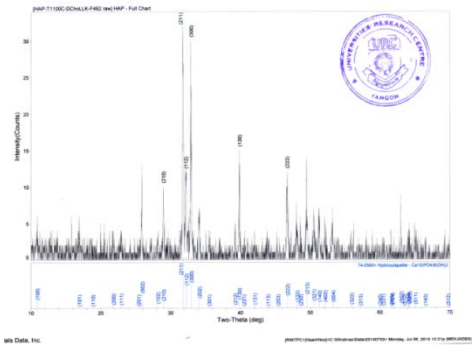
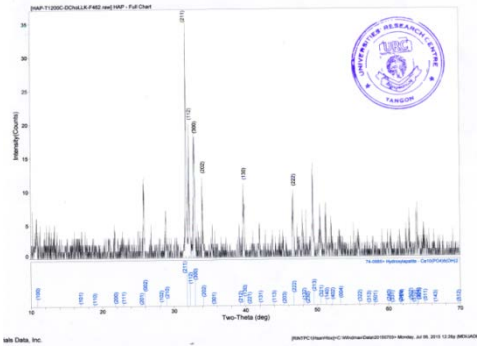


(e)



(f)

Figure 3.1 X-ray diffractograms of HAp(a) uncalcined and calcined at (b) 800 °C (c) 900 °C (d) 1000 °C (e) 1100 °C and (f) 1200 °C

Table 3.1 Peak Locations, Millller Indices and Lattice Constants of Hydroxyapatite

No.	HAp Samples	Lattice Constants (Å)		Crystal structure
		a=b	c	
1.	Uncalcined sample	9.3927	6.9403	Hexagonal structure
2.	Calcined sample (800 °C)	9.4058	6.8719	Hexagonal structure
3.	Calcined sample (900 °C)	9.4009	6.8757	Hexagonal structure
4.	Calcined sample (1000 °C)	9.4135	6.8769	Hexagonal structure
5.	Calcined sample (1100 °C)	9.4167	6.8970	Hexagonal structure
6.	Calcined sample (1200 °C)	9.4352	6.8839	Hexagonal structure

Table 3.2 Average Crystallite Sizes and Crystallinity Percents of Hydroxyapatite

No.	HAp Samples	Average crystallite size (nm)	% Crystallinity
1.	Uncalcined sample	46.82	33.7
2.	Calcined sample (800 °C)	61.98	56.1
3.	Calcined sample (900 °C)	69.92	63.5
4.	Calcined sample (1000 °C)	71.81	64.6
5.	Calcined sample (1100 °C)	78.24	65.9
6.	Calcined sample (1200 °C)	78.30	66.4

Table 3.3 Thermal Analysis Data of Uncalcined Hydroxyapatite

No.	Temperature range (°C)	Break in Temp (°C)	Weight loss (%)	Peak nature	Remark
1.	39.79-60	-	1.22	-	Evaporation of residual water
2.	60-288	275.70	8.42	Exothermic peak	Combustion of organic residue
3.	288-436	387.84	35.51	Exothermic peak	Combustion of organic residue
4.	436-599.26	-	-	-	Thermally stable

Table 3.4 Weight Loss of Hydroxyapatite by Thermal Analysis

No.	HAp Samples	Weight loss (%)
1.	Uncalcined sample	42.120
2.	Calcined sample (800 °C)	1.578
3.	Calcined sample (900 °C)	1.716
4.	Calcined sample (1000 °C)	1.797
5.	Calcined sample (1100 °C)	0.974
6.	Calcined sample (1200 °C)	1.177

3.2.3 FT IR analysis

FT IR spectra of the cow bone samples before and after thermal treatment at 800°C, 900 °C, 1000 °C, 1100°C and 1200 °C are shown in Table 3.5. Differences between the spectra of raw bones and calcined samples are due to changes in their chemical structure, occurred during the heating. This fact indicates the presence of the proteins and the organic phase in raw bone samples and their absences in heated samples. The characteristic peaks of hydroxyapatite at 557, 600, 960 (shoulder), 1012 and 1030 (shoulder) cm^{-1} due to phosphate vibrations were observed. In addition, most bands of phosphate vibrations of hydroxyapatite have largely increased in intensity after calcination. Moreover, after calcination, absorption bands originated from the collagen (C=O stretching vibration at 1634 cm^{-1}, N–H in-plane bending at 1548 cm^{-1}, C–H and N–H stretching modes in the 2800–3400 cm^{-1} region) disappear due to the removal of organic component from the bone samples. In the500-700 cm^{-1} region, there are now three bands in the spectra of the calcined samples (570,601,632 cm^{-1}) whereas in the original sample only two are clearly discernible. The weak band observed in the spectra of calcined hydroxyapatite samples around 630 cm^{-1} could not be identified in the spectrum of the uncalcined sample. Carbonate peak around 871 cm^{-1} disappear after calcination at 1000 °C, 1100°C and 1200 °C. FT

IR spectra showed bands of small intensity at 1411cm^{-1} and 1413 cm^{-1}due to lattice carbonate vibration. Disappearance of the doubly band was noticed after calcination at 1200°C.

Table 3.5 FT IR Spectral Data of HAp (Uncalcined and Calcined) Samples

No.	Raw	Wavenumber (cm^{-1})					Reported Values*	Remark
		800 °C	900 °C	1000 °C	1100 °C	1200 °C		
1.	3392	3472	3443	3462	3471	3473	3100-3500	Vibration of OH
2.	2820	-	-	-	-	-	2800-3400	CH stretching
3.	1652	-	-	-	-	-	1653	Amide I adsorption of collagen
4.	1546	-	-	-	-	-		NH plane bending
5.	1467	1460	1456	1456	1454	-	1400-1629	Carbonate groups
6.	1413	1411	1413	1411	1411	-		
7.	1172	1089	1089	1089	1091	1089		
8.	-	-	1060	-	1060	-	1100-1200	Stretching Phosphate
9.	-	1045	1047	-	-	1045		
10.	1031	1031	1033	1030	1033	1037		
11.	960	962	962	962	962	962	900-1200	Stretching Phosphate
12.	871	873	877	-	-	-	871	Carbonate group
13.	-	632	632	632	632	632		
14.	603	601	601	601	601	601	500-700	Bending Phosphate
15.	563	570	570	569	570	570		

*** Nakamoto, 1970**

3.2.4 SEM analysis

From the microstructure observation using SEM, Figure 3.2 presents SEM images of uncalcined hydroxyapatite and calcined at different temperatures (800°C, 900°C, 1000°C, 1100°C and 1200°C).Before calcination, hydroxyapatite crystals were embedded in organic materials. After heat treatment, elimination of collagen was observed. At higher temperature particles had begun to coalesce and contact areas between particles were increased by neck

growth. At the temperatures of 1100°C and 1200°C, the SEM images show the densification of the sample. The same observation was also observed by Sriasiliza *et al*.(2009).

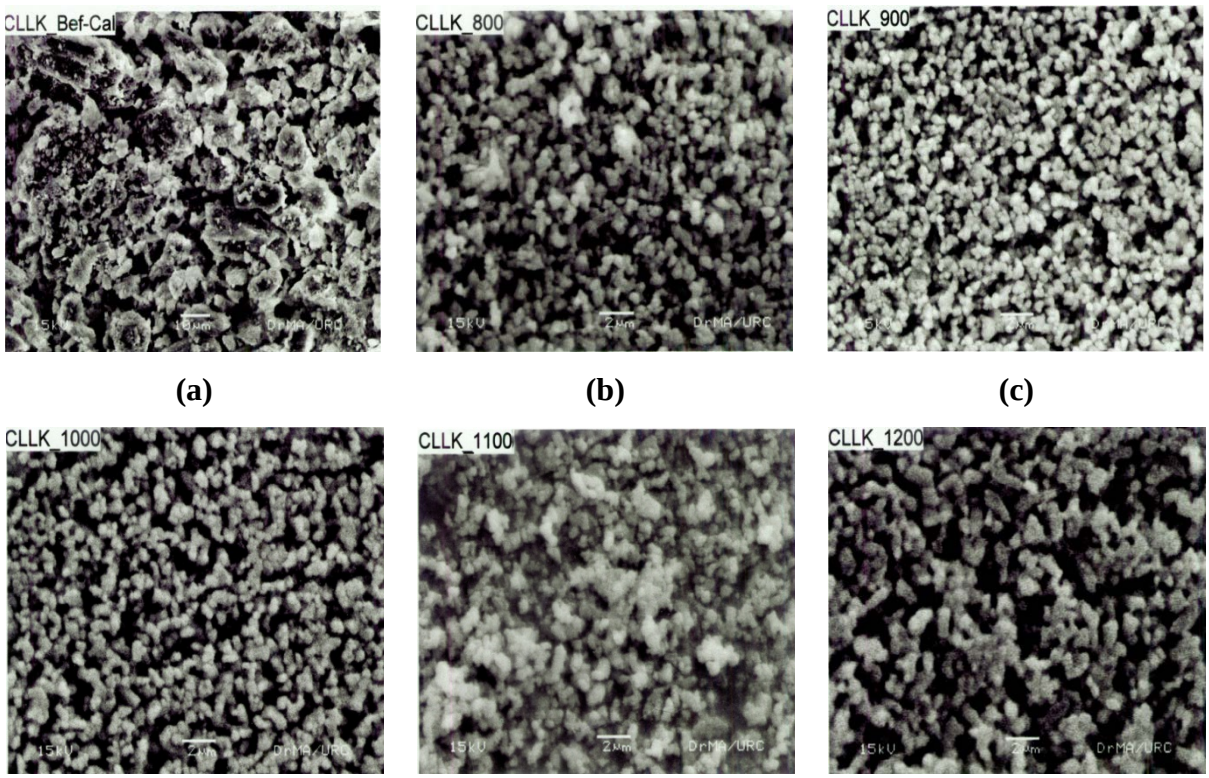


Figure 3.2 SEM images of HAp (a) uncalcined and calcined at (b) 800 °C (c) 900 °C (d) 1000 °C (e) 1100 °C and (f) 1200 °C

3.2.5 EDXRF analysis

EDXRF is an analytical technique used for elemental analysis or chemical composition of a sample. Table 3.6 represents the EDXRF spectra for hydroxyapatite at 800°C, 900 °C, 1000 °C, 1100 °C and 1200 °C, respectively. According to the chemical formula of hydroxyapatite, calcium and phosphorus, the most significant minerals of the bone, are noticeable in this analysis. It was observed that calcined cow bone contained Ca, P, Sr, Fe, K, Zr and Zn. Among these elements Ca was the highest.

Table 3.6 Relative Elemental Abundance of Hydroxyapatite

HAp Samples	Relative abundance (%)						
	Ca	P	Sr	Zn	Fe	K	Zr
Uncalcined sample	70.379	29.480	0.105	0.036	-	-	-
Calcined sample (800 °C)	83.752	14.643	0.236	0.112	1.257	-	-
Calcined sample (900 °C)	78.592	18.509	0.189	0.102	1.791	0.818	-
Calcined sample (1000 °C)	80.921	18.184	0.113	0.059	0.048	0.675	-
Calcined sample (1100 °C)	78.974	20.119	0.160	0.082	0.664	-	-
Calcined sample (1200 °C)	78.965	19.620	0.144	0.075	0.357	0.813	0.025

3.3 Characterization of Magnesium Hydroxide and Magnesium Oxide

3.3.1 XRD analysis

XRD pattern of magnesium hydroxide depicts the eight well-defined diffraction peaks corresponding to (001), (100), (101), (102), (110), (111), (103) and (200) planes which are in agreement with the standard library data of magnesium hydroxide (Figure 3.3).

The prepared magnesium oxide samples were subjected to XRD analysis and three well-defined different peaks were observed in each diffractogram at Miller indices of (111), (220) and (200) (Figure 3.4). A single phase of magnesium oxide with space group of Fm3m was observed from XRD analysis. Since Miller indices appeared as all odd or all even the structure of magnesium oxide was found to be face-centered cubic structure (Table 3.7).

Crystallite size of prepared magnesium hydroxide was found to be 22.33 nm and those of magnesium oxide were calculated as 13.79 nm, 21.28 nm and 21.71 nm, respectively, for samples obtained by calcination at 400 °C,500 °C and 600 °C (Table 3.8). The crystallite sizes of magnesium oxide calcined at 600 °C was found to be the highest. As the temperature increased, the crystallite size of magnesium oxide was found to increase. The same observation was reported by Tang *et al*., 2012. This phenomena can be explained as follows. Different size crystals have different surface energies. Crystal size is proportional to its surface energy, so the process of small crystals turning into large crystals happens automatically. The process proceeds very quickly especially at high temperature. With prolonged calcination time, the process will be achieved completely. The crystal size grows for long times at high calcination temperatures (Shi *et al.,* 2012; Tang and Shi, 2008). Thus, large size nanoparticles can be obtained.

Crystallinity of MgO also increased with increased in temperature showing that 27.44 %, 48.17 % and 54.39 % for MgO calcined at 400 °C, 500 °C and 600 °C, respectively (Table 3.8).

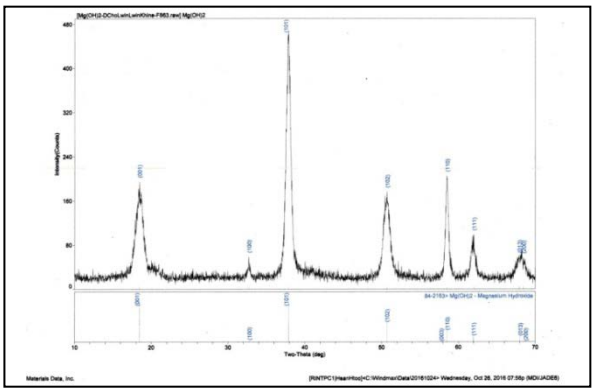


Figure 3.3 X-ray diffractogram of magnesium hydroxide

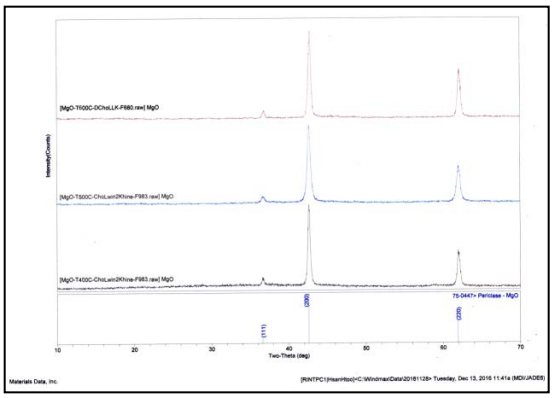


Figure 3.4 Comparison of X-ray diffractograms of magnesium oxide at 400, 500 and 600 °C

Table 3.7 Phase Purity and the Crystallographic Structural Properties for Magnesium Oxide

MgO (°C)	Diffraction angle (2θ) degree	Interplanar spacing (d) Å	Miller Indices			Phase	Axial length (Å)
			h	k	l		
400	36.613	2.4523	1	1	1	MgO	4.2475
	42.780	2.1120	2	0	0	MgO	4.2240
	62.012	1.4953	2	2	0	MgO	4.2294
500	36.828	2.4385	1	1	1	MgO	4.2236
	42.793	2.1114	2	0	0	MgO	4.2238
	62.081	1.4938	2	2	2	MgO	4.2252
600	36.658	2.4494	1	1	1	MgO	4.2425
	42.654	2.1179	2	0	0	MgO	4.2359
	65.024	1.4951	2	2	2	MgO	4.2287

Average Lattice Constants = a = b = c = 4.2337 Å (400 °C)
Average Lattice Constants = a = b = c = 4.2239 Å (500 °C)
Average Lattice Constants = a = b = c = 4.2357 Å (600 °C)
Crystal system = cubic

Table 3.8 Average Crystallite Sizes and Crystallinity Percents of Magnesium Hydroxide and Magnesium Oxide

No.	Samples	Average crystallite size (nm)	% Crystallinity
1.	$Mg(OH)_2$	22.33	51.71
2.	MgO (400 °C)	13.79	27.44
3.	MgO (500°C)	21.28	48.17
4.	MgO (600 °C)	21.71	54.39

3.3.2 TG-DTA analysis

Table 3.9 shows thermal analysis data of magnesium hydroxide. One decomposition step was observed in TG-DTA thermogram of magnesium hydroxide with a sharp endothermic peak appeared at 335.28 °C because of phase transition from magnesium hydroxide to magnesium oxide. Weight loss of conversion of magnesium hydroxide to magnesium oxide is due to the elimination of lattice water molecule. In the temperature range of 37.33 ^{o}C to 351^{o}Cweight loss was calculated to be 30.86 % which agreed with the theoretical weight loss of 31.03 %. According to TG-DTA analysis the decomposition temperature of $Mg(OH)_2$ was 335.28 °C. After phase transition to magnesium oxide the weight loss was negligible and thermal stability of the product was observed.

Moreover, thermal analysis data of magnesium oxide samples calcined at 400 ^{o}C, 500 ^{o}C and 600 ^{o}C are shown in Table 3.10. Two endothermic peaks appeared at 72.59 ^{o}C and 291.22 ^{o}C due to the loss of water absorbed on the surface. Similarly, a very small endothermic peak was observed in each thermogram of magnesium oxide samples calcined at 500 ^{o}C and 600 ^{o}C (282.57 ^{o}C and 273.44 respectively) because of the loss of absorbed water. It was noted that the smallest weight loss of 0.868 % was observed for magnesium oxide calcined at 600 ^{o}C indicating having higher thermal stability.

Table 3.9 Thermal Analysis Data of Magnesium Hydroxide

No.	Temperature range (°C)	Break in Temp (°C)	Weight loss %	Peak nature	Remark
1.	37.33-351	335.28	30.86	Endothermic peak	Phase transition from $Mg(OH)_2$ to MgO(lattice water)(theoretical wt loss 31.03 %)
2.	351-601.45	-	3.04		Thermally stable

Table 3.10 Thermal Analysis Data of Magnesium Oxide

Magnesium oxide (°C)	Temperature range (°C)	Break in Temp (°C)	Weight loss %	Peak nature	Remark
400	38.72-180	72.59	11.94	Endothermic	Loss of absorbed water
	180-601.61	291.22	17.80	Endothermic	Loss of absorbed water
500	39.81-600.54	282.57	12.781	Endothermic (very small)	Loss of absorbed water
600	38.09-601.35	273.44	0.868	Endothermic (very small)	Loss of absorbed water

3.3.3 FT IR analysis

FT IR spectrum of magnesium hydroxide showed stretching vibration of O-H in magnesium hydroxide appeared as a sharp peak at 3697 cm^{-1} and O-H stretching vibration of physically absorbed water at 3446 cm^{-1}. O-H bending modes were observed between 1400 - 1600 cm^{-1} and the peak at 441 $cm^{-1}$is assigned to at Mg-O vibration (Table 3.11).

In FT IR spectra of magnesium oxide samples calcined at 400 ^{o}C, 500 ^{o}C and 600 ^{o}C the intensitiy of the O-H stretching vibration appeared at 3697 cm^{-1}decreased noticeably showing that conversion of hexagonal magnesium hydroxide to cubic magnesium oxide. Characteristic peaks of magnesium oxide at 653 cm^{-1} and 474 cm^{-1} due to Mg-O vibration were seen on the spectra.

Table 3.11 FT IR Spectral Data of Magnesium Hydroxide and Magnesium Oxide

No.	Wavenumber (cm^{-1})				Reported values* (cm^{-1})	Remark
	$Mg(OH)_2$	MgO (°C)				
		400	500	600		
1.	3697	3697	3697		3697	O-H stretching vibration of $Mg(OH)_2$
2.	3446	3441	3446	3443	3444	O-H stretching vibration of physically absorbed water molecules
3.	1635	1612	1639	1635	1600-1400	O-H bending mode of
4.	1483	1445	1445	1444		vibration of physically absorbed water molecules
5.		653	653	653	680-450	Mg-O deformation vibration
6.	441	474	441	474		

* Karthikeyan *et al.*, 2016

3.3.4 SEM analysis

Figure 3.5 shows the SEM image of magnesium hydroxide. Aggregates of irregular shaped particles were observed.

SEM images shown in Figures 3.5, 3.6, 3.7 and 3.8 depict the morphology of magnesium oxide nanoparticles as spherical granules with slight agglomeration. At 600 °C, the morphology was more pronounced and some cubical shaped aggregated particles were observed.

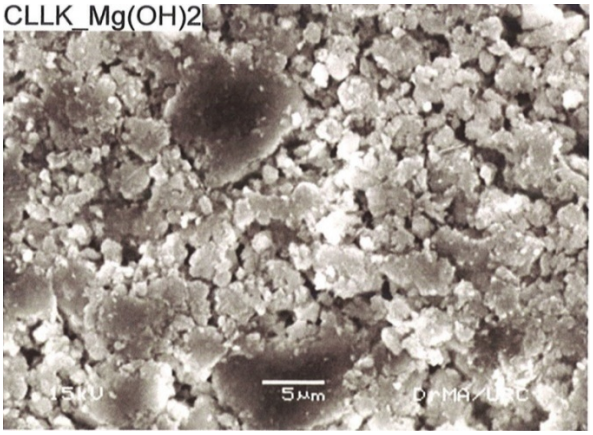


Figure 3.5 SEM image of magnesium hydroxide (5500 X magnification)

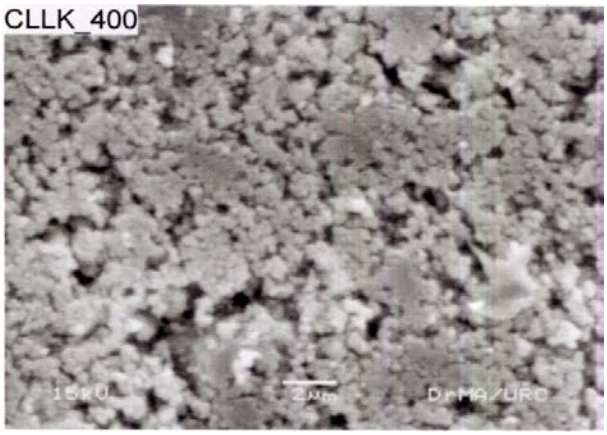


Figure 3.6 SEM image of magnesium oxide (400 °C) (5500 X magnification)

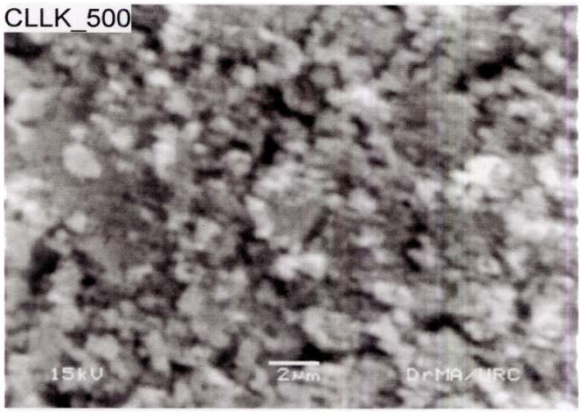


Figure 3.7SEM image of magnesium oxide (500 °C) (5500 X magnification)

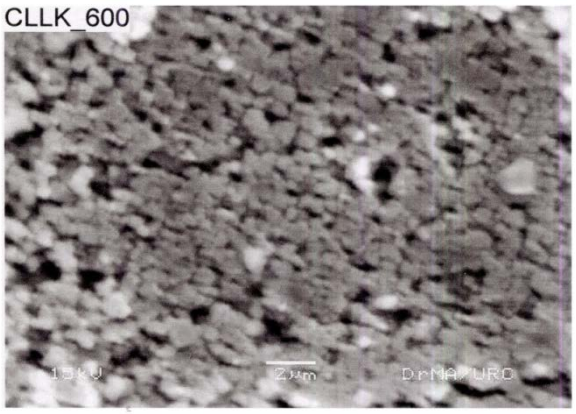


Figure 3.8 SEM image of magnesium oxide (600 °C) (5500 X magnification)

3.4 Characterization of HAp-MgO Nanocomposites

3.4.1 XRD analysis

HAp-MgO nanocomposites was prepared using HAp calcined at 900 ^{o}C and MgO obtained by heating $Mg(OH)_2$ at 600 ^{o}C.Two different weight percentages of 5 % and 10 % magnesium oxide were added into HAp sample in this study.

HAp calcined at 900 ^{o}C showed well-resolved XRD pattern which could be easily indexed on the basis of hexagonal crystal system with equal length of a and b axes (9.4009 Å) and shorter length of c axis (6.8757 Å). When the prepared magnesium oxide sample obtained at 600 ^{o}C was subjected to XRD analysis three well-defined diffraction peaks were observed at Miller indices of (111), (220) and (200). After incorporation of magnesium oxide to HAp, the XRD patterns of HAp-MgO nanocomposites showed two new peaks corresponding to magnesium oxide peaks at (200) and (220) in addition to HAp peaks (Figure 3.9).

With increase in temperature the crystallite size of HAp-MgO nanocomposites were found to increase. However, the results were reversed as the amount of magnesium oxide was increased (Table 3.12). For HAp, the crystallite size was 69.92 nm. Crystallite sizes of HAp-MgO nanocomposites were 32.17 nm and 37.87 nm for HAp-5 % MgO nanocomposites calcined at 1000 °C and 1100 °C, respectively. For HAp-10 % MgO nanocomposites the crystallite sizes were 31.46 nm and 36.70 nm, respectively for calcination temperature of 1000 °C and 1100 °C.

Crystal structures of HAp and all of the HAp-MgO nanocomposites were hexagonal.The lattice constants of HAp-MgO nanocomposites noticeably changed from those of HAp indicating the formation of composites. Among the HAp-MgO nanocomposites, the lattice constants changed slightly with change in temperature and amount of magnesium oxide.

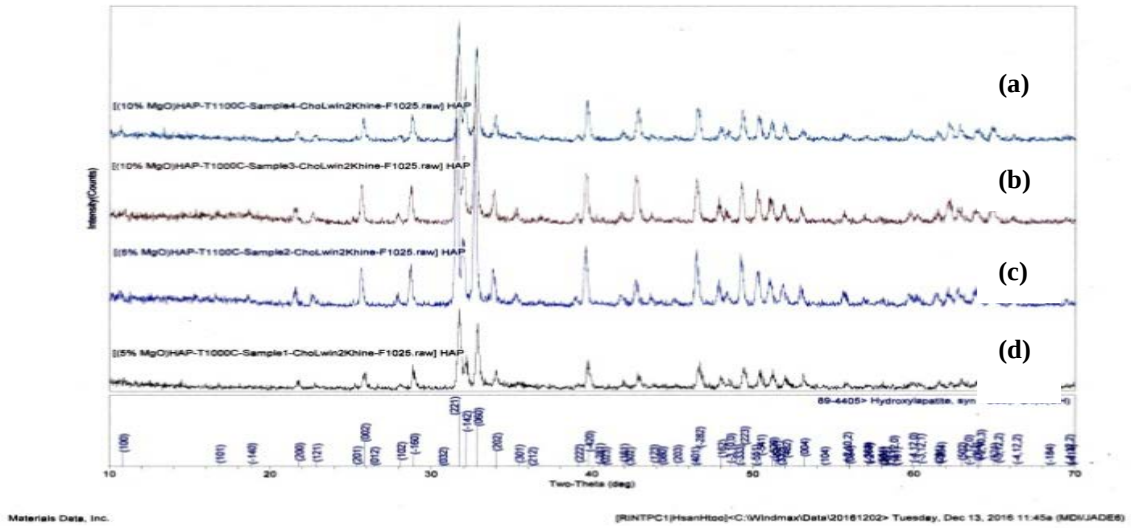


Figure 3.9 X-ray diffractograms of HAp-MgO nanocomposites
(a) HAp-10 % MgO (1100 ^{o}C) (b) HAp-10 % MgO (1000 ^{o}C)
(c) HAp-5 % MgO (1100 ^{o}C) (d) HAp-5 % MgO (1000 ^{o}C)

Table 3.12 Average Crystallite Sizes, Lattice Constants and Crystal Structures of HAp and HAp-MgO Nanocomposites

No.	Samples	Average crystallite size (nm)	Lattice constants (Å)		Crystal structure
			a=b	c	
1.	HAp	69.92	9.4009	6.8757	Hexagonal
2.	HAp-5 % MgO nanocomposite (1000 ^{o}C)	32.17	9.5469	6.8434	Hexagonal
3.	HAp-5 % MgO nanocomposite (1100 ^{o}C)	37.87	9.5998	6.9544	Hexagonal
4.	HAp-10 % MgO nanocomposite (1000 ^{o}C)	31.46	9.5650	6.7985	Hexagonal
5.	HAp-10 % MgO nanocomposite (1100 ^{o}C)	36.70	9.5295	6.8878	Hexagonal

3.4.2 TG-DTA analysis

TG-DTA thermal data of HAp-MgO nanocomposites at 1000 °C and 1100 °C are presented in Table 3.13. No inflection of TG curve with small weight loss was observed in each TG curve of HAp-MgO nanocomposites indicating the stability of the sample.

3.4.3 FT IR analysis

FT IR spectral data revealed the assignment of the vibration bands of HAp-MgO nanocomposites together with the characteristic peaks of both HAp and MgO (Table 3.14). The characteristic peaks of HAp in nanocomposites were observed between 700-500 cm^{-1} due to P-O bending vibration and between 1200-900 cm^{-1} due to P-O stretching vibration (Karthikeyan *et al.*, 2016). Similarly, the characteristic peaks of MgO in HAp-MgO nanocomposites were observed at 474 cm^{-1} (Nakamoto, 1970).

Table 3.13 Thermal Analysis Data of HAp-MgO Nanocomposites

Samples	Temperature range (°C)	Initial weight(mg)	Final weight(mg)	Weight loss (%)	Remark
HAp-5 % MgO nanocomposite (1000 °C)	38.94-601.14	8.192	8.178	0.171	Thermally stable
HAp-5 % MgO nanocomposite (1100 °C)	39.32-601.59	9.586	9.526	0.626	Thermally stable
HAp-10 % MgO nanocomposite (1000 °C)	36.92-601.48	3.793	3.786	0.185	Thermally stable
HAp-10 % MgO nanocomposite (1100 °C)	39.38-601.78	7.959	7.863	1.206	Thermally stable

Table 3.14 FT IR Spectral Data of HAp, MgO and HAp-MgO Nanocomposites

No.	Wavenumber (cm^{-1})						Reported values (cm^{-1})	Remark
			HAp-MgO Nanocomposites					
	HAp (900°C)	MgO (600°C)	5 % (1000°C)	5 % (1100°C)	10 % (1000°C)	10 % (1100°C)		
1.	3697		3570	3570	3510	3568	3500-3100*	Vibration of O-H
2.	3443	3440	3427	3419	3479	3443	3444**	O-H stretching vibration of physically absorbed water molecules
3.	1456		1460	1462	1460	1462	1629-1400*	Carbonate group
4.	1413		1413	1413	1413	1413		
5.	1089		1091	1089	1091	1091	1200-900*	P-O stretching of phosphate
6.	1047		1047	1047	1047	1047		
7.	962		960	960	960	960		

No.	Wavenumber (cm^{-1})						Reported values (cm^{-1})	Remark
	HAp (900°C)	MgO (600°C)	HAp-MgO Nanocomposites					
			5 % (1000°C)	5 % (1100°C)	10 % (1000°C)	10 % (1100°C)		
8.	877						871*	Carbonate group
9.		653					650-450**	Mg-O deformation vibration
10.	632		632	632	632	634	700-500*	P-O bending of phosphate
11.	601		601	601	601	601		
12.	570		569	570	569	569		
13.		474	472	474	474	474	650-450**	Mg-O deformation vibration

* Nakamoto, 1970 ** Karthikeyan*et al.*, 2016

3.4.4 SEM analysis

Microscopic observations illustrated that the HAp-5 % MgO nanocomposite calcined at 1000 °C showed elongated shape. As the concentration of MgO increased, irregular shape are observed. Increasing temperature to 1100 °C, the poorly connected particles tend to agglomerate.

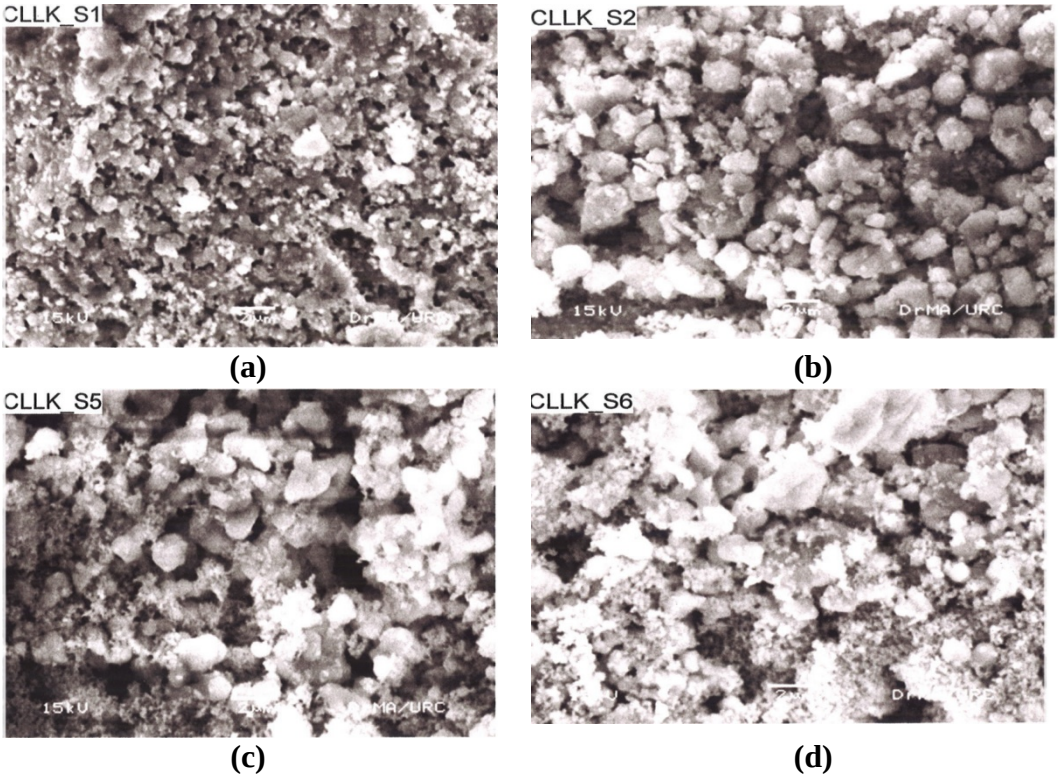


Figure 3.10 SEM images of HAp-5 % MgO nanocomposite at (a) 1000 °C (b) 1100 °C and HAp-10 % MgO nanocomposite at (c) 1000 °C (d) 1100 °C

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3.4.5 EDXRF analysis

The relative abundance of elements in oxide form are given in Table 3.15. Calcium oxide contents were in the range of 38.834 % to 44.242 % and found to be the highest in all nanocomposites. The second highest P_2O_5 was in the range of 29.998 % to 35.253 %.

Table 3.15 Relative Abundance of Elemental Oxide in HAp-MgO Nanocomposites

Samples	Relative abundance of element (in terms of oxide %)													
	CaO	P_2O_5	MgO	SiO_2	Al_2O_3	SO_3	K_2O	SrO	TiO_2	Fe_2O_3	ZnO	Ag_2O	CuO	BaO
1	44.242	33.253	16.252	2.764	2.567	0.562	0.257	0.038	0.021	0.013	0.012	0.009	0.009	-
2	42.985	35.223	16.274	2.514	2.113	0.534	0.274	0.036	0.019	0.011	0.006	-	0.013	-
3	38.984	29.998	24.951	2.697	2.518	0.485	0.269	0.032	-	0.014	0.005	-	0.017	0.029
4	38.834	31.200	23.871	2.658	2.400	0.731	0.215	0.031	-	0.010	0.004	0.009	0.007	0.030

Sample 1 = HAp-5 % MgO nanocomposite (1000 °C)
Sample 2 = HAp-5 % MgO nanocomposite (1100 °C)
Sample 3 = HAp-10 % MgO nanocomposite (1000 °C)
Sample 4 = HAp-10 % MgO nanocomposite(1100 °C)

3.5 Physicochemical Properties of HAp and HAp-MgO Nanocomposites

HAp calcined at 900 ^oC was found to have pH value of 9.6 (Table 3.16). Addition of MgO nanoparticles in HAp caused slight decrease in pH values i.e., 9.3 for 5 % MgO (1000 ^oC), 9.5 each for 5 % MgO (1100 ^oC) and 10 % MgO (1000 ^oC) and 9.4 for 10 % MgO (1100 ^oC). All HAp-MgO nanocomposites samples and HAp sample were found to have alkaline in nature.

Bulk density of HAp sample was 1.52 g mL^{-1} and it slightly decreased after incorporation with MgO in HAp-MgO nanocompositesin the range of 1.18 g mL^{-1} to 1.43 g mL^{-1}. Among the HAp-MgO nanocomposites, it was observed that as the temperature increased the bulk density of the nanocomposites slightly increased.It is due to the effect of high temperature and agglomeration at high content of reinforcement. However, as the amount of MgO increased from 5 % to 10 % the bulk density was slightly decreased from 1.18 g mL^{-1} to 1.23 g mL^{-1}respectively.

Porosity of HAp increased from 28.31 % to 43.20 % - 48.90 % in HAp-MgO nanocomposites. Among HAp-MgO nanocomposites, porosity increased with the addition of MgO increased. Furthermore, increasing the calcination temperature slightly decreased the porosity percent.It is because at higher temperature most of the pores were shrunk.

For bulk density and porosity determinations, the powdered samples were used. For hardness determination, the powdered samples were moulded into regular blocks and these blocks were used for determination.

Hardness of HAp prepared from cow bone was found to be 12 N. Hardness increased as the amount of the addition of MgO increased in the range of 19 N to 53 N. HAp-10 % MgO at 1100 ^oC was found to have the highest hardness value of 53 N.

Table 3.16 Physicochemical Properties of HAp and HAp-MgO Nanocomposites

No.		HAp	Sample 1	Sample 2	Sample 3	Sample 4
1.	pH	9.6	9.3	9.5	9.5	9.4
2.	Bulk density(g/mL)	1.52	1.36	1.43	1.18	1.23
3.	Porosity (%)	28.31	46.30	43.20	48.90	47.60
4.	Hardness(N)	12	19	31	42	53

Sample 1 = HAp-5 % MgO nanocomposite (1000 °C)
Sample 2 = HAp-5 % MgO nanocomposite (1100 °C)
Sample 3 = HAp-10 % MgO nanocomposite (1000 °C)
Sample 4 = HAp-10 % MgO nanocomposite (1100 °C)

3.6 Antimicrobial Activities of HAp and HAp-MgO Nanocomposites

Antimicrobial activities of HAp and HAp-MgO nanocomposites (5 % and 10 %) were investigated against six microorganisms. HAp and HAp-MgO nanocomposites (5 % and 10 %) only showed mild antimicrobial activities on all tested organisms such as *Bacillus subtilis, Pseudomonas aeruginosa, Candida albicans, Escherichia coli, Staphylococcus aureus and Bacillus pumilus*(Table 3.17).

Table 3.17 Antimicrobial Activities of HAp and HAp-MgO Nanocomposites

Samples	Inhibition Zone Diameters (mm)					
	B. subtilis	***S. aureus***	***P. aeruginosa***	***B. pumilus***	***C. albicans***	***E. coli***
HAp	12 (+)	12 (+)	12 (+)	12 (+)	12 (+)	12 (+)
HAp-5% MgO nanocomposite (1000 °C)	13 (+)	13 (+)	12 (+)	12 (+)	13 (+)	13 (+)
HAp-5% MgO nanocomposite(1100 °C)	13 (+)	13 (+)	12 (+)	13 (+)	13 (+)	13 (+)
HAp-10% MgO nanocomposite (1000°C)	13 (+)	12 (+)	13 (+)	12 (+)	13 (+)	12 (+)
HAp-10% MgO nanocomposite (1100°C)	13 (+)	12 (+)	13 (+)	13 (+)	13 (+)	13 (+)

Agar well – 10 mm 10 mm ~ 14 mm (+) 15 mm ~ 19 mm (++) 20 mm above (+++)
Control = distilled water

3.7 Acute Toxicity of HAp-MgO Nanocomposites on Albino Mice Model

Acute toxicity screening of HAp-MgO nanocomposite was done with the dosage of 2000 mg/kg and 5000 mg/kg body weight in each group of albino mice. The condition of mice groups were recorded after fourteen days administration. No lethality of the mice was observed until 2 weeks with the maximum dose of administration (Table 3.18). Each group of animals was also observed still alive and did not show any visible symptoms of toxicity like restlessness, respiratory disorders, convulsion, aggressive activities, coma and death. Even with the dose up to 2000 mg/kg and 5000 mg/kg body weight administration, there was no lethality at the day of fourteen.

Table 3.18 Acute Toxicity Study of HAp-MgO Nanocomposites on Albino Mice Model

Groups	Dose (mg/kg)	No. of mice tested	Observed periods (d)	Death per test
A 1	2000	6	14	0/6
A 2	5000	6	14	0/6
B 1	2000	6	14	0/6
B 2	5000	6	14	0/6
C 1	2000	6	14	0/6
C 2	5000	6	14	0/6
D 1	2000	6	14	0/6
D 2	5000	6	14	0/6
E (Control)	-	6	14	0/6

A 1, A 2 = HAp-5 % MgO nanocomposite (1000 °C) C 1, C 2 = HAp-10 % MgO nanocomposite (1000 °C)

B 1, B 2 = HAp-5 % MgO nanocomposite (1100 °C) D 1, D 2 = HAp-10 % MgO nanocomposite (1100 °C)

3.8 Cytotoxicity Test

Brine shrimp cytotoxicity bioassay was used for the cytotoxicity test of HAp and HAp-MgO nanocomposites. Brine shrimp was used for this assay (Tawhawa, 2006). This was expressed in terms of mean ± SEM (standard error mean) and LD_{50} (50 % Lethality Dose).The data are described in Table 3.19.According to Meyer's toxicity index, the sample with LD_{50}<1000 µg/mL are considered as toxic, while the sample with LD_{50}> 1000 µg/mL are considered as non-toxic (Meyer *et al*., 1982). The prepared HAp and HAp-MgO nanocomposites were found to be noncytotoxic in the brine shrimp bioassay so they can be used as biomaterial.

Table 3.19 Cytotoxicity of HAp and HAp-MgO Nanocomposites

Samples	Percentage of dead brine shrimp (Mean ± SEM) in various concentrations (µg/mL)				LD_{50} (µg / mL)
	1	10	100	1000	
HAp	0 ± 0	0 ± 0	3.3 ± 1.90	6.7 ± 11.54	> 1000
A 1	0 ± 0	0 ± 0	3.3 ± 1.90	3.3 ± 1.90	> 1000
A 2	0 ± 0	0 ± 0	3.3 ± 1.90	3.3 ± 1.90	> 1000
B 1	0 ± 0	0 ± 0	6.7 ± 11.54	6.7 ± 11.54	> 1000
B 2	0 ± 0	0 ± 0	3.3 ± 1.90	6.7 ± 11.54	> 1000
*Caffeine	0 ± 0	0 ± 0	9.58 ± 0.92	12.73 ± 4.10	> 1000
*$K_2Cr_2O_7$	48.63±19.19	73.13 ±4.08	74.67 ±11.8	100 ± 0	1.5

* = used as cytotoxic standard

A 1 = HAp-5 % MgO nanocomposite(1000 °C)

A 2 = HAp-5 % MgO nanocomposite(1100 °C)

B 1 = HAp-10 % MgO nanocomposite(1000 °C)

B 2 = HAp-10 % MgO nanocomposite(1100 °C)

3.9 Biocompatibility Tests

3.9.1 *In vitro* protein adsorption test

Cellular response on the implant after implantation depends on the initial amount of serum proteins that get adsorb to the implant.

Among the HAp-MgO nanocomposites, protein adsorption capacity increased and found to be in the range of 72.07 μg/10 mg to 90.09 μg/10 mg (Table 3.20). It may be due to the decrease of the crystallite size and hence, increase of surface area of the nanocomposites. In other words protein adsorption increases with increase in surface area of the samples where the crystal size is small (Feng *et al*., 2002).

3.9.2 *In vitro* hemolysis test

The prepared composites were tested for hemolytic activity and the results obtained were quite satisfactory (Table 3.21). The results obtained clearly indicated that, with incorporation of MgO content, the extent of hemolysis slightly increased. The observed results may be attributed to the reason that, with the incorporation of MgO in the composite, the surface composition favorably changes, which increased the hemolytic property of the material. Among the composites the hemolysis percentages did not change appreciably.If hemolysis percentage is below 2% the material is considered non-hemolytic, between 2% and 5% slightly hemolytic, and above 5% it is considered hemolytic (Laranjeiraa *et al.,* 2016). All the samples were found to have hemolysis percentages less than 5 %. Thus, these samples exhibit good biocompatibility and may be suitable biomaterials for clinical implant purposes.

Table 3.20 Protein Adsorption Capacities of HAp and HAp-MgOnanocomposites

No.	Samples	Residual protein (μg/10 mg)	Protein adsorption (μg/10 mg)	Mean (μg/10 mg)
1.	HAp	1145.95	54.05	
		1167.57	32.43	54.05 ± 21.63
		1124.32	75.68	
2.	HAp-5 % MgO	1124.32	75.68	
	nanocomposite (1000 ^{o}C)	1145.95	54.05	75. 68 ± 21.63
		1102.70	97.30	
3.	HAp-5 % MgO	1102.70	97.30	
	nanocomposite (1100 ^{o}C)	1145.95	54.05	72. 07 ± 22.50
		1135.13	64.87	
4.	HAp-10 % MgO	1091.89	108.11	
	nanocomposite (1000 ^{o}C)	1113.51	86.49	90.09 ± 16.52
		1124.32	75.67	
5.	HAp-10 % MgO	1102.70	97.30	
	nanocomposite (1100 ^{o}C)	1135.13	64.87	82. 88 ± 16.53
		1113.51	86.49	

*Initial protein in 1 mL sample = 1200 μg/10 mg

Table 3.21 Hemolysis Percentages of HAp and HAp-MgO Nanocomposites

No.	Samples	Absorbance of test sample	Hemolysis (%)	Mean (%)
1.	HAp	0.096	1.61	
		0.099	1.91	1.71 ±0.17
		0.096	1.61	
2.	HAp-5 % MgO	0.099	1.91	
	nanocomposite (1000 ^{o}C)	0.101	2.11	1.94 ±0.15
		0.098	1.81	
3.	HAp-5 % MgO	0.102	2.21	
	nanocomposite (1100 ^{o}C)	0.099	1.91	1.98 ±0.21
		0.098	1.81	
4.	HAp-10 % MgO	0.097	1.71	
	nanocomposite (1000 ^{o}C)	0.101	2.11	1.94 ±0.21
		0.100	2.00	
5.	HAp-10 % MgO	0.099	1.91	
	nanocomposite (1100 ^{o}C)	0.103	2.31	2.11 ±0.20
		0.101	2.11	

*Absorbance of negative control = 0.080
Absorbance of positive control = 1.077

3.10 *In Vivo* Orthopaedic Application of HAp and HAp-MgO Nanocomposites

HAp, HAp-5 % MgO (1100 ^{o}C) and HAp-10 % MgO (1100 ^{o}C) nanocomposites were separately applied as bone cement on skull bones of Wistar rats (Figure 3.11). The progress of these operation skull bone were recorded by the photos at specified time interval and the recorded photographs are shown in Figure 3.12. After 15 days, the hairs of the Wistar rats were started to grow and after 30 days it was found to be normal.

The Wistar rats were radiographed on the operation day, after 15 days and 30 days of operation (Figure 3.13).Bone gap were found to be 0.28 cm for control, 0.30 cm each for HAp and HAp-10 % MgO nanocomposite (1100 ^{o}C) and 0.32 cm for HAp-5 % MgO nanocomposite (1100 ^{o}C). After 15 days of operation, bone gap was found to decrease to 0.10 cm in control and 0.08 cm in Wistar rat filled with HAp.This means that tiny bony defects were still observed in these rats. However, complete bone healing was observed for Wistar rats filled with nanocomposites. The composites bridged the defects and new bonds were formed. After 30 days of operation the defects were completely filled in all Wistar rats whether unfilled or filled with HAp and HAp-MgO nanocomposites. It was found that application of HAp-MgO nanocomposites for bone defect enhanced bone healing effect compared to control and HAp only. Due to histological findings (Tables 3.22 and 3.23), HAp-10 % MgO nanocomposite (1100°C) group is the best in the good scoring within 30 days after application.

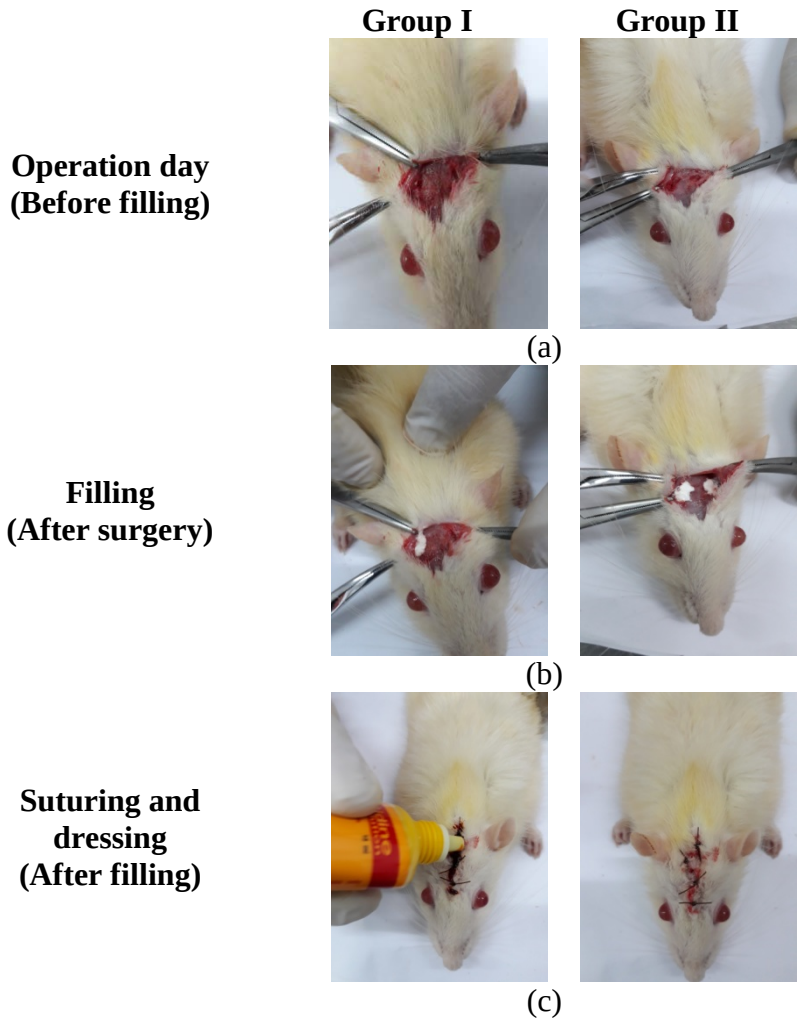


Figure 3.11 Surgical procedure (a) skin incision in the dorsal portion of skull bone with surgical knife (b) filling the skull bone cavity (c) closing with suturing cat gut continuously and dressing with septidine solution

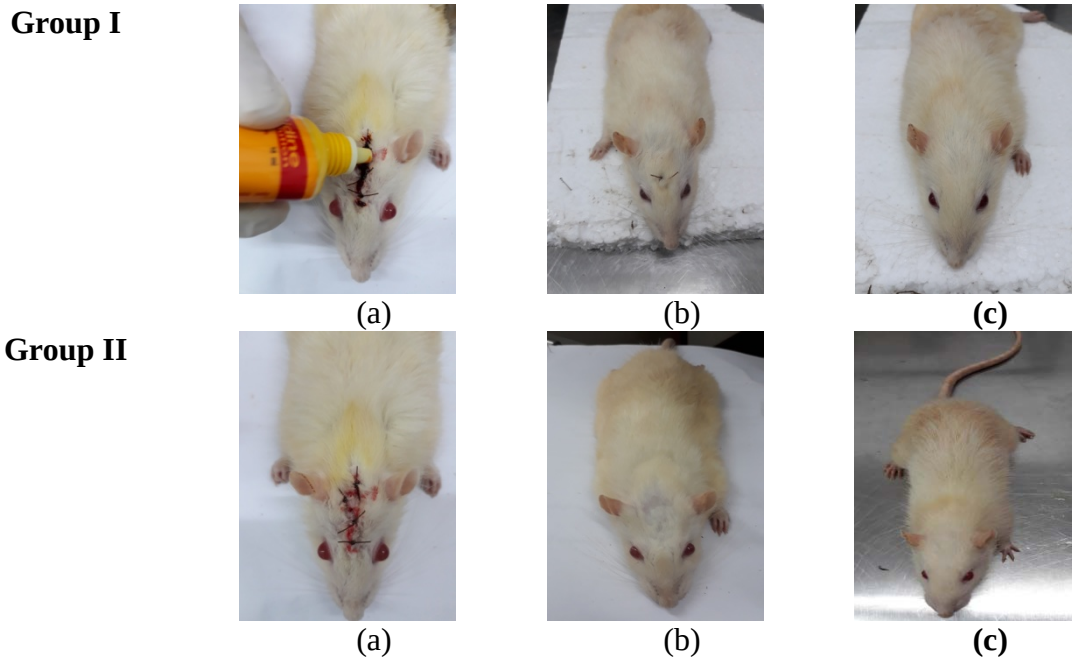


Figure 3.12 External feature of the skull bone defect healing progressiveness of Wistar rats (a) Operation day (b) 15 days after surgery (c) 30 days after surgery

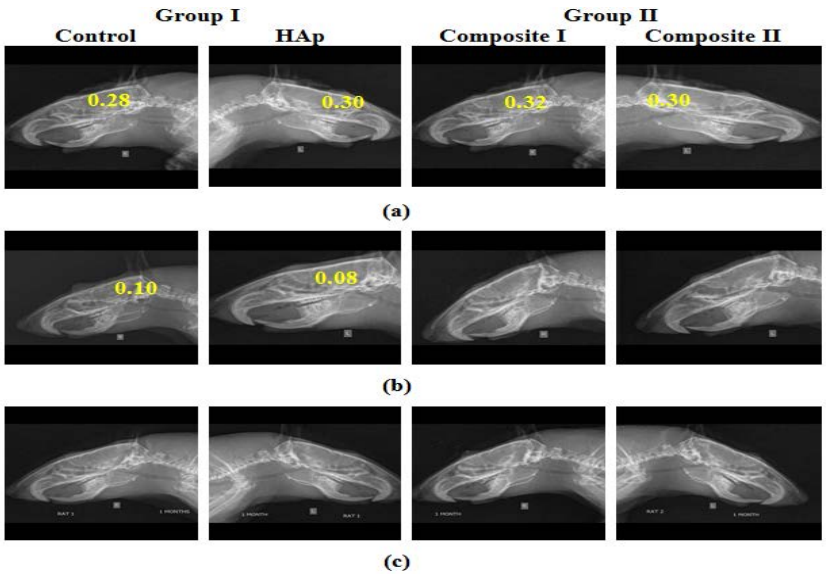


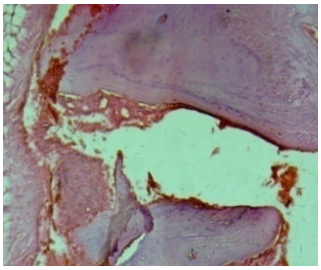
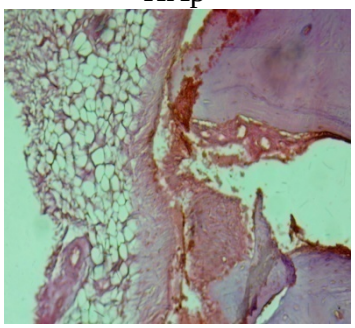
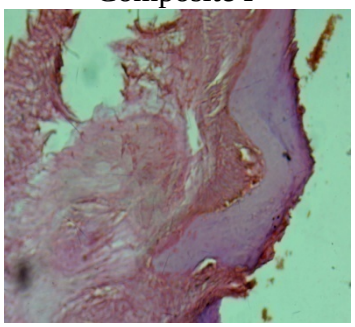
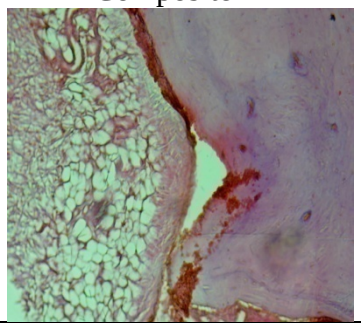
Figure 3.13 Progressiveness of skull bone defect healing in X-ray view of Wistar rats (a) Operation day (b) 15 days after surgery(c) 30 days after surgery

Composite I = HAp-5 % MgO nanocomposite (1100 ^{o}C)
Composite II = HAp-10 % MgO nanocomposite (1100 ^{o}C)

3.11 Histopathological Report of Skull Bone Healing of the Wistar Rats

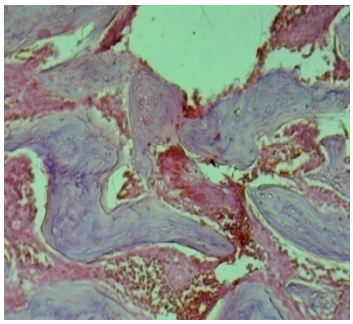
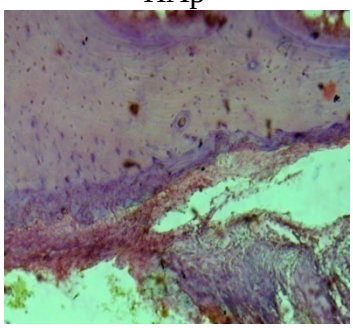
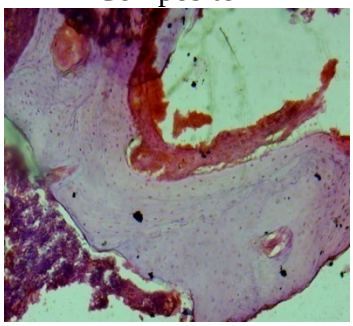
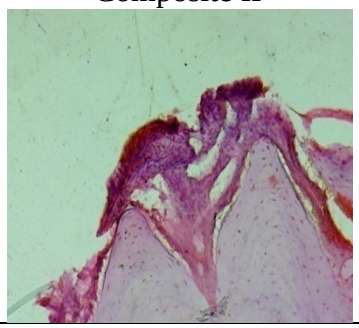
Histology features of bony healing (15 days after operation) are shown in Table 3. 22.

Table 3.22 Histological Report of Bone Healing (15 Days after Operation)

No.	Slide Image	Histology Description	Bony Healing Results
1.	Control 	Histology of fracture skull bone revealed that connective tissue was occupied especially fibroblast and admixed with net work of delicate bone trabeculae lined with osteoblast and formed from inner surface of wall of skull bone. Blood clot remnants were observed.	Score - 0 Non-union of skull bone
2.	HAp 	Fracture site was filled with fibroblast and blood clots. Net work of delicate bone trabeculae lined with osteoblast and formed from inner surface of wall of skull bone.	Score- 1 Incomplete cartilage union
3.	Composite I 	Coagulum (blood clot) was reduced in size and observed woven bone formation composed of few osteoblast and increased amount of chondrocytes.	Score- 2 Complete with cartilage union
4.	Composite II 	A few coagulum was found and mixed with few fibroblast. Woven formation was noted and accompanied with increased osteoblast and chondrocytes. A fracture site was replaced by few amount of trabecular bone.	Score -3 Predorminantly cartilage with some trabecular bone

Histology features of bony healing (30 days after operation) are shown in Table 3.23.

Table 3.23 Histological Report of Bone Healing (30 Days after Operation)

No.	Slide Image	Histology Description	Bony Healing Results
1.	Control 	New trabecular bone formation was started from fracture site and composed of osteoblast and increased amount of chondrocytes.	Score - 3 Predorminantly cartilage with some trabecular bone
2.	HAp 	Trabecular bone formation was well organized and absence of blood clots and fibroblast. Osteoblast was seen in inner layer of fracture bone. Chrondrocytes were filled in some trabecular bone areas. Incomplete bony union with intermediate ossification was observed.	Score-4 Equal amounts of cartilage and trabecular bone
3.	Composite I 	There was increased amount of osteocytes in centre area of bony fracture site. Chrondrocytes were filled in some trabecular bone areas. Incomplete bony union with late ossification was observed.	Score-5 Predorminantly trabecular bone with some cartilage
4.	Composite II 	There was complete new formation of trabecular bone in fracture site. Complete union of fracture area was observed in entire bony fracture site.	Score-6 Complete union of fractured bone

3.12 *In Vitro* Orthopaedic Application of HAp-MgO Nanocomposite as Bone Glue

Since HAp-MgO nanocomposite has low adhesive property of non-living bone, addition of polyethylene glycol to HAp-MgO nanocomposite with ratio of 1:1 (w/w) was prepared and the paste was used as bone glue for the broken non-living chicken femur bone in this study. After application of the prepared bone glue on the intentionally broken femur bone, it was observed that HAp-MgO nanocomposite and polyethylene glycol particles adhered to the bone.

(a) (b) (c)

Figure 3.14 HAp-10 % MgO nanocomposite (1100 °C) as bone glue for broken chicken femur bone
(a) completely cut bone (broken straight across)
(b) almost completely cut bone
(c) connection of two pieces of bone

Conclusion

Hydroxyapatite was prepared from waste cow femur bone by calcination method.The morphological, structural and thermal properties of hydroxyapatite were compared to determine the effect of calcination temperature of hydroxyapatite. The results showed that the calcination temperature highly affects the morphological and structural properties of hydroxyapatite. Dense and compact hydroxyapatite was produced via calcination. Higher temperatures lead to higher percent crystallinity resulting with increased crystallite sizes. Complete formation of stable hydroxyapatite crystals occurred at 900°C. Decrease in MgO content caused the lower percent crystallinity and crystallite size.

HAp-MgO nanocomposites were successfully prepared using natural HApin order to enhance the bioactivity of the HAp,to improve the mechanical properties and to increase its potential use as scaffold for bone tissue engineering application in this research. Increase in hardness was observed after incorporation with magnesium oxide.HAp and HAp-MgO nanocomposites have mild antimicrobial activities on six tested microorganisms. *In vivo* acute toxicity test revealed that no lethality of the albino mice was observed up to fourteen days administration. Brine shrimp cytotoxic assay showed that the HAp and its nanocomposites were noncytotoxic. Protein adsorption test and hemolysis test revealed that HAp and HAp-MgO nanocomposites were found to be biocompatible with living tissue. So, cow bone-derived HAp-MgO nanocomposites would be useful for both in biomedical and environmentally friendly antimicrobial applications due to its biocompatibility, cytotoxicity and antimicrobial activity.

X-ray examination showed that complete bone healing was observed for Wistar rats filled with nanocomposites after 15 days of surgery.HAp-MgO nanocomposites promoted the bone

healing activity of HAp. Although two composites were found to speed up the new bone formation histological evaluation indicated that HAp-10 % MgO nanocomposite (1100 ^{o}C) showed a tendency towards better regeneration for bone formation after one month. *In vitro* study of HAp-MgO nanocomposites as bioglue showed a good adherence between the two non-living broken bones. Thus, the composites can be used as bioglue in museums for repairing the broken bones. These results indicate that the prepared HAp-MgO nanocomposites has demonstrated better osteoconductive and osteopromotive abilities with faster proliferation of new bone tissue formation than HAp.

References

Agrawal, R. M., Charpe, S. D., Raghuwanshi, F. C. and Lamdhade, G. T. (2015).“Synthesis and Characterization of Magnesium Oxide Nanoparticles with 1:1 Molar Ratio via Liquid-Phase Method”.*International Journal of Application or Innovation in Engineering and Management,* vol. 4(2), pp.141-144

Ali, N., Allen, U.,Shaha, S. W. A.,Shaha, I.,Junaid, M., Ahmed, G., Ali, W. and Ghias, M. (2013). “Acute Toxicity, Brine Shrimp Cytotoxicity, Anthelmintic and Relaxant of Fruits of *Rubusfruiticosis* Agg”.*BMC Complement. Alter. Med.*, vol. 13, pp. 138-143

Burg, K. J. L., Porter, S. and Kellam, J. F.(2000). “Biomaterial Developments in Bone Tissue Engineering”. *Biomaterials,* vol. 21, pp. 2347-2359

Dhanalakshmi, C. P., Vijayalakshmi, L. and Narayanan, V. (2012).“Synthesis and Preliminary Characterization of Polyethylene Glycol (PEG)/Hydroxyapatite (HAp) Nanocomposite for Biomedical Applications”. *International Journal of Physical Sciences,* vol. 7(13), pp. 2093-2101

Feng, B., Chen, J. and Zhang, X. (2002). “Interaction of Calcium and Phosphate in Apatite Coating on Titanium with Serum Albumin”.*Biomaterials*, vol. 23, pp. 2499-2507

Figueiredo, M., Fernando, A., Martins, G., Freitas, J., Judas, F. and Figueiredo, H. (2010). “Effect of the Calcination Temperature on the Composition and Microstructure of Hydroxyapatite Derived from Human and Animal Bone”. *Ceramics International*, vol. 36, pp. 2383–2393

Holme, J.D. and Peck, H. (1998).*Analytical Biochemistry*. London:3rd Ed., Longman, pp. 390-391

Hornez, J. C., Chai, F.,Monchau, F., Blanchemain, N., Descamps, N. and Hildebrand, H. F. (2007). “Biological and Physico-chemical Assessment of Hydroxyapatite (HA) with Different Porosity”. *Biomol. Eng*., vol. 24, pp. 505-509

Joseph, R. and Tanner, K. E. (2005).“Effect of Morphological Features and Surface Area of Hydroxyapatite on the Fatigue Behavior of Hydroxyapatite-Polyethylene Composites”.*Biomacromolecules,* vol. 6, pp. 1021-1026

Karthikeyan, V., Dhanapandian, S. and Manoharan, C. (2016). “Characterization and Antibacterial Behavior of MgO Nanoparticles Synthesized via Co-precipitation Method”. *International Journal for Scientific Research and Development,* vol. 10(1), pp. 2321-2323

Laranjeiraa, M. S., Moc, A., Ferreira, J., Coimbra, S., Costa, E., Santos-Silva, A., Ferreira, P. J. and Monteiro, F. J. (2016). “Different Hydroxyapatite Magnetic Nanoparticles for Medical Imaging: Its Effects on Hemostatic, Hemolytic Activity and Cellular Cytotoxicity”. *Colloids and Surfaces B: Biointerfaces*, vol. 146, pp. 363–374

Meyer, B. N., Ferrigni, N. R., Putnam, J. E., Jacobsen, L. B., Nichols, D. E. and McLaughlin, J. L. (1982). “Brine Shrimp: A Convenient General Bioassay for Active Plant Constituents”. *PlantaMedica*., vol. 45, pp. 31-34

Mishra, U. (2013).*Development of Cobalt-Magnesium Doped Hydroxyapatite for Bone Tissue Engineering Application.* Rourkela: A Project Report Submitted to National Institute of Technology,Department of Biotechnology and Medical Engineering National Institute of Technology, Rourkela

Nakamoto, K. (1970). *Infrared Spectra of Inorganic and Coordination Compounds*. New York: 2nd Edition, Wiley Interscience Publication, pp. 233-235

Rajkumar, M.,Sundaram, N. M. and Rajendran, V. (2010).“In-situ Preparation of Hydroxyapatite Nanorod Embedded Poly (Vinyl Alcohol) Composite and its Characterization”.*International Journal of Engineering Science and Technology*, vol. 2(6), pp. 2437-2444

Sahgal, G., Ramanathan, S.,Sasidlharan, S.,Mordi, M. S., Ismail, S. andMansor, S. M. (2010). “Brine Shrimp Lethality and Acute Oral Toxicity Studies on *Swieteniamahagoni*(Linn.)Jacq. Seed Methanolic Extract”. *Pharmacognosy Research*, vol.2, pp. 215-220

Shi, L. E., Fang, X. J., Zhang, Z. L., Zhou, T., Jiang, D., Wu, H. H. and Tang., Z. X. (2012).“Preparation of Nano-ZnO using Sonication Method and its Antibacterial Characteristics”.*Int. J. Food Sci. Tech.*, vol. 47, pp. 1866-1871

Sriasliza, M. A., Zaheruddin, K. and Shahrizal, H. (2009). “Study the Properties of Dense Hydroxyapatite Extract from Cow Bone”. *Journal of Nuclear and Related Technologies*, vol. 6(1), pp. 175-182

Tang, Z. X., Fang, X. J., Zhang, Z. L., Zhou, T., Zhang, X. Y. and Shi, L. E. (2012). “Nanosize MgO as Antibacterial Agent: Preparation and Characteristics”. *Braz. J. Chem. Eng.*, vol. 29(4), pp. 775-781

Tang, Z. X. and Shi, L. E. (2008). “Preparation of Nano-MgO using Ultrasonic Method and its Characteristics ”. *Eclét.Quím.,*vol. 33, pp.15-20

Tawaha, K. A. (2006). “Cytotoxicity Evaluation of Jordanian Wild Plants using Brine Shrimp Lethality Test”.*J ApplSci*., vol. 8(1), pp. 12-17

Venkatesan, J. and Kim, S. K. (2010). “Effect of Temperature on Isolation and Characterization of Hydroxyapatite from Tuna *(Thunnusobesus)* Bone”.*Materials*, vol. 3, pp. 4761-4772

Wang, H., Li, Y.,Zuo, Y., Li, J., Ma, S. and Cheng, L. (2007).“Biocompatibility and Osteogenesis of Biomimetic Nanohydroxyapatite/Polyamide Composite Scaffolds for Bone Tissue Engineering”.*Biomaterials*, vol. 28, pp. 3338-3348

Ye, W. and Wang, X. X. (2007). “Ribbon-Like and Rod-Like Hydroxyapatite Crystals Deposited on Titanium Surface with Electrochemical Method”. *Mater.Lett*., vol. 61, pp. 4062-4065

IMPLEMENTATION OF ANALOG SIGNAL SYNTHESIZING SYSTEM TO GENERATE DIGITAL SOUND OF MYANMAR GONG

IMPLEMENTATION OF ANALOG SIGNAL SYNTHESIZING SYSTEM TO GENERATE DIGITAL SOUND OF MYANMAR GONG

Thein Tun Oo*

Abstract

The purpose of this research work is to construct a digital system which generates the sound of C-note Myanmar gong. The system stores the predefined data code for generating the harmonics of proposed analog signal and composes these harmonics to reconstruct the sound of the gong. So this research work includes the digital signal processing techniques to create codes for pure sinusoidal signals in digital signal processor and arithmetical functioning to synthesize composite analog signal. The output signals are generated by using direct digital synthesis (DDS) method. DDS method produces a time varying signal in digital form and then performs as a digital to analog converter. Phase accumulator is used to sum phase angles for the sine look up table. The digital data are imported to the Dynamic Random Access Memory (1M x 16-bit DRAM) by using serial in parallel out register chip. The output data of DRAM is sent to digital to analog convertor (DAC), 16-bit R2R ladder network. The output signal of DAC passes through the active low pass filter to remove unwanted high frequency signals. The output signal of low pass filter is fed into the modulating circuit composing a voltage controlled amplifier (VCA) and an RC network so that the composite signal is modulated in exponentially decay form. Implementation of hardware portion includes the construction of control section using microcontroller, DAC section, external memory section, voltage controlled amplifier (VCA) and audio amplifier section. In order to get the standard quality of sound, 16-bit data processing is used. The constructed system can generate composite beat waveforms of C-note Myanmar Gong. The beat frequency of composite waveforms is 4 Hz and it is the sum of two sinusoids of adjustable amplitude and phase angle. The main component frequency of synthesized signal is 128 Hz which includes 372 sampling points and minor frequency is 124 Hz including 384 sampling points. The control program code is written using Assembly Language and it is converted to machine code (.HEX) by using MPLAB V8.50 software of Microchip Inc.

Keywords: direct digital synthesis (DDS) method, dynamic random access memory(DRAM), voltage controlled amplifier (VCA)

Introduction

Signal processing is a discipline concerned with the acquisition, representation, manipulation and transformation of signals required in a wide range of practical applications. Signals are processed for a variety of reasons, such as to remove unwanted noise, to correct distortion, to make them suitable for transmission or to extract certain meaningful information. This research work describes the approach to analyzing the frequency content of the sounds of Myanmar Gong. Fourier-based techniques are required analysis of a sound for frequency content and mathematical analysis for control parameters of the synthesizer.

The Fourier Transform converts signals from a time domain to a frequency domain. It converts a signal into magnitudes and phases of the various sine and cosine frequencies making up the signal. To simplify the analysis and design of signal processing system it is necessary to represent signals by mathematical functions of one or more independent variables. We applied Fast Fourier Transform Function of digital oscilloscope to analyze the sound of Myanmar Gong.

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A digital signal has only a finite number of values and can change only in discrete steps. A digital signal can always provide any desired precision if a sufficient number of bits is provided for each value. Digital Signal Processing (DSP) is concerned with the representation of analog signals by sequences of numbers, the processing of these sequences by numerical computation techniques and the conversion of such sequences into analog signals.

Memory stores binary data, data can be put into the memory and data can be taken out of the memory when needed. The write operation puts data into a specified address in the memory, and the read operation takes data out of a specified address in the memory. The addressing operation, which is part of both the write and the read operations, selects the specified memory address. Large systems use Dynamic RAM (DRAM) rather than Static RAM (SRAM) because of its lower cost per bit. DRAMs require more complex interface circuitry because of their multiplexed address bus and because of the need to refresh each memory cell periodically. DRAM chip is used in this research work and it is responsible for temporary storage of binary codes for output audio signal. The voltage controlled amplifier (VCA) is a four quadrant multiplier that allows a control voltage input to modify the amplitude of an input audio signal. Voltage controlled amplifier is widely used in audio systems for several purposes especially for modulation. In this research, VCA was designed to get exponential decay function.

1.1 Direct Digital Synthesis (DDS) Technology

DDS technique is rapidly gaining acceptance for solving frequency (or waveform) generation requirements in both communications and industrial applications because single-chip IC devices can generate programmable analog output waveforms simply and with high resolution and accuracy. DDS principle of operation can be easily understood with the Fig.1.1. Phase accumulator will take the frequency tuning word as input and converts into angular phase and then it is converted into the sine wave amplitudes. Algorithm and then it is converted to analog sine wave output by DAC converter. The output frequency mainly depends on the reference-clock frequency and tuning word. The frequency tuning word is the main input to the phase accumulator. Phase accumulator is used to compute the phase (angle) address.

$$F_o = \frac{M \times F_c}{2^N}$$

Where: F_o is the output frequency of DDS, M is the frequency tuning word, F_c is the internal clock frequency and N is the length of the phase accumulator in bits.

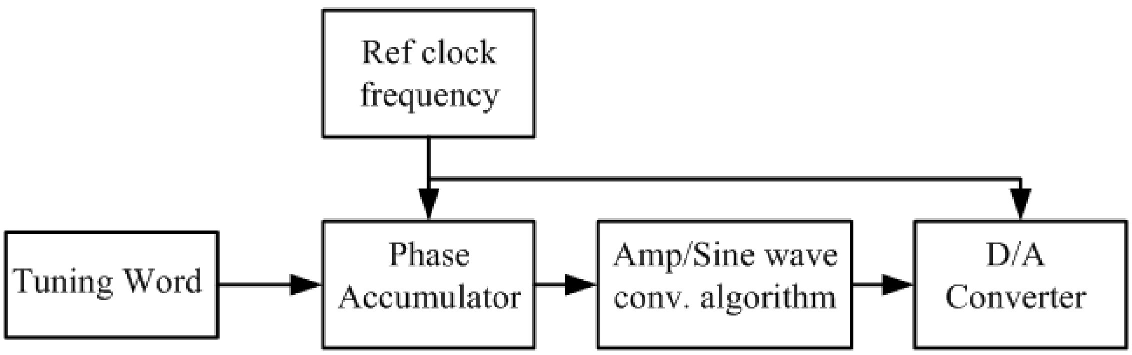


Figure 1.1 Direct digital synthesis (DDS) architecture

1.2 Myanmar Traditional Musical Instruments and Gong (ဂေါင်း)

Myanmar traditional musical instruments can be classified into five groups. They are Kyey (ကြေး) (metal instruments such as brass gong), Kyo (ကြိုး) (string instruments such as harps), Thaye (သားရေ) (instruments made of leather such as drums), Lei (လေ) (wind instruments such as flutes) and Let Khoke (လက်ခုပ်) (percussion instruments used for timing such as bamboo clappers). Among them we analyze the sound of gong and then construct a digital system which generates the sound of Myanmar gong. There are different kinds of gong depending on their size (eg. Maung, Kyey Naung, Wa Maung, Teta Maung, etc.).

International notes of music are Do (C), Re (D), Me (E), Fa (F), So (G), La (A) and Te (B). As for Myanmar gone, the method of naming is Ta Pauk (တစ်ပေါက်သံ, သံမှန်) (first note C), Khunhit Pauk (ခုနှစ်ပေါက်သံ) (seventh note D), Chauk Pauk (ခြောက်ပေါက်သံ), Nga Pauk (ငါးပေါက်သံ), Lay Pauk(လေးပေါက်သံ) (fourh note G), ThonePauk(သုံးပေါက်သံ) (third note A) and Ngha Pauk (နှစ်ပေါက်သံ)

A gong is an East and South East Asian musical percussion instrument that takes the form of a flat, circular metal disc which is hit with a mallet. Suspended gongs are more or less flat, circular discs of metal suspended vertically by means of a cord passed through holes near to the top rim. Gongs are deliberately made to generate in addition a beat note in the range from about 1 to 5 Hz. Photograph of front view and back view of the C-note Myanmar Gong (တစ်ပေါက်သံ) is shown in Fig.1.2.

(a) (b)

Figure 1.2 Photograph of front view and back view of the C-note Myanmar Gong (တစ်ပေါက်သံ)

1.3 Application Review

DDS is a method of producing an analog waveform usually a sine wave by generating a time-varying signal in digital form and then performing a digital-to-analog conversion. Because operations within a DDS device are primarily digit, it can offer fast switching between output frequencies, fine frequency resolution, and operation over a broad spectrum of frequencies. With advances in design and process technology, today's DDS devices are very compact and draw little power. Fig.1.3 shows the photograph of LeCroy wave station 2052, 50 MHz arbitrary waveforms generator. This instrument is manufactured by Teledyne LeCroy instruments Ltd,

USA. LeCroy 2052 generator can generate a wide variety of waveforms between 1 μHz and 50 MHz with 14-bit resolution, up to 500 MS/s (mega-samples per second).

Figure1.3 Photograph of arbitrary waveforms generator, LeCroy wave station 2052

Block Diagram of the Whole System

The proposed system consists of seven main units. They are user interface input unit, main control unit, random access memory unit, display unit, digital to analog converter unit, voltage controlled amplifier unit and audio amplifier unit. The block diagram of the system is described in Fig.2.1. The main control unit is responsible for generating the digital data, process control for other units and detecting the status of adjustable potentiometers. Display unit show input data, variable amplitude or phase angle. The sinusoidal waves are synthesized by using predefined binary codes and those codes are permanently stored in read only memory (ROM) of main control device, PIC16F887. The binary codes those are embedded in ROM of microcontroller and are transferred into external memory, DRAM, before they are fed to DAC in order to get faster access time of processing. So the output binary codes for DAC come from DRAM under the control of microcontroller. The DAC unit will convert binary codes coming from DRAM to the composite analog signal passing through the low pass filter. The gain of the VCA unit is controlled by the sum of the input signal control voltages and negative bias voltage of JFET. These provide all of the amplitude modulation (AM) capacity. The audio power amplifier unit is included as the final unit of the system such that the output signal strength is adequate to drive a speaker.

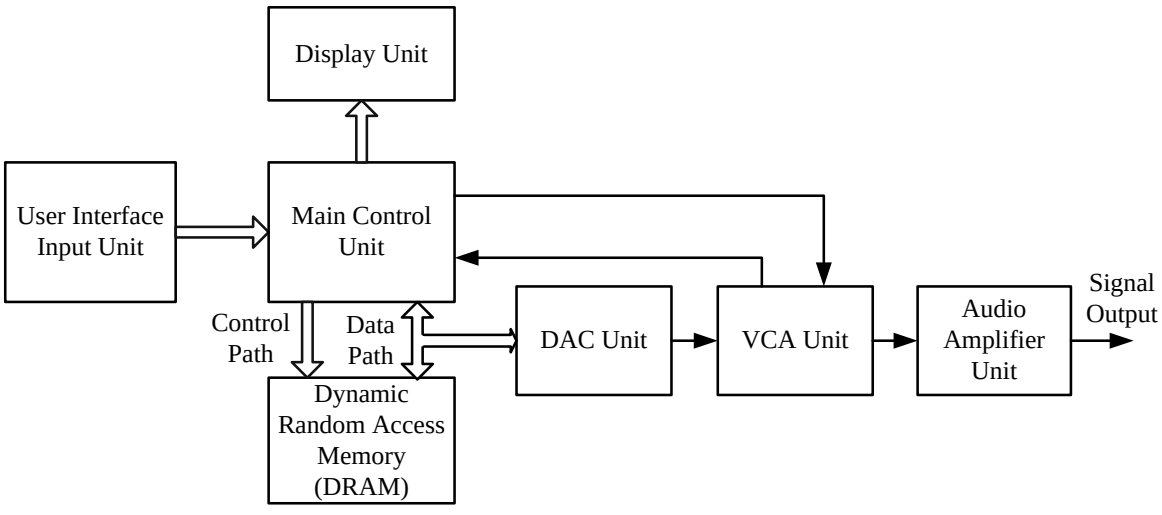
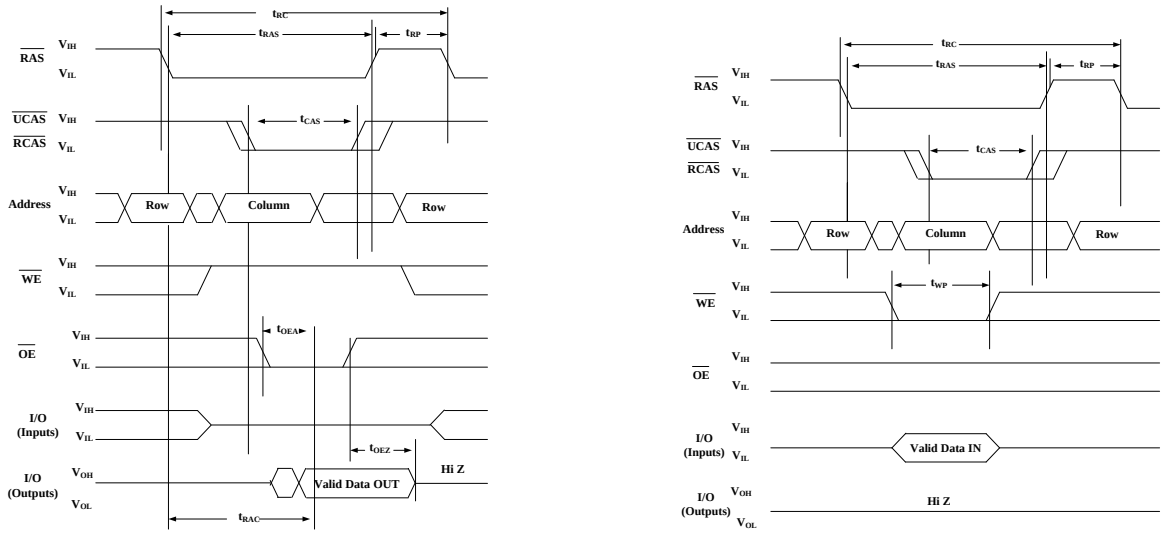


Figure 2.1 Block diagram of the whole system

2.1 Timing Diagram of Dynamic RAM (HYB5118165)

The timing diagram of DRAM for read cycle is shown in Fig.2.2(a). The falling edges of $\overline{RAS}$ and $\overline{CAS}$ strobe the address bits into the row and column latches, respectively. These must be separated by at least t_{RAS} ($\overline{RAS}$ to column address delay). As with other memories, multiple access times are specified, and the time to valid data out will depend on which is the critical path t_{OEA} ($\overline{OE}$ access time). There are two access times, t_{RAS} and t_{CAS}, for access time from valid row address and valid column address, respectivel. The read cycle time, t_{RC}, is typically much larger than the access time due to the required precharge time t_{RP}.

Write timing diagram is similar. If the write command pulse width t_{WP}, $\overline{WE}$ is asserted on the falling edge of $\overline{CAS}$, data is written from valid data IN instead of being read to data OUT. Most timing parameters are identical to the read cycle. t_{RAS} and t_{CAS} are minimum pulse widths that also apply to the read cycle but were left out of that diagram for clarity. The timing diagram of DRAM for write cycle is shown in Fig.2.2(b).



(a) (b)

Figure 2.2 Timing diagram of DRAM (a) for read cycle and(b) write cycle

2.2 Active Low-Pass Filter

A filter is a circuit that passes certain frequencies and attenuates or rejects all other frequencies. The passband of a filter is the region of frequencies that are allowed to pass through the filter with minimum attenuation (usually defined as less than -3dB of attenuation). The critical frequency, f_c, (also called the cutoff frequency) defines the end of the passband and is normally specified at the point where the response drops -3dB (70.7%) from the passband response. A low-pass filter is one that passes frequencies from dc to f_c and significantly attenuates all other frequencies.

Filters that used op-amp as the active element provide several advantages over passive filters (R, L, and C elements only). The op-amp provides gain, so that the signal is not attenuates as it passes through the filter. The high input impedance of the op-amp prevents excessive loading of the driving source and the low output impedance of the op-amp prevents the filter from being affected by the load that it is driving.

Fig.2.3 shows the response curve of active low pass filter with –20dB/decade cutoff frequency. The critical frequency of the single pole is $f_c = \frac{1}{2\pi RC}$ .The Sallen-Key is one of the most common configurations for a second-order (two-pole) filter. There are two low-pass RC networks that provide a roll-off of -40dB/decade above the critical frequency. One RC network consists of R_A and C_A and the second network consists of R_B and C_B. A unique feature is the capacitor C_A that provides feedback for shaping the response near the edge of the passband. The critical frequency for the second order Sallen-Key filter is

$$f_c = \frac{1}{2\pi\sqrt{R_A R_B C_A C_B}}$$

The component values can be made equal so that $R_A = R_B = R$ and$C_A = C_B = C$. in this case, the expression for the critical frequency simplifies to$f_c = \frac{1}{2\pi RC}$. Second order of active low-pass filter is shown in Fig.2.4.

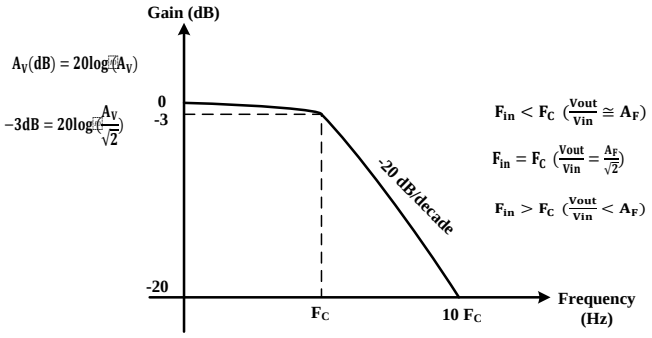


Figure 2.3 Response curve of single-pole active low-pass filter

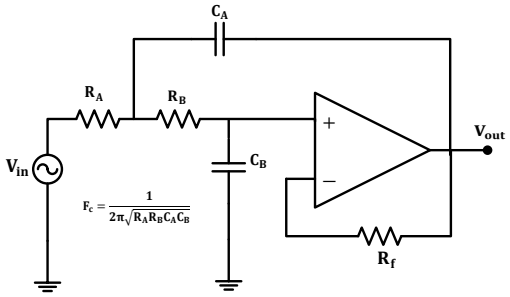


Figure 2.4 Circuit diagram of second order active low-pass filter

2.3 Voltage Controlled Amplifier (VCA)

A simple linear voltage controlled amplifier is constructed with one op-amp and two JFETs as shown Fig.2.5. VCA employs an operational amplifier with negative feedback for setting the gain (A_v). JFETs act as linear resistors over a very small range of drain-to-source voltages. VCA takes in one control input and one signal input. The voltage controlled amplifier is used in combination with envelope generators to give notes a realistic time response.

A VCA may be referred to as being two quadrants or four quadrants in operation. In a two quadrant VCA, if the control voltage input drops to less than or equal to zero, the VCA produces no output. In a four quadrant VCA, once the control voltage drops below zero, the output gain rises according to the absolute value of the control voltage but the output is inverted in phase

from the input. A four quadrant VCA is used to produce amplitude modulation and ring modulation effects.

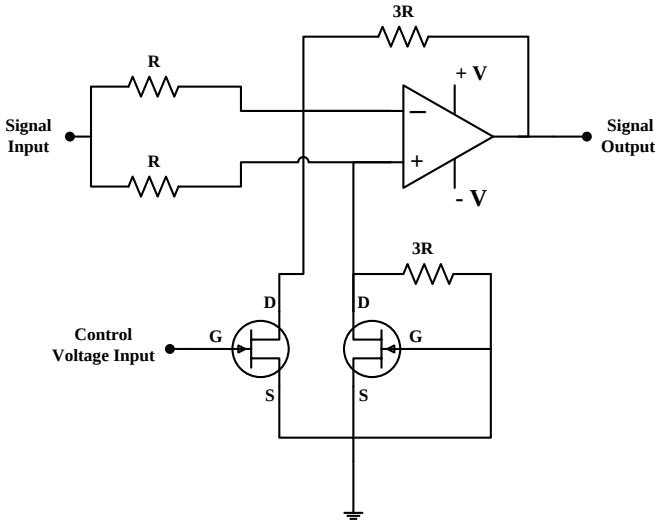


Figure 2.5 Circuit diagram of voltage controlled amplifier

Electronic Circuits of Constructed System

The main sections of constructed system are user interface section, data processing section, 16-bit R2R DAC section and voltage controlled amplifier section.

3.1 User Interface Section

In this section, a push switch and three potentiometers are used as the user interface parts for microcontroller. RB2 of microcontroller is assigned for output signal. When the "**Operate**" switch at RB2 is pressed, stored data is taken out from DRAM to generate the composite signal. The setting value can be manually changed by using potentiometers and analog voltages are detected at AN9 (RB3), AN11 (RB4) and AN13 (RB5) of the microcontroller. The input analog voltages are converted to digital data by means of built in 10-bit ADC of microcontroller and results are used as settings for output composite signal. The system can be reset using "**Reset**" switch button which is installed at RB7 of microcontroller.

A 20-character 4-line LCD module is used as the manual setting display device. The display section will show variable input data of amplitude, phase angle of minor frequency and initial phase angle of first beat. LCD shows "**Write**" while the digital data from microcontroller is writing to DRAM. When the write process is finished, LCD will show "**Ready**". The higher four data bus lines of LCD are connected to PORD (RD4 to RD7) for four bits interface method. The two control lines of LCD (RS and E) are controlled by RD2 and RD3 of microcontroller. The circuit diagram of the user interface section with display is shown in Fig.3.1.

3.2 Data Processing Section

The data processing section is the heart of the system and it uses PIC16F887 microcontroller, serial to parallel IC (74HC595) and DRAM. This section is responsible for digital data generating, process control for other sections and accepting the user interface input

switch status. In this work, the two sine waves are stored using predefined digital codes. Those codes are permanently stored in microcontroller. The microcontroller generates those codes after it is powered on and sends to the serial to parallel converter IC.

The 8-bit data is sent in a serial format of MSB first. The serial data input (DS) and shift register clock input (SHCP) are controlled by the RA0 and RA1 of the microcontroller, respectively. The 8-bit data is shifted on the positive-going transitions of the shift register clock input (SHCP). The data in each register is transferred to the storage register on a positive-going transition of the storage register clock input (STCP). If both clocks are connected together, the shift register will always be one clock pulse ahead of the storage register. Two chips are used for 16-bit data storage because each chip can handle 8-bit data. The data output of 74HC595 is put to the DRAM's for temporary storage. In order to form 16-bit digital data for digital to analog (DAC) section, control data originates from a microcontroller. Data is transferred between the PIC and the DRAM via serial to parallel IC, in conjunction with a clock signal.

RE1 and RA4 of microcontroller is controlled DRAMs row address strobe ($\overline{RAS}$) and column address strobe ($\overline{CAS}$). Microcontroller is put row address on the bus and activates the DRAM's row address strobe ($\overline{RAS}$), then put the column address onto the bus and activate the column address strobe ($\overline{CAS}$). The ($\overline{RAS}$) and ($\overline{CAS}$) lines play an important role in the refresh process. DRAM requires refresh every 16 milliseconds. A total of 10 bits are required for address lines and two ports are used for addresses. Portc (RC0 to RC7) is assigned for lower 8 bits of address and portd (RD0 to RD1) is used for higher 2 bits. Circuit diagram of data processing section is shown in Fig.3.2.

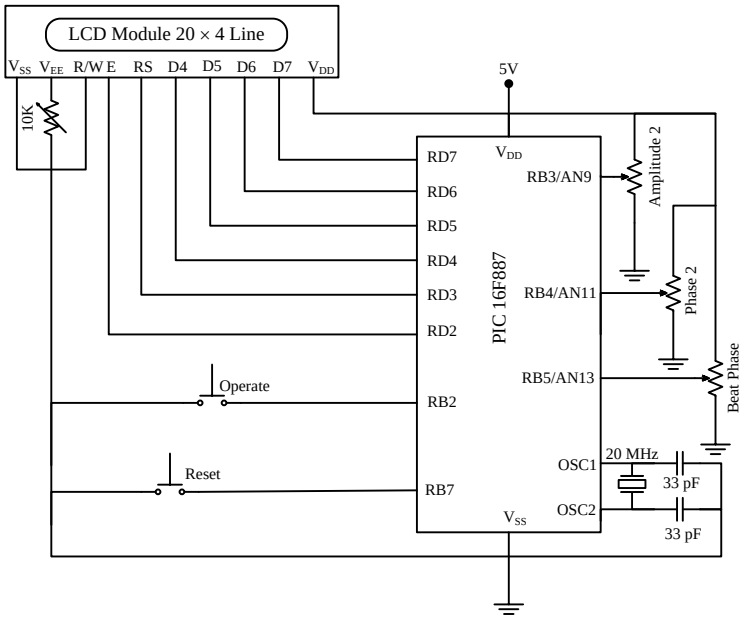


Figure 3.1 The circuit diagram of the user interface section with display

Figure 3.2. The circuit diagram of data processing section

3.3 16-bit R2R DAC Section

A 16-bit R2R ladder network is constructed by using 5 kΩ and 10 kΩ resistors (of precision 1%). Since digital devices such as microcontroller and DRAM can generate only digital data, an R2R ladder network is used to convert the analog signal using an op amp output. The output lines of DRAMs are connected to CD4050 buffer ICs. The function of buffer is to ensure the output level of dynamic RAM preventing from loading by DAC unit. The output lines of buffer IC are connected to input points of 16-bit R2R ladder network. The circuit diagram of 16-bit R-2R DAC is shown in Fig.3.3.

The output voltage of R2R ladder network is fed to the active low-pass filter. Low pass filter will pass frequencies from DC up through the cutoff frequency (f_c = 23.4 kHz) with no attenuation. If the input signal frequency is greater than cutoff frequency the circuit will attenuate the signal with -40dB/decade roll-off. Resistor R_3 (2 kΩ) is included in the feedback loop to compensate for the effects of bias currents flowing through R_1 (1 kΩ) and R_2 (1 kΩ).

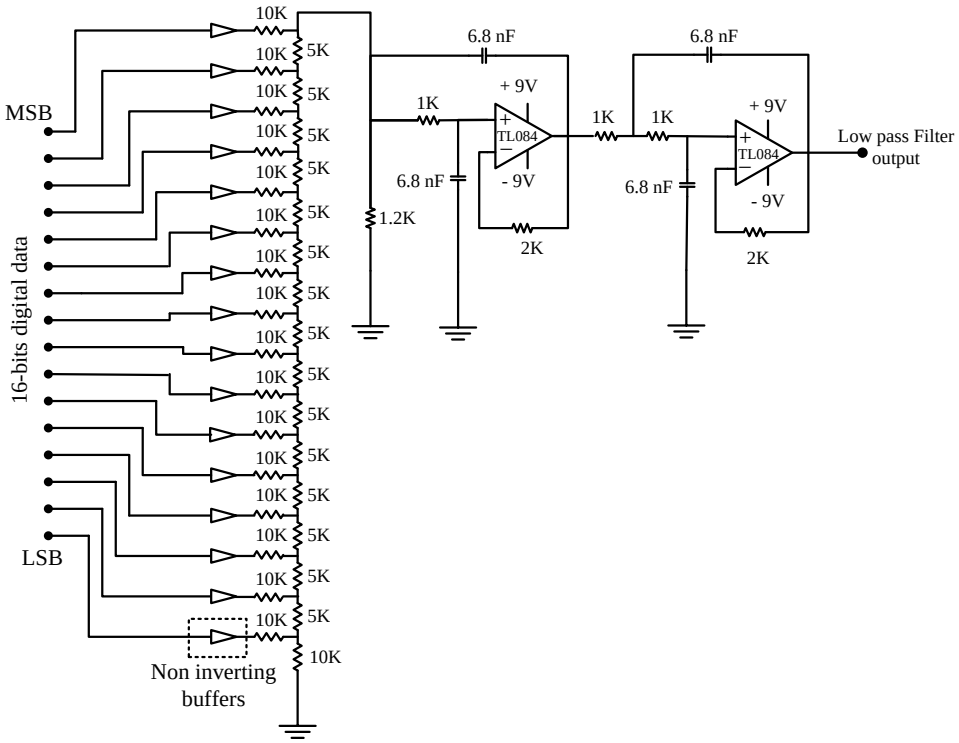


Figure 3.3 Circuit diagram of 16-bit R2R DAC section

3.4 Voltage Controlled Amplifier Section

The voltage controlled amplifier (VCA) is constructed using one op amp and two n-channel JFETs. The linear gain element in the VCA is a JFET operated in its linear region, its drain to source voltage should not exceed threshold negative voltage for the n-channel JFET. The output signal of low pass filter is fed into the non-inverting terminal and inverting terminal of the op-amp by using coupling capacitor and via resistors. The precession potentiometer (10 kΩ) which is installed at non-inverting input of op-amp is important for the operation of the circuit. It balances the differential input for common mode rejection action when the input control voltage of JFET is zero.

The negative gate voltage for n-channel JFET is provided from RC network and it exponentially changes from negative saturation voltage to zero volts. The rate of exponential decay function of RC network can be manually adjusted by means of potentiometer installed at front panel and the potentiometer is labeled as "**Sustain**". LF353 op-amp which acts as a comparator with hysteresis is used to determine whether the voltage of RC network is lower than the reference voltage or not. The output of comparator is connected RB1 of the microcontroller and if the RB1 becomes high, the microcontroller will stop generating the beat signal. Circuit diagram of the voltage controlled amplifier section is shown in Fig.3.4.Also the complete circuit diagram of the constructed system is shown Fig.3.5.

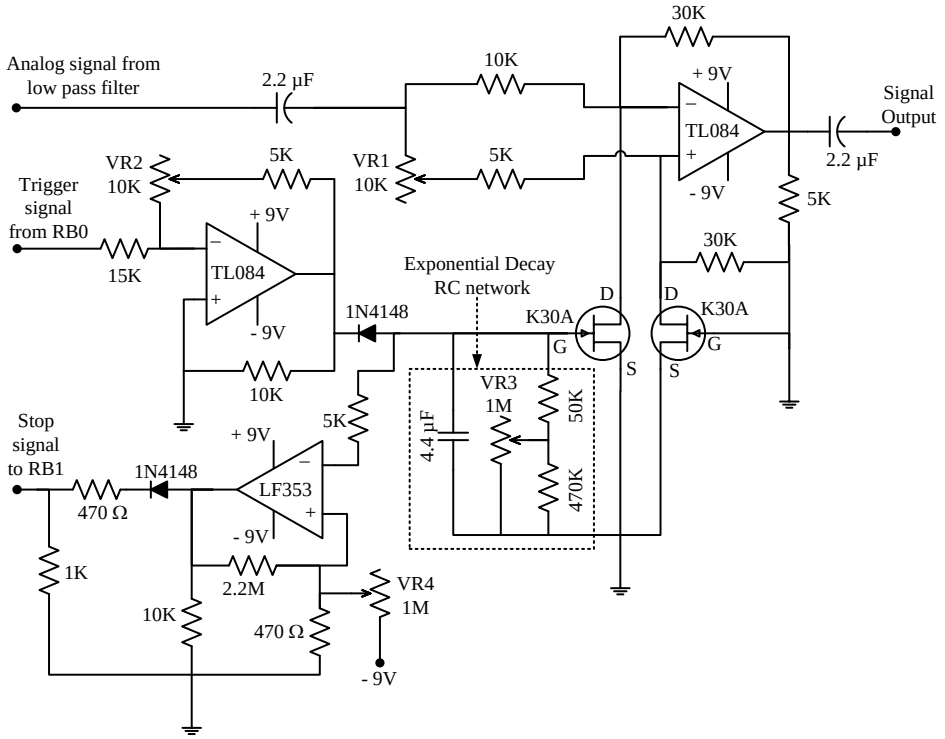


Figure 3.4 Circuit diagram of the voltage controlled amplifier section

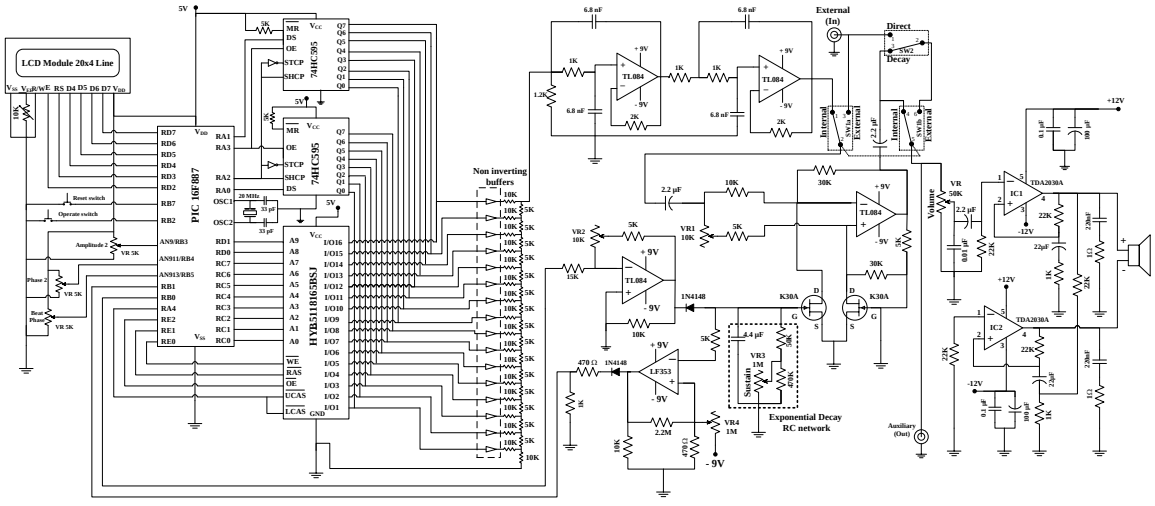


Figure 3.5 Complete circuit diagram of the constructed system

3.5 Control Program

The operation of the system is controlled by the main control unit which is the microcontroller based embedded system. The program code of analog signal synthesizing system is written with Assembly Language and the program code is converted to machine code (.HEX) by using MPLAB V8.5 software of Microchip Inc. In this section, algorithms of the control programs are presented using flowcharts. The process of function is described in flowcharts shown in Fig.3.6.

The control programs includes the LCD subroutines, calculation subroutine of each beat signal, lookup tables for data values of sinusoids, DRAM access for composite signal subroutine and composite signal data output subroutine of DRAM access. Some processes, which require routing the variable data, are assembled in macros. At the beginning of the program, the variables are initialized and located in RAM and the constants for I/O port interfacing with external devices are defined. LCD module is initialized for data communication in 4-bit mode. In order to send the command to the LCD, three different control signals are needed for LCD. The 10-bit ADC module is configured for corresponding analog input pins RB3, RB4 and RB5 for the function of manual adjusting the amplitude, phase and beat phase values. The beat frequency of composite signal is 4 Hz which is difference of major frequency 128 Hz and minor frequency 124 Hz. Microcontroller does not support negative output voltage and also the DAC section is a unipolar type, we have to compensate the negative value of sine function.

The beat frequency can be calculated by using equation (3.1).

$$f_b = f_2 - f_1 \tag{3.1}$$

The time period of the beat is inversely proportional to the beat frequency and can also be calculated by using equation (3.2).

$$T_b = \frac{1}{f_b} = \frac{1}{f_2 - f_1} \tag{3.2}$$

The data values of sampling points (X_n) is calculated by using equation (3.3).

$$X_n = \frac{(A_1 D_1 + A_2 D_2)}{(200)} \tag{3.3}$$

Where, A_1 and A_2 are amplitudes of sinusoids and A_2 can be manually adjusted by means of potentiometer. D_1 and D_2 are data values of sampling points.

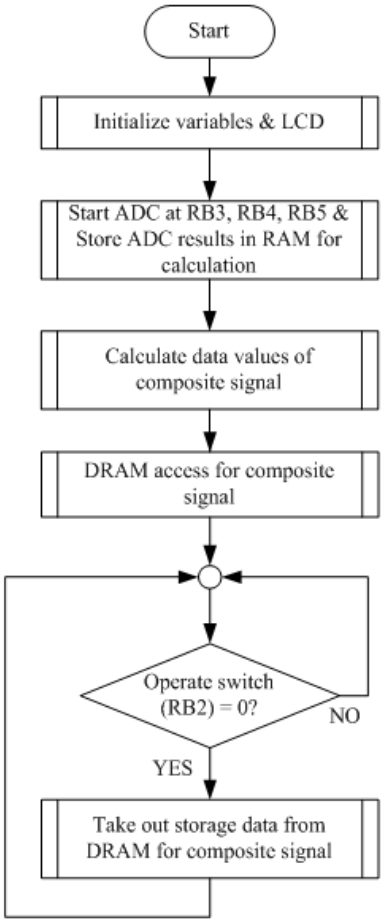


Figure 3.6 The flowchart of main function

Results

A digital system, which can generate the sound of Myanmar gong, is constructed in this research work. The system is designed for production of analog signal using digital data. The preliminary step of processing is to store the predefined data code for generating the harmonics of referred analog signal and then to construct the sound of gong. So this research work includes the studying on digital signal processing techniques as well as arithmetical functioning to synthesize composite analog signal.

The system is separated into three main boards: digital data processing board, voltage controlled amplifier (VCA) board and audio amplifier board. In the digital data processing unit, DDS method is used to generate the corresponding digital codes for proposed analog signal. The digital codes are stored in a DRAM and then outputted with constant sampling rate. The DRAM's digital signal output is converted to an analog sinusoidal signal by a DAC. The stair-case steps seen at the DAC output are filtered by a low pass filter to provide a clean sinusoidal wave output. The output signal of the low pass filter is fed to input of the voltage controlled amplifier (VCA) which is used in exponential modulator circuit. The final output composite signal is amplified to get adequate signal level for speaker. The VCA is designed for reliable performance for required exponential decay gain control, low distortion and low dc bias

modulation. This part controls gain by converting an input signal to a logged voltage, adding a RC network control voltage, and re-converting the summed voltage back to a signal output.

The photograph of digital data processing circuit boards of constructed system is shown in Fig.4.1. The photograph of voltage controlled amplifier circuit is shown in Fig.4.2. The front view and back side view photographs of the constructed system are described in Fig.4.3 (a) and Fig.4.3 (b) respectively.

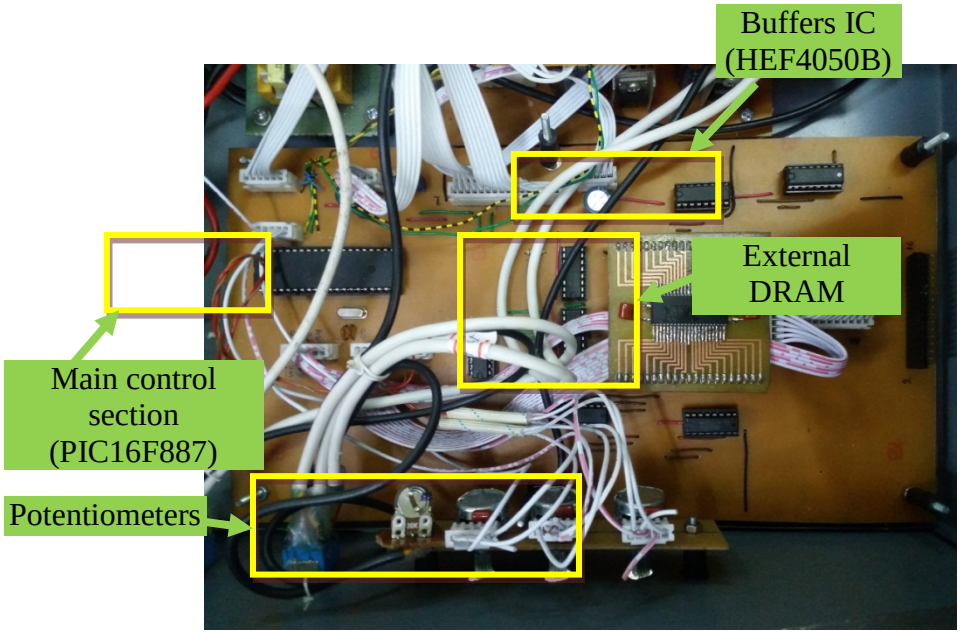


Figure 4.1 Photograph of digital data processing circuit

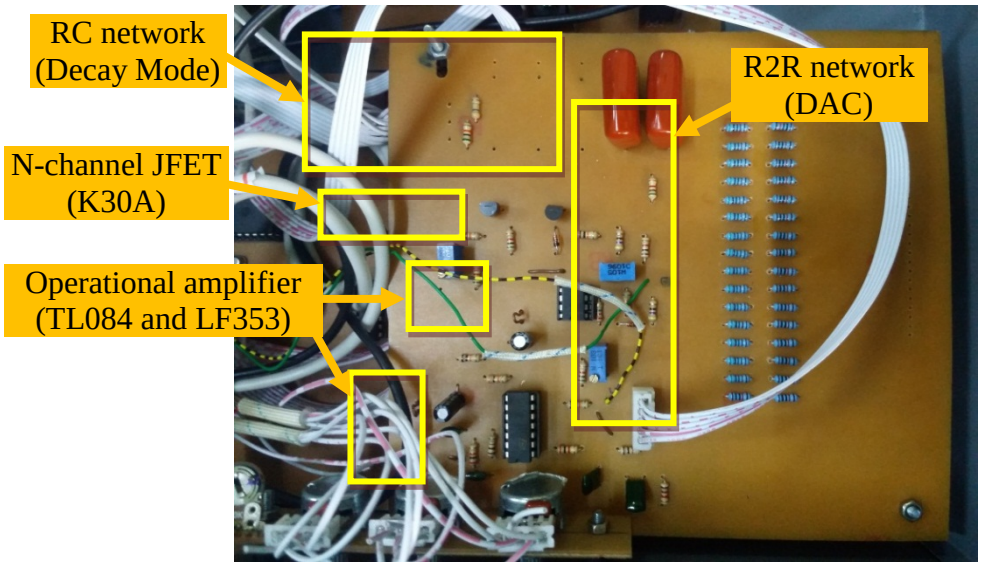


Figure 4.2 Photograph of voltage controlled amplifier (VCA) circuit

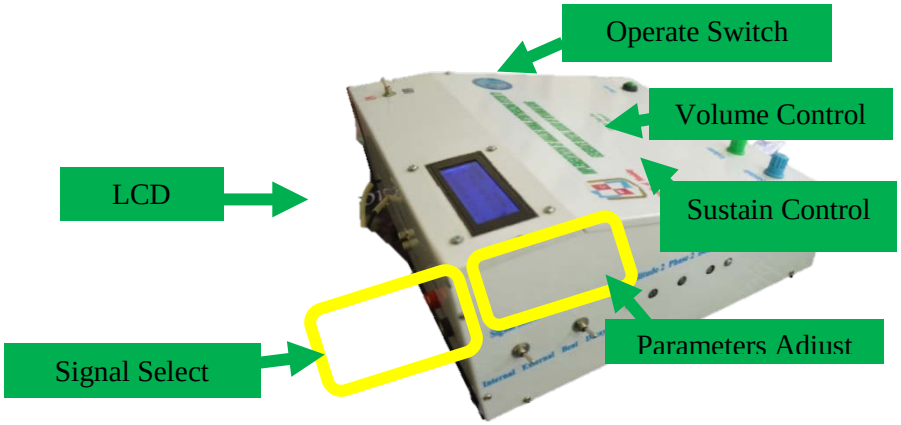


Figure 4.3 (a)Photograph of the left side front view of the system

Figure 4.3(b) Photograph of the right side front view of the system

4.1 Generating the Digitized Composite Waveform

The proposed signal is generated by using direct digital synthesis (DDS) method under the control of microcontroller. In DDS method, a time varying signal is produced in digital form and the phase accumulator is used to add the phase angle for data fetching from the sine lookup table. The digital data are imported to the Dynamic Random Access Memory by using serial in parallel out IC. After that, output data from DRAM is fed to a digital to analog converter and then to fourth order active low-pass filter. The demonstration of step by step signal processing and synthesizing in our system is depicted in Fig.4.4.

The final output is smoothened analog signal which is the composition of two sinusoids of different frequencies, amplitude and phases. The waveform of gong sound which is used as the reference signal is taken from Mandalay National High School of Arts (မန္တလေးပန်တျာကျောင်း) by using digital oscilloscope (DS1102E), microphone and personal computer. The oscilloscope snap-shot of sample sound is depicted in Fig.4.5. This composite waveform contains eleven beats and the signal is found to be decayed exponentially. Also the FFT spectrum of sample sound is described in Fig.4.6 and two peaks show the beat frequency.

The composite signal is synthesized using two sinusoids and the corresponding predefined binary codes are embedded in ROM of main control device in the form of lookup

tables. The number of sampling points in each sinusoid differs from another according to their frequencies. The predefined codes for the component frequencies of composite signal are used in arithmetic process to form the beat and then they are transferred into external memory, DRAM, in order to apply as sampling points. In this step, the data is not directly transferred to DAC section and DRAM is used for temporarily storage because data accessing via DRAM is fast so that the optimum sampling rate can be obtained. The DRAM chip used in this system can store the 1048576 words in16-bit format and data size is organized in 20-bit wide address bus, 10 rows and 10 columns.

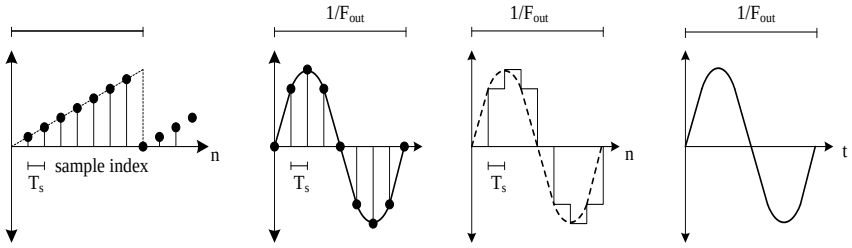


Figure 4.4 Demonstration of data flow in DDS method (a) phase accumulator output (b) phase to amplitude converter output (c) DAC output and (d) filter output

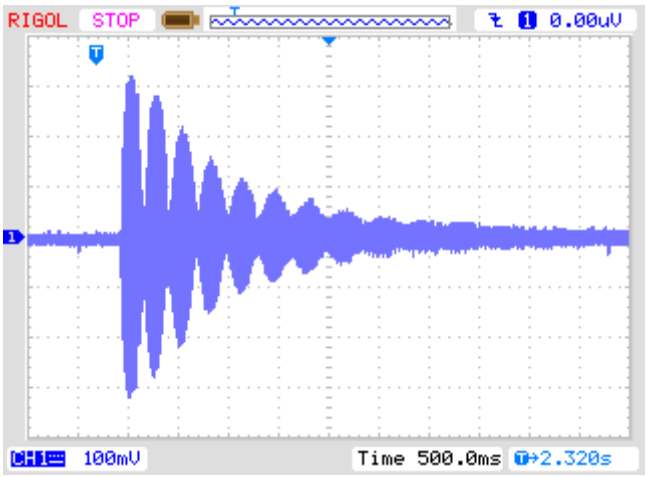


Figure 4.5 Oscilloscope snap-shot of referred waveform of gong

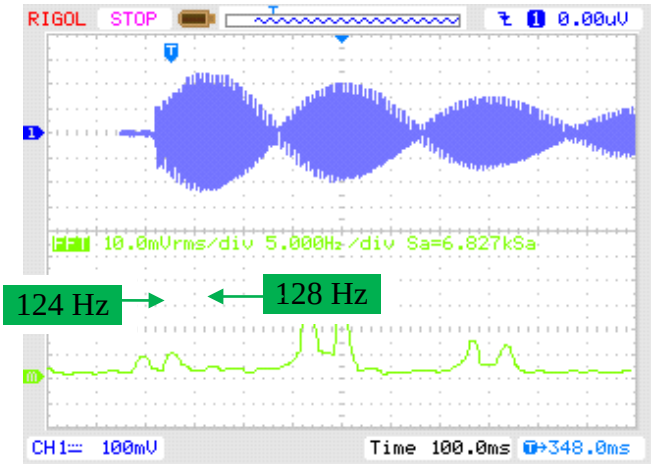


Figure 4.6 FFT spectrum of sample waveform of gong

The main component frequency is 128 Hz which includes 372 sampling points and minor frequency 124 Hz includes 384 sampling points. The time interval between two successive sampling points (sampling time) is 21 μs and so sampling frequency is 47.61905 kHz. Thus we can analytically obtain the frequencies of components in output waveform using above parameters such that the period of main component frequency is 7812 μs resulting the frequency value 128.0082 Hz. For the minor component, the period is 8064 μs and the frequency is 124.0079 Hz. By interference, the resultant composite signal has beat frequency 4 Hz and it is rounded value using 128 Hz and 124 Hz. In analytical point of view, the total number of sampling points in a beat is 11904 and it is obtained by using the parameters of two component frequencies. Since the sampling time is 21 μs, the period of beat signal is 249984 μs which resulting the beat frequency 4.0002 Hz.

4.2 Exponential Decay of Beat Signal

The main purpose of the VCA is to provide amplitude control function and exponentially decayed beats are formed by means of VCA in this system. The VCA in this system is a two quadrant multiplier that allows the negative gate voltage of JFET controls the overall gain of VCA. The negative gate voltage of JFET is obtained from RC network and it exponentially decays after triggering. The prolongation time of output signal depends on the RC time constant and it can be adjusted by varying the resistance in our system.

In the user interface section of system, the potentiometer for "**Sustain**" is used to set prolongation time of output signal. This is an important feature to adjust the sustain level because it allows the user to create more realistic sound sample of Myanmar Gong. The oscilloscopes snapshots of decay waveform are shown in Fig.4.7 through Fig.4.9 for different sustain levels. The digitally synthesized beats are continuously generated from digital data processing section during the decay function is in active and they are stopped when the output signal becomes fade out. The maximum and minimum sustain levels causes 29 beats and 5 beats in output signal respectively.

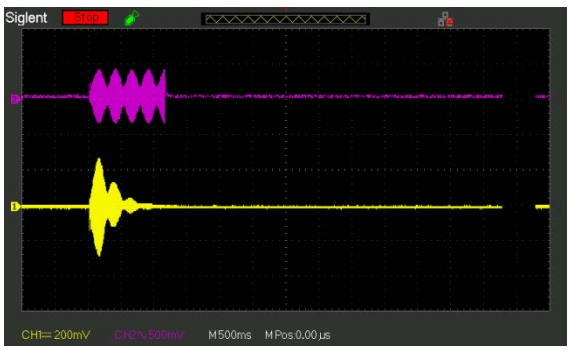


Figure 4.7 Oscilloscope snap-shot of output signal with minimum sustain level

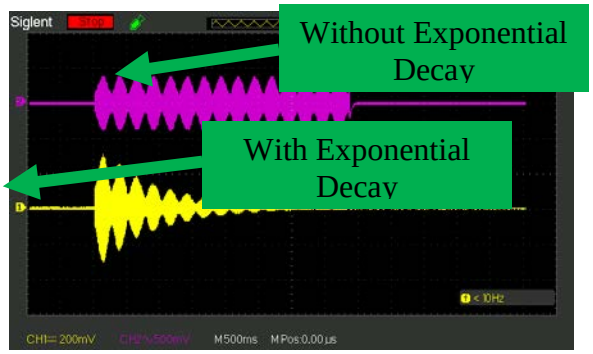


Figure 4.8 Oscilloscope snap-shot of output signal with moderate sustain level

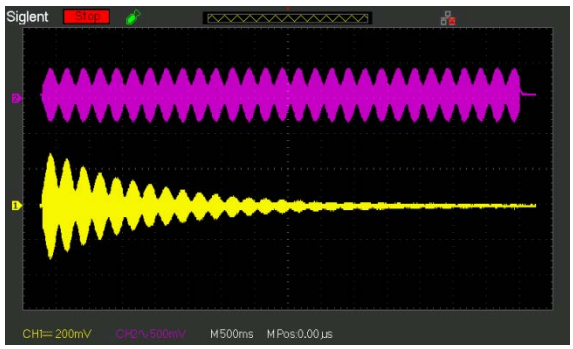


Figure 4.9 Oscilloscope snap-shot of output signal with maximum sustain level

4.3 Discussions

The proposed system has been implemented and the system can generate sound of Myanmar Gong. The performance characteristic of the system is analyzed. The important parts hardware section and control program are also described. In this system, the composition of two sinusoids to form the beats is accomplished by means of digital data processing and the exponential function is integrated with an analog circuit. This is because of limitation of memory space of microcontroller and also to save the initialization time of system.

In the previously discussed version of this system, the decay function is tested with linear function and the output signal is synthesized in digital processes fully. The weakness of that version is that the system needed too long time (about 7 minutes) for calculation to get a complete group of beats as in sound of gong. That processing time is requirement to store the sampling point data of 11 beats in DRAM. The oscilloscope snapshot of linearly decayed signal is described in Fig.4.10 and it can be compared with present signal (with exponential decay function) in Fig.4.11.

The output signal is analyzed with FFT function of digital oscilloscope. The FFT spectrum of generated waveform is described in Fig.4.12 for decayed beats and in Fig.4.13 for pure beats. The pure beats are generated from the digital section and they are fed to VCA section for decay process. In both Fig.4.12 and Fig.4.13, the two significant peaks show the component frequencies and also the beat frequency can be obtained.

The LCD module shows the status of system such as component frequencies, relative amplitudes, phase angles and operation condition. While the system is at the state of data processing according to input setting, the word "**Write**" will be displayed at LCD and it will take a time for 17 s. If the system finishes data processing, it is ready to generate the output signal and the word "**Ready**" will be displayed as shown in Fig.4.14. Also the different waveforms for different input settings are described in Fig.4.15 through Fig.4.17 comparing with LCD and oscilloscope snapshots.

Figure 4.10 Oscilloscope snapshot of linearly decayed output signal (previous version without VCA)

Figure 4.11 Oscilloscope snapshot of exponentially decayed output signal (using VCA for decay function)

Figure 4.12 Decayed beats and FFT spectrum

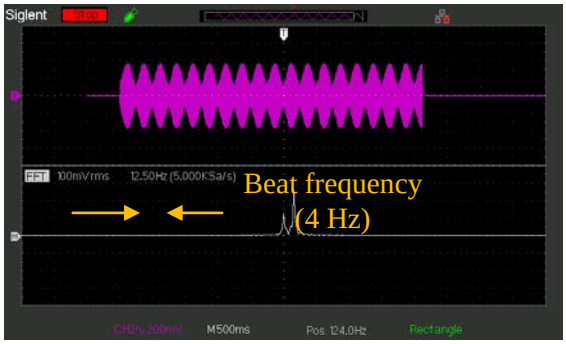
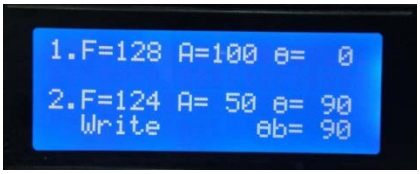
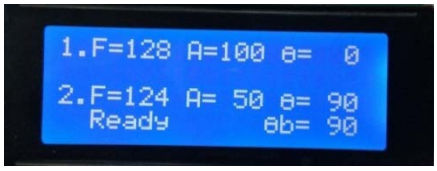


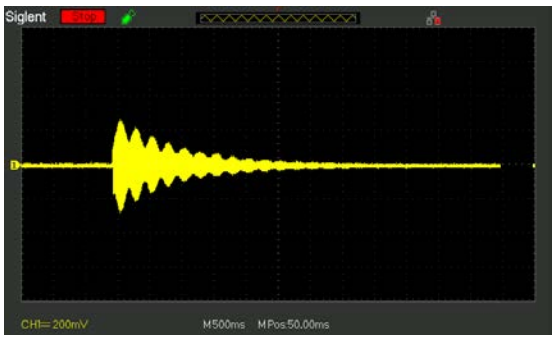
Figure 4.13 Pure beats and FFT spectrum





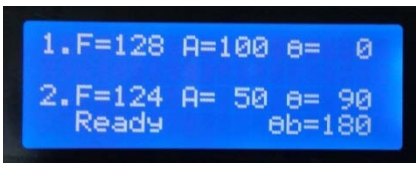
(a) (b)

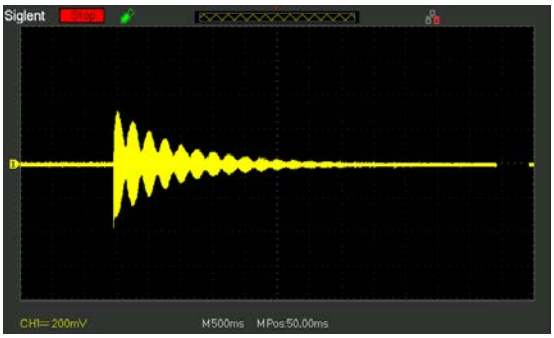
Figure4.14 The photographs of the LCD display for (a) user input data writing to DRAM (b) ready state to generate output signal



(a) (b)

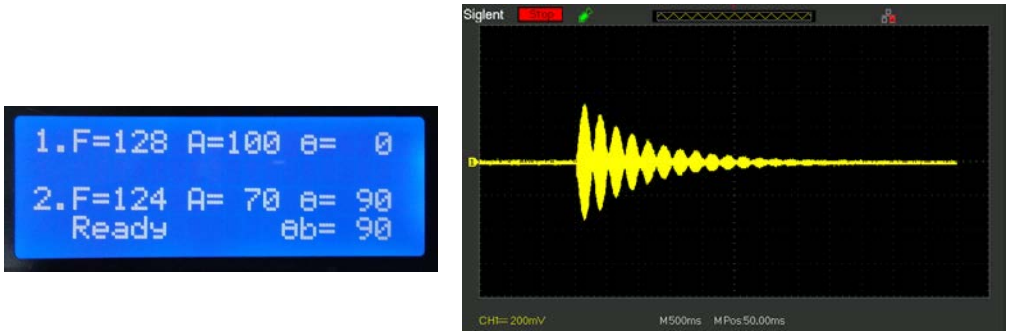
Figure 4.15 The photographs of (a) LCD display and (b) oscilloscope waveform of composite signal for A1=100, A2=30, Θ1=0°, Θ2=90°, and Θb=90°





(a) (b)

Figure 4.16 The photographs of (a) LCD display and (b) oscilloscope waveform of composite signal for A1=100, A2=50, Θ1=0°, Θ2=90°, and Θb=180°



(a) (b)

Figure 4.17 The photographs of (a) LCD display and (b) oscilloscope waveform of composite signal for A1=100, A2=70, Θ1=0°, Θ2=90°, and Θb=90°

Conclusion

In this research work, a digital system which generates the sound of C-note Myanmar gong has been constructed. The reference sound of Myanmar Gong is obtained from Mandalay National High School of Arts (မန္တလေးပန်တျာကျောင်း). The output signal of system is the exponentially decayed 4 Hz beats. The main component frequency of synthesized signal is 128 Hz and minor frequency is 124 Hz. Some parameters of output signal such as prolongation, relative amplitude of minor sinusoid, phase of minor sinusoid and initial phase of output beat signal can be manually adjusted. The implemented system can be used to generate the sample sound of gong for various conditions of composition. Based on this system, further research works can be conducted for other different music notes of gongs. The present system is expected to be a useful framework for future researchers in the field of digital synthesizing the sound of Myanmar musical instruments.

References

B.Suresh and M. V.Srikanth, “DDS Based Multi-Channel Radar Waveform Generator”, International Journal of Recent Technology and Engineering (IJRTE), ISSN: 2277-3878, Volume-2, Issue-3, July (2013).

D.G. Manolakis and V. K. Ingle, “Applied Digital Signal Processing”, Cambridge University Press, United Kingdom (2011).

G. Kavaiya, “AN778: Implementing the External Memory Interface on PIC18C601/801 MCUs”, Microchip Technology Inc., United State of America (2001).

J. Ilett, “How to Use Intelligent LCDs”, Everyday Practical Electronic magazine, December (2006).

Microchip Technology Inc., “PIC16F882/883/884/886/887 Data Sheet, 28/40/44-Pin, Enhanced Flash-Based 8-Bit CMOS Microcontrollers with nanoWatt Technology”, United State of America (2008).

National Semiconductor Corporation, “LF353 Wide Bandwith Dual JFET Input Operational Amplifier Data Sheet” (2003).

NXP Semiconductors, “74HC595 8-bit serial-in, parallel-out shift register with output Latches:3-state,” Rev.7-26 January (2015).

NXP Semiconductors, “HEF4050B Hex non-inverting buffers,” Rev.8-18 November (2011).

R. R. Y. Yarlagadda, “Analog and Digital Signals and Systems”, Oklahoma State University, United State of America(2010).

Teledyne LeCroy Instruments Co. Ltd**,** “LeCroy Wave station 2050, 50MHz”,United States of America.

T. L. Floyd, “Electronic Devices”, Seventh Edition, Pearson Prentice- Hall, United States of America (2005).

T.L. Floyd, “Digital Fundamental”, Ninth Edition, Pearson Prentice- Hall, United States of America (2006).

SIEMENS Semiconductor Group, “HYB 5118165BSJ/BST-60 Data Sheet, 1Mx16-bit Dynamic RAM”, (1998).

တင်ထွန်းဦး (ယဉ်ကျေးမှု) ၊ “မြန်မာ့ရိုးရာယဉ်ကျေးမှုဆိုင်းတူရိယာများ” ၊စာပေဗိမာန်ထုတ် ပြည်သူ့လက်စွဲစာစဉ် (၂၀၀၇ ခုနှစ်)။

ယဉ်ကျေးမှုဝန်ကြီးဌာန၊ “မြန်မာ့ရိုးရာတူရိယာပစ္စည်းများ” ၊ ဂုဏ်လင်းကျော် ပုံနှိပ်တိုက် (၂၀၀၃ခုနှစ်)။

APPLICABILITY OF FISH SCALE BASED BIOMATERIALS IN HARD TISSUE IMPLANTATION

၂-၆၊ APPLICABILITY OF FISH SCALE BASED BIOMATERIALS IN HARD TISSUE IMPLANTATION

Lai Lai Aye*

Abstract

Optimum temperature to extract fish (*Notopterus notopterus*) scales for hydroxyapatite (HAp) without other impurities was 800°C. XRD, FTIR and SEM analyses showed that these HAp were nano-sized porous particles. Purity was confirmed by TGA, protein content and Ca/P ratios, and pore %was calculated by image J software. EDX was used to analyse the concentration of elements in the F.S.HAp. Toxic heavy metals detected at ppb level by AAS were much lower than that of maximum permitted level of International/National Standards for heavy metals in food. Albino mices given F.S.HAp showed no toxic symptoms up to fourteen days after administration. The hardness value, 274 (HV) of F.S.HAp-GIC compound solid structure (3:1:8), was greater than that of pure GIC compound and F.S.HAp-ZPC compound. This value is very near to that of human hard tissues and the studied F.S.HAp-GIC compound may be suitable as a substitute in hard tissue engineering. The 75.8 nm crystals and 151.6 nm-265.4 nm particles of F.S.HAp may not be able to diffuse naturally into the tooth enamel which has pores of smaller in size. The F.S.HAp-GIC compound (3:1:8) was found to be firmly attached to the tooth defect areas. This compound was also successfully used to substitute in defective skull bone in Wistar rat. Histological evidences showed this compound coalesced into natural skull bone tissue and they coexisted well after substitution.

Keywords: hydroxyapatite; XRD; SEM; EDX; AAS; F.S.HAp-GIC

Introduction

Unprecedented expansion of human populations causes increased consumption of aquatic fauna which have many proven health benefit. As a consequence, fishery by-products are subject to strict environmental regulations due to limited land and increased environmental concerns such as ground water contamination and foul odor. Nevertheless these biowastes are not always considered as a mainproblem in human welfare because many potential values contained in these biowastes. As most of these biowastes are rich source of calcium, the extracted biomaterials may be applied in reconstruction of human hard tissues(teeth and skeletons). Therefore many researchers are trying to produce biomaterials from various biowastes such as egg shells and its membrane, fish collagen and fish oil, corals, snail and oyster shells, vertebrate bones, shrimp and crab exoskeletons. One of the aquatic biowastes, fish scales are biocomposite of highly ordered type I collagen fibers and hydroxyapatite $\{Ca_{10}(PO_4)_6(OH)_2\}$. Moreover, hydroxyapatite is always considered as a basic structural compound of tooth and skeletal tissues, and the biomaterial extracted from fish scales may fulfill the mineral requirement of tooth and skeletal tissues. At the same time there has been a growing interest in natural ingredients which are readily available from animal by-products rather than using synthetic chemicals to fulfill the needs of human beings. HAp is most important to synthesize nano-composites in order to have good biocompatibility, high bioactivity and great bonding properties. HAp promotes faster bone regeneration, and direct bonding to regenerated bones without intermediate connective tissue (Palanivelu, 2013). Due to the properties of hydroxyapatite it has widely been used in biomedical and dental practices due to its similarity to main mineral components of hard tissues of human

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body. Therefore HAp biomaterials from different biowastes can widely be used in human body for tissue repair and substitution still expand to date.

In bone defect reconstruction caused by a benign tumor or trauma, use of autologous and allograft bone has been popularly used in clinics. However use of autologous bone is known to result in secondary trauma and allograft bone induces immune repulsion. In addition, since bone grafts are avascular and are dependent on diffusion, the use of autologous and allograft bones are limited by the size of the defect and viability of the host vascular bed. It was reported that graft in large defects were resorbed by the body before the completion of osteogenesis. To solve these problems, many researches have focused on the use of artificial bone-like materials such as bone cement and bioglass. However as some cements are prepared in the operation room, they are therefore susceptible to infection (Oh *et al*., 2006). In an attempt to solve some of the problems associated with the use of autologous bone, allograft and bone cement, the advent of tissue engineering has become a major area of medical research as the search continue to develop better materials to replace lost or missing tissue from the human body (Oh *et al*., 2006). For reconstruction of local bone defect, usually an autogenous bone graft is used; particulate cancellous bone and marrow grafting especially give superior results, because the transplanted cells are capable of forming new bone. There are some disadvantages, however, in the use of autogenous bone grafts, such as (i) the limitation in the amount of available bone for transplantation, (ii) the difficulty in forming a desired shape, and (iii) the requirement for a second surgical procedure with its associated risks. Recently, many kinds of synthetic materials have been developed for use as a bone substitute. Hydroxyapatite, in particular, is considered to be one of the best bioactive ceramics for a bone substitute because of its superior osteoconductivity (Asahina *et al*., 1997). Because of the constant and increasing demand for reconstruction of hard tissues in the treatment of bone defect, autologous bone graft options have been designed. Though the most widely used are allografts and xenografts, synthetic alternative known as bone substitutes are currently being developed. Ideally, these substitutes must be biocompatible and possess a structure similar to bone, easy to use and affordable. It is reasonable to believe that combination of the materials will provide better results than the autologous bone graft (Sesman *et al*., 2013).In conjunction with glass ionomer cement, nano-HAp extracted from fish scales can be used in field of restorative dentistry and bony substitution as a bioceramic material.

Aim and Objectives of the Study

The aim of this study is an attempt to provide a production of HAp from the fish scales and to determine the applicability of this HAp as substitution of bony defect.

The objectives of the present study were

(1)to extract hydroxyapatite (HAp) from scales of the fish (*N. notopterus*)

(2) to determine the particle size of F.S.HAp

(3) to formulate HAp-GIC compound and determine its hardness and pore diameter and

(4) to assess the feasibility of HAp-GIC as a substitute for bone defects by test on Wistar rat skull bone.

Materials and Methods

3.1 Study area and study sites

Fish scales were collected from Mingaladon market. Extracted teeth and GC Glass Ionomer was bought from dental pharmacy, University of Dental Medicine, Yangon. Characterization of fish scales hydroxyapatite (F.S.HAp)was done at Universities' Research Centre at Yangon University, National Laboratory, Department of Research and Innovation, and Customer Support Analytical laboratory atAmtt Company, Yangon. Animal study was carried out at Animal Services Division, Department of Medical Research. Repair of tooth defect area was carried out at the Department of Zoology, University of Dental Medicine, Yangon. Substitution of bone defect with F.S.HAp-GIC solid structure was done at the Animal Services Division, Department of Medical Research, Yangon. Microscopic study was carried out at the Department of Pathology, University of Medicine-1, Yangon.

3.2 Study period

This study was conducted from December, 2014 to May, 2018.

3.3 Materials

The following materials were used in this study.

- Fish (*Notopterus notopterus*) scales
- 1N HCl
- 1N NaOH
- Microwave-oven (800 watts)
- Balance
- Muffle furnace
- X-ray Diffractometer
- Scanning Electron Microscope (SEM)
- Energy Dispersive X-ray Diffractometer (EDX-720, Shimadzu, Japan)
- Atomic Absorption Spectrophotometer (AA-6300), Shimadzu, Japan
- Spectrophotometer (UV-1800), Shimadzu, Japan
- Female Albino mice(foracute toxicity test)
- Male Wistar rat (for skull bone reconstruction)
- Glass Ionomer, Fuji I (GC, Japan)
- Ketamin
- Xyla
- Surgical instruments
- Bone driller
- Betadine

3.4 Methods

3.4.1 Fish scale collection and nutrition test

Notopterus notopterus fish scales were collected from Mingaladon Market in Yangon Region. Peeled fish skins were bought from fish sellers. The scales were removed from the fish skins and washed repeatedly with tap water up to get externally cleaned fish scales. And then the scales were filtered with plastic sieve to remove debris. Components in the raw fish scales were examined by nutrition package test at FIDSL in UMFCCI.

3.4.2 Fish scale treatment

Fish scales were initially deproteinized with 1(N) HCl (Analytical grade, 35%) solution(2:1, v/w, water HCl/fish scales) for 24 hours at room temperature. After that they were filtered and washed thoroughly several times with distilled water. Next, remaining proteins of fish scales were treated with 1(N) NaOH solution. The filtered fish scales were washed thoroughly with distilled water(Plate 3.2) and dried in microwave-oven for several hours to reach the state of brownish coloured brittle scales.

3.4.3 Synthesis of biomaterial powders from fish scales

Fish scale sample batches (Plate 3.2) were heated separately in the Muffle furnace at different temperatures i.e-600°C, 700°C, 800°C, 900°C and 1000°C respectively to obtain the powder (Plate 3.3).

3.4.4 Extraction of fish scales biomaterials

Fish (*Notopterus notopterus*) scales biomaterials were extracted using procedure shown in Fig. 3.1.

3.4.5 Powder characterization

All powders of different temperatures were confirmed as hydroxyapatite by XRD analysis. Purity of F.S.HAp was confirmed by protein content and Ca/P ratio. Toxic heavy metal content was examined by EDX and AAS. Ca/P ratios (weight ratio and mole ratio) of F.S.HAp were calculated at customer support analytical laboratory, Amtt company and matched with that of enamel and dentine. Particle sizes were determined through Scanning Electron Microscope at National Laboratory. Pore %in the F.S.HAp was calculated by Image J software.

Effect of thermal treatment on physical appearance, ash yield % and protein content of all powders were observed in the range of temperature between 600°C-1000°C. Protein content in each sample was examined by titration method at FIDSL in UMFCCI.

Ca/P weight ratios and molar ratio of fish scales HAp were calculated at Laboratory Services, Amtt Company.

Presence of HAp in *N.notopterus* fish scales powders at different temperatures are confirmed by X-ray diffraction study results. For tissue engineering work, particle size was important to penetrate into the host tissue. The crystallite size of HAp of different powders were calculated by Scherrer's equation (Mondal and Mondal, 2012).

$$\text{Crystallite Size} = \frac{0.9\lambda}{\beta \text{Cos}\theta}$$

Measurements of particle size and pore diameter were done by scanning electron microscope at the National Laboratory of the Department of Research and Innovation. Pore % in the HAp is very important for tissue engineering work. Pore size in the HAp extracted from *N.notopterus* scales was measured by image J software.

3.4.6 Toxicity Assessment

The presence of elements in F.S.HAp, mineral analysis was carried out by EDX. And then the elements of toxic heavy metals like arsenic, cadmium, lead and mercury that could not be detected by EDX analysis was analyzed by AAS at the Fish Inspection and Quality Control Division, Department of Fisheries, Yangon.

Acute toxicity of single dose of HAp extracts of fish (*N.notopterus*) scales was evaluated by the methods of OECD Guidelines for the Testing of Chemicals 425. According to the test description, total number of 12 adult female albino mices, weighting (25-30g) were selected and divided into two groups. Each group contained six animals (plate 3.4). They were fasted for 18 hrs before giving the extracts. Group (1) mices were orally administrated with fish scale's HAp extract 60mg (2000 mg/kg dose) (Plate 3.5).Group (2) mices performed as a control group and they were treated with clean water and normal animal food. All groups of mice were kept in the two mouse cages in the separate room at the room temperature of 26 ± 1ºC. After administration of extracts on each group of animals were observed for the first 6 hrs continuously for mortality and behavior changes. Then the animals were checked at every 24 hrs for fourteen days. The mortality during this period was noted.

3.4.7 Formation of Glass Ionomer Cement, F.S.HAp-ZPC and F.S.HAp-GIC compound

To make a block of pure GC Glass Ionomer Cement (Plate 3.6), as described in direction for use, two drops of GI liquid was added to one scoop of Glass Ionomer powder at ratio of 1:2. The following steps were done:

1. To make a block of GIC, as described in direction for use, two drops of Glass Ionomer liquid was added to one scoop of GI powder (1 : 2).
2. And then to make a block of F.S.HAp.-ZnO-Glass Ionomer liquid (F.S.HAp-ZPC) and F.S.HAp.-Glass Ionomer powder-Glass Ionomer liquid (F.S.HAp-GIC), two drops of GI liquid was added to one scoop of F.S.HAp-ZnO mixture in different ratios and F.S.HAp-GI powder mixture in different ratios respectively.
3. Powder and liquid of each sample were mixed thoroughly in porcelain basin with glass paddle to get in the form of paste.
4. Each paste was put into the disc shaped plastic container (13mm in diameter x 5mm in depth) and pressed with glass plate (Plate 3.7).
5. Each sample gradually changes into hardened cake within 2 days (Plate 3.8).

Procedure for formation of F.S.HAp-ZPC/F.S.HAp-GIC was shown in Fig. 3.2.In order to determine which ratio is suitable for appropriate hardness of teeth and skeleton, seven kinds

composites were tested at different ratios (Table 3.1). Hardness of all samples was measured by Mitutoyo Micro-hardness Testing Machine at Weapon Industry in Meikhtila.

3.4.8 Hardness measuring of the samples

Before application, the hardness of the composites in different ratios were measured by Vickers hardness measurement at Military Weapon Industry at Meikhtila(Plate 3.9).

To improve mechanical property of F.S.HAp composite, instead of being only used GIC, a number of efforts was done by adding the GI liquid into F.S.HAp.-ZnO mixture and F.S.HAp. -GC powder mixture. These composite were made in different ratios (3:1:8, 3:2:10, 3:3:12 respectively) (Table 3.1). Hardness of GIC and F.S.HAp.-ZPC compound were found to be identical. So the improvement on hardness property was not significant. But incorporation of F.S.HAp.-GIC compound gave increment in hardness of 50HV compared to the GIC, F.S.HAp. -ZPC compound.

3.4.9 SEM analysis of F.S.HAp-GIC

SEM analysis of the composite sample was done at National Laboratory, the Department of Research and Innovation (Plate 3.10).

3.4.10 Repair of tooth defect area

Nano-sized biomaterials from *N. notopterus* were able to pass through into dentine which has micro-sized pores. But they can not pass through into enamel surface because it is composed of angstrom-sized pores. As it is impossible to replace solid tooth structure in damage area by using F.S.HAp. only, it is necessary to use cement for reconstruction of damaged tooth. Among various dental adhesives, due to outstanding properties of GC Glass Ionomer (Japan), it was selected to use in repair of enamel defect area. In order to overcome the problem of particle size difference in repair of tooth defect area, liquid of glass ionomer was added to fish scale hydroxyapatite-ZnO (3:1) and fish scale hydroxyapatite-Glass Powder (3:1) mixture. Incorporation of fish scales HAp into Glass Ionomer was selected to repair the tooth defect area of extracted teeth (Plate 3.11). Eight drops of liquid of Glass Ionomer was added into the mixture of fish scale HAp-Glass Powder (3:1) (Fig. 3.3).

3.4.11 Substitution of F.S.HAp-GIC (F.S.HAp:GI powder: GI liquid=3:1:8) in skull bone defect of Wistar rat

Male Wistar rat was selected just to endure the severity of a surgical trauma. The rat was fasted for 18hours up to morning of operation day. At 9:30 am of operation day, the fasted rat was given intra-peritoneal injection of a mixture of Ketamin (0.6 cc) and Xyla (0.4 cc) (Plate 3.13 A). Five minutes after injection, under the influence of anaethesia, it reached to the state of unconsciousness. The rat was placed onto the operation table and cut the hairs on the head with scissor (Plate 3.13 B). Incised the scalp down to the parietal bone.A hole was made on the right side of exposed skull surface (parietal area) with bone driller (Plate 3.13 C). The hole was about 3mm in diameter and 1 mm in depth (Plate 3.13 D).This bone defect was immediately filled with freshly prepared F.S.HAp-GIC (Plate 3.13 E). After the filling of the defect, the scalp was

sutured back with cat-gut (Plate 3.13 F) and Betadine was applied onto the suture to prevent infection (Plate 3.13 G).

About one hour after operation, the rat regained consciousness. It was treated everyday with clean drinking water and normal animal food, and kept in the mouse cage (Plate 3.14). The condition of rat was observed and recorded every day (Plate 3.15 A, B and C). One and half month after operation, skull X-ray was taken at Crown Diagnosis Center in Yangon (Plate 3.16). Four months after operation, the sutured skin was reopened and the filled up area was observed (Plate 3.17 A and B). Subsequently the rat was sacrificed for histological study and the rat head was preserved in 10% formalin. And then the portion of skull bone including normal skull bone tissue was cut out with a bone cutter and soaked in 10% formalin (Plate 3.18). After two days, the cut tissue(4 micron in thickness) was prepared for microscopic study and it was stained with H and E method. With the help of compound microscope (Olympus, Japan), histopathological study was carried out at the Pathology Department, University of Medicine-1, Yangon.

Plate 3.1*Notopterusnotopterus*(Pallus,1769)

Plate 3.2*N. notopterus*scales

Fish scales are washed thoroughly with tap water

⬇

Cleaned fish scales are soaked in 1N HCl solution for 24 hours (Deproteinization)

⬇

Wash thoroughly several times with distilled water

⬇

Soak again in 1N NaOH solution for 24 hours (Deproteinization)

⬇

Filter and wash thoroughly with distilled water

⬇

Dry in microwave-oven (800 watts)

⬇

Deproteinized, and dried fish scales are heated at different temperatures in Muffle furnace

⬇

Fish scale biomaterials powders of different temperatures(600°C, 700°C, 800°C, 900°C, 1000°C)

Figure3.1 Flow chart for extraction of biomaterials from fish scales

Plate 3.3 Physical appearance of biomaterial powders prepared from scales of *N. notopterus* at different temperatures

Plate 3.4 Mices utilized in the cage

Plate 3.5 Administration of fish scale HAp with water to albino mice (60mg/25-30g)

Plate 3.6 GC Glass Ionomer pack(Japan)

GI liquid

⬇

Drops into

⬇

Mixture of F.S.HAp.-ZnO/GI powder

⬇

Stirs with small glass paddle

⬇

Paste of F.S.HAp.-ZnO/Glass Ionomer Cement (F.S.HAp-ZPC/F.S.HAp-GIC)

⬇

Adds into

⬇

Disc shaped plastic container (13 mm in diameter and 5 mm in depth)

⬇

Press with glass plate for two days

⬇

F.S.HAp.-ZnO/Glass powder-Glass Ionomer Cement Composite

Figure 3.2 Flow chart showing steps in formation of F.S.HAp.-ZPC and F.S.HAp-GIC compound

Plate3.7 Disc shaped plastic container (13mm in diameter and 5mm in depth)

Plate3.8 F.S.HAp.-GIcompound (13mm in diameter and 5mm in depth)

Table 3.1 The ratios of seven kinds of sample prepared

F.S.HAp-Glass Ionomer Powder-Glass Ionomer liquid compound ratios	F.S.HAp-ZnO-Glass Ionomer liquid compound ratios	GIC ratio (Glass Ionomer powder-Glass Ionomer liquid)
3 : 1 : 8	3 : 1 : 8	1 : 2 (as direction for use)
3 : 2 : 10	3 : 2 : 10	
3 : 3 : 12	3 : 3 : 12	

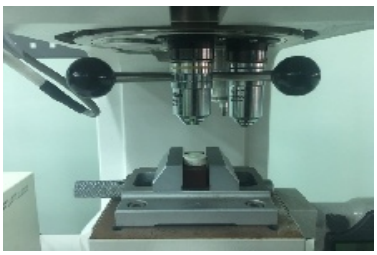


Plate 3.9 Hardness measuring of F.S.HAp-GIC compound with Mitutoyo Micro-hardness testing machine (Vickers hardness tester)

Plate 3.10 Particle size and pore diameter measurement of F.S.HAp-GIC by SEM

Extracted tooth

⬇

Treated with 10% formalin for 1 day

⬇

Clean with purified water

⬇

Fill up freshly prepared fish scale HAp-GI Powder-GI liquid (3:1:8) in tooth defect area

Figure 3.3 Flow chart showing procedure for repair of tooth defect area with F.S.HAp-GIC compound

Plate 3.11 Extracted tooth with cavity

Plate 3.12 Chemicals, reagents, kits and apparatuses utilized in the animal study

A. Injection of anaesthesia into Wistar rat

B. Preparation for operation on the Wistar rat

C. Drilling the skull bone

D. Bone defect made in skull

E. Filling of F.S.HAp-GIC

F. Suturing the scalp after operation

G. Application of Betadine onto the wound

Plate 3.13 Steps in operation to create skull bone defect in the Wistar rat

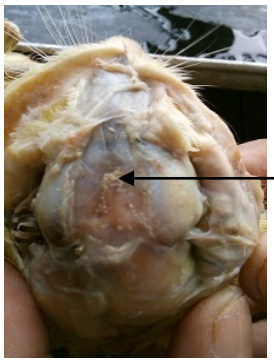
Plate 3.14 Daily treatment on Wistar rat with normal animal food and purify drinking water



A.Second week after operation B.3rd week after operation C.4th week after operation

Plate 3.15 Condition of the Wistar rat after operation

Plate 3.16 Takingskull X-ray of Wistar rat (One and half month after operation)

A. Live specimen B. Preserved specimen

Plate 3.17 Re-examination of the scalp by exposing the skull bone defect area (after four months)

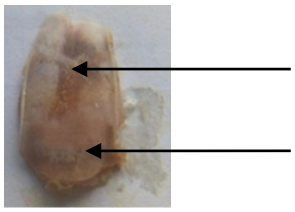


Plate 3.18 The portion of the skull bone showing successfully substituted F.S.HAp-GIC in the bone defect of Wistar rat

Results

Moisture, ash, protein, crude fiber, ether extract, carbohydrate and energy value were detected in raw fish scales.

4.1 Thermal analysis for purity of F.S.HAp powder

The colour of raw fish scale was observed as white which gradually changed into grey, white, white and white tint with light blue green respectively at up series of temperatures (Table 4.1).Different colors observed below 800˚C indicate the association of organic matrix in the fish scales. The colors become white and white tint with blue green with the use of increasing temperatures. It is evidence of removal of organic portion from fish scales at different temperatures. Among various samples, no significant weight loss was observed in *N. notopterus* scale powder but weight loss was 1.1% at 800ºC(Table 4.1).This indicates that *N. notopterus* scale powder at 800˚C lacks organic moieties and water, and further confirms that it has a very low concentration of impurities.

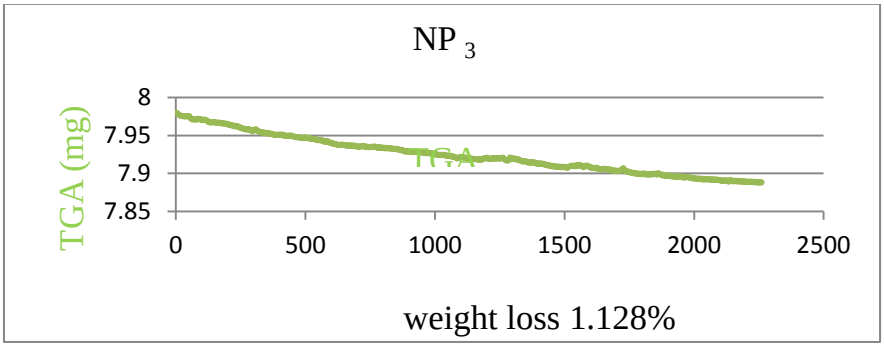


Figure 4.1 TGA pattern of *N. notopterus* scale biomaterial powder (NP_3 800˚C)

4.2 F.S.HAp powder characterization

4.2.1 Physical appearance, protein content and ash yield %

Protein content was not observed in the powder at 800˚C. Ash yield % of *N.notopterus* scale powder was about 44.8%. Pure hydroxyapatite without protein chosen for present study was shown in table 4.1.*N.notopterus* scale HAp, lacking protein with properties of white color when heated at 800˚C, was selected to use in substitution of hard tissues in teeth and skeleton.

4.2.2 Ca/P weight ratio

Ca/P weight ratio of fish scale F.S.HAp powder was calculated at the Laboratory Services of Amtt Company. Ca/P weight ratio of fish scale hydroxyapatite

is 1.94 which is identical to those of enamel, dentine and tuna bone (Table 4.2).

4.2.3 Ca/P mole ratio

To confirm purity of fish scale HAp, Ca/P mole ratio of F.S.HAp was also calculated at the Laboratory Services, Amtt Company. Ca/P mole ratio of 1.63 in fish scale hydroxyapatite is found within the range of hydroxyapatite (Table 4.3).

Table 4.1 Physical appearance, protein content and ash yield % of *N. notopterus* scale biomaterial powders after heating

Temp.(˚C)	*N. notopterus* F.S.HAp Properties		
	Color	Protein%	Ash%
Raw	white	53.76	0.0000
600	grey	2.30	45.5768
700	white	0.34	45.0099
800	white	0.00	44.8409
900	white tint with blue green	0.00	44.7351
1000	white tint with blue green	0.00	44.3015

Table4.2 Ca/P weight ratio of enamel, dentine, tuna bone and F.S.HAp

Source	HwaYen liu *et al.*(2013)		Venkatesan *et al.*(2010)	this study
Sample	Enamel	Dentine	Tuna bone	*N.notopterus* (F.S.HAp)
Ca/Pratio	1.94-1.83	1.91-1.78	1.94	1.94

Table 4.3 Ca/P mole ratio of hydroxyapatite references and F.S.HAp

Source	Hydroxyapatite (Berzina-Simdina and Borodajenko, 2012)	Hydroxyapatite with calcium deficient(Berzina-Simdina and Borodajenko, 2012)	*N.notopterus* scale(F.S.HAp)
Ca/Pratio	1.67	1.5-1.67	1.63

4.2.4 X-ray diffraction analysis

The presence of HAp was confirmed by a strong characteristic peak of 100% intensity for HAp was obtained at 2θ value of 31.808° corresponding to 211 hkl (Table 4.4 and Table 4.5).

4.2.5 Calculation of crystallite size

For tissue engineering work, particle size is important to penetrate into the host tissue. According to X.R.D results, the biomaterial powders extracted from fish scales were proved to be HAp. Average crystallite size of *N.notopterus* scale powder at 800 °C was calculated by Scherrer's equation (Mondal and Mondal, 2012). The required data were taken from XRD results. The F.S.HA pcrystallite size was calculated to be75.8nm.Calculation of crystallite sizes of F.S.HAp (800 °C) at different hkls were shown in table 4.6.

$$\text{Crystallite Size } D(\text{Å}) = \frac{0.9\,\lambda}{\beta \text{Cos}\,\theta}$$

0.9λ = $0.9 \times 1.54056 = 1.386504$ Å

β = FWHM (°)

Cosθ = Cos$\{2\,\theta/2 \times \pi(3.142)/180\}$

For 211 hkl

0.9λ	$= 0.9 \times 1.54056$	= 1.386504 Å
β(FWHM)	= 0.109	= 0.001902 radians
θ	= 2 θ/2	= 31.808/2= 15.904
Cosθ	= 0.277577	= 0.961722 radians
βCosθ	= 0.001902 x0.961722	= 0.001829 radians

Crystallite size D (Å) at 800°C $= \dfrac{1.386504}{0.001829}$ = 758 Å

Crystallite size D at 800°C = 75.8 nm

Table 4.4 XRD analysis of fish scale biomaterial powder (F.S.HAp) heated at 800°C

Sr. No.	2-Theta	d(Å)	Height	Height %	Phase ID	d(Å)	I%	(hkl)	2-Theta	Delta
1.	25.919	3.4347	13	31.0	Hydroxyapatite	3.4395	35.3	(002)	25.882	-0.037
2.	31.808	2.8110	42	100.0	Hydroxyapatite	2.8147	100	(211)	31.765	-0.043
3.	32.220	2.7759	19	45.2	Hydroxyapatite	2.7781	52	(112)	32.194	-0.026
4.	32.976	2.7140	23	54.8	Hydroxyapatite	2.7205	60.9	(300)	32.896	-0.080
5.	34.089	2.6279	14	33.3	Hydroxyapatite	2.6299	20.8	(202)	34.062	-0.027
6	46.727	1.9424	12	28.6	Hydroxyapatite	1.9437	28.1	(222)	46.693	-0.034

Table 4.5 Comparison of XRD data for in I%, 2θ value, hkl of F.S.HAp and references

Samples	Markovic (2004)	XRD JPCDS-09-0432	Tuna bone (Venkatesan, 2010)	*N.notopterus*(800°C) F.S.HAp (This study)
hkl	211	211	211	211
I%	100	100	100	100
2θvalue	31.77	31.77	31.91	31.808

Table 4.6 Calculation of crystallite size of F.S.HAp (800 ºC) at different hkls

hkl	2 θ	θ			β(FWHM)		λ		Crystallite Size	
		Degree	Radian	Cos	Degree	Radian	λ	0.9 λ	Å	nm
211	31.808	15.904	0.277577	0.961722	0.109	0.001902	1.54056	1.386504	757.8227	75.8
300	32.976	16.488	0.287770	0.958879	0.131	0.002286	1.54056	1.386504	632.4243	63.2
002	25.919	12.9595	0.226186	0.974529	0.058	0.001012	1.54056	1.386504	1405.4684	140.5
112	32.22	16.11	0.281173	0.960731	0.118	0.002059	1.54056	1.386504	700.7451	70.0
222	46.727	23.3635	0.407770	0.918007	0.115	0.002007	1.54056	1.386504	752.4882	75.2
202	34.089	17.0445	0.297483	0.956077	0.104	0.001815	1.54056	1.386504	798.9459	79.9

4.2.6 Functional groups study

Presence of the functional groups in *N.notopterus* scale powder proved the powder was HAp. Functional groups of the scale powder at 800 ºC were as follows:

PO_4^{3-} : 570.95cm^{-1}, 601.81cm^{-1}, 962.51cm^{-1}, 1037.74cm^{1} ,1089.82cm^{-1}

OH^- : 632.67cm^{-1}, 3504.77cm^{-1}

CO_3^{2-} : 1413.87cm^{-1}, 1462.09cm^{-1}

The most characteristic chemical groups in the FTIR spectrum of synthesized HAp are PO_4^{3-},OH^-, CO_3^{2-}, as well as HPO_4^{2-}, that characterize HAp. OH^- ions prove presence of HAp. (Berzina-Simdina, and Borodajenko, 2012). Functional groups of fish scale powder at 800°C were also found to be very close to those of HAp references. Except HPO_4^{2-} functional group, wave numbers of all functional groups (PO_4^{3-}, CO_3^{2-}, and OH^-) of the studied fish scale powder at 800˚C are very close to those of standard spectrum. By matching with spectrums of standard HAp and animal hard tissues, functional groups of biomaterial powders at 800˚C extracted from fish scales are chemically proved to be hydroxyapatite.

4.2.7 Study of F.S.HAp particle size by SEM analysis

Table 4.7 shows particle sizes gradually increased with the rise of temperature up to 900°C, but at 1000°C some particles broke up into smaller size. But the particle sizes of powders at different temperatures were found to be nano-sized (Plate 4.1, 4.2, 4.3, 4.4 and 4.5). All hexagonal shaped particles were fragile in texture. The particle size of the fish scale powder at 800°C (lacking fish protein) ranges from 151.6 nm to 265.4 nm (Plate 4.1).

4.2.8 Pore % of the F.S.HAp.

Pore % in the HAp is very important for tissue engineering work. Pore sizes in the HAp extracted from fish scales were measured by image J software. Pore % was found to be 15.86% at 800˚C (Table 4.8).

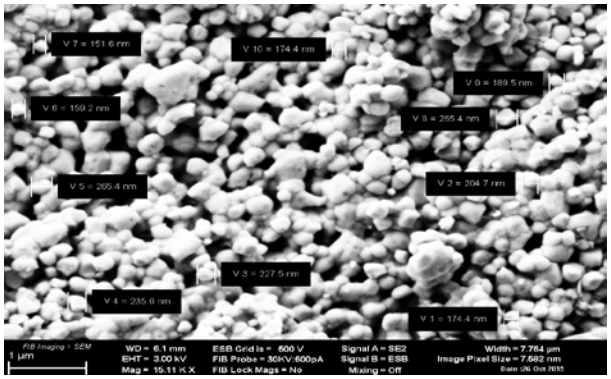


Plate 4.1 SEM image of *N.notopterus* scale biomaterial powder (800˚C) showing particle sizes

Table 4.7 Particle size range of the fish scale biomaterial powders at different temperatures

Temperature(°C)	Particle size
600	45.45 nm to 219.7 nm
700	73.4 nm to 333.6 nm
800	151.6 nm to265.4 nm
900	303.3 nm to 925 nm
1000	128.9 nm to746.1 nm

Table 4.8 Pore % of F.S.HAp

***N.notopterus* scale HAp**		**Pore %**
Total Area	41448400.44 nm^2	15.86
Pore Area	6575553 nm^2	

4.3 Toxicity assessment of F.S.HAp

4.3.1 Mineral analysis

Toxic heavy metals like mercury, arsenic, lead and cadmium were not detected by EDX in the fish scale powders at high ppm level (Table 4.9). Therefore, application of fish scale HAp in hard tissue engineering, it seems to be non-toxic to host tissue.

In addition the concentrations of toxic heavy metals mercury, arsenic, lead and cadmium were detected in the F.S.HAp powders by AAS methods at ppb level(Table 4.10).But the concentrations were much lower than the maximum permitted concentrations of International/ National Standards for Heavy Metals in food.

4.3.2 Acute toxicity test of the F.S.HAp on albino mice model

Acute toxicity screening of HAp extracted from *N.notopterus'*s scales extracts was done with the dosage of 2000 mg/kg in 6 albino mices of group (1), and group (2) was kept as a control group. The conditions of all mices were recorded during and after fourteen days administration. During these period, both groups were treated with normal animal food and

purified drinking water. The results show no lethality of the mice was observed up to fourteen days after administration. Each group of animals were also observed to be still alive and did not show any visible sign and symptoms of toxicity like restlessness, respiratory disorders, convulsion, aggressive activities, coma and death. There is no lethality up to the last day of the fourteen day period (Table 4.11).

4.4 Evaluation of hardness of GIC, F.S.HAp-ZPC and F.S.HAp-GIC by Vickers hardness tester

Hardness of all samples were measured by Micro Vickers Hardness Tester (Mitutoyo Microhardness Testing Machine). Table 4.13 shows the hardness value of GIC and F.S.HAp-ZPC were 222 HV and 224-226 HV respectively. Incorporation of Glass Powder and Glass Ionomer Cement into F.S.HAp revealed increase in hardness of 50 HV more harder than GIC and F.S.HAp-ZPC. Among the samples of F.S.HAp-GIC, the powder of F.S.HAp, powder and liquid of GIC ratio at 3:1:8 showed the most hardest value of 274 (HV). So this ratio is selected to use in present study (Table 4.12 and Table 4.13).

4.5 SEM analysis of F.S.HAp-GIC compound (F.S.HAp reinforced GIC)

4.5.1 Measurement of pore diameters in F.S.HAp-GIC

With Scanning Electron Microscope, pore diameter in the FS HAp-GIC was found within the range of 26 nm – 1402 nm. Majority of pores in the composite were nano-sized (Plate 4.2).

Table 4.9 Mineral analysis of *N.notopterus* scale biomaterialpowder(EDX analysis)

Analyte	Mineral (%/ ppm)	
Ca	7.084%	(70840 ppm)
P	4.411%	(44110 ppm)
K	0.254%	(2540 ppm)
Sr	0.012%	(120 ppm)
Fe	0.004%	(40 ppm)
Zn	0.006%	(60 ppm)
Mn	0.003%	(30 ppm)

Table 4.10 Heavy metals analysis of *N.notopterus* scale powder (AAS method)

Metals	Detected concentration of Heavy Metals in Fish Scales HAp	International/National standards for heavy metals in food (Choi,YY., 2011)
Arsenic(Al_2O_3)	41 ppb	1400 ppb
Cadmium(Cd)	17 ppb	2000 ppb
Lead(Pb)	100 ppb	6000 ppb
Mercury(Hg)	35 ppb	500 ppb

Table 4.11 Acute toxicity test of HAp extract of *N.notopterus* scales on albino mice model after two weeks administration

No	Group	Extract administration	Dosage	No. of death at day fourteen	% of deathat day fourteen
1	Group1	Hap extract of *N.notopterus* scales with water	2000 mg/kg	Nil	0 %
2	Group2	No administration	Nil	Nil	0%

Table 4.12Hardness measurement by Vickers hardness tester

Kind of Sample	Ratio	Hardness(HV)
Pure GC Glass Ionomer (Powder : Liquid)	1 : 2	222 (average)
F.S.HAp-ZnO-Glass Ionomer Cement Composite	3 : 1 : 8	224 (average)
	3 : 2 : 10	226 (average)
	3 : 3 : 12	225 (average)
F.S.HAp-Glass Powder-Glass Ionomer Cement Composite	3 : 1 : 8	272 (average)
	3 : 2 : 10	261 (average)
	3 : 3 : 12	268 (average)
Chun, JK.,Choi, HH., and Lee, JY. (2014)	Enamel	274.8
	Dentine	65.6

Table4.13 Hardness measurement of three samples of F.S.HAp-GIC compound(3:1:8)

Kind of Sample	Ratio	Hardness(HV)	Average Hardness(HV)
F.S.HAp-Glass Powder-Glass Ionomer Cement Composite	3 : 1 : 8	274	272
		270	
		273	

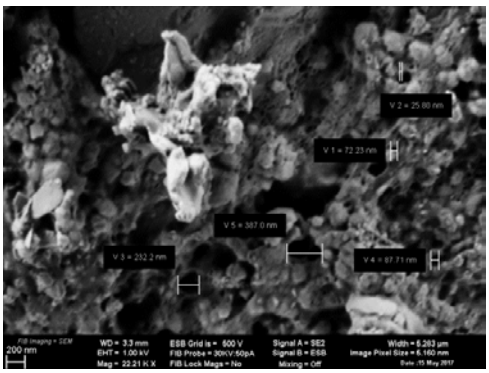


Plate 4.2 SEM image showing pore diameter measurement of F.S.HAp-GIC

4.6 *In vitro* substitution of F.S.HAp-GIC in tooth defect area

Enamel itself is mainly composed of 20-40 nm sized HAp particles and without supplying of blood vessels and nerves, it is a structure made of non-living minerals. Once eroded the enamel, there is no regeneration of HAp in the enamel defect area. If the particle size of F.S.HAp can diffuse into enamel defect area, F.S.HAp can supply directly into the defect organ. However, F.S.HAp cannot diffuse into enamel defect area because of differences in particle size of F.S.HAp and enamel pores. Moreover, F.S.HAp cannot adhere to tooth structure alone. So to retain the F.S.HAp into enamel surface, it is necessary to add adhesive material into F.S.HAp. Because of outstanding properties of GC Glass Ionomer, it is popularly used in daily clinical practice. In the present study, for adhesion, F.S.HAp:GIPowder:GI liquid ratio of 3:1:8 was used for filling tooth and bone. Having no interference from the time of commencement of filling up to the present time, the substituted HAp-GI powder-GI liquid composite was still attached to the area of filling in the defect area (Plate 4.3 A, B and C).



A. Tooth before filling B. Tooth after filling C. Binding of vertically divided tooth

Plate 4.3 Extracted tooth before and after filling and binding with F.S.HAp-GIC

4.7 *In vivo* bservation of F.S.HAp-GI powder-GI liquid (3:1:8) substituted in skull bone defect of Wistar rat

Even though the rat suffered from severity of the surgical trauma, it was healthy, actively moving, eating well everyday and growing normally during the whole observation period of four months. One and half month after operation, X-ray was taken. The opaque image of the filled up area at the right side of parietal bone was seen in X-ray (Plate 4.4).Four months after operation, the sutured skin was reopened and the filled up area of bone defect was observed. The substitution was still present intact at the right side of skull at the bone defect area (Plate 4.5).The rat was subsequently sacrificed for histopathological study of the skull bone where F.S.HAp-GIC was substituted on the right side of the parietal bone of the skull in the defect area. Aggregates of particles could be easily seen with the naked eye (Plate 4.6 and 4.7).Under the view of compound microscope, the aggregate of HAp composite was surrounded by connective tissue with giant (inflammatory) cells in inflammatory reaction areas. A significant finding is that the microscopic study shows the coexistence of F.S.HAp-GIC and normal bone tissue in the rat skull bone. The composite was coalesced in natural bone tissue. A view at magnification of 100× shows that there was direct contact between the F.S.HAp-GIC and normal bone tissue (Plate 4.8).As normal bone tissue, osteocytes and Haversian systems were observed in the skull bone without substitution of F.S.HAp-GIC compound. There is no inflammatory cells in this tissue (Plate 4.9).

Plate 4.4 Radiographic image of Wistar rat skull bone (one and half month after substitution)

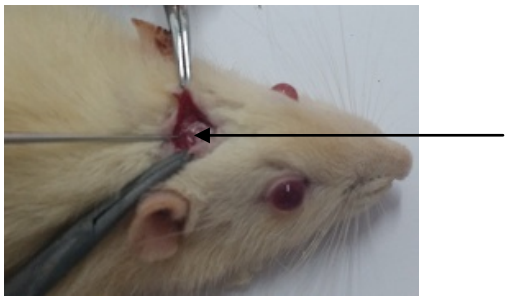


Plate 4.5 Substituted F.S.HAp-GIC compound in bone defect (four months after operation)

F.S.HAp-GIC compound
in skull bone defect

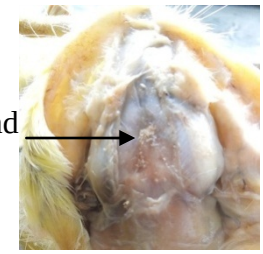


Plate 4.6 F.S.HAp-GIC compound *in situ* Wistar rat skull bone

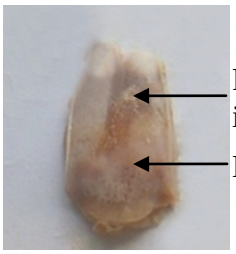


Plate 4.7 The portion of the skullbonein showing substituted F.S.HAp-GIC in the bone defect area

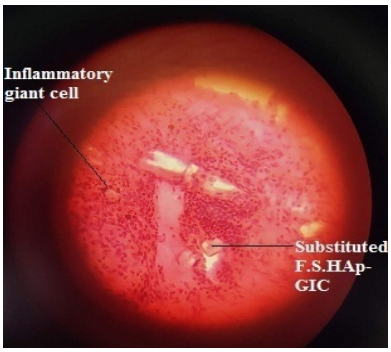


Plate 4.8 Microscopic image of F.S.HAp-GIC area(100×)

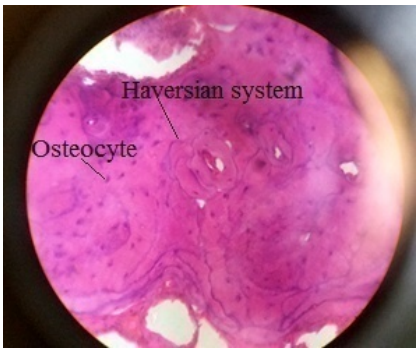


Plate 4.9 Microscopic image of in bone defect normal bone (100×)

Discussion

Sadat (2009) stated that hydroxyapatite had been used widely in biomedical and dental applications due to its similarity to main mineral components of natural hard tissues of human body such as bone, dental enamel and dentin, and due to its biocompatibility, bioactivity and low solubility in moist medias. Biocompatibility means that the substituted biomaterial must have nano-sized particles, porosity and no toxic effect on the host tissues. The properties of having nano-sized particles and 16% porosity in the present substituted F.S.HAp and its non-toxic effect on the albino mice indicate that the F.S.HAp from *N. notopterus* is suitable for tissue engineering application.

Heating the fish scale samples at 800°C is to detach all the unwanted organic matters mainly proteins. In coral and tuna bone, nearly no weight loss was detected at 900°C. It can be assumed that the optimum temperatures for different sources of biomaterials depend on the amount of proportion of organic materials contained in the samples. White color appearance of the fish scale HAp with more ash yield and lacking protein was suitable for hard tissue repair.

All fish scale powders obtained after heating at different temperatures were proved to be hydroxyapatite (HAp) by X-ray diffraction data. Presence of HAp in biomaterial isolated from tuna bone was confirmed by a strong diffraction peak at 2θ value of 31.91° (211 hkl), and from egg shell at 31.77° (211 hkl) (Mondal and Mondal, 2012). In this study presence of HAp in fish scale powders was confirmed by a strong X-ray diffraction peak at 2θ value of 31.808° (211 hkl). XRD data of this study also proved that the fish scale powder heated at 800°C was hydroxyapatite.

Ca/P weight ratio and mole ratio in the fish scale hydroxyapatite (F.S.HAp),were 1.94 for Ca/P weight ratio which was identical to that of tuna bone and enamel and Ca/P mole ratio 1.63 was very near to that of standard hydroxyapatite.

Therefore results of the present study revealed that the fish scale HAp extracted and heated to 800°C was chemically hydroxyapatite.

The extremely pure HAp powder is very expensive and needs high quality precursors. In the present work, the purity of the fish scale powder obtained was assessed by protein content and Ca/P weight ratio and mole ratio. Apart from this, the HAp powder must be biocompatible for hard tissue engineering application for which a highly porous nanocrystal structure is a perquisite to ensure that the biological environment is conductive for cell attachment, proliferation, tissue ingrowth, and adequate nutrient flow (Venkatesan and Kim, 2010). SEM analysis revealed that the nano-sized HAp having porosity could be produced from *N.notopterus* scales at different temperatures (600°C, 700°C, 800°C, 900°C and 1000°C respectively). As the data shows, particle sizes of the F.S.HAp become gradually increased with the rise of temperature at and above800°C. But all were found to be porous and nanometer in size. It could be assumed that the porous nano-sized F.S.HAp biomaterial from *N. notopterus* may be inline with the perquisite for hard tissue engineering applications. In the aspect of damaged tooth repair, nano-sized HAp biomaterials from *N.notopetrus* scales were able to pass through into dentine which has micro-sized pores. But they cannot pass through into enamel surface because it it composed of angstrom-sized pores. As it is impossible to replace solid tooth structure in damage area by using F.S.HAp only, it is necessary to use cement for reconstruction of damaged tooth.

Among various dental adhesives, due to outstanding properties of GC Glass Ionomer (Japan), it was selected to use in repair of enamel defect area.

Toxicity testing, known as safety assessment, was conducted to determine the degree to which a substance can damage tissues of living or non-living organisms. *In vitro* and *in vivo* experiments were conducted to determine the safe dose of exposure on albino mice before a first in-man study. In the present study, test for toxicity was done on albino micebut, no clinically harmful effects were found. Signs and symptoms of toxicity like restlessness, respiratory disorders, convulsion, gastro-intestinal problems, aggressive activities, coma and death were not observed up to fourteen days of fish scales HAp administration. Showing no signs and symptoms of toxicity means the F.S.HAp tested might be suitable for hard tissue engineering application. As *N. notopterus* is globally recognized as non toxic aquatic fauna and its derivative, (HAp) is also a non toxic biomaterial. In addition Glass powder and Glass Ionomer Cement are currently used in daily clinical practice and dental therapy. Due to the properties of F.S.HAp and GC glass Ionomer described above, the composite applied in the present work is non toxic to human beings. Therefore, application of *N. notopterus* powder in hard tissue engineering is possible without harming to host tissues.

According to Venkatesan and Kim(2010), suitable pore diameters in the substituted tissue are very important for nutrient flow and cell to cell connection. In present study, to achieve retention of F.S.HAp in bone structure, the *N. notopterus* F.S.HAp was mixed with GIC which has adhesive property for chemical adhesion to bone structure. In this research work, in repairing the bone defect, the nano-sized F.S.HAp crystallites and particles may enter into bone tissue in a certain period of time. But to get a functional status of the solid structure organ like tooth and bone in a very short period of time, the help of the GICis absolutely necessary.

Rahman (2013) stated that adding of glass ionomer cement into hydroxyapatite-silica nanopowder composite makes enhancement of hardness. So many efforts were done in order to increase hardness. In this study, to perform hardness test, different cements with different ratios were combined with the F.S.HAp. Hardness tests were done on GIC, F.S.HAp-ZPC and F.S.HAp-GIC. Among them, F.S.HAp-GIC combination showed highest physical properties like low fracture strength, increase fracture toughness and increase wear resistance compared to GIC and F.S.HAp-ZPC. The highest hardness value of 274 HV was obtained by mixing F.S.HAp powder and GI powder at 3:1 into liquid of GIat 8 (3:1:8 ratio).

Pore diameters in the F.S.HAp-GIC composite ranges from 26 nm – 1402 nm. Majority of pores in the composite was nano-sized. Mour *et al.*(2010) stated that minimal pore diameter necessary for bone ingrowth was considered to be approximately 100 µm. The minimum pore size required to generate mineralized bone is generally considered to be 100 µm due to cell size, migration requirement and nutrient transport. Large pores (100-150µm and 150-200µm) showed substantial bone ingrowth. Small pores (75-100µm) resulted in ingrowth of unmineralized osteoid tissue. Smaller pores (10-44 and 44-75 µm) were penetrated only by fibrous tissue.

The diameter of the smallest capillary is 3 to 4 µm (Capillaries, https://www.histology.leeds.ac.uk>capill.). Based on the record stated above, for reconstruction of hard tissues (teeth and bone), it is impossible to get nutrient supplementation by capillaries into the substituted F.S.HAp-GIC of the present study. It is seemed to be difference in diameter of pore and capillary may lead to a barrier for nutrient supplementation and cell to cell connection into the substituted

tissue. So there is a very little chance of capillary penetration into defect area with use of F.S.HAp-GIC.

When macrophages derived from monocytes reached into bone tissues, they are called osteoclasts. Their alternative name is multinucleate giant cells (inflammatory cells). Monocytes are motile and phagocytic and migrate into the tissues where they develop further into various types of macrophages such as tissue macrophages, Kupffer cells and osteoclasts. Macrophages may survive for months (Edwards, 1995). Four months after substitution in the present study, inflammatory cells were still present in the histological preparations of the skull bone tissue. It was likely to be an immunologic response. It is noteworthy that this response obviously did not prevent reconstruction of the damaged bone tissue with F.S.HAp in the present work.

This research is an attempt to produce mass HAp from the *N. notopterus* fish scales, which is a new product from this experimental research, with particular attention to use commonly in restorative dentistry and reparation of bone defects. This process of extracting F.S.HAp from fish scales also helps as a way in environmental sanitation and waste material recycling.

F.S.HAp of the present work is therefore, considered a promising additive for GIC used as restorative materials in tooth repair and bone grafting. Within limitation of this study, nano-F.S.HAp-GIC complex compound gave promising results which could lead to increase in scientific research on the subject. Further researches are necessary for more application of calcium based materials, which are optimized by specifying their geometry, dimension, density, pore size, mechanical strength, purity and chemical phase.

The materials in current use for reconstruction of bone and teeth are mostly metals(gold, steel, platinum, titanium), plastic (polyethylene, polytetrafluoethylene) and ceramics. Instead of using these expensive ready made synthetic substitutes, it is a better alternative way of using affordable biomaterials in bone and teeth reconstruction. There are many advantages of using fish scales HAp-GIC in reconstruction of bone and teeth. It can be used to give easy to be moulded to desired shape, easily available and may be cheaper than the materials already in use in clinical practice. It can be used as restorative material in dentistry and restoration of bone defect area which are in non-load bearing regions like skull bone, maxillofacial, cleft palate, vertebrae deformity, ribs and digits.

This preliminary pilot study showed that the implantation of fish scale HAp, with the aid of GC Glass Ionomer, induced successful reconstruction of hard tissues. It is very much hopeful that the mass production of HAp from *N.notopterus* scales may fulfill the need of HAp materials for hard tissue engineering in our country. Moreover, F.S.HAp can be produced easily and it can be reinforced in GIC manufacturally or by user easily.

This study revealed that the potential use of nano-sized F.S.HAp in natural bone healing process is believed to penetrate into the pores of dentine tissue and bone tissue.

Conclusion

Fish scales, once thought to be a waste in fishing industry and fishery market, and a nuisance to the environment and human beings, are now can be regarded as an environmentally friendly and cost effective source of an invaluable biomaterial known as hydroxyapatite

(HAp).This HAp which has been extracted from the *N.notopterus* scales may be a new biomaterial for future hard tissue engineering technology as it can be applied as an alternative source in reconstruction of hard tissues, (human as well as animals), needing not to regard race and religion of the recipients.

Summary

1. XRD analysis confirms that the HAp biomaterials could be extracted from fish (*N. notopterus*) scales at different temperatures.
2. According to FESEM data, nano-sized hydroxyapatite biomaterial powders could be produced from the fish scales.
3. The extracted F.S.Hap are free from toxic heavy metals like mercury, lead, arsenic and cadmium at ppm level. Moreover even at ppb level, the heavy metal concentrations were much lower than the maximum permitted levels of international standards.
4. The average hardness of the F.S.HAp.-Glass powder-GIc composite at the ratio of 3:1:8 was found to be 272 HV .
5. The most hardest value of 274 HV was found at the sample at 3 : 1 : 8 ratio.
6. To get a functional status of hard tissues in a short period of time, F.S.HAp alone is of no use and the help of the cement is necessary.
7. Histological evidence suggests that this F.S.HAp-GIC composite coalesced successfully in natural bone tissue indicating the fish scale's HAp-GIC compound tested is suitable for use in bone tissue engineering.

Cost Estimation for the Research

- Necessary materials buying - 530000Ks
- Productionof fish scale biomaterial - 140000Ks
- Characterization of fish scale biomaterial - 299000Ks
- Experiments - 69000Ks
- Transport - 300000Ks

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References

Adele, L., Boskey, (2007). Mineraliztion of Bones and teeth. *Elements*, Vol.3, pp.387-393.

Agrawal, K., Singh, G., Puri, D., Prakash, S.,(2011).Synthesis and Characterization of Hydroxyapatite Powder by Sol-Gel Method for Biomedical Application. *Journal of Minerals and Materials Characterization and Engineering*, Vol.10, No.8, pp.727-734.

Asahina, I., Watanabe, M., Sakurai, N., Mori, M. and Enomoto, S. (1997). Repair of bone defect in primate mandible using a bone morphogenetic protein (BMP)-Hydroxyapatite-Collagen Composite. *J Med Dent Sci 1997*; 44; 63-70.

Choi, HH., Chun, KJ., and Lee, JY., (2014). *J Dent Biomech.*,5:1758736014520 809.

Choi, YY.,(2011). International / national standards for heavy metals in food.

Edwards, C.R.W., Bouchier, I.A.D., Haslett, C., (1995). Davisons principles and practice of medicine. Seventeenth edition, *Churchill living stone*.

Fengxiang Zhang, Anning Wang, ZhihuaLi, Shengwen He, and Lijun Shao, (2011). Preparation and characterization of collagen from freshwater fish scales. *Food and Nutrition Sciences*,2011,2,818-823.

Ferreira, G.R., Cestari, T.M., Granjeiro, J.M., and Taga, R., (2004). Lack of repair of rat skull critical size defect treated with bovine morphometric protein bound to microgranular bioabsorbable hydroxyapatite. *Braz. Dent. J.*(online).2004,vol.15,n.3, pp.175-180. ISSN 0103-6440.

FFTC document data base, (2010). Improved utilization of fishery by-products as potential nutraceuticals and functional food.Food and fertilizer technology center for the Asian and pacific region, copy right © *1998-2018copy* right.

Hedzelek, W., Wachowiak, R., Marcinkowska and Domka, L.,(2008).Infrared Spectroscopic Identification of Chosen Dental Materials and Natural Teeth. *Acta Physica Polonica A*,Vol.114, Issue 2, p.471.

Hinedi, Z.R., Goldberg, S., Chang, A.C., and Yesinowski, J.P., (1992). $A^{31}P$ and ^{1}H MAS NMR Study of Phosphate Sorption onto Calcium Carbonate. Department of Soils and Environmental Sciences, University of California, USA, *Journal of Colloid and Interface Science*, Vol.152, No.1.

Hwa-Yen Liu, Jium-Hsing Chao, Chun-Yu Chuang, Hung-Lin Chiu, Chung-Wei Yang, Yuh-Chang Sun, (2013). ©*2013 Sci Res*, vol.3, No.2, 71-77, Taiwan. http://dx.doi.org/10.4236/aa.2013.32010.

Kantharia, N., Naik, S., Apte, S., Kheur, M., Kheur, S., and Kale, B., (2011). Nanohydroxyapatite and its comtemporary application, *Journal of Dental Research and Scientific Development.* JDRSD 2014.,1:15-9..

Let Thwe Mu, (2016). Preparation and characterization of hydroxyapatite-chitosan nanocomposite for biomedical application. Department of Chemistry, University of Yangon, Myanmar.

LiuH.Y., Chao, J.H., Chuang, C.Y., Chiu, H.L., Yang, C.W., Sun, Y.C. (2013). Study of P, Ca, Sr, Ba and Pb level in enamel and dentine of human third molar for environmental and archaeological research", Au. Institute of Anthropology. *Advances in Anthropology*, 2013.Vol.3,No.2,71-77.

Lyapina, M, G., Tzekova, M., Dencheva, M., Krasteva, A., Yaneva-Deliverska, M., kisselova, A. (2016).Nano-glass ionomer cement in modern restorative dentistry. *Journal of IMAB-Annual Proceeding Scientific Paper*, Vol. 22, Issue2.

Markovic, M., Fowler, B.O. and Tung, M.S., (2004). Preparation and comprehensive characterization of a calcium hydroxyapatite reference material. *Journal of Research of the National Institute of Standards and Technology*, 109(6): 553-568.

Mondal, S., and Mondal, B., (2012).Studies on processing and characterization of hydroxyapatite biomaterials from different biowastes.*Journal of Minerals and Materials Characterization and Engineering*, Vol.11, No.1, pp.55-67.

Mour, M., Das, D., Winkler, T., Hoenig, E., Mieke, G., Michael M. Morlock, M.M., and Schilling, A.F., (2010).Advances in porous biomaterials for dental and orthopaedic applications. *Materials*, 3,29472974; 10.3390 /ma 3052947.

Myatnyan, (2009).Bone regeneration by local application of Simvastatin, Tokyo Medical and Dental University, Tokyo, Japan.

Nguyen, T.T, Miller, A., Maria F. and Orellana, (2011). Characterization of the porosity of human dental enamel and shear bond strength *in vitro* after variable etch times: initial finding using the BET method. *Angle Orthodontist.* Vol 81, No 4, 2011.

Oh, S., Oh, N.,Appleford, M. and Ong, J.L. (2006). Bioceramics for tissue engineering application, a review, *American Journal of Biochemistry and Biotechnology* 2(2):49-56.

Palanivelu.R.,(2013). Synthesis and spectroscopic characterization of hydroxyapatite by sol-gel method. *International Journal of Chem. Tech.*5, (6) : 2965-2969.

Rahman, I.A., Masudi, S.M., Luddin, N. and Shiekh, R.A., (2013). One-pot synthesis of Hydroxyapatite-silica nanopowder composite for hardness enhancement of glass ionomercement. *Bull. Mater. Sci., Vol.37,No.2*, pp. 213-219.

Sadat-Shojai, M., (2009). Preparation of hydroxyapatite nanoparticles: Comparison between hydrodermal and solvo-treatment processes and colloidal stability of produced nanoparticles in a dilute experimental dental adhesives.*J.Iran.Chem.Soc.*Vol.6, No.2, pp.386-392.

Sesman, A., Ruvalcaba, E., Herrera, A., Sanchez, G.S., Lecona, H.., Baena-Ocampo, L., Solis, L., Avila.H., Delapuente, G. S., Vargas, B., Guerrero, X., and Velasquillo, C., (2013).Morphological study of bone cranial in athymic mice", *Int. J.Morphol., 31(I)*; 321-328.

Sharpe, P.T., (2001). Fish scale development, *Current Biology*, Volume 11, Issue 18, pR751-R752, DOI:https://doi.org/10.1016/S0960-9822(01)00438-9.

Thamaraiselvi, T. V. and. Rajeswari.S.(2004). Biological evaluation of bioceramic materials-a review, *Trends Biomater. Artif. Organs*, Vol.18(1),pp.9-17(2004).

Urist, MR., (1965).Bone regeneration by autoinduction. *http : // dx. doi. Org /10.1126 / Science.*150.3698.893.

Urist, MR., (1984).Radioimmunoassay of bone morphogenetic protein in specific parameter of bone metabolism. *Pro Soc Exp Biol Med.* 176:.

Venkatesan, J. and Kim, S.K. (2010).Effect of temperature on isolation and characterization of hydroxyapatite from tuna bone.*Materials*, 3(10),4761-4772.

Xiaoying, L., Yongbin, F., Dachun, G. and Wei, C. (2007).Preparation and characterization of hydroxyapatite from animal hard tissues. .*Key Engineering Materials* Vol.342-343, pp.213-216.

Zaragoza, L.D., Romeo-Guzman, E.T. and Reyes-Gutierrez, L.R., (2009), Surface and physicochemical characterization of phosphates. vivianite, Fe2(PO4) 3OH. *Journal of Minerals and Materials Characterization & Engineering*,8, 8 :591-609.

Zhu, D., Ortega, C.F., Motamedi, R., Szewciw, L., Vernerey, F., and Barthelat, F., (2011). Structure and mechanical performance of a modern fish scale. DOI:10.1002/adem,201180057.

Web-sites

Capillaries, https://www.Histology.leeds.ac.uk>capill...

https://www.webmd.com>oral-health

https://training.Seer. Cancer.gov>skeletal

https://en.wikipedia.org>wiki>flat-bone

https://courses.lumen learning.com>bone

PROCESS DEVELOPMENT ON THE PRODUCTION OF DRY CAT FOOD FROM FISH FACTORY WASTES

၂၄။ PROCESS DEVELOPMENT ON THE PRODUCTION OF DRY CAT FOOD FROM FISH FACTORY WASTES

Kyaing Thuzar Mon*

Abstract

Presently, most of the dry cat food is imported from other countries namely Thailand and Malaysia. In the present work dry cat food was prepared using low grade fish to produce a value added product. Pyi-taw-thar and Nga-khaung-pwa were collected as low grade fish from Ngwe Pin Laefish factory, Hlaingthayar Township, Yangon Region. Nutritive values of both fish were determined, indicating protein content and moisture content were nearly the same. Therefore 1:1 ratio of both fish was used to prepare fish powder. Hot air oven was used for drying the ingredients. Dry cat food was prepared from fish by mixing with each cereal namely wheat, corn or soybean and undergone steaming and extruding. The respective conditions were investigated for varying ingredient compositions and steaming time. The results showed thatthe optimum parameters were 3:7 ratio of fish powder and wheat flour with steaming time of 25 min., 1:1 ratio of fish powder and corn flour with steaming time of 25 min. and 2:8 ratio of fish powder and soybean with steaming time of 20 min.. The optimum dry cat food (fish and cereal) was selected based on the comparison of nutritive value of each of dry cat food. Fish and soybean formula was chosen due to the highest protein content and metabolizable energy.

Vegetables namely pumpkin and carrot were also mixed to the optimum dry cat food (fish and soybean) by formulating. The protein content, moisture content, metabolizable energy, cost and cat feeding of different dry cat food were compared and the dry cat food (fish, soybean, pumpkin) was chosen as the suitable sample. The microbiological investigation was also carried out on the optimum dry cat food (fish and soybean) and dry cat food (fish, soybean and pumpkin) and *Salmonella* was not detected. Dry cat food was also prepared with Kyaung-yo-thay leaves powder using the formulae. The moisture content and cat feeding of dry cat food was studied it was found that 15 % of Kyaung-yo-thay leaves powder was the acceptable value according to the highest consumption. To develop the production of dry cat food with low cost technology and to reduce the expenditure of electricity, direct solar cabinet dryer was constructed and used instead of hot air oven. It was found that the protein content of fish powder with solar dryer was slightly higher than that of fish powder with hot air oven.

Keywords: Dry cat food, fish, cereals, moisture content, protein content,

Introduction

The term "dry pet food" means a pet food having less than 15% moisture. Typically, dry pet food is produced as kibbles. The term "kibbles" refers to particulate pieces formed by either a pelleting or extrusion process. The pieces can vary in size and shape, depending on the process or the equipment (Ruaud, Guiller and Levesque, 2011).

Commercial cat foods are formulated as dry, semimoist, and canned. These products differ in water content, protein level, caloric density, palatability, and digestibility. Proteins, fats and carbohydrates are the three major groups of nutrients in any cat food. Protein is essential for cat's growth, where it is required to maintain the total structure of this animal, which comprises of muscle, bone, ligaments and tendons. They also differ in composition. i.e. ingredients and chemical analysis. Dry foods have a long shelf-life because of their low moisture content. Dry foods for cats are usually in the form of extruded products. There are several types of cat food

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which are graded based on their ingredients and nutritive values especially the protein content(Rivera, 1998).

Raw ingredients commonly used in the cat food manufacturing are derived from various sources such as meat, meat byproducts, fish, poultry, vegetables, vegetables byproducts, cereals, fruits, and bones (Amir and Mona, 2013).

Cereals provide an important source of energy, a proportion of protein and other nutrients including thiamine and niacin**.** Although cats have no absolute dietary requirement for carbohydrates, they present an excellent energy source in an easily digestible form. Good sources of carbohydrates in pet foods are usually cereal based such as corn (maize), rice, wheat, barley or sorghum (Pet Food Manufacturers Association, 2010).

Although vegetables are tertiary ingredients in commercially available cat food, they can provide some benefits including: they are a relatively low calorie source of fibre and vitamins, they are a natural way to add sweetness to the food and they are a healthy, whole food source of vitamins and minerals (Fact Sheets,2014).

Herbs and botanicals are used in cat foods to provide flavor or to have a medicinal effect on the body. Kyaung-yo-thay (or) Kyaung-say-pin is one of the well-known Myanmar medicinal plants used for bronchodilating and mucolytic activities (Myint, Myint and Myint, 2005).

Different drying methods (sun and oven) have different effects on nutrient composition of fish. Solar drying is very simple and low-cost technology. Solar drying saves energy, time, occupies less area, improves product quality, makes the process more efficient and protects the environments (Hii, Jangam, Ong, and Mujumdar, 2012).

Objectives of the Study

The main objective of this research work was to perform process development on the production of dry cat food from the rejected fish species of factory.

The specific objectives of this study were:

- to produce dry cat food pellets prepared from fish mixed with brown rice using hydraulic press
- to modify extruded dry cat food from fish and cereals namely wheat, soybean and corn using an extruder
- to develop extruded dry cat food from fish incorporated with soybean, vegetables namely carrot and pumpkin, and medicinal plant
- to investigate the effect of hot air oven drying and solar drying on nutritional value of fish powder and dry cat food
- to evaluate the physico-chemical properties and the cat feeding of dry cat food by varying the ingredients composition
- to determine the water activity, size stability and safety of microorganisms of dry cat food
- to provide the import substitution of dry cat food

Materials and Methods

3.1 Materials

Torpedo scad **(**Pyi-taw-thar) and White mouth croaker (Nga-poke-thin (a) Nga-khaung-pwa) were collected as rejected fish from Ngwe Pin Lae Fish Factory, Ngwe Pin Lae Marine Industrial Zone, Hlaingthayar Township, Yangon Region. Brown rice was purchased from Ocean Supermarket, Mayangone Township, Yangon Region and Soybean were purchased from Nyaungpinlay Market, Lanmadaw Township, Yangon Region, and then both were milled at 21st Street, Latha Township. Wheat powder and table salt were also purchased from Ocean Supermarket, Mayangone Township, Yangon Region. Corn flour was purchased from Orange Supermarket, Kyeemyindaing Township, Yangon Region.Citric acid (Analar grade, BDH) was purchased from Academy Chemical Shop, 28th Street, Pabedan Township, Yangon Region. Pumpkin and Carrot were purchased from Ahlone Market, Ahlone Township, Yangon Region. Kyaung-say-pin (a) Kyaung-yo-thay plant was purchased from Pyay Township, Bago Region.

3.2 Methods

3.2.1 Determination of Physico-chemical Characteristics of Fish (Pyi-taw-thar and Nga-khaung-pwa)

Pyi-taw-thar fish and Nga-khaung-pwa fish were cleaned with water and the head and tail of fish were cut. All the flesh of fish was removed from the bone and ground. The ground sample of each king of fish was used for the determination of physico-chemical characteristics such as moisture content, ash content, protein content, crude fibre content, crude fat content, carbohydrate, energy value and salt content.

3.3 Preparation of Ingredients of Dry Cat Food

3.3.1 Preparation of Fish Powder Using Hot Air Oven Drying

The (1:1) ratio of Pyi-taw-thar and Nga-khaung-pwa fish was cut into 1cm to 2 cm length. The fish was dried in a hot air oven at 60˚C by varying the drying time (1hr - 12 hr). After that the dried fish meal was ground into powder using grinder. Finally, the powder was sieved with mesh no. 14 screen.

3.3.2 Preparation of Vegetable Powders

3.3.2.1 Preparation of Pumpkin Powder

First of all, the seeds of pumpkin were scooped out, and the skin was scraped off. Then pumpkin was sliced into 1/8 in. thick and 1 in. long and blanched with water for 1 min. Next, the blanched slices were cooled immediately in ice water for the same amount of time as blanching to prevent further cooking. Then, the cooled slices were spread on the trays and dried at 60˚C in a hot air oven for11 hr. Finally, the dried pumpkins were cooled at room temperature and ground into powder using a grinder.

3.3.2.2 Preparation of Carrot Powder

First of all, the carrots were washed. Then, the carrots were sliced into about 1/8 in. thick and were blanched with water for 4 min.. Next, the blanched slices were cooled immediately in

ice water for the same amount of time as blanching to prevent further cooking. After that, the carrots were spread on the trays and dried at 60˚C in a hot air oven for 12 hr. Finally, the dried carrots were cooled at room temperature and ground into powder using a grinder.

3.3.3 Preparation of Kyaung-yo-thay Leaves Powder

Kyaung-yo-thay leaves were left to dry at room temperature (28-32˚C) for 10 days. Next, the dried leaves were chopped into smaller pieces and then ground into powder. Then, the powder was sieved with mesh no. 20 screen.

3.4 Analysis of Fish Powder, Pumpkin Powder and Carrot Powder

The nutritional value of each powder such as moisture content, ash content, protein content, crude fibre content, crude fat content, carbohydrate and energy value, and bulk density, tapped density, compressibility index and flow character were determined.

3.5 Phytochemical Analysis and Physical Properties of Kyaung-yo-thay Leaves Powder

Phytochemical analysis of Kyaung-yo-thay leaves powder were conducted at the Laboratory of Medicinal Plant, Pharmaceutical and Food Research Department, Ministry of Industry, Insein Township and physical properties such as moisture content, bulk density, tapped density compressibility index and flow character of Kyaung-yo-thay leaves powder was determined.

3.6 Preparation of Dry Cat Food (Fish and Cereals)

3.6.1 Preparation of Dry Cat Food (Fish and Wheat)

3.6.1.1 Effect of Steaming Time on the Characteristics of Dry Cat Food (Fish and Wheat)

Dry ingredients such as 50 g of fish powder and 50 g of wheat powder were mixed together in a steel tray. Then 1 g of salt and 0.5 g of citric acid were added into the mixture and mixed thoroughly. And the mixture was pre-steamed at 90-95˚C for 20 min. to gelatinize the starch. The mixture was thoroughly mixed with 50 ml. of distilled water to form a moist mixture for cooking. The moist mixture was cooked with steam at 90-95˚C by varying the steaming time 10 min., 15 min., 20 min., 25 min., 30 min. and 35 min. respectively. After that the cooked mixture was dried in a hot air oven at 60˚C for 3 hr. The dried mixture was ground into powder and screened with sieve(-30+40). The moisture content, pH and yield percent were determined.

3.6.1.2 Effect of Ingredients Composition Ratio on the Characteristics of Dry Cat Food (Fish and Wheat)

In order to get the proper ratio for the preparation of wheat mixed dry cat food, fish powder and wheat powder were firstly mixed together in a steel tray by varying the weight ratio of 10:90, 20:80, 30:70, 40:60, 50:50, 60:40 and 70:30. Then 1 g of salt and 0.5 g of citric acid were added into the mixture and mixed thoroughly. After that the mixture was pre-steamed at 90-95˚C for 20 min. to gelatinize the starch and it was thoroughly mixed with 50 ml. of distilled water to form a moist mixture for cooking. The moist mixture was then cooked with steam at 90-95˚C at the suitable steaming time of 25 min.. The cooked mixture was extruded by using a

meat grinder/extruder. Finally the extrudates were dried at 60˚C for 3.5 hr to dry the cat food. The protein value, moisture content, ash content, pH, yield percent and the cat feeding of wheat mixed dry cat food were determined. From these results, the most suitable sample was selected and the nutritive value of HFW_3 was investigated.

3.6.2 Preparation of Dry Cat Food (Fish and Corn)

3.6.2.1 Effect of Steaming Time on the Characteristics of Dry Cat Food (Fish and Corn)

Dry ingredients such as 50 g of fish powder and 50 g of corn flour were mixed together in a steel tray. The same procedure was carried out as described in Section (3.6.1.1).The moisture content, pH and yield percent were determined. From these results, the suitable steaming time was 25 min. for the preparation of dry cat food (fish and corn).

3.6.2.2 Effect of Ingredients Composition Ratio on the Characteristics of Dry Cat Food (Fish and Corn)

In order to get the proper ratio for the preparation of corn mixed dry cat food, the same procedure was carried out as described in Section (3.6.1.2). The protein value, moisture content, ash content, pH, yield percent and the cat feeding of corn mixed dry cat food were determined. The most suitable sample was selected and the nutritive value of it was investigated.

3.6.3 Preparation of Dry Cat Food (Fish and Soybean)

3.6.3.1 Effect of Steaming Time on the Characteristics of Dry Cat Food (Fish and Soybean)

Dry ingredients such as 50 g of fish powder and 50 g of soybean flour were mixed together in a steel tray. The same procedure was carried out as described in Section (3.6.1.1).The moisture content, pH and yield percent were determined.

3.6.3.2 Effect of Ingredients Composition Ratio on the Characteristics of Dry Cat Food (Fish and Soybean)

In order to get a proper ratio for the preparation of soybean mixed dry cat food, the same procedure was carried out as described in Section (3.6.1.2). The protein value, moisture content, ash content, pH, yield percent and the cat feeding of soybean mixed dry cat food were determined to choose the most suitable sample.

3.7 Preparation of Dry Cat Food (Fish, Soybean and Vegetables)

3.7.1 Preparation of Dry Cat Food (Fish, Soybean and Pumpkin)

3.7.1.1 Effect of Different Ingredients Composition on the Characteristics of Dry Cat Food (Fish, Soybean and Pumpkin)

Pumpkin mixed dry cat food was prepared by using the different ingredients composition of fish powder, soybean flour and pumpkin powder and the samples are shown in Table (4.18). According to the formulae, the ingredients were blended manually. The prepared mixture was pre-steamed at 90-95˚C for 20 min. to gelatinize the starch and it was thoroughly mixed with 50 ml. of distilled water to form a moist mixture for cooking. The moist mixture was then cooked

with steam at 90-95˚C with the suitable steaming time of 20 min. selected for soybean mixed dry cat food. After the cooked mixture was extruded by using an extruder, the extrudates were dried at 60˚C for 3.5 hr and cut into 1.5 to 2.5 cm in length. The protein value, moisture content, pH and cat feeding of pumpkin mixed dry cat food were analyzed. From these results, the most suitable sample was selected and the nutritive value of it was determined.

3.7.2 Preparation of Dry Cat Food (Fish, Soybean and Carrot)

3.7.2.1 Effect of Different Ingredients Composition on the Characteristics of Dry Cat Food (Fish, Soybean and Carrot)

Carrot mixed dry cat food was prepared by using the different ingredients composition of fish powder, soybean flour and carrot. The preparation of dry cat food (fish, soybean and carrot) was carried out as mentioned in Section 3.7.1.1. The protein value, moisture content, pH and the cat feeding of carrot mixed dry cat food were analyzed. From these results, the most suitable sample was selected and the nutritive value of it was determined.

3.8 Preparation of Dry Cat Food (Fish, Soybean and Kyaung-yo-thay Leaves)

3.8.1 Effect of Ingredients Composition Ratio on the Moisture Content and Cat Feeding of Dry Cat Food (Fish, Soybean and Kyaung-yo-thay Leaves)

Kyaung-say-pin (a) Kyaung-yo-thay leaves powder mixed extruded dry cat food was prepared by using the ratio of fish powder, soybean flour and Kyaung-yo-thay leaves powder. The preparation of dry cat food (fish, soybean and pumpkin) was carried out as mentioned in Section 3.7.1.1. The moisture content and the cat feeding of Kyaung-yo-thay leaves powder mixed extruded dry cat food were analyzed.

3.9 Characteristics of Dry Cat Food

The nutritional value of dry cat food such as moisture content, ash content, protein content, crude fibre content, crude fat content, carbohydrate and energy value, and pH, metabolizable energy, *Salmonella*, water activity, size stability and cat feeding were determined.

3.10 Determination of Feline Body Mass Index of Experimental Cats

Feline Body Mass Index is a simple measure of body fat content in cats. FBMI

$$= \frac{\left(\frac{rib \quad cage}{0.7062}\right) - \text{LIM}}{0.9156} - \text{LIM}$$

where, LIM = Lower Hind limb Measurement (cm)

rib cage = rib cage Measurement (cm)

(The world's leading authority on pet care and nutrition, 2003)

3.11 Efficiency of Direct Solar Cabinet Dryer

The drying rate and the system drying efficiency were determined.

3.12 Preparation of Fish Powder Using Direct Solar Cabinet Dryer

The 1:1 ratio of Torpedo scad (Pyi-taw-thar) and White mouth croaker (Nga-khaung-pwa) fish was cut into 1cm to 2 cm length and the cut fish was dried in a direct cabinet solar dryer at 50-64˚C for 4 hr. Afterwards, the dried fish was ground by using a meat grinder. And the ground meal was again dried by using a direct cabinet solar dryer for 2 hr in order to dehydrate. Finally, the dried ground meal was again ground by using a grinder.

3.13 Physico-chemical Characteristics of Prepared Fish Powder Using Direct Solar Cabinet Dryer

The physico-chemical characteristics of fish powder prepared fish powder using direct solar cabinet dryer were determined as mentioned in Section 3.4.

3.14 Preparation of Dry Cat Food Using Solar Drying (Fish and Soybean)

First of all,fish powder, soybean flour, citric acid and salt were thoroughly mixed and the mixture was pre-steamed at 90-95°C for 20 min. to gelatinize the starch. Then the mixture was thoroughly mixed with 50 ml. of distilled water. After that, the moist mixture was cooked with steam at 90-95°C for 20 min.. Next, the cooked mixture was extruded by using an extruder, dried using solar dryer at 58-70°C by varying the drying time 2 hr, 2.5 hr, 3 hr and 3.5 hr respectively and cut into 1.5 to 2.5 cm in length. Finally, the dry cat food was stored in air tight container. The moisture content, protein content and pH of the samples were investigated. From these results, the suitable dry cat food was selected and the nutritive value of it was determined.

3.15 Physico-chemical Characteristics of Dry Cat Food Prepared with Solar Drying (Fish and Soybean)

The physico-chemical characteristics of dry cat food such as moisture content, ash content, protein content, crude fibre content, crude fat content, carbohydrate and energy value, and pH, metabolizable energy, water activity, size stability and cat feeding were determined.

3.16 Statistical Analysis

t-test was applied for different drying methods on the protein value of dry cat food (fish and soybean) in the present study.

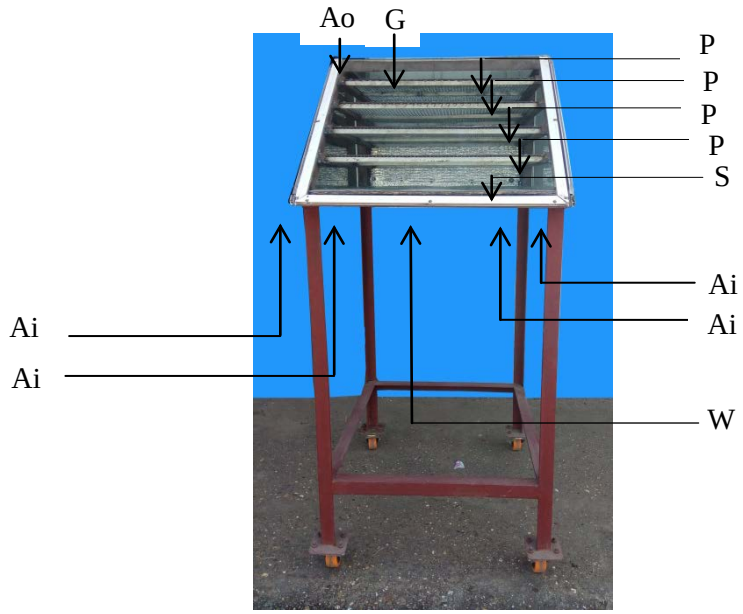


Figure 3.1 Direct Solar Cabinet Dryer

Ai = Air Inlet, Ao= Air Outlet, G = Glass Cover

P = Plastic Coated Metal Trays, W = Wood, S = Plastic Sheet as Reflector and Insulator

Results and Discussion

Fish is a food excellent nutritional value, providing high quality protein and a wide variety of vitamins and minerals, including vitamins A and D, phosphorus, magnesium, selenium and iodine in marine fish. Fish factory (Ngwe Pin Lae) in Yangon Region, Myanmar exported high quality fish and distributed the rejected low grade fish to local markets with a cheaper cost. Rejected marine fish was mostly purchased by the cat owners to feed the cats in markets. Therefore, Torpedo scad (Pyi-taw-thar) and White mouth croaker (Nga-khaung-pwa) collected from Ngwe Pin Lae fish factory were used as the principal constituent in the preparation of dry cat food.

Experiments were conducted to evaluate the physico-chemical characteristics of each raw fish and the data are shown in Table (4.1). It was found that protein value and moisture value of both fish were nearly the same. The salt content was also nearly the same.The ingredients used in the production of dry cat food are usually powder form and therefore 1:1 ratio of both fish were firstly converted into fish powder by drying in hot air oven.

The investigated nutritive value of prepared fish powder was compared with the prepared fish powder from tuna trimmings and the results are shown in Table (4.2). It was found that the moisture content and ash content were markedly higher than that of Tuna trimmings, however, the protein content was found slightly lower.

In the preparation of dry cat food (fish and cereal), the cereals used were wheat, corn and soybean. In the preparation of dry cat food from fish and wheat, pre-steaming method of ingredients was used to gelatinize the starch before mixing with distilled water. The effect of steaming time on physico-chemical characteristics of dry cat food (fish and wheat) was studied and shown in Table (4.3). The samples were coded as sample WST_1 to WST_6. Although the

yield percent of WST_1 to WST_5 were the same, the attractable fishy smell was observed in WST_4 to WST_6. Among them, WST_6 showed the lowest yield percent. Therefore WST_4 was selected as the suitable condition based on the odour, moisture content and short steaming time. Table (4.4) shows the effect of ingredient composition ratio on physico-chemical characteristics and cat feeding of extruded dry cat food. Extruded dry cat food was prepared with the suitable steaming time of 25 min. and the samples were coded as HFW_1 to HFW_7. The moisture content of HFW_1 to HFW_7 was within the range of literature value and the ash content of HFW_1 to HFW_7 depends on the amount of mineral matter contained in the fish flour. Among the different composition ratio, HFW_3 was selected as the suitable sample because of low moisture content, high yield percent and economic point of view. On the study of cat feeding of dry cat food, it was found that all the samples were consumed by the domestic cat. Although HFW_5 with the ratio of 50 g : 50 g had the highest consumption of cat, based on the content of fish, the ratio used in HFW_3 was chosen as the optimum ratio based on the economic point of view. In this research work, the preparation of dry cat food was also prepared by mixing fish with corn and soybean. The preparation method was the same as wheat. The optimum steaming time used for corn and soybean was found 25 min. and 20 min. respectively. Table (4.5) and (4.7) pointed out the comparison of steaming time for corn and soybean.

The physico-chemical analysis data obtained in Table (4.6) and (4.8) represented the value obtained for corn and soybean. The effect of ingredients composition ratio on cat feeding of dry cat food (fish/corn) and (fish/soybean) were also tasted with the domestic cat. It was found that all the samples were consumed by the domestic cat and HFC_5 and HFS_2 were found the highest consumption. Among them, HFC_5 was chosen as the most suitable sample based on the moisture content and protein content for dry cat food ingredients of corn.HFS_2 was also chosen as the most suitable sample based on the moisture content and protein content, nutrition of fish and economic point of view for dry cat food ingredients of soybean.

Table (4.9) pointed out the comparison of the nutritive value of dry cat food containing fish mixed with wheat, corn and soybean. It was obvious that the physico-chemical analysis of fish mixed with soybean, HFS_2 showed the most suitable sample for preparation of dry cat food based on the highest protein content and metabolizable energy.

Table (4.10) pointed out the physical properties of pumpkin and carrot powder. It was found that both pumpkin and carrot powder showed the range of good flow character.In Table (4.11), the comparison of the nutritive values of pumpkin and carrot powder was done and it was found that the protein content of carrot powder was higher than that of pumpkin powder. For the preparation of two types of dry cat food (fish, soybean, pumpkin) and (fish, soybean, carrot), the determination of the composition based on 100 g of dry cat food containing the fixed amount of fish and different ratio of pumpkin powder and carrot powder were done (Table 4.12 and Table 4.14). Based on the protein content and cat feeding results, $HFSP_2$ (Table 4.13) and $HFSC_2$ (Table 4.15) were chosen as the suitable composition. In both Tables, although $HFSP_1$ and $HFSC_1$ showed the higher protein content than $HFSP_2$ and $HFSC_2$, $HFSP_2$ and $HFSC_2$ were chosen as the optimum ratio because the protein content difference is not too much but the intension was more vitamin content contained in pumpkin and carrot to fulfill the nutrient of dry cat food.

Table (4.16) pointed out that the dry cat food prepared with the mixture of fish, soybean and pumpkin was better than fish, soybean and carrot after comparing the value of protein and

metabolizable energy value. After measuring the microbial investigation of the optimum cereal mixed dry cat food and vegetable mixed dry cat food, it was found that both samples were free of *Salmonella*.

The phytochemical analysis of Kyaung-yo-thay leaves powderexhibited the presenceof alkaloid, carbohydrate, glycoside, phenol,α-amino acid, trace of saponin, starch and tannins (Table 4.17). According to the literature, tannins protect heart diseases and cancer and they can disable bacteria in the mouth.

Table (4.18) shows the physical properties of Kyaung-yo-thay leaves powder. Cats usually consume Kyaung-yo-thay plants under the abnormal condition of health. In this study the acceptable mixing ratio of Kyaung-yo-thay leaves powder to dry cat food, the effect of Kyaung-yo-thay leaves powder on the moisture content and cat feeding of dry cat food was studied and the results were shown in Table (4.19). $HFSK_3$ was selected as the most suitable ratio because Table (4.19) pointed out that $HFSK_3$ possessed low moisture content, highest consumption and acceptable taste for cat.

Effect of different ingredients on water activity and size stability of the most suitable dry cat food using hot air oven drying was studied and shown in Table (4.20). According to this Table, the water activity of HFS_2 and $HFSP_3$ were the lowest among the other samples and the water activity of all the samples was around the value of 0.3. Bacteria, molds and yeast require water for growth and every microorganism has a minimum water activity below a_w =0.61 it does not grow. Bacteria will grow at about a_w =0.85 and mold and yeast about a_w =0.61 according to the literature. Size stability of dry cat food was determined by using drop test. In terms of drop test, the size stability of kibble made from fish and brown rice was the least because the kibble was made by pelleting the dry powder with hydraulic press and it could be easily broken into powder. Since the other kibbles were made by extruding and drying, these samples were not easily breakable.

Table (4.21) shows the determination of feline body mass index (FBMI) of experimental cats. From these results, the weight of C_1 (domestic cat) and C_3 were the same; however, the FBMI of C_1 was greater than the FBMI of C_3. According to literature, all the cats tested were under the condition of normal weight and the daily consumption of cats except C_4 was 80 g/day and that of C_4 was 60 g/day.

The hot air oven dried kibbles with different ingredients and recipes were fed simultaneously to the neighbour's cats in the evening and the results are shown in Table (4.22). It was evident that only $HFSK_3$ (Fish, Soybean and Kyaung-yo-thay) and $HFSC_2$ (Fish, Soybean and Carrot) were consumed by C_2 although C_3 and C_4 consumed all the dry cat food. Although all of the recipies of dry cat food were consumed by the cats, dry cat food prepared with Kyaung-yo-thay leaves was found to be lowest consumption of all cats. This is because of the odour of Kyaung-yo-thay leaves.

To develop the manufacturing of dry cat food with low cost technology, direct solar cabinet dryer was used to dry the ingredients and cat food. The drying rate of fish was determined by using direct solar cabinet dryer in November and December and the results are shown in Table (4.23). It was observed that after the fish had dried for 10 hr, 380.5g of total moisture was reduced. The drying rate was markedly decreased at drying time of 2 hr. Then beyond drying time of 2 hr the drying rate was gradually decreased.

System drying efficiency of direct solar cabinet dryer was determined in November and December and the results are shown in Table (4.24). It was noted that drying efficiency in December was better than that in November and the drying time of December was shorter than November.

Table (4.25) shows the physical properties of prepared fish powder by using solar dryer. It was found that the flow character of fish powder was within the excellent range according to the literature range of compressibility index (1-10). The effect of different drying methods on nutritive value of the prepared fish powder is shown in Table (4.26). It was observed that the protein content of prepared fish powder with solar dryer was slightly higher than that of fish powder with hot air oven. In addition, the moisture content, ash content, crude fiber and crude fat content of prepared fish powder with solar dryer were lower than that of fish powder with hot air oven.

Among the prepared dry cat food with hot air oven, dry cat food prepared from fish and soybean was chosen as the suitable sample based on the nutritive value. To compare the function of different drying methods from the points of nutritive value and cost estimation, solar dryer was also used for the preparation of dry cat food by using the optimum ingredients composition of dry cat food with hot air oven. Table (4.27) shows the effect of solar drying time on the characteristics of dry cat food (fish and soybean). According to this Table, the least solar drying time of 2 hr was selected for the preparation of dry cat food because all of the variables of the moisture content, protein content and water activity differences were very closer and all of the values were under allowable limit. Low value of moisture content gave low value of water activity and bacteria cannot grow at this condition. However, overheating adversely affects the nutritive value of dried products. The size stability percent of all the dry cat food was nearly the same (96 %) because their moisture content was around the value of 3%.

The effect of different drying methods on nutritive valueof prepared dry cat food was evaluated and presented in Table (4.28).It was evident that the protein content and metabolizable energy of dry cat food using solar drying were significantly higher and the crude fat and crude fiber content were also slightly higher than that of dry cat food using hot air oven. In addition, the cost of prepared dry cat food with solar drying was lower than the cost of dry cat food with hot air oven. Moreover, t-test was used for different drying methods on the protein value. The calculation is shown in appendices. According to this results, t_0 =-10.41<-2.306 means the two drying methods are different.

The comparison of cat feeding of dry cat food using solar drying and commercial dry cat food were conducted and the results are shown in Table (4.29). The home cat was simultaneously fed with prepared samples and commercial dry cat food (MeO). From these results, it was found that, prepared samples was consumed first because of the fishy smell of dry cat food was stronger than MeO. However, MeO was fully consumed because of the smooth appearance, crispy, meat flavor coating and meat broth as the wet ingredient.

Table 4.1 Physico-chemical Characteristics of Raw Fish for the Preparation of Dry Cat Food

Sr.No.	Value of Sample	Pyi-taw-thar	Nga-khaung-pwa
1	Moisture Content (% w/w)	73.06	74.16
2	Ash (% w/w)	5.35	3.63
3	Protein (% w/w)	19.03	17.81
4	Crude Fat (% w/w)	0	0.2
5	Crude Fibre (% w/w)	1.04	3.34
6	Carbohydrates	1.52	0.86
7	Energy Value (kcal/100 g)	82.2	76.48
8	Salt (% w/w)	0.04	0.03

Table 4.2 The Nutritive Value of Prepared Fish Powder

Sr.No.	Value of Sample	Fish Powder	Literature Value (Prepared fish powder from Tuna Trimmings)
1	Moisture Content (% w/w)	11.37±0.2	4.8
2	Ash (% w/w)	9.51±0.1	3.4
3	Protein (% w/w)	72.33	80.71
4	Crude Fat (% w/w)	0.09	-
5	Crude Fibre (% w/w)	4.08	5.7
6	Carbohydrates	2.31	5.39
7	Energy Value (kcal/100 g)	299.37	344.4

Table 4.3 Effect of Steaming Time on the Characteristics of Dry Cat Food (Fish andWheat)

Weight of Fish Powder = 50 g Weight of Citric Acid = 0.5 g
Weight of Wheat Flour = 50 g Weight of Salt = 1 g
Volume of Distilled Water= 50 ml Steaming Temperature= 90-93°C
Drying Temperature= 60°C for 3 hr

Sr. No.	Sample	Steaming Time (min.)	Moisture Content (% w/w)	pH	Yield (%)	Observations
1	WST_1	10	5.75±0.25	6	93.5	Relatively weak fishy smell, brown colour
2	WST_2	15	6.55±0.25	6	93.5	Moderately strong fishy smell, brown colour
3	WST_3	20	7.5±0.3	6	93.5	Moderately strong fishy smell, brown colour
4	WST_4	25*	8.25±0.25	6	93.5	Attractable fishy smell, brown colour
5	WST_5	30	8.88±0.2	6	93.5	Attractable fishy smell, brown colour
6	WST_6	35	11.5±0.1	6	88.1	Attractable fishy smell, brown colour

* Most suitable condition

Table 4.4 Effect of Ingredients Composition Ratio on the Characteristics and CatFeeding of Extruded Dry Cat Food (Fish and Wheat)

Volume of Distilled Water = 50 ml
Weight of Citric Acid = 0.5 g
Weight of Salt = 1 g
Steaming Temperature = 90-93˚C for 25 min.
Drying Temperature = 60˚C for 3.5 hr

Sr.No.	Sample	Weight of fish powder to wheat flour based 100 g	Moisture Content (% w/w)	Ash (% w/w)	Protein (% w/w)	pH	Yield (%)	Cat Feeding (%)
1	HFW_1	10:90	9.85±0.15	12.5±0.5	ND	6	89	28.1
2	HFW_2	20:80	9.6±0.3	12.5±0.5	24.65	6	89	69.5
3	HFW_3^*	30:70	9.6±0.3	13.5±0.5	33.16	6	94	76.6
4	HFW_4	40:60	9.9±0.1	14.5±0.3	34.27	6	94	64.2
5	HFW_5	50:50	9.8±0.1	14.5±0.5	39.47	6	94	100
6	HFW_6	60:40	9.65±0.05	15.5±0.5	48.28	6	89	83.7
7	HFW_7	70:30	9.45±0.35	15.8±0.2	53.15	6	89	68.4

*Most suitable sample

Table 4.5 Effect of Steaming Time on the Characteristics of Dry Cat Food (Fish and Corn)

Weight of Fish Powder = 50 g Weight of Citric Acid = 0.5 g
Weight of Corn Flour = 50 g Weight of Salt = 1 g
Volume of Distilled Water = 50 ml Steaming Temperature = 90-93˚C
Drying Temperature= 60˚C for 3 hr

Sr.No.	Sample	Steaming Time (min.)	Moisture Content (% w/w)	pH	Yield (%)	Observations
1	CST_1	10	10.2±0.2	5.8	84	Relatively weak fishy smell, brown colour
2	CST_2	15	10.5±0.1	5.8	91	Moderately strong fishy smell, brown colour
3	CST_3	20	10.3±0.2	5.9	91	Moderately strong fishy smell, brown colour
4	CST_4	25*	10.4±0.1	5.9	93	Attractable fishy smell, brown colour
5	CST_5	30	11.8±0.4	6.1	94	Attractable fishy smell, brown colour
6	CST_6	35	12.3±0.9	6.1	89	Attractable fishy smell, brown colour

* Most suitable condition

Table 4.6 Effect of Ingredients Composition Ratio on the Characteristics and Cat Feeding of Extruded Dry Cat Food (Fish and Corn)

Volume of Distilled Water = 50 ml
Weight of Citric Acid = 0.5 g
Weight of Salt = 1 g
Steaming Temperature = 90-93˚C for 25 min.
Drying Temperature = 60˚C for 3.5 hr

Sr. No.	Sample	Weight of fish powder to Corn flour based 100 g	Moisture Content (% w/w)	Ash (% w/w)	Protein (% w/w)	pH	Yield (%)	Cat Feeding (%)
1	HFC_1	10:90	9.1±0.1	9±0.1	ND	6	95	57
2	HFC_2	20:80	9.6±0.1	10±0.1	12.46	6	95	98
3	HFC_3	30:70	9.8±0.2	11.3±0.1	18.93	6	94	94
4	HFC_4	40:60	9.3±0.2	12.3±0.1	28.23	6	90	93
5	HFC_5*	50:50	9.4± 0.1	12.7±0.1	33.88	6	90	100

ND = Not determined
* Most suitable sample

Table 4.7 Effect of Steaming Time on the Characteristics of Dry Cat Food (Fish and Soybean)

Weight of Fish Powder = 50 g Weight of Citric Acid = 0.5 g
Weight of Soybean Flour = 50 g Weight of Salt = 1 g
Volume of Distilled Water = 50 ml
Steaming Temperature = 90-93˚C
Drying Temperature = 60˚C for 3 hr

Sr.No.	Sample	Steaming Time (min.)	Moisture Content (% w/w)	pH	Yield (%)	Observations
1	SST_1	10	7.5±0.15	6	91	Relatively weak fishy smell, brown colour
2	SST_2	15	7.8±0.1	6	91	Moderately strong fishy smell, brown colour
3	SST_3	20*	7.9±0.1	6	95	Attractable fishy smell, brown colour
4	SST_4	25	8.1±0.13	6	93	Attractable fishy smell, brown colour
5	SST_5	30	8.3±0.15	6	93	Attractable fishy smell, brown colour
6	SST_6	35	7.6±0.1	6	93	Attractable fishy smell, brown colour

* Most suitable condition

Table 4.8 Effect of Ingredients Composition Ratio on the Characteristics and Cat Feeding of Extruded Dry Cat Food (Fish and Soybean)

Volume of Distilled Water = 50 ml
Weight of Citric Acid = 0.5 g
Weight of Salt = 1 g
Steaming Temperature = 90-93˚C for 20 min.
Drying Temperature = 60˚C for 3.5 hr

Sr. No.	Sample	Weight of fish powder to Soybean flour based 100 g	Moisture Conten (% w/w)	Ash (% w/w)	Protein (% w/w)	pH	Yield (%)	Cat Feeding (%)
1	HFS_1	10:90	8.8±0.8	14±0.1	38.18	6	90	92
2	HFS_2*	20:80	10± 0.05	13± 0.1	41.50	6	92	94
3	HFS_3	30:70	10.2±0.02	13±0.1	45.51	6	92	54
4	HFS_4	40:60	10.9±0.05	12±0.07	47.33	6	93	54
5	HFS_5	50:50	9.8±0.2	11±0.05	51.01	6	93	89

ND = Not determined
* Most suitable sample

Table 4.9 Comparison of the Nutritive Value of Suitable Dry Cat Food (Fish and Cereals)

Sr.No.	Value of Sample	Fish + Wheat (HFW_3)	Fish +Corn (HFC_5)	Fish + Soybean (HFS_2)
		30 g : 70 g	50 g : 50 g	20 g : 80 g
1	Moisture(% w/w)	96± 0.3	9.4±0.1	10± 0.05
2	Ash(% w/w)	13.5±0.5	12.7±0.1	13± 0.1
3	Protein(% w/w)	33.16	33.88	41.50
4	Crude Fat (% w/w)	1.3	3.15	14.89
5	Crude Fibre(% w/w)	0.35	0.17	3.13
6	Carbohydrates	37.69	34.4	15.98
7	Energy Value(kcal/100g)	295.1	301.47	363.93
8	pH	6.0	5.9	6.0
9	Metabolizable Energy (ME) (kcal/kg)	2590.3	2657.6	3277.5

Table 4.10 Physical Properties of Pumpkin and Carrot Powder

Sr. No.	Properties of Sample	Pumpkin Powder	Carrot Powder
1	Bulk Density (g/ml)	0.56	0.59
2	Tapped Density (g/ml)	0.63	0.67
3	Compressibility Index (%)	11.1	12
4	Flow Character	Good	Good

Table 4.11 Nutritive Value of Pumpkin and Carrot Powder

Sr.No.	Value of Sample	Pumpkin Powder	Carrot Powder
1	Moisture Content (% w/w)	2.59±0.13	7.20±0.04
2	Ash(% w/w)	6.99±0.7	9.79±0.74
3	Protein(% w/w)	6.78	12.70
4	Crude Fat (% w/w)	8.62	10.98
5	Crude Fibre(% w/w)	1.62	2.48
6	Carbohydrate (% w/w)	72.57	53.06
7	Energy Value (kcal/100g)	394.98	361.86

Table 4.12 Different Ingredients Composition Ratios of Dry Cat Food Using Hot Air Oven (Fish, Soybean and Pumpkin)

Sr. No.	Sample	Weight of Ingredients Based on100 g			Citric Acid (g)	Salt (g)	Distilled Water (ml)
		Fish Powder (g)	Soybean Flour (g)	Pumpkin Powder (g)			
1	$HFSP_1$	30	67	3	0.5	1	50
2	$HFSP_2$	30	64	6	0.5	1	50
3	$HFSP_3$	30	61	9	0.5	1	50
4	$HFSP_4$	30	58	12	0.5	1	50
5	$HFSP_5$	30	55	15	0.5	1	50

Table 4.13 Effect of Different Ingredients Composition Ratios on the Characteristics and Cat Feeding of Dry Cat Food (Fish, Soybean and Pumpkin)

Pre-steaming Time = 20 min.
Steaming Time = 20 min.
Steaming Temperature = 90-93˚C
Drying Temperature = 60˚C for 3.5 hr
Feeding Time = 30 min.

Sr. No.	Sample	Moisture Content (% w/w)	Protein (% w/w)	pH	Cat Feeding (%)
1	$HFSP_1$	7.24±0.4	43.31	5.9	75.1
2	$HFSP_2^*$	7.6±0.05	43.11	5.9	78.9
3	$HFSP_3$	8.1± 0.6	41.64	5.9	56.6
4	$HFSP_4$	8.2±0.2	40.22	5.7	57.3
5	$HFSP_5$	12.58±0.5	37.21	5.5	95.5

* Most suitable sample

Table 4.14 Different Ingredients Composition Ratios of Dry Cat Food Using Hot Air Oven (Fish, Soybean and Carrot)

Sr. No.	Sample	Weight of Ingredients Based on100 g			Citric Acid (g)	Salt (g)	Distilled Water (ml)
		Fish Powder (g)	Soybean Flour (g)	Carrot Powder (g)			
1	$HFSC_1$	30	67	3	0.5	1	50
2	$HFSC_2$	30	64	6	0.5	1	50
3	$HFSC_3$	30	61	9	0.5	1	50
4	$HFSC_4$	30	58	12	0.5	1	50
5	$HFSC_5$	30	55	15	0.5	1	50

Table 4.15 Effect of Different Ingredients Composition Ratios on the Characteristics and Cat Feeding of Dry Cat Food (Fish, Soybean and Carrot)

Pre-steaming Time = 20 min.
Steaming Time = 20 min
Steaming Temperature = 90-93˚C
Drying Temperature = 60˚C for 3.5 hr
Feeding Time = 30 min.

Sr.No.	Sample	Moisture Content (% w/w)	Protein(%w/w)	pH	Cat Feeding (%)
1	$HFSC_1$	10.2±0.08	42.77	5.8	77.2
2	$HFSC_2^*$	11.71±0.07	41.84	5.8	78.1
3	$HFSC_3$	11.8±0.36	41.78	5.7	65.3
4	$HFSC_4$	12.62±0.6	39.71	5.7	69.0
5	$HFSC_5$	13.19±0.5	38.98	5.6	96.5

* Most suitable sample

Table 4.16 Comparison of the Physico-chemical Characteristics of the Dry Cat Food (Fish, Soybean and Vegetables)

Sr.No.	Value of Sample	$HFSP_2^*$	$HFSC_2$
1	Moisture(% w/w)	7.6±0.05	10.2±0.08
2	Ash(% w/w)	11.6±0.9	12.09±0.7
3	Protein(% w/w)	43.11	41.84
4	Crude Fat(% w/w)	12.92	11.76
5	Crude Fibr (% w/w)	3.45	3.21
6	Carbohydrates	17.68	18.51
7	Energy Value (kcal/100g)	359.44	347.24
8	pH	5.9	5.8
9	Metabolizable Energy (ME) (kcal/kg)	3225.85	3111.85

* Most suitable sample

Table 4.17 Phytochemical Properties of *Acalypha indica* Linn. (Kyaung-yo-thay) Leaves Powder

Sr.No.	Type of compound	Extract	Reagent used	Observations	Inference
1	Alkaloid	1% HCl	Hager's reagent	Yellow precipitate	+
2	Carbohydrate	H_2O	10% α-naphthol and H_2SO_4(Conc:)	Red ring	+
3	Glycoside	H_2O	10% Lead acetate solution	White precipitate	+
4	Phenol	H_2O	5% $FeCl_3$ solution	Brownish black precipitate	+
5	α-amino acid	H_2O	Ninhydrin reagent	Purple colour	+
6	Saponin	H_2O	No reagent used	Persistent foam	Trace
7	Starch	H_2O	Iodine solution	Bluish brown precipitate	+
8	Tannin	H_2O	1% Gelatin and 10% NaCl solution	Precipitate	+

(+) = presence (-) = absence

Table 4.18 Physical Properties of *Acalypha indica* Linn. (Kyaung-yo-thay) Leaves Powder

Weight of Leaves = 230 g
Drying Temperature = Room Temperature (28-32℃) for 10 days
Weight of Leaves Powder = 36.35 g
Dryness Test = Crispy
Initial Colour = Light Green
Final Colour = Dark Green

Sr. No.	Properties of Sample	Kyaung-yo-thay Leaves Powder
2	Moisture Content (% w/w)	15.13±0.03
3	Bulk Density (g/ml)	0.15
4	Tapped Density (g/ml)	0.16
5	Compressibility Index (%)	8
6	Flow Character	Excellent

Table 4.19 Effect of Ingredients Composition Ratio on the Characteristics and Cat Feeding of Dry Cat Food (Fish, Soybean and Kyaung-yo-thay Leaves)

Volume of Distilled Water = 50 ml
Weight of Citric Acid = 0.5 g
Weight of Salt = 1 g
Pre-steaming Time = 20 min.
Steaming Temperature = 90-93˚C for 20 min.
Drying Temperature = 60˚C for 3.5 hr
Feeding Time = 30 min.
Experimental Cat = Domestic Cat

Sr. No.	Sample	Composition	Moisture Content (% w/w)	Cat Feeding (%)
1	$HFSK_1$	30 F:65 S:5 K	8.3±0.2	99.2
2	$HFSK_2$	30 F:60 S:10 K	7.9±0.1	98.5
3	$HFSK_3^*$	30 F:55 S:15 K	7.54±0.15	99.4
3	$HFSK_4$	30 F:50 S:20 K	7.2±0.1	96.7

* Most suitable sample
F = Fish powder
S = Soybean flour
K = Kyaung-yo-thay leaves powder

Table 4.20 Effect of Different Ingredients and Recipes on Water Activity, Size Stability of the Most Suitable Dry Cat Food Using Hot Air Oven Drying

Sr.No.	Sample	Water Activity	Size Stability Percent (Drop Test)
1	HFB_2	0.32	62
2	HFW_3	0.32	95
3	HFC_5	0.31	98
4	HFS_2	0.30	98
5	$HFSP_2$	0.30	99
6	$HFSC_2$	0.36	98
7	$HFSK_3$	0.37	99

Table 4.21 The Feline Body Mass Index (FBMI) of Experimental Cats

Sr. No.	Cats	Gender	Age (yr)	Weight of Cat (lb)	Rib Cage (cm)	Lower Hind limb Measurement (cm)	Feline Body Mass Index (Percentage Body Fat)
1	C_1	Male	4	15	43	20	24.66
2	C_2	Female	6	14	41	22	17.38
3	C_3	Male	7	15	44	22	22.02
4	C_4	Male	1	10	26	14	10.92

C_1= Ahlone Township
C_2= Kyeemyindaing Township
C_3= North Dagon Township
C_4= Kamaryut Township

Table 4.22 Effect of Different Ingredients and Recipes on Neighbour's Cats Feeding of the Most Suitable Dry Cat Food Using Hot Air Oven Drying

Weight of Kibbles = 10 g
Feeding Time = 1hr
Feeding Period = Evening

Sr. No.	Sample	Cat Feeding (%)		
		C_2	C_3	C_4
1	HFB_2	0	100	100
2	HFW_3	0	100	100
3	HFC_5	0	100	100
4	HFS_2	0	100	100
5	$HFSP_2$	0	100	75
6	$HFSC_2$	62	100	100
7	$HFSK_3$	35	32	11

C_2 = Kyeemyindaing Township
C_3 = North Dagon Township
C_4 = Kamaryut Township

Table 4.23 Effect of Drying Time on the Drying Rate of Raw Fish Using Direct Solar Cabinet Dryer (November and December, 2018)

Initial Weight = 500 g
Drying temperature = 40-60˚C
Length of fish = (1-2) cm

Sr. No.	Drying Time (hr)	November			December		
		Weight of Sample (g)	Moisture Content (% w/w) (Wet Basis)	Drying Rate (g/hr sq.cm)	Weight of Sample(g)	Moisture Content (% w/w) (Wet Basis)	Drying Rate (g/hr sq.cm)
2	1	396.45	20.71	0.052	396.94	20.61	0.052
3	2	384.33	2.42	0.029	314.47	16.49	0.047
4	3	369.30	3.01	0.022	259.63	10.97	0.040
5	4	289.35	15.99	0.026	201.20	11.69	0.038
6	5	243.63	9.14	0.026	160.28	8.18	0.034
7	6	202.08	8.17	0.025	135.31	4.99	0.030
8	7	189.4	2.54	0.023	123.59	2.34	0.027
9	8	136.2	10.64	0.023	115.43	1.63	0.024
10	9	130.9	1.06	0.021	-	-	-
11	10	119.5	2.28	0.019	-	-	-

Table 4.24 System Drying Efficiency of Direct Solar Cabinet Dryer during Drying of Fish

Sr.No.	Drying Period	System Drying Efficiency (%)
1	November	9
2	December	14

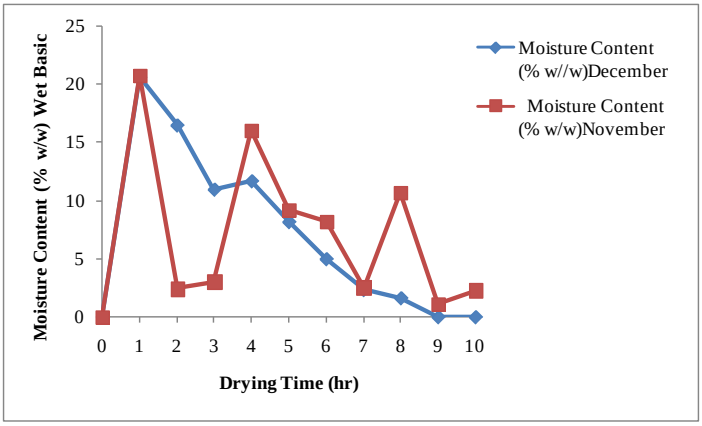


Figure 4.1 Drying Curve during Drying of Fish in November and December

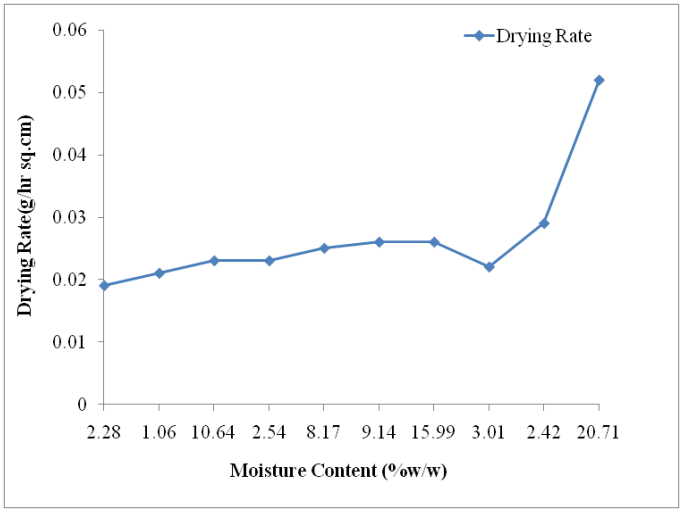


Figure 4.2 Drying Rate Curve during Drying of Fish in November

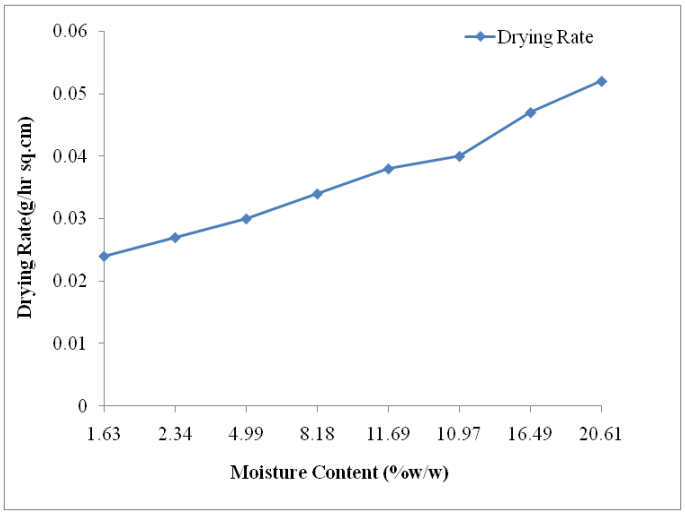


Figure 4.3 Drying Rate Curve during Drying of Fish in December

Table 4.25 Physical Properties of Prepared Fish Powder Using Solar Drying

Drying time = 6 hr

Sr.No.	Properties of Sample	Fish Powder
1	Moisture Content (% w/w)	9.12±0.02
2	Bulk Density (g/ml)	0.40
3	Tapped Density (g/ml)	0.43
4	Compressibility Index (%)	8
5	Flow Character	Excellent

Table 4.26 Effect of Different Drying Methods on Nutritive Value of Fish Powder

Solar drying time = 6 hr
Hot air oven drying time = 6.5 hr

Sr.No.	Value of Sample	Solar Drying	Hot Air Oven Drying
1	Moisture Content (% w/w)	9.12±0.02	11.37±0.2
2	Ash (% w/w)	8.7±0.07	9.51±0.1
3	Protein (% w/w)	72.48	72.33
4	Crude Fat (% w/w)	0.06	0.09
5	Crude Fibre (% w/w)	3.20	4.08
6	Carbohydrates	6.35	2.31
7	Energy Value (kcal/100 g)	315.86	299.37

Table 4.27 Effect of Solar Drying Time on the Characteristics of Dry Cat Food (Fish and Soybean)

Weight of fish powder = 20 g Weight of salt = 1g
Weight of soybean flour = 80 g Volume of distilled water = 50 ml
Weight of citric acid = 0.5g Steaming temperature = 90-93˚C
Drying temperature = 58-70˚C

Sr. No.	Sample	Drying Time (hr)	Moisture Content (%w/w)	pH	Water Activity	Protein Value (% w/w)	Size Stability(%)
1	SFS_1	2*	3.68±0.1	6.4	0.38±0.1	47.44	96.8
2	SFS_2	2.5	3.50±0.1	6.4	0.36±0.1	48.32	96.5
3	SFS_3	3	3.33±0.2	6.4	0.32±0.2	48.87	96.4
4	SFS_4	3.5	3.11±0.1	6.4	0.31±0.1	45.86	96.2

*Most suitable sample
SFS= Prepared dry cat food with solar drying (Fish and Soybean)

Table 4.28 Effect of Different Drying Methods on Nutritive Value of Dry Cat Food (Fish and Soybean)

Sr. No.	Value of Sample	Solar Drying	Hot Air Oven Drying
1	Moisture Content (% w/w)	3.68±0.1	10± 0.05
2	Ash(% w/w)	10.81± 0.19	13± 0.1
3	Protein (% w/w)	47.44	41.50
4	Crude Fat (% w/w)	15.20	14.89
5	Crude Fibre (% w/w)	3.92	3.13
6	Carbohydrates	18.95	15.98
7	Energy Value (kcal/100 g)	402.36	363.93
8	Metabolizable Energy (ME)(kcal/kg)	3615.65	3277.5
9	Estimated Cost (kyat) (400 g/bag)	1036	1175

Table 4.29 Comparison of Cat Feeding of Dry Cat Food Using Solar Drying and Imported Dry Cat Food (MeO)

Sr. No.	Parameters	Morning		Afternoon		Evening	
		Prepared Dry Cat Food	MeO	Prepared Dry Cat Food	MeO	Prepared Dry Cat Food	MeO
1	Choice of Dry Cat Food	Second	First	First	Second	First	Second
2	Feeding (g)	20	30	29	30	21.5	30
3	Percent Feeding	66.7	100	99	100	71.7	100

Figure (4.4) Dry Cat Food (Fish and Wheat) Using Hot Air Oven

Figure (4.5) Dry Cat Food (Fish and Corn) Using Hot Air Oven

Figure (4.6) Dry Cat Food (Fish and Soybean) Using Hot Air Oven

Figure (4.7) Dry Cat Food (Fish, Soybean andPumpkin Using Hot Air Oven

Figure (4.8) Dry Cat Food (Fish and Soybean and Carrot) Using Hot Air Oven

Figure (4.9) Dry Cat Food (Fish, Soybean and Kyaung-yo-thay Leaves) Using Hot Air Oven

Figure 4.10 Dry Cat Food (Fish and Soybean) Using Solar Drying

Conclusion

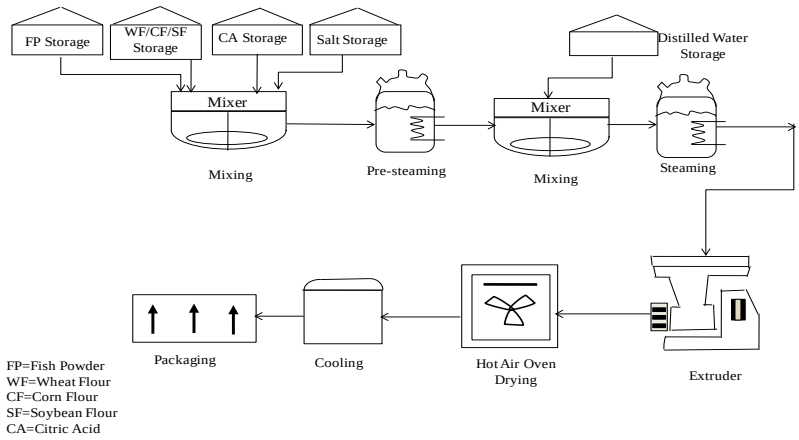
The aim of this research was to investigate the process development on the production of dry cat food based on fish factory wastes, low grade fish for factory, by converting to acceptable products for cat consumption and import substitution. This research gave practically how various low grade fish resources could be processed to high grade protein fish powder and dry cat food.

In Myanmar, the cat owners usually feed home-made diets. Dry cat food of the present invention is under the form of kibbles that are crunchy, crispy pieces. Hence, dry cat food was intended to produce from fish by incorporating cereals such as wheat, corn and soybean. The protein content of dry cat food was 33.16 % from fish and wheat, 33.88% from fish and corn, 41.5 % from fish and soybean. It can be concluded that soybean was the suitable cereal for the preparation of dry cat food because it gave the highest protein content.

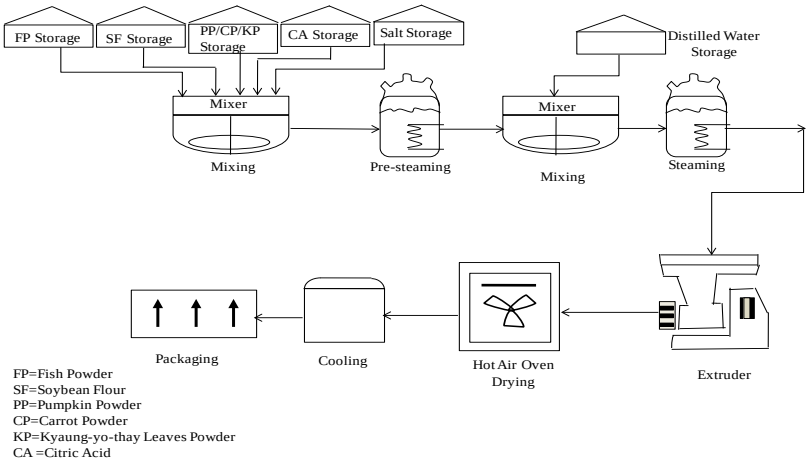
A study was also conducted to the production of dry cat food by mixing pumpkin or carrot with the optimum dry cat food (fish and soybean). Pumpkin and carrot are mostly used as ingredients in imported dry cat food and they provide essential phytonutrients, antioxidants and enzymes plus natural vitamins, minerals and fibres that promote health and wellness.The result of this study showed that a combination of pumpkin or carrot gave not only the attractive colour to the cat owners but also natural vitamins to the cats. Although both pumpkin and carrot gave the best results, the final conclusion was the selection of 30:61:9 of fish, soybean and pumpkin as the optimum due to the moisture content, protein content and metabolizable energy. As the product safety, *Salmonella* was not also detected in prepared dry cat food and so dry cat food could be assumed to be of acceptable quality.

This study also revealed the feasibility of using solar drying instead of hot air oven to produce dry cat food with the acceptable quality based on the nutritive value and economic point of view and to support the import substitution. It was observed that the nutritive value of dry cat food using solar dryer was markedly higher than using hot air oven. The conclusion was that dry cat food could be produced by using direct solar cabinet dryer as constructed in this research work in some areas of country where solar radiation is abundantly available.

Hypothetical Process Design

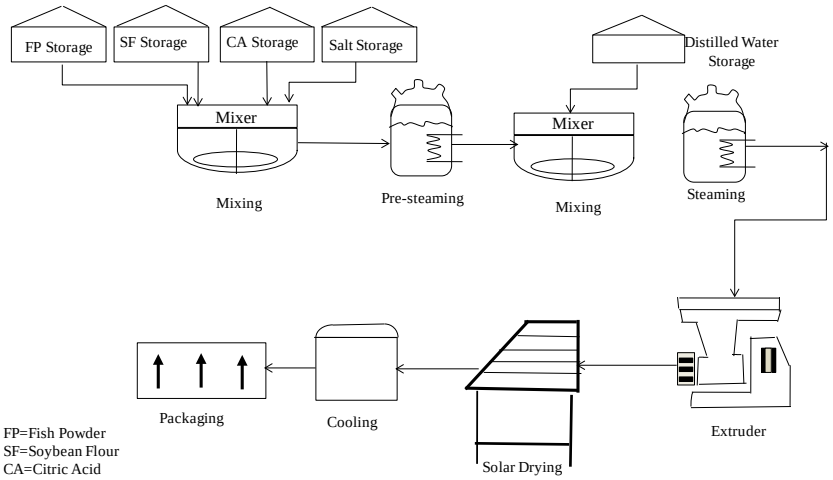


Schematic Diagram for the Production of Dry Cat Food (Fish and Wheat)/(Fish and Corn)/(Fish and Soybean) Using Hot Oven Air



Schematic Diagram for the Production of Dry Cat Food (Fish, Soybean and Pumpkin)/ (Fish, Soybean and Carrot)/ (Fish, Soybean and Kyaung-yo-thay Leaves) Using Hot Air Oven

JºJ



Schematic Diagram for the Production of Dry Cat Food (Fish and Soybean) Using Solar Dryer

Estimated Cost for Production of Dry Cat Food

Manufacturing cost for one bag (400 g) of Dry Cat Food (Fish and Soybean) Using Hot Air Oven = K 1175/bag

Manufacturing cost for one bag (400 g) of Dry Cat Food (Fish, Soybean and Pumpkin) Using Hot Air Oven = K 1452/bag

Manufacturing cost for one bag (400 g) of Dry Cat Food (Fish, Soybean and Carrot) Using Hot Air Oven = K 1562/bag

Manufacturing cost for one bag (400 g) of Dry Cat Food (Fish and Soybean) Using Solar Dryer =K 1036/bag

t-Test of Hypothesis

If one –sided alternative hypothesis, $H_1=\mu_1<\mu_2$, $H_o: \mu_1=\mu_2$

If $t_0< (-t_\alpha, n_1+n_2-2)$ Reject H_o.

Problem: Protein constant in dry cat food (fish and soybean)

Hot Air Oven Drying	Solar Drying
41.50	47.46
41.09	47.44
41.14	48.32
41.26	48.87
42.64	45.86

$\overline{X_1}$ = 41.526 % $\overline{X_2}$ = 47.59%

S_1^2 = 0.413 S_2^2 = 1.302

S_1 = 0.643 S_2 = 1.141

To test the hypothesis

$\alpha=0.05$

V=n-2=10-2=8

From t table, t_{α}=2.306

$$S_P^2 = \frac{(n_1 - 1)S_1^2 + (n_2 - 1)S_2^2}{n_1 + n_2 - 2}$$

$$= \frac{4(0.41) + 4(1.302)}{5 + 5 - 2} = 0.855$$

$$S_p = 0.92$$

$$t_0 = \frac{\overline{y_1} - \overline{y_2}}{S_p\sqrt{\frac{1}{n_1} + \frac{1}{n_2}}} = \frac{41.53 - 47.59}{0.92\sqrt{\frac{1}{5} + \frac{1}{5}}} = -10.41$$

If t_0=-10.41<-2.306, reject H_o and conclude that the mean protein value of dry cat food of the two drying methods are different.

(Montgomery, 2001)

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References

Amir, H.M.S., and Mona, Z., (2013). Raw Ingredients in Cat Food Manufacturing,*Journal of Tropical Resources and Sustainable Science*, Volume 1, University Malaysia Kelantan Publisher, Retrieved August 16, 2014 from www.jtrss.org/JTRSS/volume1/UN-0/1-1-1-15.pdf.

Fact Sheets,(2014).Fruits and Vegetables in Pet Food, Retrieved November 20, 2016 from https://petnet.io/blog/fruits-and-vegetables-in-pet-food.

Hii, C.L., Jangam, S.V., Ong, S.P., and Mujumdar, A.S., (2012). *Solar Drying: Fundamentals, Applications and Innovations*, published in Singapore.

Myint, K.T.Y., Myint, M.M.S., and Myint W. (2005). Detection of cyanogenic glycoside in *Acalyphaindica* Linn.(Kyaung-hsay-pin), *The Myanmar Health Sciences Research Journal*, Vol.17, No.2,2005, 99-103 Retrieved December 20, 2016 from http://myanmarhsrj.com/index.php?page=sviewabstract&articleid=Reg000364&articleyear=2005&articlevolume=17&articleissue=2&s=.

Peters, S.M. and Klaus, D.T. (1968).Plant Design and Economics for Chemical Engineers, Second Edition, Mc Graw-Hill Kogakusha Ltd., Tokyo.

Pet Food Manufacturers Association, (2010).Ingredients in Pet Food, Retrieved February 9, 2014 from http:// www.pfma.org.uk/ingredients-in-pet-food.

Rivera, J.A. (1998). *Petfood:physico-chemical characteristics and functional properties of meat by-products and mechanically separated chicken(MSC) in a high-moisture model system*,Iowa State University Retrieved July 7, 2016 from http://lib.dr.iastate.edu/cgi/viewcontent.cgi? article=12885&context=rtd.

Ruaud, J., Guiller, I. and Levesque, A., (2011). Method for producing highly palatable dry cat food,RetrievedJanuary 29, 2015 fromhttp://wwwgoogle.com/patents /cat food.htm/EP2651239A1.htm.

The world's leading authority on pet care and nutrition, (2003). Feline Body Mass Index,Retrieved May 26, 2017 from https://www.felinediabetes.com/FelineBMI.pdf.

AN ASSESSMENT OF REASONING SKILLS ENHANCING PROBLEM SOLVING ABILITY AMONG STUDENT TEACHERS FROM UNIVERSITIES OF EDUCATION IN MYANMAR

J-01 AN ASSESSMENT OF REASONING SKILLS ENHANCING PROBLEM SOLVING ABILITY AMONG STUDENT TEACHERS FROM UNIVERSITIES OF EDUCATION IN MYANMAR

Yar Zar Chit*

Abstract

The main aim of this study was to assess reasoning skills enhancing problem solving ability among student teachers from universities of education in Myanmar. A total of 1626 student teachers from Yangon University of Education, Sagaing University of Education and University for the Development of National Races of the Union participated in this study. In this study, sequential explanatory research design was chiefly used. To achieve the main goal, a reasoning skill test and a problem solving ability test were firstly developed by using Item Response Theory (IRT) and Classical Test Theory (CTT). Based on the tests, findings from field testing revealed that the student teachers had higher reasoning skills and higher problem solving ability. Moreover, although there were no significant gender differences in reasoning skill, it was found that male students' problem solving ability was significantly higher than females. In reasoning skill, the student teachers in University 1 got the highest mean score and those in University 3 got the lowest mean score among three universities. Concerning with problem solving ability, student teachers in university 1 and university 2 were significantly higher than those of university 3. As predicted, each component of reasoning skill was positively and moderately correlated with problem solving ability. Similarly, the result showed that the reasoning skills accounted for approximately 28.6% of the variance of problem solving ability. The results of the regression advocated that four reasoning skills included in the reasoning skill test are best predictors and can enhance the problem solving ability of student teachers. Finally, an intervention practice was conducted to improve student teachers' reasoning skills and to confirm the predictive validity of the reasoning skill test based on the quantitative results. The intervention protocol was based on Tim van Gelder's (2000) argument mapping technique. The results pointed that the reasoning skills of student teachers after intervention were significantly higher than before intervention. Therefore, this study highlighted the fact that reasoning skills can well enhance problem solving ability of student teachers and that their reasoning skills can be trained by using argument mapping technique based practice.

Introduction

In the living world, a chief characteristic which can distinguish human beings from other species including the higher animals is cognitive ability. It includes thinking, reasoning, problem solving and other aspects based on human brain functions. The challenges and problems faced by the individual, or by society, in general, are solved through serious efforts involving thinking and reasoning. The powers of thinking and reasoning may thus be considered to be the essential tools for the welfare and meaningful existence of the individual as well as society.

Moreover, Prof. Dr. Khin Zaw (1994) remarked that man's history on this planet earth is one of the change and achievement. From the cave to cosmos: emerging from the brutish existence of pre-man, he has managed in the span of some hundreds of generations to gain the present range of mastery of nature. He is now living in a world of fantastic scientific and technology achievements ranging from those which contribute to the maximum welfare and pleasure of man to those which are capable of his complete annihilation. This event is the best example of human's cognitive or reasoning ability.

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Moreover, Prof. Dr. Khin Zaw (2001) pointed the fact that man has reason and imagination leading not only to the necessity for having a sense of his own identity, but also for orienting himself in the world intellectually. Additionally, he differentiated reason from intelligence. Reason is man's faculty for grasping the world by thought, in contradiction to intelligence, which is man's ability to manipulate the world with the help of thought. Reason is man's instrument for arriving at the truth; but intelligence is his instrument for manipulating the world more successfully; the former is essentially human, the latter belongs to the animal part of man. Therefore, human reasoning skill and problem solving ability are essential in daily life and they are interdependent like the head and tail of a coin.

At the present time, in the modern technological world, communications are sophisticated, and people have a variety of information to stimulate and inform their thinking. However, it is not just right information that is distributed in society. False and misleading information is also spread out to people too. People have to be able to analyze, discriminate and make good decisions on the basis of sound reasons. Education therefore has a crucial role to play in developing that ability.

Consequently, the teachers' tasks are getting more and more complex because of the technically, economically, socially, and politically changing world. Teachers have to face with increasing challenges (new ways of technology, motivation, team work, differentiation, classroom management, assessment connection with parents). Nearly every class has students facing integration problems, students who are under-motivated, aggressive or have other behavioural problem or students who have learning problems. For this reason, it is important that student teachers who will take responsibility for national education should have the problem solving ability about the issues.

As indicated above it can be argued that reasoning skills for problem solving ability have become more important for teachers and student teachers in the modern world because there is too much information, and too many choices that come into human's minds. Those who have made the right decisions or act in a more reasonable way are likely to have less of a problem. Moreover, reasoning skills become more important for more practical reasons because many organizations (both government and non government) test the candidates' reasoning skills before employing them in their particular association.

Accordingly, these facts become the reasons for the researcher to investigate the reasoning skills that can enhance problem solving abilities among Myanmar student teachers and explore the relationship between these skills and abilities. The researcher hopes that the results from this study will be able to contribute as the background factors in creating effective teaching learning environment especially in teacher education.

Aim of the Study. The primary aim of this study is to investigate the reasoning skills that can enhance problem solving ability among student teachers from Universities of Education in Myanmar. The specific objectives can be expressed in detail as follows.

1. To develop a reasoning skill test by using Item Response Theory (IRT) and a problem solving ability test by using Classical Test Theory (CTT)
2. To examine the reasoning skills and problem solving ability of student teachers
3. To compare the student teachers' reasoning skills by gender and university
4. To compare the student teachers' problem solving abilities by gender and university

5. To explore the relationship between reasoning skills and problem solving ability
6. To find out the extent to which reasoning skills can predict problem solving ability
7. To improve student teachers' reasoning skills by using an intervention practice
8. To confirm the predictive validity of the reasoning skill test on problem solving ability

Review of Related Literature

As the theoretical framework for reasoning skill, this study was based on Evans and Over's Dual-Process theory.

Evans and Over's Dual-Process Theory. Evans's (1989) heuristic–analytic theory provided the foundations for Evans and Over's (1996) current dual-process theory. Evans (1984) proposed that heuristic processes are preconscious, and their function is to select representations relevant to a particular problem space. Analytic processes are conscious, which means broadly that they are a type of deliberate, explicit thinking.

This theory divided reasoning into two systems. System 1, implicit or tacit process, which is essentially pragmatic, is based on prior experiences, beliefs, and background knowledge and achieves goals reliably and efficiently without necessarily accompanying awareness. System 2 is explicit, intentional, sequential, controllable, and makes high demands of working memory. System 2 does not typically operate according to normative logical conventions, but it is capable of achieving solutions to logical problems as well as a range of problem types.

On the other hand, reasoning involves both conscious (or explicit) and unconscious (or tacit) processes. For example, inductive reasoning largely depends on the retrieval and unconscious evaluation of world knowledge, whereas deductive reasoning depends on rule-based or conscious formal procedures.

In fact, reasoning refers to the process of drawing conclusions or inferences from information. Reasoning always requires going beyond the information that is given (Bruner, 1957). In logic, an inference is called *deductive* if the truth of the initial information (or premises) guarantees the truth of the conclusion. The inference is called *inductive* if the truth of the premises makes the conclusion probable but not certain. Many researchers have found that performance on deductive and inductive tests is strongly related (Wilhelm, 2005). Although there are several kinds of inductive reasoning, this research will focus on analogical and numerical reasoning.

Analogical Reasoning. The ability to reason analogically involves the ability to make judgments or predictions about unfamiliar problems on the basis of perceived similarities and relationships with familiar problems. This form of inferential reasoning also serves a variety of different functions ranging from drawing people's attention to already known relations to the reorganization and development of existing knowledge (Deloache, Miller, &Pierroutsakos, 1998).

Numerical Reasoning. It includes the ability to solve problems and arrive at answers, i.e., solution in a logical way and making generalization (Fatima, 2008). Numerical reasoning is about using numerical data to make reasoned decisions and solve problem. It relies on the ability to recognize how to go about solving a numerical problem, understanding the relationships between numbers, prior to completing the mathematical calculation required (Savill, 2011).

Like inductive reasoning, there are several kinds in deductive reasoning. However, this research will focus on analytical and abstract reasoning.

Analytical Reasoning. Analytic reasoning represents judgments made upon statements that are based on the virtue of the statement's own content. Analytical skill is the ability to visualize, articulate, conceptualize or solve both complex and uncomplicated problems by making decisions that are sensible given the available information. Such skills include demonstration of the ability to apply logical thinking to breaking complex problems into their component parts (Kant-Studien, 1987).

Abstract Reasoning. Abstract Reasoning is also known as fluid intelligence (Cattell, 1963) or analytic intelligence. Fluid intelligence is reasoning ability in its most abstract and purest form. It is the ability to analyze novel problems, identify the patterns and relationships that underpin these problems and extrapolate from this using logic (Carpenter, Just, and Shell, 1990).

To reveal the student teachers' problem solving abilities in this research, Mac Lellan, Langley and Walker's (2012) generative theory of problem solving was based.

Generative Theory of Problem Solving. The assumptions of generative theory of problem solving include:

- The primary mental structure in problem solving is the problem, which includes a state description and a goal description.
- A problem solution consists of a problem P; an applied intention or operator instance I; a right sub-problem, which is a sub-problem that has the same goals as P, but has a state that results from the application of I to P; a down sub-problem, which is a sub-problem that shares P's state but has preconditions corresponding to I's preconditions; and the solution to P's sub-problems. In the terminal case, a problem solution can also be a problem P that is marked as done.
- Problems and their (attempted) solutions reside in a working memory that changes over the course of problem solving, whereas operators and strategic knowledge reside in a long-term memory that changes gradually if at all.
- The problem-solving process operates in cycles that involve five stages: problem selection, termination checking, intention generation, failure checking, and intention application. Each stage involves changes to the problem structures in working memory.
- Alternative problem-solving strategies result from variations on these five processing stages, with their settings being entirely independent of each other.

Although the first three assumptions specify important commitments about representation and organization, the final two tenets are the most interesting and important. The postulation of five stages that take on orthogonal settings provides the generative power to explain the great variety of possible problem-solving strategies. Thus, problem solvers should consider each stage and its possible settings in more detail.

Method

Sampling. Sample chosen for the present study consisted of 1626 student teachers from first year to fifth year: male (n=746) and female (n=880) in 2017-2018 Academic Year. The participants for the study were chosen from Universities of Education in Myanmar: Yangon University of

Education, Sagaing University of Education and University for the Development of National Races of the Union (Sagaing). A stratified random sampling technique was used.

Research Method. Sequential explanatory design from quantitative and qualitative mixed method approaches was taken as the primary design of this study. In the first part of this study, survey method was used. As the second part, an intervention based analysis based on the experimental method was also used.

Pilot Testing on Reasoning Skill Test and Problem Solving Ability Test. There were four subtests in reasoning skill test and each subtest comprised of 23 items. The test items were multiple-choice items. The test was administered to a sample of 220 student teachers (from first year to fifth year) in Sagaing University of Education. According to data analysis of non-speediness of the test, it could be confirmed that all tasks of the tests in current study were non-speeded. After carrying out the item analysis based on an IRT parameter estimation procedure with two parameter logistic model (2 PLM), 14 items which are very easy or very difficult were removed from the original 92 items. Moreover, other 15 items were selected to be improved and reused. Therefore, the number of test items for the field testing becomes 78 items.

There were three subtests in problem solving ability test. They are logical puzzles, mathematical puzzles and classroom problems. Each subtest has 5 items. All items were open-ended types and the response for each item will be scored from 0 to 4. After carrying out the item analysis procedure based on Classical Test Theory (CTT) for essay tests, all items were selected to be reused in the field testing.

Intervention Protocol. After testing the reasoning skills and problem solving ability of student teachers, Prof. Tim van Gelder's (2000) argument mapping technique was used to improve the reasoning skill of student teachers. There were six lessons in this protocol: (1) making your core argument, (2) countering objections, (3) making your CASE, (4) defending your assumptions, (5) finding your hidden vulnerabilities and (6) presenting with impact.

Data Collection Procedure. Participants had to complete Reasoning Skill Test and Problem Solving Ability Test during 2 hours. After administering the test, data analysis for test development was conducted. Then, based on the reasoning skill levels of student teachers, 60 participants who got the low, moderate and high reasoning skill were trained with an intervention practice during three weeks. After that, their reasoning skills were tested again to assure the predictive validity of the test and how the reasoning skills can be improved.

Data Analysis and Findings

Developing Reasoning Skill Test. As the first part of the data analysis, a reasoning skill test development was conducted. The data analysis procedure followed the data analysis process of Hambleton et al. (1991) and Kolen and Brennan (2004).

Confirmatory Factor Analysis. Confirmatory factor analysis was used to establish the four factors structure of the reasoning skills test: analogical, numerical, analytical and abstract reasoning. In this study, the Kaiser-Meyer-Olkin measure of sampling adequacy was 0.856 that is indicating sufficient items for each factor. Then, Bartlett's Test of Sphericity was significant ($p < .001$) which means that the variables are highly correlated enough to provide a reasonable basic for factor analysis.

After conducting the principal axis factor analysis, 31 items of 78 items were eliminated because they had low or no loadings with any other factors. By taking out 31 items, the communalities were all above 0.2 and it indicated that the relation between each item and other items is satisfactory. Given these overall indicators, factor analysis was conducted with 47 items.

Checking for Non-speediness of the Test. According to the non-speeded (power) test method (Gulliksen, 1950), the variance ratios of the four sub tests were nearly zero: 0.001 for analogical, 0.009 for numerical, 0.005 for analytical and 0.003 for abstract reasoning. Therefore, it could be confirmed that all tasks of the tests in current study were non-speeded.

Checking the Assumption of Unidimensionality. To investigate the assumption of unidimentionality, a principal factor analysis was conducted. The values of eigenvalue 1, 2, 3, 4, 5, 6, 7 were 5.489, 1.499, 1.266, 1.149, 0.919, 0.825 and so on, and thus eigenvalue 1 was larger enough than other eigenvalues to determine that the test data satisfy the assumption of unidimensionality.

Checking the Conformity of Model and Test Data. Figure 1 clearly shows expected and observed test score distributions for two parameter model. It indicates that actual observed data score distribution is fairly close to theoretical distribution. Therefore, it is concluded that model-data fit is adequate enough to apply IRT model for this test.

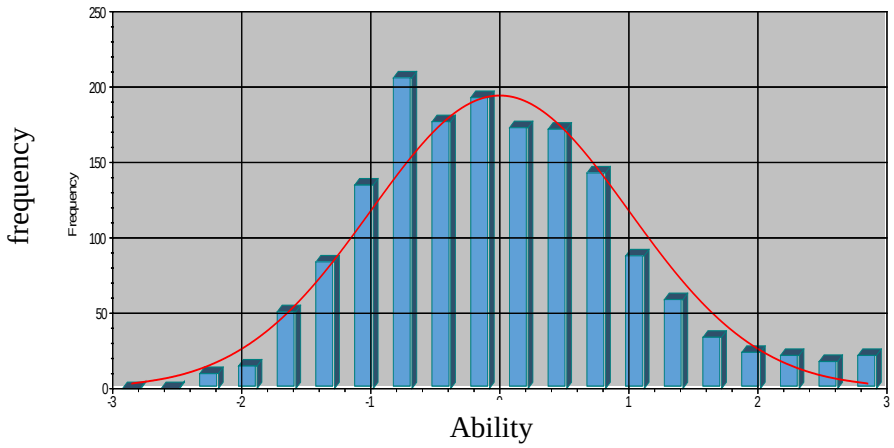

Figure 1 Frequency Distributions of Expected and Observed Scores

Estimation of Item and Ability Parameters. In order to obtain the information which items are appropriate for student teachers, an IRT parameter estimation procedure was carried out with two parameter logistic model (2 PLM) by utilizing BILOG-MG 3 software (Zimowski, Muraki, Mislevy & Bock, 2003). As the items were calibrated with 2 PLM, the characteristics of the items can be described by item difficulty (*b*) and item discrimination (*a*).

For item difficulty (*b*), easier items have lower (negative) difficulty indices and harder items have higher (positive) indices. The items with the difficulty *b* values within -3 to +3 were expected to be selected (Aye Aye Myint, 1997). In this study, all items have *b* values within the range of -3 to +3 and so they are selected as good items.

On the other hand, a higher value of item discrimination (*a*) indicates that the item discriminates between high and low proficiency examinees better. Since there are no items which have more than 2 (*a* value), all items can be acceptable.

Test Information Function. Based on the results of the parameter estimates of the test, test information curve (TIC) was also plotted. Figure 2 illustrates TIC of the 47-item test. SE is the standard error of estimation. The empirical reliability of the test was 0.902.

By looking at Figure 2, it is visually clear that the test is discriminating well among examinees with the range of ability level from -2.5 to +0.4 in the test. The maximum amount of information was I (θ) = 13.5 at θ = -1.15. These test items will be most suitable for student-teachers whose reasoning ability (θ) range is from -2.5 to +0.4. Therefore, it was judged that this test only can provide information well for student teachers with lower reasoning ability; however it may not provide enough information to assess student teachers with high and average reasoning skills.

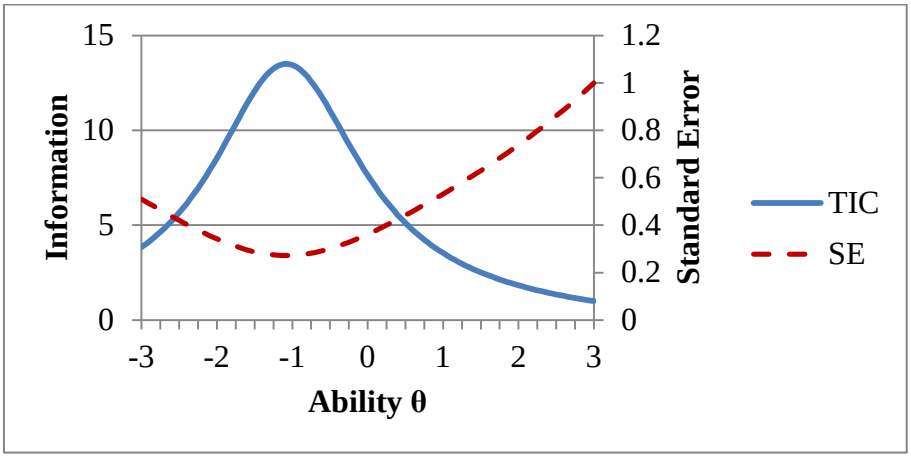

Figure 2 Test Information Curve for the Test with 47 items

Developing an Optimal Reasoning Skills Test. Since the present 47-item reasoning test is relatively easy, it is identified as an item pool and then an optimal reasoning skills test would be constructed by selecting some experimental items from that pool again. To construct systematically, a procedure to build test to meet any desired set of test specification outlined by Lord (1977) was followed.

According to Lord (1977), selecting and calculating the test items were continued again and again until the test information function approximates the target information function to a satisfactory degree.

Therefore, among 47 test items, 8 items from each subtest were selected to construct a new test. In Figure 3, a test information curve for an optimal reasoning skills test can be seen. It is visually clear that the test is discriminating well among examinees with the range of ability level from -1.9 to +1.2 in the test. The maximum amount of information was I (θ) = 5.4 at θ = -0.12. Moreover, its empirical reliability is 0.85. Therefore, it can be judged that this optimal test can provide information well for student teachers with normal reasoning ability.

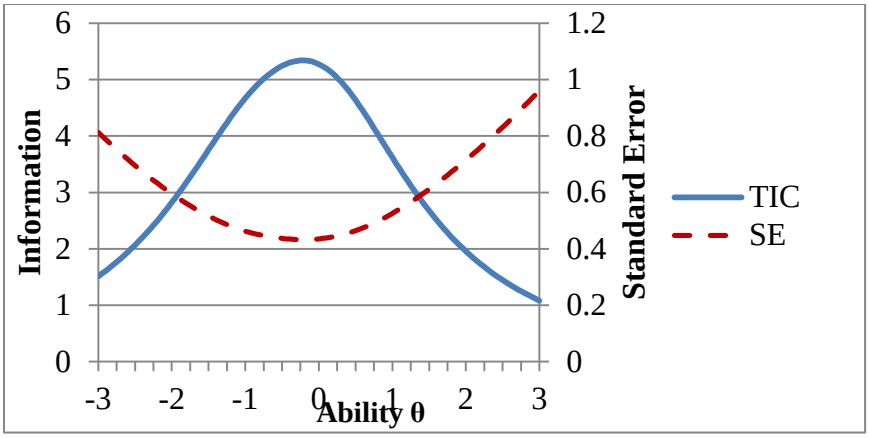

Figure 3 Test Information Curve for the Optimal Test with 32 items

Therefore, the format and content specification of the optimal reasoning skill test become as follows:

Table 1 Table of Content Specification for Optimal Reasoning Skills Test

No.	Names of Subtests	Tasks (Amount of Items)	Total Amount of Items	Time Limit (minute)
1.	Analogical Reasoning	Word (4), Figure (4)	8	3
2.	Numerical Reasoning	Word Problems (4), Data Interpretation (2), Mathematical Puzzles (2)	8	10
3.	Analytical Reasoning	Seating Arrangement (4), Combination (3), Ranking (1)	8	10
4.	Abstract Reasoning	Figure Addition/Subtraction (2), Distribution of three values (3), Distribution of two values (3)	8	7
		Total	**32**	**30**

Developing Problem Solving Ability Test. This development followed the data analysis procedure of Hambleton, Swaminathan & Rogers (1991). Moreover, item analysis procedure for essay tests based on Classical Test Theory was used.

Confirmatory Factor Analysis. Confirmatory factor analysis was used to establish the three factors structure of the problem solving ability test: logical puzzles, mathematical puzzles and classroom problems. In this study, the Kaiser-Meyer-Olkin measure of sampling adequacy was 0.725 and Bartlett's Test of Sphericity was significant ($p < .001$).

Throughout the principal axis factor analysis, items with initial values of less than 0.2 and those without loadings were decided to be discarded. However, there were no items to be eliminated because they all had loadings with respective factor. Given these overall indicators, factor analysis was conducted with 15 items. After rotation, the first factor accounted for 8.18% of the variance, the second factor accounted for 5.39% of the variance and the third factor accounted for 3.54% of the variance.

Checking for Non-speediness of the Test. After the preliminary testing, the non-speediness of the test was investigated by the non-speeded (power) test method (Gulliksen, 1950). According to the results, the variance ratios of the three sub tests were close to zero. Therefore, it could be confirmed that all tasks of the sub tests in current study were non-speeded.

Item Analysis of Field Test Data. In order to obtain the information which items are appropriate for student teachers, an item analysis procedure for essay test items was carried out with difficulty index (P-value) and discrimination index (D).

Index of difficulty (P) can range from 0% (for a very difficult item) to 100% (for a very easy one). Therefore, moderate level of P is 50% (Technical Bulletin of University of Lowa, n.d, cited in Faradillah, 2012). Since P values of all problem solving ability test items were around 50%, exactly between 40% and 60%, they can be used confidently. Moreover, for classes larger than 30 students, 0.3 should be used as a desirable standard for index of discrimination (D) (Technical Bulletin of University of Lowa, n.d, cited in Faradillah, 2012). Since D values of the current test items were above 0.3, these items can be regarded as discriminating items. Therefore, based on the item analysis results, all items were selected to be reused in field testing. The reliability of the test was 0.78. Therefore, it has high reliability.

The format and content specification of the optimal reasoning skill test are as follows:

Table 2 Content Specifications of Problem Solving Ability Test

No.	Names of Tasks	Amount of Items	Time Limit (minute)	Marks
1.	Logical Puzzles	5	15	20
2.	Mathematical Puzzles	5	15	20
3.	Classroom Problems	5	10	20
	Total	**15**	**40**	**60**

Data Analysis and Findings for Reasoning Skills. To explore the reasoning skills of student teachers, descriptive statistics, mean comparisons by gender and by university were executed.

Descriptive Statistics for Student Teachers' Reasoning Skills. Table 3 showed that student teachers' analytical reasoning was the highest skill ($\bar{X}$=4.97) and the lowest skill was abstract reasoning ($\bar{X}$=3.58) among four skills. As described in literature review section, reasoning skills were categorized into two main kinds: inductive and deductive reasoning. At present, according to mean scores, it was found that their inductive reasoning was higher than deductive reasoning.

Next, the sample mean score of the total reasoning skill (17.41) is above the theoretical mean score (16). Therefore, it can be concluded that they have healthier reasoning skills concerned with the problems they faced.

Table 3 Descriptive Statistics for Student Teachers' Reasoning Skills

Reasoning Skills	Minimum	Maximum	Mean	Std. Deviation
Inductive Reasoning	1	16	8.87	2.96
Analogical	0	8	4.75	1.73
Numerical	0	8	4.12	1.89
Deductive Reasoning	0	16	8.54	3.33
Analytical	0	8	4.97	2.12
Abstract	0	8	3.58	1.93
Total Reasoning	3	30	17.41	5.25

Comparisons of Student Teachers' Reasoning Skills by Gender. According to independent samples *t* test results, there were no statistically significant differences in reasoning skills by gender except inductive reasoning. In inductive reasoning skill, male student teachers' mean score was significantly higher than females ($p < .001$ level).

Table 4 Independent Samples *t* Test Results of Reasoning Skill by Gender

Reasoning	Gender	Mean	Std. Deviation	Mean Difference	*t*	*df*	*p*
Inductive	Male	9.18	2.91	0.568*	3.874	1624	0.000
	Female	8.61	2.97				
Deductive	Male	8.40	3.30	-0.269	-1.625	1624	0.104
	Female	8.67	3.34				
Total	Male	17.58	5.10	0.299	1.144	1624	0.253
	Female	17.28	5.38				

Note. * The mean difference is significant at the 0.001 level.

Comparison of Student Teachers' Reasoning Skills by University. ANOVA result showed that there were significant differences in reasoning skills among universities ($p < .001$ level) (see Table 5). To obtain more detailed information, Post-Hoc test was executed by Games-Howell method.

Table 5 ANOVA Result of Reasoning Skills by University

	Sum of Squares	*df*	Mean Square	*F*	*p*
Between Groups	9210.933	2	4605.466	209.919	.000
Within Groups	35607.341	1623	21.939		
Total	44818.273	1625			

According to Table 6, it became apparent that the reasoning skills of the student teachers in university 1 were significantly higher than those of others (p< .001 level). Moreover, the reasoning skills of student teachers in university 3 were significantly lower than those of others (p< .001 level). To confirm these results, a qualitative study was performed and will be described in the next section.

Table 6 Post-Hoc Test Result of Student Teachers' Reasoning Skills Across University by Games-Howell Method

(I) University	(J) University	Mean Difference (I-J)	Std. Error	*p*
University 1	University 2	2.238*	.286	.000
	University 3	5.724*	.276	.000
University 3	University 1	-5.724*	.276	.000
	University 2	-3.486*	.290	.000

Note. * The mean difference is significant at the 0.001 level.

Data Analysis and Findings for Problem Solving Ability. To explore the problem solving ability of student teachers, descriptive statistics, mean comparisons by gender and mean comparisons by university were executed.

Descriptive Statistics for Student Teachers' Problem Solving Ability. Table 7 showed that student teachers' logical problem solving ability was the highest ability among three abilities ($\bar{X}$=11.16). Besides, the sample mean score of the total problem solving ability (30.4) is above the theoretical mean score (30). Therefore, it can be concluded that they have better ability to solve several problems they faced.

Table 7 Descriptive Statistics for Student Teachers' Problem Solving Ability

Problem Solving Ability	Minimum	Maximum	Mean	Std. Deviation
Logical Problems	0	20	11.16	5.07
Mathematical Problems	0	20	9.27	4.49
Classroom Problems	0	18	9.97	3.92
Total	3	51	30.4	9.68

Comparisons of Student Teachers' Problem Solving Ability by Gender. It was found that there were statistically significant differences in problem solving abilities by gender. Specifically, all the scores on logical mathematical and total problem solving abilities were significantly higher in favour of male student teachers. However, females' classroom problem solving ability was higher than males' (p< .001 level).

Table 8 Independent Samples *t* Test Results of Problem Solving Ability by Gender

	Gender	Mean	Std. Deviation	Mean Difference	*t*	*df*	*p*
Logical	Male	9.95	4.96	2.06^{**}	8.32	1624	0.000
	Female	7.89	4.97				
Mathematical	Male	7.65	4.31	0.60^{*}	2.68	1624	0.007
	Female	7.05	4.62				
Classroom Problem	Male	7.39	4.02	-0.93^{**}	-4.80	1624	0.000
	Female	8.32	3.78				
Total Problem Solving Ability	Male	24.98	9.16	1.72^{**}	3.59	1624	0.000
	Female	23.26	10.05				

Note. $^{**}p < 0.001$, $^{*}p < .01$.

Comparison of Student Teachers' Problem Solving Ability by University. According to Table 9, ANOVA result showed that there were significant differences in reasoning skills among universities ($p < .001$ level). To obtain more detailed information, Post-Hoc test was executed by Tukey HSD method.

Table 9 ANOVA Result of Problem Solving Ability by University

	Sum of Squares	*df*	Mean Square	*F*	*p*
Between Groups	33259.147	2	16629.574	226.635	.000
Within Groups	119089.300	1623	73.376		
Total	152348.448	1625			

According to Table 10, it became obvious that the problem solving ability of the student teachers in University 1 and University 2 were significantly higher than that of University 3 ($p < .001$ level). Based on these results, qualitative study was performed and described in the next section.

Table 10 Post-Hoc Test Result of Student Teachers' Problem Solving Ability Across University by Tukey HSD Method

(I) University	(J) University	Mean Difference (I-J)	Std. Error	*p*
University 1	University 2	-.397	.530	.734
	University 3	9.228^{*}	.517	.000
University 2	University 1	.397	.530	.734
	University 3	9.626^{*}	.516	.000

Note. * The mean difference is significant at the 0.001 level.

Relationship Between Reasoning Skills and Problem Solving Ability. To inspect the relationship between reasoning skill and problem solving ability, correlation coefficients and regression analysis for predictor variables was explored.

Correlation Analysis Between Reasoning Skills and Problem Solving Ability of Student Teachers. According to Table 11, the components of reasoning skill and the components of problem solving ability are positively correlated (p< .01 level). Each component of reasoning skill is moderately correlated with problem solving ability. Similarly, total reasoning skill is moderately correlated with total problem solving ability.

Table 11 Inter-correlation among Components of Reasoning Skill and Problem Solving Ability

Variables	Logical	Mathematical	Classroom	Problem Solving Ability
Analogical	.286**	.216**	.083**	.283**
Numerical	.436**	.367**	.107**	.442**
Analytical	.312**	.369**	.160**	.399**
Abstract	.203**	.319**	.115**	.301**
Reasoning	.452**	.469**	.173**	.524**

Note. ** Correlation is significant at 0.01 level.

Regression Analysis for Reasoning Skills as Predictors of Problem Solving Ability. To measure the influence of reasoning skills on problem solving ability, regression analysis was continued. A four-step hierarchical multiple regression analysis was used to assess how much additional variance in problem solving ability can be explained by incrementally adding predictor variables to the equation. Before this analysis was performed, the independent variables were examined for collinearity. According to results, the collinearity tolerances of all independent variables are greater than 0.714, ($1\text{-}R^2$). This indicated that the estimated βs are well established in the regression model. In step 1, problem solving ability was the dependent variable and analogical reasoning was independent variable. Then, numerical reasoning was additionally entered into step 2 equation. The process was repeated at step 3 with analytical reasoning and at step 4 with abstract reasoning.

In Table 12, the results revealed that analogical reasoning was able to account for merely 8 % of the variance in problem solving ability. However, combination of analogical and numerical reasoning was able to account for 21.5% of the variance in problem solving ability. Then, the combination of analogical, numerical and analytical reasoning was able to account for 27.6% of the variance. Finally, the combination of four reasoning: analogical, numerical, analytical and abstract reasoning was able to account for 28.6% of the variance in problem solving ability. Therefore, the adjusted R-square increased from 0.08 to 0.286 with the addition of subsequent sets of variables. The multiple adjusted R-square (0.286) means that the total contribution by the combined set of reasoning skills accounted for approximately 28.6% of the variance of problem solving ability.

At step 4, the β results pointed out that analogical reasoning (β = 0.113, p< .001), numerical reasoning (β = 0.291, p< .001), analytical reasoning (β = 0.236, p< .001) and abstract reasoning (β = 0.112, p< .001) were positive and significant predictors of student teachers' problem solving ability. Therefore, it can be concluded that these four reasoning skills can

enhance the problem solving ability of student teachers. By applying regression analysis, the resultant model of reasoning skill for problem solving ability can be defined as in the following equation in which PSA represents problem solving ability and X represents respective score of reasoning skills.

$$PSA = 7.564 + 0.633\ X_{analogical} + 1.489\ X_{numerical} + 1.074\ X_{analytical} + 0.563\ X_{abstract}$$

Table 12 Standardized Regression Coefficients from Hierarchical Multiple Regression Analysis of Reasoning Skills for Problem Solving Ability

Predictors	Step 1	Step 2	Step 3	Step 4
1. Analogical	.283**	.152**	.121**	.113** (0.633)
2. Numerical		.391**	.310**	.291** (1.489)
3. Analytical			.266**	.236** (1.074)
4. Abstract				.112** (0.563)
R^2	.080	.216	.278	.288
Adjusted R^2	.080	.215	.276	.286
F value	*F*(1, 1624)= 141.523 (*p*< .001)	*F*(2, 1623)= 223.624 (*p*< .001)	*F*(3, 1622)= 207.817 (*p*< .001)	*F*(4, 1621)= 164.066 (*p*< .001)

Note. ** *p*< .001. Numbers in parentheses of step 4 column are unstandardized beta coefficients (B).

Then and there, in order to find out the best reasoning predictors for each problem solving ability, multiple linear regression analysis was conducted. The results and standardized beta coefficients are described in Table 13. The R^2 values suggested that 23.5% of the variability in logical problem solving, 22.7% of the variability in mathematical problem solving and 13.3% of the variability in classroom problem solving can be explained by the four reasoning skills.

Specifically, the results of the regression advocated that among the four reasoning skills, analogical, numerical and analytical reasoning skills can significantly predict logical problem solving ability. However, it was found that all reasoning skills are the best predictors for mathematical problem solving ability and only analytical reasoning skill is the best predictor for classroom problems.

Table 13 Standardized Regression Coefficients for Four Reasoning Skills on Each Type of Problem Solving Ability

Predictors	Problem Solving Ability		
	Logical	Mathematical	Classroom Problems
1. Analogical	.136**	.016*	.033
2. Numerical	.328**	.223**	.039
3. Analytical	.161**	.221**	.120**
4. Abstract	.025	.165**	.055
Adjusted R^2	.235	.227	.133
F value	*F*(4, 1621)= 126.082 (*p*< .001)	*F*(4, 1621) = 120.565 (*p*< .001)	*F*(4, 1621) = 13.619 (*p*< .001)

Note. * *p*< .01, ** *p*< .001.

Intervention Based Analysis and Results

Based on the quantitative data results, an intervention practice was conducted to improve student teachers' reasoning skills and to confirm the predictive validity of the reasoning skill test based on the quantitative results.

Participants: There were 30 participants from university 1 (highest reasoning) and University 3 (lowest reasoning) respectively and totally 60 participants in this practice. The participants for this study are specifically described in Table 14 by stratum.

Table 14 Number of Participants from Selected Universities of Education

University	Reasoning Groups	Gender		Total
		Male	Female	
University 1	High	5	5	10
	Moderate	5	5	10
	Low	5	5	10
	Total	15	15	30
University 3	High	5	5	10
	Moderate	5	5	10
	Low	5	5	10
	Total	15	15	30
Total		**30**	**30**	**60**

Research Method. As the research method, one group pretest-posttest experimental design was used.

Intervention Protocol. For intervention, a protocol is based on a technique for improving reasoning skills called argument mapping by Tim van Gelder (2000). The basic idea of the technique is that the participants create diagrams showing the parts of their reasoning, and how these diagrams are logically related. Myanmar contexts which may be familiar with them were supplemented to the lessons to be convenient for all Myanmar student teachers. Each lesson was managed with two parts: first 30-minute section was for lecture and second 30-minute section was for practicum. This intervention protocol comprised of six lessons and six periods were taken to practice.

Reasoning Skill Test for Posttest. To construct a posttest, 50% (16 items) of posttest items were taken from the pretest items as the common items and 50% of them were from the field testing results. Based on the item parameter estimates, a test information curve for reasoning skill posttest was drawn as in Figure 4. It is visually clear that the test is discriminating well among examinees with the range of ability level from -1.8 to +0.9 in the test. The maximum amount of information was I (θ) = 4.9 at θ = -0.35. Moreover, its empirical reliability is 0.83. Therefore, it can be judged that this posttest is similar to the pretest (see Figure 4) and can provide information well for student teachers with normal reasoning ability. Hence, the format and content specifications of the posttest were also similar to the pretest.

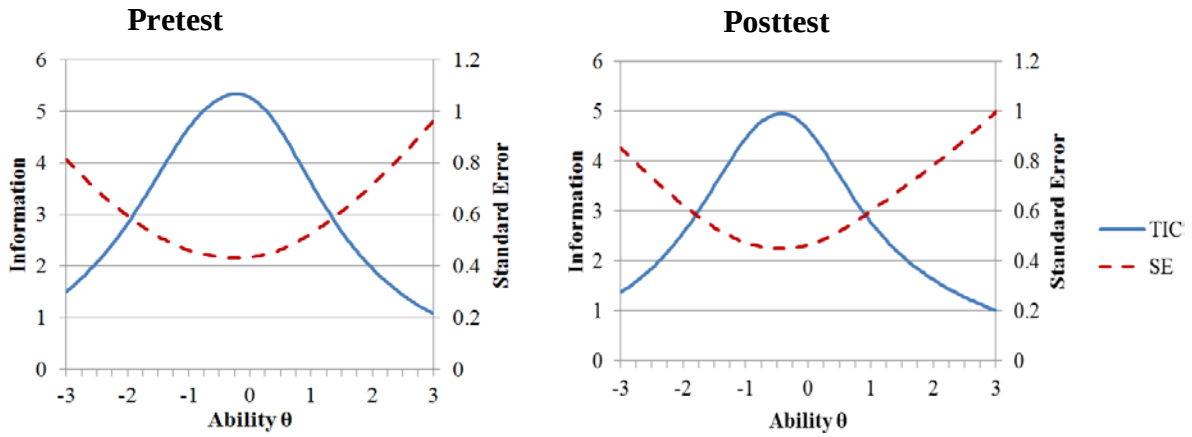

Figure 4 Comparison of Test Information Curves for the Reasoning Skill Pretest and Posttest

Problem Solving Ability Test for Posttest. In this study, problem solving ability pretest was an essay type and posttest was decided to be administered after 7 months of the pretest. Therefore, the problem solving ability pretest was used again for posttest.

Comparisons of Reasoning Skills Before and After Intervention. According to paired samples *t* test result, it can be perceived that their reasoning skills after intervention are significantly higher than before intervention ($p < .001$ level). Moreover, the same results were also found in both University 1 and University 3. Therefore, it can be concluded that Argument Mapping Technique intervention practice could well increase the student teachers' reasoning skills.

Table 15 Paired Samples *t* Test Results of Reasoning Skills before and After Intervention

University	Intervention	Mean	Std. Deviation	Mean Difference	*t*	*df*	*p*
University 1	Before	17.30	7.77	-2.93*	-8.04	29	0.000
	After	20.23	7.36				
University 3	Before	15.30	7.64	-2.63*	-7.18	29	0.000
	After	17.93	7.22				
Total	Before	16.30	7.71	-2.78*	-10.82	59	0.000
	After	19.08	7.32				

Note. * The mean difference is significant at the 0.001 level.

Comparisons of Problem Solving Ability Before and After Intervention. According to paired samples *t* test result, it can be perceived that their problem solving ability after intervention are significantly higher than before intervention ($p < .001$ level). Moreover, the same results were also found in both University 1 and University 3. This may be due to the any effect of intervention and reasoning skills improvement.

Table 16 Paired Samples *t* Test Results of Problem Solving Ability Before and After Intervention

University	Intervention	Mean	Std. Deviation	Mean Difference	*t*	*df*	*p*
University 1	Before	25.07	9.37	-1.27	-2.63*	29	0.014
	After	26.33	9.63				
University 3	Before	23.27	9.96	-2.67	-7.48**	29	0.000
	After	25.93	9.93				
Total	Before	24.17	9.63	-1.97	-6.33**	59	0.000
	After	26.13	9.41				

Note. ** The mean difference is significant at the 0.001 level.
* The mean difference is significant at the 0.05 level.

Regression Analysis for Reasoning Skills as Predictor of Problem Solving Ability. The result revealed that the model significantly explained the problem solving ability, $F(1, 58)=102.931$, $p< .001$. The *R* value (0.562) showed the significant positive correlation between reasoning skill and problem solving ability. Moreover, the adjusted R^2 (0.311) indicated that the reasoning skills contributed 31.1% variance to problem solving ability. Therefore, it can be reasonably seen that these results are closely fitting with the pretest results. Therefore, it can be concluded that Myanmar student teachers' reasoning skills can enhance and predict their problem solving abilities.

Table 17 Regression Analysis for Reasoning Skills as Predictor of Problem Solving Ability

Predictor	*B*	β	*t*	*R*	R^2	Adj R^2	*F*
Constant	6.514						
Reasoning Skills	1.028	0.562	10.156**	0.562	0.342	0.311	102.931**

Note. ** $p< .001$.

Conclusion, Discussion and Recommendation

Confucius, a prominent Chinese philosopher, said that learning without thoughts is labor lost, thought without learning is perilous. This highlights the point that no one can learn without reasoning and thinking well. In this new millennium, the world is changing rapidly in science and technology and the changes have the greatest influence on economic, educational, environmental, cultural and social trends of the future. Consequently, these effects also fall on youths' thoughts and actions. They need to think correctly and to do properly. Reasoning skills have become more important in the modern world because there is too much information, and too many choices that come into human's minds. How can the new generation be educated to overcome the above mentioned challenges? Therefore, the tasks of teachers in the 21st century are not as straight forward as in the 20th century. They need to solve many problems and challenges reasonably inside and outside the classroom.

According to this study, it is obvious that reasoning skills were necessary for student teachers in solving many problems. The student teachers were better in inductive reasoning rather than deductive reasoning such as analytical and abstract skills. As mentioned above, a deductive reasoning is aimed to test the theory whilst an inductive reasoning is concerned with the generation of new theory emerging from the data. It is impossible for a teacher to possess only

creation skill about new things. They should have to reason and critique a problem. This is also a caution for the teacher educators to train their trainees in order to gain both inductive and deductive reasoning.

The foremost responsibility would be the universities. After the students have selected to attend the respective university, they will study about specific knowledge which is expected to use for working in the future. Normally the Universities of Education teaches them academic and teacher education knowledge because this is their main duty. In the meantime, the challenges of the modern era would like the graduated students to have some other skills to work such as reasoning skills and problem solving ability.

Future professionals are no longer to satisfy with their own expertise only, however they need to constantly study, learn, review, analyze, and classify the thinking ability to fit the needs of society in the future world. For that reason, the Universities of Education should consider their teaching techniques on how to improve the students' working skills. They should also consider whether the assessment methods reflect sufficiently an emphasis on reasoning skill and problem solving ability. Then only, the student teachers would have confidence to face many inside and outside the classroom problems when they become teachers.

In order to fulfill the goal of teacher education programs and improve students' reasoning skill and problem solving ability, this study finally offers the following recommendations based on research findings and literature reviews:

- The aims of learning and teaching may need to be revised to improve the skills which are necessary for working after graduation.
- The curriculum contents and implementation of the courses need to foster students' in-depth understanding of subject knowledge, analyses of theoretical background, and higher order cognitive competencies. This emphasis of teaching strategy and curriculum materials can enhance teacher educators' and student teachers' recognition concerning "Thinking is learning".
- Teaching methods need to be revised to increase the reasoning skills, and problem solving ability.
- The culture of teaching and learning in the classroom should provide more opportunities for student teachers to discuss and give the reason to their teachers.
- Teacher educators should discuss and guide occasionally their trainees about how to solve classroom problems and how to reason methodically a problem.
- Assessment methods need to be examined to determine whether there is sufficient emphasis on reasoning and problem solving.
- Student teachers should be sporadically provided with the skills test, such as, reasoning skills test, problem solving ability test and so on, so that they know their levels of these skills since the beginning of their university life and it will help them to improve their working skills by practice.
- To improve the student teachers' reasoning skills, the teacher educators should use any practice like argument mapping technique performed in this study.
- A series of campus symposia for public discussions on academic issues and social events might assist students to visualize the functions of reasoning skills and create beneficial

campus environment facilitating reasoning skills development. Additionally, these symposia can also evoke the interactive atmosphere between teachers and students for insightful and multifarious thinking.

- The internet technology must benefit and facilitate knowledge production and distribution; universities are certainly the center to the development of reasoning skills. The internet, therefore, can be utilized in universities for students to reach the social issues and understand multifarious viewpoints.

To sum up, since education is to prepare citizens with reasoning skills and to create more rational society or culture, it is hoped that the contributions of this study can not only provide insight to know about reasoning skill and problem solving ability but also be a support for upgrading teacher education in Myanmar.

References

Aye Aye Myint.(1997). Investigation of the numerical reasoning ability of Myanmar high school students. *Bulletin of the Graduate School of Education and Human Development*, Toyko University Press, *37*, 165-176.

Bruner, J. S., (Ed.). (1957). Going beyond the information given. In *Contemporary approaches to cognition: A symposium held at the University of Colorado* (pp. 41- 69). Cambridge, MA: Harvard University Press.

Carpenter, P., Just, M., & Schell, P. (1990). What one intelligence test measures: A theoretical account of the processing in the Raven's progressive matrices test. *Psychological Review*, *97*, 404 – 431.

Cattell, R. B. (1963). Theory of fluid and crystallized intelligence: A critical experiment. *Journal of Educational Psychology*, *54*(1), 1-22.

Deloache, J. S., Miller, K. F., & Pierroutsakos, S. L. (1998).Reasoning and problem solving. In Kuhn, D. & Siegler, R. S. (Eds.), *Handbook of child psychology: Cognition, perception and language* (5th ed., Vol. 2, pp. 801-850). New York: Wiey.

Evans, J. S. B. T. (1984). Heuristic and analytic processes in reasoning. *British Journal of Psychology*, *75*, 451-468.

Evans, J. S. B. T. (1989). *Biases in human reasoning: Causes and consequences.* London: Erlbaum.

Evans, J. S. B. T., & Over, D. E. (1996).*Rationality and reasoning.* Hove, U.K. Psychology Press.

Faradillah, I. (2012). *An analysis of essay test on English final test for grade eleven students of Sman I, Lamongan* (Unpublished master's thesis). University of State Institute of Islamic Studies: Sunan Ampel Surabaya.

Fatima, S. K. (2008). *Reasoning ability of adolescent students*. Study conducted in Rangareddy District of Andhra Pradesh, India.

Gulliksen, H. (1950). *Theory of mental tests*. New York: Wiley.

Hambleton, R. K., Swaminathan, H., & Rogers, H. J. (1991).*Fundamentals of item response theory (MMSS)*. London: Sage Publications, Inc.

Kant-Studien.(1987). Kant's system of perspectives.In Stephen Palmquist, *Knowledge and Experience - An Examination of the Four Reflective Perspectives in Kant's Critical Philosophy*, pp.170-200. Lanham: University Press of America (1993).

Khin Zaw. (1994). *Fundamentals of professional ethics for pedagogues*. MPhil (Education)/ MEd Course Research Reference SR 8, Sagaing: University for the Development of National Races of the Union, UDNR.

Khin Zaw. (2001). *Cybernetic analysis of learning theories*. Yangon Institute of Education, PhD Program, Yangon: YIOE.

Lord, F. M. (1977). Practical applications of item characteristic curve theory. *Journal of Educational Measurement, 14*, 117-138.

Mac Lellan, C. J., Langley, P., & Walker, C. (2012).A generative theory of problem solving. *First Annual Conference on Advances in Cognitive Systems*. Poster Collection, 1-18.

Savill, O. (2011). *What are numerical reasoning tests: the difference between numerical reasoning and numerical comprehension*? Retrieved March 2, 2016 from www.assessment.co.uk.

Tim van Gelder. (2000). *Argument mapping short course*. Retrieved December 1, 2018 from http://www.vangeldermonk.com/free-emailcourse.html

Wilhelm, O. (2005). Measuring reasoning ability. In O. Wilhelm & R. W. Engle (Eds.), *Handbook of measuring and understanding intelligence* (pp. 373-392). Thousand Oaks, CA: Sage Press.

Zinmowski, M., Muraki, E., Mislevy, R., & Bock, D. (2003). *BILOG-MG [Computer software and manual]*. Lincolnwood, IL: Scientific Software International.

THE INCIDENCE OF NON-TARIFF MEASURES ON MARKET ACCESS FOR MYANMAR FISHERY EXPORTS

J-๔ THE INCIDENCE OF NON-TARIFF MEASURES ON MARKET ACCESS FOR MYANMAR FISHERY EXPORTS

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Abstract

This study assesses the incidence of non-tariff measures, which are standards on fish safety and quality that is originally regulated by trading partner countries and to be complied by exporting countries. The study identifies types of non-tariff measures in fishery products exports, and examines the effects of most frequently applied non-tariff measures on fishery exports and prices received by exporter of fishery products. The methods used for the research include descriptive and quantitative on secondary and primary data. The study is carried out using panel data estimation technique in an augmented gravity model. Random effects model with generalized least squares (GLS) regression fits in this study. The empirical study found that Sanitary and phyto-sanitary (SPS) measures are most regulated measures by all importing countries. Myanmar fishery exports are determined by the GDP of importing countries in a sense that economically larger trading partner countries tend to demand more for Myanmar fishery products. It is also found that the more the countries are located farther, the larger will be imported from partner countries. Total fish export value is not affected by any NTM including SPS measure, while EU-approval of SPS is important factor to determine the fish export to the world market. In addition, colonial ties between Myanmar and trading partners are also important in fish trade. At firm level behaviour, adjacency is quite important. Prices of fish are determined by EU-approval and the number of SPS measures to be complied with by fish exporters. The sector needs to upgrade and diversify its fish exports primarily by meeting international food safety and sanitary standards.

Keywords: Non-Tariff Measures, Market Access, Sanitary and phyto-sanitary (SPS) measures

Introduction

Within the frame of economic integration, common challenges to countries when traded is to comply with trade-regulations of the importing countries as sometimes it could reduce the competitiveness of their exports in the international market. Those trade-related regulations are recognized as non-tariff measures and sometimes interchangeably described as non-tariff barriers. The non-tariff measures (NTMs) are non -price instruments of trade policy measures that are used to regulate the flow of trade in trading countries. They are of particular concern to exporters and importers in developing countries. As tariffs tend to disrupt supply chains, especially when they are levied on raw materials and intermediate inputs, non-tariff measures can become as non-tariff barriers (NTBs) to trade once they are a major impediment to international trade and prevent market access. Kareem (2012) proved that tariffs are a measure of market access conditions, and it can be translated that an increase in the rate of preferential tariffs will lead to a rise in the level of importation of its trading partner country. Oppositely, if a government decided to raise revenue and/ or protect its economy through imposition of higher tariffs on imported products, it would lead to a reduction in imports. The non-tariff measures, NTMS, are another measure of market access condition. This means that whenever there is an increase in the incidence of NTMs in economies of trading partners, there will be reduction in imports from those trading partners due to the fact that most of these imported products may not be able to pass the test of these incidences of NTMs. Therefore, it is to be better able to understand the needs for export development and diversification to tap the potential of the fishery sector. Since fishery

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exports are subject to the quality management throughout the catching place to the mouth of consumers, it first involves the awareness and recognition in the investment in sanitary and phyto-sanitary (SPS) requirements, then application of good practices which is to be done by the application of suitable regulations called non-tariff measures. In this regard, well-defined structure of institutions plays important role to ensure the legal mandate for the export promotion of a certain export item, that is fishery exports in this study. It should therefore be examined carefully whether the compliance of standards on fish safety and quality that is originally regulated as non-tariff measures of trading partner countries turns to become the non-tariff trade barriers that have adverse effect on the international trade sector of Myanmar.

Objectives of the Study

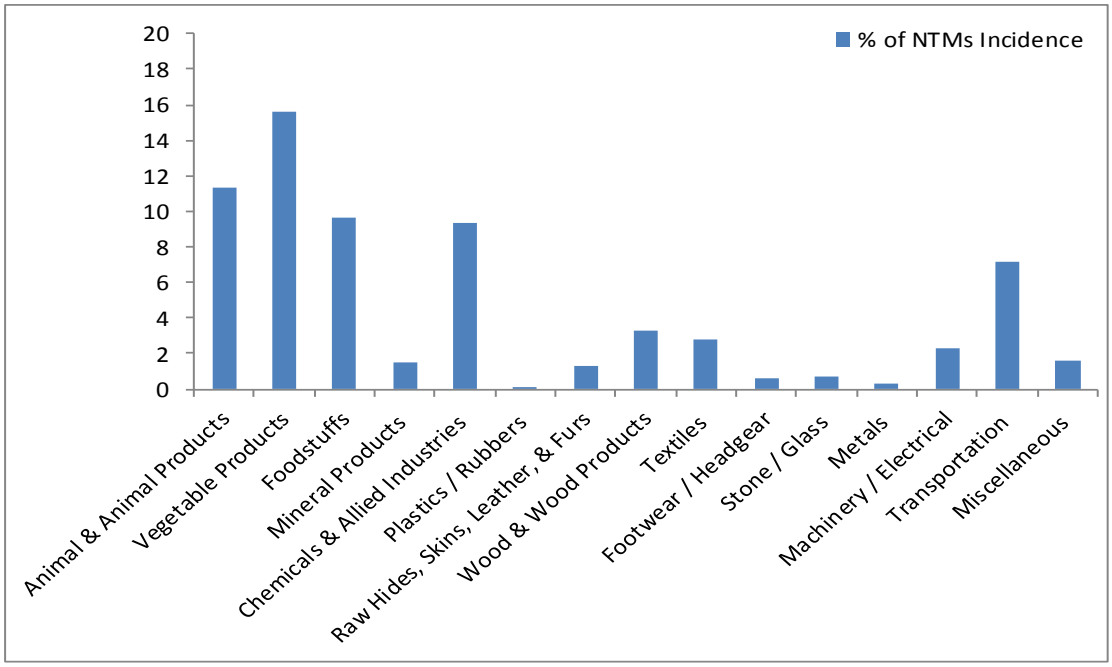
The objective of the study is to identify types of non-tariff measures in fishery products exports, and to analyse the effect of most frequently applied non-tariff measure on fishery in terms of total fish exports of Myanmar and prices received by exporters of fishery products.

Method of the Study

The methods used for the research include descriptive and quantitative on secondary and primary data. The descriptive part include the discussions on trade policy measure, especially regarded as non-tariff measures regulated domestically and in trading partner countries. Non-tariff measures in different trading countries are essentially obtained from the secondary sources such as the departmental records of Department of Fishery, Ministry of Agriculture Livestock and Irrigation, Customs Department, Ministry of Planning and Finance, and the database of WTO information system and World Integrated Trade Solution (WITS). For the primary source of information, interviews with key informant persons and questionnaire surveys are carried out in control samples. The research is focused more on case qualitative analyses, although some quantitative analysis is conducted to back up qualitative findings. The objective is to turn the abstract model, i.e., gravity model, into a practical tool for the fish export sector of Myanmar.

Non-tariff Measures in Myanmar

Many regulations related to NTMs in Myanmar are ratifications to the international conventions. A lenient regulatory environment with less bureaucracy and less cost of compliance is the desirable path in the political arena for Myanmar and for the world. However, consumers everywhere are increasingly demanding food safety; they consider it as the role of governments to ensure that food supply chains are safe. In a world of open trade, so many countries have resorted to heavy regulation of foodstuffs and agricultural products. These types of measures on such products ensure that food security and food safety are ensured. Like in many countries, TBT and SPS measures play a significant role in the incidence of NTMs in Myanmar.



Source: Compiled from the available NTM data of Myanmar from UNCTAD I-TIP

Figure 1 Incidence of NTM by Product Group

The pattern prevails the relatively moderate use of NTMs, as no sector has more than a third of its tariff lines covered by measures according to the data. There are multiple NTMs on several products. Most of the product groups have total NTMs exceeding their total number of tariff lines. This indicates that some of the products within that group are subject to more than one NTM, compared or relative to the number of tariff lines in each product. As Ando and Obashi observed in 2010, Myanmar was found to cover all product lines with one or other types of NTMs. Compared to the previous study on Myanmar's NTMs (Ando and Obashi, 2010), it is observed from this study that finance control measures, such as multiple exchange rates and quantity control measures like quotas linked with export performance and quotas for sensitive product categories no longer exist in Myanmar's NTMs. Instead, technical measures such as marking, labelling, and packaging requirements have become important in Myanmar's NTM composition. An examination done by Cadot and Ing (2015) on the frequency of NTMs by type in Myanmar suggests that TBT measures is the most frequent measures, followed by SPS and safeguard measures, according to the data in 2014.

Empirical Study using Gravity model for Fish Export of Myanmar

This section attempts to find out the major determining factors of Myanmar fishery trade using panel data estimation technique in a generalized gravity model. In fact, the gravity model is a tool of the applied international trade literature, for example, of Anderson and Van Wincoop (2003), Chaney (2008) and Helpman et al. (2008).

Regarding NTMs, there is a multiplicity of efforts to gather information according to needs. Broadly, there are two families of databases: Private-sector surveys and official data. Private-sector surveys provide subjective measurement of the effect of NTMs on market access and the cost of doing business as perceived by exporters or importers. Their value is that they reflect what is happening on the ground, including not just the regulations on the books, but

how they are administered. However, surveys should be interpreted carefully. They do not always have rigorous sampling frames and thus may not be representative. This can be a problem when some segments of the private sector—say, large firms or particular industries—have strategic reasons to portray regulations either favorably or unfavorably. Respondents can also be imperfectly informed; for instance, producers are sometimes told by intermediaries that their products fail to comply with some new regulation just to convince them to accept lower prices. In estimation, the gravity model takes the log-form as follows.

$$\ln X_{ij,t} = ß_0 + ß_1 \ln (Y_i) + ß_2 \ln(Y_j) + ß_3 \ln(t_{ij}) + e_{ij,}$$

Apart from the GDPs of countries, proxies for trade costs(t_{ij}) can be Distance between capital of home and trading each partner, Adjacency and Colonial links between the home country and trading partner countries. Empirical equation for the gravity model in the study is as follows.

$$\ln Xfob_{ij,t} = ß_0 + ß_1 \ln (gdpimporter_{i,t}) + ß_2 \ln (gdphome_{j,t}) + ß_3 \ln (produce_{j,t}) + ß_4 \ln(distance_{ij}) + ß_5 contig_{ij} + ß_5 comcol_{ij} + e_{ij,t}$$

Variables	Description of Variables
$\ln Xfob_{ij,t}$	The logrithm of nominal bilateral fishery export flows from exporter (home country) *i* to importer *j* at time *t*, where the value of fishery export is in US$ at f.o.b price.
$ß_0$	A constant term, whose structural interpretation is as world output
$\ln (gdpimporter_{i,t})$	The logarithm of GDP of importing country at time *t*
$\ln (gdphome_{j,t})$	The logarithm of total production of exporting country (Myanmar) at time *t*
$\ln (produce_{j,t})$	The logarithm of GDP of exporting country (Myanmar) at time *t*
$\ln(distance_{ij})$	The logarithm of bilateral distance between trading partners *i*and *j*
$contig_{ij}$	An indicator variable capturing the presence of contiguous borders between trading partners *i* and *j* , *yes=1*
$comcol_{ij}$	An indicator for the presence of colonial ties between countries *i* and *j* , *yes = 1*

Source of Data

Variables	Source of data	Measure
$Xfob_{ij,t}$	Customs Department and Central Statistical Organization	US dollar
$produce_{j,t}$	Department of Fishery, MoALI	US dollar
$gdpimporter_{i,t}$	WITS of World Trade Organization	US dollar
$gdphome_{j,t}$		US dollar
$distance_{ij}$		Miles between capital cities
$contig_{ij}$		If *yes = 1*, otherwise, 0.
$comcol_{ij}$		If *yes = 1*, otherwise, 0.

Hypothesis and Expectations of Variables

Dependent Variable ln$Xfob_{ij,t}$	Expected sign of coefficient
$ß_0$	Positive
ln ($gdpimporter_{i,t}$)	Both positive and negative can be expected. Positive if the GDP in the importing country increases, imports increase as well, showing the tendency of trade with larger economies. Negative if the country is at the self-sufficiency. More GDP supports more for domestic production, leading to a decrease in imports.
ln ($gdphome_{j,t}$)	
ln ($produce_{j,t}$)	Positive, assuming that consumption of types of the fishery products exported remains unchanged.
ln($distance_{ij}$)	Negative sign
$contig_{ij}$	Positive
$comcol_{ij}$	Both positive and negative can be expected. Positive if being a colony of same country, or common colony, influences on bilateral trade relations. Negative if the situation of common colony is no longer affective.

Descriptive Statistics

Variable	No. of Observations	Mean	Minimum	maximum
Xfob	324	7094950	0	2.20e+08
distcap	324	7361.46	288	16807.73
gdpimporter	324	1.25e+12	9.77e+9	1.86e+13
gdphome	324	6.14e+10	5,97e+10	6.54e+10

Methodology

Techniques used to analyse panel data are fixed effects and random effects. Before estimating fixed effects and random effect model, the estimation starts with Ordinary Least Square method.The panel data of 54 importing countries for years between 2011/2012 and 2016/2017 are used. When observations are repeated per individual, there can be a problem that the observations are not independent, but, on the other hand, there can be an advantage that the repetition gets better parameter estimates. When the observations are pooled and used OLS, the estimates can be biased. The study employs a fixed and random effects model to verify the estimation of gravity equation.

Fixed Effects model estimation with OLS method

Variable	Coef.	Std.Err	t	P>|t|	[95% Conf. Interval]	
ln(gdpimporter)	-0.1108672	0.2172819	-0.51	0.610	-0.5394475	0.3177131
ln(gdphome)	-6.293543	11.87264	-0.53	0.597	-29.71188	17.12479
lndistcap	-1.372238	.3162739	-4.34	0.000	-1.996076	-.7483994
contig	-1.399784	.6500755	-2.15	0.033	-2.682034	-.1175353
comcol	2.463912	.6340124	3.89	0.000	1.213347	3.714477
_cons	183.6232	294.6676	0.62	0.534	-397.5975	764.8439
Number of	252					
obsProb> F	18.14					
R-squared	0.8507					
Adj R-squared	0.8038					

All OLS estimates other than *lndistcap*and*comcol*are not statistically significant, Then, for the better estimation, fixed effect model is repeated using generalized least squares (GLS) regression.

Fixed-effects (within) regression

Variable	Coef.	Std.Err	t	P>|t|	[95% Conf. Interval]	
Ln(gdpimporter)	-0.1108672	0.2172819	-0.51	0.610	-0.5395	0.3177
Ln(gdphome)	-6.293543	11.87264	-0.53	0.597	-29.712	17.1248
lndistcap	0 (omitted)					
contig	0 (omitted)					
comcol	0 (omitted)					
_cons	173.0553	294.6628	0.59	0.558	-408.16	754.2664
sigma_u	2.1504534					
sigma_e	0.95495553					
rho	0.83528255 (fraction of variance due to u_i)					
Number of obs	252					
Number of groups	54					
F(7,191)	1.27					
Prob> F	0.2697					
R-sq: within	0.0443					
Between	0.0482					
overall	0.0265					

Source: Estimation result.

Heteroscedeasticity test confirms as follows: -

F test that all $\mu_i = 0$*;* *F(53, 191) = 17.06* *Prob> F = 0.0000*

Then, the variation across trading partners is assumed to be random and uncorrelated with dependent variable (*Xfob*) or independent variables (*gdpimporter, gdphome, distance*) included in the model.

Random-effects Model Estimation using a panel data

Random-effects GLS regression

Number of obs = 252
R-sq: within = 0.0265
between = 0.4099
overall = 0.2916
Prob> chi2 = 0.0000
(Std. Err. adjusted for 54 clusters in pairid)

lXfob	Coef	Robust Std. Err	z	P>|z|	[95% Conf. Interval]	
lgdpimporter	0.3803646	0.1392842	2.73	0.006	0.1073726	0.6533566
lgdphome	-6.481532	1.669257	-3.88	0.000	-9.753217	-3.209848
ldistcap	-0.9900287	0.366634	-2.70	0.007	-1.708618	-0.2714393
contig	-0.2040099	1.1355	-0.18	0.857	-2.429549	2.021529
comcol	0.8106135	0.6511278	1.24	0.213	-0.4655735	2.086801
_cons	173.0073	43.11273	4.01	0.000	88.50795	257.5067
sigma_u	1.4066414					
sigma_e	0.95495553					
rho	0.68451312	(fraction of variance due to u_i)				

Source: Estimation result.

Testing for random effects: Breusch-Pagan Lagrange multiplier (LM)

Breusch and Pagan Lagrangian multiplier test for random effects is resulted as follows.

	Variable	*sd = sqrt(Var)*
lnXfob	4.647893	2.155897
e	0.9119401	0.9549555
u	1.97864	1.406641

Test: Var(u) = 0

$\overline{\chi}_{(01)}^{2}$ = 259.24

Prob> $\overline{\chi}^{2}$ = 0.0000

Here, the null hypothesis that variances across countries equals zero is rejected. That is evidence of significance differences across countries (i.e panel effects exist.). The random effects model is appropriate and random effects estimation is suggested. Since serial correlation tests are supposed to apply to macro panels with long time series over 20-30 years, it is not a problem in this micro panels with 6 years.

Augmented Gravity Model estimation with NTM variable

The OLS estimation confirms the gravity model with panel effects, i.e, random effects and fixed effects, and, particularly random effects existed. Then, the estimation process is proceed with different estimating methods applied in the gravity model. Total NTM counts and SPS counts of each importing countries are also included in the random effects estimation and check the significance of NTM variables on fishery exports. Total fish production is also included in the estimation.

Table 1 Results of Random Effects and Fixed Effects

lXfob	Random effects	Fixed effects
	GLS regression	
ln(gdpimporter)	0.226	0.183
	(0.000)	(0.008)
ln(gdphome)	-19.176	-19.781
	(0.000)	(0.414)
lndiscap	-0.606	-0.459
	(0.021)	(0.266)
lnSPS	0.281	0.387
	(0.053)	-0.266
lnNTM	0.438	omitted
	(0.027)	
lproduce	-1.590	-1.59086
	(0.010)	(0.111)
comcol	1.827	2.298
	(0.000)	(0.023)
contig	-0.2092021	-0.232
	(0.613)	(0.693)
Number of obs	256	256
R-sq: within	0.1106	0.1137
between	0.3896	0.2884
overall	0.266	0.2187
Wald $chi^2(13)$	1610.48	
Prob> chi^2	0.000	
F (12,214)		2.29
Prob>F		0.0093

Source: Estimation Results.

In random effects estimation using GLS regression, standard errors are adjusted for 30 clusters in the group variable. Random effects estimators give better results. Then Breusch and Pagan Lagrangian multiplier test for random effects against fixed effects is carried out. Test approves that Random effect model is significant. Total NTM counts and SPS counts are not significant to determine the fish export at the country level. Firms with EU-approved certificates are also used as a proxy for the SPS compliance of exporting fishery firms.

For Omitted Variable, Ramsey RESET test for random effects estimates is carried out. The estimation by random effects models passed the misspecification test. Random effects estimators can then explain the incidence of non-tariff measures on fishery exports. Again, firm level estimation using the data collected from fishery processing and exporting firms is proceeded to verify the result.

Table.2 Random Effects and Fixed Effects at firm level

lfirmX	Random effects	Fixed effects
	GLS regression	
lgdpimporter	0.242	1.137
	(0.077)	(0.495)
lgdphome	7.780	8.490
	(0.088)	(0.195)
ldiscap	0.245	Omitted
	(0.496)	
lSPS	0.015	Omitted
	(0.960)	
EU-approved	-1.519	Omitted
	(0.001)	
comcol	0.077	Omitted
	(0.874)	
contig	-1.343	Omitted
	(0.027)	
Number of obs	101	101
R-sq: within	0.167	0.175
between	0.216	0.017
overall	0.233	0.2187
Wald $chi^2(8)$	30.72	
Prob> chi^2	0.000	
F (3,38)		2.29
Prob>F		0.061

Source: Estimation Results.

The panel data of firms exporting to 21 countries for year 2014-2015 and 2015-2016 are studied using a fixed and random effects model to verify the estimation of gravity equation. The estimation at firm level applies the firm specific variables such as the dummy variable for firms which hold EU-approval and the variable for the number of SPS measures regulated on the firms' fishery products by respected importing countries.

Signs of estimates of the random effects models are as expected. The coefficient of the GDP of importing countries, the distance between two countries, colonial ties and the count of SPS are not significant to determine the export value of fishery products, while contingency with trading partner seems to be significant at any significant level larger than conventional levels. Interestingly, dummy variable for EU approval is significant and it has negative effects on the export value of firms.

The model specification is confirmed between random effects and fixed effects by Hausman test as follows.

Test: Ho: difference in coefficients not systematic

chi2(3) = (b-B)'[(V_b-V_B)^(-1)](b-B)

= 2.56

Prob>chi2 = 0.4645

If this is < 0.05 (i.e. significant at 5 % level) use fixed effects. Since this is not < 0.05, fixed effects cannot be used and random effects model is confirmed.

Table 3 Estimation ofNTM on Price of Fishery Export

lP	OLS estimates
lX	-0.050
	(0.010)
lSPS	0.180
	(0.003)
lEu-dummy	-0.478
	(0.000)
contig	-0.216
	(0.507)
comcol	0.056
	(0.303)
No. of observations	1352
R-squared	0.767

Source: Estimation result

The effect of NTM can be estimated with the responsiveness of a variable under consideration with respect to the incidence of particular NTM. OLS estimators of the log-log function gives such responsiveness. In OLS estimation, X denotes the fish export, which has the negative sign, expressing the fact that the more can be exported, the less will be the prices received by the exporters of fishery products. Coefficient of the log of value of fish export represent "the responsiveness of fishery products' price" with respect to the world demand for Myanmar fishery products . Negative coefficient means that, with same volume of export, percentage change in prices of fishery products will move in the opposite direction with the percentage change in the export level. The variables SPS and EU-dummy are significant at any level, saying that number of SPS measures on fishery products regulated by importing countries and being an EU-approved firm is significant in pricing of fishery exports.

Interpretation of results

It is to draw from this study that random effects model with Generalize Least Squares method is suggested in forcasting the export of fishery products. As variables are expressed in natural logarithms, coefficients obtained from linear estimation can be read directly as elasticities. Size of importing countries measured by GDP is statistically significant at any level to determine the export value of fish firms, and positively affected. Size of Myanmar economy is also statistically significant at any level, with negative sign, showing Myanmar economy is relatively small in fish trade.Negative value of elasticity in the variable distance shows the inverse relationship between the distance and export values, describing more fish trade with farther countries, with a significant level larger than 20%. The dummy variable for contingency supports this finding. Total number of NTM is not statistically siginificant at all while the number of SPS on fishery products are also not significant at any conventional level of significant. For the fishery export sector as a whole or at the country level, colonial ties with

trading partner for fishery products is statistically significant, while contingency or adjacency with trading partner countries is not statistically significant at all. Given the existence of SPS requirement and particularly the compliance with EU-standards of sanitary and phyto-saintary requirements. The estimation for the country as a whole implies Myanmar would do better if the trading countries which have ever been sharing the same historic ties such asIndia, Malaysia, and EU countries as well as Japan. At firm level, however, colonial ties is not statistically significant, but nearness with trading partners is quite significant at the significant level greater than any conventional level, i.e. greater than 20%. Myanmar fishery products trading companies would do more with neighbours of the countries such as China and Thailand. In addition, firm level estimation suggests the statistical significance of holding EU-approval by fishery cold-storage and exporting firms, apart from the insignificance of other varaibles. Again, the importance of EU-approval and the number of SPS on fishery firms are supported by the estimation results of pricing in which log of SPS and EU-dummy variable is statistically significant.

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References

Anderson, J. E., and E. Wincoop (2004), Trade Costs, *Journal of Economic Literature*, Vol. 42, No. 3. (Sep., 2004).

Anderson, J. E., and E. Wincoop (2001), *Gravity with Gravitas: A solution to the border puzzle*, NBER working paper No. 8079 (January, 2001).

Ando, M. and A. Obashi (2010), 'The Pervasiveness of Non-tariff Measures in ASEAN–Evidence from the Inventory Approach', in M. Micik (ed.), *Rising Non-tariff Protectionism and Crisis Recovery*. Bangkok: Economic and Social Commission for Asia and the Pacific.

Baier, S.L. and J.H. Bergstrand (2007). "Do Free Trade agreements actually increase Members' international Trade?" *Journal of International Economics*, Elsevier, vol, 7191), pp. 72-95, March.

Balassa, B. (1989). *Comparative advantage, trade policy and economic development*. New York: Harvester Wheatsheaf.

Basu, S. R., H. Kuwahara and F. Dumesnil. (2012). Evolution of non-tariff measures: emerging cases from selected developing countries. Annex" A Summary of the firm-level results of the seven-countries NTMs survey, United Nations Conference on Trade and Development, Policy Issues in international trade and commodities study series, no. 52.

Cadot, O. and L. Y. Ing. (2015). Non-tariff measures and harmonization: Issues for the RCEP. *ERIA discussion paper series, September 2015*. Jakarta: Economic Research Institute for ASEAN and East Asia.

ERIA (2016). "Non-Tariff Measures in ASEAN", edited by Lili Yan Ing, Santiago Fernandez de Cordoba, and Olivier Cadot, ERIA and UNCTAD, April 2016, pp. 103-112. http://asean.i-tip.org/

Kareem, O. I. (2012). *Non-tariff barriers and exports: An Impact analysis from Africa-Eu and Africa-USA trade relations*. Conference: Fifteenth GTAP Annual Conference on Global Economic Analysis_ New challenges for global trade and sustainable development, Geneva.

Lubas, E. (2011). Trade potential of the Republic of Balrus: gravity model approach, a Ph. D dissertation submitted to Lyiv School of Economics, available at http://www.kse.org.ua/uploads/file/library/ MA Thesis 2011/ Lubas

Mikic, M. Gilbert, J. (2007).Trade statistics and policymaking.A handbook of commonly used *trade indices and indicators.*Economic and Social Commission for Asia and the Pacific.128 p. New York. Localised on 15th April 2012 on http://www.scribd.com/doc/5730938/2/III-Trade-and-Economy.

Ministry of Commerce (2015).*National Export Strategy of the Union of Myanmar (2015-2019).* Yangon.

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စဉ်		ပါရဂူကျမ်း/သုတေသနလုပ်ငန်းအစီရင်ခံစာအမည်	ဘာသာရပ်	ကျမ်းပြုစုသူ
၁	၁	မြန်မာဘာသာ စကားရှိအပြော စကားပုံစံများ လေ့လာချက် *	Myanmar	Dr Sai Maung Maung Myint Assistant Lecturer Defence Services Academy
၂	၂	ဦးတိုး၏ ရာမရကန်ကိုရေးဟန်ရှုထောင့်မှစိစစ်ချက် (ဘာသာ)	Myanmar	Dr Aye Mya Mya Soe Assistant Lecturer Yangon University of Foreign Languages
၃	၃	မြန်မာကဗျာများတွင် တွေ့ရှိရသော သွေဖည်မှုများ (၁၉၈၀–၂၀၀၀) လေ့လာချက် (စာပေ)	Myanmar	Dr San Myint Thin Lecturer, Mohnyin Degree Collage
၄	၄	ကုန်းဘောင်ခေတ်တွင်ပေါ်ပေါက်ခဲ့သော ယိုးဒယားသီချင်းများကို စာပေရှုထောင့်မှ လေ့လာခြင်း (စာပေ)	Myanmar	Dr San San Win Professor Head Nationality Youth Resources Development Degree College, Yangon
၅	၅	အမျိုးသားစာပေဆုရဝတ္ထုတိုများဖန်တီးမှုကိုခွဲခြားစိတ်ဖြာလေ့လာခြင်း(၁၉၆၂–၁၉၇၀) (စာပေ)	Myanmar	Dr Thida Mya San Associate Professor Technological University (Painlone University)
၆	၆	လူထုဒေါ်အမာ၏ ၁၂ ပွဲဈေးသည်နှင့် ကျွန်မတို့အညာ ဆောင်းပါးများမှ အတွေးနှင့်အရေး	Myanmar	Dr Kyi Kyi Win Lecturer Taunggyi University
၇	၁	Geographical Analysis of Land Cover and Land Use Changes in Chaungzon Township*	Geography	Dr Khin Toe ToeLwin Lecturer Hpa-an University
၈	၂	Geographic Analysis of Irrigated Agriculture in Aunglan Township	Geography	Dr Khin Thida Win Lecturer Hpa-an University
၉	၁	Royal Boatman Groups in Lower Myanmar (1752-1852) *	History	Dr Mya Phyu Moe Assistant Lecturer Yangon University of Foreign Languages
၁၀	၂	Agriculture in the Early Konbaung Period (1752-1819)	History	Dr Hline Sandar Han Assistant Lecturer University of Pakokku
၁၁	၁	The Effect of Parenting Styles on Children's Emotional and Behavioral Problems Among Some Ethnicities in Myanmar	Psychology	Dr Khin Mar Thein Associate Professor University of Taunggyi
၁၂	၂	Some Psychosocial Predictors of Prosocial Behaviour Among a Sample of Myanmar Undergraduates (Kyaukse, Myitkyina, Kalay and Taunggyi Universities)	Psychology	Dr Esther Cing Lun Hau Associate Professor Yadanabon University
၁၃	၁	Survival Strategies of Migrant Workers in Industrial Zone(1), Mandalay	Anthropology	Dr Lwin Lwin Aung Lecturer University of Yangon

စဉ်		ပါရဂူကျမ်း/သုတေသနလုပ်ငန်းအစီရင်ခံစာအမည်	ဘာသာရပ်	ကျမ်းပြုစုသူ
၁၄	၁	Isolation, Structure Elucidation and Screening of the Antioxidant and Cytotoxic Activities of Secondary Metabolites from the Stem Bark of *Aegle marmelos*(L.) Corrêa. (Ohshit)	Chemistry	Dr Thu Zar Associate Professor University for the Development of the National Races of the Union, Sagaing
၁၅	၂	A Study on the Preparation and Performance of a Particleboard Derived from Betel Nut Fiber Treated with Cashew Nut Shell Liquid	Chemistry	Dr Saw Win Associate Professor West Yangon Technological University
၁၆	၃	Preparation, Characterization and Application of Hydroxyapatite Derived from Goat Bone	Chemistry	Dr Lin Lin Naing Assistant Lecture Mandalar Degree College
၁၇	၄	Hydroxyapatite and Hydroxyapatite-Magnesium Oxide Nanocomposites from Waste Cow Bone*	Chemistry	Dr Cho Lwin Lwin Khine Assistant Lecturer University of Yangon
၁၈	၁	Analysis on $\Sigma\pi$ Invariant Mass Spectrum of D(K^-,n) L (1405)Reaction	Physics	Dr Win Win Maw Assistant Lecturer University of Mandalay
၁၉	၂	Photoelectrochemical Properties of Mesoporous SnO_2 Nanorod for Chlorophyll-Based Dye-Sensitized Solar Cell	Physics	Dr Theint Wah Wah Khine Assistant Lecturer University of Magway
၂၀	၃	Theoretical Analysis on $\pi^{\pm},K^+),(\gamma,K^+),(K^-,K^+),(K^-,\pi^-)$ Hyperon Production Reactions and $^{A}_{Z}X\,(K^-,\pi^-)^{A}_{\Lambda}X$ Hypernuclear Production Reactions	Physics	Dr Thu Thu Soe Student University of Mandalay
၂၁	၄	Implementation of Analog Signal Synthesizing System to Generate Digital Sound of Myanmar Gong*	Physics	Dr Thein Tun Oo Lecturer Kalay University
၂၂	၅	Coupled-Channels Analysis for Heavy-Ion Fusion Reactions and Barrier Distributions	Physics	Dr No No Htike Demonstrator University of Nursing, Mandalay
၂၃	၆	Growth and Characterization of Nanocrystalline Dye-Sensitized Solar Cells Using Natural Dyes as Sensitizers	Physics	DrShwe Yee Win Demonstrator Kyaukse University
၂၄	၁	Molecular Phylogeny of Rattus Exulans (Peale, 1848) in Pathein Environs, Myanmar	Zoology	Dr San Maung Maung Theint Assistant Lecturer University of Yangon
၂၅	၂	Molecular Phylogeography of Species of the Subgenus *Mus* Along Ayeyarwady Rivers Segment (Sagaing to Pyay) and Yangon Environs in Myanmar	Zoology	Dr Khin Myat Myat Zaw Part time Demonstrator University of Yangon
၂၆	၃	Applicability of Fish Scale Based Biomaterials in Hard Tissue Implantation*	Zoology	Dr Lai Lai Aye Lecturer/Head University of Medicine-1, Yangon

စဉ်		ပါရဂူကျမ်း/သုတေသနလုပ်ငန်းအစီရင်ခံစာအမည်	ဘာသာရပ်	ကျမ်းပြုစုသူ
၂၇	၁	Effects of the System of Rice Intensification (SRI) with Green Manure on Growth and Yield of Selected Commercial Rice *Oryza Sativa* L. Varieties from Kawa Township, Bago Region	Botany	Dr Yin Mar San Assistant Lecturer Dawei University
၂၈	၁	Mineralogical and Petrological Studies of Metamorphic Rocks Exposed in Pinwe-Mawlu Area, Indaw Township, Sagaing Region	Geology	Dr Aung Khin Soe Associate Professor University of Mandalay
၂၉	၂	Geological and Petrological Aspects of the Rocks Exposed at Pang Yawng-Wan Ping Area, Kyaing Tong Township, Eastern Shan State	Geology	Dr Khine Zar Wai Assistant Lecturer University of Yangon
၃၀	၁	Process Development on the Production of Dry Cat Food from Fish Factory Wastes*	Industrial Chemistry	Dr Kyaing Thuzar Mon Lecturer West Yangon Universtiy
၃၁	၁	An Analysis on the Influencing Factors of Basic Education Improvement and Changes in Agricultural Share of CLMV	Applied Economics	Dr Pwint Phyu Aung Lecturer Yangon University of Economics
၃၂	၂	The Incidence of Non-tariff Measures on Market Access for Myanmar Fishery Exports*	Applied Economics	Dr Zin Zin Naing Associate Professor Yangon University of Economics
၃၃	၃	Analysis on the Quality of Educational Services at the universities of Economics in Myanmar	Economics	Dr Htun Htun Lecturer Meiktila University of Economics
၃၄	၄	Competitive Strategies and Performance of Supermarkets	Business and Economics	Dr Win Yin Htike Lecturer National Management Degree College
၃၅	၅	Innovation and Performance of Confectionery Business	Commerce	Dr Ma Phyo Lecturer, Yangon University of Economics
၃၆	၆	Innovation Practices of Small and Medium Entreprises Owned by Myanmar Women	Commerce	Dr Aye Aye Win Lecturer, Yangon University of Economics
၃၇	၇	Job Satisfaction and Organizational Commitment of Academic Staff of Public Universities in Yangon	Management Studies	Dr Sanda Win Associate Professor Yangon University of Economics
၃၈	၈	Analysis on Relationship between Marketing Mix and Performance of Purified Drinking Water Manufacturing Businesses in Yangon	Management Studies	Dr Yan Yan Myo Naing Lecturer Yangon University of Economics
၃၉	၉	Adoption of M-Marketing in Tourism Industry of Myanmar	Management Studies	Dr Khin Thet Htwe Lecturer Meiktila University of Economics

စဉ်		ပါရဂူကျမ်း/သုတေသနလုပ်ငန်းအစီရင်ခံစာအမည်	ဘာသာရပ်	ကျမ်းပြုစုသူ
၄၀	၁၀	Corporate Social Responsibility Practices and Performance of Large manufacturing Firms	Management Studies	Dr Moe Moe Khaing Associate Professor Monywa University of Econnomics
၄၁	၁၁	On Some Socio-Economic and Demographic Aspects of Maternal Health Care Utilization in Myanmar	Statistics	Dr Aye Thida Associate Professor Yangon University of Economics
၄၂	၁၂	Student Perception on Performance of Monywa University of Economics (Graduate Tracer Study)	Statistics	Dr Win Kyaw Kyaw Moe Lecturer Monywa University of Economics
၄၃	၁	An Analytical Study of Social Intelligence and Job Performance of Teacher Educators	Educational Psychology	Dr Su Myat Aye Assistant Lecturer Yangon University of Education
၄၄	၂	An Assessment of Reasoning Skills Enhancing Problem Solving Ability Among Student Teachers from Universities of Education in Myanmar*	Educational Psychology	Dr Yar Zar Chit Assistant Lecturer Sagaing University of Education
၄၅	၁	An Analytical Study of Principals' Knowledge Management Practices for Reengineering Primary Teachers' Teaching Performances	Education Theory	Dr Nu Nu Htwe Assistant Lecturer Yangon University of Education
၄၆	၂	An Analytical Study of Factors Affecting Primary School Teachers' Knowledge and Practices for Promoting Students' Creative Thinking Skills	Education Theory	Dr Thwe Thwe Aung Assistant Lecturer Yangon University of Education

*ဆုရသုတေသနလုပ်ငန်းအစီရင်ခံစာဖြစ်ပါသည်။

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(ခ) ဂုဏ်ပြုလွှာမှတ်တမ်း (ဝိဇ္ဇာပညာရပ်)

ဂုဏ်ပြုလွှာမှတ်တမ်း (သိပ္ပံပညာရပ်)

ဂုဏ်ပြုလွှာမှတ်တမ်း (လူမှုရေးပညာရပ်)

ပြည်ထောင်စုသမ္မတမြန်မာနိုင်ငံတော်အစိုးရ

ပညာရေးဝန်ကြီးဌာန

မြန်မာနိုင်ငံ ဝိဇ္ဇာနှင့်သိပ္ပံပညာရှင်အဖွဲ့,

မြန်မာနိုင်ငံ ဝိဇ္ဇာနှင့်သိပ္ပံပညာရှင်အဖွဲ့ဆု

(ဝိဇ္ဇာ ပညာရပ်)

_ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ အား

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သုတေသနလုပ်ငန်းအတွက် _ _ _ ခုနှစ်၊ မြန်မာနိုင်ငံ ဝိဇ္ဇာနှင့်သိပ္ပံ ပညာရှင်အဖွဲ့ဆု (ဝိဇ္ဇာ ပညာရပ်) ကို ချီးမြှင့်သည်။

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ပြည်ထောင်စုဝန်ကြီး

ပညာရေးဝန်ကြီးဌာန

_ _ _ ခုနှစ်၊ _ _ _ လ _ _ _ ရက်

ပြည်ထောင်စုသမ္မတမြန်မာနိုင်ငံတော်အစိုးရ

ပညာရေးဝန်ကြီးဌာန

မြန်မာနိုင်ငံ ဝိဇ္ဇာနှင့်သိပ္ပံပညာရှင်အဖွဲ့

မြန်မာနိုင်ငံ ဝိဇ္ဇာနှင့်သိပ္ပံပညာရှင်အဖွဲ့ဆု
(သိပ္ပံ ပညာရပ်)

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သုတေသနလုပ်ငန်းအတွက် - - - ခုနှစ်၊ မြန်မာနိုင်ငံ ဝိဇ္ဇာနှင့်သိပ္ပံ ပညာရှင်အဖွဲ့ဆု (သိပ္ပံ ပညာရပ်) ကို ချီးမြှင့်သည်။

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ပြည်ထောင်စုဝန်ကြီး

- - ခုနှစ်၊ - - - လ - - - ရက် ပညာရေးဝန်ကြီးဌာန

၃ (ခ-၂) ဂုဏ်ပြုလွှာမှတ်တမ်း (သိပ္ပံ ပညာရပ်)

ɹɟo

ပြည်ထောင်စုသမ္မတမြန်မာနိုင်ငံတော်အစိုးရ

ပညာရေးဝန်ကြီးဌာန

မြန်မာနိုင်ငံ ဝိဇ္ဇာနှင့်သိပ္ပံပညာရှင်အဖွဲ့

မြန်မာနိုင်ငံ ဝိဇ္ဇာနှင့်သိပ္ပံပညာရှင်အဖွဲ့ဆု

(လူမှုရေး ပညာရပ်)

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သုတေသနလုပ်ငန်းအတွက် - - - ခုနှစ်၊ မြန်မာနိုင်ငံ ဝိဇ္ဇာနှင့်သိပ္ပံပညာရှင်အဖွဲ့ဆု (လူမှုရေး ပညာရပ်) ကို ချီးမြှင့်သည်။

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ပြည်ထောင်စုဝန်ကြီး

ပညာရေးဝန်ကြီးဌာန

- - - ခုနှစ်၊ - - - လ - - - ရက်

၃ (ခ–၂) ဂုဏ်ပြုလွှာမှတ်တမ်း (လူမှုရေး ပညာရပ်)

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ဒေါက်တာ မြဖြူမိုးကို ၁၉၇၉ ခုနှစ်၊ အောက်တိုဘာလ(၅) ရက်နေ့တွင် မွေးဖွားခဲ့ပါသည်။ ဒေါက်တာမြဖြူမိုးသည် ၂၀၀၂ခုနှစ်တွင် ရန်ကုန်အဝေးသင်တက္ကသိုလ်မှ ဝိဇ္ဇာဘွဲ့(သမိုင်း)၊ ၂၀၀၆ ခုနှစ်တွင် ရန်ကုန်အရှေ့ပိုင်းတက္ကသိုလ်မှ မဟာဝိဇ္ဇာဘွဲ့(သမိုင်း)ကိုရရှိခဲ့ပြီး၊ ၂၀၁၈ခုနှစ်တွင် ရန်ကုန်တက္ကသိုလ်မှ ပါရဂူဘွဲ့(PhD. History)ကို ဆွတ်ခူးရရှိခဲ့ပါသည်။

ဒေါက်တာမြဖြူမိုးသည် ပုသိမ်တက္ကသိုလ် (သမိုင်း)ဌာနတွင် ၂၀၀၉ခုနှစ်၌ နည်းပြအဖြစ် စတင်တာဝန်ထမ်းဆောင်ခဲ့ပြီး၊ ၂၀၁၁ခုနှစ်မှ ယနေ့အထိ ရန်ကုန်နိုင်ငံခြားဘာသာတက္ကသိုလ် (သမိုင်း) ဌာနတွင် လက်ထောက်ကထိကအဖြစ် တာဝန်ထမ်းဆောင်လျက်ရှိပါသည်။

ယခု နိုင်ငံခြားဘာသာတက္ကသိုလ်တွင် မြန်မာ့သမိုင်း၊ မြန်မာ့ယဉ်ကျေးမှုဆိုင်ရာသမိုင်းနှင့် ခေတ်ပြိုင် ဥရောပ သမိုင်းတို့ကို သင်ကြားပြသနေသူ တစ်ဦးဖြစ်ပါသည်။ ဒေါက်တာမြဖြူမိုးသည် မြန်မာ့လူမှုရေးသမိုင်း နှင့်ပတ်သက်၍ အထူးစိတ်ပါဝင်စားစွာ လေ့လာသူတစ်ဦးဖြစ်ပါသည်။

ဒေါက်တာမြဖြူမိုးသည် ၂၀၁၄ခုနှစ်၊ ရန်ကုန်နိုင်ငံခြားဘာသာတက္ကသိုလ် ၏ သုတေသန ဂျာနယ်တွင် “A Study of the Use of Royal Crafts in the Reign of Bagan, Innwa-Hanthawaddy and Taungoo Period”နှင့် ၂၀၁၇ ခုနှစ် ရန်ကုန်နိုင်ငံခြားဘာသာတက္ကသိုလ်၏ သုတေသနဂျာနယ်တွင် “Historical Perspective on Maha Dhammayanthi Eindawyar Zedi” ဟူ၍ သုတေသနစာတမ်း(၂)စောင် ရေးသားခဲ့ပါသည်။

a'guwm ciw;w;vi\ u , a&;tu0;

ဒေါက်တာ ခင်တိုးတိုးလွင်သည် အဖဦးခင်ထွေး၊ အမိဒေါ်မြစိန် တို့မှ ၁၉၇၀ခုနှစ် ဧပြီလ(၁)ရက် နေ့တွင်၊ မော်လမြိုင်မြို့တွင် မွေးဖွားပါသည်။ ဗမာ/ကရင် တိုင်းရင်းသူတစ်ဦး ဖြစ်ပြီး ဗုဒ္ဓဘာသာကို ကိုးကွယ်ပါသည်။ အမျိုးသားမှတ်ပုံတင်အမှတ်မှာ ၁၀/မလမ(နိုင်) ၀၁၆၃၃၆ ဖြစ်ပါသည်။ ၁၉၇၅ ခုနှစ် မှ ၁၉၈၃ခုနှစ်အထိ အ.လ.က(၇) မော်လမြိုင်မြို့၌ လည်းကောင်း၊ ၁၉၈၄ ခုနှစ်မှ ၁၉၈၅ ခုနှစ်အထိ အ.ထ.က(၃) မော်လမြိုင်မြို့ ၌လည်းကောင်း ပညာသင်ကြားခဲ့ပါသည်။ ပထဝီဝင် ဘာသာရပ်ဖြင့် ဝိဇ္ဇာဂုဏ်ထူးဘွဲ့ကို ၁၉၉၄ခုနှစ်တွင် လည်းကောင်း၊ မဟာဝိဇ္ဇာဘွဲ့ကို ၁၉၉၇ ခုနှစ် တွင်လည်းကောင်း၊ မော်လမြိုင်တက္ကသိုလ်မှ ရရှိခဲ့ပါသည်။ ပါရဂူဘွဲ့ကို ပထဝီဝင်ဘာသာရပ်ဖြင့် ၂၀၁၈ ခုနှစ်တွင် ရန်ကုန်တက္ကသိုလ်မှ ရရှိခဲ့ပါသည်။

မော်လမြိုင်တက္ကသိုလ် ပထဝီဝင်ဌာနတွင် နည်းပြ ရာထူးဖြင့် ၁၉၉၅ ခုနှစ် မှ ၂၀၀၃ ခုနှစ် အထိလည်းကောင်း၊ လက်ထောက်ကထိကရာထူးဖြင့် ၂၀၀၃ ခုနှစ် မှ ၂၀၁၀ ခုနှစ် အထိလည်းကောင်း၊ ကထိက ရာထူးဖြင့် ၂၀၁၀ခုနှစ် မှ ၂၀၁၃ ခုနှစ် အထိလည်းကောင်း တာဝန်ထမ်းဆောင်ခဲ့ပါသည်။ ၂၀၁၃ ခုနှစ် မှ ၂၀၁၄ ခုနှစ်အထိ ကထိကရာထူးဖြင့် ရန်ကုန်တက္ကသိုလ်၌လည်းကောင်း၊ ၂၀၁၄ ခုနှစ် မှ ၂၀၁၇ ခုနှစ်အထိ မော်လမြိုင်တက္ကသိုလ်၌ လည်းကောင်း၊ ၂၀၁၇ ခုနှစ် မှ ၂၀၁၈ ခုနှစ်အထိ မြိတ်တက္ကသိုလ်၌ လည်းကောင်း တာဝန်ထမ်းဆောင်ခဲ့ပါသည်။ ၂၀၁၈ ခုနှစ် ဒီဇင်ဘာလမှစ၍ယနေ့အထိ ဘားအံတက္ကသိုလ်၊ ပထဝီဝင်ဌာနတွင်၊ ကထိကရာထူးဖြင့် တာဝန်ထမ်းဆောင်လျက်ရှိပါသည်။

a'guwm pi;armiarmijri\ u , a&;tus0;

ဒေါက်တာ စိုင်းမောင်မောင်မြင့်ကို ၁၉၈၂ ခုနှစ်တွင် မွန်ပြည်နယ်၊ ပေါင်မြို့၌ မွေးဖွားခဲ့ပါသည်။ မိဘများမှာ ဦးစိုးမြင့် နှင့် ဒေါ်ကြည်ကြည် တို့ဖြစ်ပြီး မွေးချင်း ညီအစ်ကို ၅ ယောက် အနက် ဒုတိယမြောက်သား ဖြစ်ပါသည်။

၁၉၉၉ ခုနှစ်တွင် အခြေခံပညာ အထက်တန်းအဆင့်ကို အထက–မုတ္တမမှ အောင်မြင်ခဲ့ပါသည်။ ၂၀၀၀ ပြည့်နှစ်တွင် စစ်တက္ကသိုလ် အမှတ်စဉ်(၄၅) ဗိုလ်လောင်းသင်တန်းသို့ တက်ရောက်ခဲ့ပြီး ၂၀၀၃ ခုနှစ်တွင် ဝိဇ္ဇာဘွဲ့(မြန်မာစာ)ကို ရရှိခဲ့ပါသည်။ ၂၀၀၉ ခုနှစ်တွင် မဟာဝိဇ္ဇာဘွဲ့(မြန်မာစာ)ကို ရန်ကုန်တက္ကသိုလ်မှ အထူးအောင်ဖြင့် အောင်မြင်ခဲ့ပြီး ဆရာ ဇော်ဂျီဆု (မြန်မာစာထူးချွန်ဆု)ကို ရရှိခဲ့ပါသည်။ ၂၀၁၂ ခုနှစ်တွင် မဟာသုတေသနဘွဲ့ (မြန်မာစာ)ကိုလည်းကောင်း၊ ၂၀၁၈ ခုနှစ်တွင် ပါရဂူဘွဲ့(မြန်မာစာ)ကိုလည်းကောင်း မန္တလေးတက္ကသိုလ်မှ ရရှိခဲ့ပါသည်။

၂၀၀၉ ခုနှစ်တွင် စစ်တက္ကသိုလ်၊ မြန်မာစာဌာန၌ လက်ထောက်ကထိက(ဗိုလ်ကြီး) အဖြစ် စတင် တာဝန်ထမ်းဆောင်ခဲ့ပြီး ၂၀၁၄ ခုနှစ်တွင် လက်ထောက်ကထိက(ဗိုလ်မှူး) အဆင့်သို့ တိုးမြှင့်ခြင်း ခံခဲ့ရပါသည်။ ယခုအခါ စစ်တက္ကသိုလ်၊ မြန်မာစာဌာနတွင် လက်ထောက်ကထိက(ဗိုလ်မှူး)အဖြစ် တာဝန်ထမ်းဆောင်လျက် ရှိပါသည်။ ဒေါက်တာ စိုင်းမောင်မောင်မြင့်၏ ဝါသနာနှင့် စိတ်ဝင်စားမှုများမှာ စာပေဖတ်ရှုခြင်း၊ ရေးသားခြင်း၊ သုတသုတေသနပြုလုပ်ခြင်းနှင့် စာပေသင်ကြားရေးတို့ ဖြစ်ပါသည်။

a'guwm csvivici\ u, a&;tus0;

ဒေါက်တာ ချိုလွင်လွင်ခိုင်ကို မွန်ပြည်နယ် ၊ မော်လမြိုင်မြို့တွင် အထက်တန်း ရှေ့နေ ဦးစိုးလွင် နှင့် ဒေါ်လင်းလင်းမြတ်တို့မှ ၁၉၈၈ ခုနှစ် ၊ ဒီဇင်ဘာလ (၂၅) ရက်နေ့တွင် မွေးဖွားခဲ့ပါသည်။

ဒေါက်တာ ချိုလွင်လွင်ခိုင်သည် ၂၀၀၅ ခုနှစ်တွင် မော်လမြိုင်မြို့၊ အမှတ်(၆) အခြေခံပညာ အထက်တန်းကျောင်းမှ တက္ကသိုလ်ဝင်တန်း စာမေးပွဲကို ဓာတုဗေဒ၊ ရူပဗေဒ ဂုဏ်ထူး (၂)ဘာသာဖြင့် အောင်မြင်ခဲ့ပါသည်။ ၂၀၁၀ ခုနှစ်တွင် မော်လမြိုင်တက္ကသိုလ်မှ သိပ္ပံဂုဏ်ထူးဘွဲ့(B.Sc, Honours: Biochemistry) ကို ရရှိခဲ့ပြီး၊ ၂၀၁၂ ခုနှစ်တွင် ရန်ကုန်တက္ကသိုလ်မှ မဟာသိပ္ပံဘွဲ့ (M.Sc, Biochemistry) နှင့် ၂၀၁၃ခုနှစ်တွင် မဟာသုတေသနဘွဲ့(M.Res, Biochemistry) ကိုရရှိခဲ့ ပါသည်။ ၂၀၁၄ခုနှစ်တွင် ရန်ကုန်တက္ကသိုလ် ဓာတုဗေဒဘာသာရပ် ပါရဂူကြိုတန်းတက်ရောက် အောင်မြင်ခဲ့ ပါသည်။ ပါရဂူဘွဲ့အတွက် သုတေသနလုပ်ငန်းများ ဆောင်ရွက်နေစဉ်၊ ၂၀၁၅ ခုနှစ်တွင် ရန်ကုန်တက္ကသိုလ်၊ ဓာတုဗေဒဌာနတွင် သရုပ်ပြအဖြစ် စတင်အမှုထမ်းခဲ့ပြီး၊ ၂၀၁၈ ခုနှစ်တွင် ရန်ကုန်တက္ကသိုလ်မှ ပါရဂူဘွဲ့(Ph.D. Chemistry) ကို ဆွတ်ခူးရရှိခဲ့ပါသည်။

ဒေါက်တာချိုလွင်လွင်ခိုင်သည် ၂၀၁၈ခုနှစ်၊ နိဝင်ဘာလတွင် မြန်မာနိုင်ငံ ဝိဇ္ဇာနှင့် သိပ္ပံ ပညာရှင်အဖွဲ့က ကြီးမှူးကျင်းပသည့် (၁၈)ကြိမ်မြောက် သုတေသနစာတမ်းဖတ်ပွဲတွင် ဓာတုဗေဒ ဘာသာရပ်အတွက် အကောင်းဆုံး သုတေသနစာတမ်းရှင်ဆုကိုရရှိခဲ့ပါသည်။ ၂၀၁၉ခုနှစ်၊ မတ်လတွင် ရန်ကုန်တက္ကသိုလ် ဓာတုဗေဒဌာနဦးစီးဌာန အဖြစ် ရာထူးတိုးမြှင့်ခန့်ထားခြင်းခံရပြီး၊ ယနေ့အထိ တာဝန်ထမ်းဆောင်လျက်ရှိပါသည်။

a'guwm oe;xe;0;\ u , a&;tu;0;

ဒေါက်တာ သိန်းထွန်းဦးကို မဟာအောင်မြေမြို့နယ်၊ မန္တလေးမြို့၌ မတ်လ၊ ၁ ရက်၊ ၁၉၈၃ ခုနှစ်တွင် မွေးဖွားခဲ့ပါသည်။ မိဘများမှာ ဦးတင်ဦး၊ ဒေါ်အေးမြင့် ဖြစ်ပါသည်။ မွေးချင်းမောင်နမ (၂)ဦး အနက် အကြီး ဖြစ်ပါသည်။

၂၀၀၀ ခုနှစ်တွင် အခြေခံအထက်တန်းဆင့် အောင်မြင်ခဲ့ပြီး ၂၀၀၄ ခုနှစ်တွင် ရတနာပုံတက္ကသိုလ်မှ သိပ္ပံဂုဏ်ထူးဘွဲ့(ရူပဗေဒ) ဘာသာရပ်ကို ရရှိခဲ့ပါသည်။ ၂၀၁၂ ခုနှစ်တွင် ရတနာပုံတက္ကသိုလ်မှ မဟာသိပ္ပံဘွဲ့ (ရူပဗေဒ) ဘာသာရပ်ကို ရရှိခဲ့ပြီး၊ ၂၀၁၃ ခုနှစ်တွင် ဗန်းမော်တက္ကသိုလ်မှ မဟာသုတေသနဘွဲ့ (ရူပဗေဒ) ဘာသာရပ်ကို ရရှိခဲ့ပါသည်။ ၂၀၁၈ ခုနှစ်တွင် မန္တလေးက္ကသိုလ်မှ ပါရဂူဘွဲ့(ရူပဗေဒ) ဘာသာရပ်ကို ရရှိခဲ့ပါသည်။

၂၆.၇.၂၀၀၇ မှ ၃.၁၂.၂၀၁၅ ထိ (ရတနာပုံတက္ကသိုလ်၊ ဗန်းမော်တက္ကသိုလ်နှင့် မန္တလေး တက္ကသိုလ်) တွင် သရုပ်ပြအဖြစ် တာဝန်ထမ်းဆောင်ခဲ့ရာ၊ ၄.၁၂.၂၀၁၅ မှ ၇.၁၂.၂၀၁၈ ထိ (မန္တလေး တက္ကသိုလ်နှင့် ကလေးတက္ကသိုလ်)တို့တွင် လက်ထောက်ကထိက ရာထူးဖြစ် တာဝန်ထမ်းဆောင်ခဲ့ပြီး၊ ၇.၁၂.၂၀၁၈ မှ ယနေ့ထိ ကထိက တာဝန်များကို ဆက်လက် ထမ်းဆောင်လျက်ရှိပါသည်။ ဒေါက်တာ သိန်းထွန်းဦး၏ ဝါသနာနှင့် စိတ်ဝင်စားမှုများမှာ ကွန်ပျူတာပရိုဂရမ်၊ သုတေသနလုပ်ငန်းနှင့် သင်ကြားရေးတို့ဖြစ်ပါသည်။

a'guwm vvat; \u,a&;tu0;

ဒေါက်တာလဲ့လဲ့အေးကို အဖဦးထိုက်ရှုန်နှင့် အမိဒေါ်သန်းအေးတို့မှ ၁၉၆၅ ခုနှစ်၊ နိုဝင်ဘာလတွင် ရန်ကုန်မြို့၌ မွေးဖွားခဲ့ပါသည်။ တက္ကသိုလ်ဝင်တန်း စာမေးပွဲကို ၁၉၈၂ခုနှစ်တွင် မင်္ဂလာဒုံမြို့နယ် အ.ထ.က(၂)မှ ဖြေဆိုအောင်မြင်ခဲ့ပါသည်။

၁၉၈၂ ခုနှစ်မှစတင်၍ သတ္တဗေဒ ဘာသာရပ် အထူးပြုဖြင့် ရန်ကုန်တက္ကသိုလ် (လှိုင်နယ်မြေ) တွင် သင်ကြားခဲ့ပါသည်။ ရန်ကုန်တက္ကသိုလ်မှပေးအပ်သော B.Sc.(Hons) ဘွဲ့ကို ၁၉၈၇ ခုနှစ်တွင် လည်းကောင်း၊ M.Sc ဘွဲ့ကို ၁၉၉၄ ခုနှစ်တွင် လည်းကောင်း၊ ၂၀၁၈ ခုနှစ် တွင် Ph.D ဘွဲ့ကို လည်းကောင်း အသီးသီးရရှိခဲ့ပါသည်။ ၁၉၉၈ ခုနှစ်တွင် နိုင်ငံခြားဘာသာ တက္ကသိုလ်(ရန်ကုန်)မှ ပေးအပ်သော Diploma in Japanese ကို Credit အဆင့်ဖြင့် အောင်မြင် ခဲ့ရာ ဂျပန်အစိုးရမှ Outstanding Student အဖြစ် ရွေးချယ်ခဲ့ပြီး ၂၀၀၀ ခုနှစ်တွင် ဂျပန်နိုင်ငံ သို့ Study Tour Award ဆုဖြင့် ဖိတ်ခေါ်ခြင်း ခံခဲ့ရပါသည်။

၁၉၉၀ခုနှစ်တွင် ကျန်းမာရေးနှင့်အားကစားဝန်ကြီးဌာန အောက်ရှိ ဆေးတက္ကသိုလ်–၂၊ သတ္တဗေဒ ဌာနတွင် သရုပ်ပြ အဖြစ် စတင်တာဝန်ထမ်းဆောင်ခဲ့ပါသည်။ ၁၉၉၈ ခုနှစ်တွင် လက်ထောက်ကထိက အဖြစ်လည်းကောင်း၊၂၀၀၁ ခုနှစ်တွင် ကထိက။ဌာနမှူးအဖြစ်လည်းကောင်း အသီးသီး ရာထူးတိုးမြှင့် ခန့်ထားခြင်းခံရ၍ ကျန်းမာရေးနှင့်အားကစား ဝန်ကြီးဌာနအောက်ရှိ ဆေးနှင့်ဆေးနှီးနွယ် တက္ကသိုလ် များတွင် လှည့်လည် တာဝန်ထမ်းဆောင်ခဲ့ပါသည်။ ယခုအခါ ဆေးတက္ကသိုလ် –၁ (ရန်ကုန်)၊ သတ္တဗေဒဌာနတွင် ကထိက၊ ဌာနမှူး တာဝန်ကို ထမ်းဆောင် နေလျက်ရှိပါသည်။

နိုင်ငံတော်မှပေးအပ်သည့် ဝန်ထမ်းဝတ္တရားဆိုင်ရာ စွမ်းဆောင်ရည်အတွက် ဂုဏ်ပြုချီးမြှင့်လွှာများ ကိုလည်း ရရှိခဲ့ပါသည်။ ပညာရေးပြုပြင်ပြောင်းလဲမှုအတွက် ဆေးတက္ကသိုလ်များ၏ သင်ရိုးညွှန်းတမ်း ရေးဆွဲရာတွင် အဖွဲ့ဝင်အဖြစ် ပါဝင်ဆောင်ရွက်နေပါသည်။ ဌာနမှူးတာဝန်အပြင် သုတေသနလုပ်ငန်း များ စဉ်ဆက်မပြတ် လုပ်ကိုင်နေပြီး သုတေသနစာတမ်းများ ရေးသားခြင်း လုပ်ငန်းကို ဆောင်ရွက်လျက် ရှိပါသည်။

a'guwmukiozmre\ u, a&;tus0;

ကျွန်မ ဒေါက်တာ ကြိုင်သူဇာမွန်ကို ၁၉၇၈ ခုနှစ်၊ ဇွန်လ၊ ၂ ရက်နေ့တွင် ရန်ကုန်မြို့တွင် မွေးဖွားခဲ့ပါသည်။ ကျွန်မသည် ၂၀၀၄ခုနှစ်တွင် ကုန်ထုတ်ဓာတုဗေဒဘာသာရပ်ဖြင့် သိပ္ပံဘွဲ့၊ ၂၀၀၆ခုနှစ်တွင် ကုန်ထုတ်ဓာတုဗေဒဘာသာရပ်ဖြင့် မဟာသိပ္ပံဘွဲ့တို့ကို ဒဂုံတက္ကသိုလ်မှရရှိခဲ့ပါသည်။ ကျွန်မသည် ၂၀၁၈ခုနှစ်တွင် ကုန်ထုတ်ဓာတုဗေဒဘာသာရပ်ဖြင့် ပါရဂူဘွဲ့ကို ရန်ကုန်တက္ကသိုလ်မှ ရရှိခဲ့ပါသည်။ ကျွန်မ၏ အဖအမည်မှာ ဦးအောင်ကြိုင် ဖြစ်ပြီး အုတ်ဖိုမြို့၊ ပဲခူးတိုင်းတွင်မွေးဖွားခဲ့ပါသည်။ ကျွန်မ၏ အမိအမည်မှာ ဒေါ်စန်းဝေကျော် ဖြစ်ပြီး အုတ်ဖိုမြို့၊ ပဲခူးတိုင်းတွင် မွေးဖွားခဲ့ပါသည်။ ကျွန်မသည် ၁-၉-၂၀၀၅ ခုနှစ်တွင် မန္တလေးတက္ကသိုလ်၌ သရုပ်ပြအဖြစ် စတင်တာဝန်ထမ်းဆောင်ခဲ့ပါသည်။ ကျွန်မသည် ၂၀၀၅ ခုနှစ်မှ ၂၀၀၉ခုနှစ်ထိ မန္တလေးတက္ကသိုလ်တွင် သရုပ်ပြ အဖြစ်လည်းကောင်း၊ ၂၀၀၉ ခုနှစ်မှ ၂၀၁၃ ခုနှစ်ထိ ရတနာပုံတက္ကသိုလ်တွင် သရုပ်ပြအဖြစ်လည်းကောင်း၊ ၂၀၁၃ ခုနှစ်မှ ၂၀၁၆ ခုနှစ်ထိ ရန်ကုန်အနောက်ပိုင်းတက္ကသိုလ်တွင် လက်ထောက်ကထိက အဖြစ်လည်းကောင်း တာဝန် ထမ်းဆောင်ခဲ့ပါသည်။ ကျွန်မသည် ၂၀၁၆ ခုနှစ်မှ ယနေ့ထိ ကထိကအဖြစ် ရန်ကုန်အနောက်ပိုင်း တက္ကသိုလ်တွင် တာဝန်ထမ်းဆောင်နေပါသည်။

a'guwm&mZmcsp \u , a&; tus0;

ဒေါက်တာရာဇာချစ် ကို အဖ ဦးချစ်ငွေ အမိ ဒေါ်ခင်နွဲ့သီတို့မှ ၁၉၈၇ ခုနှစ်တွင် စစ်ကိုင်းတိုင်း ဒေသကြီး၊ အင်းတော်မြို့ ၌ မွေးဖွားခဲ့ပါသည်။

၂၀၀၃ ခုနှစ်တွင် တက္ကသိုလ်ဝင်တန်းစာမေးပွဲကို အောင်မြင်ခဲ့ပြီး ၂၀၀၇ ခုနှစ်တွင် ပညာရေးဘွဲ့ (BEd) နှင့် ၂၀၁၁ ခုနှစ်တွင် မဟာပညာရေးဘွဲ့ (MEd) ကို ပညာရေးစိတ်ပညာ အထူးပြုဖြင့် စစ်ကိုင်း ပညာရေးတက္ကသိုလ်မှ လည်းကောင်း၊ ၂၀၁၈ ခုနှစ်တွင် ပညာရေးပါရဂူဘွဲ့ (PhD) ကို ရန်ကုန်ပညာရေး တက္ကသိုလ်မှ လည်းကောင်း အသီးသီးရရှိခဲ့ပါသည်။

၂၀၀၈ ခုနှစ်တွင် ပင်လည်ဘူးမြို့နယ်၌ အလယ်တန်းပြဆရာအဖြစ် စတင် တာဝန်ထမ်း ဆောင်ခဲ့ပြီး ၂၀၁၁ ခုနှစ်တွင် အမှတ်(၂)အခြေခံပညာဦးစီးဌာန၊ မန္တလေးမြို့သို့ ဒု–ဦးစီးမှူး(စစ်ဆေးရေး) အဖြစ် ရာထူးတိုးမြှင့်ခြင်းခံခဲ့ရပါသည်။ ထို့နောက် ၂၀၁၂ ခုနှစ်တွင် စစ်ကိုင်းပညာရေးတက္ကသိုလ် ပညာရေးစိတ်ပညာဌာနသို့ နည်းပြရာထူးဖြင့် ပြောင်းရွှေ့ တာဝန်ထမ်းဆောင်ခဲ့ပြီး၊ ၂၀၁၆ ခုနှစ်တွင် လက်ထောက်ကထိကအဖြစ် ရာထူးတိုးမြှင့်ခြင်း ခံခဲ့ရပါသည်။

၂၀၁၃ ခုနှစ်တွင် မြန်မာနိုင်ငံဝိဇ္ဇာနှင့်သိပ္ပံပညာရှင်အဖွဲ့မှချီးမြှင့်သည့် အကောင်းဆုံး သုတေသန စာတမ်းဆုကိုလည်းကောင်း၊ ၂၀၁၈ခုနှစ်တွင် ဒေါက်တာနုနုဝင်း ပညာရေးသုတေသနဆုကိုလည်းကောင်း ရရှိခဲ့ပါသည်။ ယခုအခါ နိုင်ငံ့အကျိုးပြု၊ ဘာသာရပ်အကျိုးပြု သုတေသနစာတမ်းများ ရေးသားပြုစုရင်း စစ်ကိုင်းပညာရေးတက္ကသိုလ်တွင် လက်ထောက်ကထိက တာဝန်များကို ထမ်းဆောင်လျက်ရှိပါသည်။

a'guwm ZiZiEi\ u, a&;tus0;

ဒေါက်တာ ဇင်ဇင်နိုင်ကို ၁၉၆၅ ခုနှစ်၊ ဖေဖော်ဝါရီလ (၂၃)ရက်နေ့တွင် မွေးဖွားခဲ့ပါသည်။ ၁၉၈၅ ခုနှစ်တွင် ရန်ကုန်စီးပွားရေးတက္ကသိုလ်မှ B.Econ ဘွဲ့ကိုလည်းကောင်း၊ ၁၉၈၆ ခုနှစ်တွင် B.Econ (Hons) ဘွဲ့ကိုလည်းကောင်း ရရှိခဲ့ပါသည်။ ၁၉၉၆ ခုနှစ်တွင် ကမ္ဘာဘဏ်ပညာသင်ဆုကို ရရှိခဲ့သဖြင့် အမေရိကန်နိုင်ငံ ကိုလံဘီယာတက္ကသိုလ်၊ School of International and Public Affairs (SIPA) တွင် စီးပွားရေးမူဝါဒ စီမံခန့်ခွဲမှု အစီအစဉ်ဖြင့် ပညာသင်ကြားခဲ့ပြီး M.I.A မဟာဘွဲ့ကို ရရှိခဲ့ပါသည်။ ပညာသင်ကြားစဉ်အတွင်း ဘွဲ့၏လိုအပ်ချက်တစ်ရပ်အနေဖြင့် World Bank Institute တွင် (၆)လ ပညာဆည်းပူးခဲ့ပါသည်။ ၂၀၀၅ ခုနှစ်တွင် ဂျပန်နိုင်ငံ၊ ဆုကုဘတက္ကသိုလ်မှ M.Econ (Economics) မဟာဘွဲ့ကို ထပ်မံရရှိခဲ့ပါသည်။ ၂၀၁၈ ခုနှစ်တွင် ရန်ကုန်စီးပွားရေးတက္ကသိုလ်မှ ပါရဂူဘွဲ့ ရရှိခဲ့ပါသည်။

ဒေါက်တာ ဇင်ဇင်နိုင်သည် ရန်ကုန်စီးပွားရေးတက္ကသိုလ်၊ ဘောဂဗေဒဌာနတွင် ၁၉၈၆ ခုနှစ်၊ နိုဝင်ဘာလ(၁)ရက်နေ့မှ စတင်၍ နည်းပြအဖြစ် တာဝန်ထမ်းဆောင်ခဲ့ပြီး၊ စစ်ကိုင်းပညာရေး တက္ကသိုလ်၊ မန္တလေးအဝေးသင်တက္ကသိုလ်၊ မိတ္ထီလာစီးပွားရေးတက္ကသိုလ်တို့တွင်လည်း တာဝန်ထမ်းဆောင်ခဲ့ပါသည်။

ဒေါက်တာ ဇင်ဇင်နိုင်သည် အပြည်ပြည်ဆိုင်ရာကုန်သွယ်မှုဆိုင်ရာ စည်းမျဉ်း၊ နည်းလမ်းများနှင့် သက်ဆိုင်သော သုတေသနများ၊ မြန်မာနိုင်ငံ၏ မူလထုတ်ကုန်စည်ထုတ်လုပ်မှု၊ တင်ပို့မှုဆိုင်ရာ သုတေသနစာတမ်းများကိုလည်း ပြုစုရေးသားခဲ့ပါသည်။

jrermEii 0ZmEioyynm&i traqmi tz

ဥက္ကဋ္ဌ၊ ဒေါက်တာ သက်လွင်

ဒုတိယ ဥက္ကဋ္ဌများ၊ ဒေါက်တာ ဒေါ်ကြည်ကြည်လှ၊ ဒေါက်တာ အောင်မင်း

အတွင်းရေးမှူး၊ ဒေါက်တာ သိန်းဝင်း

တွဲဖက်အတွင်းရေးမှူးများ၊ ဒေါက်တာ ဖိုးကောင်း၊ ဒေါက်တာ ဒေါ်လွင်လွင်စိုး၊
ဒေါက်တာ ဒေါ်ခင်နိုင်ဦး

tz0irsm;

ဒေါက်တာ ဒေါ်ခင်သန်းဦး	ဦးသီဟ
ဒေါက်တာ ဒေါ်မိမိကြည်	ဒေါ်ခင်လတ်
ဒေါ်ကယ်ရယ်အောင်ချစ်သာ	ဒေါက်တာ မောင်ကျော်
ဒေါက်တာ မျိုးသန့်တင်	ဒေါက်တာ လှဖေ
ဦးကျော်မြင့်ဦး	ဒေါက်တာ ဦးဝင်း
ဒေါက်တာ မောင်သင်း	ဒေါက်တာ ဒေါ်ရီရီမြင့်
ဒေါက်တာ ဇော်ဌေး	ဒေါက်တာ ဒေါ်သန်းနွဲ့
ဒေါက်တာ တင်ညို	ဦးမြင့်ဟန်

pmwn;tz

ဒေါက်တာဒေါ်ကြည်ကြည်လှ	ဥက္ကဋ္ဌ	ဒေါက်တာဇော်ဌေး	ဒုတိယဥက္ကဋ္ဌ
ဒေါက်တာ အောင်မင်း	အဖွဲ့ဝင်	ဒေါက်တာ ဒေါ်ခင်သန်းဦး	အဖွဲ့ဝင်
ဦးသီဟ	အဖွဲ့ဝင်	ဒေါက်တာ ဒေါ်မိမိကြည်	အဖွဲ့ဝင်
ဒေါ်ခင်လတ်	အဖွဲ့ဝင်	ဒေါက်တာ မောင်ကျော်	အဖွဲ့ဝင်
ဒေါက်တာ လှဖေ	အဖွဲ့ဝင်	ဦးကျော်မြင့်ဦး	အဖွဲ့ဝင်
ဒေါက်တာ မောင်သင်း	အဖွဲ့ဝင်	ဒေါက်တာ ဒေါ်ရီရီမြင့်	အဖွဲ့ဝင်
ဒေါက်တာ ဒေါ်သန်းနွဲ့	အဖွဲ့ဝင်	ဒေါက်တာ မျိုးသန့်တင်	အဖွဲ့ဝင်
ဒေါက်တာ တင်ညို	အဖွဲ့ဝင်	ဒေါက်တာ ဦးဝင်း	အတွင်းရေးမှူး

ဒေါ်ကယ်ရယ်အောင်ချစ်သာ၊ တွဲဖက်အတွင်းရေးမှူး