



ANNUAL ACADEMIC SESSIONS - 2015

PROCEEDINGS

19th & 20th November

The Open University of Sri Lanka



**THE OPEN UNIVERSITY OF
SRI LANKA**

**Extended Abstracts
Annual Academic Sessions
19th & 20th November, 2015**

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MESSAGE FROM THE VICE CHANCELLOR

It is my pleasure to send this felicitation message to the Proceedings of the Annual Academic Sessions 2015 of the Open University of Sri Lanka (OUSL). I have been following the progress Annual Academic Sessions of the OUSL has made over the years and delighted to note its advancement from humble beginnings to what it is now. It has now become an annual regular event of the University which is being looked up to by the OUSL community and other researchers to disseminate their research findings.

The Open University of Sri Lanka being the pioneer institute in Open and Distance Learning (ODL) in Sri Lanka has made a tremendous impact on the higher education sector of the country. We need to further strengthen and advance our capabilities and effectiveness by adopting newer approaches with the ever changing scenario in the worldwide ODL concepts. For this purpose, research plays important and vital role in ascertaining the best practices that are suitable to cater the needs of our local environment. I am sure based on the research experiences that are being shared in this year's annual sessions, we will be able to learn and adopt practices for the betterment of our learners.

From the inception, the OUSL has insisted that along with research in ODL, the subject based research must be an integral part of the academic life of our University. I am glad to note that many academics and students of the OUSL have embraced this culture and have regularly contributed their research experiences at various forums, including the OUSL Annual Academic Sessions. In recent years, the OUSL Annual Academic Sessions, as a higher calibre forum, has also attracted researchers from other institutes to publish their research findings.

Let me take this opportunity to express my appreciation to the Organizing Committee of the Annual Academic Sessions 2015 and other staff who have contributed their time and effort to make this event a success.

I am confident that the OUSL Annual Academic Sessions 2015 would be an academically enriching and rewarding experience for all the presenters and participants.

Prof. S. A. Ariadurai
Vice Chancellor

PREFACE

It is indeed a special privilege and a pleasure to present this published Proceedings of the Annual Academic Sessions, 2015 of the Open University of Sri Lanka, on behalf of the Senate Sub-Committee. The Annual Academic Sessions will be taking place on 19th and 20th November at the Open University premises and the extended abstracts accepted for presentation are published in this volume.

We received 84 extended abstracts of which 26 were from researchers outside the OUSL. After a rigorous peer review process, a total of 62 extended abstracts were selected for presentation. It is to be noted that substantial number of research papers are outcome of collaborative work within and outside the Open University. Abstracts appearing in this proceedings fall into broad areas including Open and Distance Learning (ODL), Education, Engineering, Natural Sciences, Health Sciences, and Humanities and Social Sciences.

Highlighting the uniqueness of the OUSL, Annual Academic Sessions have a distinct session on Open and Distance Learning. The remainder of the papers are categorized in to 10 areas reflecting the diverse and inter-disciplinary nature of research undertaken by the academia within and outside the OUSL.

On behalf of the Senate Sub-Committee on Annual Academic Sessions, I wish to sincerely thank

- All the authors for their valuable contribution and cooperation in preparing and finalizing the extended abstracts within the given time frame.
- All the reviewers (more than 125) who reviewed the extended abstracts with due care.
- The team of language editors from the Department of Language Studies and Postgraduate Institute of English of the Open University of Sri Lanka.
- The Senate Sub-Committee members for Annual Research Awards for selecting the awardees within the required time frame.
- The Professors of the OUSL for agreeing to serve as Session Chairs at this event. We are grateful that you are joining the community of volunteers who are absolutely critical for the conference success.
- Mr. Priyantha Nawaratne and Mr. P. H. J. Arunasiri in for the untiring efforts in all sessions-related work and Miss. Nayana Wijesinghe for the secretarial assistance.
- Mr. Priyantha Nawaratne for the creative work in preparing the invitation, cover page and compiling the abstracts in a professional manner.
- Mr. Mudith Somaratne, Acting Director Operations for the cooperation extended and Mr B. A. D. J. Balachandra, Acting Printer and his staff in printing this volume.
- Mr. S. H. Uwaisulkarni, former Deputy Registrar, Ms. Kala Suresh, Deputy Registrar and her staff and all others who helped us in numerous ways to make this year's OUSL Annual Academic Sessions, a success.

Prof. Tuley De Silva and Prof. Narada Warnasuriya have kindly agreed to deliver key note addresses at these sessions. We are very grateful to both of them for taking time off from their busy schedules to be with us at the sessions.

This year we were able to issue a conference bag to authors who have registered for the sessions. This would not have been possible without the generous support of Link Natural Products (Pvt.) Limited. Our special thanks go to Dr. Devapriya Nugawela, CEO, in this regard.

We also wish to record our thanks to the Vice Chancellor Prof. S. A. Ariadurai and the former Vice Chancellor Dr. Vijitha Nanayakkara, for their ready support in carrying out our work to make this event success.

Our Chancellor, Prof. Colvin Goonaratna is gracing this occasion as our Chief Guest. We are indeed happy and honoured by his presence.

I sincerely thank all the members of the Senate Sub-Committee of the Annual Academic Sessions 2015 for their unstinted support given when crucial decisions had to be taken and, for their active participation and contribution in all matters connected with this event. A special word of thanks goes to Prof. K. S. Weerasekera, Chairman, Annual Academic Sessions 2014 for his valuable contribution. No doubt, without them this event would not have been a reality.

Finally, let me wish the very best to all the participants, and hope that there would be intellectually stimulating and academically productive deliberations at the Annual Academic Sessions, 2015.

Prof. G. M. Kamal Bandara Gunaherath

Senior Professor of Chemistry and Deputy Vice Chancellor

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Keynote Address 1

BUSINESS DRIVEN MULTIDISCIPLINARY RESEARCH

Businesses have to ensure that their products meet the needs of customers and provide a good return on investment. Hence their activities are based on commercial targets and the scientists liaise closely with their commercial colleagues, production and formulation staff so that strategic objectives can be fulfilled. Research and Development is thus an important part of the business strategy. Business challenges include achieving rapid growth, delivering shareholder value by exploiting opportunities created by technology advances and identifying the key value-creation areas. A sustainable business competitive advantage can be derived by reducing the time to market new products.

Business-Driven Research & Development requires management of S&T to meet well defined business objectives within a framework of time and cost targets. Research is directed towards development of new products and technologies, improvement of existing products, extending their uses, improving their performance and monitoring their long-term environmental impact.

Growth of a company can be achieved by introducing new products and services and by cost-cutting by effectively harnessing its R&D capabilities to achieve a higher growth rate. This can be Technology-driven research to develop the 'best technologies' for products involving innovative solutions or Market-driven research to develop products that the customers demand to create more chance of value delivery. It must be emphasized that Return on Investment (ROI) drives every business decision. An investment is made when it is possible to increase profits, lower costs and take advantage of an opportunity that fully justifies the investment in some substantial way based on well defined business plans that take into account market requirements and trends, competitive practices, customer demands, resource requirements, action plans, measurable goals and other factors that influence the ability to return profits.

With technology advancement it has become imperative for different disciplines to work together to solve complex problems and develop new products and services. Multidisciplinary Research (MDR) is bringing different disciplines together to discuss issues from each of their perspectives and conduct research. It can be collaborative, but they maintain a separation of their disciplines in that process. This is different to Interdisciplinary research which is bringing different disciplines together to use their expertise to create new knowledge, tools, techniques etc. that could not happen if they were separately handled by integrating their disciplines for problems whose solutions are beyond the scope of a single discipline of research applications. Interdisciplinary teams are interdependent, but efforts are collaborative and team members work together toward a solution.

Multidisciplinary Research involves a team of scientists from multiple disciplines to redefine problems outside normal boundaries and reach solutions based on their own perspective and expertise and then come together bringing their individually developed ideas to formulate a solution.

MDR has many advantages in that the number of distinct topics to be studied is large and varied; the selection of diverse disciplines is wide bringing together a team of experts with specific approaches and knowledge to result in synergy. This will bring about increased chances in high-impact research that will lead to more output with less work.

The challenges for MDR include understanding the concepts of a discipline other than your own, finding a common language to communicate ideas, trusting research you haven't the skills to assess yourself, and maintaining good relationships with partners.

Each MDR project should be precisely defined, be on time and budget and meet or exceed client expectations. For better performance the partners should determine the operational route

as well as value to the company early in each project, embrace the new strategic thinking, adapt the structure and a business model and address and correct any issues prior to any negative effects on operations, customer relationships or finance.

A Research University should be a vital centre of competence to deal with social challenges and drive economic growth. It has to have the autonomy to operate effectively, and form partnerships. Policymakers need to ensure a stable environment of funding and regulation for long-term strategic partnerships and reward universities and companies that form strong partnerships. Universities should strive for excellence as Companies want to work with the best.

Some factors to be considered by the Industry for successful collaboration with Universities include opening their corporate research labs to academics, building trust as it takes time to get to know university researchers, work with them on starter projects before engaging in large-scale collaborations (e.g. sharing a lab or equipment, students projects for theses and getting experienced university experts as consultants). University Industry links have to be established with the right people who share the same objective, deliverables and commitment. Many partnerships fail due to poor leadership. These projects are collaborations rather than sponsorships promoting cross-disciplinary work. Do not let IP or papers to journals be stumbling blocks for the successful implementation of MDR projects. Another difficulty is the evaluation of MDR research projects as it needs reviewers at all levels to highlight the value of collaborative research and explain how individual efforts relate to the whole. Such peer review panels are not easy to assemble and operate due to operational difficulties of a common framework for output driven research in setting performance goals for evaluation.

In order to make MDR a business-driven process, it has to be aligned to consumer needs and a business strategy. Innovation comes through promoting creativity in multidisciplinary teams oriented towards a clearly articulated business goal. Project goals should be negotiated with the stakeholders by the team. Risk management needs to be explicitly considered and discussed openly at all levels in the project.

Companies need to innovate in response to changing customer demands and lifestyles and in order to take advantage of opportunities offered by new technology and changing marketplaces, structures and dynamics. Company's innovation can be performed in relation to products, services, operations, processes, and people.

Innovation is the multi-stage process whereby organizations transform ideas into new/improved products, service or processes, in order to advance, compete and differentiate themselves successfully in their marketplace. (Baregheh A, Rowley J and Sambrook S.(2009) Towards a multidisciplinary definition of innovation, Management decision, vol. 47, no. 8, pp. 1323-1339). The most recent definition for Innovation is, *"The first successful application of a product, a process or a service"*

Companies thus need to form multidisciplinary teams tailored to meet the demands of each challenging problem, combine scientific and engineering talent, and draw from a diverse combination of knowledge, skills, and experience to generate innovative solutions or develop products, processes or services. Innovation if properly managed is the most important determinant of every business' success. Business driven MDR is the backbone of a globally competitive, knowledge-driven economy. Investment in MDR helps develop new products and services that drive growth, create jobs, and improve the national economy.

Prof. Tuley De Silva

Chancellor, Wayamba University of Sri Lanka

Professor Emeritus, University of Sri Jayewardenepura

Director and Research & Development Consultant, Link Natural Products (Pvt) Ltd.

Keynote Address 2

THE ROLE OF THE UNIVERSITY IN SOCIETY: CHANGING PARADIGMS

It was in 1852 that Cardinal John Newman in a classic essay on the “Idea of a University” distinguished universities from schools of theology and described them as autonomous centres for discussion and dissemination of universal knowledge. He saw them providing space for discussion of controversial topics free from the interference of the church and the state.

One hundred years later in his seminal work “Idea of the University” the German philosopher Karl Jaspers defined the university as “the corporate realization of the man’s basic determination to know”.

He visualized the modern university to comprise of three interconnected centres, a training centre to produce the professionals needed by society, a research centre to solve its problems and a cultural centre to provide a liberal environment for its thinkers. He envisaged the three roles merging imperceptibly as a composite whole.

Nearly fifty years later Manuel Castells the Spanish sociologist saw the role of the university somewhat differently as being four fold; being ideological apparatuses expressing the ideological struggles present in all societies, being mechanisms for selection and socialization of the dominant elites, generating knowledge and supporting its application in society, and training a skilled labor force of professionals.

He saw the universities as social systems which attempt to make these seemingly contradictory functions compatible.

The traditional view point emphasizes personal growth and development that occurs through education and its contribution to citizenship and social values.

The new economic perspective of the knowledge economy, an euphemism coined by the World Bank for the all-pervading globalised free market, emphasizes market demand, work readiness and economic returns through research and innovation.

Though some see these two viewpoints to be contradictory and mutually exclusive others consider them to be complementary and amenable to blending within the same institution or within a differential higher education frame work within one country.

The Dearing Report on “Higher Education in the Learning Society” (1997, UK) combines these into four purposes for higher education in the 21st century namely personal effectiveness and self-realization through ‘learning how to learn’, generating intellectual capital to promote knowledge and understanding, learning and innovation to sustain a knowledge based economy and generating social capital to shape a democratic, civilized and inclusive society.

In this presentation the speaker will deal with these evolving concepts analytically with reference to both local and global contexts. He would emphasize the common thread running through all, of seeking and using knowledge to the benefit of society and even more importantly of providing a ‘protected space’ for individuals singly or collectively to think the unthinkable .

Prof. Narada Warnasuriya

Senior Professor of Paediatrics

General Sir John Kotelawala Defense University

Professor Emeritus, University of Sri Jayewardenepura

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EFFECTIVENESS OF A MODIFIED VERSION OF PEER-ASSISTED STUDY SESSIONS IN IMPROVING ACADEMIC PERFORMANCE: AN OPEN AND DISTANCE LEARNING CASE STUDY

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INTRODUCTION

Course completion rates constitute a measure of the efficacy of an academic programme. As such, academic institutions must search for ways of enhancing course completion rates in improving efficacy. This is especially true in Open and Distance Learning (ODL) where completion rates are intrinsically low (Simpson, 2013). Improvement in the academic performance of students is vital in enhancing course completion rates. An important factor that determines the academic performance of a student is student engagement (Leach and Zepke, 2011). Hence, academic institutions must search for interventions to improve student engagement to enhance the efficacy of their academic programmes.

Motivation and competency of students, students' transactions with teachers and peers, institutional support that is received by students, the realization of students' social beliefs and practices, and support by family and friends are identified as key factors that positively influence student engagement (Leach and Zepke, 2011). Peer Assisted Study Sessions (PASS) have the potential to influence most of the above factors, if not all. Hoping to influence the above mentioned factors, the Faculty of Natural Sciences of the Open University of Sri Lanka (OUSL) conducted a modified version of PASS, Study Sessions with Young Mentors (SSYM) (Bandarage *et al.*, 2011), for new entrants to the B.Sc. programme in the 2013/2014 academic year. The Young Mentors (YM) who conducted SSYM were recent OUSL B.Sc. graduates, who completed the programme with a class, and OUSL B.Sc. students of high academic standing. In general, each SSYM had at least one graduate YM, which is a factor that differentiated SSYM from PASS.

SSYMs were conducted for courses at entry level to the B. Sc. Degree, which amounted to six Open University Credits (5 Carnegie Credits) in each of the five subject areas, which are Botany Chemistry, Pure Mathematics, Physics, and Zoology. A total of 15 SSYMs (of 4 hour duration each) were held per subject, spread throughout the academic year. SSYM were conducted in the Colombo, Kandy, Matara, and Jaffna regional centres of OUSL.

PASS is considered as a supplemental instructional scheme that is used in rendering academic support in courses. However, the major objective of conducting SSYMs (Bandarage *et al.*, 2011) was to influence the above mentioned factors that affect student engagement in all students who enter the B. Sc. Degree programme. The subject was used only as the vehicle in achieving the above-mentioned objective. As such, the attendance at a minimum of ten SSYMs in one subject of choice by a student was made compulsory to progress in the B. Sc. Degree programme.

A commonly used measure of academic performance of a student is the Grade Point Average (GPA) or average marks. Since a positive influence by SSYM on generic factors affecting student engagement is expected, we used the average mark in all the science subject-based courses a student had registered (not only the course for which the student attended SSYM) in 2013/2014 as the indicator of academic performance of that student.

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In this study, we report the results of an exploration of the effectiveness of SSYM in improving the academic performance of students.

METHODOLOGY

The entire student population that was registered at the Colombo Regional Centre for SSYMs for the 2013/2014 academic year was included in the study. Their Weighted Average Overall Marks (WAOM) was calculated on the basis of number of credits per course. The courses for which a student had not completed the final examination were omitted in calculating the total number of credits offered by a student since a student was allowed to postpone sitting the final examination. Further, students who obtained a WAOM of zero were omitted as extreme cases. The WAOM was considered as the indicator of academic performance (which, in turn, is a measure of student engagement).

The total set (nine) of potential predictors of academic performance of a student that were included in the study were: attendance at SSYM (Attend-Code), the total number of credits offered, age, gender, General Certificate of Education (Advanced Level) results (as an average index mark giving scoring as 1-S, 2-C, 3-B, 4-A) (AL-IND), attendance at the Induction programme (IND-ATTEND-COD) that was conducted at the entry to the B. Sc. Degree Programme before any academic activities began, the motivation level of the student (IN-Mot) at entry to the B.Sc. programme as measured using a modified version of the questionnaire of Tuan *et al.*, 2005 that was administered on the first day of the Induction programme), students' employment (Employment) and marital status (Marital-S). Except for the total number of credits, all the other predictors were considered as categorical variables (levels of which are given in Table 1).

The academic performance of participants was determined by the WAOMs. Descriptive statistics, Chi-square tests, and Ordinal Logistic Regression (OLR) were used to analyse data. WAOM was coded into 4 levels (0-29.99, 30-39.99, 40-49.99, 50-100), used as the response variable. The OLR model (Agresti, 2013) used is given by

$$\left[\frac{\Pr(Y \leq i)}{1 - \Pr(Y \leq i)} \right] = \exp(\alpha_i + \beta_1 X_1 + \beta_2 X_2 + \dots + \beta_m X_m); \quad i = 1, 2 \dots k$$

where m is the number of predictors (= 9 at initial level), Y – response, ordinal variable with n levels ($n = 4$) and $X_j = j^{\text{th}}$ predictor.

The OLR model allows simultaneous analysis of the effect of several predictor variables on a categorical response variable (Agresti, 2013). Since our response is categorical and has several simultaneous predictors, the OLR model is appropriate for our analysis. Minitab Version 14 and SPSS PC Version 20 (2009) were used.

To find the simultaneous effect of variables, the OLR model was first fitted using all nine predictors in order to identify significant predictors. Then OLR was refitted using only the significant predictors with interactions among them, and the final model was concluded.

RESULTS AND DISCUSSION

A total of 413 students (after screening) were included in the analysis and sample mean of WAOM, and the medians were 36.383 ± 17.996 and 39.000 , respectively. The Chi-square test indicates that WAOM has bi-variate associations with Attend-Code, AL-IND, and Employment ($p < 0.05$). Considering WAOM as a numerical variable, the Pearson correlation coefficient between WAOM and the total number of credits was found to be 0.005 ($p = 0.914$), which implies that WAOM does not depend on the total number of credits.

Summary statistics obtained with the initial model (fitted with all 9 predictors) is given in Table 1. $WAOM \geq 50$ was used as the reference level of the response.

Table 1. Summary of the results of initial OLR

Factor	Factor Level	Coefficient	Std. Err.	Odds ratio
Attend-Code	0 to 4 days (ref)			
	5 to 9 days (p = 0.578)	-0.18	0.33 0.283	0.83
	10 and above days (p < 0.001)	-1.41		0.25
Total Credits	(p = 0.158)	0.087	0.063	0.92
IN-Mot	index 0 to 1.50 (ref)			
	index 1.51 to 2.00 (p = 0.866)	0.07	0.44	1.08
	index 2.01 to 2.50 (p = 0.351)	0.42	0.45	1.52
	index 2.51 to 3.50 (p = 0.673)	-0.34	0.80	0.71
AGE-CO	≤ 25 years (ref)			
	> 25 years (p = 0.779)	0.11	0.41	1.12
AL-IND	index 1 – 1.50 (ref)			
	index 1.51 – 2.0 (p < 0.001)	-0.84	0.22 0.492	0.43
	index 2.1 to 2.5 (p = 0.008)	-1.31	0.58	0.27
	index above 2.5 (p = 0.008)	-1.53		0.22
Gender)	Male (ref)			
	Female (p = 0.291)	-0.27	0.26	0.76
Marital -S	Married (ref)			
	Unmarried (0.873)	-0.08	0.51	0.92
Employment	Un employed (ref)			
	Teacher (p = 0.058)	0.52	0.27	1.68
	Other (p = 0.013)	0.65	0.26	1.92
IND-ATTEND-CODE	0 to 4 sessions 5 to 6 sessions (p = 0.857) (Session = 4 hours)	-0.06	0.35	0.94

Attend-Code, AL-IND, and Employment were found to be significant at initial OLR ($p < 0.05$). The model fitting statistics of the ordinal regression with nine predictor variables indicated that the model is satisfactory (Log-Likelihood = -419.342, Test that all slopes are zero: $G = 86.240$, $DF = 15$, $p < 0.001$, p -Pearson = 0.364, p -Deviance = 0.985).

OLR was refitted using only the significant predictors Attend-Code, AL-IND, and Employment. It was found that the regression coefficients for the levels of Attend-code, 0 to 4 days, and 5 to 9 days were not significantly different ($p = 0.675$). Therefore, the levels of the Attend-Code were re-defined (denoted by RDAttend-code) as < 10 days and ≥ 10 days by amalgamating the above two categories.

The OLR was fitted again using the predictors RDAttend-Code, AL-IND, Employment, and the interaction terms RDAttend-Code and AL-IND, RD Attend-Code and Employment, AL-IND and Employment, and RD Attend-Code and AL-IND and Employment. It was found that all the interaction terms were not significant. Therefore, the OLR model with predictors RDAttend-Code, AL-IND, and Employment was concluded as the final model. The model fitting statistics of the final OLR model indicated that the model is satisfactory (Log-Likelihood = -423.930, and tests that all slopes are zero: $G = 79.164$, $DF = 6$, $p = < 001$, p -Pearson= 0.279, p -Deviance= 0.240.) The summary of the output of the final OLR model is given in Table 2.

According to Table 2, the effect estimate (Coefficient) for RDAttend is negative (-1.31), which indicates that the probabilities of a student obtaining WOAM < 30 , WOAM < 40 , and WOAM < 50 decreases when the attendance in SSYM is increased from less than 10 sessions (not completing SSYM) to greater than or equal to 10 sessions (completing SSYM) (when ALIND and Employment are kept at fixed levels). Therefore, the results suggest that the effect of SSYM on WOAM is positive.

Table 2. Summary of the final OLR model

Factor	Factor levels	Coefficient	Std. Err.	Odds Ratio
RDAttend-code	< 10 days (ref)	—	—	—
	≥ 10 days	-1.31 (p < 0.001)	0.21	0.27
AL-IND	Index 1 to 1.5(ref)	—	—	—
	index 1.51 to 2.0	-0.88 (p < 0.001)	0.22	0.41
	index 2.1 to 2.5	-1.36 (p < 0.001)	0.48	0.26
	index above 2.5	-1.39 (p = 0.014)	0.57	0.25
Employment	Un employed (ref)	—	—	—
	Teacher	0.57 (p = 0.025)	0.26	1.77
	Other	0.76 (p = 0.02)	0.25	2.13

Further, Figure 1 shows that the higher the number of SSYMs attended a higher probability of reaching a WAOM of > 50.

CONCLUSIONS/RECOMMENDATIONS

SSYMs were conducted in relation to subject specific courses and students were required to attend SSYMs in only one subject of their choice. The objective was to improve the academic performance in all the courses a student offers. Our results show that attendance in SSYM can improve the academic performance of a student in all the courses he/she offers. As such, it is recommended that conducting SSYMs be continued by studying and mitigating any difficulties encountered by students in attending them.

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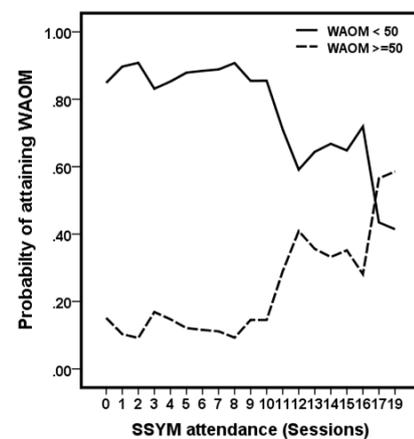


Figure 1: Relationship between the SSYM attendance and academic performance of a student.

PEER LEARNING HABITS OF OPEN DISTANCE LEARNERS - A STUDY BASED ON THE UNDERGRADUATE STUDENTS OF THE OPEN UNIVERSITY OF SRI LANKA

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INTRODUCTION

The Open University of Sri Lanka (OUSL) is the only institution that caters to a wide population of people in Sri Lanka to pursue higher education at their choice, which provides educational opportunities for working adults through Open Distance Learning (ODL). It offers many degree programmes through its Regional and Study Centres that are spread all over the country. ODL is a form of education where the student and instructor are not in the same place, and the instructions may occur through formats such as printed modules, online instruction, and multimedia packaged formats (Somuah *et al.*, 2014). This is a mode of study where the students are not physically present in a traditional setting, such as a classroom, and are separated by space and time from their tutor and the institution, but keep in close touch with specially formulated study materials. Brindley *et al* (2012) state that distance education expands rapidly as it gains worldwide acceptance by students, educational institutions, employer organizations, and the public at large. It makes education accessible to underserved populations and is flexible in fitting into complex lifestyles, schedules, and responsibilities of today's learners. However, Dadigamuwa & Senanayake (2012) observe that the number of students dropping out in an ODL programme is significantly higher than those of a conventional programme. They further expressed that several factors affect students' performance and subsequent drop out rates in ODL systems.

Gao (2012) indicate that in ODL, students are physically, emotionally, and socially separated from the institution and feel isolated. The risk of students feeling isolated is very common in distance learning and also needs to be addressed and minimized. To address this problem, student-student interactions should be encouraged. According to Dzakiria (2012), learning interaction is fundamental to ODL because study completion success is dependent on how effectively students are interacting with course material, tutors, and their peers in their learning. Peer learning is one method to encourage meaningful learning that involves students teaching and learning from each other. It involves a sharing of ideas, knowledge, and experiences, and emphasizes interdependent, as opposed to independent, learning (Boud, 2001). Boud further describes it as a 'two-way reciprocal learning activity' in which there is mutual benefit to the parties involved. The Regional Centre in northern Sri Lanka, the Jaffna Regional Centre (JRC), of the OUSL extends its services to fulfill the educational aspirations of students in the northern region. However, empirical evidence shows that undergraduate students at JRC face difficulties in completing their courses successfully, and eventually become inactive in their study programmes. This is illustrated by the following diagram:

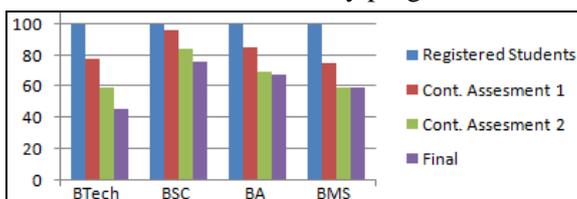


Fig. 1. Undergraduate students' involvement in academic activities at JRC in 2013/2014
(From Centre statistics)

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OBJECTIVES OF THE STUDY

The general objective of this study is to explore the peer learning habits of undergraduate students who are following their degree programmes through ODL at the JRC of OUSL.

The specific objectives of the study are

- To explore the different peer learning habits of ODL learners,
- To study the relationship between demographic characteristics of ODL learners and their peer learning habits,
- To identify factors that inhibit peer learning among ODL learners, and
- To provide suggestions to improve peer learning skills among ODL learners.

METHODOLOGY

A descriptive survey research design was used for this study, which is considered appropriate as this study was designed to describe, analyse, and determine the peer learning habits of undergraduate students. The population of this study was students pursuing degree programmes at OUSL. The target population was students following degree programmes at the JRC of OUSL. Purposive sampling was used for 150 respondents from students following four degree programmes, namely the BA in Social Sciences, the B.Sc, the B.Tech, and the B.M.S. The main data collection instrument was a questionnaire that was developed by reviewing related literature on peer learning. In this self-developed questionnaire, questions were set under three thematic areas, namely student background information, peer learning habits, and barriers for peer learning. Out of the 150 questionnaires that were distributed, 96 were successfully retrieved. Data analysis was done by using quantitative techniques, which were mainly frequencies, mean, one way ANOVA, and t-tests. The responses for the open-ended questions were coded and categorized into emerging themes.

RESULTS & DISCUSSION

A questionnaire survey was utilised to explore the peer learning habits of ODL learners. Data under three thematic areas were examined. These aspects were measured on a discrete five-point scale.

Table 1. - Background information of students

	Main categories	Sub Groups	Number	Percentage
1	Sex	Male	35	36
		Female	61	64
2	Age	20-40 Years	89	93
		41-50 years	7	7
3	Degree programme	B.A.(Social Sciences)	37	39
		B.Sc (Natural Sciences)	29	30
		B.M.S	16	17
		B.Tech	14	15
4	Marital status	Single	72	75
		Married	22	23
		Divorced	1	1
		Widow/Widower	1	1
5	Employment	Employed	67	70
		Unemployed	29	30

According to Table 1, it is clear that 70% of the students are employed and about 23% are married. It shows that most of the undergraduate students have family-, social-, and job-related responsibilities.

Table 2 indicates that the most-used peer learning habit is group members helping each other in subject matters, with a high mean value of 3.7083. More than four people forming a group was found to be the least used learning habit ($\bar{x} = 2.2708$). Other forms of peer learning habits, such as support by senior students for learning, peers teaching subject matter, mentoring by peers, and through discussions with peers through social networks and phones were also widely used by ODL learners.

Table 2. Peer learning habits of ODL learners

	Peer learning habits	Mean	Std. Deviation
1	Groups of 2-4 people joined together to study	2.9167	1.35853
2	More than 4 people joined as a group to study	2.2708	1.14689
3	Discuss on a topic or question in groups	2.8229	1.30582
4	Group members help each other in subject matter	3.7083	2.397
5	Senior students support for learning	3.1771	4.23269
6	Peers teach subject matter	3.1979	1.25337
7	Peers perform as mentors for learning	3.2604	1.28346
8	Peers assess the learning	2.9896	1.2607
9	Discussions with peers through social networks	3.0104	1.32581
10	Discussions with peers over the phone	3.3958	1.22671

Independent sample t-tests were conducted to study the effect of sex, age, employment status, and marital status on the peer learning habits of ODL learners. Table 3 reveals that there is no significant difference in the peer learning habits of male and female students ($t = 0.638 > p = 0.05$). The results also showed that, when the two age groups 20-40 and over 40 were compared, the age of students did not affect their peer learning habits ($t = 0.111 > p = 0.05$). Peer learning habits of ODL learners were not affected by their employment status ($t = 0.212 > p = 0.05$). The results also indicated that there is no significant difference in the peer learning habits of married and unmarried students ($t = 0.06 > p = 0.05$).

Table 3. Group statistics

		N	Mean	Std. Deviation	Std. Error Mean	t-test Sig. (2-tailed)
Sex	Male	36	3.0056	1.12933	0.18822	0.638
	Female	60	3.1167	1.10946	0.14323	
Age	19 - 40	89	3.1258	1.12285	0.11902	0.111
	More than 40	7	2.4286	0.75656	0.28595	
Employment status	Employed	68	2.9838	0.94262	0.11431	0.212
	No	28	3.2964	1.44106	0.27233	
Marital status	Married	76	3.1842	1.1181	0.12825	0.06
	Unmarried	20	2.66	1.0112	0.22611	

To study the effect of a study programme and the level of study on the peer learning habits of ODL learners, a one-way ANOVA test was conducted. The results are shown in Table 4 as follows:

Table 4. ANOVA on the overall mean scores of peer learning habits

		Sum of Squares	df	Mean Square	F	Sig.
Level of study	Between Groups	4.392	2	2.196	1.805	.170
	Within Groups	113.148	93	1.217		
	Total	117.540	95			
Programme of study	Between Groups	21.196	3	7.065	6.747	.000
	Within Groups	96.344	92	1.047		
	Total	117.540	95			

According to Table 4, peer learning habits of ODL learners are not affected by the level of study ($p = 0.170 > 0.05$). However, the results revealed that programmes of study significantly affected the peer learning habits of ODL learners ($f(93,92) = 6.747$, $p = 0.000 < 0.05$). Responses to the open-ended questions on students' perceptions of barriers for peer learning were coded and categorized into emerging themes. A range of perceived barriers was elicited. The findings are summarised and presented under two analytical types:

1. Personal barriers

- Tension in working environment
- Lack of knowledge and appropriate skills among students
- Students' reluctance to take the responsibility to teach others

2. Institutional barriers
 - Unavailability of space for students to use for peer learning
 - Difficulties in finding time for peer learning due to tight time schedule
 - Lack of motivation towards peer learning

CONCLUSION

Peer learning plays a crucial role in the success of a learner in the ODL learning system. Various forms of peer learning habits were exhibited by the undergraduate students at JRC. Most of them study in groups where group members help each other in subject matter. It was only in a few instances, where more than 4 people joined as a group to study that is found to be unsuccessful. Factors such as age, gender, employment status, marital status, and the level of study of the undergraduate students did not affect their peer learning habits. However, the programme of study they follow significantly affected their peer learning habits. This may be related to the content, structure, assessment methods, and instructional materials of those programmes. Further studies can be conducted to examine how programmes affect the peer learning habits of students. A number of personal and institutional factors were perceived as barriers for peer learning of students in the ODL system.

Based on the findings of the study, the following recommendations can be made:

1. The university should encourage peer learning,
2. Students should be guided to initiate formal study groups,
3. Physical facilities for peer learning, such as space and furniture, should be provided by the university,
4. Students should be motivated towards peer learning,
5. Time should be allocated for peer learning in the activity schedules of each study programme, and
6. Competitions, presentations, and seminars can be organized among study groups.

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**LEARNING STYLE PREFERENCES OF ENGLISH AS SECOND LANGUAGE
LEARNERS IN THE OPEN UNIVERSITY ENGLISH FOR GENERAL ACADEMIC
PURPOSE (EGAP) PROGRAMME**

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INTRODUCTION

At present language teaching is moving more toward the learner-centered approach where individual learner differences too are considered as an important factor. According to the educational research there are a number of factors that account for learner differences. Among these factors learning style plays a major role. Learning style can be defined as the characteristic cognitive, affective, social and physiological behaviours that function as relatively firm indicators of how learners perceive, interact with, and respond to the learning environment (MacKeracher, 2004). It shows that the individuals learn in different ways such as by seeing and hearing; reflecting and acting; reasoning logically and intuitively; memorizing and visualizing (Reid, 1987). Learning English language plays a crucial role as it is one of the predominant factors that influences the academic success of the Sri Lankan undergraduates. Therefore, for ESL practitioners it is important to have an awareness of their students' learning style preferences as it can contribute greatly in curriculum design, material development, teacher training and student orientation.

Learning Style Models

During the last three decades educational theorists and researchers have formulated a number of learning style models and instruments to recognize individual learning styles. Accordingly, Reid (1995) has developed learning style modes based on how students learn best using their perceptions- visual, auditory and kinesthetic preferences, and also two social aspects of language learning- group and individual preferences.

Perceptual Learning Styles

- Visual: Visual students like to read and obtain information from visual stimulation. These learners prefer using pictures, imageries, and spatial perceptions.
- Auditory: Auditory students are comfortable without visual input and learn from straightforward lectures, conversations, and oral directions.
- Kinesthetic: Kinesthetic students like lots of hands-on movements and enjoy working. They favour using body, hands, and tactile sense.

Social Learning Styles

- Group (interpersonal): They favor learning in groups or with other people.
- Individual (intrapersonal): They prefer to work alone and to be self-readers.

The current study examines the predominant learning style preferences of ESL learners of the Open University of Sri Lanka (OUSL) in the English for General Academic Purposes (EGAP) Programme. Furthermore, it investigates the learning style preferences of these ESL learners with respect to their gender and field of study.

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METHODOLOGY

Two hundred and fifty OUSL students from the EGAP Programme were selected as the sample of this study. These students represent four different degree programmes: B.Sc Health (45), B. Technology (66), B. Sc / B.Ed Natural Sciences (56) and B. Management Studies (61). These students learn English as a second language. As the current study is descriptive in nature, a survey method was adopted to collect data. The Perceptual Learning Style Preference Questionnaire (PLSPQ) developed by Reid (1987) was adapted and utilized as the research instrument. Although the questionnaire was administered to 250 students only 228 were completed and returned. Twenty five items that comprised the questionnaire were randomly arranged into sets of 5 statements that were related to visual, auditory, kinesthetic, group and individual learning style preferences. The individual student variables and the responses from the questionnaire were statistically analyzed by utilizing descriptive and inferential statistical techniques. With the help of Statistical Package for Social Sciences (SPSS 18) the data obtained were analyzed while calculating frequency distribution and percentages to identify the learning preference of students. To observe the significant differences if any among the field of studies Analysis of Variance (ANOVA) and Multiple Comparison of Means Tests (Scheffé test) were used. At the same time, Independent Samples Test was employed to investigate whether there is any difference between learning style preferences of female and male students. Preference means for each set of variables were classified into three ranges: major (means 13.50 and above), minor (means of 11.50 -13.49) and negative (11.49 or less) learning style preferences (Reid, 1987). Analysis of variance and Multiple Comparison of Means Tests were run on the preferences means ($p < .05$). Significance from the multiple comparison of means analysis was applied on the basis of the Scheffé test which is the most valid test for unequal sample sizes.

RESULTS AND DISCUSSION

Question 1: What is the predominant learning style preference of the Open University ESL learners in the EGAP Programme?

Table 1. Perceptual Learning Style Preference of ESL Learners in the EGAP Programme

Learning Style	Frequency	Percentage
Visual	37	16.2
Auditory	35	15.4
Kinesthetic	58	25.4
Group	55	24.1
Individual	43	18.9
Total	228	100.0

According to the percentage analysis score for each learning style, the majority of the learners favoured a kinesthetic learning style (25.4%) followed by group learning style (24.1%) as the secondary learning

style preference. Next to group learning style, students preferred individual learning style (18.9%) and visual learning style (16.20%) respectively. Auditory learning style (15.4%) became the least preferred learning style of the EGAP students. Thus, it shows that kinesthetic learning style is the predominant learning style of the Open University ESL learners in the EGAP Programme. These results support the results of Reid's (1987) investigation on learning and cognitive styles for both native and non-native speakers of English as she too found that ESL students strongly preferred kinesthetic and tactile learning styles.

Question 2: Is there any difference in the learning style preferences of ESL learners in the EGAP Programme with respect to their gender and field of study?

Table 2 shows the results of the Independent Samples Test that was carried out in order to observe whether there is any difference in the learning style preferences of ESL learners in the EGAP Programme with respect to their gender.

Table 2. Perceptual Learning Style Preference Means According to Gender

Learning Style Preference	Mean		P value
	Female	Male	
Visual	19.27	18.00	.000
Auditory	18.99	18.22	.039
Kinesthetic	19.74	19.10	.112
Group	19.26	19.13	.769
Individual	17.98	17.80	.738

Note: Preference means 13.50 and above = major learning style preference; means of 11.50-13.49 = minor learning style preference; means of 11.49 or less = negative learning style preference.

According to Table 2, in general all five learning styles were selected as 'major learning preference' by both male and female students. When compared to the mean values of the learning style preferences of the female and male students, females indicated a marginally higher preference for all five learning styles than males. In addition to that, females preferred visual and auditory learning significantly more than males, $t = 4.268$, $p = .000$ and $t = 2.081$, $p = .039$ respectively. Accordingly, females were significantly more visual and auditory than males. That means female students may prefer to learn through reading, studying charts and

listening to lectures, audiotapes etc. than male students. However, in general female students demonstrated that they prefer more experiential and total physical involvement learning whereas male students indicated that they favour learning in groups.

Table 3 illustrates the results of the Multiple Comparison of Means Tests that were carried out in order to examine whether there is any difference in the learning style preferences of ESL learners in the EGAP Programme with respect to their field of study.

Table 3. Perceptual Learning Style Preference Means According to Field of Study

Field of Study	Learning Style				
	Visual	Auditory	Kinesthetic	Group	Individual
Health Sc.	19.68 a*	18.95	19.91	18.77	17.60
Engineering Tech.	17.87 a*b*	18.25	19.54	19.63	16.77 c*
Natural Sc.	18.60	18.60	19.44	19.16	18.12
Management Studies	19.26 b*	19.06	19.18	19.13	19.19 c*
F- value	7.387	1.102	.534	.680	4.391

Note:1- a=visual learning style preference of Health Sc. Students different from visual learning style preference of Engineering Tech. students,
 b= visual learning style preference of Management Studies different from visual learning style preference of Engineering Tech. students,
 c= individual learning style preference of Management Studies different from individual learning style preference of Engineering Tech. students

Note:2- Significance level; * $p < 0.01$

Of all fields of study, Health Sciences ($p = .001$) and Management ($p = .006$) students were the most visual in their learning style preferences; they were significantly more visual than Engineering Technology students (Scheffé test, $p < .01$). Once again Management students

became the most auditory learners although any significant differences were not reported within the other fields. Both Health Sciences and Natural Sciences students indicated that they strongly preferred to learn kinesthetically. Engineering Technology students selected group learning as their major learning style preference and they were the strongest group learners as well. On the other hand, Management students were the most individual in their learning style preferences; they were significantly more individual than Engineering Technology students (Scheffé test, $p = .006 < .01$).

CONCLUSIONS/RECOMMENDATIONS

The overall results show that students from different fields of study appear to have multiple major learning style preferences while supporting the results of the related studies (Karthigeyan & Nirmala, 2013; Gilakjani, 2012; Reid, 1987). These studies demonstrated that irrespective of the field of study, students' preferences have represented all the categories of learning styles. In general, the majority of the learners of the current study revealed that they preferred to learn kinesthetically indicating that they would like to learn through active participatory experiences. That means majority of the EGAP students do not like conventional teaching, and they learn best by being involved physically in classroom experiences. Furthermore, it revealed that ESL students from different fields of study and gender sometimes differ significantly from each other in their learning style preferences. Although the university offers a common English Programme for majority of the undergraduates irrespective of their field of study, the outcome of the study shows that some learners might need instruction presented more visually, while others might require more auditory, kinesthetic, group or individual types of instruction. Specially, Management students showed that learning style preferences are very diverse. If the Open University ESL teachers do not have adequate knowledge about their individual students' learning style preferences, they cannot systematically deliver the needed instructional variety. Thus, the results of the current study point out the necessity of the teacher training to make them aware of the different leaning styles of their ESL learners and to train them to employ a broad instructional approach. Moreover, constant monitoring of the teaching is also very important as the OUSL employs a considerable number of external ESL teachers for the EGAP Programme. These findings stress that the learning style diversities should be taken into account in course material development as the EGAP Programme caters to undergraduates from different disciplines in the Open Distance Learning mode as well. Finally, the current study shows the importance of ESL practitioners investigating OUSL learners' learning styles and adapting the teaching methods to suit all the students. Otherwise, there can be a mismatch between the classroom teaching and students' learning potential and their attitudes toward learning English.

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PERSPECTIVES AND PRACTICES OF STUDENT TEACHERS OF OUSL IN THE USE OF OER IN TEACHING AND LEARNING

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INTRODUCTION

Open Educational Resources (OER) are "teaching, learning and research materials in any medium, digital or otherwise, that reside in the public domain or have been released under an open license that permits no-cost access, use, adaptation and redistribution by others with no or limited restrictions" (UNESCO, 2012). The use and adaptation of OER have been recommended as a very cost-effective investment in curriculum development and quality teaching-learning material development (Dhanarajan & Porter, 2013). OER offer significant opportunities in the teaching-learning process, especially in developing contexts. However, the adoption of OER by educators can be truly effective only if it reflects a 'change' in their thinking and actions. Educators are expected to be 'change agents' and every stakeholder in the educational change process is a change agent (Fullan, 2007).

Raising awareness among educators in Sri Lanka about OER and encouraging the use and creation of OER within the education system in the country have been identified as current needs (Karunanayaka, 2013). Several inhibiting factors on the use of OER in developing countries have been identified, including educational restrictions, English language and technical issues, concerns about quality and copyrights, limitations in teaching capacity and teaching practices, traditions, and a lack of awareness of OER (Hatakka, 2009). The Open University of Sri Lanka (OUSL) can play a major role in promoting the adoption of OER by educators, and the Faculty of Education at OUSL has taken several initiatives in this regard (Karunanayaka, Fernando & De Silva, 2013; Karunanayaka & Naidu, 2013).

As part of a project initiated on the Research on Open Educational Resources for Development (ROER4D) programme, which was supported by the International Development Research Centre (IDRC), Canada, through the Wawasan Open University of Malaysia, a research project is currently underway in the Faculty of Education to engage student teachers of its Postgraduate Diploma in Education (PGDE) Programme in integrating OER in their teaching and studying its impact. A preliminary investigation was conducted at nine Centres of OUSL – Colombo, Ratnapura, Kandy, Kurunegala, Badulla, Matara, Anuradhapura, Jaffna, and Batticaloa - representing the nine provinces of the country. This paper presents the findings of this pre-intervention survey that was conducted to find out the current perspectives and practices among teachers in the use of instructional resources and OER in teaching and learning

METHODOLOGY

The key objective of the pre-intervention survey was to understand the existing perceptions and practices among school teachers in relation to their use of instructional resources, including OER. It addressed the following specific research questions: what are the instructional resources teachers currently use? What are the pedagogical perspectives of teachers on the use of instructional resources? and what are the pedagogical practices among teachers?

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The participants consisted of 230 graduate teachers of secondary school level, representing the nine OUSL Centres. They constituted of 78 males and 152 females (34:66), a majority representing the Jaffna (16.5%), Batticaloa (15.7%), and Colombo (14%) Centres. More than half of them (50.4%) had less than 5 years of teaching experience, while 47.9% had between 6-15 years and 1.7% had experience above 15 years. A majority were teaching in the subject areas of Science (14%), Mathematics (14%), and Commerce (14%).

Data was collected mainly through a questionnaire consisting of both open-ended and close-ended questions and rating scales. A concept mapping exercise was also conducted. In addition, a checklist was used to analyse their lesson plans while focus group interviews were also held with the participant teachers.

RESULTS AND DISCUSSION

The participants' awareness on OER was found to be very minimal, with only 10% having even heard the term OER before. Their current use of instructional resources ranged from print materials 100%, videos 27.4%, multimedia 24.8%, online resources 20.4%, audio 18.3, and OER 3.5%. The features considered by teachers when selecting instructional resources are presented in Table 1.

Table 1. Features considered by teachers when selecting instructional resources

Feature	5 (Extremely)		4 (To a large extent)		3 (Somewhat)		2 (To a little extent)		1 (Not at all)		0 (Not responded)	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Relevance	180	78.3	33	14.3	12	5.2	1	0.4	0	0	4	1.7
Informative	92	40	71	30.9	23	10	16	69.5	10	4.3	18	7.8
Copyrighted	26	11.3	52	22.6	52	22.6	36	15.7	42	18.3	69	30.0
Easily available	135	58.7	51	22.2	26	11.3	6	2.6	1	0.4	11	4.8
Reliable	117	50.9	67	29.1	24	10.4	5	2.2	1	0.4	16	7.0
Freely accessible	104	45.2	64	27.8	36	15.7	20	8.7	6	2.6	0	0
Reusable	101	43.9	54	23.5	43	18.7	12	5.2	4	1.7	16	7.0
Cost-effective	85	40.0	73	31.7	48	20.9	10	4.3	4	1.7	10	4.3
Attractive	115	50.0	66	28.7	35	15.2	2	0.9	0	0	12	5.2
Easily adoptable	104	45.2	72	31.3	32	13.9	19	8.3	1	0.4	2	0.9
Updated	112	48.7	64	27.8	40	17.4	2	0.9	3	1.3	9	3.9
Flexible	94	40.9	60	26.1	41	17.8	11	4.8	7	3.0	17	7.4

The ratings given by participants on features that they considered 'extremely' and 'to a large extent' when selecting instructional resources revealed that 'relevance' (92.6%) to be the most prominent feature, while 'easily available' (80.9%), 'reliable' (80.0%), and 'attractive' (78.7%) emerged as the next popular ones. Interestingly, 'copyrighted' was found to be the feature least considered, whereas 'informative', 'freely accessible', 'reusable', 'cost-effective', 'easily adoptable', 'updated', and 'flexible' received average ratings. This implies that teachers were either unaware or insensitive about using 'copyrighted' materials, when compared with the other features of instructional resources. Further, 50% of them believed that individuals who developed the materials should be the owners of copyright, while 45.6% stated that it should be the institution or the publisher/s, while 13% were unsure.

Through a checklist used to analyse the lesson plans of teachers, their current pedagogical practices were observed. In relation to the overall approach on teaching methodology and instructional resources used, it was revealed that a majority (> 60%-70%) demonstrated constructive alignment between learning outcomes, activities and assessments, the use of a learner-centered pedagogic approach, opportunities for knowledge construction, a variety of learning activities, opportunities for interactions, and promoting a sharing culture. At the same

time, only a small percentage (>10%-20%) demonstrated innovative learning designs/resources, the use of a variety of learning resources/media types, the use of technology, creating an enjoyable learning experience, promoting self-directed/self-regulated learning, opportunities for learner creativity, opportunities for application of knowledge, links with real life situations, and catering to different learning styles. Further, no one (0%) has demonstrated the use of online resources or OER.

When considering the pedagogical perspectives of teachers on the use of instructional resources, it was revealed that a high majority used instructional materials developed by others (96.1%) and also shared their own instructional materials with others (92.6%). Participants' responses given for open-ended questions on freely and openly using educational resources developed by others and freely and openly sharing educational resources developed by themselves indicated mixed feelings. A majority were very positive about using others' resources, stating mainly because it will 'save time', 'give innovative ideas', and 'give updated knowledge'. However, there were certain concerns expressed about the 'quality', 'accuracy', 'relevance', 'unfamiliarity' of materials, and the need to 'modify' them according to their requirements. On the other hand, almost all participants were quite willing to share their materials with others because they thought 'sharing is good', 'it will help others', and 'can get feedback to improve'. Most of them stated that they feel 'happy', 'satisfied', 'proud', and 'motivated' when any others use material developed by them. Yet, there were also a few concerns expressed about 'protecting ownership', 'maintaining identity', and 'not realizing the intended purpose' when others use their materials.

The participants' initial perceptions on "Openness in Education" were gathered via open-ended questions and a concept mapping exercise, as well as through focus group discussions. It was encouraging to note that even though the concept of OER was novel to the teachers, they expressed very optimistic views about "openness" and its relevance to teaching and learning. Despite facing various challenges that were identified, such as limited resources, technical issues, and English language skill limitations, as well as time constraints, all participants mentioned that they are prepared to face such challenges and integrate these concepts in their teaching and learning.

Some quotes to support their views are presented below:

"...I think openness in education will lead to learning and teaching towards equal quality of global education..."

"...I consider that these concepts in teaching and learning are worthwhile for all..."

"...We should update our knowledge on these concepts ...and make the teaching-learning process more efficient and effective..."

"...I would like to integrate these concepts in our teaching-learning process..."

"...As a teacher, I am eager to adapt myself towards any positive change that will reinforce my students' learning..."

"...I think it can be used innovatively for the teaching-learning process..."

"...I can integrate it in the teaching process if training is provided..."

The concept maps developed by the participants further elaborated their perspectives on "openness" and related issues, diagrammatically.

The findings revealed that the instructional resources currently used by teachers mainly consisted of print materials, that were supplemented with video, multimedia, and audio, with a negligible use of online materials and no use of OER. When selecting instructional resources, they placed high importance on relevance, easy access, and attractiveness, but very low emphasis on copyright. The participants' knowledge on OER was minimal, and thus reaffirm the need to raise their awareness on this aspect (Karunanayaka, 2013). While their perspectives on 'sharing' and 'openness' were very positive, certain concerns do exist about 'openly sharing' instructional resources. The current pedagogical practices of teachers were

mostly activity-based, yet innovative practices in their teaching methods and the use of instructional resources were lacking, while opportunities for learner creativity and the application of knowledge were also minimal. Despite various inhibiting factors and challenges being identified (similar to Hatakka, 2009), teachers' motivation and preparedness towards integrating "open" concepts in their pedagogical practices is an aspect to inspire by educators to develop future strategies to promote such concepts.

CONCLUSIONS/RECOMMENDATIONS

Based on the findings, it can be concluded that the instructional resources teachers currently use in their teaching are very limited in scope and lack creativity, while awareness on and use of OER are minimal. The pedagogical practices among teachers lack innovativeness. Yet, the pedagogical perspectives of teachers on the use of instructional resources encourage openly sharing resources and, thus, exhibit "openness" in their thinking to some extent. Teachers' positive thinking and their preparedness to integrate such concepts into the teaching-learning process is optimistic, and provides insights into designing an appropriate intervention programme to promote the integration of OER in their teaching. Such an intervention should support further 'change' in their thinking, as well as actions, towards a more innovative, participatory, and sharing culture in education.

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BRIDGING THE DIGITAL DIVIDE IN SRI LANKA: ISSUES IN INTERNET ADOPTION AMONG RURAL COMMUNITIES

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INTRODUCTION

Information and Communication Technology (ICT) plays an important role in the modern information society. ICT media provide a space where individuals can create opportunities for interaction and the rehearsal of invented identities and relations. Updated UNESCO Discussion Paper (2013) mentioned that the Internet facilitated new media communications such as chat-rooms, email, blogs and micro blog sites, social media, mobile phones and modern wireless networks, for instance, have had positive effects on human and community socio-economic development. The Internet is also a vehicle to help attain rural development goals such as promoting the rural economy, mobilizing the efforts of rural populations and developing infrastructure in developing countries.

ICTs have the potential to bridge the digital divide in rural areas and urban areas in developing countries, but the new communication technologies have not brought the same developmental changes for all countries in the world. Xiaoming & Jinqiu (2008) note that developed countries, for example, the United States of America (USA) and European countries have gained large amounts of revenue from these modern media. However, many developing countries have only limited access to modern media for development purposes, creating a great digital divide between the information rich and the information poor.

Majority of developed and some developing countries use the Internet to achieve their development goals. Some 84.2% of people in the United States of America have used ICT facilities successfully for their development purposes. Developed Asian countries such as Singapore (73%), the Republic of Korea (84.8%), Japan (86.2%) and developing countries such as India (15.1%) are also using ICT facilities for their development purposes (World Bank Report, 2013).

The Internet has a larger role to play in the rural development of Sri Lanka. According to a report of the Department of Census and Statistics (2012), 81.8% of the people in Sri Lanka belonged to rural communities while only 18.2% of comprised the urban population. This elucidates the fact that 81.8% of the people in Sri Lanka remain separated from the facilities provided by this medium. Sri Lankan Internet user percentage was a mere 21.9% (World Bank Report, 2013). Wategama, Gunawardene & Wickremasinghe (2005) also note that digital divide is one of the major issues in Sri Lanka. Traditional media such as newspapers, radio and television are still popular among Sri Lankans when compared to the Internet usage.

The Internet was introduced to the Sri Lankan information and communication system in 1990. However the Internet is still an innovation in Sri Lanka when compared with developed and other developing countries. The problem is, why Sri Lankan rural community is lagging behind in Internet adoption? The aim of this study is to identify the issues hindering Internet adoption among rural communities in Sri Lanka with a view to recommend the solutions to overcome these issues in order to bridge the digital divide. The objectives are to determine the relationship between Internet adoption and infrastructural facilities, the adopter characteristics of rural communities, the characteristics of technology and affordability. Taking into consideration the objectives of this study, several hypotheses are postulated. The hypotheses

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are formulated to test the relationship between Internet adoption and above mentioned variables. Based on the Five Stages Innovation- Decision model designed by Everett M. Rogers (2003), this study identifies the issues of Internet adoption among rural communities in Sri Lanka.

METHODOLOGY

This study used the survey research method to obtain data from randomly selected rural communities in **Bibile Divisional Secretariat (DS)** within a specific four week period, in order to identify issues of Internet adoption among rural communities. Viraj (2011) notes that Bibile has poor infrastructural facilities and it has a large number of rural communities with 72% of its labor force involved in agriculture. Bibile is the poorest area in Monaragala district (poverty headcount index - 35.2%). Satharasinghe (2004) claims that the lowest rate of computer literacy, computer awareness, availability of computers in households and the lowest Internet facility from the Monaragala District in the Uva province. The researchers distributed 470 questionnaires but only 413(87.87%) were able to be collected. Of these, only 400 (85.10%) questionnaires were usable.

Quantitative data analysis using SPSS (version 20) involves a description of inferential statistics and descriptive statistics. The inferential statistics included reliability tests and correlation. Correlation was used to determine the relationship between Internet adoption and infrastructural facilities, adopter characteristics, technology characteristics and affordability. Internet adoption is the dependent variable and the independent variables include infrastructural facilities, adopter characteristics (needs, relevance, attitudes, computer skills and English language skills), technology characteristics (ease of use, perceived benefits) and affordability.

RESULTS & DISCUSSION

Out of a total 400 respondents analysed, 201 (51 %) were males and 199 (49%) were females. In terms of age, 131(32.8%) of these rural communities belong to the 15-30 age group, 119 (29.8%) in 31- 40 age group, 101(25.2%) in 41-50 age group, and 49 (12.2%) in 51-60 age group. In terms of education qualifications, 59% (236) have Advanced Level qualifications and 5.3% (21) have ordinary Level qualifications, 26 % (104) have Diploma qualifications, 8.8% (35) have Bachelor qualifications, and 1.1% have Master Qualifications.

In this study, all variables have a high reliability as all the variables tested revealed an alpha of more than 0.7 ($p < .05$). From the correlation analysis, all nine variables had a significant relationship with Internet adoption. Hypothesis testing was carried out to understand the relationship between Internet adoption and independent variables. As a result, hypotheses 1, 2, 3 and 4 were accepted (figure 3.1).

The main purpose and objectives of the study have been achieved by determining the variables which have a relationship to Internet adoption. There are relationships between Internet adoption and nine ID variables. Some issues in Internet adoption among rural communities in Bibile are lack of infrastructural facilities, problems of affordability and low computer and English skills. Apart from these factors, there are other cultural perceptions such as negative attitudes like the use of Internet socially corrupts their values. This means that these highlighted variables are significant factors for internet adoption. It shows that, the Diffusion and Innovation theory which provides the theoretical framework has been validated through the findings of this study. The proposed model for this study goes beyond Rogers's model to look at other variables related to issues and problems of Internet adoption. These theoretical implications which contribute to the knowledge are infrastructural facilities, relevancy, and technology characteristics for Internet adoption (figure 3.2).

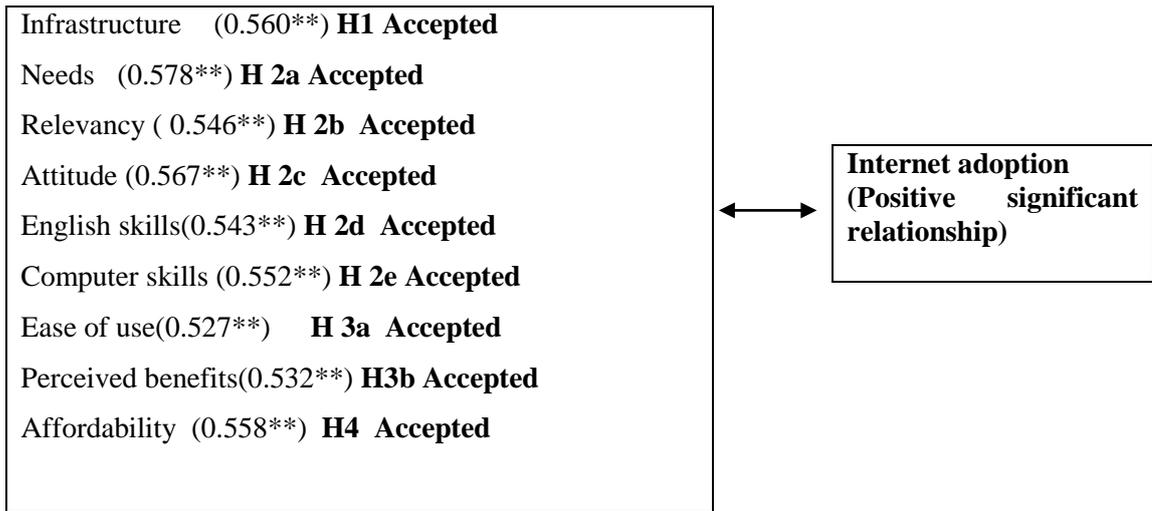


Figure 3.1. The acceptance of hypothesis

** . Correlation is significant at the 0.01 (2-tailed)

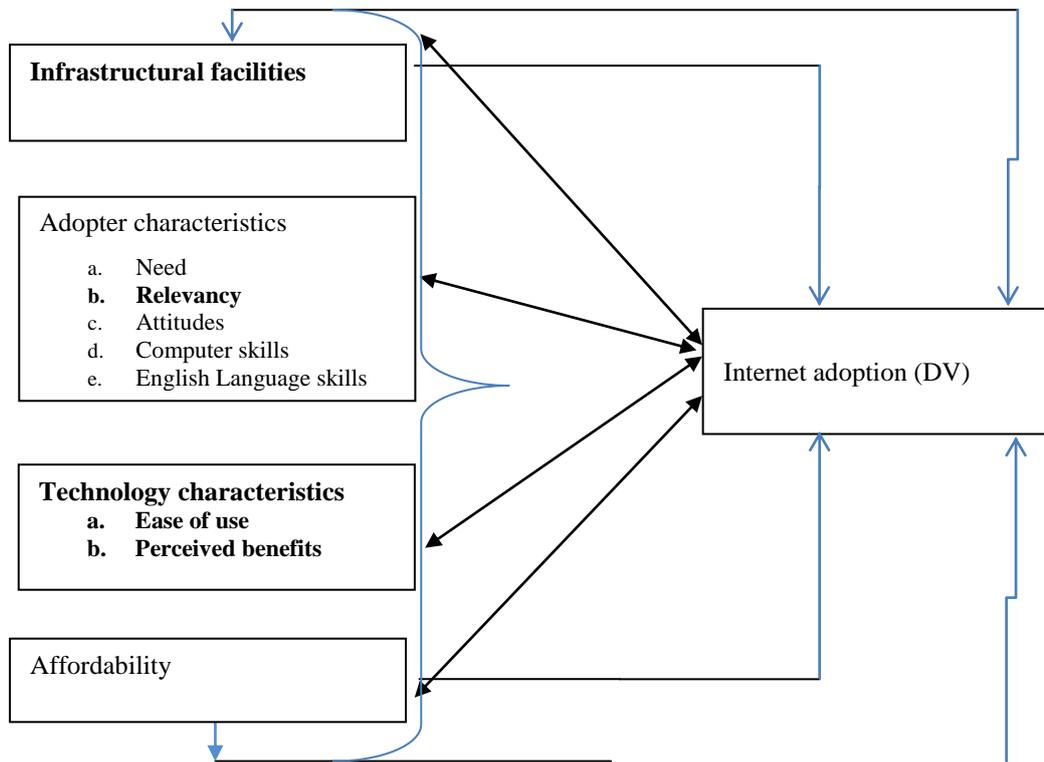


Figure 3.2. The proposed model for the study

CONCLUSION/ RECOMMENDATIONS

The findings and suggestions of this study will be valuable to all relevant authorities, especially those responsible for ICT and Internet initiatives, in an effort to increase Internet adoption among rural communities and to bridge the digital divide in Sri Lanka. This is where improving infrastructural facilities, affordability, adopter characteristics (needs, relevance, attitudes, computer skills and English language skills), technology characteristics (ease of use, perceived benefits) become crucial. Therefore, there should be a practical policy framework to support the aforementioned issues of Internet adoption. As mentioned earlier, without greater

Internet adoption, the benefits of the Internet cannot be accessed by rural communities. Therefore, issues related to Internet adoption should be overcome with significant solutions.

The government, or any other responsible organization should develop infrastructural facilities such as transport, telecommunication, electricity and so on in rural areas. The responsible authorities also should fund large-scale education to overcome ICT, computer and English illiteracy. These are three elements: teaching English, building Sinhala and Tamil keyboards or introducing IT Packages that can translate between Sinhala, Tamil and English, and providing computer training for the masses, for example conducting community classes on software and applications (e.g. MS Office, hardware course, and graphic design). There should also be a proper mechanism to provide these facilities at reasonable cost as well as introduction of Island wide projects to change the attitudes and behavior of rural communities in Sri Lanka. Kapadia (2005) claims that the government involvement is very important to overcome issues in Internet adoption. The government should build ICT infrastructure and capacity, fund large-scale ICT education, create rural employment, enable self-employment and political empowerment.

All the variables highlighted in this study are significant to have a relationship with, contribute greatly to and have practical importance to Internet adoption. Therefore, this study has suggested that attention should be given to the highlighted variables in order to increase the Internet adoption.

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**“IF MY FATHER WERE A MAN, HE WOULD NOT SPEAK THUS...”¹:
ANALYSIS OF THE ‘MALENESS’ OF KING DUTUGEMUNU AS DEPICTED
IN THE MAHAVAMSA**

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INTRODUCTION:

“This king is himself a warrior and in truth many warriors (follow him). What think the ministers, what should we do?” (King Elara discussing the war with his ministers; Mahavamsa, Chapter XXV)

*“His bravery in war and his piety in peace captured the imagination of a young and virile people, ...” (S. Paranavithana, in a Forward to the book *Dutugemunu* by John M. Senaveratna)*

The hero of the Mahavamsa, King Dutugemunu tends to arouse a superfluity of responses among the 21st century people of Sri Lanka. While politicians would claim to be his reincarnation, and scholars would exercise caution and skepticism about the “romantic shape” (Paranavithana, 1946) the stories about the King had taken among people, it would not be inaccurate to say that King Dutugemunu is a sacred entity for many people of Sri Lanka, representing the Sinhala ethnic community. Paranavithana (1946) aptly summarizes this position when he argues that Dutugemunu’s successors like Vijayabahu I (who ruled Sri Lanka a thousand years after Dutugemunu) had even more difficult challenges in battling the mighty Chola Empire to secure Sri Lanka’s sovereignty. Mahasena was arguably a great builder and Parakramabahu possibly earned greater military glory. Whereas their names have been kept in public circulation only through the labors of scholars and historians, Dutugemunu’s name is protected and preserved by the general public of Sri Lanka and none of the above kings have been able to oust him from the position of the national hero of Sri Lanka. His deeds have become the focus of powerful orally transmitted medium of folklore, thus permeating and reproducing them among a large group of people and, as folklorists would argue, have survived the vicissitudes of time.

The present study re-reads Dutugemunu, as depicted in the Mahavamsa from a gendered perspective – particularly from a view point of masculinity. In doing so, this research hopes to fill a research gap that exists in scholarship about Dutugemunu, who has been studied from various other perspectives – other than from a gendered viewpoint. Dutugemunu and his deeds and his identity, one could argue, is closely connected to the creation of nationalism in Sri Lanka and some of these pre-modern ideological foundations could be present in the creation of the modern Sri Lankan state. In that sense, it is of interest to the academia to understand the ‘male’ called Dutugemunu from a gendered perspective, in addition to other focuses.

¹ A message sent by Prince Gamini to his father, and the King, Kakavanna Tissa, along with women’s ornament, after the king refused to give Prince Gamini to make war upon the South Indian invaders (Mahavamsa, Chapter XXIV, pg: 164)

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LITERATURE SURVEY

King Dutugemunu has been the focus of scholarly studies from various perspectives other than from a gendered angle. Senaveratna (1946) and Suraweera (2002) explored the life of King Dutugemunu and his socio-political context. While Senaveratne used his study to articulate and demonstrate the struggles of the Sinhalese against foreign invasions, Suraweera's focus has the objective of creating pride among the younger generation. Medhananda (2006) carried out an exhaustive study of the King with the sole intention of responding to scholars who criticized *King Dutugemunu* as a "killer of the Tamil people" (Medhananda, 2006). Medhananda for most part leaves the folklore out of his study and focuses on mostly inscriptions and historical sources for his study. Rahula (1993) analyzed King Dutugemunu as a great nurturer and a promoter of Buddhism, who initiated the Vesak celebrations in the country. Obeyesekere (1988) reflected on the presence/absence of Dutugemunu's conscience from some historical accounts and also in incidents of significance in the King's life. Siriweera (2012) in his historical analysis of Sri Lanka examines Dutugemunu with the intention of understanding Sri Lanka's past and the present. However, none of these scholars have touched on the gender aspect of the king, despite the fact that Mahavamsa as a text contains questionable gender representations.

Medawattegedara (2013) in an unpublished research titled "*There are no men here*": *Politics of Being a 'Male' in the Mahavamsa*, argues that masculinity of Mahavamsa is a class-bound act, with the entire focus of the chronicle granted to the males of royal aristocracy – and not common people. Thus the 'maleness' that could be located and interrogated in the Mahavamsa is a conditioned –bound identity. This masculinity in the Great Chronicle is arguably morphed into three attributes, namely, strength, intelligence and virtue; the virtue endorsed in Mahavamsa – particularly with regard to war and its moral consequences – the researcher argues, is more aligned to those principles of war as portrayed in the Mahabharatha. The females in the Mahavamsa, are largely passive and are largely omitted, thus aiding and abetting the male order through their absence and inactivity.

Munasinghe (2004) in a study of the females of the Mahavamsa interprets the role played by females in the textual space as "unpretentious" (Munasinghe, 2004). The female of the Mahavamsa, Munasinghe argues, uses her influence in the domain of home to participate in the decision making process. She commanded respect of the society for her leading role played in religious rituals. Munasinghe's study suggests that the female gender, though seemingly marginalized in the narratives of the chronicles, is not so when closely scrutinized.

Chinese masculine researcher, Louie (2002) carried out an extensive study of the Chinese male in both the classical and contemporary Chinese literature, and a summary of his findings would be of interest to the present study. In his exploration of the classical Chinese literature, Louie discovered two traditional cultural dyads that were used to represent the males, namely *wen* (cultural attainments) and *wu* (martial valor). These dyads, Louie argued, were not consistent in China's past – rather they changed from time to time. At certain periods of time, (as evident from classical literature) *wu* became associated with an elite form of masculinity, while *wen* was a non-elite form.

The literature survey would demonstrate a gap in studying Dutugemunu from a gendered perspective. The present research wishes to initiate a scholarly debate and attempt to fill the gap.

METHODOLOGY

This research will entail re-reading of the chapters pertaining to Dutugemunu in the Mahavamsa (there are 11 chapters dedicated to Dutugemunu in the Mahavamsa, which is the largest textual space granted for a single king in the Great Chronicle) by focusing on the frames where gender engagements take place. Rather than reading the male gender as normative, this study will problematise the male gender and attempt to explore how the male gender is created with respect to the female gender. This study acknowledges the gender research assumption that singularity requires a pair for a sense of identity, to not only affirm what one is, but also what one is not. Feminist research in literature has shown that within narrative spaces a male gender is created in response to the female gender. Thus this research will re-read the male spaces in the Mahavamsa with respect to the female spaces. This research will also explore the Mahavamsa for polarities of class (there are elite hierarchies in Chinese literature: elite and non-elite) since Mahavamsa is primarily a text about kings and queens who largely belong to one ethnic community. The research will also scrutinize the inter-male power hierarchies.

RESULTS AND DISCUSSION

The ‘maleness’ of Dutugemunu as depicted in the Mahavamsa is an identity that constructed against his father’s ‘maleness.’ The patient, yet politically mature and strategic thinking ‘maleness’ of Kaanna Tissa is contrasted with brash, impatient and military-minded male representation of Dutugemunu. One male needed the other to fulfill the great national mission of saving the nation (and Buddhism) from foreign invaders. While the de-valorized ‘male’ (father) brought time for the son through his political acumen, the valorized ‘male’ (son) took on the enemy in a 15-year war and inflicted a heavy defeat upon them. The son receives his inspiration for his ‘maleness’ from a female (mother) than from the father. He sits at the war councils and aids the son in decision making. Later on in the narrative, a female (daughter-in-law) destroys his hard-won kingdom by depriving his son of the throne. Like the royal aristocrats featured in the bulk of folktales of ancient Sri Lanka, Dutugemunu possesses attributes which separates him from the other males around him. Dutugemunu’s maleness is carefully framed in a combination of ideas ranging from mythological hero (who builds order out of chaos) to war hero (who uses his brains and brawn equally well,) to a Buddhist idol (who transformed himself from a war mongering king to a pious king who was responsible for the greatest Buddhist monuments in the country).

CONCLUSIONS AND RECOMMENDATIONS

Dutugemunu’s ‘maleness’ in the Mahavamsa is a ‘maleness’ that was created for the circumstances; a ‘maleness’ that was need to counter a national threat from foreign invasions whose efficacy could be seen in the fact that they controlled a major portion of the country and had Dutugemunu’s father on a defensive and a diplomatic position. The reclaiming of the invaded land – and therefore, the nation – and the invaded and humiliated racial identity (Sinhala) also coincided with the reclaiming of the losses the religion, Buddhism, suffered under the Chola invaders. Dutugemunu’s ‘maleness’ helped blend the three, the nation, the race and the religion, thus creating a powerful combination of ideologies and forces whose influence, arguably, could be grasped in the modern nation state of Sri Lanka.

LIMITATIONS

This research depended on the English translation of Mahavamsa by Wilhelm Geiger. This researcher understands that translation is not a straight forward simple act – but a

political one. Translation, according to modern scholarship, is not a simple communicative act, but a domestication of a foreign text. This research acknowledges that there could have been problematic issues in the act of 'translation' by Geiger despite his best intentions.

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HIRED LABOUR IN THE TEA SMALLHOLDING SECTOR IN KOTAPOLA IN THE DISTRICT OF MATARA IN SRI LANKA

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INTRODUCTION

The prominence of tea smallholding (TSH) is a recent phenomenon in the economy of Sri Lanka. TSH overwhelmingly contributes to 70 percent of the total tea production in the country and pushes back the century's old Large Scale tea plantation sector that was introduced during the British rule in the country. The contribution of the TSHs is one of the major economic activities in the southern low country districts of Matara, Galle and Ratnapura. The Tea sector is a labour intensive sector and it requires 2.5 labour per hectare (Tea Master Plan Position Paper No.4:1979-81) and undeniably the labour requirement of TSH is also the same as in the large scale tea sector of the country. Indeed, regular labour supply is required mainly for field operations like 'plucking of tea leaves', and other 'sundry works'. The recent estimation of the Asian Development Bank on Tea Development of the Ministry of Plantation Industry has mentioned that there are 50,000 families living in the smallholdings sector that labour for TSHs. The report is also highlighting that these workers are very poor and there is a need for basic provisions such as housing, sanitation and health facilities with immediate effect. However, further information in relation to such workforce living in the TSHs is lacking. Thus, the main objectives of this study are to look at the formation of hired labour in the TSHs and examine the challenges that are encountered by the TSHs who are depending on labour for their task and draw an attention to policy makers on the issues of labour in the TSHs in the country.

As per the Tea Control Act, the tea lands under the 4 hectares in size are considered as "Tea Smallholding". The limitation was, however, expanded by the Tea Smallholding Development Authority (TSHDA). According to TSHDA, privately owned tea lands under the provisions of the land reform Act are also treated as tea smallholdings in Sri Lanka (Annual Report:2009). Early policy makers and researchers assumed that tea could be grown economically and efficiently only in large scale plantations, whereas later studies tend to suggest that no obvious economic scale exists to give superiority to large estates over smaller ones. According, to Ben Crow and Mary Thorpe (1988) the small estates can be more efficient if given proper institutional support. The successful conduct of the Kenya Tea Development Authority (KTDA) is recognized internationally as one doing the most successful small holder operation in tea producing countries. The establishment of Tea Smallholding Development Authority (TSHDA) has been introduced as role model of the KTDA in Sri Lanka in 1977 (Patrick Mendis: 1991). The TSHDA has been boosted after the implementation of land reforms during 1972-75 in the country. A considerable number of privately owned tea estates were brought under the purview of TSHDA and the tea land has nearly doubled in size for TSH from around 39,000 hectares in 1970s to 78,000 hectares in 1980s. According to the census of TSH conducted in 1994/95 it has further extended from 82,919 to 40 percent increase to 116,449 hectares. At present the total extent of TSH is around 130,000 hectares and it is roughly 59 percent of the total tea land and it is distributed amongst 400,000 tea smallholders in the country (Statistical Pocket Book: 2011).

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METHODOLOGY

The study is based on primary and secondary data. The primary data has been obtained from two sources. They are (1) the owner of the TSHs and (2) the workers employed by the TSHs in their premises in the Kotapola Divisional Secretariat in the District of Matara. The land extended to TSH in the district of Matara is 25,417 hectares and it is distributed amongst 67,613 TSHs. A list of TSHs who are employing permanent labour for their task were obtained from the Regional Office of TSHDA in Matara by randomly selecting twenty owners of the TSHs. Systematic random sampling techniques were used to select five TSHs amongst the twenty TSHs selected in order to have close interaction with them to collect information in relation to managing the labour force of TSHs. The other fifteen TSHs were communicated in order to get their permission to conduct the household survey amongst workers living within their premises. Ironically only six owners of the TSHs permitted the study group to meet their workers to conduct the household survey. The households living within the premises of TSH were selected randomly and a structured questionnaire has been used to collect the household data. A total of 43 families were interviewed amongst the six TSHs. Apart from the primary data the study also used published data from the publications of the Central Bank of Sri Lanka, the Annual Reports of TSHDA in Sri Lanka and other relevant publications.

RESULTS AND DISCUSSIONS

The TSH are largely owned by local enterprises and the greatest concentration of them is found in the southern low country districts of the country. The large extent of the tea land is the major factor influencing the recruitment of labour force amongst the TSHs. The Total extent of TSHs in the sample area in the district of Matara is 25,417 hectares and it is owned by 67,613 tea smallholders in the district. Tea land has been vastly extended in the district during last three decades. It is important to note that the tea land belonging to TSH was only 5,415 hectares in 1980s and it has extended by nearly five times to 25,417 hectares in 2014.

The distribution of tea land varies in size. Accordingly, 292 of the tea smallholders possess the extent of more than 4 hectares in size and most of the land owners are employing permanent labour for their production. Those who are having the extent of less than 4 hectares in size are not employing permanent labour, therefore they are depending on the supply of labour from the permanent residence. Furthermore, the TSHs having an extent of less than ½ hectare of tea land are utilizing their own family members mainly for plucking of green leaves. However, they are also depending on supply of labour to carry out certain sundry work like pruning, weeding etc. The relationship between the ownership and the supply of labour could be look at the Table 1.

Table 1. Relationship of Ownership and Labour Supply in the TSHs.

Category	Extend of TSH	Number of Tea Smallholders	Type of Labour
1	4 hectares and more	292	Provided residential facilities for the workers within the premises of the TSH and depending on regular supply of labour*
2	½ to 4 hectares	8,851	No permanent resident workers but depending on regular supply of labour
3	Less than ½ hectares	58,470	No permanent resident workers and depending on supply of labour occasionally for sundry works

*The extent of tea land is the determinant factor in accommodating the number of resident families in the TSH.

The study is focused on the 1st category of the workers in the TSH sector. Though the details of the extent of tea land and the number of holdings are available for the study, hardly any records on accountability of labour in the TSH sector are available. The permanent resident workers are the third or fourth generation of migrated South Indian Tamils and were recruited for work in the (then) privately owned tea plantations during the British period of the country. Most of them belong to the Hindu religion and fluent in the Sinhala language. The size of the (then) privately owned tea lands was from 25 to 100 hectares in size and largely owned by the local entrepreneurs. The nationalization of the lands by successive governments after the independence of the country has led to fragmentation. Further, fragmentation of the tea land has been carried out under the Land Reforms Act in 1972-75 in the country. The process of fragmentation also led to redistribution of the resident workers amongst the TSHs into the present setup. It should be noted that some of the workers were repatriated under India- Sri Lanka pact implemented in 1965 and a considerable number of them also migrated and settled in the North and East of the country. As we mentioned above the fragmented tea lands were brought under the purview of TSHDA in 1977.

The household survey was conducted amongst the 1st category workers as mentioned in the Table 1. Accordingly, 43 families were interviewed. The total labour force in the sample was 79 and it is 41 percent of the total population of the sample. Out of them 39 are males and 40 are females. Among the labour force 61 (roughly 77 percent) of them are directly involved in tea estate work and only 7 of them are engaged in other work which are not related to the estate. The females do the plucking of tea leaves, while the males are involved in sundry works. The unemployed in the sample was 6 and it is roughly 8 percent of the total labour force. Among the workers, 5 female workers are not engaged in the estate jobs and of them 3 are working in the Middle East and the other 2 are volunteering as teachers after completing secondary education in the government school at Deniyaya. It is also found out that the school education for the children of the estate workers in the sample area is very limited. Amongst the sample 25 percent of them are illiterates and 58 percent of them went up to primary level of education and the rest (17 percent) up to secondary education. It should be noted that, there are around 30 families living about 15 kilometers away from the Deniyaya town and are not in a position to afford school education thus leaving them illiterates.

The sample households have limited access for generating income for their survival. The workers residing like the 1st category are compelled to work for two to three days in their tea land and receive only the minimum wage of Rs.450/= per day. The workers do not receive the recommended allowances and wage as agreed upon in the Collective Agreement (CA) even if they work for more than 75 percent of the work offered by the owner of the estate. The resident workers are also allowed to work in the other estates as mentioned in the Table 1 and this enables them to generate additional incomes. Accordingly, the worker who is engaged in 22 days of work is able to receive Rs.9,900/= per month. Hence, average family income of the hired workers in the TSH is roughly Rs.9000/= in 2014. The owner of the TSHs are providing rent free housing and some of them also receive free electricity which is only for lighting the rooms. The housing condition of the workers is very poor. Large number of houses in the sample was constructed by using poor quality wood and the roofs were made of polythene. The sample household workers are the third or fourth generation of estate workers who do not receive any means to construct their own house and do not have the freedom of leaving estate jobs. The workers have bondage with the owner and thereby it is difficult for them to get rid of this engagement. The owners of the TSHs strongly believe that they will not expect any shortage of labour in the future as the avenue for school education and opportunity for alternative employment for the children of the workers in the vicinity of the TSHs are very limited. In contrast, many of the young people in the sample household are not willing to go for their parental jobs in the estates and prefer other alternate jobs to estate work.

CONCLUSIONS AND RECOMENDATIONS

The contribution of the TSHs is one of the major economic activities in the southern low country districts of Matara, Galle and Ratnapura. At present the total extent of TSH is around 130,000 hectares and it is roughly 59 percent of total tea land and it is distributed amongst 400,000 tea smallholders in the country. The TSHDA has seen a boost in the aftermath of the implementation of land reforms during 1972-75 in the country. The TSH also requires regular supply of labour and it is provided by the resident workers living in land more than 4 hectares in size. Those who are having extent of less than 4 hectares of land in size are not keeping permanent labour and are rather depending on the supply of labour that comes from the permanent residence. The sample survey was conducted in Kotapola DS of Deniyaya in the district of Matara. The labour force in the sample household was 79 and it is 41 percent of the total population of the sample. The average family income of the workers in the TSHs is very relatively less and opportunity for generating additional income is very limited for the workers in the TSH sector. The workers have bondage with the owner and do not have any alternative other than supplying labour continuously to the TSHs in this area. The owners of the TSHs also strongly believe that they will not expect shortage of labour in the future because the avenue for school education and opportunity for alternative employment for the children of the workers in the vicinity of the TSHs are very limited. In contrast, many of the young people in the sample household are not willing to go for their parental jobs in the estates and prefer other jobs to estate work.

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FACTORS AFFECTING VEGETABLE FARMERS' PREFERENCE TOWARDS ORGANIC FARMING

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INTRODUCTION

In most developing countries, agriculture plays a major role by being one of the most important sectors. Many farmers today believe that cultivating without agrochemicals is not possible. However, excessive dependence on synthetic fertilizer, pesticides and 'weedicides' can be extremely harmful and have resulted in health problems among living beings; they also can cause soil erosion, environmental pollution and loss of biodiversity. On the other hand, sustainable farming systems try to increase production while becoming a solution for most problems such as health hazards, increased input costs and environmental pollution

The suspected rise of threats of new diseases owing to consumption of agricultural products dependent on chemical fertilizer and pesticides etc., People are in the look out of alternative solutions. Buyers now seek safe food with minimum chemical applications or products certified as 'organic' food. To meet the new demand, some growers have shifted to organic agriculture; there is an advantage that such products fetch very high prices. As in other developing countries Sri Lanka too has identified the potential of organic products, and many growers are now shifting to organic farming.

Although organic agriculture is practiced in Sri Lanka to certain extent, it is important to look at the factors affecting on organic farming. It is necessary to identify why farmers get motivated to engage in organic farming, what factors influence their decision to engage in organic farming and, potentials of and constraints to organic farming and also policies of the government that contribute to organic farming

METHODOLOGY

Sampling frame was the entire community of vegetable farmers in the Tangalle D.S Division. Of which 117 vegetable farmers were selected as the research sample by using simple random sampling technique. Primary data were collected through pre tested interviewer administered questionnaire. Data were analyzed by using SPSS 16.0 and MS Excel 2010, Descriptive statistics, chi square test and binary logistic regression were used as data analyzing tools.

RESULTS AND DISCUSSION

Majority of the sample are male (78%) and most of them are in the age range between 41 years to 50 years. Most of the farmers are educated up to primary level. A logistic regression was performed to ascertain the effects of age, education, income, experience, gender, land area on the likelihood that participants' preference to engage in organic agriculture. According to table 1 male were 4.90 times more likely to engage with organic agriculture than females. While Income significantly affects likelihood of preference to engage with organic agriculture, increasing education level and cultivated land area were associated with a reduction in the likelihood of preference to engage with organic agriculture

When the education is getting higher farmers' willingness to engage in organic farming is reduced. This might be due to the fact that, educated farmers might be worried about the risk involved in organic farming including the demand for product, market, and price factors.

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They may not be much concerned about traditional approaches, instead, they may give priority to new ways of farming such as using synthetic chemical fertilizers, pesticides and herbicides and genetically modified organisms, modern agricultural machines etc. which come with modern technology that can give more yield within a short period of time. Further, in organic farming more labor has to be used for the management of the crops.

Income significantly affects likelihood of preference to engage with organic agriculture. When the income increases farmers may more likely to engage in organic agriculture. Compared to the lower income farmers, higher income farmers are ready to stand with organic agriculture because they are more stable in their economy than lower income farmers. So this creates a tendency for them to take more risks as their income is high. In relation to gender, males are more likely to engage in organic agriculture. Given the laborious work needed in management of organic farming females would not want to engage in organic farming. Male farmers are at an advantage with their social capital, and less of household chores to take care of organic farming enterprises. In the case of females they have to make a trade off with leisure time and work time. The care that the family members need has to be primarily looked after by the females.

When cultivated land area increases, farmers are less likely to engage in organic farming. Organic farming in large cultivation areas is difficult. It requires more manpower and time of his/her family. Management of crops in an extensive land is difficult. Thus, farmers with large cultivated land areas will not prefer to engage in organic farming. This will increase the cost of production as well as the risk.

When considering the risks involved the majority of the farmers (72 out of 117) believe that there is a high risk of engaging in organic farming and most of the farmers who believe high risk is in the age range of 36 to 50 years and most of the farmers who think that there is no risk in engaging with organic farming are belong to more than 50 years. When considering the awareness about existing market, 47% of farmers (55 out of 117) aware of the existing

Table 1. Logistic regression output for Farmers preference to engage in Organic farming

Variable	B	S.E	significance	Exp.(B)
Constant	2.501	1.957	0.201	12.194
Age	0.001	0.049	0.980	1.001
Education	-0.804***	0.310	0.009	0.447
Income	0.000***	0.000	0.010	1.000
Experience	-0.075	0.047	0.107	0.928
Gender(1)	1.589***	0.591	0.007	4.900
Area	-0.005***	0.002	0.007	0.995

market for organic vegetables while 24% of farmers (28 out of 117) are not aware and 29% of farmers (34 out of 117) have no idea about existing market for organic agricultural products. Farmers give more priority to health benefits and least priority to sustainable yield as potential factors. With respect to constraints, they prioritize the short supply of inputs but give the least priority to lack of knowledge. Most of the farmers (65.81%) have participated in the extension programs related to organic farming and quite a number of them (50 out of 117) participated in the extension programs more than once.

Table 2 shows the association between extension programs and preference to engage in organic agriculture. Chi square test was used to analyse the association between these 2 factors. Accordingly, there is an association between extension services and preference to engage with organic agriculture.

Table 2. Association between preference for organic agriculture and extension programs

Factor	value	df	p value
prefer to engage with organic agriculture versus participation in extension programs	12.242	1	0.0000

Table 3 shows the association between extension services and awareness in existing market. The chi square test was used to test the association between the dependent and independent variables separately. Accordingly there is an association between extension services and preference to engage in organic agriculture.

Table 3. Association between awareness in existing market and extension services

Factor	value	df	p value
Awareness in existing market versus extension services	6.529	2	0.038

There is an association between extension services and awareness of the existing market. When the farmer participation in extension services is high, their awareness of the market potential becomes greater.

CONCLUSIONS

The study concludes that among several socio economic factors farmers' preference to engage with organic agriculture depends on their income, educational level, gender and cultivated land area. Amongst that increasing the educational level and cultivated land area affect negatively to increased likelihood of preference to engage with organic agriculture. According to farmers' view health benefits is the most potential factor in organic agriculture while short supply of inputs stands for the most constraint factor and most of the farmers believe high risk is involving in organic farming. According to the study there is an association between extension services and farmers' awareness in existing market and also there is an association between extension services and preference to engage with organic agriculture.

RECOMMENDATIONS

It is recommended that increasing the awareness further the farmers would actively engage in organic agriculture. It may also be useful to create awareness among the consuming public regarding the benefits of consuming organic vegetables. Provision of physical and market infra-structure would help promoting the culture of organic farming among small farmers in the area.

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A STUDY ON CONSUMPTION PATTERN & AWARENESS OF UNDERUTILIZED FRUITS AMONG URBANITES WITHIN MAHARAGAMA DS DIVISION

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INTRODUCTION

Sri Lanka has around 60 underutilized crops with rich potential. Most of these underutilized species have lost their significance among the present generation due to many reasons such as urbanization and changing food habits. There is no organized or proper cultivation of these crop species. Most of these underutilized plant species are fruit crops and they are found in wild habitats or in home gardens, which are 100 m² to 1,000 m² in extent and are commonly found in many rural areas of Sri Lanka. (FAO 2015) Vitamins and minerals can be returned to contemporary diets through the use of micronutrient-rich underutilized and neglected species by transplanting them from their wild habitats into home gardens. (FAO 2014)

Neglected and underutilized species are those to which little attention is paid or which are entirely ignored by agricultural researchers, plant breeders and policymakers. Typically, underutilized species are not traded as commodities (Malkanathi *et al.*, 2014). Many of these varieties and species, along with a wealth of traditional knowledge about their cultivation and use, are being lost at an alarming rate, although they have been used for centuries for their food, fibre, fodder, oil or medicinal properties. Underutilized fruit (UUF) crops have many values such as, rich in nutrients, high potential to survive, easy management, environmental friendliness, *etc.* Despite low yield and relatively longer duration, the underutilized indigenous cultivars are palatable and are resistant to pests and diseases, as well as being tolerant to drought and natural hazards (FAO 2014). But these are disappearing from the consumption of most of the people, primarily in urban areas. So, the purpose of this research is to find out the reasons for under consumption of those fruits. Neglected and underutilized food resources constitute the bedrock of the diversity in traditional and indigenous food systems of developing country communities. Traditional and indigenous foods are less deleterious to the environment and address cultural needs and preserve the cultural heritage of local communities. (FAO 2014)

METHODOLOGY

The research approach was deductive and survey strategy was used as the research strategy. Primary data was obtained through pre tested interviewer administered structured questionnaire and the response rate was 95%. The Maharagama Divisional Secretariat (DS) Division was selected randomly among other DS divisions in Colombo district and 100 households were selected by using multi stage sampling technique for the study. Sixteen (16) underutilized fruits in Sri Lanka were used to investigate the consumption patterns of urban people as stated in the Table 1. Data were analysed by using Microsoft Excel 2010 and SPSS Statistical Analysis 16.0 Software programs. Frequency Distribution and Chi-square Tests were used as the statistical techniques which was applied for the quantitative analysis of data.

RESULTS AND DISCUSSION

Socio- economic characteristics of the consumers

The major characteristics of the consumers who belong to the sample; age, gender, household size, educational level, occupation, monthly income, nationality and religion were observed in order to find the relationship between the underutilized fruits and the consumption patterns. The majority, 31% of the consumers relatively, falls within the category between 40-50 years

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of age and 21% falls within the category of age more than 60 years. This shows that the majority (more than 50%) of the sample are the people over 40 years of age, hence the elder generation is highly focused. Of the consumer families, 31% consisted of 3 member families, 30% consisted of 5 member families and 23% consisted of 4 member families. The majority of the responded (more than 50%) families consist of more than 4 member families. Of the consumers 64% were women who represent the majority of the sample.

Table 1. List of Underutilized fruits which was used to investigate the consumption patterns

No	Common name	Scientific name
1	Louvi(<i>lovi</i>)	<i>Flacourtia inermis</i>
2	Bitter orange (<i>Ambuldodam</i>)	<i>Citrus aurantium</i>
3	<i>Uguressa</i>	<i>Baccaurea motleyana</i>
4	Rose apple	<i>Syzygiumspp</i>
5	Ceylon atalantia (<i>naranspp</i>)	<i>Atalantia ceylanica</i>
6	Pomelo	<i>Citrus maxima</i>
7	Annona/Custard apple	<i>Annona muricata</i>
8	Sapodilla	<i>Manilkara zapota</i>
9	<i>Himbutu</i>	<i>Salacia reticulata(spp)</i>
10	<i>Madan</i>	<i>Carissa ovata spp.</i>
11	Golden apple/bael (<i>beli</i>)	<i>Aegle marmelos</i>
12	<i>Nelli</i>	<i>Phyllanthus emblica</i>
13	Ceylon olive (<i>weralu</i>)	<i>Laeocarpus serratus</i>
14	Wood apple	<i>Limonia acidissima</i>
15	Mangrove apple (<i>Kirala</i>)	<i>Sonneratia caseolaris</i>
16	Egg fruit (<i>Laulu</i>)	<i>Pouteria campechiana</i>

It was found that 44% of the consumer's educational level is up to advanced level and 17% of the respondents are graduates hence it reveals that most of the consumers in the Maharagama DS Division were well educated. Twenty nine percent of the respondents had studied upto Ordinary Level. Regarding monthly income, 26% of the customers in the sample fall into income category of SLR 20,000 - 30,000 income level, 21% falls into SLR 30,000-40,000 income level. Nearly 50% of the respondents are having incomes between SLR 20,000 and 40,000 depicting that most of the respondents are in medium level of the social strata based on income. Eighty one percent of the sample represents the nationality of Sinhala and 72% of the sample represents Buddhists.

In order to study the consumption pattern of underutilized fruits the normal fruit consumption behaviours was investigated to obtain a background for the study. Of the households 65% directly purchase fruits for their day-to-day consumption rather than growing them in their home gardens. There are many reasons which were obtained for not cultivating underutilized fruits in their homegardens as mentioned below. Ninety nine percent of consumers prefer to buy fruits in their fresh form depicting that most of the people like to consume fresh fruits as they possibly can and only 2% of the sample is engaged with commercial fruit selling. Most of the people consume banana, papaya and mango in their day-to-day consumption compared to the other fruits. As figure1 depicts, among their popular fruit types, banana has 96% of popularity, papaya has 76% and mango has 51% of popularity within households.

Consumption pattern of selected 16 underutilized fruits among households

Consumption pattern was examined obtaining 5 parameters such as daily consumption, frequently consumed, periodically consumed, seldom and never, based on a time scale.

Average Consumption frequency of underutilized fruits

Depicting that urban people rarely or never consume underutilized fruits, there is 44% of the households who never consume underutilized fruits, 28% rarely consume, 24% periodically, 3.6% frequently and 0.44% daily consume underutilized fruits as a whole.

Figure 1. Consumption frequency rate of the selected UUF among households.

No	Common name	Consumption frequency of fruits				
		Daily	Frequently	Periodically	Rarely/Seldom	Never
1	<i>Louvi/lovi</i>	-	-	19%	43%	38%
2	Bitter orange	-	4%	35%	35%	26%
3	<i>Uguressa</i>	-	1%	19%	43%	37%
4	Rose apple	-	-	35%	43%	22%
5	Ceylon atalantia (<i>naran</i> spp)	6%	16%	32%	25%	21%
6	Pomelo	-	5%	10%	47%	38%
7	Annona	-	3%	21%	35%	41%
8	Sapodilla	-	-	10%	22%	68%
9	<i>Himbutu</i>	-	-	-	-	100%
10	<i>Madan</i>	-	-	2%	5%	93%
11	Beli (Bael)	-	16%	49%	20%	15%
12	Nelli	1%	5%	35%	45%	15%
13	Ceylon olive (<i>weralu</i>)	-	3%	48%	40%	9%
14	Wood apple	-	6%	71%	19%	4%
15	Mangrove apple (<i>Kirala</i>)	-	-	2%	13%	35%
16	Egg fruit (<i>Laulu</i>)	-	-	3%	7%	90%

The association between socio-economic factors and consumption pattern of UUF

Among the above 15 fruits the relationship between consumption pattern and socio-economic factors were tested using chi square test. There was no relationship with the consumption pattern of fruits with socio-economic factors except, bitter orange and Ceylon atalantia (*naran*), those also with income level only. This shows that income level affects the preference of underutilized fruits.

Identifying the reasons for non-consumption of the given type of under-utilized fruits

From Likert scale of 10 categories it was proved that the most common reasons of non-consumption of underutilized fruits are fruit scarcity which has 92% response rate and less commercial cultivation where response rate is 79%. Other reasons are high cost, less nutrient level, less tastiness, low market demand, seasonality, less awareness *etc.*

Identifying the reasons for non-cultivation of UUF in Homegardens

There were five factors which were tested by Likert scale for non cultivation of underutilized fruit crops in their home gardens. They were; time limitation, land scarcity, high cost of production, scarcity of seeds or plants and less awareness where 82% of the respondents have problems with land scarcity hence they cannot cultivate any kind of fruit. Also very few were engaged in cultivating UUF in their homegardens although home gardens provide sites to cultivate and domesticate valuable crops for the future through transplanting of micronutrient-rich, neglected and underutilized species from their wild habitats. (FAO 2014) A simple and inexpensive solution for improving the nutritional health of affected populations, particularly in the rural areas of developing nations, is to promote the consumption of micronutrient-rich neglected and underutilized species (NUS) of indigenous wild edible plants (IWFPs) (FAO 2014). Many neglected and underutilized species are nutritionally rich and are adapted to low input agriculture. The use of these species – whether wild, managed or cultivated – can have immediate consequences on the food security and well-being of the poor (FAO 2014).

Banana, papaya and mango are consumed by over 50% of the households that have these fruits in their home gardens. Home gardens play a minor role as the source of wood apple, pineapple and oranges, while consumption and availability of 17 less common fruit species were reported by less than 10 percent of the households (Chamila,2010).

CONCLUSIONS/RECOMMENDATIONS

The fruits which are mostly popular among people in the Maharagama DS Division are banana, mango and papaya where banana has the highest popularity of 96%, papaya has the popularity of 76% and mango has 51% of popularity. Among the indicated underutilized fruits bitter orange and Ceylon atalantia (*naran*) are the only fruits which have a significant difference with socio-demographic factor income level. All other fruits except bitter orange and Ceylon atalantia (*naran*) have no relationship with any socio-economic factors. Even bitter orange and Ceylon atalantia (*naran*) has no relationship with socio-economic factors except monthly income level. The majority (43.88%) of households never consume underutilized fruits. From the other fruits, 28% rarely consume, 24% periodically, 3.6% frequently and 0.44% daily consumes underutilized fruits. Although there are factors such as high cost, less tastiness, less healthiness, *etc.* which affect non-consumption of underutilized fruits, the major factors were fruit scarcity and less cultivation. The factors which affect non cultivation in home gardens are land scarcity and less time availability.

Programs should be implemented to increase the consumption level of underutilized fruits among urban household. Programs which promote farming/cultivation of underutilized fruits commercially should be developed and farmers should be advised. Promoting the use of underutilized species needs to be achieved by highlighting their importance in their current production areas as well as exploiting further opportunities to extend their production and consumption (FAO 2014). Proper programs should be implemented to promote proper market facilities for underutilized fruits. Marketing strategies for underutilized foods and consumer awareness of the value of underutilized wild foods (FAO 2014). Education and behavioral change programs need to be promoted on underutilized fruit awareness and consumption where it should be based on local knowledge as the demographic, cultural and psychosocial factors affect consumer preferences. These programs should focus on translating accurate and useful information to consumer about the health benefits nutrient content, resistivity for adverse climates, *etc.* of underutilized fruits. Public awareness on the value of underutilized foods and information sharing; promoting food festivals, diversity fairs, food competitions, food tasting using indigenous foods; Multisectoral policy advocacy should be implemented (FAO 2014). Many neglected and underutilized species play a role in keeping cultural diversity alive. Different dishes were introduced to exemplify how to promote various underutilized wild plants in salads. Local farmers should keep growing native crop varieties, protect their food heritage and pass on traditional and local wisdom on how to eat and cook such produce (FAO, 2014).

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ANTIMICROBIAL AND ANTIOXIDANT PROPERTIES OF LEAF, TWIG AND CALLI EXTRACTS OF *Neolamarckia cadamba* (Roxb.) Bosser

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INTRODUCTION

Neolamarckia cadamba (Roxb.) Bosser (“Bakmee” S., “Wild cinchona” E.) is an important medicinal plant used in traditional medicine for the treatment of fever, uterine diseases, skin diseases, dysentery and diabetes (Dubey *et al.*, 2011). Large scale destructive collection of plant parts for herbal formulations and research purposes possibly pose a potential threat of extinction on this plant. The production of secondary metabolites is influenced by various environmental conditions (Okudera and Ito, 2009) and therefore, calli can be subjected to varying conditions for desired secondary metabolites.

Studies have been carried out on phytochemical analysis (Dubey *et al.*, 2011), antioxidant activity of leaf and bark (Alekhya *et al.*, 2013; Ganjewala *et al.*, 2013), antifungal activity of leaf and bark (Patel *et al.*, 2011), antibacterial activity of fruit (Mishra, 2011), antidiabetic property of leaf, hypoglycemic activity of leaf (Ahmed *et al.*, 2011) of *N. cadamba*. However, attempts to raise callus of *N. cadamba* explants for secondary metabolites is not extensively studied.

The objective of the present study is to explore the possibility of deducing whether the calli raised from *N. cadamba* can be used as a potential source for extraction of secondary metabolites instead of destructive sampling. The present study reports a comparison of antimicrobial and antioxidant potential of natural plant extracts of leaves and twigs of *N. cadamba*, and calli derived from leaf and internode explants of *N. cadamba*.

MATERIALS AND METHODS

Leaf and twig samples of *N. cadamba* were collected from Thalgahawila, Horana in the District of Kalutara, Sri Lanka between February to May 2014 and samples were identified by comparing herbarium specimens deposited at Herbarium, Peradeniya Botanical Gardens and related literature.

a) Calli Induction

Tender leaves emerging from axillary buds and internodes used for calli induction were washed and the surface sterilized using 0.05% HgCl₂ solution for 7 minutes 70% alcohol for 30 seconds and in warm sterile distilled water three times before placing on the culture medium (Indu *et al.*, 2013). A series of ten MS culture media of MS medium (20.0 ml) each with varying NAA and BAP hormone concentrations (NAA:BAP- 0.5:5.0/ 1.0:4.5/ 1.5:4.0/ 2.0:3.5/ 2.5:3.0/ 3.0:2.5/ 3.5:2.0/ 4.0:1.5/ 4.5:1.0 and 5.0:0.5) along with 3 mg/l of activated charcoal was used for calli generation. Ten explants were tested with each hormonal treatment.

b) Crude extraction

Air dried plant tissues (leaves and twigs) (10 g) and air dried calli tissue (three leaf-calli and three internode-calli) (4.5 g) were separately macerated and extracted into cold methanol and dried in a vacuum to a constant dry weight.

c) Bioassays

Antibacterial assay

Antibacterial activity against *Bacillus* sp., *Micrococcus* sp., *E. coli* and *Salmonella typhi* was deduce using standard well diffusion method using DMSO (Dimethyl sulfoxide) as the solvent. Extreme precautions were used when handling *Salmonella typhi* collected from the Durdans Hospital, Colombo. The bacterial suspension was prepared to 0.5 McFarland standards. Crude extracts (50 µg/µl) of leaf, twig, leaf-calli and internode-calli of *N. cadamba* were separately used for antibacterial assays. Gentamycin (2.6 µg/µl) was used as the positive control and 100% DMSO as the negative control (Dubey *et al.*, 2011).

Antifungal assay

Antifungal activity against *Aspergillus* sp., *Trichoderma* sp., *Penicillium* sp. and *Candida* sp., were determined using standard TLC plate method with a fungal spore suspension of 0.1 OD (measured

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at 550 nm). Crude extracts (50 µg/µl) of leaf, twig, leaf-calli and internode-calli of *N. cadamba* were separately used for antifungal assays. DMSO was used as the solvent. Amphotericin B of 5 µg/µl was used as the positive control and 100% DMSO as the negative control (Wadhawa *et al.*, 2013).

Antioxidant assay

Antioxidant assay of leaves and twigs of *N. cadamba* and calli extracts were tested by measuring the total phenolic content using FolinCiocaltau Phenol Reagent and DPPH radical scavenging method.

i) Total Phenol Content (TPC)

Crude extracts (1.0 g) of leaf, twig, leaf-calli and internode-calli were separately added to distilled water (0.9 ml) followed by adding FolinCiocaltau Reagent (0.5 ml), and 20% sodium carbonate (1.5 ml). The final volume of the mixture was made up to 10 ml with distilled water. Absorbance of mixture was measured at 750 nm. Phenolic content of extracts was calculated as gallic acid equivalents (GAE) in mg/g on the basis of standard curve of gallic acid (Chandel *et al.*, 2012).

ii) DPPH Radical scavenging activity

This method is for evaluating the ability of antioxidants to scavenge free radicals. Different concentrations of extracts (20, 40, 60 and 80 µg/ml) of leaf, twig, leaf-calli and internode-calli were dissolved in methanol and taken in test tubes in triplicates. Then 2.0 ml of 0.1 mM methanol solution of DPPH was added to each test tube and shaken vigorously. After keeping in dark for 30 minutes, absorption was measured at 517 nm. Results were compared with standard compound rutin (IC₅₀ = 54.05 µg/ml). Radical scavenging activity (RSA) % was calculated as follows (Chandel *et al.*, 2012).

RSA (%) = $\frac{Ab_{control} - Ab_{sample}}{Ab_{control}} \times 100$ (Chandel *et al.*, 2012).

Ab_{control} - Absorbance of DPPH in methanol, Ab_{sample} - Absorbance of a DPPH solution with the test sample. Statistical analyses of data were performed on the statistical software package SPSS PC Version 20.

RESULTS AND DISCUSSION

Table 1. Antibacterial activity of extracts of *N. cadamba* at 50 µg/µl

	Positive control	Negative control	Twig/internode extract			
	Gentamycin	DMSO	Callus	Natural	Callus	
<i>Micrococcus</i> sp.	30.03 (0.05)b	0.00	6.13 (0.15)a	4.93 (0.06)b	6.00 (0.10)a	4.83 (0.06)b
<i>E-coli</i>	26.05 (0.05)b	0.00	6.50 (0.10)a	5.10 (0.10)c	7.13 (0.12)b	5.33 (0.06)c
<i>Bacillus</i> sp.	28.02 (0.04)b	0.00	0.00	0.00	0.00	0.00
<i>Salmonella typhi</i>	28.00 (0.06)b	0.00	5.53 (0.06)a	4.73 (0.06)b	5.67 (0.12)a	4.73 (0.06)b

* Mean with standard deviation in parenthesis of triplicate analysis

Different letters across the rows indicate that no significant difference at $p \leq 0.05$.



(a)

(b)

Figure 1. Anti-bacterial assays for crude extracts of natural plant (leaf and twig) of *N. cadamba* against (a) *Micrococcus* sp. And (b) *Salmonella typhi* (well diameter = 4.5 mm) (1-positive control, 2-negative control, 3-leaf extract, 4-twig extract)

The following hormone combinations used in MS medium were able to induce and develop calli from leaf and internode explants of *N. cadamba*.

Leaf - NAA 5.0mg/l : BAP 0.5mg/l and NAA 2.5mg/l : BAP 3.0mg/l (60% calli development)

Internode - NAA 5.0mg/l : BAP 0.5mg/l and NAA 2.5mg/l : BAP 3.0mg/l (70% calli development)

The calli extracts of leaves and internodes showed positive antibacterial activity (Figure 1) but comparatively lesser degree than that of the extracts of natural plant parts (Table 1). According to Wadhawa *et al.* (2013), the highest activity was against *E. coli*, *Bacillus* and *Staphylococcus* sp. for

methanolic extracts when a maximum of 75 µl/ml of *N. cadamba* leaf sample was used but in the present study antibacterial activity was not shown against *Bacillus* spp. at 50 µg/µl. If a higher concentration of the sample was used positive results could have been observed for *Bacillus* sp.

Methanolic extracts of leaves and twigs showed antifungal activity. Antifungal activity of natural twig extract (Figure 2 and Table 2) against *Trichoderma* spp. was considerably higher [11.17 mm] and lowest against *Candida* spp. [5.3 mm]. This supports the use of paste of crushed plant parts as a cure for skin diseases by ancient tribal communities. No antifungal activity of methanolic crude calli extracts of leaves and internodes was observed. Leaf extracts showed the highest activity against *Aspergillus fumigatus* (Wadhawa *et al.*, 2013) compared to *Candida albicans*. In the present study also, the highest antifungal activity was against *Aspergillus* sp. Patel *et al.* (2011) observed that the leaf extract possesses considerably higher activity than that of the bark extract, whereas in the present study the twig extract has shown better antifungal activity than that of the leaf extract.

Table 2. Antifungal activity of extracts at 50 µg/µl of extracts of *N. cadamba*

Microorganism	Zone of inhibition (mm)*				
	Positive Amphotericin B	Negative DMSO	Leaf	Twig	Leaf/Internode calli
<i>Penicilium</i> sp.	15.07 (0.06)a	0.00	6.07 (0.06)b	9.03 (0.06)c	0.00
<i>Aspergillus</i> sp.	14.10 (0.10)a	0.00	11.63 (0.23)c	10.03 (0.06)c	0.00
<i>Trichoderma</i> sp.	19.03 (0.06)a	0.00	9.07 (0.06)c	11.17 (0.15)d	0.00
<i>Candida</i> sp.	13.47 (0.06)a	0.00	5.47 (0.06)b	5.30 (0.00)b	0.00

* Mean with standard deviation in parenthesis of triplicate analysis

Different letters across the rows indicate that no significant difference at $p \leq 0.05$.

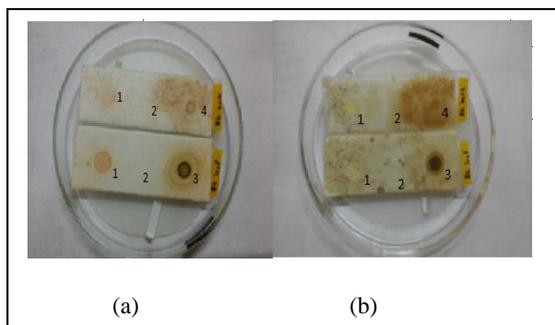


Figure 2. Anti-fungal assays for crude of natural plant (leaf and twig) extracts of *N. cadamba* against (a) *Aspergillus* sp. and (b) *Trichoderma* sp. (spot diameter= 6.0 mm) (1-positive control, 2-negative control, 3-leaf extract, 4-twig extract)

Total phenolic content (TPC) (mg/g GAE) was highest in crude (1.0 g) extracts of twigs (17.0) and leaf (4.0) compared to that of internode-calli (3.5) and leaf-calli (2.0) (Table 3). Radical scavenging activity (RSA) % increased with concentration of extracts. In RSA of extracts of *N. cadamba*, activity decreased in the order of twig, leaf, internode-calli and leaf-calli (Table 3), confirming the findings of Ganjewala *et al.* (2013). TPC and RSA values showed a similar trend in twig, leaf, Internode-calli and leaf-calli.

CONCLUSIONS/RECOMMENDATIONS

The results of the present study revealed that calli development was successful in *N. cadamba* (Roxb.) Bosser. The most effective hormonal combinations for calli formation were NAA 5.0mg/l:BAP 0.5mg/l and NAA 2.5mg/l:BAP 3.0 mg/l in MS medium for leaf-calli and internode-calli of *N. cadamba*. Although extracts of leaf-calli and internode-calli demonstrated positive antibacterial and antioxidant activities, they are less and reveal that secondary metabolites responsible for such properties are produced in calli but to a lesser extent. However, natural environment imposes various conditions of stress on naturally growing plants stimulating to produce more secondary metabolites in higher concentrations. This could be the reason, why leaf and twig extracts showed higher antimicrobial and antioxidant activity compared to that of calli extracts. As suggested in the literature (Indu *et al.*, 2013) if calli are subjected to optimization with stresses such as salinity, water stress, electric stimulation, etc., there may be a possibility of production of secondary metabolites is higher in concentrations. The present study reveals that development of

calli from leaves and internodes of *N. cadamba* could be considered as a potential source of bio-active compounds against some selected pathogenic and non-pathogenic bacteria and antioxidants to act against free radicals.

Table 3. Total Phenolic content (TPC) and Radical Scavenging activity (RSA) for different concentrations of leaf, twig and calli crude extracts of *N. cadamba*

Plant Part	TPC* (mg/g GAE) (SD)	RSA (%)* (SD) based on IC ₅₀ values for different concentrations (µg/ml) of extracts
Leaf-calli	2.0 (0.00)	20 µg/ml - 11.00 (0.58) 40 µg/ml - 20.67 (1.00) 60 µg/ml - 30.33 (1.16) 80 µg/ml - 81.33 (0.58)
Internode-calli	3.5 (0.00)	20 µg/ml - 19.00 (1.00) 40 µg/ml - 59.67 (0.58) 60 µg/ml - 85.67 (2.08) 80 µg/ml - 94.33 (0.58)
Leaf	4.0 (0.00)	20 µg/ml - 72.67 (6.43) 40 µg/ml - 69.67 (0.58) 60 µg/ml - 86.33 (2.31) 80 µg/ml - 95.00 (1.73)
Twig	17.0 (4.58)	20 µg/ml - 61.67 (0.58) 40 µg/ml - 81.33 (1.16) 60 µg/ml - 90.67(0.58) 80 µg/ml - 98.00 (0.00)

*Mean with standard deviation in parenthesis of triplicate analysis

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ELEMENTAL ANALYSIS OF RICE HUSK ASH OBTAINED FROM DIFFERENT VARIETIES OF RICE GROWN IN POLONNARUWA DISTRICT

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INTRODUCTION

Rice husk is one of the most widely available agricultural wastes in many rice producing countries around the world. Approximately 600 million tons of rice is produced globally each year. On average 20% of the paddy is rice husk (RH), giving an annual total production of 120 million tones (Giddel and. Jivan, 2007). In majority of rice producing countries much of the husk produced by processing rice is either burnt or dumped as waste. Burning RH in atmospheric conditions leaves a residue, called rice husk ash (RHA) and it is approximately 25% of the rice husk.

Rice husk removal during rice refining, creates disposal problem due to less commercial interest. Also, handling and transportation of RH is problematic due to its low density. RHA is a great environment threat causing damage to land and surrounding area where it is dumped. Therefore, commercial use of rice husk and its ash is an alternative solution to the disposal problem. There are many uses in rice husk.

According to Basha *et al.* 2005, there are possibilities of improving residual soil properties by mixing RHA and cement in suitable proportions as stabilizing agents. Indian Space Research Organization has successfully developed a technology for producing high purity silica from RHA that can be used to manufacture silicon chips for industry. Attempts have been made to utilize RHA in vulcanizing rubber (Saha *et al.* 2001). RHA has been found to be effective as an oil spill absorbent, and for use in waterproofing chemicals, flame retardants, and as a carrier for pesticides and insecticides.

Presently, RH usually ends up being burnt in open space, thus causing environmental pollution. To conserve energy and resources, efforts have been made to burn the husk under controlled conditions and to utilize the resultant ash in building, semiconductor, composite, and abrasive materials (Siqueira *et al.* 2009). Also, ash is an active catalyst and a good material for catalyst support because of its high surface area (Rafiee *et al.* 2012). Rice husks are known to have a relatively high content of inorganic compounds. Depending on the soil content, some hazardous metal elements may also be included in them (Junko *et al.*, 2008). Combustion is the conventional technique for rice husk to exploit the calorific value and to obtain silica for commercial use, but cations such as K^+ , Al^{3+} , P^{5+} , Fe^{3+} and Mn^{2+} can remain in RHA as oxides, decreasing its purity and further limiting its use. Moreover, in the direct combustion process of rice husk, the obtained rice husk ash consists of many black particles, which are very difficult to be fully burnt off. The high impurity level of potassium is generally recognized to be the cause (Krishnarao *et al.* 2001). Burning RH produces high ash content, varying from 13% to 29% depending on the rice variety, climate and geographical location. The ash is largely composed of silica (80-90%) with small amounts of inorganic salts. Therefore this research is carried out to identify the metal content in various types of rice husk ash and also to calculate the percentage of silica that exists in different varieties.

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METHODOLOGY

The rice husk samples of Kuruluthuda, Pokuru samba, Red samba, White samba, B.G.359, Suwandal and Mavee collected from Polonnaruwa district were used in this research for elemental analysis and determination of silicon content.

Rice husk samples of different varieties were washed with ample of water followed by distilled water and dried well at a temperature of 120 °C in an oven to remove the moisture. Then it is grinded to reduce the volume and burnt under temperature of 450 °C for 6 hours to get the black ash. The black ash was grinded again and burnt in a furnace at 700 °C for 6 hours until it becomes white colour. White ash is analyzed for different elements using Energy Dispersive X-ray Diffraction and Atomic Absorption Spectroscopy.

Hitachi SU6600 Analytical Variable Pressure FE-SEM was used to get the Energy Dispersive X-ray Diffraction (EDX) and Atomic Absorption Spectroscopy (AAS) was used to quantitatively analyze the elements in different varieties of rice husk ash.

RESULTS AND DISCUSSION

Energy Dispersive X-ray Diffraction or EDX is a technique used in the elemental analysis of solid samples. This is a reliable method to realize the elements in a sample and the following results were obtained for B.G.359 RHA by analyzing with EDX.

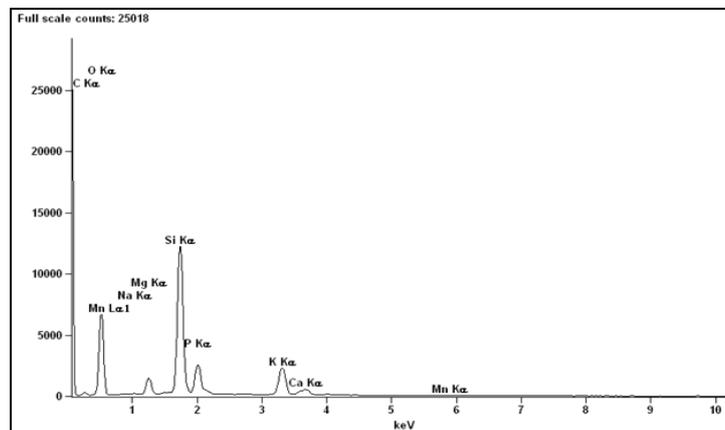


Figure 1. EDX analysis of BG 359 RHA for different elements

Presence of the elements such as carbon, oxygen, sodium, magnesium, silicon, phosphorous, potassium, calcium, magnesium and aluminium could be detectable from the EDX analysis in the BG359 rice husk ash sample (figure 1). Therefore EDX is very useful to identify the elements present in an unknown sample. However EDX is not suitable to calculate the percentages of elements at low levels because it fails to give accurately results when the percentage of elements are less than 3% by weight. Table 1 gives the analyzed results of different elements in BG359 rice variety by EDX with the percentage error.

Table 1. Weight % of different elements present in the BG359 RHA

Element	Weight %	Weight % error
Si	22.83	± 0.11
O	46.33	± 0.24
C	10.36	± 0.23
Na	0.18	± 0.04
Mg	2.45	± 0.05
P	6.29	± 0.11
K	9.18	± 0.11
Ca	1.96	± 0.09
Mn	0.43	± 0.07
Al	0.18	± 0.02

Atomic absorption spectroscopy is a process involved in the absorption of light by free atoms of element at a wavelength specific to that element, or it means a technique by which the concentration of metals can be measured in a sample. In Atomic Absorption Spectrometry, emission, absorption and fluorescence, energy is put into the atom population by thermal, electromagnetic, chemical and electrical forms of energy and is converted to light energy by various atomic and electronic processes before the measurement. Atomic Absorption Spectrometry is useful not only for the identification but also for the quantitative determination of many elements present in a sample. The technique is specific, in that individual elements in each sample which can be reliably identified and it is sensitive, enabling small amount of an element to be detected up to $1\mu\text{g l}^{-1}$ (1ppm) i.e. one part in one million using straightforward flame procedures.

Table 2 shows the weight % of some minute elements in different varieties of RHA (white ash) calculated using AAS.

Table 2. Weight % of some minute elements in different varieties of RHA

Elements	Rice variety						
	Mavee	B.G. 359	Red samba	White samba	Pokuru Samba	Kuruluthuda	Suwandal
Ca % by mass	0.56	1.25	0.86	0.65	1.72	1.15	0.59
Mg % by mass	0.74	1.52	0.01	0.44	0.01	1.43	0.61
Fe % by mass	0.11	0.28	0.27	0.18	0.18	0.21	0.21
Cd % by mass	0.004	0.003	1.05	0.005	0.63	0.002	0.004

The result shows the weight % of Calcium, Magnesium, ferrous and Cadmium in different varieties of rice husk ash. When analyzing the data, it shows that Pokuru samba contains 1.72 % calcium and it is the highest percentage that is recorded. B.G.359, Kuruluthuda, Red samba, White samba, Suwandal and Mavee also contain calcium in order. Magnesium is the other element that was analyzed. B.G.359 contains highest amount of magnesium comparing with other samples. Then Kuruluthuda, Mavee, Suwandal, Pokuru Samba and Red samba contain magnesium next in order. But both Pokuru Samba and Red samba have a similar percentage of 0.01 %. It is a less amount comparing with B.G.359 which has 1.52 %. Mavee contains 0.11 % of Ferrous which is the least amount in the studied samples and other samples also have more or less a similar amount. Because these samples were collected from Polonnaruwa district, curiosity aroused to check for the cadmium level in these samples which is suspected to cause chronic kidney disease. The amount of Cadmium in red samba RHA and pokuru samba RHA is comparatively very high compared to othersamples given in table 02. All other samples also contained reasonable amount of cadmium as can be seen.

As Cadmium is a poisonous heavy metal which should not contain in food, even the lower level of cadmium in the diet for long-term can cause various chronic diseases. It can also lead to the formation of kidney stones and affect the skeleton, which can be painful and debilitating. The U.S. Department of Health and Human Services determined that cadmium and certain cadmium compounds are probable or suspected carcinogens (Agency for Toxic Substances and Disease Registry 1989).

Table 3. Percentage of silica in different varieties of RHA

Rice variety	% of SiO_2 by mass.
1.Mavee	14.31%
2.B.G.359	24.87%
3.Red samba	16.70%
4.White samba	13.87%
5.Pokuru samba	12.43%
6.Kuruluthda	09.23%
7.Suwandal	11.68%

White ash of rice husk contains the industrially important element Silicon as silica. When compared the silica percentage, the maximum is recorded in B.G.359 (24.87%) and the other rice varieties also follow the order as Red samba, Mavee, White samba, Pokuru samba, Suwandal and Kuruluthda (Table 3).

CONCLUSIONS/RECOMMENDATIONS

It is evident from this study that the EDX measurement is useful to identify the elements in different rice varieties but to analyze the elements in low concentration AAS is more reliable. The above study intended to identify the elements present in different varieties of rice husk ash, and the amount of silica which is an industrially important in pure form. Silica content is highest in the BG359 and other elements such as calcium, magnesium and ferrous are also comparatively higher in this variety except cadmium. The RHA of red samba grown in the Polonnaruwa district had the highest percentage of cadmium which is at a risky level that suspects to cause chronic kidney disease.

Therefore it can be concluded that the amount of elements present in rice husk depends on the rice variety, soil and climatic conditions.

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SYNTHESIS AND ELECTRICAL CHARACTERISATION OF
 $\text{Na}_x\text{Co}_{(1-x)}\text{O}_2$, ($x = 0.05, 0.1, 0.25, 0.5, 0.75, 0.9$) and $\text{Na}_x\text{Ni}_{(1-x)}\text{O}_2$, ($x = 0.1, 0.25, 0.5, 0.75$)
FOR THE CATHODE OF Na-ION RECHARGEABLE BATTERIES

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INTRODUCTION

Alternative rechargeable battery systems with transporting ions other than Li ion have attracted growing interests in recent years. Sodium is a cheap, nontoxic and abundant element that is uniformly distributed around the world and therefore would be ideal as a transporting ion for alternative rechargeable batteries.

Known for their commercial domination of the Li-ion battery market, layered oxides of the type AMO_2 ($A = \text{Li, Na}$; $M = \text{Co, Mn, Ni}$ and combinations thereof) are sought after for their high intercalation potentials and energy densities. The alkali cation A is reversibly de/intercalated between the two-dimensional layers of transition metal MO_6 octahedra on electrochemical cycling (Ellis, 2012).

It is no wonder that sodium layered oxide compounds (Na_xMO_2) have drawn significant attention as cathode materials in Na-ion batteries (NIB) considering that their Li analogues have been comprehensively understood for the last two decades.

In this study, powder compositions of $\text{Na}_x\text{Co}_{(1-x)}\text{O}_2$, ($x = 0.05, 0.1, 0.25, 0.5, 0.75, 0.9$) and $\text{Na}_x\text{Ni}_{(1-x)}\text{O}_2$, ($x = 0.1, 0.25, 0.5, 0.75$) were synthesized by Pechini method. This is a low cost synthesis technique but can result in powders with high purity, homogeneity and particle morphology (Wijayasinghe, 2006).

METHODOLOGY

$\text{Na}_x\text{Co}_{(1-x)}\text{O}_2$, ($x = 0.05, 0.1, 0.25, 0.5, 0.75, 0.9$) and $\text{Na}_x\text{Ni}_{(1-x)}\text{O}_2$, ($x = 0.1, 0.25, 0.5, 0.75$) powder samples were synthesized using Pechini method. For this purpose, stoichiometric amount of metal Nitrates, NaNO_3 , $\text{Co}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$ and $\text{Ni}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$ (BDH, England) of analysis grade were used as starting materials with the organic precursor solutions of citric acid (CA) and ethylene glycol (EG). Powders were prepared with the EG: CA molar ratio of 4:1, because previous studies have proved that optimal gelling condition occur at this molar ratio. (Samarasinghe, *et al.*, 2008).

The mixture of metal nitrates, citric acid and ethylene glycol were stirred for 24 hours and then heated while being stirred. The resultant powders were calcined at 800 °C for two hours in air in a box furnace.

Phase analysis of the compositions $\text{Na}_x\text{Co}_{(1-x)}\text{O}_2$ and $(\text{Na}_{0.1}\text{Ni}_{0.9})\text{O}_2$ was carried out with X-ray diffractometry and surface morphology of $\text{Na}_x\text{Co}_{(1-x)}\text{O}_2$ was investigated using scanning electron microscopy. The synthesized powders of $\text{Na}_x\text{Co}_{(1-x)}\text{O}_2$ and $\text{Na}_x\text{Ni}_{(1-x)}\text{O}_2$ were uniaxially pressed at 150 MPa and the green pellets were subsequently sintered at 800 °C for two hours in static air. The electrical conductivity of these materials were determined by performing DC conductivity measurements on sintered pellets by the four-probe method. The conductivity measurements were performed in a cyclic manner on heating and cooling in air, in the temperature range 25 - 200 °C.

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RESULTS AND DISCUSSION

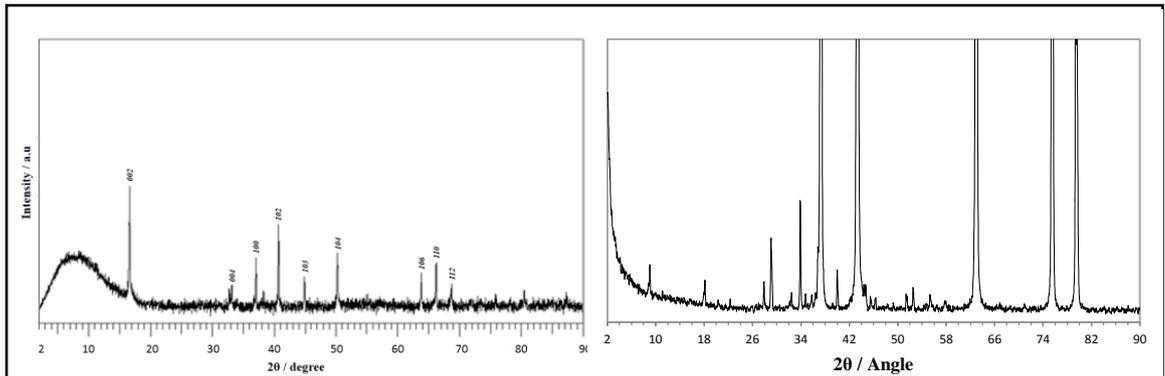


Figure 1. XRD Pattern of $(\text{Na}_{0.5}\text{Co}_{0.5})\text{O}_2$ (left) and $(\text{Na}_{0.1}\text{Ni}_{0.9})\text{O}_2$ (right)

Figure 1 (left) shows the XRD pattern of the $(\text{Na}_{0.5}\text{Co}_{0.5})\text{O}_2$ powder. The diffraction peaks at $2\theta = 17.00^\circ, 32.80^\circ, 37.20^\circ, 40.80^\circ, 45.00^\circ, 50.20^\circ, 64.00^\circ, 66.20^\circ, 68.50^\circ$ are in good agreement with the values reported for the required composition. These peaks could be well assigned to the reflection of crystal structure type of P2-phase with space group P63/mmc.

Figure 1 (right) shows the XRD pattern of the $(\text{Na}_{0.1}\text{Ni}_{0.9})\text{O}_2$ powder. It indicates the formation of the appropriate crystalline structure of the synthesized cathode material (De Silva, 2014).

Figure 2 shows the SEM images of the powders $(\text{Na}_{0.1}\text{Co}_{0.9})\text{O}_2$ and $(\text{Na}_{0.25}\text{Co}_{0.75})\text{O}_2$. The images indicate a disordered morphology composed individual particles in the range of 0.2 - 0.5 μm with higher crystallinity. The small particles agglomerate together to form micro-sized irregular agglomerates.

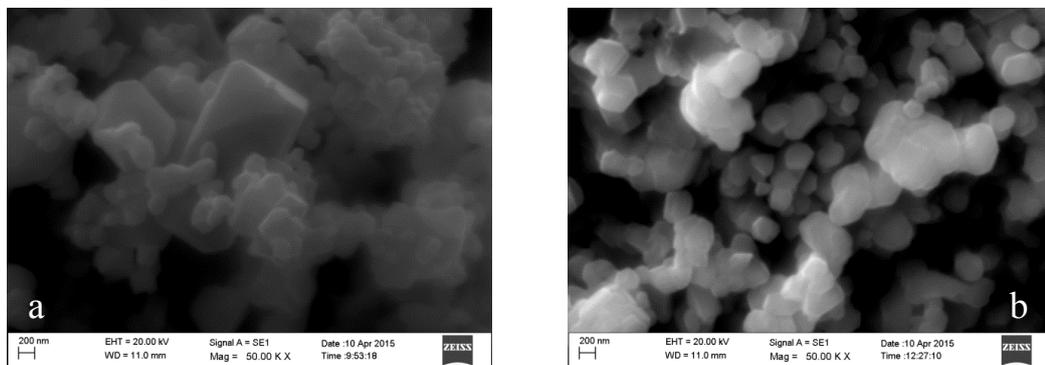


Figure 2. (a) SEM image of $(\text{Na}_{0.1}\text{Co}_{0.9})\text{O}_2$; (b) SEM image of $(\text{Na}_{0.25}\text{Co}_{0.75})\text{O}_2$.

Figure 3 shows the electrical conductivity behavior patterns observed from the prepared compositions of both Na-Co and Na-Ni systems. As seen in the figure, all these materials showed the increase of the conductivity in an exponential manner with the increase of ambient temperature. The electrical conductivity of these materials increases with increasing temperature, which is a good indication for the semiconducting nature and a prime requirement to be an electrode material. This is due to the excitation of the electrons over the band gap and occupying energy levels in conductivity band simultaneously creating holes in valence band. This process is thermally activated, so that conductivity increases with temperature.

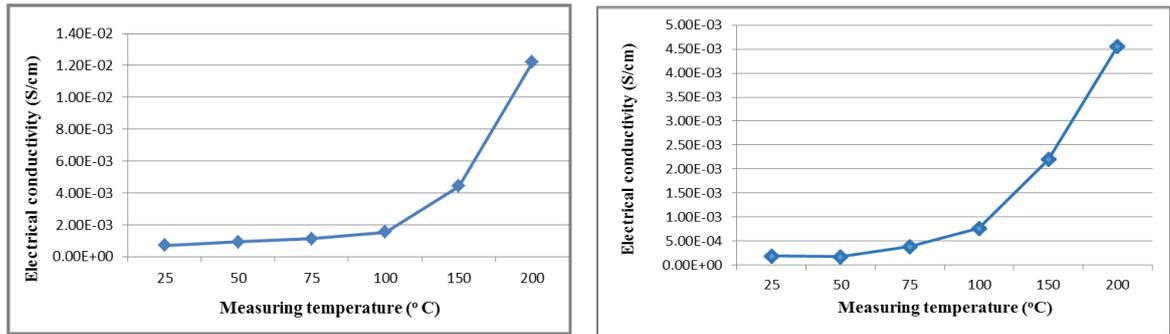


Figure 3. Variation of electrical conductivity of materials with measuring temperature, left: $\text{Na}_{0.5}\text{Co}_{0.95}\text{O}_2$ right: $\text{Na}_{0.25}\text{Ni}_{0.75}\text{O}_2$

The variation of the electrical conductivity of $\text{Na}_x\text{Co}_{1-x}\text{O}_2$ compositions is shown in the Figure 4(a). Increase of the Na content has drastically increased the conductivity and the composition with $x = 0.75$ has produced an electrical conductivity close to 1 S/cm at the room temperature. This is a significant achievement in electrical conductivity and this material can directly be used without any other additional conductivity enhancer, for electrode application

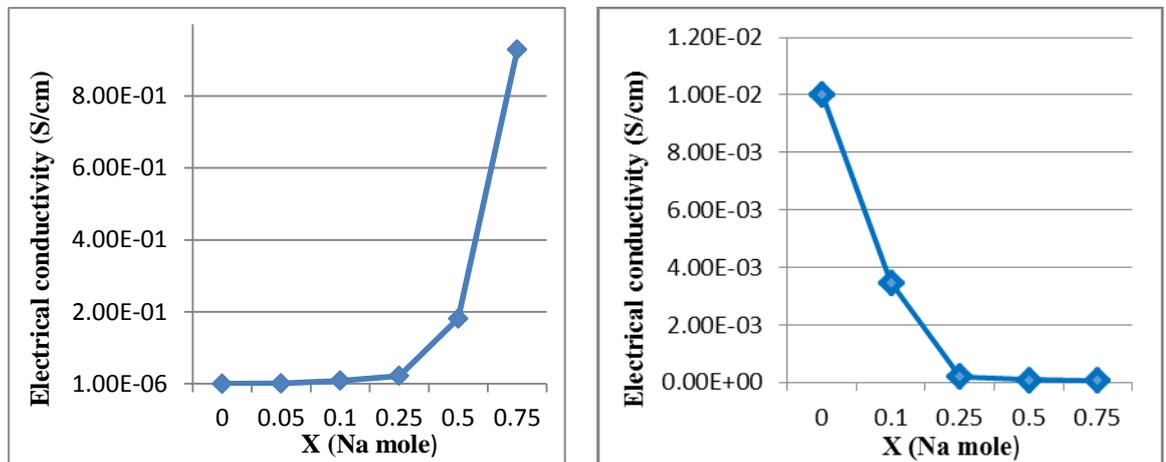


Figure 4. Variation of the electrical conductivity with composition $\text{Na}_x\text{Co}_{1-x}\text{O}_2$ (left), $\text{Na}_x\text{Ni}_{1-x}\text{O}_2$ (right).

Similarly, Figure 4(b) shows the electrical conductivity behaviour of the $\text{Na}_x\text{Ni}_{1-x}\text{O}_2$ compositions. The base composition NiO (with $x = 0$) shows an electrical conductivity of 1.0×10^{-2} S/cm and with each further addition of Na, it shows decrement down to 7.34×10^{-5} S/cm at $x = 0.75$. It needs further investigations especially with suitable conductive additives for enhancing electrical conductivity of these $\text{Na}_x\text{Ni}_{1-x}\text{O}_2$ materials before using in cathodes for the NIB.

CONCLUSIONS

This study revealed the possibility of synthesizing $\text{Na}_x\text{M}_{1-x}\text{O}_2$, $M = \text{Co}, \text{Ni}$ and $x = 0 - 0.75$ compositions by the Pechini wet chemical synthesis technique. All these prepared materials showed semiconducting behaviour. In the $\text{Na}_x\text{Co}_{1-x}\text{O}_2$ system, the electrical conductivity increased drastically to about 1 S/cm with the increase of Na content to 0.75. Among the $\text{Na}_x\text{Ni}_{1-x}\text{O}_2$ system, the $x = 0.1$ composition showed the highest electrical conductivity of 3.47×10^{-3} S/cm at room temperature. In order to explain the observed effect in electrical conductivity after adding Na to these systems, these systems should be subjected to thorough electrical characterization. However, these significant achievements in electrical conductivity of this study indicate the potentiality of these $\text{Na}_x\text{M}_{1-x}\text{O}_2$, $M = \text{Co}$ and Ni , compositions for the NIB cathode application.

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ALTERNATE SOURCES OF DNA FOR MOLECULAR IDENTIFICATION OF *Aedes aegypti*

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INTRODUCTION

In the study of mosquito-borne diseases, the precise identification of the vector is important in many respects including vector surveillance and control strategies. Conventionally mosquito vectors are identified using morphological methods that utilise keys. These keys use a large number of specific taxonomic characters and are also specific to a developmental stage or gender. As such, separate keys and a close review in the laboratory are required for the identification of the male and female adults, larvae, pupae and eggs. In addition, many field collected specimens of adults are damaged and important identification characters such as bristles and scales may be lost. Because of these limitations in species identification based on morphological characteristics, especially in the case of field collected specimens, increasingly morphological methods are being complemented with DNA-based methods (Cywinska *et al.*, 2006, Kumar *et al.*, 2007, Engdahl *et al.*, 2014). The application of molecular tools in the identification of the mosquito vector species has several potential advantages, such as the ability to make an identification based on DNA obtained from even a small piece of tissue from any development stage, both sexes, dried and frozen samples.

For molecular identification of any species, one of the primary requirements is the successful isolation of PCR amenable DNA from the specimen. Most commonly, the whole adult mosquito, or its body parts such as legs, thorax, wings are used as the source of DNA. Very few studies (Beebe *et al.*, 2007, Dhananjeyan *et al.*, 2009) have examined the utility of immature stages or the associated exuviae (exocuticle shed during moulting) as alternate sources of DNA for use in molecular based tools. Such specimens are particularly important as breeding habitats may usually contain only the eggs, immature stages or the exuviae left after metamorphosis.

The ability to survey all life cycle stages of the vector will contribute to the rapid identification of the adult and their immature stages and in turn permit the quick assessment of the disease transmission risks and facilitate the timely implementation of control measures. The objective of this study therefore was to examine whether DNA isolated from different life stages and exuviae of *Aedes aegypti*, one of the principle vectors of dengue in Sri Lanka, could be successfully used in molecular approaches. Here we used the barcode region of the cytochrome *c* oxidase I (COI) of the mitochondrial genome as the molecular marker to evaluate the isolation success of PCR amenable genomic DNA and thereby investigate the utility of these alternate sources of DNA for the molecular identification of *A. aegypti*.

METHODOLOGY

- Collection of *A. aegypti* samples:

Samples of life cycle stages including eggs, 1st instar larvae (L1), 2nd instar larvae (L2), 3rd instar larvae (L3), 4th instar larvae (L4), pupae and adults were collected from the mosquito rearing bowls in the Insectory of the Open University of Sri Lanka.

To obtain egg shells, individual eggs were allowed to hatch in separate rearing bowls and the egg shell remaining in each bowl was collected. Similarly, L1 to L4 larvae and pupae were separately reared and when they moulted to the next following stage, the larval (L1 to L4) and

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pupal exuviae present in the bowls were immediately collected.

A time scale experiment was conducted with individual 3rd instar larvae reared in separate rearing bowls until after adult emergence to investigate whether DNA present in any cells attached to the exuviae decayed with time. After the emergence of adults, the shed exuviae in the water were allowed to remain in the same bowl until collection at different days post-eclosion (until after adult emerge). Adequate number of rearing bowls was set up to collect samples from 0 days up to 13 days post-eclosion.

Samples collected in replicates were air dried on a filter paper. They were transferred individually to labelled sterile microcentrifuge tubes, and were stored at -20°C until further analysis. A few samples of the collected eggs were laid on filter paper and left for desiccation at room temperature for up to 8 weeks.

- DNA extraction and PCR amplification of COI barcode region:

DNA was extracted from the specimens using the Invitrogen Genomic DNA mini kit (Life technologies, USA) following the manufacturer's instructions. The DNA concentration of the samples at 260nm absorption was quantified using a NanoDrop 2000C spectrophotometer (Thermo Fisher Scientific Inc. USA). The purity of the samples (absorption at 260/280nm) was also noted.

PCR amplification of the COI barcode region was carried using published primers and reaction conditions (Former *et al.*, 1994) using a thermal cycler (veriti 96-well Thermal cycler, Applied Bio System, USA). The PCR amplified DNA fragments were visualised in 2% agarose gel stained with Ethidium Bromide using a UV transilluminator.

RESULTS AND DISCUSSION

a) PCR amenable DNA from adults and immature stages of *Aedes aegypti*

It was possible to obtain PCR amenable DNA from all stages of the life cycle, such as the egg, larva, pupa and adult of *A. aegypti* (Fig. 1A). The amount of DNA that could be isolated increased with the advancement of the development stages from the egg to adult (Table 1).

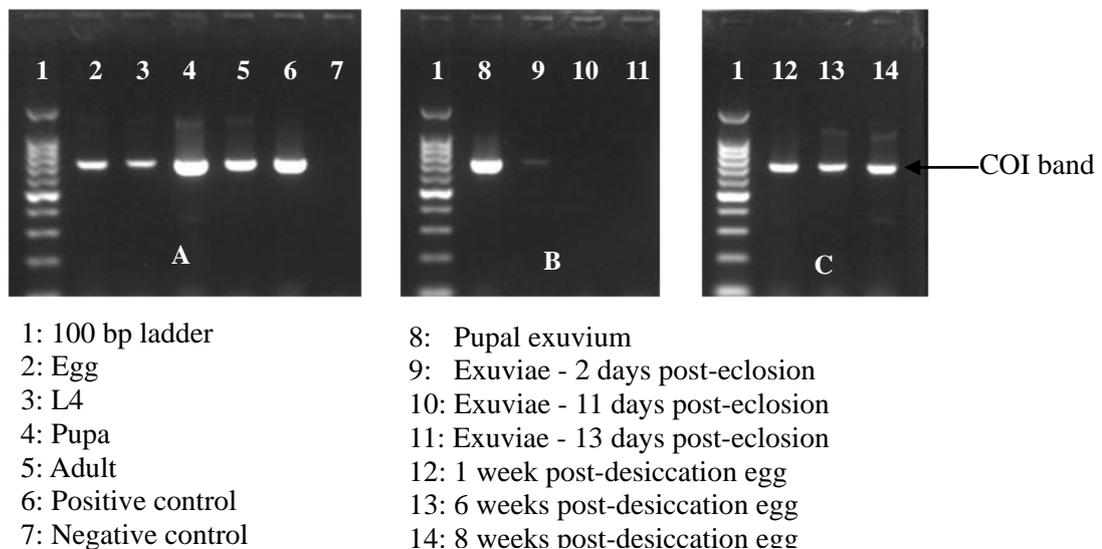


Figure 1. Agarose gel pictures showing PCR amplification of COI region of *A. aegypti* life cycle stages (A), exuviae (B) and desiccated eggs (C).

Table 1. Average concentrations of DNA isolated from *A. aegypti* eggs and exuviae.

Specimen	DNA isolated (ng/μl)	Specimen	DNA isolated (ng/μl)
Egg	16.8	Egg shell	1.9
L2	19.4	L2 Exuvium	2.7
L3	21.2	L3 Exuvium	5.2
L4	74.4	L4 Exuvium	8.3
Pupa	76.7	Pupal Exuvium	7.2
Adult	87.0		

These results are expected because each stage grows in size with the advancement in the developmental stage and the larger size would mean more cells with DNA. Similarly, as would be expected the amount of DNA isolated from the adult varied with the size of the specimen taken for the extraction procedure. For instance, the whole mosquito yielded around 87 ng/μl while it decreased to 30 ng/μl and 7 ng/μl when only the abdomen and thorax, and wings and legs of a mosquito, respectively were used as the starting specimen in DNA extractions.

b) PCR amenable DNA from egg shells and shed exuviae of *Aedes aegypti*

The results revealed that it was also possible to PCR amplify the COI region of the DNA isolated from larval and pupal exuviae of *A. aegypti* (Figure 1B) though the DNA concentrations were comparatively less (Table 1) than the DNA concentrations obtained from the life-cycle stages. Whilst the mosquito or its body parts will contain cells that ultimately yield genomic DNA, the exuviae are the remains of the exocuticle shed from each stage when it moults to the next stage. These sloughed-off skin parts, though mainly composed of dead cells, appear to contain some cells that contain DNA, which could be successfully used in molecular methods.

c) Time scale analysis of *Aedes aegypti* exuviae, post-eclosion

A previous study conducted using *A. aegypti* samples from India, reported that no PCR amplification of ITS region was recorded from genomic DNA extracted from exuviae collected from 1st day to 9th day post-eclosion in the laboratory and that only fresh exuviae (0-days) gave a positive band (Dhananjeyan *et al.*, 2009). Our study shows that it is possible to isolate DNA from exuviae collected from 0 to 13 days post-eclosion (Table 2). It was observed that the amount of DNA isolated appear to decline with time from 85 ng/μl to 11 ng/μl, respectively, though a characteristic gradual decrease was not apparent. The barcode region of the COI gene of this DNA could be successfully PCR amplified to give the expected band around 650 bp (Fig. 1B), however, the intensity of the PCR band reduced with time and the band became very faint by 13 days post-eclosion. It is clear that the DNA degrades with time. In spite of degradation, especially if sampled early, there is potential for exuviae to be used in the identification of *A. aegypti* breeding sites, even after the adult has emerged.

Table 2. Average concentration of DNA isolated from *A. aegypti* exuviae specimens, days post-eclosion.

Days post-eclosion	DNA isolated (ng/μl)	Days post-eclosion	DNA isolated (ng/μl)
0	84.7	8	174.1
2	11.4	9	7.1
3	33.9	10	37.2
4	34.9	11	8.5
6	39.4	12	2.9
7	112.9	13	10.9

d) Time scale analysis of desiccated eggs

The PCRs gave positive COI bands with desiccated egg DNA up to 8 weeks (Fig. 1C), even though the DNA concentration gradually decreased from 15.6, 11.7 and 1.5 ng/μl with longer period of desiccation from 1, 6 and 8 weeks, respectively. Beebe et al., (2007) reported that PCR amplification success reduced gradually with longer desiccation time with only 1 egg out of 10 giving positive results after a period of 160 days of desiccation. Our results show that *A. aegypti* eggs can withstand prolonged periods in the absence of water and may implicate their ability to undergo development at a later stage when environmental conditions become suitable. Eight weeks was the maximum time observed in this study due to time limitations, however as dried eggs of *A. aegypti* are known to hatch and produce larvae, it would be interesting to examine how desiccation affects the DNA when left for longer periods of time.

CONCLUSIONS/RECOMMENDATIONS

DNA that can be amplified by PCR is a pre-requisite for molecular identification of species. The results reported here show that not only the adult, but DNA isolated from immature life cycle stages such as the eggs, larvae, pupa, and the left out parts during moulting, like the larval and pupal exuviae, could also be successfully used in the PCR amplification of the COI barcode region. The study has shown that the use of these alternate sources of DNA will enable the early identification of the species, even before or after the adult emergence, under laboratory conditions, and thereby implicate their utility in the molecular identification of *A. aegypti* mosquitoes. As the DNA present in cells attached to the exuviae appear to decay fast, future studies need to be conducted under field conditions, to examine the utility of mosquito exuviae in PCR-based molecular studies.

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A STUDY TO ASSESS THE STATUS OF MOSQUITO BREEDING IN LARVAL HABITATS IN RUMASSALA HILL IN GALLE DISTRICT, SRI LANKA

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INTRODUCTION

The chemical control interventions are usually targeted against adult mosquito vectors expecting a rapid reduction in diseases transmission. However it has been realized that the highly mobile flying adult insects can readily detect and avoid such interventions. (Killeen *et al*, 2002) Unlike adults, mosquito eggs, larvae and pupa are confined to small aquatic habitats where they cannot readily escape control measures directed against larvae and pupae (Tadesse *et al*, 2011).

Many studies report on the importance of assessing the breeding ecology of mosquitoes, their species-specific use of different larval habitats, identification of most productive habitats, prevalence of larvae correlated with physical and biological properties of larval habitats for effective management of larval population (Tadesse *et al*, 2011, Muturi *et al*, 2007, Suganthi *et al*, 2014).

Rumassala hill in Galle district, Sri Lanka, visited frequently by local and foreign tourists, is a suburban area having in its surrounding forest patches bordering the sea on its south western side. It contains potential natural larval habitats due to hilly and uneven nature of its landscape and also artificial larval habitats due to recent urbanization. Systematic scientific studies on mosquito species and their breeding ecology have not been carried out at Rumassala, although filariasis is a common disease among inhabitants and Dengue cases have also been reported.

The present study was designed to investigate the prevalence and abundance of mosquito species and their utilization of larval habitats at Rumassala hill, Galle district.

METHODOLOGY

The study was carried out from January to July 2014 in 8 sampling sites at Rumassala hill in Galle district and each sampling site was approximately 80 m² and was located 100meters from each other. Considering the variation in the terrain, four sampling sites were located in the coastal forest area while the remaining four were located in the nearby residential area. Monthly collections of immature mosquito stages were carried out from 52 larval habitats of the 8 sampling sites, using the standard 13 cm diameter ladle with 90 cm wooden handle and 3 ml dipper using the WHO recommended standard techniques in collecting larvae. Third and fourth instar larvae and pupae in the collections were counted and reared up to adult stage in the laboratory and identified using standard keys. Larval identification was not attempted since it requires years of experience, skill and practice. Data analysis was performed using MINITAB Version 17.1 and ANOVA was used to determine differences in larval counts during sampling months, species present and habitats types.

RESULTS AND DISCUSSION

Mosquito breeding was observed in 11 larval habitat types within the 8 sampling sites during the study period from January to July 2014. They included fallen coconuts, leaf axils, tree

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holes, rock pools, discarded items, boats, baskets, flowerpots, ponds, house drains and rock holes. Of these, fallen coconuts and tree holes were restricted to the forest patches while house drains, baskets, flower pots and ponds were found only in the residential area. Breeding sites sampled monthly had 680 mosquito larvae (L₃ and L₄ stages) and on rearing them under laboratory conditions, 663 emerged as adult mosquitoes (Percentage emergence 97.5%). The emerged adults belonged to 7 species of mosquitoes (figure1).

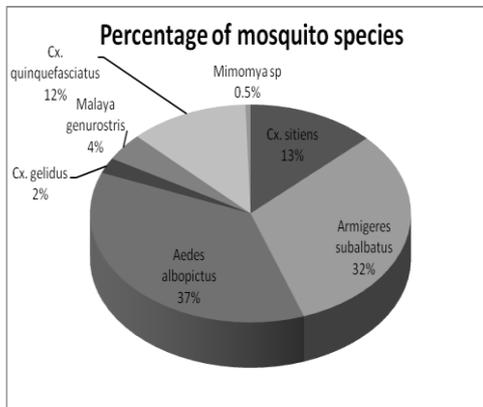


Figure 1. Species distribution in study area

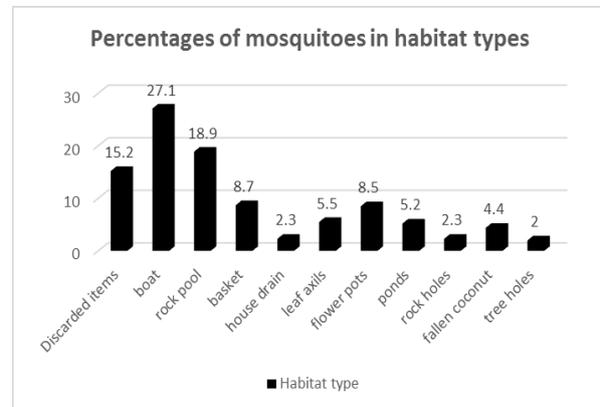


Figure 2. Percentage total of mosquito larvae in habitat types

Of these species *Aedes albopictus* and *Culex quinquefasciatus* were vectors of human diseases namely dengue and bancroftian filariasis and *Armigeres subalbatus* is a carrier of *Dirofilaria repens* causing parasitic infections in dogs. *Aedes albopictus* was the most abundant mosquito species (37%) followed by *Aedes albopictus* (32%). *Culex quinquefasciatus* and *Culex sitiens* having respectively 12% and 13% were next highest among 7 species and the remaining 3 species, namely *Malaya genurostris*, *Culex gelidus* and *Mimomyia* sp, had percentage abundances less than 5%. Previous studies on similar habitat types and using the same method of sampling in other locations in Galle also records the presence of the seven species and indicate the predominance of *Aedes albopictus* (53%), followed by *Aedes albopictus* in larval samples (14%) (Seneviratne, 2014)

Figure 2 indicates the total percentage of mosquito larvae in different larval habitat types. The highest percentage of larvae were observed in boats followed by rock pools and discarded items. Of these habitats, rock pools were natural habitats whereas boats and discarded items were artificial habitats. Baskets and flower pots had comparatively higher percentages of mosquitoes and the remaining habitat types had less than 5.5 % of larvae. Leaf axils, tree holes and fallen coconut were natural habitats, but had lower percentage of larvae probably because they held a smaller content of water during the study period.

Monthly variations in the total mosquito larvae from all habitat types indicate that the highest percentage of mosquito larvae were sampled in July 2014 and the lowest percentage of larvae were sampled in April 2014 (Figure3). Species wise fluctuation in mosquito larva with time (Figure 4) showed an upward trend throughout the sampling period of *Armigeres subalbatus* and highest percentages during the months of June and July. *Aedes albopictus* in contrast showed a downward trend from January to March but after March it showed an upward trend. Majority of *Aedes albopictus* was encountered in July from larval habitat types. The remaining species including *Culex quinquefasciatus*, vector of Bancroftian filariasis showed fluctuations throughout this time but contributed to less than 3% of the total sample every month. One reason for lesser percentages of *Culex quinquefasciatus* may have been clearing of house drains, a characteristic habitat of *Culex quinquefasciatus* by residents just after sampling began.

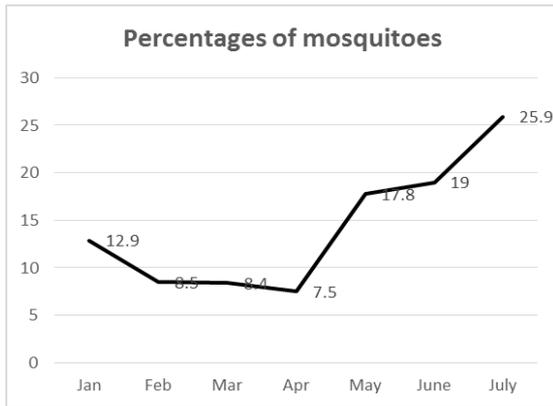


Figure 3. Monthly variation in mosquito larvae

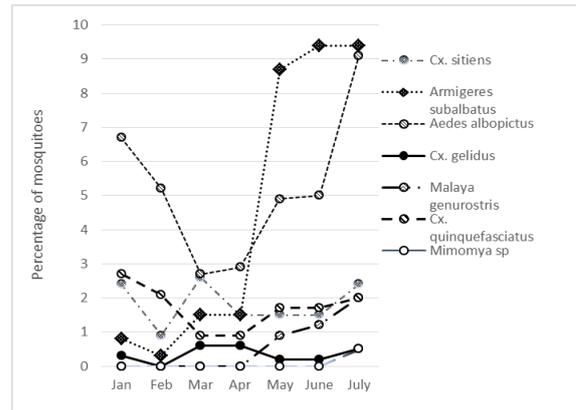


Figure 4. Monthly variation in larval species

When species wise distribution in different larval habitats was investigated (Figure 5) maximum number of larval species was encountered in boats. Boats had in descending order of abundance, *Cx.sitiens*, *Cx.quinquefasciatus*, *Armigeres subalbatus* and *Aedes albopictus*. In contrast to this study, Seneviratne (2014) reports 43% abundance of *Aedes albopictus* in boats in Galle district.

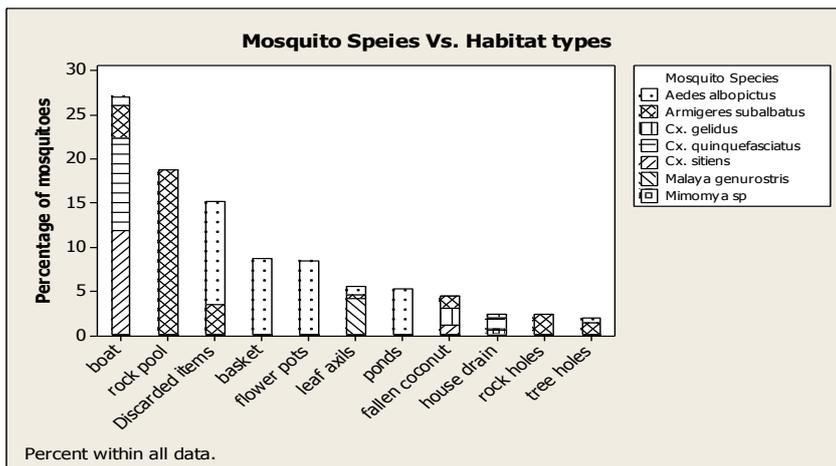


Figure 5. Species wise mosquito abundance in different larval habitats

Since maximum total of larvae were found in boats (Figure 2) and also the maximum total number of species were found within boats (Figure 5), boats can be considered as the most productive larval habitat type at Rummassala. *Aedes albopictus* was the only species found in ponds, flower pots and baskets. However, discarded items, a characteristic larval habitat of this species had the highest percentage of *Aedes albopictus*, similar to larval surveys conducted in Kandy, Kurunegala and Nuwara Eliya (Kusumawathi and Siyabalagoda, 2005, Weeratne, *et al.* 2013) Leaf axils and tree holes, had less than 2% of *Aedes albopictus*. Approximately 12% of the *Culex quinquefasciatus*, vector of Bancroftian filariasis, was found in boats docked near the coast line containing water rich in organic matter.

Monthly variation of the total number of mosquitoes was not significant at 5% significance level ($p=0.111$). However the abundance of mosquitoes varied significantly with species and the habitat types ($p= 0.000$ and $p = 0.006$ respectively at 5% significance level). Tukey test performed to prove which species were most abundant revealed that *Aedes albopictus* and *Armigeres subalbatus* were predominant species in sampling sites at Rumassala and that their abundance was significantly different from other mosquito species. Abundance in boats, rock pools and discarded items were significantly different from other habitat types.

CONCLUSIONS/RECOMMENDATIONS

Seven mosquito species, of which two vectors of human diseases, *Aedes albopictus* and *Culex quinquefasciatus*, were found in larval habitats during January to July 2014. High abundance of *Aedes albopictus*, may cause a threat to transmission of Dengue among people living at Rumassala. Species present did not utilize all larval habitat types, equally. Further studies coupled with water quality studies are required to characterize the larval habitats and determine the species-specific utilization of larval habitats. Boats were the most productive larval habitat in terms of larval abundance. Discarded items had the highest abundance of *Aedes albopictus*. Removal of discarded items, applying oil to the surface water in abandoned boats and draining of water from other larval habitat by the community or the health authorities can be considered as practices that will reduce mosquito breeding at Rumassala.

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THE VISIBLE SPECTRA OF SELF-ASSEMBLED AGGREGATES OF β -CAROTENE

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INTRODUCTION

Carotenoids are important group of multifunctional naturally occurring pigments used in several photosynthetic organisms where they act as molecules having important photophysical properties such as light harvesting and photoprotecting functions. They are also efficient quenchers of singlet oxygen and free radicals, where they interrupt the chain propagation reaction in oxidative degradation (Olsina *et al.*, 2012). The diverse functions of carotenoid molecules are directly related to their excited state properties. Carotenoids aggregation behavior is a common phenomenon in biological systems and it affects the functions of naturally occurring dyes. The formation of dimeric and polymeric aggregates of carotenoids can alter the photophysical properties of carotenoids such as absorption, reflection and emission of light.

The excited state dynamics and absorption spectra of monomeric carotenoids and their radical cations have been studied extensively by several researchers (Amarie *et al.*, 2010, Alwis *et al.*, 2015; Krawczyk, 1998). The absorption spectra show the characteristic, strongly allowed $S_0 \rightarrow S_2$ electronic transition with a vibronic structure corresponding to the 0–2, 0–1 and 0–0 transitions in the 400–500 nm regions. This strongly allowed transition is responsible for the bright red-orange colors to the carotenoid containing foods.

β -carotene is $C_{40}H_{56}$ hydrocarbon carotenoid consists of eleven conjugated double bonds and has β -ionone rings at the two ends of the structure (Figure 1).

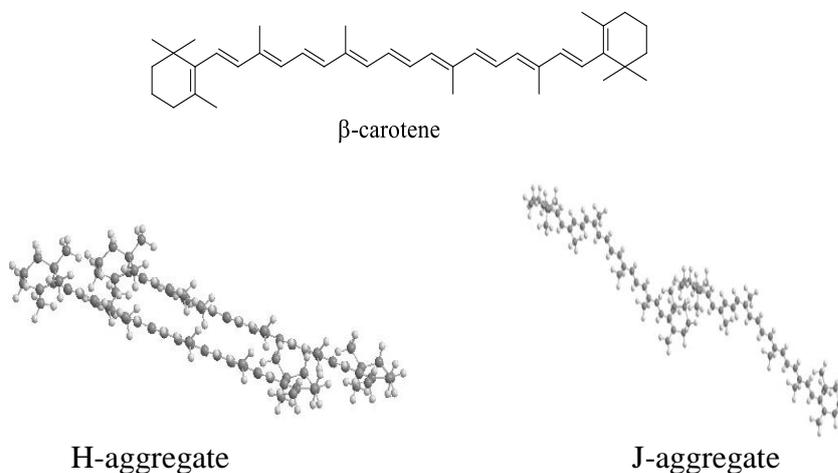


Figure 1. Molecular structures of β -carotene, J-, H-aggregates

The formation of aggregated structures in hydrated solvents is important both in natural and artificial systems. Typically carotenoids tend to form aggregates when present in lipid-bilayers and carotenoid-protein interacts in natural systems. In artificial systems carotenoids are usually form H-aggregates when deposited on conducting or semiconducting surfaces such as on TiO_2 nanoparticles (Olsina *et al.*, 2012). The aggregates formed in hydrated solvents, can be clearly distinguished by their absorption spectra. It is well known (Billsten *et al.*, 2005) that two types of aggregates are formed according to their assembling modes. The

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H-aggregate (card-pack) where the conjugated chains are closely packed parallel to each other. The other type of aggregate is J-aggregate, in which the conjugated chains are organized in a head-to-tail manner. The formation of either J- or H-aggregate depends on three factors such as (I) initial concentration of β -carotene (II) ethanol: water ratio and (III) pH of the solution.

In the present work we have investigated the molecular aggregates formed by nonpolar, hydrocarbon carotenoid, β -carotene. We studied the spectroscopic properties of self-assembled aggregates of β -carotene in ethanol/water mixtures at different pH values which have not been studied to our knowledge.

METHODOLOGY

β -carotene of a purity $\geq 93\%$ was purchased from Sigma Chemicals (PVT) Ltd. β -carotene was dissolved in absolute EtOH to achieve samples with initial concentration 50 and 100 μM . The UV-vis absorption spectra of the samples were measured with a Perkin-Elmer Lambda 35, double beam UV-Vis spectrophotometer. Samples were held in a quartz cuvette with 1 cm path length. Deionized water was used throughout this experiment.

The mixtures of ethanol/water were prepared by adding water to a final content of 0 %, 25%, 35%, 45%, 60%, 70% and 80% (v/v) to a stock solution of β -carotene in EtOH having initial concentration of 100 μM . The UV-vis absorption spectra were obtained for all the above solutions at room temperature. The formation of aggregates were also analyzed by absorption spectra obtained for ethanol and water mixtures by the addition of water to a final content of 80% to a stock solution of β -carotene in EtOH having initial concentration of 50 μM .

The pH dependence of aggregates was investigated by varying the pH of the β -carotene solution having initial concentrations of 100 and 50 μM separately. The pH dependence was made by addition of water with pH 4, 7, 8 and 10 to samples of β -carotene in EtOH. The required pH values were obtained by adding strong HCl/NaOH.

RESULTS AND DISCUSSION

UV-VIS ABSORPTION SPECTROSCOPY

The formation of aggregates of β -carotene in EtOH/water mixtures was studied by UV-vis

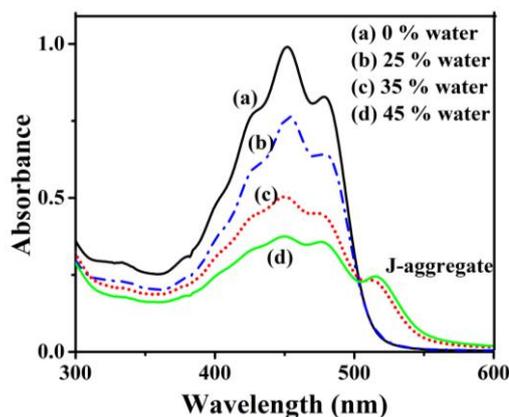


Fig. 2 UV-vis absorption spectra of J-aggregates of β -carotene formed with the addition of water. Initial concentration of β -carotene in EtOH 100 μM .

spectra obtained at different water content in 100 μM β -carotene in EtOH. The results shown in (Figure 2.) indicate that addition of water up to 25 % has not observed any difference in the

spectral shifts and the shapes of the spectra obtained at room temperature. It was observed that the strongly allowed $S_0 \rightarrow S_2$ electronic transition of β -carotene monomer with vibronic features corresponds to 0-2, 0-1 and 0-0 transitions occurred in the 400-500 nm region with maximum absorption at 452 nm. Analysis of UV-vis spectral data of β -carotene aggregates show that aggregation behavior of carotenoids in hydrated solvents depends on several factors. Effects of EtOH:water ratios, initial concentration of β -carotene and the pH of the solution on aggregation behavior are some of the factors determined during the present work.

The formation of J- or H-aggregates with varying ethanol:water ratios was determined by analyzing the UV-vis

absorption spectrum even its vibronic features were retained. The appearance of new red shifted peak around 510-520 nm region with decrease of resolution of the vibrational bands was appeared with increasing the water content upto 35-45 %. The similar type of spectral shift was also observed by (Olsina *et al.*, 2012) for the carotenoid astaxanthin in dimethylsulfoxide solutions.

This red shifted band observed at high initial concentration of β -carotene and at 35-45 % water content could be assigned to the J-aggregates. However, further increasing water content from > 45 %, observed the relative amplitude of red band increases slightly with disappearance of vibrational features of the monomer, clearly indicates the stabilization of the J-aggregates at this conditions (Billsten *et al.*, 2005).

The H-aggregates of β -carotene was distinguished from the monomer by their UV-vis absorption spectra (Figure 3). UV-vis spectra obtained at 50 μ M initial concentrations of β -carotene in EtOH and the addition of 80 % water to the mixture. A new absorption band was observed at \sim 437 nm which is blue shifted compared to the monomer absorption. This band was appearing with the addition of 80 %

water to the 50 μ M concentration of β -carotene in EtOH could be assigned to the H-aggregates (Olsina *et al.*, 2012). However the analysis of band positions suggest that this H-aggregate consists of the strongly coupled H-aggregate band (\sim 437 nm) and a subpopulation of weakly coupled band (as a weak shoulder around \sim 510 nm) as shown by the Fig.3 (b) (dotted line). Therefore it can be suggested that at low initial concentration of carotenoids and low ethanol:water ratios is the preferred conditions for the formation of H-aggregate of β -

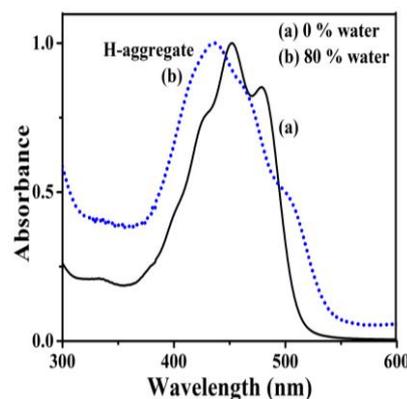


Fig. 3 UV-vis absorption spectra of H-aggregates of β -carotene formed with the addition of 20:80 (v/v) (EtOH/water). Initial concentration of β -carotene in EtOH 50 μ M.

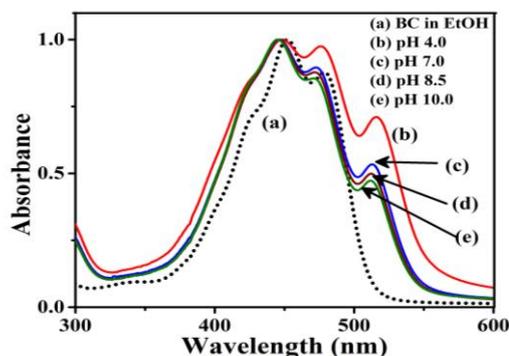


Fig. 4 UV-vis absorption spectra of β -carotene with the addition of 40% water at different pH values. Initial concentration of β -carotene in EtOH 100 μ M. (Normalized at 452 nm).

mixture addition of acidic pH (pH \sim 4) water, the formation of J-aggregate as the distinct peak at \sim 515 nm (Figure 4(b)) was observed. The appearance of a shoulder implies that a very low fraction of H-aggregates could also be formed. However the addition of water with pH \sim 7 and under more basic conditions (pH \sim 8 and 10) the magnitude of red band is decreased (Figure 4 (c,d,e)).

In general, a high initial concentration of β -carotene and ethanol:water ratios are the key factors to produce J-aggregate of β -carotene.

Another important factor that determines the type of aggregate form in EtOH is the pH of the solution. The effect of pH on the determination of either J- and H-aggregate formation was investigated by changing the pH of water added to EtOH solution of β -carotene.

In order to study the pH effect on J-aggregate formation, water having different pH values which was obtained by adding strong HCl/NaOH to β -carotene in EtOH solution with initial concentration of 100 μ M until the final concentration of water reaches to 40 % was analyzed. In this

It was also observed that the variation of pH had little effect on the aggregation pattern beyond pH~7. The H-aggregation of β -carotene can be induced by adding water at different pH values to 50 μ M β -carotene in EtOH up to final concentration of 80%. When acidifying this mixture (pH~4) we could expect clearly to produce only the blue shifted band for H-aggregate as the dominant band. But significantly a high fraction of J-aggregate was also present at low pH (pH~4) value indicated by a peak observed (Figure 5(b)) ~ 515 nm.

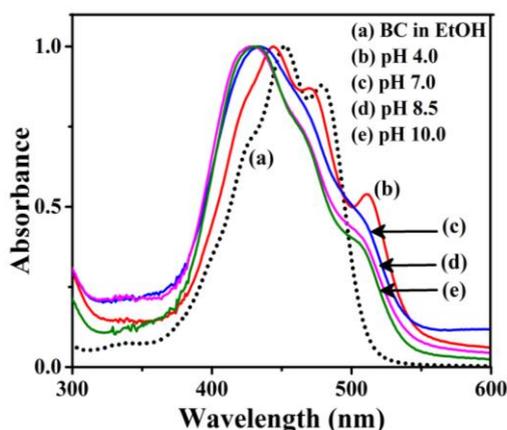


Fig. 5 UV-vis absorption spectra of β -carotene with the addition of 80% water at different pH values. Initial concentration of β -carotene in EtOH 50 μ M. (Normalized at 452 nm).

However at neutral and basic conditions the magnitude of the red band was disappeared and a distinct blue shifted peak at 437 nm was stabilized (Figure 5 (c,d,e)). Interestingly no significant change was observed in the spectra obtained at pH values beyond 7. The carotenoids such as β -carotene which

lack hydroxyl groups can be stabilized by other molecular forces such as π - π stacking or weak van der Waals interactions. In the case of β -carotene two carotenoid molecules are bound each other via weak hydrogen bond between the water molecules and π -electrons of the polyene chain (Wang *et al.*, 2012) and hence favorable for the formation of both aggregates at low pH.

CONCLUSION

Formation of both H-aggregates with blue shifted absorption, maximum around 437 nm and J-aggregates with red shifted absorption band peaking around 490 nm for β -carotene was observed. Formation of H-aggregate is possible under the low initial concentration of β -carotene and low ethanol: water ratios, whereas J-aggregates formed at higher initial concentration of β -carotene and higher ethanol: water ratios. Two β -carotene molecules are bound each other via weak hydrogen bond between the water molecules and π -electrons of the polyene chain and hence favorable for the formation of H-type aggregates. Therefore at low pH (pH ~ 4) both types of aggregates can generate irrespective of the concentration of β -carotene and ethanol: water ratio.

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A SIMPLE GREEN REMEDY OF CHROMIUM FROM LEATHER TANNERY EFFLUENT

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INTRODUCTION

Pollution of aquatic systems results mainly due to industrial effluents in Sri Lanka. The tanning industry in Sri Lanka is relatively a small scale industry. There are about 16 private tanneries in Sri Lanka and mostly situated in and around Colombo. Of the 16 tanneries only one has an effluent treatment plant, but even this does not function effectively due to the inappropriate design, inadequate maintenance and inefficient operations (Mubarak, 1998).

Leather tanning is the process of converting the raw hides/ skins into leather. During this process, Cr (III) is oxidized to Cr (VI). Reducing agents are used to reduce excess Cr (VI) to Cr (III) in the effluent. Mostly all the tanneries discharge their untreated effluent into inland waterways and / or marsh lands. This causes a considerable amount of pollution in the water bodies (Ileperuma, 2000).

Cr (III) is the main component in the tannery wastewater. Although Cr (III) is an essential micro-nutrient, it is hazardous at relatively high concentrations. However Cr (VI) is very harmful. It is carcinogenic, mutagenic and also more toxic than Cr (III). Chromium (III) is relatively stable and slowly oxidized to the much more toxic Cr (VI). The conversion of Cr (III) into Cr (VI) is thermodynamically feasible in water bodies ($\Delta G^\circ = -150 \text{ kJ/mol}$). Hence, there is a need to remove the chromium from the wastewater or reduce it to an acceptable level, before discharging into water bodies.

Biosorption is now recognized as a green remedy of heavy metals from wastewater. *Cabomba caroliniana*, an aquatic plant was selected for this study as it is known to adsorb both Cr (III) and Cr (VI) (Chathuranga *et al.* 2012).

The objective of this study is to investigate the feasibility of application of *Cabomba caroliniana* to remove Cr (III) from leather tannery effluent.

METHODOLOGY

CHARACTERIZATION OF LEATHER TANNERY EFFLUENT

Effluent (50 litres) was collected from a leather factory in Mattakkuliya, Colombo 15. The physical parameters (colour, pH, conductivity and temperature) and the chemical parameter (total chromium content) were measured by using calibrated instruments in the laboratory.

DIGESTION OF TANNERY EFFLUENT

The tannery effluent (25.0 cm³) was pipetted into a test tube of the heating digester. Conc. HNO₃ (5 cm³) and conc. H₂SO₄ (5 cm³) were added to the above sample inside the fume hood. The mixture was heated to 120 °C, until white dense fumes of SO₃ gas appeared. Then 0.5% v/v HNO₃ (15 cm³) was added. The mixture was heated again until the brownish color fumes disappeared. Mixture was allowed to cool. The solution was transferred to a 50 cm³ volumetric flask, and the volume was made up to 50.0 cm³ by using distilled water. The digested samples were stored in a refrigerator until the determination of the total chromium content (Gatew and Mersha, 2013).

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PREPARATION OF BIOSORBENT

Healthy and mature *Cabomba caroliniana* were collected from a water stream in Horana. Plants were thoroughly cleaned and air dried for 2 days and oven dried for 3 days at 60 °C. Dried plant samples were ground to a powder and were sieved through a sieve with pore size 710 µm.

BIOSORPTION EXPERIMENT

The successful biosorption process is greatly affected by ambient conditions such as pH, dosage of biomass, contact time, initial concentration of metal solution, agitation speed *etc.* In order to improve the biosorption process it is essential to optimize these conditions. These conditions were optimized for the biosorption of Cr(III) from the tannery effluent (Ariharan and Thayaparan -manuscript preparation in progress) and reported as pH 4.5, contact time- 45 minutes and dosage of the biomass 4.0 g/100 cm³ of 1500 ppm of tannery effluent. These parameters were used in this experiment which was carried out in two ways as follows.

EXPERIMENT – I

Biomass (7.0 g - calculated from the experiment which was carried out for optimization of biomass) was introduced to one litre of 40 fold diluted effluent (150 ppm). The pH was maintained at the optimized pH 4.5 and ambient temperature was 34 °C in the mesh house. The suspension was mixed thoroughly with a glass rod and kept for 2 hours in the mesh house under natural conditions. Samples from the residual solution were withdrawn at 45 minutes intervals (Figure 1) over 2 hours and analyzed total chromium using Atomic Absorption Spectrometry (AAS).

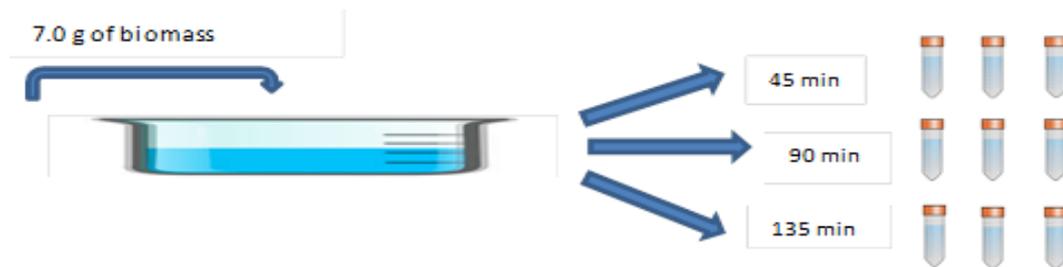


Figure 1. Schematic diagram for Experiment I

EXPERIMENT - II

Experiment I was repeated under the same experimental conditions and by introducing new biomass to the filtrate each time and samples were withdrawn at 45 minutes intervals over 2 hours (Figure 2). All the samples were analyzed for total chromium using AAS.

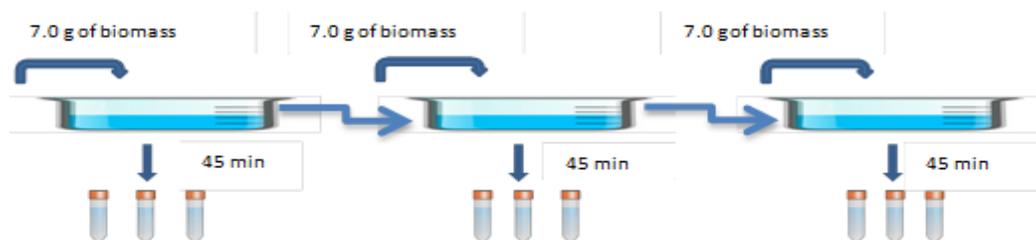


Figure 2. Schematic diagrams for Experiment II

DESORPTION EXPERIMENT

The biomass was loaded with raw tannery effluent under optimized conditions (pH 4.5 and contact time 45 minutes). Then biomass was separated by filtration and washed with tap water followed by distilled water. The filtrate was acid digested and analyzed for total Cr content using AAS. Cr loaded biomass was desorbed under the same experimental conditions with 0.1 M HNO₃, 0.05M H₂SO₄, 0.1 M HCl, 0.1 M EDTA, distilled water and tap water. Finally Cr content in the desorbing agents was analyzed using AAS. Desorption efficiency was calculated.

RESULTS AND DISCUSSION

CHARACTERIZATION OF LEATHER TANNERY EFFLUENT

The physical and chemical parameters are given Table 1.

Table 1. The physical and chemical parameters of the Tannery Effluent

Parameters	Results
Colour	blackish Green
pH	3.72 ± 0.01 at 28.8 °C
Conductivity	57.7 ± 0.01 mS / cm at 28.4 °C
Total chromium (undigested)	3068 ppm
Total chromium (digested)	6333 ppm.

The effluent is very acidic and contains a very high amount of total chromium (~6000 ppm).

BIOSORPTION EXPERIMENT

The result of both biosorption experiment I and II is shown in Figure 3.

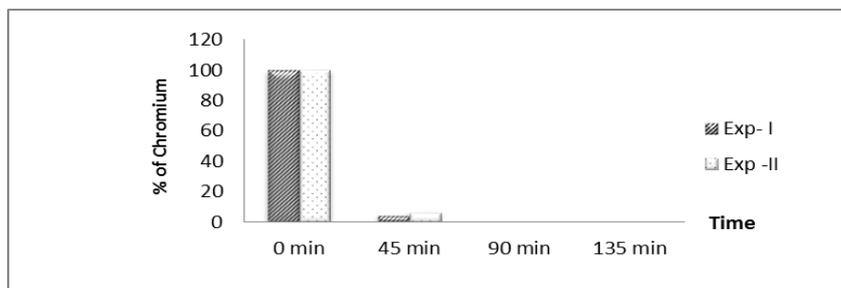


Figure 3. Percentage chromium remaining in the residual solution with time.

It was observed that after the first 45 minutes, the percentage of chromium in the residual solution of both experiments (Experiment I and II) was 4.72% and 6.66% respectively. No chromium was detected after 90 minutes in both experiments. This result indicated that 7.0 g biomass removed around 95% of the total chromium from the diluted tannery effluent (~150 ppm) at pH 4.5 and ambient temperature 34 °C within one hour.

DESORPTION EXPERIMENT

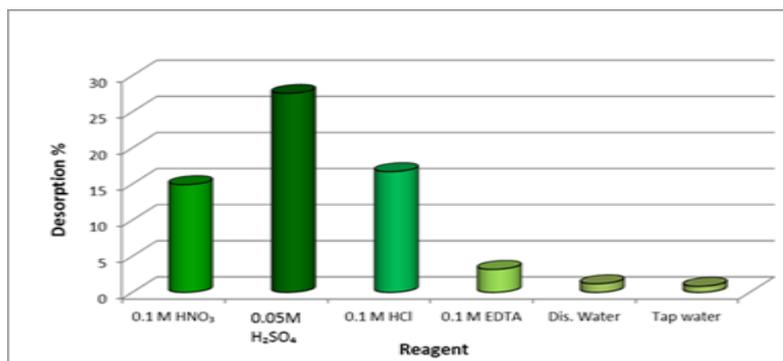


Figure 4. Desorption of Cr from Cr- loaded biomass with different desorbing agents

Among the acids used, H₂SO₄ desorbed more total chromium (27%) from the biomass (Figure 4). It may be due to the relative affinity of sulphate anion towards chromium. It is reported that percentage desorption can be increased by increasing acidic strength of sulphuric acid (Ferraz *et al.* 2004).

CONCLUSION

Leather tannery effluent contained a very high amount of total chromium (~6000 ppm). This method is simple and biosorption is very rapid. It can be applied to Industrial effluent / wastewater at the site as a cheap, eco-friendly green remedy. Adsorbed chromium can be recovered (~30%) using H₂SO₄ from the Cr-loaded biomass in one cycle. It may be possible to use *Cabomba caroliniana* as a biosorbent to remove Cr(III) from leather tannery effluent/ wastewater.

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MODEL-BASED ANALYSIS OF INTERNATIONAL TOURISM INCOME OF SRI LANKA: POST-WAR PERIOD

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INTRODUCTION

The tourism industry is one of the fastest growing industries in Sri Lanka, especially after 2009 with the end of 3 decades of war. Over the past years, international tourism in Sri Lanka has shown growth by value. The foreign exchange earnings from international tourism industry in Sri Lanka increased from Rs 37,506 million (US\$ 326.3 million) in 2009 to Rs. 221,147.1 million (US\$ 1,715.5 million) in 2013 (SLTDA, 2013). Sri Lanka Tourism Development Authority reported the rank of the tourism has increased up to fourth level as the largest source of foreign exchange earnings of the Sri Lankan economy in 2013.

RESEARCH PROBLEM

Forecasting is an essential planning tool that helps any industry to cope with the uncertainty of the future. According to Witt and Witt (1995) and Song and Witt, (2006) finding appropriate forecasting techniques is essential for planning at all levels. There were many attempts done for forecasting the volume of tourism as well as the demand for tourism. But least attempts were found for forecasting the value of tourism. Therefore, this study was designed to fill that knowledge gap. On view of the above, the current study was focused to identify a suitable econometric model for forecasting international tourism income of Sri Lanka.

METHODOLOGY

Autoregressive Distributed Lag Model (ADLM) is commonly used within the tourism industry to model the tourism demand. Yi-Yi (2010) defines that the regressors may include lagged values of the dependent variable and current and lagged values of one or more explanatory variables. Chau, (1970) applied the same ADL approach for forecasting income and employment. ADLM with log transformation used and model in this study is;

$$\log Y_t = \alpha + \beta_1 \log Y_{t-1} + \beta_2 \log Y_{t-2} + \dots + \beta_n \log Y_{t-n} + \varepsilon_t \quad (1)$$

Monthly income data from 2009 to 2013 were obtained from statistical reports of 2012 and 2013 by Sri Lanka Tourism Development Authority (SLTDA). Study concern the period of post war, which is after the year 2009. Model fitting was done by utilizing data from January 2009 to April 2012 and data from May 2012 to May 2013 utilized for model verification. ADLM was tested on forecasting tourism income at different lags. One- way Analysis of Variance (ANOVA) technique was used for overall model testing and t-test was used for individual parameter testing. Residual plots, Anderson Darling and Durbin Watson tests for residuals were used as a model validation criterion. Forecasting ability of the models was assessed by considering adjusted R² (R-Sq adj), Mean Absolute Percentage Error (MAPE), Mean Square Error (MSE) and Mean Absolute Deviation (MAD). Three measurements of errors as follows;

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$$MAPE = \frac{1}{n} \sum \left| \left(\frac{Y_t - F_t}{Y_t} \right) \right| \cdot 100 \quad (2)$$

$$MAD = \frac{1}{n} \sum | (Y_t - F_t) | \quad (3)$$

$$MSE = \frac{1}{n} \sum (Y_t - F_t)^2 \quad (4)$$

Where; Y_t = Observed value of time t, F_t = Forecasted value of time t

RESULTS AND DISCUSSIONS

Box and whisker plot showed one outlier and it was removed. The model tested with six lags at the first stage. The model as follows:

$$\log Y_t = \alpha + \beta_1 \log Y_{t-1} + \beta_2 \log Y_{t-2} + \beta_3 \log Y_{t-3} + \beta_4 \log Y_{t-4} + \beta_5 \log Y_{t-5} + \beta_6 \log Y_{t-6} + \varepsilon \quad (5)$$

The ANOVA output of the above model presented in the table 1.

Table 1. ANOVA table for model with six lags

Source	DF	SS	MS	F	P
Regression	6	0.91035	0.15173	45.83	0.000*
Residual Error	33	0.10925	0.00331		
Total	39	1.01961			

P value of ANOVA = 0.000 < α = 0.05. It clearly showed that there is a linear relationship between the variables $\log Y_{t-1}$, $\log Y_{t-2}$, $\log Y_{t-3}$, $\log Y_{t-4}$, $\log Y_{t-5}$ and $\log Y_{t-6}$, with $\log Y_t$. The next step of the study was to test the individual regression coefficient. Results available in table 2.

Table 2. Summary table for regression Coefficients with all lags

Predictor	Coef	SE Coef	T	P
Constant	0.4532	0.3263	1.39	0.172
$\log Y_{t-1}$	1.1327	0.1389	8.16	0.000*
$\log Y_{t-2}$	-0.6472	0.2141	-3.02	0.004*
$\log Y_{t-3}$	0.1009	0.2444	0.41	0.682
$\log Y_{t-4}$	0.5637	0.2527	2.23	0.031*
$\log Y_{t-5}$	-0.5638	0.2286	-2.47	0.017*
$\log Y_{t-6}$	0.3592	0.1390	2.58	0.013*

The results of the table 2 revealed that, except variable with lag 3, all other variables were significant. Their P values were < α = 0.05. The next step of the analysis was fitting models with different significant lags and select the best model for forecasting. Various combinations of lags were tested. The Durbin Watson statistics of the models were between 2 and 4. If the

Durbin Watson statistic value falls between 2 and 4, then residuals are negatively correlated. Therefore, such models cannot be taken for forecasting. Model with variable lag 1 confirmed the normality and uncorrelated of residuals: P value of Anderson Darling test was 0.155 and Durbin Watson statistic was 1.65. Adjusted R² of the model is 86.1%. As such the best fitting model was;

$$\log Y_t = 0.745 + 0.907 \log Y_{t-1} \tag{6}$$

Table 3 gives the summary outputs of model fittings and verifications of model (6).

Table 3. Summary outputs of model fittings and model verifications

Model	Model Fitting		Model Verification	
	$\log Y_t = 0.745 + 0.907 \log Y_{t-1}$	R-Sq(adj)	86.1%	
	MAPE	0.872	MAPE	0.869
	MAD	0.068	MAD	0.070
	MSE	0.006	MSE	0.006
	Normality	0.155		
	Durbin Watson	1.65		

MAPE values of fitting and verification of model with lag 1 were 0.872 % and 0.869% respectively. Mean Absolute Deviation (MAD) and Mean Square Error (MSE) also very small.

Figure 1 and 2 shows that fits and forecasting values of model with lag 1 are very close to the actual values.

Figure 1. Actual Income Vs Fits

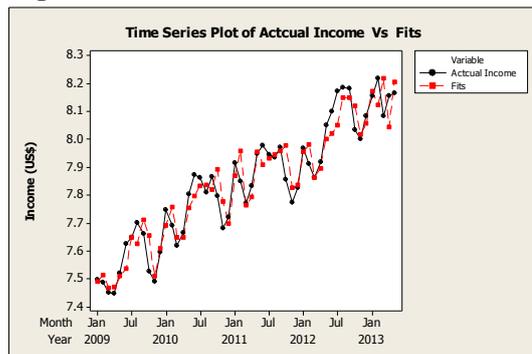
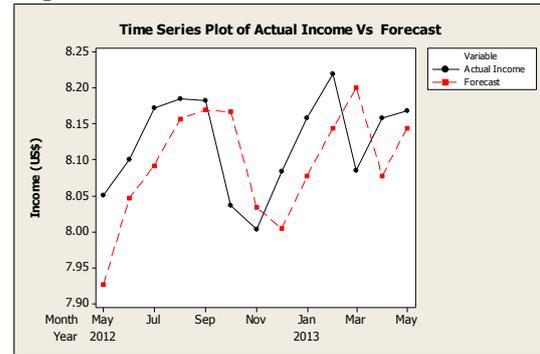


Figure 2. Actual Income Vs Forecast



ONCLUSIONS AND RECOMMENDATIONS

This study was a model based analysis on forecasting international tourism income in Sri Lanka. ADLM were tested with log transformation for the post war period in Sri Lanka. Models with different lag combinations were tested and it was concluded that ADLM with log transformation is suitable in forecasting international tourism income in Sri Lanka.

Figure 1 shows that actual income data has an increasing trend with a wave like pattern. In general waves can be explained by Auto Regressive Integrated Moving Average (ARIMA) models. Konarasinghe and Abeynayake (2015), and many others have given evidence for the success of ARIMA models in explaining wave like patterns. However, the trend has to be captured first. Therefore, it is recommended to do the trend analysis first, detrend the data and test ARIMA models in forecasting international tourism income in Sri Lanka.

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CONSUMPTION BEHAVIOR ON FRESH AND PROCESSED FORM OF FISH IN RATHNAPURA DISTRICT

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INTRODUCTION

Fish are important in the Asian context, where they contribute significantly to overcome the risk of under nutrition and malnutrition. Sri Lanka is blessed with adequate fish resources for consumption. Both fresh and processed fish products are an important source of animal protein providing around 70% of the animal protein consumed in the country (MFARD, 2013). The Medical Research Institute (MRI) of Sri Lanka has indicated that an average per capita consumption of 60 grams of fish per day would be satisfactory to ensure adequate nutritional status. It has increased from 22 grams per day in 2009 to 45 grams per day now but it is far below the target of 60gms/ day. Fish products also serve as remedy for thyroid problems, and patients with goitre are encouraged to eat sea food. However, consumer behaviour and choice attitude have a significant bearing on the fish market development in Sri Lanka.

In order to identify the factors affecting consumer buying behaviour on fresh and processed fish this study was undertaken in the Rathnapura District. Rathnapura is a district with a high incidence of poverty and malnutrition issues and rising inequality. Though district level fish consumption levels are unknown, it can be inferred that like in the other social and health indicators, fish consumption also would be one of the lowest in Sri Lanka. This paves the avenue to base the research in the Rathnapura District. The objectives of the study are (a) To identify the purchasing pattern and buying behaviour of fresh and processed fish consumers in the study area, (b) To investigate whether there is an association between socio economic factors and fish consumption.

METHODOLOGY

The research type adopted was descriptive with a survey strategy. By using the multistage sampling method, 122 sample sizes were selected. It was periodically done by selecting 3 district secretarial divisions from the Rathnapura district and then 10 Grama Niladhari (GN) divisions among them. Primary data were collected by personally delivering the questionnaire to the respondents at their residence through a pretested questionnaire. It included mostly ranking based questions and a few open ended questions regarding their fish consumption patterns for fresh fish and processed fish products. All the quantitative data were analyzed by using the analytical tools of descriptive analysis, and chi-square analysis. This seemed to be the best approach for analyzing preferences and patterns. Microsoft Excel and SPSS 16 were used as Statistical Analysis Software.

RESULTS AND DISCUSSION

The sample was equally represented by males (49%) and females (51%). Among them 65% were married and the rest were unmarried. Age category representation was as follows; 20-30 years (25%), 30-40 years (23%), 40-50 years (19%), 50-60 years (16%) and above 60 years (17%). Most of the respondents were from Semi urban areas (48%) followed by urban areas (41%). The educational levels were as follows: primary education (20%), G.C.E O/L (23%),

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G.C.E. A/L (31%), Diploma (8%), Degree (16%) and other (2%). Most of them were Buddhists (83%), followed by catholic (8%), Hindu (7%) and Muslims (3%). The majority of them were receiving a monthly income between Rs. 25,000 to Rs. 40,000 (44%). Little over 30% were receiving between Rs. 12,000 to Rs. 25,000.

The influence for the buying behaviour of fresh marine fish was identified by different factors through the RBQ method and it was stated that about 60% of respondents consider the freshness of the fish while about 41% and 32% care about fish variety and the price accordingly. So this result has obviously support the previous studies which Houston *et al.* (1996) contended that freshness is the primary concern of Omani consumers. So comparatively the price seems to be a less important factor to the respondents when it comes to the purchasing decision.

The total average fresh fish consumption by the respondents was between 0.5- 4 kg per month (55%). This cannot be accepted as a satisfactory amount; since the consumption of marine fish among some respondents was greater than the average amount of fresh fish consumed, as can be seen in figure 1. So the average fresh fish consumption could be said to be at a poor consumption level.

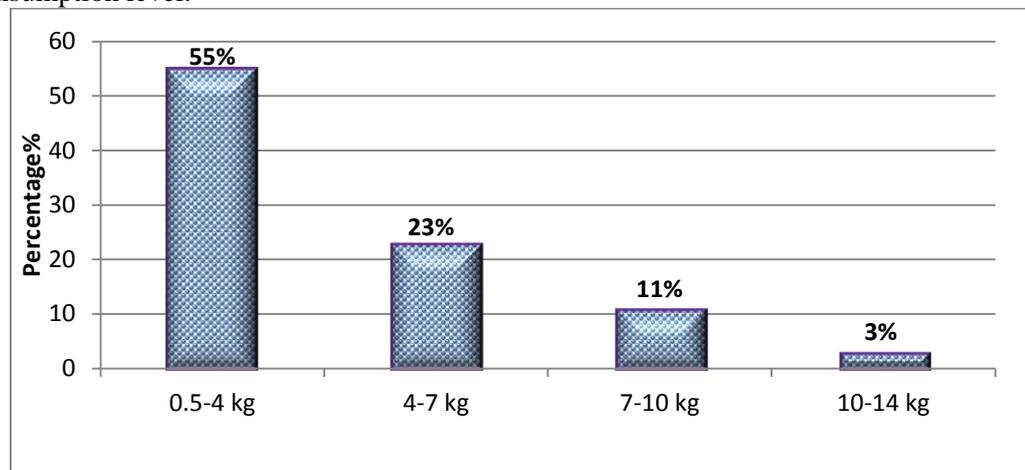


Figure 1. Fresh fish amount eaten by consumers per month

Preferences of respondents regarding places to purchase fresh fish were asked, stating more than one choice is possible. The most preferred place was the fish market (39%) followed by the Fisheries Department (32%) and mobile vendors (31%). This reveals that in order to get more fresh fish, the respondents choose the Fisheries Department. Also it is noted that the majority of the respondents consume fresh marine fish, more than once a week.

The factors which influenced the purchasing behaviour of processed fish were also identified through the RBQ method. Most of the respondents (about 30%) purchase them as they are easily available in the market, also the easiness of preparing the processed fish. Good taste was another major reason for people (about 24%) to purchase processed fish. So the fish processors have a good opportunity to identify the market trends and supply more processed fish fulfilling the above conditions. The highly preferable processed fish type was dried fish (39%) rather than the other processed forms (canned fish, whole dried fish and sprats). The consumption frequency is at least one meal per day.

For the first objective, the relationship between socio economic factors and the consumption of fresh marine and processed fish is tested by using the chi-square method. Null hypothesis were set for each socio economic character that there is no association between them and the consumption of fresh and processed fish (Table 1).

Table 1. Association between socio economic factors and consumption of fish types

Factor	Chi Square value		Degrees of Freedom		P value	
	Fresh	Processed	Fresh	Processed	Fresh	Processed
Locality	1.996	5.676	2	4	0.369	0.225
Gender	3.673	1.117	1	2	0.005*	0.572
Age	4.259	27.282	5	10	0.513	0.002*
Religion	4.8882	6.709	3	6	0.181	0.349
Education	6.503	21.471	5	10	0.260	0.018*
Income	6.073	8.536	4	8	0.194	0.383
Marital Status	8.538	26.530	1	2	0.003*	0.000*

Gender has a significant difference ($p \geq 0.05$) in the consumption of fresh marine fish and that result did not support the previous studies which say that gender does not affect the fish consumption levels (Myrland, 1998). Marital status also has an important difference, with only 11% married respondents declaring that they did not consume fresh marine fish, while the rate was 16% for singles. This shows that being part of a family has an important effect on the consumption of healthy foods. Locality, age, religion, education and income were totally independent according to χ^2 independence tests. On the decision concerning consumption of processed fish, age, education and marital status have a significant difference.. Marital status, as mentioned earlier, is not independent, 18% of the married persons accept that they do not consume processed fish and 28% is the rate for singles. This result is helpful to prove our previous decision about consuming fresh fish. The education level of course, is not independent, but the consumption values are varied from level to level. Age is also related to the consumption of processed fish, with 19% of those who consume fresh fish being of the age category of 30-40, and those not consuming fresh fish in the age category of 20-30 years being 19%.. It seems a vice versa relationship. Locality, religion and income have again become independent. So from that statement, the ultimate decision revealed through this study is that the respondents in the study area consume both fresh and processed fish regardless of any external factors.

Table 2. Association between educational level and consumption frequency of fresh fish

Factor	Chi Square Value	D. F	P value
Educational level	48.463a	30	0.018

Here according to the observations in table 2, the educational level has a significant difference with consumption frequency. Although the consumption decision of fresh marine fish seems to be independent, according to χ^2 independence tests, the consumption frequency is not independent of education ($P < 0.05$). This means that there might be a potential for suppliers to supply better quality fish products to consumers according their educational levels.

CONCLUSION

The current study shows that many people are more concerned about the freshness and the variety of fish they purchase rather than the price. Therefore, it is important to pay much attention to the above factors when providing fresh marine fish.

The average fresh marine fish consumption is at a low level in the study area and therefore, immediate steps should be taken to increase production. Increase in the quality of fish sold in super markets and the street sellers will help to increase the demand for fresh marine fish. Fish processors should identify the future trends and seek innovative ways to increase production and protect the healthiness of processed fish. The findings about the consumer purchasing behaviour mentioned above may be helpful to the seafood sector to increase fish consumption or for developing new processed fish products among the Sri Lankan population.

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THE PROTECTION OF GEOGRAPHICAL INDICATIONS IN DEVELOPING COUNTRIES: THE CASE OF CEYLON TEA

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INTRODUCTION

In the last two decades, the protection of Geographical Indications (hereinafter referred to as GIs) has gained worldwide recognition as a theme of industrial property protection in the global Intellectual Property (hereinafter referred to as “IP”) law agenda, attracting both economical and socio-cultural value to them. According to the Section 161 of the Intellectual Property Act, “a GI means an indication which identifies any goods as originating in the territory of a country or a region or locality in that territory where a given quality, reputation or other characteristics of the goods is essentially attributable to its geographical origin.”¹ For example, *Indian Basmati*, *French Champagne*, *Italian Parma ham*, *Feta Greek Cheese*, *Colombian Coffee*, *Ceylon Tea*, *Mexican Tequila*, *Portuguese Porto wine* etc...

According to the definition embedded in Article 22(1) of the Trade Related Aspects of Intellectual Property Rights (hereinafter referred as TRIPS) Agreement², a GI has inherent qualities which can be attributed to its origin. Generally speaking, a GI serves as the marketing tool, providing consumers the information about special qualities and attributes of a product. It is not easy to establish a reputation as a GI. It requires long time, patient application and sustained commitment. Therefore, the owners of GIs are required to take necessary measures against direct or indirect use of any false indication, unfair competition or any other malpractices in relation to GIs. As some scholars have pointed out GIs are not exclusively commercial or legal instruments, they are multi-national. They exist in a broader context as an integral form of rural development that can effectively advance commercial and economic interests, while fostering local values such as environmental stewardship, culture and tradition.”³

The main objective of this research is to analyse and make suggestions on the existing IP protection pertaining to GIs in Sri Lanka. It also attempts to make in-depth analysis of the law relating to GIs internationally, as well as domestically. Moreover, it discusses the pros and cons of the influence of TRIPS agreement on GIs. Furthermore, it explores lessons from successful experience of other jurisdictions such as from India, in particular, the case of ‘Darjeeling Tea’ for the purpose of evaluating Sri Lankan protection for, ‘Ceylon Tea’. Finally, it offers suggestions to enhance the existing legal regime in Sri Lanka.

METHODOLOGY

This study is a normative research and thus based on literature review. Moreover, primary and secondary sources are used to carry out the research. The literature review includes legal instruments such as statutes, international conventions, published research on GIs.

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¹ Intellectual Property Act, No.36 of 2003

²At the end of the Uruguay Round of the General Agreement on Tariffs and Trade (GATT) in 1994 TRIPS agreement was implemented to regulate standards of IPR Regulations in World Trade Organization (WTO) members. This considers as the most comprehensive multilateral agreement on Intellectual Property ever.

³Daniele Giovannucci - Tim Josling - William Kerr - Bernard O'Connor - May T. Yeung, “Guide to Geographical Indications: Linking products and their origins”, Geneva: ITC, 2009. xix, vii

Furthermore, the case studies on other countries such as Darjeeling Tea, Italian Parma Ham are used extensively on the subject matter to enrich the research as to find its objectives.

RESULTS AND DISCUSSION

The contemporary importance of GIs is basically derived from development and business aspect of them. In terms of developmental aspect one can discuss its socio-cultural value and environmental-ecological value. GIs can directly help create rural employment, on one hand, and on the other hand, they provide a structure to promote Intellectual Property rights while promoting the socio-cultural values embedded in indigenous life style of a particular community.

For an example, tea is grown in hill country regions of Sri Lanka since the colonial era and it has acquired well known GI name for “Ceylon Tea” for centuries. In this area, the whole rural lifestyle is established based on tea culture. Sri Lanka relies overwhelmingly on its most famous GI, the Ceylon tea, which brings in nearly \$700 million in annual export earnings and provides employment to over 1 million people.⁴ It provides many job opportunities to countryside residents who lack of education and who are not skilled labours. If the hill country tea industry is neglected, it would certainly create a major blow on the national economy of the country and to the rural lifestyle of the hill country⁵.

The laws relating to GIs are deprived from common system but distinct forms of protection can be seen in different countries and regions.⁶ Nevertheless, there are three main approaches to protect GIs in different jurisdictions:

- The use GIs specific laws or *sui generis* systems
- The use of trade mark system or other legal or administrative means
- Some countries do not formally recognize or protect GIs

There are, at least, more than hundred countries where GIs are recognized as a separate type of intellectual property and *sui generis* protection of GIs are in place.⁷

Even more importantly, the TRIPS Agreement set out a more comprehensive interpretation on GIs in Article 22(1), 22(2) (a), 22(2) (b) and 22(3) than any other international agreements. It can be observed that TRIPS mandates two- tiered model of protection on GIs.⁸ Basically, it gives specific and additional protection for ‘wine’ and ‘spirits’, but leaving the legal means of protection to individual countries for other agricultural products and foods. While TRIPS providing higher level of dilution-type protection mechanism for wine and spirits, it only provides minimum safeguards of protection on non-alcoholic GIs. Therefore, the developing countries who own GIs other than wine and spirits have to bargain for a proper system to protect their GIs in the global arena.⁹ However, any such initiatives have been prevented by

⁴Surbhi Jain, “Effects of the Extension of Geographical Indications: A South Asian Perspective”, Asia-Pacific Development Journal, Vol. 16, No. 2, December 2009, at p17.

⁵In 2009, Sri Lankan Tea production is contributed to earn 534,140million rupees (value added % is 1.6 of Gross Domestic Products), source; Economic and Social Statistic of Sri Lanka, 2011, at <http://www.cbsl.gov.lk>

⁶the basic guidelines for GI are illustrated in several international agreements. such as; Paris Convention of 1883, Madrid Agreement of 1891, Lisbon Agreement of 1958, and TRIPS Agreement

⁷Argentina, Chile, Colombia, Costa Rica, European Community, India, Iran, Nicaragua, Qatar, Sri Lanka and Thailand are instances for countries using *sui generis* GIs protection.

⁸84% of GIs are attributable to four product categories, wines (61.4%), sprits (9.5%), agro (6.7%) and cheese (6.5%). International Protection on Geographical Indications and Developing Countries, South Center, TRADE Working Papers no 10, 2001.

⁹Most of non-alcoholic GIs are originated in developing countries, for example; ‘Ceylon Tea’ in Sri Lanka, ‘Antigua Coffee’ - Guatemala, ‘Darjeeling Tea’ -India, ‘Gobi Desert Camel Wool’ - Mongolia,

the lack of consensus among different member States of the World Trade Organization (WTO).

There are several identified GIs in Sri Lanka, including; ‘Ceylon Tea’, ‘Ceylon Cinnamon’, ‘Ruhunu Buffalo Curd’, ‘Dumbara Mats’, ‘Malwana Rambutan’, and ‘Bibile Oranges’. As a member of WTO, and country which can probably establish a number of GIs, Sri Lanka has a responsibility to provide legal means to protect GIs. The current protection of GIs in Sri Lanka is governed by provision of the IP Act No. 36 of 2003 (hereinafter referred to as ‘the act’) which may be described as a kind of *sui generis* system. In addition to the Section 161 of the Act, a GI in Sri Lanka can be protected as a collective mark, {Sec. 138 (3)}, certification mark {Sec. 142(1)}, trade mark {Sec. 103 (h)} and under the unfair competition law.¹⁰

On the other hand, India has developed an effective mechanism for the protection of GI in order to prevent violation of GI rights. Indian protection mechanism on GIs can be basically divided into two levels of protection against infringement of GIs viz., the protection of domestic level and the steps taken at international level. At domestic level, the Tea Board of India has registered the ‘Darjeeling Logo’ and the word ‘Darjeeling’ as a certification trade mark.¹¹ India has taken fruitful steps to protect ‘Darjeeling tea’ at international level. Indian Tea Board has registered the ‘Darjeeling logo’ and ‘Darjeeling’ marks in various countries through out of the world such as Canada, Japan, Egypt, the United States and United Kingdom.¹²

CONCLUSIONS/RECOMMENDATIONS

This part aims to analyse the practical issues relating to protection of ‘Ceylon Tea’ as a GI and the legal measures that Sri Lanka should introduced to strengthen the GIs protection at domestic as well as global level. According to the Sri Lanka Tea Board (hereinafter SLTB), production report in 2010, Sri Lankan total tea production was 331426 (metric tons), and has earned 148.6 billion SL Rupees, by exporting pure “Ceylon Tea”. In the global scene, Kenya, China and Sri Lanka accounted for more than 60% of global export of tea.¹³

Therefore, to protect ‘Ceylon Tea’ as well as other GIs in Sri Lanka, it should be given priority to enact proper legal provisions domestically. Registration of Geographical Indications for a particular product in the home country is a pre-requisite for international registration. The Indian perspectives on ‘Darjeeling tea’, Sri Lanka can learn a lot to improve protection for GIs in Sri Lanka. The most important feature of the Indian legislation is that it provides a clear and efficiency registration procedure and registry for GIs. In this regard, Sri Lankan legislation, the Intellectual Property Act, No.36 of 2003 lacks of registration mechanism for GIs.

Establishing a new GI registration system is not be an easy task. It needs patient application and sustained commitment which would also involve high costs, for registration, monitoring and legal enforcement process. Specially, the establishing of a domestic legal framework, defining exact physical boundaries, establishing criteria and standards, marketing and promoting, assessing and applying in overseas involve high costs. Nevertheless, such a system can create a number of benefits such as improving market access, increasing sale,

‘Blue Mountain Coffee’-Jamaica, ‘Kona Coffee’- Hawaii, ‘Pampas beef’, ‘Tellicherry pepper’, ‘Basmati rice’, ‘Rooibos tea’ are well-known agricultural GIs originated in developing countries.

¹⁰ See Section 160 of the Act.

¹¹ This registration is proceeded under the Trade and Merchandise Market Act, 1958

¹² On 3rd August 2001, the UK trade registry granted the word ‘Darjeeling’ under the UK Trade Marks Act, 1994.

¹³ World Tea Production Statistics, Annual ICT Bulletin of Statistics, 2010.

increasing market value and profitability, elevating land values, complementary effects on other products and increasing employment.¹⁴

Enacting a domestic legislation on GIs may be a more effective way to deal with the situation and it can be considered as a preliminary step in protecting GIs.¹⁵ India is one of the best examples in providing effective domestic legal protection for GIs. Therefore, Indian perspectives on GIs could be used affirmatively in developing a specific law on GIs in Sri Lanka. Last, but certainly not least, Sri Lanka has an obligation to contribute to other countries to constitute an effective legal instrument and multilateral agreement on protecting GIs. In sum, if Sri Lanka is to reap the benefits of its GIs, the country should design a sound, competitive, user-friendly, and strong legal regime to protect Geographical Indications.

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¹⁴ *Ibid*, Srivathsava S.C.

¹⁵ Eg: Georgia- Law on Appellation of Origin and Geographical Indication of Goods 1999, Lebanon- Wine Law of 2000, Switzerland- Federal Law on Trade Marks and Indication of Sources 1994, Vietnam- Intellectual Property Law 2005.

FUNDAMENTAL RIGHTS VS DIRECTIVE PRINCIPLES OF STATE POLICY: A COMPARATIVE ANALYSIS OF SRI LANKAN POSITION WITH INDIA.

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INTRODUCTION

Fundamental rights are the rights guaranteed by the Constitution of the country and the directive principles of state policy serve as guidelines for the organs of the state while performing the functions they are legally obliged to do. In Sri Lanka directive principles are designed to be mere guidelines under the Constitution and not enforceable in any court of law¹. Even though the directive principles of state policy have no enforceability before the court of law under Constitution, the judiciary has struck a balance between the concepts of fundamental rights and directive principles of state policy, obliging the state to be bound by both set of standards in India.

The objective of the research is to explore the inter relation between Fundamental Rights and Directive Principles of State Policy in the governance of a country particularly with regard to protection of rights. The research also aims at finding out the suitable approach to be adopted by our courts in the interpretation of both fundamental rights and directive principles of state policy, not giving predominance to one over the other, like the Supreme Court of India.

METHODOLOGY

The research is carried out based on the following hypotheses: the harmonious construction of fundamental rights and directive principles of state policy will contribute to the full realization of the rights guaranteed to the people and the executive and the legislative arms of the government will be kept under control to act in line with both set of standards. The Sri Lankan judiciary has failed to adopt the principle of harmonious construction, oblige the executive and legislature to conduct the respective state functions in compliance with the fundamental rights chapter and the separate chapter for directive principles of state policy and superintend whether they do so in practice

The research is doctrinal in nature and desk based. The relevant Constitutional provisions of both Sri Lanka and India are analysed. The researcher has analysed the case reports decided by the Supreme Court of India and Sri Lanka.

RESULTS AND DISCUSSIONS

Both the First Republican Constitution (1972) and the Second Republican Constitution (1978) of Sri Lanka had a separate chapter on directive principles of state policy in order to guide the law making process and the governance of the country. But both the Constitutions declared directive principles of state policy are not enforceable in any court of law under Article 17 and 29 respectively. On the other hand Article 18 of the first republican Constitution guaranteed certain fundamental rights and Chapter III of the 1978 Constitution deals with fundamental rights. The rights recognized as fundamental rights under the two constitutions are subject to certain limitation via Article 18 and 15 respectively. Notwithstanding the limitations, fundamental rights are expressly declared to be enforceable².

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¹ Article 29, Chapter VI Directive Principles of State Policy, Constitution of the Democratic Socialist Republic of Sri Lanka

² Article 126 of the 1978 Constitution of the Democratic Socialist Republic of Sri Lanka

The 1972 Constitution of Sri Lanka gave the state a virtually blanket indulgence to restrict fundamental rights in the name of directive principles³. Restriction of fundamental rights in the interests of directive principles of the state policy is not permitted under the 1978 Constitution of Sri Lanka, but the state is not constitutionally bound to apply directive principles. The state is merely guided by them. According to Article 27 of the Constitution, the directive principles of state policy shall guide the Parliament, the President and the Cabinet of Ministers in the enactment of laws and the governance of Sri Lanka for the establishment of a just and free society, but when the organs of government act not in compliance with this Article, no citizen could question this matter before any court of law under Article 29 of the Constitution.

Under the Indian Constitution Directive principles are expressly made unenforceable, but they are nevertheless fundamental and it shall be the duty of the state to apply directive principles of state policy⁴. The Indian Supreme Court constantly admits the importance of both Fundamental Rights and Directive Principles of State Policy. The Supreme Court of India insisted in *Minerva Mills Vs Union of India*⁵ that anything that destroys the balance between the two parts destroys an essential element of the basic structure of the Constitution.

The question of the inter relation between fundamental rights and directive principles of state policy arose in *Seneviratne vs U.G.C. in Sri Lanka*⁶. Wanasundara J referred to many Indian cases and held that the UGC's decision to implement the relevant directive principles was reasonably acceptable. The Supreme Court neither permitted the directive principles to restrict fundamental rights nor imposed a constitutional duty on the state to apply directive principles of state policy.

While the fundamental rights chapter of the Constitution of 1978⁷ guarantees certain rights as Fundamental Rights from Article 10 to Article 14 mainly focusing on Civil and Political Rights whereas Article 14(1) (d), 14(1)(e) 14(1)(f) and 14(1)(g) guarantee the freedom to form and join trade union, manifest his religion, the right to enjoy and promote his own culture, to use his own language and freedom to engage in any lawful occupation, profession, trade, business or enterprise respectively which form part of the Economic Social and Cultural Rights. The chapter VI on directive principles of state policy promotes the Economic, Social and Cultural Rights which are not adequately guaranteed under the fundamental rights chapter. The two branches of Human Rights namely, Civil and Political Rights and Economic, Social and Cultural Rights need to be protected and promoted by the three organs of a state simultaneously so that the people realize the full enjoyment of human rights. Chapter VI of the 1978 Constitution is the only constitutional arrangement where adequate reference is made to Economic Social and Cultural Rights in Sri Lanka unlike the Indian Constitution where fundamental rights chapter covers both branches of human rights. In this background, the people of Sri Lanka are denied their substantial rights by the denial of protection of either Fundamental Rights or Directive Principles of State Policy. It is essential that the court must strike a sustainable balance between the concepts giving equal importance to both concepts.

CONCLUSIONS AND RECOMMENDATIONS

When comparing the approach of the Sri Lankan Judiciary and India, we notice that the Indian judiciary has adopted a smart approach in the construction of chapter III and chapter IV the Constitution, fundamental rights and directive principles of state policy respectively. In

³ Section 18(2) of the 1972 Constitution of Socialist Democratic Republic of Sri Lanka

⁴ Article 37 of the Indian Constitution

⁵ AIR 1980 SC 1789

⁶ [1978-79-80] 1 Sri LR 182

⁷ Chapter III of the 1978 Constitution of Sri Lanka

*Re Kerala Education Bill*⁸, Das CJ observed that while directive principles must subserve and not override fundamental rights, in determining the scope of and ambit of fundamental rights “the court may not entirely ignore the directive principles...but should adopt the principle of harmonious construction and should attempt to give effect to both as much as possible”. Likewise in *Golak Nath v State of Punjab*⁹, Court held that directive principles of state policy can reasonably be enforced without taking away or abridging fundamental rights. In *Kesavananda Bharati v State of Kerala*¹⁰, the Court stated that no conflict on the whole between the provisions contained in Parts III and IV. In *Minerva Mills v Union of India* the court observed that parts III and IV together constitute the core of the Indian Constitution and combine to form its conscience to give absolute primacy one over to the other disturbing the harmony of the Constitution.

Apart from Indian Judiciary, it is also important to identify that there exists a developing international opinion regarding the integration of directive principles of state policy with the fundamental rights as can be seen by the United Nations Draft Country Programme for Ghana (2006 -2010) which encourages drawing links between the rights and the directive principles of state policy¹¹.

The Supreme Court of Sri Lanka emphasized the importance of directive principles of state policy in *Re the Thirteenth Amendment to the Constitution Bill*. The attempt to set up a provincial council with legislative power is in compliance with Article 27(4) of the Constitution which requires the state to strengthen and broaden the democratic structure of the government and the democratic rights of the people by decentralizing the administration and by affording all possible opportunities to the people to participate at every level in national life and government, the Court held. Sharvananda.CJ, observed that although directive principles are not enforceable in courts of Law, that shortcoming did not detract from their values as projecting the aims and aspirations of a democratic government. In *Bulankulama v. Secretary, Ministry of Industrial Development (Eppawela case)*¹² Amerasinghe.J emphasized the duty on the part of the state to protect the national environment in line with the directive principles of state policy. Although it is expressly declared in the Constitution that the directive principles and fundamental duties ‘do not confer or impose legal rights or obligations and are not enforceable in any Court or Tribunal’ Courts have linked the Directive Principles to the public trust doctrine and have stated that these principles should guide state functionaries in the exercise of their powers.¹³

Even though the Sri Lankan Courts emphasized the importance of directive principles of state policy in certain cases, neither the judiciary through judicial pronouncement nor the constitution impose a duty on the executive and the legislature to apply directive principles in their respective activities. The hypothesis is accepted that the Sri Lankan judiciary has not attempted well to insist on and explicitly provide for the harmonious construction of fundamental rights and directive principles of state policy there by making the executive and

⁸ AIR 1958 SC 956

⁹ AIR 1967 SC 1643

¹⁰ AIR 1973 SC 1461

¹¹ *Danushka Medawatte, Non enforceability of directive principles of state policy : Real barrier or fake?, E-Newsletter, CSHR, Univeristy of Colombo 12/2012*

¹² [2003] 3 Sri. LR 243

¹³ *Sugathapala Mendis vs. Chandrika Bandaranayake Kumaratunga, SC FR 352/2007*
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the legislature adhere to both fundamental rights and directive principles of state policy equally,

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WATER CRISIS IN NORTH CENTRAL PROVINCE OF SRI LANKA-PAST, PRESENT AND FUTURE PREDICTIONS

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INTRODUCTION

North central province (NCP) comprising two districts called Pollonnaruwa and Anuradhapura is the largest province in Sri Lanka. It falls under the Low Country Dry Zone of Sri Lanka, covering 16% of total country's land area (7,128km²). NCP is well known as the bread basket of the country as it produces the largest portion of rice. A majority of the farmers in the NCP has been engaged in intensive paddy cultivation since ancient time. According to history the Aryan civilization that emerged in Sri Lanka with migration from Bengal, East India in 543 BC took root in the Dry zone, the rolling plains of North and North Central (Rajarata) and the South Eastern (Ruhunu) of ancient Sri Lanka. Even though the land was excellent for agriculture, the difficulty in diverting enough water for cultivations was the main problem. A majority of the rural population in the NCP depends on agriculture as their main source of income. Rice appears to be the most popular crop among the farmers. Other crops cultivated include maize (*Zea maize*), finger millet (*Eleusine coracana*), soybean (*Glycine max*), brinjal (*Solanum melongena*), hot pepper (*Capsicum frutescens*), banana (*Musa spp.*), okra (*Hibiscus esculentis*), pumpkin (*Cucurbita maxima*), etc. which are usually considered to be drought tolerant species.

Rice, being the staple food and cultivated under flooded conditions, requires an abundant supply of water. Farmers cultivate paddy during both *maha* and *yala* seasons, and very often rainfall satisfy only a fraction of the water requirements for a double-cropped rice harvest and the rice fields of these areas are therefore heavily dependent on supplementary irrigation from tanks and reservoirs. Without artificial storage of water, human existence in the NCP is impossible. The NCP, although apparently flat, is in reality undulating, and the ancient kings took advantage of the nature of the terrain to make strings of tanks in the valleys called the small tank cascade system numbered about 30000. Today Sri Lanka has about 10,000 village tanks irrigating the paddy cultivation. These magnificent irrigation schemes of tank cascade systems were developed as the population was dependent on an agriculture-based economy.

The dry zone in Sri Lanka faces a wide range of environmental management challenges that are tied to its economic development. Among these are the interlinked problems of land and water degradation. Over the past two decades, dozens of studies have been conducted on the large number of kidney patients in Sri Lanka's agro-rich NCP (Nanayakkara, et al, 2012). As many as 400,000 people in the NCP may be suffering from kidney disease and as many as 22,000 people may have died as a result. The affected area covers approximately 17,000 square km, with a population of about 2.5 million, in which more than 95 percent live in rural areas (Bandara *et, al* , 2011). Farm animals including cattle have also been affected with strange disorders including poor vision and frequent abortions. Damage of crops from elephants, mismanagement of the water distribution and finding a reasonable market for their farm products appear to be some crucial problems that farmers faced in the past even at present. Having considered the complex situation in the NCP it will be extremely important to transform the present status of farming to an environmentally sound sustainable system – i.e. ecological agriculture. Water is the major factor for sustainable farming. But climate change also has impacts on the availability of water for NCP. Therefore, this study is designed to analyze the past, present and future predictions on the rainfall pattern and design suitable adaptation measures to ensure sustainable paddy and cash crop cultivation, in

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addition to providing safe and clean drinking water for the population to avoid serious health problems.

METHODOLOGY

For the past and present situation rainfall data from Meteorological Department, Colombo for the period from 1951 to 2010 was obtained. The climate change predictions for 2050s in Sri Lanka have been studied using climate change projections of HadCM3- a General Circulation Model of Hadley Centre for Climate Prediction and Research, UK. These predictions were then applied to the IPCC-Emission Scenario A2 (Worst case) (De Silva *et al*, 2007). Two districts, namely Anuradhapura and Polonnaruwa in the NCP were used in this study. Results of HadCM3 for 2050s - A2 scenario were compared with baseline data of 1961 to 1990 as the World Meteorological Department (WHO) recommended.

RESULTS AND DISCUSSION

Rainfall analysis of past to present decade

The meteorological department data for Polonnaruwa from 1951 to 2010 showed that the rainfall during the *Maha* season (second inter-monsoon and northeast monsoon) had decreased by 230 mm over a period of 55 years at the rate of 4 mm/year (Figure 1). Even though this value is not significant the volume of water reduction over 55 years is to be taken in to consideration. The population has increased over the period and the demand for water also has increased. Similarly the rainfall during yala season (first inter monsoon and southwest monsoon) also has been decreased according to the Meteorological department data (Figure 2). There was a decrease of 150 mm of rainfall over a period of 55 years.

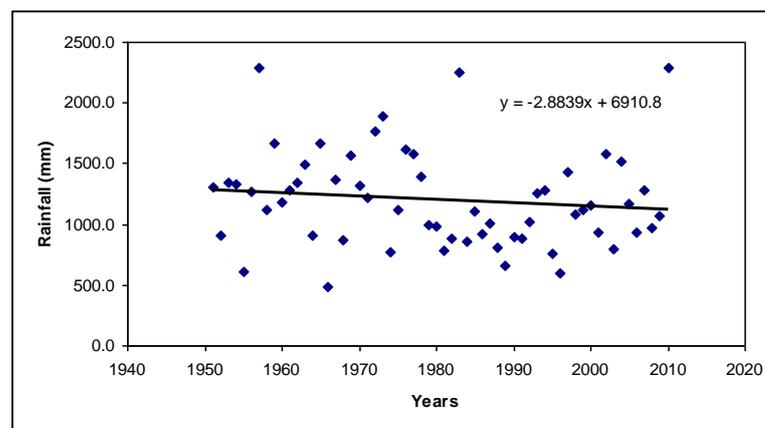


Figure 1. Rainfall variation during the *Maha* season in Polonnaruwa 1951 to 2010

Similarly, in Anuradhapura according to the meteorological department data the rainfall decreased during *Maha* and *yala* seasons approximately at the rate of 2mm/year. Even though this value is not significant statistically and not noticeable, the reduction in the volume of water in the area of the NCP ($2 \text{ mm} \times 7,128\text{km}^2$) has a significant effect on agricultural activities over the past and recent decades. It was reported that in July and September 2012 (Bandara, 2012), drought conditions continued with the lowest rainfall received in May and June, which has devastating effects on agriculture and hydropower generation. The low rainfall has resulted in a drastic drop in water levels in hydro catchments and reservoirs, with severe disruption to hydropower generation, domestic water supply and agriculture. Anuradhapura and Polonnaruwa districts were the worst affected by the drought.

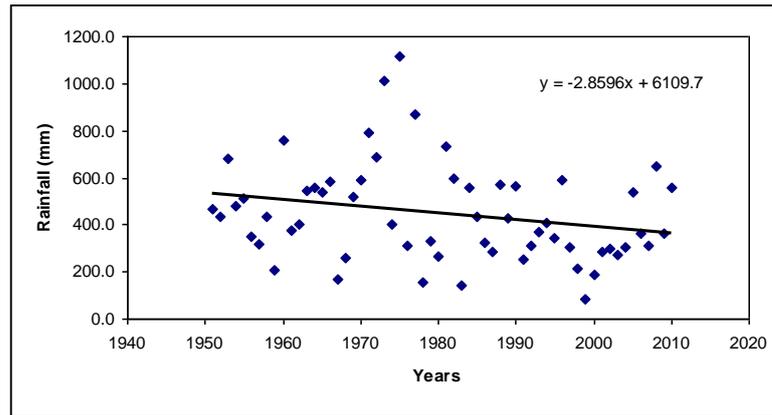


Figure 2. Rainfall variation during the *Yala* season in Polonnaruwa 1951 to 2010

Predictions for Rainfall in 2050

According to the rainfall predicted by HadCM3 for Polonnaruwa there is a drastic decrease in rainfall during the months of January, February and March and slight decrease in April, September and December compared to the base line (1961-1990). A drastic decrease in the northeast monsoon rains in January and February is foreseen and it is predicted to decrease by 37% in 2050 compared to the baseline (Figure 3). This decrease will affect the *Maha* season rains badly on which farmers are heavily depend for their paddy cultivation. Accordingly, the *Maha* season rains (October – February) are predicted to decrease by 12% in 2050 compared to the baseline. Further, the first inter-monsoon (March- April) is predicted to decrease by 84% in 2050 compared to the baseline (1961-1990). This decrease will definitely affect the rains in the *yala* season too. According to the HadCM3 prediction there will be a 10% decrease compared to the baseline during *yala* season (March –September) rainfall in 2050.

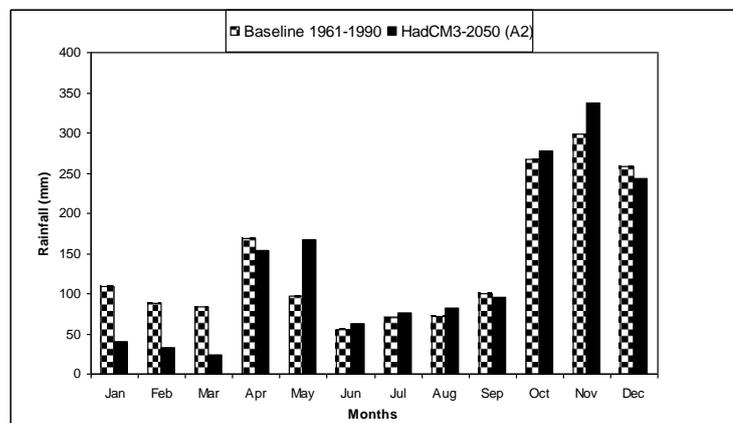


Figure 3. HadCM3 predicted rainfall for 2050 and the basinline (1961-1990) in Polonnaruwa

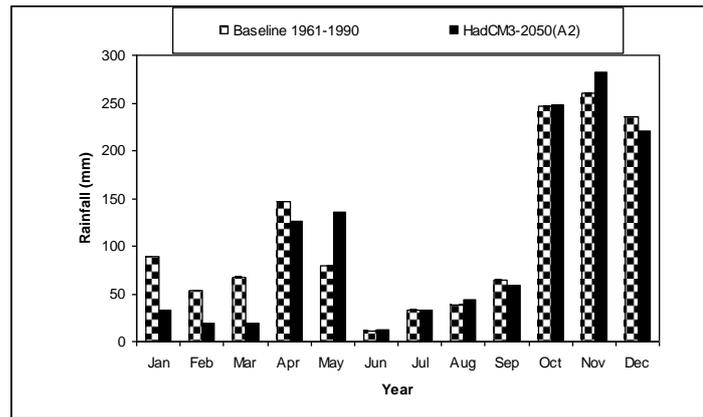


Figure 4. HadCM3 predicted rainfall for 2050 and the baseline (1961-1990) in Anuradhapura

According to the HadCM3 prediction, in Anuradhapura too there will be a drastic decrease in rainfall during January, February and March (Figure 4). There will be a slight decrease in rainfall during April, September and December too. Therefore there will be a 3% and 8% decrease in *yala* and *maha* seasons respectively. Further paddy irrigation requirement is predicted to increase by 18% in 2050 (de Silva *et al*, 2007). Therefore, additional irrigation water is needed for sustainable paddy cultivation.

CONCLUSIONS AND RECOMMENDATIONS

The past, present and future predictions on rainfall indicate that there will be drastic reductions in rain fall during *Maha* and *Yala* seasons and therefore additional irrigation water must be developed for sustainable paddy and other cash crop cultivation in NCP. Reductions in rainfall will pose severe threats to safe and clean water for drinking purposes; therefore treated water supply is mandatory for domestic purposes. Government development programmes should be focused on developing water resources in NCP with special reference to climate change impacts.

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WILL THE DRY ZONE FARMERS COPE WITH CLIMATE CHANGE IMPACTS? A CASE STUDY IN HAMBANTOTA DISTRICT

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INTRODUCTION

Climate change is considered one of the most challenging current global issues. Climate is the totality of above-ground environmental factors, which includes rainfall, air temperature, solar radiation, relative humidity, atmospheric composition, air circulation, and their long-term variation. Agriculture, especially crop production, is highly sensitive to both short and long-term changes in climate. Smallholder farmers are particularly vulnerable to changes in the climate that reduce productivity and affect their weather-dependent livelihood systems negatively.

Agriculture, especially crop production, is highly sensitive to both short and long-term changes. Agricultural production remains the main source of livelihoods for the most rural communities in Sri Lanka as it provides employment for 31 % of the population and contributed 11.1 % to the Gross Domestic Production in the year 2012 (CBSL, 2012). Climate change will have greater negative impact on poor farm households as they have a low adaptive capacity to climatic change. In spite of the technological advances made in improved crop management, irrigation, plant protection and fertilization, weather and climate remain the key factors of agricultural productivity in any country. Whether farmers could use the advanced technology to adapt to the climate change is a crucial question. This paper aims to examine the farmers' perception about climate change and how they could adapt to these impacts.

METHODOLOGY

This study was based on a primary questionnaire survey conducted in three villages of Hambantota district: Weerawila, Pannegamuwa and Weeraketiya with a total sample size of 90 farmers. The main variables measured included demographic variables of the respondents such as age, education, and income, and the information related to climate change, knowledge on climate change adaptation and attitudes on causes of climate change, the effects on cultivation, and the level of adaptation of appropriate technology. Primary data were collected through interview schedules by conducting a social survey. The study areas were mainly dependent on agro wells or the nearby village tank for water. Thus irrigation water was not the main source.

RESULTS AND DISCUSSION

Age Distribution

The age group of the sample population was mainly 31-50 years (55%). The 18-31 year old group represented 27% of the sample population and the above the 51 years old group was only 18% (Figure 1). It showed that the younger generation is also actively involved in agricultural activities as their main livelihood. Therefore it is possible to convince them on new adaptation measures for climate change and to improve their living standards through proper guidance. More than 96% of the respondents have been living in the corresponding areas for 35 or more years. The majority (90%) of the respondents had farming experience of 30 years or more in selected areas.

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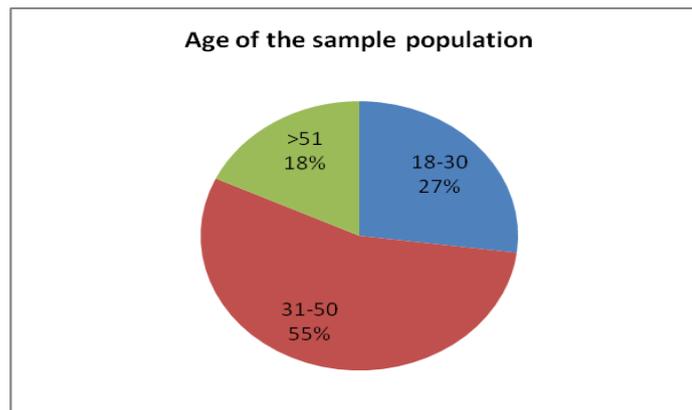


Figure 1. Age groups of the sample population

Demographic Characteristics of the Respondents

All the respondents were involved with vegetables and banana cultivation, and while 83.3% among them were heads of the households and 16.6% were spouses of households. There were 40% needs households involved in fulltime paddy cultivation. An examination of the perception of the paddy farmers and adjustment of their farm management practices in the dry zone of Sri Lanka has revealed that during the last few decades, the pattern of rainfall has significantly changed and the farmers have observed the changes in the climate affecting their livelihood. The increase in average temperature combined with decreased rainfall has forced them to change their traditional paddy cultivation by shifting to vegetable and banana cultivation and self employment.

Information sources

Agricultural information interacts with and influences agricultural sector in a variety of ways. It can help inform decisions regarding land, labour, livestock, capital and management. Agricultural productivity can arguably be improved by relevant, reliable and useful information and knowledge. Hence, the creation of agricultural information (by extension services, research, education programmes and others) is now often managed by agricultural organizations that create information systems to disseminate information to farmers so that farmers can make better decisions in order to take advantage of manage continuous changes in their production systems. But, farmers at Hambantota were not able to receive proper information. They usually use their practical knowledge with the help of friends and shop mudalalis who sell pesticides. They are unable to get good information through proper sources. Therefore, there is a need to understand the functions and use of particular agricultural information systems in order to manage and improve them. Those farmers have no knowledge of what climate change is and the status of water availability.

Knowledge on climate change

None of the farmers know about climate change or had any idea about what will happen due to climate change. They feel the increase in temperature but do not have any knowledge of global warming. No awareness programmes have been conducted by the government or NGOs. The whole sample population eagerly wants to gain knowledge on climate change and how to adapt to that situation.

Availability of water sources

The main water source for agricultural activities of 80% of the sample population is from a wewa or ela nearby whereas only 20 % depend on their agro well/pathaha or domestic well

(Figure 2). Almost 100% of the sample population experience crop damage due to adverse climatic condition. Nearly 80% of the sample population indicated that water is the main constraint for agricultural activities and 20% indicated that they do not have the technology to use the available water efficiently.



Figure 2. (a) Agro well (b) Wewa (c) Pathaha

Water storage is a major problem for agricultural activity in the dry zones of Sri Lanka. Agro wells are being introduced for supplementary irrigation. But the present agro well system does not follow the proper guidance on hydrological properties of the aquifer. The farmers pump water in to their farming lands through the agro wells. Most of them pump water for 3 or 4 hours continuously per day. Therefore, the lack of water in agro wells limits the extent of cultivation. The management of on-field water application systems constitutes a complex problem which farmers are faced with daily. It is often an important bottleneck for efficient implementation and large scale development of advanced irrigation scheduling practices. The irrigation technique of the farmers in Hambantota is very much traditional and it wastes the limited available water resources. Farmers do not have the technical and financial capacity to use sprinkler and drip irrigation methods to save water.

Major drawbacks

To obtain sustainable water savings, it will be mandatory to require a minimum degree of technical quality for systems and to transfer to users a true mastery in managing water in on-farm irrigation systems, so enabling the water losses resulting from heterogeneities in the distribution of water to be controlled. Present irrigation methods used by the farmers in the area of study are shown in Figure 3. This study revealed that the performance of irrigation practices and equipment, especially in the uniformity of water application, is still too low. This is due to farmers lacking the management skills to manage their irrigation systems properly. Consequences include reductions in crop yields and a waste of water resources. In the area of this study only 2% used sprinkler and drip irrigation systems. About 97% used the hose pipe flooding method as shown in Figure 3. All these systems were not suitable in the present condition. Sprinkler irrigation is often considered as being very effective compared to surface irrigation because it enables better control of water application. However, this control is dependent on a good level of quality in the irrigation system design and in the selection of equipment, and also requires that the farmers develop appropriate skills for managing their irrigation system (knowledge and control of the pressures and flows that enable the system to distribute water uniformly over the field).



Figure 3. Using hose pipe to flood the basin.

The major barriers to adaptation are lack of knowledge of adaptation methods (81%), lack of funding (62 %) and absence of prior information on climate change (51 %). Limited availability and supply of location specific technologies and know-how to cope with climate shocks and long term changes are also reasons. Lack of awareness of the complexities of climate change, the causal factors and implications of global warming is the major cause for adaptation to climate change. Agricultural extension service is diluted and one agricultural instructor covers a minimum of 1500 farm families (Dishani and De Silva, 2015). Limited agency support to strengthen adaptive capacity through consistent professional service delivery such as information, credit, relief, insurance, training and technology transfer is the major draw back. Limited local collective efforts, weak local organizations, networking and their engagement with agencies having state responsibility to assist communities cope with effects of climate change are the major reasons for the farmers to cope with climate change impacts.

CONCLUSIONS AND RECOMMENDATIONS

The study revealed that the farmers are incapable of facing the climate change impacts mainly on agricultural activities for livelihood. Lack of awareness, lack of information sharing and the financial status of the farmers are major barriers inhibiting these adaptation measures as they are the socioeconomic determinants of adaptations to climate change in Hambantota district. Specifically, policies should ensure that farmers have access to affordable credit, which would give them greater flexibility to modify their production strategies in response to climate change. Because access to water for irrigation increases farmers' resilience to climate variability, greater investments in smart irrigation are needed. Reforming the pricing policies, clearly defining property rights, and strengthening farm-level managerial capacity should also be emphasized to promote efficient water use. More importantly, given that land reform has increased the number of less experienced and unskilled farmers, extension services need to be expanded with highly qualified personnel.

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STRUCTURAL ASSESSMENT OF MASONRY ARCH BRIDGES IN SRI LANKA

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INTRODUCTION

Masonry arch bridges are one of the oldest and most attractive structural forms of bridge construction in the world. At present, there are about 150 masonry arch bridges on roads and railway networks in Sri Lanka. Most of these bridges are more than 150 years old. The current condition of these bridges is not satisfactory and need urgent attention and maintenance. At the time of construction there was little consideration given to future sustainability. Increase in loading, high traffic frequency and age of masonry arch bridges have directly affected their structural decay. Structural decay has negatively impacted the load carrying capacity of these masonry arch bridges. Hence, it is necessary to assess the load carrying capacity of existing masonry arch bridges and check that bridges remain serviceable.

The capacity of an arch bridge cannot be determined accurately only by assessment. However, it can be assessed with a greater degree of reliability using reliable input parameters and visual inspections, which are required for calculations. Existing damages in arch bridges reduce their structural capacities. Therefore visual inspections are important to determine their capacities. Assessment of masonry arch bridges is a difficult task, because there is no widely accepted and reliable structural assessment procedure. Most of the bridges are in remote areas with limited access and some parts of the structure are hidden from view. The comprehensive evaluation of these bridges and developing an effective structural assessment methodology is critically important in maintaining these bridges in usable condition.

Assessment is a quantitative determination of the capacity of a bridge to carry static and dynamic loads. It is the combined effect of geometric form of structure, the materials used, the structural interaction of the parts and the condition of the structure.

Assessment is necessary for a number of reasons. Perhaps, most important is that bridges deteriorate with time so their capacity to withstand load also declines. The loading to which bridges are exposed also changes with time. The axle loads, numbers of axles and vehicle speeds increase with time, and in the process they might exceed known or unknown safety margins.

The structural assessment of masonry arch bridges is therefore necessary to check that bridges remain serviceable for continued use. A reliable assessment method is needed to ensure that strengthening is used only where necessary, and is as economical and efficient as possible.

METHODOLOGY

The main objective of this study is to propose a more effective assessment technique for masonry arch bridges. The study consists of three phases: (1) literary review on previous theoretical studies on masonry arch bridges; (2) assessment of current conditions of masonry arch bridges in Sri Lanka; (3) utilization of current state-of-art techniques in assessment of a few masonry arch bridges in Sri Lanka. The Military Engineering Experimental Establishment (MEXE) method is used to check the routine strength of existing masonry arch bridges in this research article.

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The MEXE method

Load carrying capacity has traditionally been evaluated using the Military Engineering Experimental Establishment (MEXE) method (or a modified version of this method) for assessment of masonry arch bridges. The MEXE method is a semi-empirical method, which was developed during the Second World War and into the 1950's because the British Ministry of Supply wanted to classify bridges according to the military loads they could carry. This method was derived by the Military Engineering Experimental Establishment based on the work done by Pippard. The method is based on some classic elastic theories and a series of experimental studies. At present, the modified MEXE method is used to find the residual strength of masonry arch bridges in developing countries. Its use in Sri Lanka is rare but in European countries, it is popularly used as a routine strength checking method.

Using the MEXE method

Analysis was carried out using the Modified MEXE method. As stated in the current bridge assessment code BA16/97 [4], the MEXE method may be used to estimate the carrying capacity of arch bridges (Highway Agency 2001).

During the field visit survey, seven arch bridges on the Colombo-Kandy (A1) road, one arch bridge on the Galle-Deniyaya-Madampe (A17) road and six arch bridges on the Colombo-Badulla Railway line were inspected. The Mawenella four span brick masonry arch bridge was selected to illustrate the analysis. A side view of the bridge is shown in Figure 2 and geometric details of the bridge are given in Table 1.

Table 1. Geometric details of the Mawenella Bridge

Geometric parameter	Value
Bridge length (L_b)	69.00 m
Clear span of an arch (L)	15.20 m
Thickness of the barrel (d)	1.00 m
Height of the compacted fill from the crest of the barrel (h)	1.33 m
Rise of the arch at mid span (r_c)	4.90 m
Rise of the arch barrel at the quarter point (r_q)	4.20 m
Number of arches (n)	4

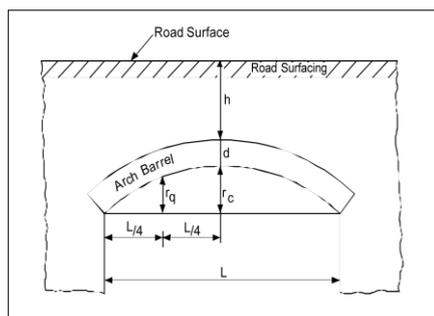


Figure 1. Arch Dimensions



Figure 2. Mawenelle Bridge

Estimation of Provisional Axle Load (PAL)

PAL of the bridge is estimated by using modified MEXE method

$$PAL = 740 \frac{(d + h)^2}{L^{1.3}}$$

$$PAL = 740 \frac{(1.0 + 1.33)^2}{15.2^{1.3}}$$

$$PAL = 116.83 \text{ tonne}$$

The following modification factors have been applied to the calculated value of PAL to

generate the modified axle load. The current bridge assessment code BA16/97 was used to evaluate these modification factors.

Span rise factor F_{sr}

$$L/r_c = 3.1 < 4.0$$

Therefore, $F_{sr} = 1.0$

Profile factor F_p (Clause 3.12)

$$r_q/r_c = 0.9 > 0.75, \text{ (If } r_q/r_c < 0.75, F_p = 1.0)$$

$$\text{Therefore, } F_p = 2.3 \left[\frac{r_c - r_q}{r_c} \right]^{0.6}$$

$$F_p = 2.3 \left[\frac{4.9 - 4.2}{4.9} \right]^{0.6}$$

$$F_p = 0.7$$

Material factor F_m : (Clause 3.13)

Arch barrel consist of engineering bricks and similar sized masonry. Therefore,

$$F_b = 1.2 \text{ (Table 3/1)}$$

Assumed as filling material was well compacted,

$$F_f = 0.7 \text{ (Table 3/2)}$$

$$F_m = \frac{(F_b \cdot d) + (F_f \cdot h)}{d + h}$$

$$F_m = \frac{(1.2 \times 1.0) + (0.7 \times 1.33)}{1.0 + 1.33}$$

$$F_m = 0.91$$

Joint factor F_j : (Clause 3.16)

Width of the mortar joints were about 20mm. Therefore,

$$F_w = 0.8 \text{ (Table 3/3)}$$

Joints were good condition of this bridge and there's not appeared missing mortar.

$$F_d = 1.0 \text{ (Clause 3.16)}$$

Mortar was in good condition. Therefore,

$$F_{mo} = 1.0 \text{ (Table 3/4)}$$

Joint factor (F_j) = width factor (F_w) x depth factor (F_d) x mortar factor (F_{mo})

$$(F_j) = 0.8 \times 1.0 \times 1.0$$

$$(F_j) = 0.8$$

Condition factor F_c :

Condition of the arch was good in the Mawenella bridge. It was found that arch barrels are free of cracks. Therefore,

$$F_c = 1.0 \text{ (Clause 3.18)}$$

Number of spans factor F_n :

In fact, this factor takes in to account the multispans effects of the arch bridge.

For outer arch, $F_n = 0.9$, (arches supported by one abutment and pier)

For inner arch, $F_n = 0.8$, (arches supported on two piers)

The modification factors are applied to the provisional axle load to generate a modified axle load as follows:

$$\text{Modified axle load (MAL)} = (F_{sr}) \times (F_p) \times (F_m) \times (F_j) \times (F_c) \times (F_n) \times \text{PAL}$$

$$\text{For Outer Arch, MAL} = 1.0 \times 0.7 \times 0.91 \times 0.8 \times 1.0 \times 0.9 \times 116.83$$

$$\text{MAL} = \mathbf{53.58 \text{ tonne}}$$

$$\text{For Inner Arch, MAL} = 1.0 \times 0.7 \times 0.91 \times 0.8 \times 1.0 \times 0.8 \times 116.83$$

$$\text{MAL} = \mathbf{47.63 \text{ tonne}}$$

RESULTS

The results obtained with regard to load carrying capacities of the masonry arch bridges are shown in Table 2.

Table 2. Load carrying capacities of Road & Railway masonry arch bridges

Road No.	Bridge No.	Bridge Name	No. of Spans	PAL (tonne)	Modification factors										MAL (tonne)	MAL (tonne)	
					F _{sr}	F _p	F _b	F _f	F _m	F _w	F _d	F _{mo}	F _j	F _c		Outer Arch	Inner Arch
A001	67/5	Bridge at Nelundeniya	1	136.81	0.96	0.50	1.20	0.70	0.91	0.80	1.00	1.00	0.80	1.00	47.85	47.85	
	84/2	Muadimawatta Bridge	1	490.06	0.79	0.89	1.20	0.70	0.80	0.80	1.00	1.00	0.80	1.00	221.54	221.54	
	85/1	Weragoda Bridge	1	556.16	0.78	0.96	1.20	0.70	0.81	0.80	1.00	1.00	0.80	1.00	270.43	270.43	
	88/4	Bridge at Walakadayawa	1	191.56	0.83	0.85	1.20	0.70	0.86	0.80	1.00	1.00	0.80	0.60	55.58	55.58	
	90/3	Bridge at Anwarama	1	1113.11	1.00	0.87	1.20	0.70	0.77	0.90	1.00	1.00	0.90	0.70	468.32	468.32	
	91/1	Mawenella Bridge	4	116.83	1.00	0.70	1.20	0.70	0.91	0.80	1.00	1.00	0.80	1.00	59.54	53.58	47.63
	99/8	Bridge at Gala widapu thena	1	647.02	1.00	0.84	1.20	0.70	0.83	0.80	1.00	1.00	0.80	1.00	361.62	361.62	
A017	64/2	Porupitiya Arch Bridge	1	139.32	1.00	0.91	1.50	0.70	1.06	0.80	1.00	0.90	0.72	1.00	95.93	95.93	
	Mileage	Name or Location of the Arch Bridge	No. of Spans	PAL (tonne)	Modification factors										MAL (tonne)	MAL (tonne)	
					F _{sr}	F _p	F _b	F _f	F _m	F _w	F _d	F _{mo}	F _j	F _c		Outer Arch	Inner Arch
MAIN LINE	168/02	Before Ella railway station	1	156.36	1.00	0.81	1.50	0.70	1.07	0.80	1.00	1.00	0.80	1.00	108.65	108.65	
	168/51	After Ella railway station	3	45.19	1.00	0.68	1.50	0.70	1.30	0.80	1.00	1.00	0.80	1.00	32.21	28.99	25.77
	169/58	Nine Arch Bridge	9	51.46	1.00	0.69	1.50	0.70	1.27	0.90	1.00	1.00	0.90	1.00	40.43	36.39	32.34
	169/63	After nine arch bridge	1	131.83	1.00	0.83	1.50	0.70	1.17	0.80	1.00	1.00	0.80	1.00	102.10	102.10	
	170/26	Before Demodara station	4	80.41	1.00	0.67	1.50	0.70	1.17	0.80	1.00	1.00	0.80	1.00	50.52	45.46	40.41
	171/28	Before Demodara station	2	155.32	1.00	0.77	1.50	0.70	1.25	0.80	1.00	1.00	0.80	1.00	119.06	107.15	-

CONCLUSION AND RECOMMENDATIONS

The MEXE method was used to assess present load capacities of a few masonry arch bridges in Sri Lanka. From the results, it is clear that the MEXE method can be applied in capacity assessment of these bridges. Further, present load capacities of these bridges exceed their live-load applications. Hence, it can be concluded that the above bridges are presently safe even though there is some structural decay. However, it is recommended to perform local modeling of these structural degradations to confirm the effectiveness of these bridges in their load carrying capacities.

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VIABILITY OF USING DEMOLISHED CONCRETE AS A MATERIAL IN SUB BASE APPLICATIONS

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INTRODUCTION

Recycling and reuse of waste materials is a topic of global. The urgent need for recycling is driven mainly by environmental considerations, due to the increased scarcity of natural resources and the increasing cost of landfills in most countries (Aulrajah et al. 2013). Construction and Demolition (C&D) materials are generated as a result of regeneration of infrastructure and demolition activities, and contribute the major proportion of waste materials present in landfills (Aatheesan et al. 2009). Demolished concrete is a viable substitute material for natural construction materials in engineering applications such as its use as a road sub-base material.

Currently, materials used for sub-base constructions are taken from gravel excavation and these resources are depleting rapidly due to large excavations. Therefore, there is an urgent need of finding alternative materials. Recycled demolished concrete and blends are viable substitute material for natural construction materials (gravelly soil) in engineering applications needing sub base materials for pavements. This will help reduce the waste material added to the environment from demolished buildings and will save gravel. In this context, the project seeks to find out the viability of using demolished concrete as a material in sub-base construction.

METHODOLOGY

The physical properties (moisture content, water absorption and specific gravity) of gravelly soil and demolished concrete were determined to compare the properties of demolished concrete with that of gravelly soil. These tests were conducted according to the specifications given in Table 4.

The material blends of gravelly soil and demolished concrete were prepared with varying proportions as shown in Table 1. Sample 1. with 100% gravelly soil was kept as the control sample.

Table 1. Mix Proportions of Gravelly soil and Demolished Concrete

	Sample 01	Sample 02	Sample 03	Sample 04	Sample 05	Sample 06
Gravelly soil	100 %	80 %	70 %	60%	50%	0%
Demolished concrete	0 %	20 %	30 %	40%	50%	100%

The particle size distribution, California Bearing Ratio (CBR) test, Atterberg limits test and Modified Proctor compaction tests were carried out on the above blends of gravelly soil and demolished concrete.

The results obtained from the tests were compared with the ICTAD specifications given in Table 2 and Table 3.

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Table 2. ICTAD Requirement of Sub-base (ICTAD, 2002)

PROPERTY	TEST METHOD (AASHTO)	UPPER SUB-BASE		
			Flexible	Rigid
Liquid Limit (LL)	T-90	Not to exceed	40%	25%
Plasticity Index (PI)	T-90	Not to exceed	15%	6%
Maximum Dry Density (MDD) (Modified)	T-180	Not less than 1750 kg/m ³		
4- day soaked CBR at 98% MDD (Modified)	T-193	Not less than 30%		

Table 3. Grading Requirement for sub-base as per ICTAD Specifications (ICTAD, 2002)

SIEVE SIZE		PERCENTAGE BY WEIGHT PASSING SIEVE
mm	µm	
50		100
37.5		80-100
20		60-100
5		30-100
1.18		17-75
	300	9-50
	75	5-25

RESULTS AND DISCUSSION

Physical properties of gravelly soil and demolished concrete

The physical properties of gravelly soil and demolished concrete are given in Table 4.

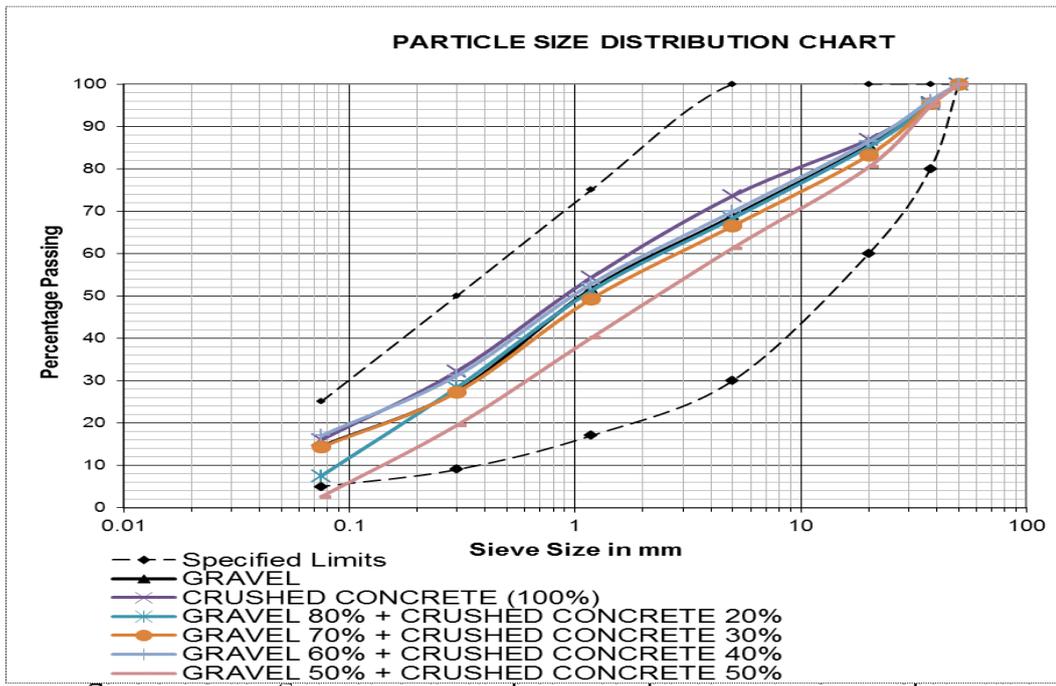
Table 4. Physical Properties of Gravelly soil and Demolished Concrete

	Testing specification	Gravelly soil	Demolished concrete
Moisture content dry%	BS 812-109:1990	2.13	2.19
Moisture content wet%	BS 812-109:1990	1.97	2.14
Water absorption %	BS 812: Part 2:1995	1.12	1.52
Specific gravity	(AASHTO T 85)	2.28	2.64

The dry and wet moisture contents of gravelly soil and demolished concrete do not show a significant difference whereas the water absorption and specific gravity of demolished concrete is slightly higher than that of gravelly soil.

Sieve analysis

The particle size distribution test (sieve analysis) was performed according to BS 812-103.1:1985 and is given in Figure 1.



The gradation requirements of all samples were satisfied as the curves lie within the upper and lower boundaries of ICTAD specified particle size distribution curves.

Liquid limit

The Atterberg limits of gravelly soil and demolished concrete are given in Table 05.

Table 5. Liquid Limit and Plasticity Index

Sample	Limit		
	LL (%)	PL (%)	PI (%)
Requirement	<40		<15
Gravelly soil	36	27	9
Demolished concrete	-	-	NP

Liquid limit and plasticity index of samples were within the standard limits. Plastic limit for demolished concrete with the samples could not be found because demolished concrete is a non-cohesive material.

Maximum dry density of Modified Proctor Compaction test

The maximum dry densities of samples are given in Table 06.

Table 6. Maximum Dry Density

Sample	Sample 01	Sample 02	Sample 03	Sample 04	Sample 05	Sample 06
MDD (kg/m³)	1808	1876	1896	1912	1935	1960
Requirement (MDD > 1750 kg/m³)	Satisfied	Satisfied	Satisfied	Satisfied	Satisfied	Satisfied

Maximum dry density of demolished concrete and in the samples was higher than the value achieved for gravelly soil while all the values satisfied the ICTAD requirement.

4- Day soaked CBR at 98% MDD (Modified)

Table 7. CBR Values of Samples

Sample	Sample 01	Sample 02	Sample 03	Sample 04	Sample 05	Sample 06
CBR (%)	42	55	62	75	101	120
Requirement (4- day soaked CBR at 98% MDD >30%)	Satisfied	Satisfied	Satisfied	Satisfied	Satisfied	Satisfied

4 – Day soaked CBR at 98% MDD for all samples tested were above 30% as per the ICTAD requirement and therefore the ICTAD specification of CBR value was satisfied.

CONCLUSIONS

The moisture content of gravelly soil compared to demolished concrete does not show a significant variation. However, water absorption and specific gravity of demolished concrete is slightly higher than that of gravelly soil. Plastic limit test results shows that demolished concrete is a non-plastic material. The gradation requirement of all samples was satisfied as the curves lie within the upper and lower boundaries of ICTAD specifications. The addition of demolished concrete to gravelly soil increases the maximum dry density of the samples and its CBR value. The requirement of ICTAD specifications for all the samples was fulfilled. According to the test results, demolished concrete can be used as either a partial or full substitute material for gravelly soil in sub-base applications.

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SAW DUST AS PARTIAL REPLACEMENT FOR SAND AND SAW DUST ASH AS PARTIAL REPLACEMENT FOR CEMENT IN THE PRODUCTION OF MASONRY SOLID BLOCKS

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INTRODUCTION

Cement mortar is an artificial and man-made construction material used as binder in masonry solid blocks consisting of natural fine aggregate (sand) ie “cement paste comprising cement and water as the binder”. Naturally existing river sand, fast becoming scarce, is used as fine aggregate for masonry in Sri Lanka and needs to be replaced. The search for an alternative binder or partial cement replacement has led to the use of waste materials believed to have the potential of exhibiting cementitious properties. Saw dust is reused in many applications but some amount remains as waste in the environment. This study investigates the strengths of cement mortar masonry mixes with partial replacement of cement with saw dust and partial replacement of sand with saw dust ash as a way towards eco-friendly construction.

MATERIALS

Cement

The cement as the binding material used in all mortar mixtures for masonry work was ordinary Portland cement (OPC) complying with SLS 107, which belongs to the strength class of 42.5.

Fine Aggregates

Fine aggregate used was in nominal size of 2.36mm (river sand)

Saw dust

A major use of sawdust is for particleboard; coarse sawdust may be used for wood pulp. Other practical uses are, as a fuel and in the growing of mushrooms.

Saw dust ash

Sun-dried saw dust samples were burnt for 2 hours in a muffle furnace at 600 °C for producing saw dust ash.”

Chemical and physical properties

Chemical properties of saw dust ash

Chemical composition of saw dust ash is shown in table (3.1). Pozzolanasity of saw dust ash was checked by using ASTM C 618. The average percentage composition of $\text{SiO}_2 + \text{Al}_2\text{O}_3 + \text{Fe}_2\text{O}_3$ was measured. It was carried out as reported by Rerth and Hanson (2007).

Table 1. Physical properties of saw dust and sand (BS882_199 (B) Percentage passing Grain size(mm)

Chemical properties of saw dust ash	
Chemical constituents	Percentage composition %
SiO_2	17-25
Al_2O_3	20-25
Fe_2O_3	0.5-6
MgO	0.1-4
SO_3	1-2.75
K_2O	1-2.75
Na_2O	1-2.75

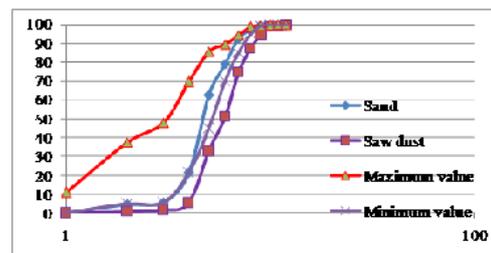


Figure 1. The Grading curve of sand and saw dust

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MIX PROPORTIONS

Weights of cement , sand and saw dust

Table 2. Weights of cement, sand and saw dust in the manufactured samples

Material	Control sample	5%	10%
Cement(g)	1250	1250	1250
Sand (g)	7500	7125	6750
Saw dust (g)	0	375	750

Table 3. Weights of cement, sand and saw dust ash in the manufactured samples

Material	Control sample	5%	10%	15%	20%
Cement(g)	1250	1187.5	1125	1062.5	875
Sand (g)	7500	7500	7500	7500	7500
Saw dust ash (g)	0	62.5	125	187.5	375

Preparation and Casting of Test Specimens

Mixing of the materials was carried out in the following sequence; Design sand amount, cement and saw dust and sand amount, cement and saw dust ash was placed into the mixture separately. During the mixing, design water content was poured into the mix. Masonry blocks were cast for each mix proportion. 3 blocks of 390mm*190mm*100 mm

RESULTS AND DISCUSSION

Compressive Strength (SLS855 part 1)

Blocks were placed in Universal Testing Machine (U.T.M), and load was applied. The readings on dial gauge were recorded and compressive strength was calculated. The results are presented in Table 4 and Table 5.

Compressive Strength = Maximum load/Cross Sectional Area.....1

Table 4. 28 days Compressive strength

Saw dust percentage %	Compressivestrength (N/mm ²)
0	1.92
5	1.79
10	0.81

Table 5. 28 days Compressive strength

Saw dust ash percentage %	Compressive strength (N/mm ²)
0	1.92
5	1.80
10	1.84
15	1.14
20	0.77

Variation of compressive Strength of control sample and saw dust samples

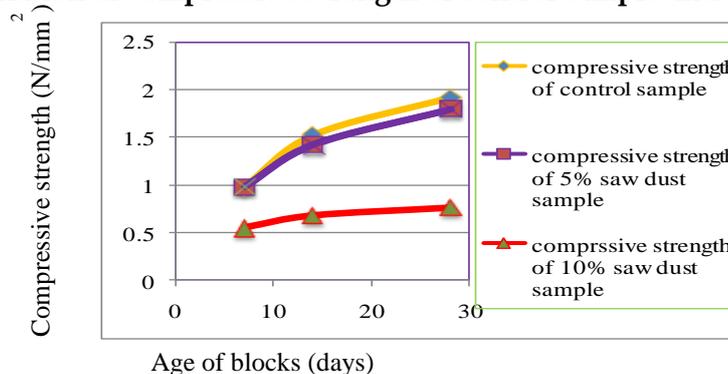


Figure 2. Variation of compressive Strength of control sample and saw dust samples

Variation of compressive Strength of control sample and saw dust ash samples

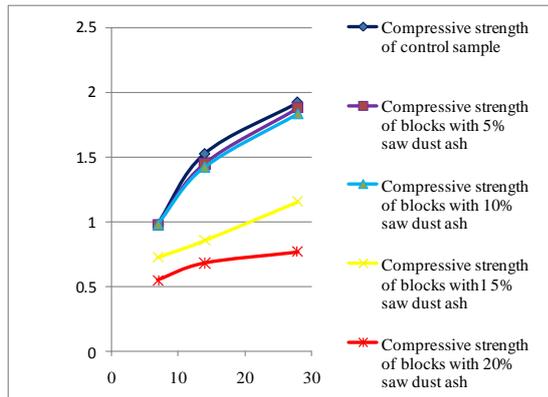


Figure 3. Variation of compressive Strength of control sample and saw dust ash samples

Water absorption of a block (BS5628 part 1)

$$W_a = \frac{W_s - W_d}{W_d} \times 100 = \text{Water absorption of a block}$$

W_s = Mass of wet block W_d = Mass of dried block

Table 6. 28 days water absorption with % saw dust

Saw dust percentage %	Water absorption (%)
0	3.75
5	4.02
10	4.32

Table 7. 28 days water absorption with % saw dust ash

Saw dust ash percentage %	Water absorption
0	3.75
5	5.09
10	5.58
15	5.97
20	6.48

Density of a block

Weight of a block / Volume = Density

Table 8. 28 days density with % saw dust

Saw dust percentage %	Density(kg/m ³)
0	1749.90
5	1742.20
10	1739.00

Table 9. 28 days density with % saw Dust ash

Saw dust ash percentage %	Density (kg/m ³)
0	1749.90
5	1728.00
10	1703.10
15	1673.00
20	1651.10

Specific gravity of materials (ASTM D-854)

Specific gravity

$$G_s = M_o / (M_o + (M_a - M_b))$$

G_s - Specific gravity

M_o – Mass of sample of oven dry saw dust ash

M_a – Mass of pycnometer filled with water

M_b – Mass of pycnometer filled with water and saw dust ash

Table 10. Specific gravity of materials

Material	Specific gravity
Sand	2.50
Saw dust	0.60
Cement	2.83
Saw dust ash	2.05

CONCLUSIONS

Physical properties of saw dust conforms BS_ 882_199B. Standard compressive strength value is 1.2N/mm². Compressive strength value of samples with 5% replacement of saw dust, are satisfied but 10% replacement are not satisfied. Compressive strength of 5% and 10% replacement of cement with saw dust ash samples are satisfied but 15% replacement are not satisfied. Water absorption test results are seen from tables 6 & 7. Water absorption of control sample is 3.75%. The test result values conforms BS5528: part 1. The density of masonry blocks decreases as the saw dust increases but increases as curing days increase.

The results from this research suggest that saw dust can be applied as partial replacement for fine aggregate in masonry blocks, to a limit of 5%, suitable for non- load bearing walls. Saw dust ash can be applied as a partial replacement for cement masonry blocks, to a limit of 10%, suitable for non- load bearing walls. It is recommended that this research be extended with a view to producing low strength building blocks using reduced percentage fine aggregate (sand) replaced by saw dust and reduced percentage of cement replaced by saw dust ash.

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SRI LANKAN CURRENCY NOTE RECOGNIZER FOR VISUALLY IMPAIRED PEOPLE

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INTRODUCTION

In Sri Lanka, visual impairments affect a considerable percentage of the population in various ways. Current estimates suggest that there are approximately 150,000 blind or partially visually impaired individuals in Sri Lanka. Visual impairments significantly impact the quality of life of these people and limit many day-to-day activities, especially handling cash money during financial transactions. Currently, the visually impaired community is using various traditional techniques, which are not very effective, to identify different denominations of currencies. Moreover, visually impaired people in Sri Lanka face a major challenge due to the introduction of new bank note series, because available features for blind people to identify denomination are not very effective. Currency notes are often printed on different sized paper or with different tactile qualities to enable people with visual disabilities to touch and recognize. However, at present, in Sri Lanka, these user-friendly features for the visually impaired are limited. There is only one feature available for visually impaired people to identify the denomination of various banknotes which is a series of embossed dots, which can be sensed by touch. (Figure 1) But these dots become worn out with usage. Also consecutive denominations only differ by 5 mm from each other and the difference is limited to length. This 5 mm length difference is not sufficient for the visually impaired to identify various denominations of new currency notes.



Figure 1. Blind recognition dots (Source: <http://www.cbsl.gov.lk>)

To address this issue, several steps have been taken to develop low cost, portable, hand held bank note recognizers. However, none of these handheld systems cater to Sri Lankan currency identification and most of the systems are specially developed for the United States and Canada. These systems are based on charge coupled device / contact image sensor (CCD/CIS) technology. The most popular device in U.S, the iBill Talking Banknote Identifier (Orbit Research, 2013) is a compact device that announces a note's value by voice, pattern of tones or patterns of vibrations. Users insert a bill into the device and press the button on the device's side to have the denomination identified. The currency reader does not identify foreign or counterfeit banknotes. Another system, Tel-money is using the same technology as used in the iBill. Tel-Money is a voice output based paper money identifier designed for individuals who are blind or having low vision. It reads U.S. currency in denominations from 1 to 100 dollars. The user slides the currency into the money identifier, and then presses a button, and the unit reads the bill's denomination. The Canadian Bank Note Reader (CNIB, 1996) has a voice output and recognizes all Canadian bank notes currently in circulation and those expected to begin circulation over the next few years. However, these foreign devices are unique to their countries.

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In Sri Lanka, one currency note recognition device has been designed and implemented as a final year undergraduate project and this system employs a light dependent resistor array located at various points over the bank note's area (Wickramasinghe, 2013). There are pre-determined reference intensity levels defined to detect each color in the banknotes. The length of the note is also measured using IR sensors which are located in a line. In this system, the drawbacks are that the system is very large and not portable as well as it takes considerable time to perform the classification. Another proposed system for currency note detection in Sri Lanka (Gunaratne, 2008) operates on image processing technology which too does not satisfy the applicability criteria because of its non-portability. Therefore, in this paper we propose an efficient, portable and a cost effective bank note recognizer for Sri Lanka.

METHODOLOGY AND DESIGN

The proposed system in Figure 2 consists of two main sub units namely the detection unit and the processing unit. The detection unit detects the color (in R, G, B) of two edges simultaneously using two color sensors and the obtained data are classified using the k-Nearest Neighbor classification (Duda, 1973). The detection points are the edges of both sides (Figure 3) and allow the generated reference data sets to be named as domains. There are 8 domains for each bank note denomination and 48 (48 R, G, B data sets) domains for all 6 denominations (20, 50, 100, 500, 1000 and 5000 rupee). These are to be summarized and included in the program memory as the training set. Moreover, the system consists of a detection system with an array of photo diodes or photo transistors to detect intensities in relation to each bank note denomination and this increases the accuracy of the detection.

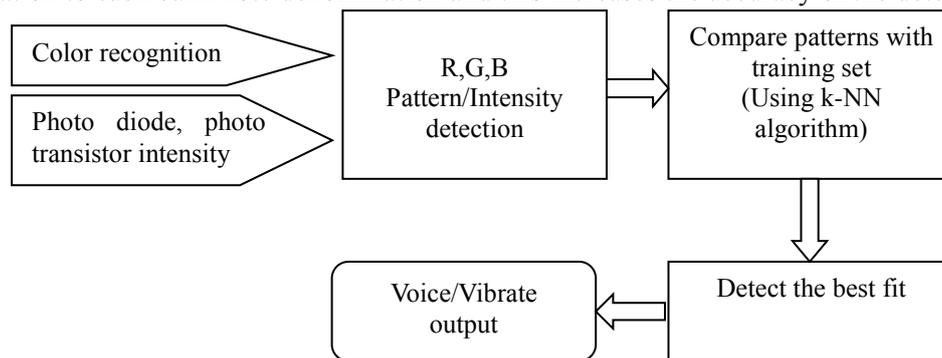


Figure 2. Block diagram of the proposed system

To develop the training data set, 20 banknotes were selected as the sample size under each denomination and the centroids of the R,G,B valued domains were calculated. However, the sample size of the 5000 rupee banknotes was not very effective because most of 5000 rupee denominations are not different in condition and are “new”. According to the nearest neighbor method the Euclidean distance (Kreyszig, 1973) between the sensed parameters of the note to be recognized and the centroids of each domain was calculated and compared. The note was then classified under the domain corresponding to the least Euclidean distance.



Figure 3. Detection points of bank notes (for 20 & 50 rupee)

Figure 4 shows the developed system’s physical implementation and Figure 5 lists the operational flow of the system.

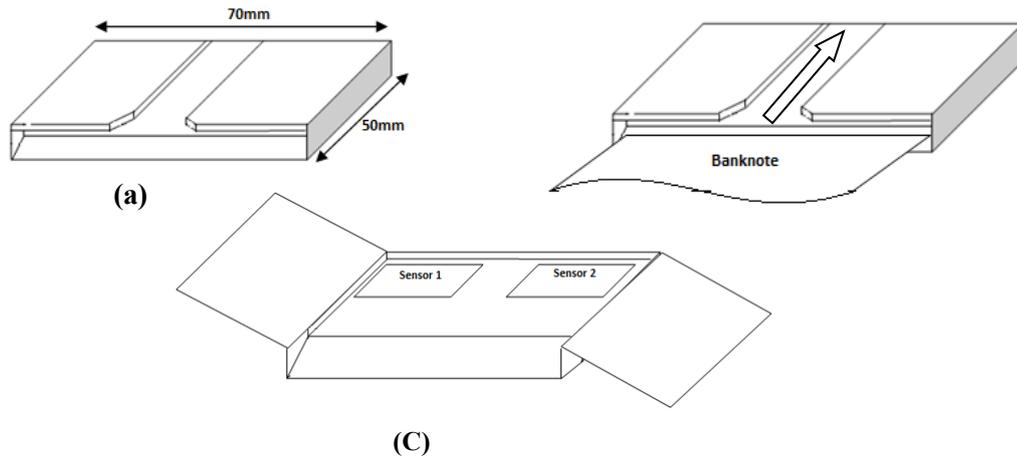


Figure 4. (a) Physical view (b) System for inserting banknote (c) Sensor locations

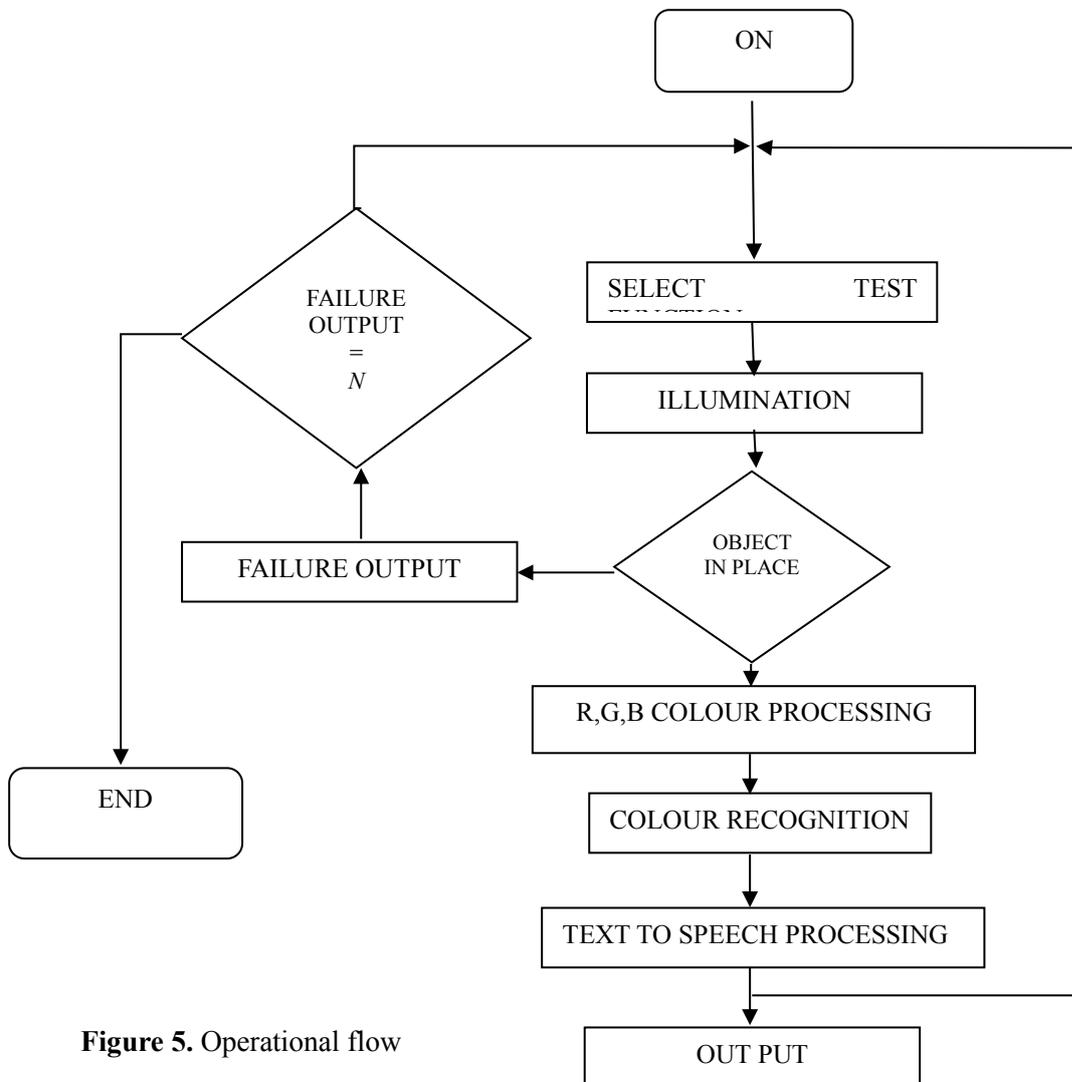


Figure 5. Operational flow

TEST RESULTS AND DISCUSSION

Table 1. Accuracy of identification

		Estimated Category						
		Accuracy	20	50	100	500	1000	5000
True Category	20	90%			10%			
	50		100 %					
	100	10%			90%			
	500	50%				50%		
	1000						100%	
	5000							100%

According to the test results for 52 bank notes, shown in Table 1, it is clear that the system is capable of maintaining high accuracies for most of the bank note recognitions. The system currently has an overall accuracy of 87.27%. This is comparatively less compared to the very high accuracies in non-portable systems in (Wickramasinghe, 2013) and (Gunaratne, 2008) where accuracies up to 98% can be attained. However, given the portability-accuracy trade-off, the proposed system is superior to others. It was also clearly observed that the system is less effective in classifying the Rs.500 note which was erroneously classified as Rs.20.

CONCLUSIONS AND FUTURE WORK

This proposed system will be of immense benefit to nearly 150,000 visually impaired people in Sri Lanka to identify the new bank note series. It will also help visually impaired people identify banknotes easily in less time. The proposed system has the added advantage of being lightweight and portable.

However, this system is not capable of identifying old series bank notes as well as counterfeit bank notes which is a possible future research direction. Furthermore, adding a fourth dimension to the input set to separate the Rs.500 note would be a potential future investigation area. Also by increasing the sample size for the training set, more accurate domain centroids can be achieved which will result in more accurate classifications.

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STREAMLINING SAFE VEHICLE & PEDESTRIAN MOVEMENT THROUGH A TRAFFIC MANAGEMENT SCHEME

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INTRODUCTION

Kottawa town was selected for this study since it is considered as a town having severe traffic and pedestrian related problems. It was observed that many people, who enter the town, face problems daily such as drivers wasting time due to the traffic and pedestrians risk their safety. Kottawa causes severe traffic blocks since many motorists and pedestrians do not follow the prevalent rules and no proper traffic management scheme is operating currently. There are three junctions in the town. Colombo-Awissawella road (A4) and Athurugiriya road (B45) meet at the one junction which is a junction of three roads. Colombo-Awissawella road (A4), Horana road (B239) and one way road meet at the second junction and it is a junction of four roads. The third junction is also a four roads junction, old Kottawa road (B47), Athurugiriya road (B45) and one-way roads are meeting there (see Figures 1 and 2). Therefore considerable amount of vehicles are frequent within the three junctions in peak hour. Users of Southern expressway travel through Kottawa town since Makumbura interchange is situated next to Kottawa and all these motorists on A4 waste their time passing Kottawa. Stage one of Outer Circular Highway is now in operation and other two stages will be open sooner. Since it is also starting from Makumbura interchange and traffic will be increased at the town further. There are illegal constructions, and street vendors conducting their daily businesses on roadsides and it too is an obstruction. Hence these activities have reduced the capacity of the surrounding road network. Situation at Kottawa is further worsen due to roadside parking, large numbers of pedestrians crossing Colombo-Awissawella (A4) road and existence of two unplanned bus parking places at both side of the A4 road.

The aim of this study is to provide solutions to improve pedestrian movement, vehicle movement and vehicle parking facilities in the Kottawa town while improving overall safety. It is expected that through this study it will be possible to provide greater mobility, shorter travel times and easy accessibility with improved safety to all road users.

METHODOLOGY

Data collection and analysis

Data was collected through manual classified traffic counts and turning movement surveys. Turning movement surveys of vehicles at all three intersections at identified morning, day, and evening peak time periods were conducted. According to the collected turning movement data it was identified that 7:30 am – 8:30 am as the morning peak, 12:00 – 13:00 pm as day time peak, and 18:00 pm -19:00 pm as evening peak and by using this data road capacity analysis for each road was conducted.

Table 1. Summary of accident data for ten years (2003-2013)

Type of Accident	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Total
Fatal	1	0	2	2	1	1	0	2	0	0	2	11
Grievous	7	1	5	4	3	3	5	7	2	5	7	49
Light	10	10	13	5	9	10	9	6	9	15	6	102

(Source: Police accident record books, Kottawa and Homagama police stations 2003-2013)

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Accident data over the last ten years (2003 to 2013) at the study location were obtained from Homagama and Kottawa Police Stations. It was used to identify the locations where large number of accidents occurred and the type and nature of the accident were noted. Three types of accidents noted were; fatal, grievous, and light (i.e. property damage only) as shown in Figure 1. Traffic growth rates of different categories of vehicles in western province, both manual and automatic traffic count data around Kottawa town along the A4 road and recent survey drawings of study area were collected from Road Development Authority (RDA). With the opening of stage 2 and 3 of Outer Circular Highway (OCH) and Sothern Expressway extending beyond Matara, traffic in Kottawa town will be further increase.

Along all the road sections in the study area carriageway widths, number of existing lanes and walkway widths were measured in field. Peak hour flows in Makumbura interchange at year 2015 and daily traffic volume forecast of Sothern Expressway was obtained from final Design report of Southern Expressway in 2001, with kind permission from RDA which is much appreciated. Capacities of current road sections were calculated using manual traffic count data obtained during peak hours to check whether the road sections could handle the present flows. There will be an increase in the traffic flow due to vehicles leaving and entering the Southern Expressway and OCH at Makumbura interchange in future. Traffic growth due to above factors was used to analyse traffic flows in town area. According to the existing vehicle parking data, necessary arrangements were made to facilitate proper parking of vehicles. To provide safe and efficient movement to pedestrians, a questioner survey was conducted to obtain opinions based on three categories of pedestrians, drivers, and business community. Pedestrian counts of cross walks and side - walks carried out in the study area for year 2014. Then cross walks and side – walks analysis done for the forecasted counts in year 2034.

Capacity analysis and design

Capacity checks were carried out using the Highway Capacity Manual using turning movement data. Allowable flows were determined using observed data at a different Level of Services (LOS) for each lane and were compared with actual entry flows. If allowable flows are lower than the actual flow modifications were proposed to the road section layout and the suitability were checked. According to the study area there were three junctions and eight road-legs were to be observed. Road sections along the Colombo-Awissawella road were considered as multilane, undivided suburban road. All other road sections were taken as two-way, two-lane, rural roads. Different factors had to be taken to account in different conditions. Level of Service from B to E was used to check the capacity and shown in Table 2. RESULTS AND DISCUSSION

Following figure shows the locations where large number of accidents happened and the type of accident.

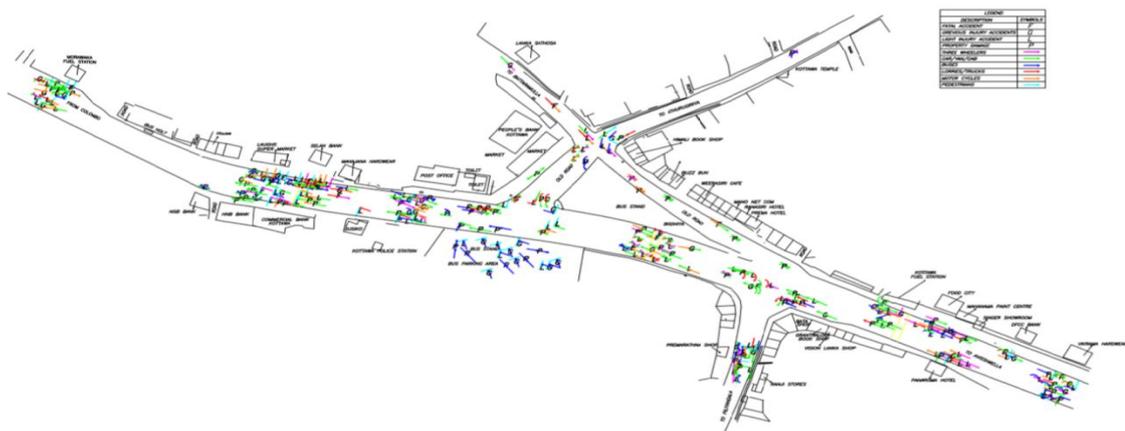


Figure 1. Collision diagram

Table 2. Capacity analysis results

Road section	Road condition	LOS	Morning condition	Evening condition
P1-P1	Multilane undivided suburban	C	Satisfied	Satisfied
		D	Satisfied	Satisfied
		C	Satisfied	Satisfied
		D	Satisfied	Satisfied
P2-P2		C	Satisfied	Satisfied
		D	Satisfied	Satisfied
P4-P4		C	Satisfied	Satisfied
		D	Satisfied	Satisfied
P3-P3	Two-way Two-way	C	Unsatisfied	Unsatisfied
		D	Unsatisfied	Satisfied
C		Satisfied	Satisfied	
D		Satisfied	Satisfied	
P5-P5		C	Unsatisfied	Unsatisfied
		D	Satisfied	Satisfied
P6-P6		C	Satisfied	Satisfied
		D	Satisfied	Satisfied
P7-P7	two-lane, rural	C	Satisfied	Satisfied
		D	Satisfied	Satisfied
C		Satisfied	Satisfied	
D		Satisfied	Satisfied	
P8-P8		C	Satisfied	Satisfied
		D	Satisfied	Satisfied

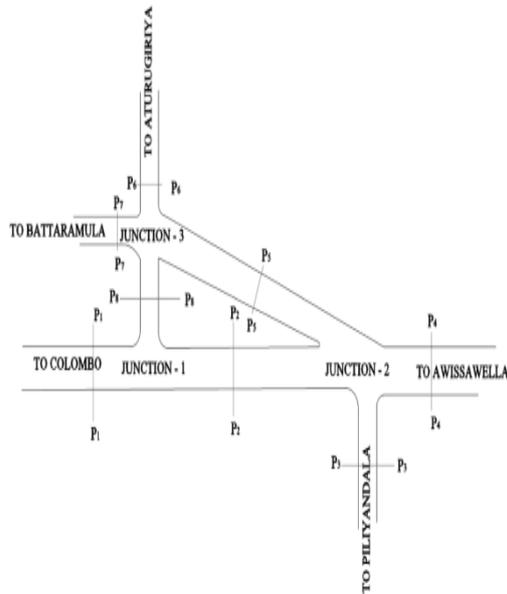


Figure 2. Road section locations

As per results it can be seen that capacity satisfied for Level of Service D in morning peak and evening peak for year 2014. But difference between the actual flow and allowable flow was insignificant. Hence actual flow will reach the allowable flow within few years. Year 2014 flows were projected to year 2034 and capacity analysis was conducted. Number of 3.7 m wide lanes required to satisfy the capacity are tabulated in Table 3.

Table 3. Number of lanes for year 2034

Location	LOS	No. - Per one direction
P1-P1	D	4
P2-P2	D	4
P3-P3	C	3
P4-P4	C	4

Location	LOS	No. - Per one direction
P5-P5	B	3
P6-P6	D	3
P7-P7	B	3
P8-P8	C	3

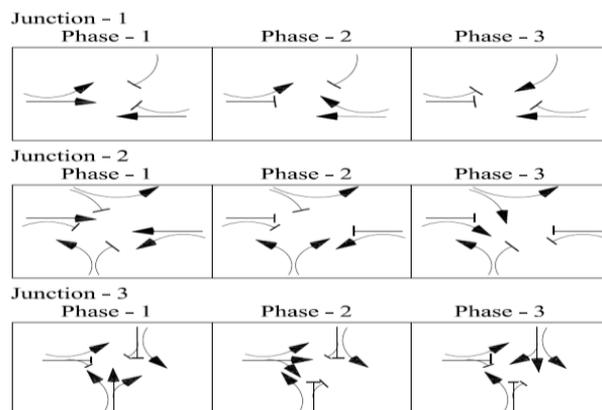


Figure 3. Phasing diagram

It was proposed to link traffic signals at three junctions with a roundabout at junction 3. From analysis a 7.75m radius roundabout was proposed at junction 3. Phasing diagram of signalized intersections shown in Figure 3. Final results of the traffic signal analysis are as follows.

Table 4. Traffic signal analysis results

	Morning Time	Evening Time
Cycle Time	120 secs	90 secs
Effective Green Time of Phase 1	33 secs	36 secs
Effective Green Time of Phase 2	20 secs	22 secs
Effective Green Time of Phase 3	55 secs	20 secs

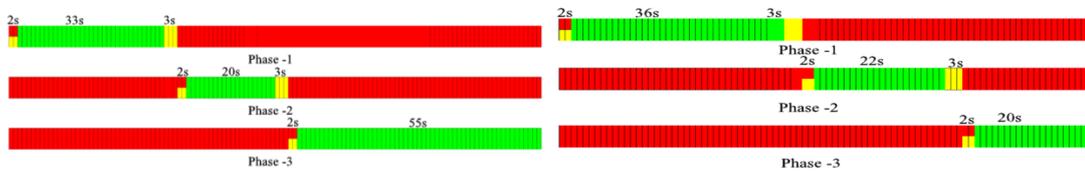


Figure 4. Signal timing diagram for morning and evening

12.00 noon was set as the signal settings changing time. At Kottawa town it was needed to provide suitable channelization to separate the opposing traffic with the traffic signal and roundabout. It is proposed to provide centre median to A4 road with semi-circular end shape. Length of the centre median was determined to suit site conditions, minimum width of centre median 1.2 m and radius of the semi-circular end as 0.6 m. Proposed centre median was indicated in final layout plan. In addition to channelization hand rail, turning regulations were too provided as suitable traffic management measures.

To facilitate a pedestrian level of service C (as per HCM2000), 2.0 m side walk width and 2.5m cross walk width were provided. As a solution for parking problems, most appropriate parking angle selected as the 90⁰, level of service selected 1 for provide parking for future parking demand and Forty vehicles can parked in half story level and total 240 vehicles can be parked in multi-story car parking arrangement proposed and it is indicated in final layout.

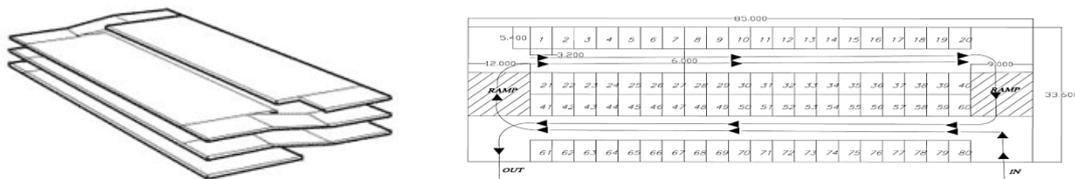


Figure 5. Split level car park arrangement and vehicle circulation pattern

Proposed final bus bay design and bus parking arrangement is given in the final layout according the AUSTRROADS requirements.

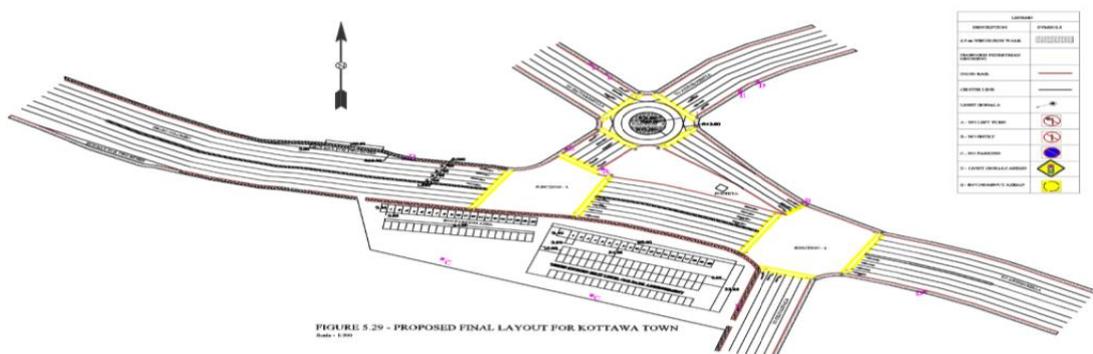


Figure 6. Proposed final layout

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EFFECT OF MANUAL TOLL COLLECTION ON CAPACITY OF SOUTHERN EXPRESSWAY

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AIM OF THE STUDY

The aim of this study is to firstly investigate the efficiency of manually operated toll gates along the Southern Expressway and secondly to observe the impact on the capacity of interchanges which may finally limit the expressway potential in the future.

Objectives

The objective of this study is to investigate the impact of toll gates efficiency on the capacity of the Southern Expressway. It consists of investigating the present condition in interchanges, and to develop recommendations for future implementation. These objectives entail the following.

- Identify the critical interchanges in the road from Kottawa to Galle exit.
- Find any inefficiency at toll gates when operated manually.
- Study ramp sufficiency and head-up length with future traffic.
- Check the off ramp length according to deceleration length with possible formation queues in critical exit ramps.
- If there are delays at toll booths to investigate whether it will affect the free flow of the Southern Expressway.

Propose suitable tolling systems to cope with the future traffic needs if there are any delays due to toll gates causing reductions in the capacity of the expressway.

Strategies

To achieve the aims of this project, the following strategies and principles were used:

- The layout arrangements of interchanges were studied in detail.
- The number of entrance and exit gates was identified for all interchanges.
- The exit ramp lengths were measured and the geometry of the intersection was studied for all the interchanges.
- The existing procedure of paying of user fee at toll gates and the toll gate operation was studied.
- Peak day/peak hour was identified for each interchange.
- Identified the critical exit ramps of the expressway by considering exit ramp distances and traffic volume.
- After identifying the peak days, traffic studies were conducted to obtain arrival rate and service rate for critical exit ramps in each interchange.
- The graphs which indicate the arrival curve and service curve at different toll gates were plotted according to the survey data.
- The longest individual delay and maximum queue were identified using above graphs for each critical exit ramps.
- By using the above graphs and collected data analyzed the effects of the capacity of Southern Expressway due to present toll gates in interchanges.
- Recommended suitable off ramp lengths considering queue length and deceleration lengths and recommended future improvements to the service rates at toll gates.

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METHODOLOGY

Graph of Time vs. Cumulative Vehicle at Ramp

Figure 1 illustrates curve of Time vs. Cumulative Number of Vehicle and how it affects service rate. The two curves shown in the Figure 1 are related arrival and service rates.

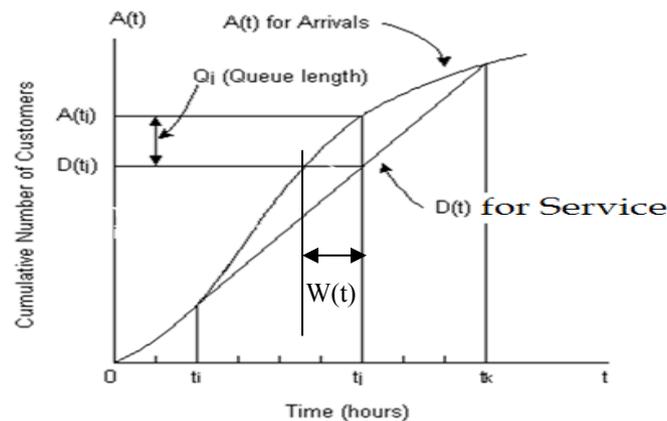


Figure 1. - Graph of Cumulative Number of Vehicle vs. Time

Area between $A(t)$ and $D(t)$ represents the total delay, or summation of delay to all vehicles.

- $Q(t)$ – Vertical distance between $A(t)$ and $D(t)$ at any time t , represents the numbers of vehicles in queue at that time (t)
- Slope of $D(t)$ in the ‘departure rate’
- Slope of $A(t)$ in the ‘arrival rate’

Note

- The departure rate cannot exceed the service rate or capacity of the service provider. Hence it has to be less.
- Cumulative departure can never exceed cumulative arrivals. Hence $D(t)$ can never be above $A(t)$ in the queuing diagram.
- When queue is present the ‘departure rate’ will equal the ‘service rate’.
- The queue first forms when the ‘arrival rate’ first exceeds the service rates.
- $W(t)$ Horizontal distance between $A(t)$ and $D(t)$ represents the delay to vehicle arriving at time t .

Service time - Service time of collection payment is the time between the vehicles entering the toll booth until the vehicle leaves the toll booth.

Service rate - The number of vehicles serves in unit time

Data collection and analysis

To investigate current toll gate efficiency on the capacity of the Southern Expressway the necessary data were collected from relevant organizations. From the collected data, peak days and peak hours were identified for each and every exit ramp. By considering the peak hours, critical exit ramps were identified. After identifying critical exit ramps of the interchanges, traffic studies were conducted to obtain arrival and service rates in peak hours during the peak days. Then after analyzing survey data maximum queue lengths and longest individual delays for critical exit ramps along the Southern Expressway was found. Simultaneously the analysis was conducted for a different number of gates.

Calculation of weight factors for each exit ramps of interchanges

The study requires correctly identifying critical exit ramps since delays occur at exit ramps. Therefore out of 14 exit ramps between Kottawa and Pinnaduwa, critical exit ramps were

identified using 'weight factors'. The method adopted for computation of 'weight factor' was based on ramp length, and peak hour volume. Then the weight factor was obtained by dividing the peak hour volume of each exit ramp by the measured ramp length. By observing traffic data during a period of one week, peak hour volumes for each interchange were identified. The number of toll gates were considered when queue length exceeded the off ramp length.

Table 1. The weight factors for each interchange

Interchange	Exit Ramps	Peak hour volume (veh/hr)	Ramp Distance (m)	Weight factor (veh/m/hr)
Kottawa	Ramp 1 – From Galle	683	197	3.47
Kahathuduwa	Ramp 1 – From Galle	75	106	0.71
	Ramp 2 - From Colombo	16	96	0.17
Galanigama	Ramp 1 – From Galle	94	181	0.52
	Ramp 2 - From Colombo	60	187	0.32
Dodangoda	Ramp 1 – From Galle	41	93	0.44
	Ramp 2 - From Colombo	74	134	0.55
Welipanna	Ramp 1 – From Galle	23	73	0.31
	Ramp 2 - From Colombo	58	69	0.83
Kurundugahahathakma	Ramp 1 – From Galle	24	45	0.53
	Ramp 2 - From Colombo	55	134	0.41
Baddegama	Ramp 1 – From Galle	9	154	0.06
	Ramp 2 - From Colombo	43	90	0.48
Pinnaduwa	Ramp 1 - From Colombo	257	378	0.68

Selection of critical exit ramps

According to the weight factors, shown in Table 1 seven critical exit ramps were selected to conduct the detailed surveys. Exit ramps consisted of weight factors above 0.5 were considered as critical exit ramps. This was to limit the number of ramps to be studied, rather than studying all the ramps. Hence at-least one exit ramp was selected from all the interchanges except Baddegama.

Present condition of toll gates considering average service time

Separate surveys were conducted for each and every gate operated in critical exit ramps. The purpose of the survey was to obtain the average service time in each toll gate according to the exit ramps. Time at the commencement of service and departure for each vehicle was recorded. The difference of departure time and service commencing time for each vehicle were used to calculate service time. Service time was calculated separately for each interchange, then considering all the interchanges the average service time for current tolling system (manual operation method) was computed and tabulated in Table 2.

Table 2. The average service time for each gate

Interchange	Exit gate No.	Average service time for each gate (seconds)	Average service time for each interchange (seconds)
Kottawa	1	15.83	17.86
	2	16.37	
	3	22.07	
	4	18.28	
	5	16.77	
Kahathuduwa	1	25.45	25.45
Galanigama	1	17.13	17.13
Dodangoda	1	19.09	19.09
Welipanna	1	19.00	19.00
Kurundugahahatakma	1	15.75	15.75
Pinnaduwa	1	15.46	15.42
	2	15.38	
Average service time (seconds)			18

RESULTS

Minimum deceleration lane length for exit ramps

Table 3. Results and Proposals

Interchange	Direction	Failure reason at year			Proposals
		Longest individual delay at year	Maximum queue length	Minimum deceleration length (170 m)	
Kottawa	Ramp 1 – From Galle	2035	2034	2034 exceeded	At year 2034 ramp length has to improve / Service rate has to improve
Kahathuduwa	Ramp 1 – From Galle	2075	2075	Existing ramp length inadequate	Ramp length has to improve from now
	Ramp 2 - From Colombo				
Galanigama	Ramp 1 – From Galle	2060	2050	2050 exceeded	At year 2050 ramp length has to improve / Service rate has to improve
	Ramp 2 - From Colombo				
Dodangoda	Ramp 1 – From Galle			Existing ramp length inadequate	Ramp length has to improve from now
	Ramp 2 - From Colombo	2040	2040		
Welipanna	Ramp 1 – From Galle			Existing ramp length inadequate	Ramp length has to improve from now
	Ramp 2 - From Colombo	2045	2045		
Kurundugahahatakma	Ramp 1 – From Galle	2060	2050	Existing ramp length inadequate	Ramp length has to improve from now
	Ramp 2 - From Colombo				
Pinnaduwa	Ramp 2 - From Colombo	2030	2030	2030 exceeded	At year 2030 ramp length has to improve / Service rate has to improve

DISCUSSION AND CONCLUSIONS

It was observed how each interchange dealt with maximum queue length, individual delay and minimum deceleration lane length. Table 3 indicates the years when exit ramp lengths will become insufficient for each interchange. Critical exit ramps of Kottawa (from Galle), Galenigama (from Galle), and Pinnaduwa (from Colombo) interchanges could cater to the traffic up to years 2034, 2050 and 2030 respectively. Kahathuduwa (from Galle), Dodangoda (from Colombo), Welipanna (from Colombo) and Kurundugahahatakma (from Galle) existing ramp lengths were selected based on without considering deceleration lane lengths. There is a tendency that vehicles begin to decelerate on the lane on expressway in advance of the off ramp lengths. This can affect the efficient and safe movements of traffic on the expressway. Therefore it has to introduce an additional lane to allow for adequate ramp deceleration distances without disturbing the expressway through traffic.

Hence the capacity of Southern Expressway will get affected due to inadequacies at tolling stations unless the number of toll gates are increased or the efficiency of the toll collecting systems is improved by introducing advanced schemes such as electronic toll collection systems.

TUNNEL VIEWER: VOICE AND COMPUTER CONTROLLED ROBOT

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INTRODUCTION

Voice communication is significant in human-robot interaction and utilizes various communication media. With the developments in communication technologies in the recent past, speech has become an important interface for many systems. Instead of using complicated interfaces, speech offers an easier and more intuitive way to communicate with computers and to control machines and environments.

A method for controlling a robot vehicle by voice and computer commands is proposed here. The proposed voice-operated robot is capable of operating in some tedious work spaces. The voice commands are used to control the movements of the robot and visual feedback is used to command the robot precisely.

Various voices were compared using different sentences for speech synthesis. With synthesis, the robot was able to operate independent of the user. The interfacing was tested and the transmitted commands were received by the microcontroller. The transmitted video was received by the USB receiver. It was possible to achieve a clear voice recognition system and visual feedback to track the movements of the robot.

Various applications like Maze Solving, Tracking and Line Following are possible with further advancements to this Robot System. With reliable, high-speed transmission there is potential to achieve more reliable and higher-quality communications.

METHODOLOGY

The block diagram of the proposed robot and the process flow is shown in Figure 1. The main units of the system are speech recognition unit, PC interface unit, Visual feedback unit and the motor driving unit.

Operation of the System

The robot vehicle is operated in dual mode, i.e., by computer command and/or by voice commands. The speech is received by a microphone and processed on a PC. When a command to the robot is recognized, the PC sends a command message to the robot using zigbee.

The robot receives the signal and takes appropriate action. A camera is mounted on the robot and it can be used to perform various tasks. The camera captures the video and sends visual feedback to the user.

Speech commands were input to the computer by a microphone and the features were extracted and recognized with Microsoft Visual Studio (based on C#) which is an integrated development environment (IDE) from Microsoft. Microsoft Visual Studio is usually used to develop console and graphical user interface applications. The verbal commands were converted to a form which the robot can recognize and when a command for the robot is recognized, the PC sends a command message to the robot using the zigbee wireless

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technology. The movement is carried out accordingly using the Arduino Software which is an open source electronics prototyping platform based on flexible, easy to use hardware and software.

There are fixed commands which can be used to control basic robot actions such as: forward, backward, right, left and stop. As in the short form, a voice command is received through a microphone, processed in the computer and sent to the robot through a wireless transmission and finally the robot acts accordingly. A special feature of the robot is the wireless camera on it. The camera captures the video sends visual feedback to the receiver wirelessly.

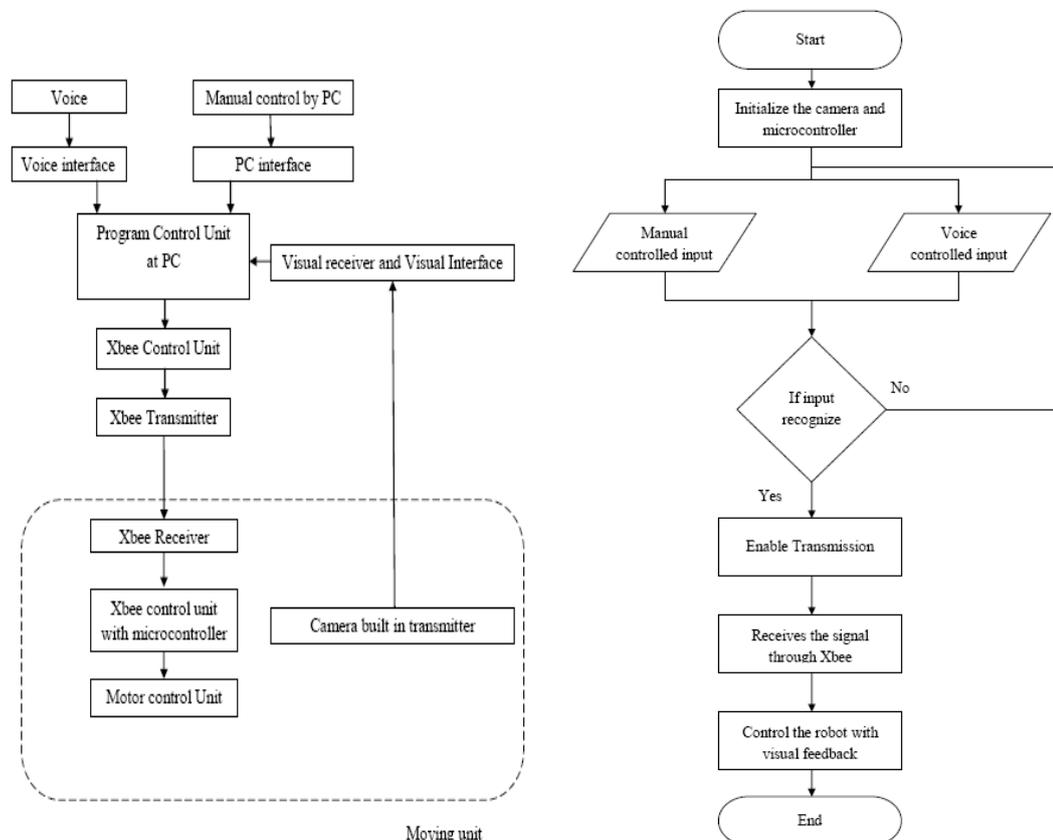


Figure 1. System Block Diagram and Flow chart for main program

The selected camera consisted of a 2.4GHz wireless 4 channel receiver and it is rechargeable. This miniature color video camera is revolutionary in size and it is completely wireless. The camera can be simply placed in a discreet position and to receive video all that needs to be done is to plug the receiver to a computer. Providing clear, quality images in color, the Wireless Hidden Spy Camera is ideal for keeping an eye on the tunnel. Power for the camera can be supplied by a standard 9 volt battery or power adapter. The transmitting range is approximately 100m line of sight and around 30m indoors.

The vehicle can be stopped ion an emergence using voice commands. Two 9V batteries are used for the system. One 9V battery is used to power the Arduino board and other battery is used to power the motors. The speed of the robot vehicle is determined by the rotation of the motor. The speed can be controlled by the PWM technique by using delays. A more efficient way to proceed is by using the pulse width modulation technique to manage the speed of DC motor. The gear motor works well between 3V and 12V. At a ratio of 1:48 it is possible to get some really good torque at 5 Volts and 15rpm output.

The final product is shown in Figure 2.

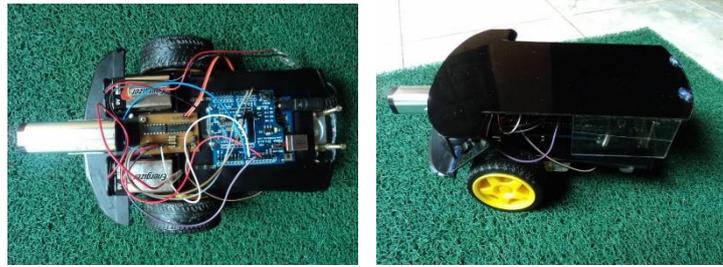


Figure 2. Final product

Dimensions of the system

Table 1. Dimensions of the system

Weight with roof	480g
Weight without roof	385g
Length	25cm
Width	16cm
Height	12cm

Uphill and downhill angle calculation

Using the observed and measured values of weight, speed and other parameters, the maximum angles of uphill and downhill movement were calculated. The calculated values did not have major differences with practical values.

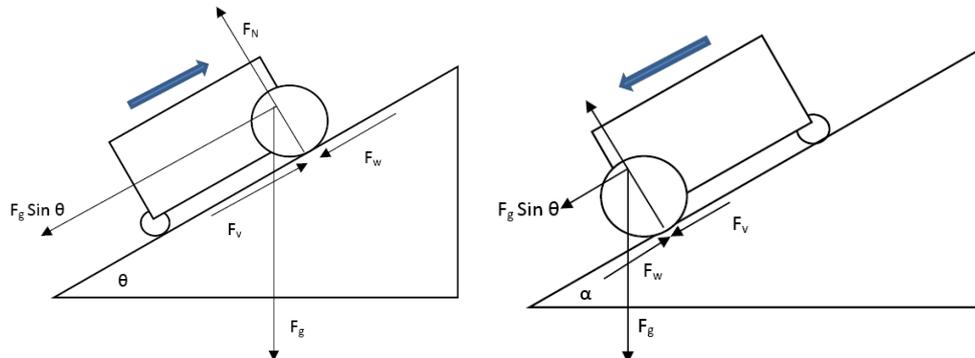


Figure 3. Considering uphill and downhill travel, the maximum angle the robot vehicle can travelling uphill: 33.410° and downhill: 45.099°

It takes several seconds to transmit the signal to the zigbee receiver due to the delay in serial port reading. But the delay is not more than 2 seconds when it is identified as the correct command. When taking bends the robot uses only one motor and other one is stopped.

RESULTS

The robot vehicle was moved inside a tunnel according to the voice commands and the visual feedback. The diameter of the tunnel was approximately 24cm.

Figure 4 shows some images taken by the camera while travelling inside the tunnel.

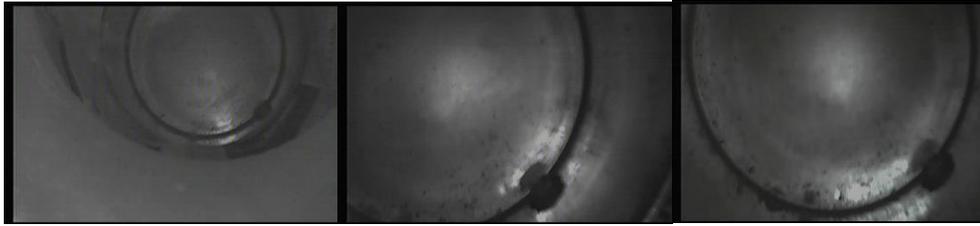


Figure 4. Real time observations: Images taken from the camera

DISCUSSION

For better operation of the system commands should be fast but not too slow and should be clear. Speaking close to the microphone will give better results. The best average is 30-50 cm from the microphone.

Environmental issues can arise because we are unaware of the exact condition of the tunnel interior when the robot vehicle moves. Better information provision can be achieved in two ways: adding a protective insulation cover and adding temperature sensing, humidity sensing, and smoking sensors. These sensor units can be directly connected to the Arduino Unit and can be controlled by the computer program.

CONCLUSIONS/RECOMMENDATIONS

Rotation of the Camera

The system cannot see the entire area very clearly before it takes bends. Rotating the wireless camera can avoid this problem. To do so, servo motors can be used in future development of the system. Servo motors are types of actuators that rotate to a specific angular position. A “robot servo” is a new type of servo that offers both continuous rotation and position feedback. All servos can rotate Counter Wise and Counter Clock Wise. The angular motion of the turning shaft can be measured using encoders or potentiometers. But when this type of motor is added to the system, it will also result in a direct increase in power consumption as well. To mitigate the power consumption issue rechargeable batteries can be placed on the robot vehicle. This will increase the total weight of the system and therefore this should be taken into consideration when deciding on the two dc motors.

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USE OF FIBERS TO IMPORVE THE TENSILE STRENGTH OF CONVENTIONAL CONCRETE

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INTRODUCTION

Concrete is one of the most commonly used civil engineering material in the modern world. It is popular due to its high compression strength, and almost all the shapes can be cast with concrete. However one of the weakest aspects of concrete is its poor tensile capacity. Concrete's tensile strength accounts for barely 6% of its compressive strength (Shetty, 2010). Due to its poor tensile capacity, the construction of thin sections with concrete causes, tensile failures.

The tensile property of concrete can be improved in many ways. According to Purvis (1987) steel fibre additive agents can be added to the concrete to improve the tensile capacity of concrete. Steel fibres are also among these substances and in recent years, it has been commonly used in concrete. As stated by Balendran et al.,(2002) the effects of fibre added to concrete depend on the type, size, density, and distribution of the fibre, as well as the interfacial effort between the concrete and fibres. Their study covers a novel organic modified polypropylene fibre (OMP), with a lower specific gravity and greater anti-corrosive property than steel fibre. Zhou et al.,(2015), showed that at 7 days, the concrete combined with OMP had a significantly higher compressive strength than the plain concrete, and maintained that status at day 28. Durability, physical and mechanical properties of fibre-reinforced concretes at low-volume fraction was investigated by Söylev and Özturan(2014). Their findings showed that the slump value was greatly affected by the addition of fibres that could be again improved by the addition of superplasticizer. However the addition of superplasticizer will increase the unit rate (price) of concrete drastically. The toughness of concrete can be increased by the addition of steel fibres (Mohamad et al, 2015) as they can bridge micro- and macro-cracks formed in the cementitious matrix. Due to this fibre reinforced concrete can show more ductile behaviour compared to the normal concrete adding a lot of favourable properties to concrete. The study carried out by Mohammad et al.,(2015) shows the use of steel fibre in precast pipe fabrication. Their results showed that a fibre dosage of 30 kg/m³ satisfied the strength requirements of ASTM C76 Class V pipe for 450 and 600 mm diameter pipes.

As Slump cone test is incapable of simulating the interaction between the main reinforcement and the secondary reinforcement, different approaches are used in the measuring the workability of concrete.

In this study the properties of fibre concrete at green stage and at the hardened stage were measured. To measure the properties at the green stage two new apparatus were fabricated.

Material and concrete mixtures

As the starting point, the Sri Lankan experience in mix design together with the UK method described by the Department of Environment for concrete mix design, United Kingdom (UK), was used for preparation of concrete mixtures. It was decided to carry out the test for grade 25 concrete as that is the widely used concrete in normal construction fields in Sri Lanka. The OPC content of concrete was kept to 340 kg/m³ (Dias, 2003). The rest of the materials were determined according to the guidelines provided by UK Department of Environment. The target slump of the mixes was 120-150 mm. Although the addition of superplasticizer is common in fibre concrete to improve the workability, it was decided not to use a superplasticizer in the mix as the production cost will increase (Söylev and Özturan, 2014).

Four different types of mixes were prepared by adding different percentage of fibres. Carbon fibre was selected as the fibre in this study (Chung, 1999). Fibre weight was presented as a percentage to cement. The second was selected changing the water content by 10%. In the mix 3, only the maximum size of the aggregate was changed to 10mm compared to mix 2 whose maximum aggregate size is 25mm. M4 mix is a grade 30 concrete that is normally used in in-situ pile casting. No any other adjustment was made in the determination of water content due to the addition of fibre which is common in modified mix design methods.

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Table 1. Mix proportions (kg/m³) for different concrete mixtures.

Mix type	M1	M2	M3	M4
Water/Cement	0.5	0.5		
Cement (kg)	300	300	300	440
Water(kg)	205	225.5	225.5	210
Fine aggregate(kg)	645	645	645	685
Coarse aggregate(kg)	1200	1200	1200	1065
Fibre content(kg)	7.5	7.5	7.5	7.5

Workability of fibre added concrete

The slump cone test is normally used in workability measurement for conventional concrete. However use of slump cone test is not appropriate for fibre concrete as the behaviour of fibre cannot be simulated with slump cone. Fibres in concrete will create barriers for the movement of concrete near the main reinforcement. Therefore it is important to reflect this behaviour in workability measurement. To measure the workability of the fibre added concrete two different apparatus were fabricated in the laboratory at the Civil Engineering Department. The U Box test was developed by the Technology Research Centre of the Taisei Corporation in Japan (Tanaka et al., 1993). These two apparatus have been used successfully in other countries (Bartos et al., 2002) to measure the workability of the fibre reinforced concrete and self-compacting concrete. U box test apparatus has four reinforcement bars (Figure 1a) that can simulate the real field situation that fibre concrete face in the field. Figure 1b also can represent the real field behaviour of concrete compared to the traditional slump cone test.

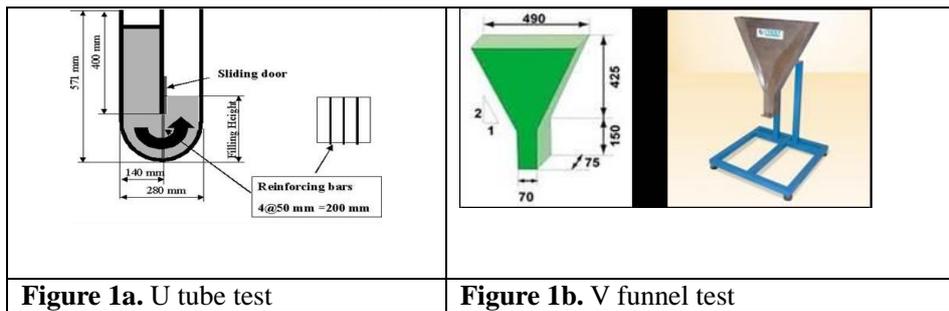


Figure 1a. U tube test

Figure 1b. V funnel test

Plastic shrinkage cracking

This test was carried out using the arrangement as illustrated in Figure 2a. The relevant code is ASTM C1579-06. The test sample is subjected to prescribed conditions of restraint and drying conditions that are severe enough to induce plastic shrinkage cracking in test sample. The severe environmental conditions recommended by ASTM C1579-06 were created inside the laboratory by creating artificial heating (electric bulbs) and wind (electric fans) as illustrated in Figure 2b.

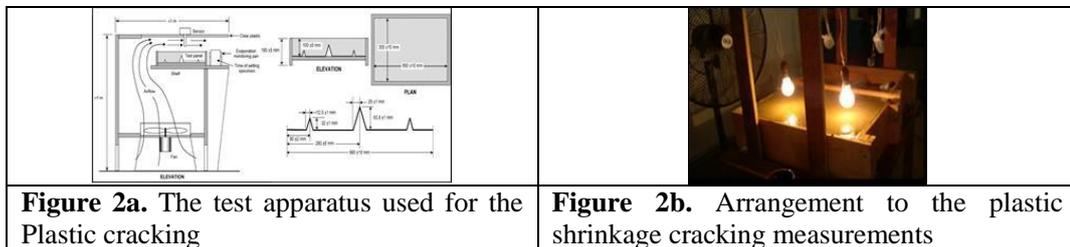
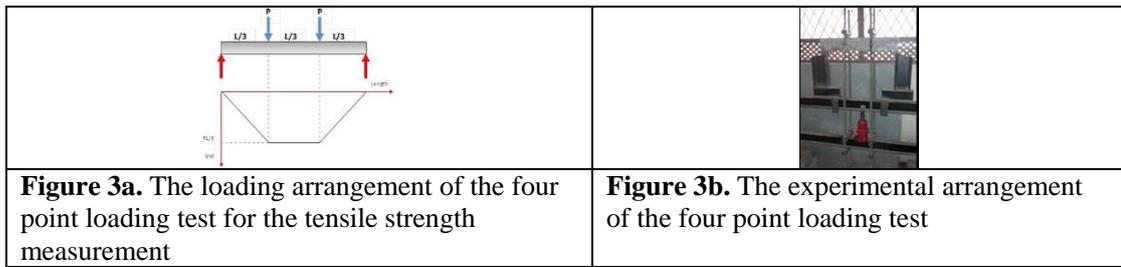


Figure 2a. The test apparatus used for the Plastic cracking

Figure 2b. Arrangement to the plastic shrinkage cracking measurements

Tensile strength test

Normally concrete has a low tensile strength compared to compressive strength. This test was conducted according to the code ASTM D6272. This test provides a quantitative measurement of the tensile strength.



RESULTS

Fresh properties

The workability measurements are presented in Table 2.

Table 2. Workability measurement

Mix	Slump(mm)	U tube(mm)	V funnel(Sec)
M1	80	Negligible	No flow
M2	165	50	No flow
M3	180	80	9
M4	185	150	7

As illustrated in the Table 1, M1 mix showed very stiff behaviour in the slump test as well as in U box tube and V funnel test. However all the other mixers shows higher slump values. However, by carrying out U box test and V funnel test more information can be obtained about the mixtures. Mix 2 denoted slump value of 165mm. However, the U tube test gave lower value of filling height indicating very low flowability due to interlocking. Therefore it is important to carry out U box type test to measure the workability of fibre concrete.

Plastic shrinkage cracking

Measurement of the plastic shrinkage cracking indicates lesser number of plastic cracking in fibre added concrete. Only one crack was observed (width is approximately 0.5mm) in all the fibre added concrete whereas in plain concrete several smaller cracking were noticed.

Tensile strength

Figure 4 shows the tensile strength results of hardened concrete. Each of the presented values is the average of three values of three samples for each mix type. As illustrated in Figure, 4 the addition of fibre has caused the improvement in tensile strength. However the addition of fibre should be made carefully as the workability is affected by fibres. As shown in our results, M2 has shown lower tensile strength. One of the reasons for the reduction of strength is that part of water has gone to wet the fibres thus causing lesser water for the chemical reaction. This has affected the strength to go down. In the mix 3 the maximum aggregate size of the mix is 10mm. The smaller aggregates help to increase the total surface area to be wetted. Therefore 10% additional water was added to compensate higher surface area due to the fact of smaller aggregate and fibres. This process gave similar strength to the previous mix (mix 1). The determination of optimum additional water content needs more test to be carried out which is on the way now. The process was hindered due to higher cost of fibres.

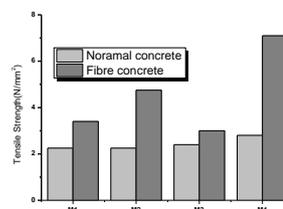


Figure 4. Variation of tensile strength in normal and fibre added concrete

CONCLUSIONS

This study investigated the measurement of workability, plastic shrinkage and tensile strength of fibre added concrete using newly developed apparatus. Workability is greatly affected by the addition of fibre. Plastic shrinkage cracking is controlled by the added fibre. Tensile strength analysis shows higher tensile strength (5N/mm^2) gain in fibre concrete compared to normal grade

25 concrete (2N/mm²). Significant tensile strength improvement was obtained in fiber concrete that increased from 3N/mm² to 8N/mm² in comparison to the normal in-situ pile concrete. Modification to the water content in mix design needs more experiments to be carried out with the selected fibre.

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DESIGN OF A PRACTICAL RADIO FREQUENCY ENERGY HARVESTER

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INTRODUCTION

Energy in useful forms has become a very scarce resource. Traditionally common sources of energy have been fossil fuels which are both finite and contribute to greenhouse emissions. Therefore, much recent attention has focused on regenerative energy sources. Solar power, hydro power, wind power and tidal wave power have been some key alternative sources which are capable of generating Kilo Watts of power. At the same time, accessibility to such sources is not practical in many applications. As an energy solution for such applications, energy scavenging is a widely accepted technology. (Priya, 2009) Thermal energy, vibration energy and also radio frequency (RF) energy can be harnessed in energy scavenging. Although thermal and the vibration energy are already harnessed in wireless sensor network applications, RF energy harvesting has not been very popular. The main reason behind this lack of popularity is because the amount of RF energy which can be harnessed is below useful levels and only a handful of practical implementations are utilizing RF energy harvesting (Patel, 2014 & Pinuela, 2013). However, with a view to a wide range of potential other applications, we propose a RF energy harvester which is capable of delivering a useful power output. We particularly focus our design on a cellular phone charger which needs a very compact design unlike many of the other RF energy harvesting applications.

Energy harvesting for low power mobile devices has been addressed in several previous research studies. In Sivaramkrishnan (2011) an energy harvester for mobile devices was proposed where the key contribution is the management of the usage of harvested energy. Ahn (2011) proposes a system where the main focus is on the design of a rectenna antenna to capture maximum power. However, this latter system generates a maximum current of around 1mA and is not scalable. Paradiso (2005) evaluates some other power harvesters designed for mobile charging applications. All these harvester systems are still generating a very low power output which is far less than the required power for mobile device charging. At the same time these designs are very inflexible and scalability is poor which makes them very hard to improve for an increased power output. In this paper, we propose an alternative system design preserving scalability and flexibility.

METHODOLOGY

The proposed system consists of two main sub units: the energy capturing sub system and the processing subsystem as shown in Figure 1.

The energy capturing system is an antenna unit with the matching circuitry. The antenna system has to be very compact to be coupled to a mobile phone and therefore, a double spiral antenna was selected. An Archimedean spiral design was followed with the physical specifications of $r = C\theta$ where C is a constant and r and θ are the radius and the rotated angle of the spiral. This particular spiral antenna also has a very wide spectral response (Amin, 2012), and matches a wide range of frequency carriers of many mobile operators in the 1900MHz band. Furthermore, the frequency response is $\frac{C}{2\pi r_2} \leq f \leq \frac{C}{2\pi r_1}$ where r_1 and r_2 are two spiral radii (Amin, 2012).

However, one of the main drawbacks of the spiral antenna is the circular polarized reception which limits the amount of absorbed power at certain received signal polarizations.

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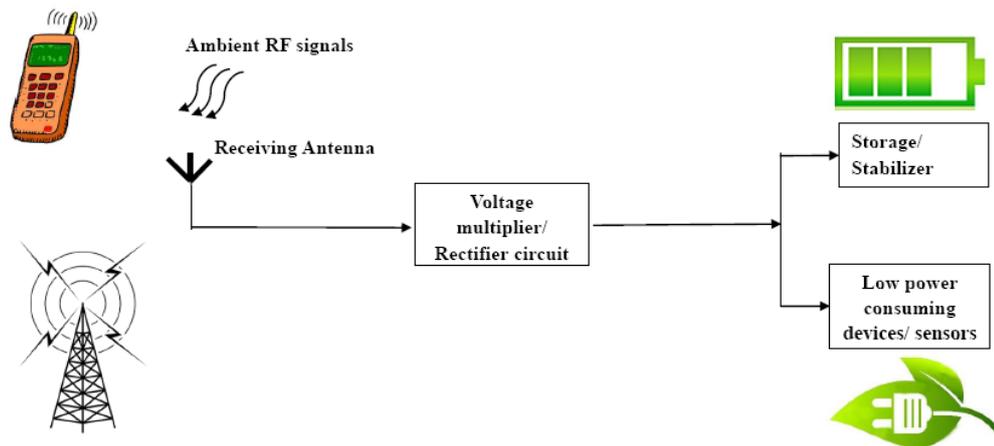


Figure 1. Proposed system architecture

We also investigated other arrangements such as patch panels, but failed to achieve the average output gained by the spiral antenna under all orientations. Furthermore, we employed an L-C matching circuit to minimize undesired power reflections back to the antenna. The use of reactive components in this passive matching circuit further minimized unnecessary power losses.

Second, our design consists of a voltage multiplier circuit which is responsible for accepting the energy from sinusoidal RF carrier and generating a direct current signal output. For this, we employ a multistage voltage multiplier as shown in Figure 2. The operation of the voltage multiplier can be described as follows. During the first negative half cycle of the sinusoidal input with V_p peak voltage, capacitor C_1 charges to V_p across D_1 and during the second positive half cycle, C_2 charges to $2V_p$ across D_2 . Therefore, a cascading voltage multiplier setup as in Figure 2(b) can deliver a multiplied voltage. On the other hand a shunt arrangement as in Figure 3 can deliver a multiplied current. In this circuit design, it is very important to avoid unnecessary voltage clippings which will ensure a maximum output voltage, thus a diode with a negligible bias voltage was employed.

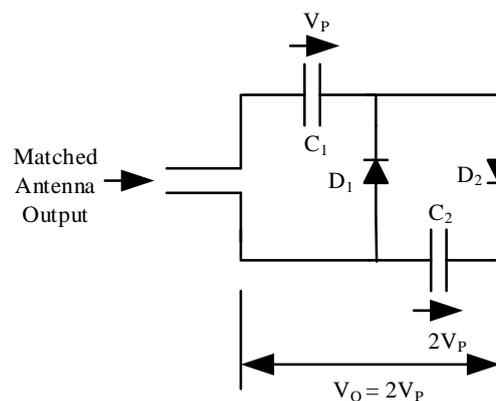


Figure 2. (a) Single stage voltage multiplier / rectifier

RESULTS AND DISCUSSION

In order to verify the performance of our proposed energy harvester, a prototype was implemented and tested. The spiral antenna was implemented on a printed copper board to have a constant $C = 0.239 \text{ cm/rad}$ for the outer spiral. This arrangement resulted in an antenna with a 3 cm radius which can be mounted on a mobile phone very easily. The voltage multiplier was also implemented on the same board using surface mounting components and SMS7630 extra low drop diodes.

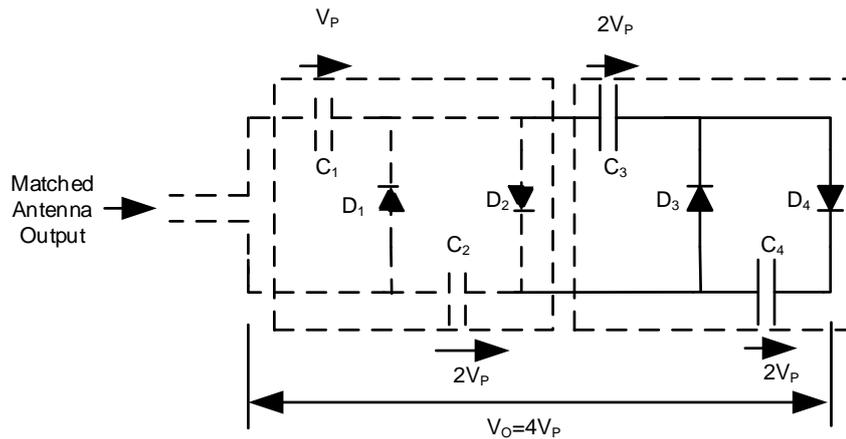


Figure 2. (b) Two stage voltage multiplier / rectifier

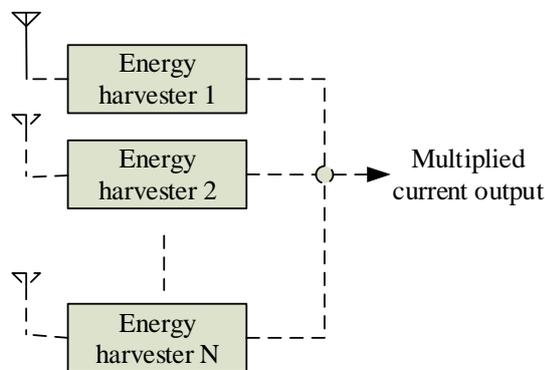


Figure 3. Multiple harvesters operating in shunt mode

The average output voltages for different voltage multiplier circuit capacitor values were measured using an oscilloscope. The results shown in Table 1, demonstrate that 470pF capacitor to be providing the maximum output voltage. This is due to the fact that the higher capacitor values result in larger charging time constants; hence failing to charge to V_p . Moreover, with the increased number of stages in the cascade, the output voltage increases.

Table 1. Comparison of performance with different capacitor values

Number of Stages	Output Voltage (mV)			
	100pF	470pF	1000pF	4700pF
1	0.23	0.72	0.66	0.67
2	0.64	0.95	0.90	0.95
3	1.15	1.38	1.33	1.18
4	1.46	1.64	1.74	1.70
5	1.89	2.27	2.23	2.13

Second, we arranged several energy harvesters in cascade and in shunt arrangements and the average output current and voltage values were observed. The results in Table 2 concludes that the cascading setup increases the output voltage and the shunt arrangement increases the current output.

Table 2. Comparison of different circuit configurations

	Max I _o (mA)	Max V _o (V)
3 stage	0.193	1.38
5 stage	0.136	2.27
3 stage parallel	1.482	1.40
3 stage cascade	0.130	5.34

CONCLUSIONS

The proposed RF energy harvester is capable of extracting the energy from RF signals approximately at a 8mW power level. Even though this is still insufficient in-itself as an energy source for charging a mobile phone, it can be fed-back as a supplementary energy source to extend battery life. Furthermore, our investigations revealed that this energy is sufficient to power up a small alarm clock. More parallel units will improve the current output, but will also increase the size of the circuit. Having an optimum size-power harnessed tradeoff would be an interesting future research area.

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FLOOD MAPPING USING HYDRODYNAMIC MODELING IN MALWATHUOYA BASIN

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INTRODUCTION

Malwathu Oya being among the 103 river basins in Sri Lanka is a highly vulnerable river basin for floods due to the significant rainfall it receives during the North-East monsoon season. Daily river flow in Malwathuoya remains below $2 \text{ m}^3\text{s}^{-1}$ for 90% of the days in a year according to the past records of Irrigation Department (Malwathu Oya at Kappachchi, 1982). However, in the rainy season, the discharge exceeds $200 \text{ m}^3\text{s}^{-1}$ and reaches higher values creating floods in the basin. According to the Disaster Management Center (DMC) records large number of people is severely affected due to floods in the basin. Frequency and magnitude of flood hazards in the basin have increased leading to widespread property losses and agricultural plantation damage, affecting the development of the country. It has become necessary to either totally control these floods or instruct people to adjust their activities to the rhythm of the river and prepare them to live with floods with minimum damages.

This paper focuses on developing a hydrodynamic model to determine water levels and inundation areas along downstream of Malwathu Oya which covers the villages such as Kiwlekada, Alpitiya, Kal Aru, Murukkan and Nanattanin in lieu of developing a flood control strategy for Malwathu Oya basin. High flood elevation and flood inundation maps generated using the hydrodynamic model which incorporates HEC-HMS hydrological model, HEC-RAS hydraulic model and HEC-GeoRAS in ArcGIS interface will be beneficial for the people living in the Malwathu Oya river basin and the relevant authorities involved in developing flood mitigation strategies for the area.

Study area

The overall length of the Malwathu Oya river is 164 km with a gross basin area of 3246 km^2 . The basin is prone to heavy floods annually during the period from October to February due to North-East monsoon rainfall. 'Bogoda' area in Mahawilachchiya District Secretarial Division is one of the most vulnerable places to floods due to its geographical location (Figure 1(a)). The study area was selected in Bogoda near the Kappachchi gauging station, 3.5 km upstream of the confluence of the Nariviti Aru and the Kal Aru rivers with Malwathu Oya in the Malwathu Oya basin (Figure 1(b)). It lies in the area specified by geographic coordinates of latitude $8^\circ 35' \text{ N}$ longitude $80^\circ 16' \text{ E}$. Upstream of Kappachchi gauging station, the catchment is strewn with a large number of small and some large tanks for irrigation of paddy fields. The rainfall-runoff process in the Malwathu Oya catchment is largely influenced by the great number of tanks mainly during the dry season. However, during a flood event such tanks are also at their maximum capacity and their role in regulating river flows is minimal.

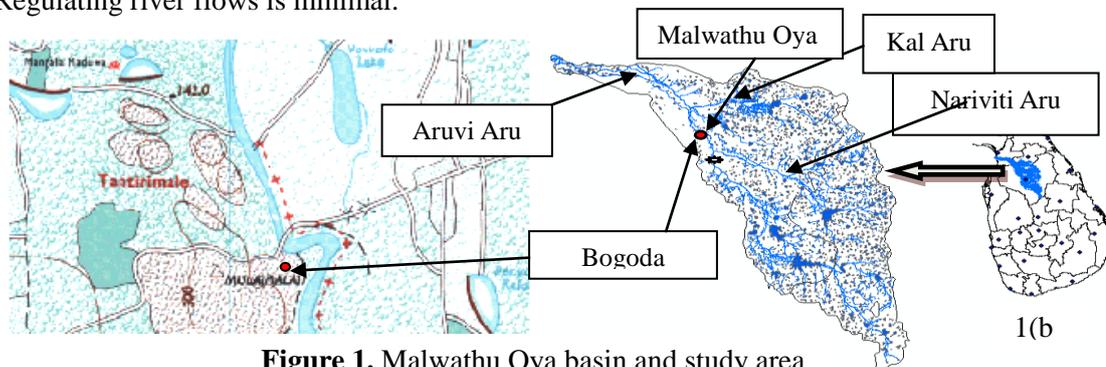


Figure 1. Malwathu Oya basin and study area

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METHODOLOGY

The methodology adopted in this study consisted of data collection, model rainfall run-off relationship for the selected area of the basin (hydrologic modeling), hydrodynamic model development to obtain flood extent and high flood levels (hydraulic modeling) calibration and verification of the model and output generation. A comprehensive framework for the methodology adopted is given in figure 2.

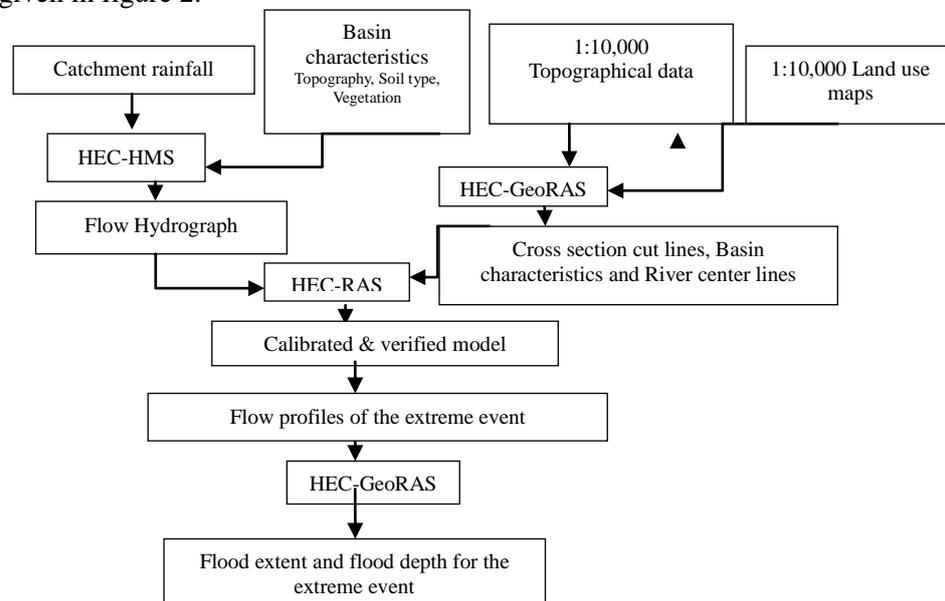


Figure 2. Schematic diagram for the process of flood modeling

Hydrological modeling

Developing a relationship between rainfall and runoff was carried out using a hydrologic modeling software HEC- HMS (User's Manual-Hydrologic Modeling System HEC- HMS , 2011). Hydrologic Engineering Center's Hydrologic Modeling System (HEC-HMS) is a hydrologic modeling software that includes many well-known and applicable hydrologic methods to simulate rainfall-runoff process in river basins (Nandalal and Rathnayake, 2011). Malwathu Oya catchment was divided into three sub – catchments namely, Malwathu Oya upstream, Nariviti Aru and Kal Aru for the purpose of estimation of volume of run-off and flow hydrograph with better accuracy. At this point it was assumed that all reservoir levels were at the full supply level. A comprehensive HEC –HMS model for the Malwathu Oya area was derived using data such as rainfall, initial storage, infiltration rate, impermeable percentage, base flow and maximum storage. The calibrated and verified HEC- HMS model output was used in obtaining design runoff hydrographs necessary for the computations in HEC-RAS hydraulic model.

Hydraulic modeling

The Hydrologic Engineering Center's River Analysis System (HEC-RAS) (Hydraulic Reference Manual-HEC-RAS River Analysis System, 2010) which is capable of one-dimensional water surface profile calculations has been used together with HEC-GeoRAS (User's Manual-HEC-GeoRAS, GIS Tools for Support of HEC-RAS using ArcGIS 10, 2012), a modeling extension which handles the 2-D aspects of flow by connecting the river geometry with a digital terrain model in the form of a Triangular Irregular Network (TIN). The distributed output provided by HEC-RAS for each cross section is interpolated and the result gives the flood extent and depth. Usage of the HEC-GeoRAS in the model involved digitizing of river centre line, river bank and cross section cut lines based on 1:10,000 digital map of the area and generating required cross sections using the TIN of the area. The developed river network along with the cross section details were exported to HEC-RAS. These cross sections were modified using the bathymetric cross section data which was obtained from field measurements along Malwathu Oya for a distance of 1.75 km from Bogoda

bridge in 250 m intervals. Geometric data, basin characteristics, and boundary condition details in terms of flow data were the main input data for the model implementation. Geometric data comprised of stream profile, cross section details at selected intervals and position of stream banks. When basin characteristics are considered Manning's roughness coefficient plays the main role. Manning's roughness coefficient varies with the vegetation pattern along the banks, condition of the stream channel, bed load and suspended load etc. Land use maps and direct observations were used in assessing the Manning's roughness coefficient. As per flow data, the hydrograph derived by HEC – HMS was used as the upstream boundary condition while a normal depth condition was adopted as the downstream boundary condition at the end of the reach.

Model calibration

The model was calibrated to obtain the 'best' parameter set which produce the best fit between the measured and the simulated values within a reasonable accuracy. Model parameters such as Manning's coefficients in different cross sections were adjusted in achieving the best fit. Model was calibrated using the high flood levels during the flood in 2012. Simulation results corresponding to different parameter values were visually compared with observed data, and the parameter set, which matched observed values and simulated data the best, was selected as the calibrated parameter set.

Model verification

In model verification, the validation domain was constrained by data availability such as recorded inundation extent for any past event. Flood depths observed during the extreme event in December 2014 were used in the verification process.

Flood mapping

Calibrated hydrodynamic model was used to produce flood inundation maps for the extreme event which occurred in January 2011 in Bogoda area.

RESULTS AND DISCUSSION

The calibration curve given in figure 2 compares the water profiles observed during the extreme event occurred in December 2012 and simulated water surface profiles for the same period using the best parameter set for the measured bathymetric cross sections in Malwathu Oya. The Mean Ratio of Absolute Error (MRAE) between the two curves was calculated to be 2.09%.

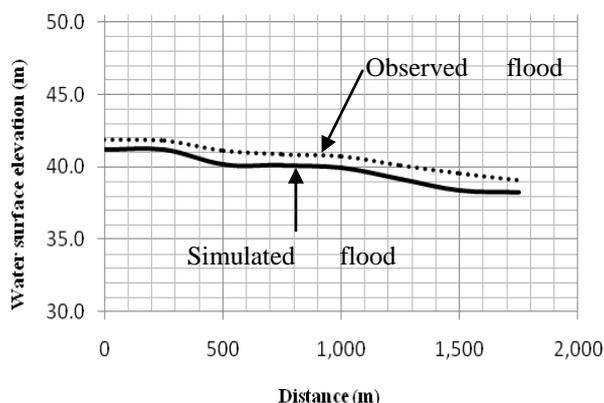


Figure 2. Calibration curve for the flood event in 2012

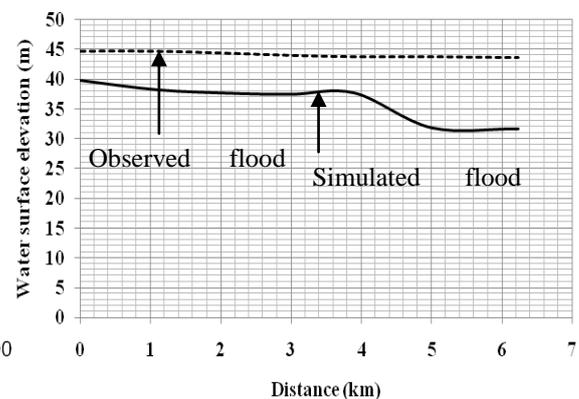


Figure 3. Verification curve for the flood event in 2014

Extreme flood event which occurred in December 2014 was used in the verification process, where the actual floods levels were compared with the simulated water levels for the same period for a distance of 6 km. According to Figure 3, as the calibrated model reasonably reproduces the actual

elevation data from the verification event, the model is considered fully suitable for the application to all other flood events in Malwathu Oya basin. During the verification process the MRAE between the two curves was found to be only 17.7% which is an indication of a successful verification.

Flood mapping for extreme event in January 2011

Figure 4 illustrates the flood extent map which was obtained using HEC-RAS tool for the extreme event occurred in January 2011. Maximum water surface elevations were derived from HEC – RAS and plotted against the elapsed time. The flood propagation which is shown in figure 4 could be visualized only for the area where bathymetric cross sections were available. Figure 5 shows the inundation map obtained using the full hydrodynamic model for the same extreme event via the cross sections generated by the HEC-GeoRAS tool using the TIN of the area.

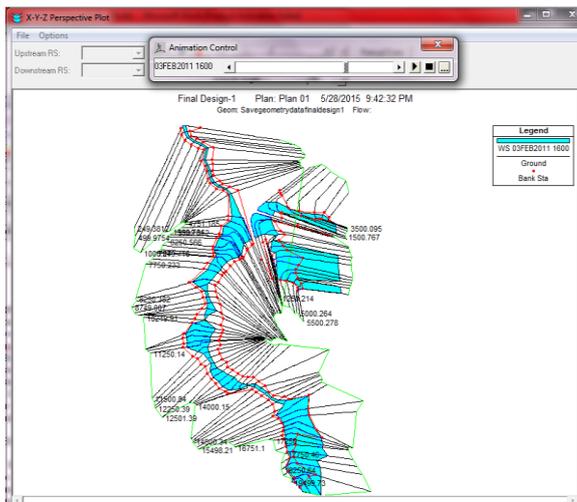


Figure 4. Flood propagation only with HEC-RAS

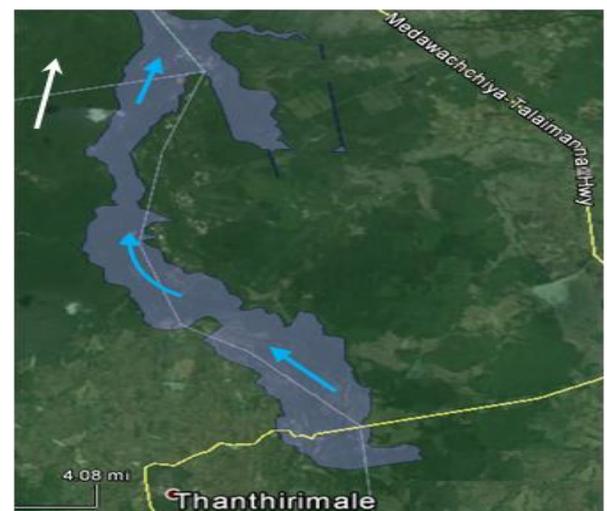


Figure 5. Inundation map generated by the hydrodynamic model shown on Google earth

CONCLUSIONS

A hydrodynamic model has been developed to determine the water levels and inundation areas along Malwathu Oya using tools such as HEC-HMS, HEC-RAS and HEC-GeoRAS in ArcGIS interface. The model was calibrated and verified using the extreme flood events which occurred in 2012 and 2014 with MRAE value of 2.09% and 17.7% respectively. The extreme event occurred in January 2011 was successfully simulated using the hydrodynamic model. Accordingly, the model is capable of preparing inundation maps for any flood that occur in the Malwathu Oya study area.

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PUBLIC HEALTH MIDWIVES' KNOWLEDGE, ATTITUDES AND PERCEIVED LEVEL OF COMPETENCY IN EDUCATING WOMEN REGARDING VAGINAL DISCHARGE

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INTRODUCTION

Vaginal discharge is a common female health concern in South Asia (Khan, 2009; Trollope-Kumar, 2001). It may be a symptom of reproductive tract infections, genital tract malignancies and other reproductive tract disorders. Reproductive tract infections include Chlamydia Trachomatis infection, Gonorrhoea and Trichomoniasis which are Sexually Transmitted Infections (STIs), and Bacterial Vaginosis (BV) and Candidiasis which are nonSTIs. The prevalence of reproductive tract infections has an increasing trend with the low socioeconomic class being affected most (Balamurugan and Bendigeri, 2012).

Pruritus, vaginal discharge and vulvovaginal soreness were significantly higher in women with trichomoniasis infection in women attending a central sexually transmitted diseases clinic in Sri Lanka (Fernando *et al.*, 2012). Furthermore patients with vaginal discharge has been found to be a common presentation in Ayurveda gynaecology clinics in a Teaching Hospital, Sri Lanka and most of them were found to have normal physiological discharge (Karunagoda, 2011). Further Bates (2003) expressed the need of assessing for the possibility of a genital tract malignancy in women presenting with a persistent bloodstained discharge to differentiate cervical, uterine, vaginal and ovarian malignancies as they all have been reported in association with vaginal discharge.

Women are anxious to get treatment for gynaecological problems and they are bound and restricted by their cultural milieu (Ross *et al.*, 2002). Availability, accessibility, acceptability, confidentiality and even lack of publicity of available services were the main barriers for using reproductive health services in Sri Lanka (Agampodi *et al.*, 2008). The Public Health Midwife (PHM) is the key family health worker at the grass root level in the Sri Lankan Health Care System and they provide services especially in Maternal and Child Health in Sri Lanka. Today the service of PHMs has evolved into a career taking a holistic approach in preventive health (Karunathilake and Silva, 2010) and they provide referral information to the community where necessary for any illness (Arulkumaran, 2011). As the PHM is the available and closest health care worker to the community, women can disclose their health problems such as vaginal discharge to the PHM.

Therefore, it is a timely need to assess public health care workers' competency in health education in relation to common women's health issues as they are the most available and the closest members of the health care team to the Sri Lankan community. The main purpose of this descriptive study was to describe the PHMs' existing level of knowledge and attitudes towards vaginal discharge and their perceived level of competency in educating women regarding normal and abnormal vaginal discharge and unhealthy practices in relation to vaginal discharge. This will help to plan an educational programme for PHMs in order to improve their knowledge, attitudes and skills related to health education on this common gynaecological complaint.

METHODOLOGY

A descriptive cross sectional study was carried out in a municipal council area in Colombo

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District, Sri Lanka. All PHMs who have worked at least 6 months during the last 12-months period in Colombo District were selected. Data were collected over a period of five months (January - May 2015) using a self-developed, validated, pretested self-administered questionnaire. The questionnaire consisted of demographic characteristics, questions related to knowledge and attitudes among Public Health Midwives' in relation to vaginal discharge and their competencies in health education in respect of hygienic practices and changing behaviours among females aged 18 to 49 years. To assess the level of knowledge, each correct answer was given a score of 1 and incorrect response 0. Knowledge levels were specified as follows; Adequate knowledge - >75% Moderate knowledge between 50%- 75% and Inadequate knowledge <50%.

Ethical clearance was obtained from the Ethics Review Committee of the Faculty of Medical Sciences, University of Sri Jayewardenepura. Permission to undertake this study in the Colombo district was obtained from Regional Directorate of Health Services, Colombo and Chief Medical Officer of the relevant Municipal Council Area. Data collection was carried out after obtaining informed written consent of the participants. Data were analyzed using Statistical Package for Social Sciences (SPSS) software version 16 and descriptive statistics were applied to obtain percentages and means and then relevant inferential statistics.

RESULTS AND DISCUSSION

Table 1. Demographic data

Variable		Frequency (n)	Percentage (%)
Age	Less than 30years	21	37.5
	31-40years	18	32.1
	More than 41years	17	30.4
	Mean age	36.57years (SD±10.10)	
Duration of working as a PHM	Less than 5years	25	44.6
	6-10years	13	23.1
	More than 11years	18	32.1
	Mean duration of working as a PHM	9.05years (SD± 9.07).	
Common topics used for health education	Family Planning	48	85.7
	Pregnancy	46	82.1
	Early childhood development	42	75
	Immunization	30	53.6
	Newborn care	30	53.6
	Breastfeeding	28	50
	Well-women clinic	25	44.6
	Other disease conditions and their consequences	19	33.9
	Personal Hygiene	08	14.3
Knowledge levels	Adequate knowledge (>75%)	1	1.8
	Moderate level of knowledge (50-75%)	29	51.8
	Inadequate knowledge (<50)	26	46.4
	Mean knowledge score	53.7 (SD±12.36).	

A total of 56 PHMs participated in the study with a response rate of 82%. Mean age of the study participants was 36.57 years (SD± 10.10). A majority of the participants were more than 30 years old (62.5%, n=35) and have worked as a PHM for less than 10 years (67.7%, n=38). Mean years of working as a PHM was 9.05 (SD± 9.07) (Table 1).

All the participants agreed that a clear, non-offensive discharge that varies with the menstrual cycle is a normal physiological secretion (100%). Participants responded to other knowledge questions by agreeing that vaginal secretions vary with menstrual cycle (50, 89.3%), the most common cause of vaginal discharge is sexually transmitted infection (16, 28.6%), women aged between 15-49 years have a normal physiological vaginal secretion (52, 92.9%), white or colored vaginal discharge which may be a sign of reproductive tract infections (42, 75%) and Candida infection is a sexually transmitted infection (34 (60.7%).

Total knowledge score for each participant was calculated by summing up the scores for correct answers. Mean knowledge score among the study participants was 53.7 (SD \pm 12.36). One participant had an adequate level of knowledge on vaginal discharge and 51.8% (n=29) had moderate level of knowledge. Forty six percent of the study participants (N=26) had inadequate knowledge on vaginal discharge which indicated that nearly half of the study sample had an inadequate level of knowledge (Table 1). There was no significant association between duration of working (p=0.329), level of education (p=0.584) and age (p=0.311) with the mean knowledge score within the study sample. The attitude towards health education on vaginal discharge was positive among the study participants. Majority (96.4%, n=54) indicated that health education on vaginal discharge is important. All participants agreed that they are interested in getting their knowledge about vaginal discharge and reproductive tract infections updated. Further they all agreed that it is one of their primary responsibilities to educate females on vaginal discharge in their PHM areas.

Nearly thirty percentage of participants (n=17) agreed that they have received training on "Health Education" during the last five years. They have received training on health education on following topics: 3.6% (n=2) on "nutrition", 1.8% (n=1) on "HIV education", 5.4% (n=3) on "family planning", 1.8% (n=1) on "breast feeding", and 12.5% (n=7) on "Non Communicable Diseases". But no one has received any training or in-service programmes related to reproductive tract morbidities after their basic training other than HIV education. Similarly, almost all Community Health care workers had previous training during their basic health training at schools (AbdulRahman, et al., 2015) than the post placement. Fourteen participants rated their competency in health education on vaginal discharge as poor (25%), twenty six as average (46.4%) and eleven as good (19.6%) (Figure 1).

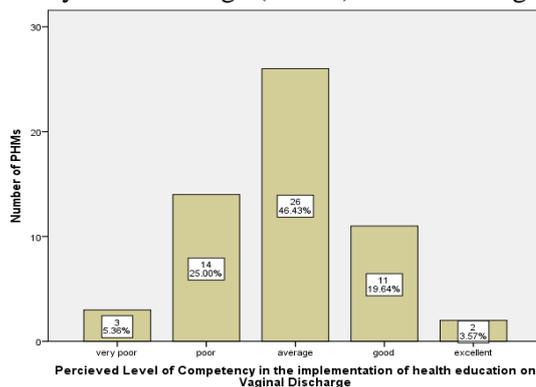


Figure 1. Perceived level of competency in the implementation of health education on vaginal discharge

n=39) and "I am confident with my ability to teach about vaginal secretion" (64%, n=36) indicating positive attitudes. In the present study, majority (73.2%, n=41) of the study participants agreed that health education helps to promote health seeking behaviors among patients.

Importantly participants were of the opinion that excessive vaginal discharge can occur due to body heat (73.2%, n=41) and body weakness (55%, n=31). Further 57% (n=32) consider that weight loss can occur due to vaginal discharge. These findings express the beliefs among PHMs regarding causes for vaginal discharge. Thus by addressing health needs of the public regarding the topic, their lack of proper knowledge could result in the wrong diagnosis and treatment, unnecessary additional treatments, unnecessary or late referrals (if at all) and compromise of final outcome as had been found in a study conducted in northern Nigeria (AbdulRahman et al., 2015).

CONCLUSIONS/ RECOMMENDATIONS

In conclusion, a majority of PHMs displayed moderate level of knowledge regarding vaginal

A majority of the participants (75%, n=42) agreed that vaginal discharge is a normal condition and it is necessary to take treatment for offensive vaginal discharge (100%, n=56). Furthermore, majority disagreed with the statements "those who have excessive vaginal secretion are not healthy" (68%, n=38), "those who have excessive vaginal secretion don't have good personal hygiene" (80%, n=45) and "I find it uncomfortable to talk about vaginal discharge" (80%, n=45) indicating positive attitudes towards caring for women with vaginal discharge. Majority of the participants agreed that "any type of vaginal discharge should be taken seriously" (69.6%,

discharge which is not sufficient for providing proper health education and referral activities at community level. Areas of weakness include recognition of abnormal vaginal discharge and common reasons for vaginal discharge suggesting more of theoretical knowledge. Majority of participants had been working for less than 10 years and have a significant number of years of service before retirement. If given additional training on health education and common gynaecological complaints they will be able to render better services for many more years.

Refresher courses on common gynaecological complaints and how to differentiate normality may be useful in improving their knowledge and skills. Further incorporating teaching methods and communication skills in to the PHM's training will help the community as health education is one of their major responsibilities.

ACKNOWLEDGMENTS

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SAFETY TECHNIQUES USED BY NURSES TO PREVENT X-RAY EXPOSURE DURING FLUOROSCOPIC GUIDED SURGERIES

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INTRODUCTION

Fluoroscopy is an imaging technique that uses X-rays to obtain real-time moving images (Suhm *et al.*, 2003). It allows surgeons to see the internal structure and function of a patient on a display screen and plays a major role in the guidance of surgical procedures (Robert, 1997). The fluoroscopy is a source of X-ray and as such, is a potential health hazard with continued exposure during surgeries (Mariscalco *et al.*, 2011). Fluoroscopic guided surgeries are increasing with providing many benefits for patients in Sri Lanka..

Following the X-ray radiation safety guide-lines is significantly important for theatre nurses. Otherwise it causes different health hazard such as developing cataracts, losing hair, birth defects and developing malignancies (World Health Organization, 2011).

There are no published studies on importance of following radiation safety in Sri Lanka. Hence, the study was focused on examine the safety techniques used during fluoroscopic guided surgeries. Further, this study was determined the knowledge and attitudes among nurses on X-ray safety.

METHODOLOGY

The quantitative descriptive design was utilized for the study. It was conducted using convenience sampling method with 100 fluoroscopic theatre nurses at the National Hospital of Sri Lanka (NHSL), Colombo South Teaching Hospital (CSTH) and Sri Jayewardenepura General Hospital (SJGH). Ethical approval was obtained from the Ethical Review Committee of above hospitals. Pre-tested validated self-administered questionnaire was used to collect data as a tool. It was focused on participants' demographic data; determine nurses' knowledge and attitudes towards X-ray safety; examine existing practice of safety techniques to prevent X-ray and identify barriers to practice safety techniques. Questionnaire was given after obtaining informed written consent. Data was collected from November to December in 2014. The response rate was 96%. Data was analyzed by descriptive statistics using Statistical Package for Social Sciences (SPSS) 16.0 version.

RESULTS AND DISCUSSION

The demographics of the participants for gender showed that 95% were female while 5% were male nurses. The sample represented with 41 from NHSL, 30 from CSTH and 29 from SJGH. In terms of academic qualifications, there were 60.2% of the respondents were diploma holders, whereas 27.8% undergraduate and 11% were graduated with B.Sc. nursing.

The highest numbers of nurses (80%) aware that X-ray can be damaged to the thyroid gland, brain, genital organs, eye, thoracic, abdominal organs and extremities. Further data showed that 60% of nurses reported that there were no harm to hair and teeth due to X-ray (Figure 1).

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Most of the nurses have satisfactory knowledge about damage of main organs due to X-ray exposure. Not only in Sri Lanka but also United State of America the situation is same (Yurt *et al.*, 2014).

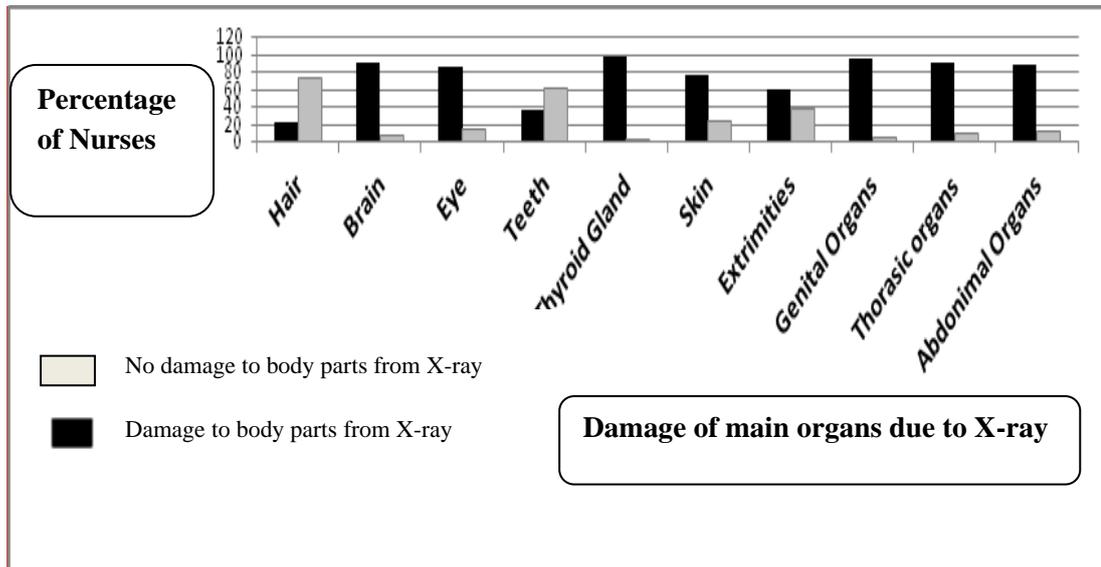


Figure 1. Nurses' knowledge regarding damage to body parts from X-ray

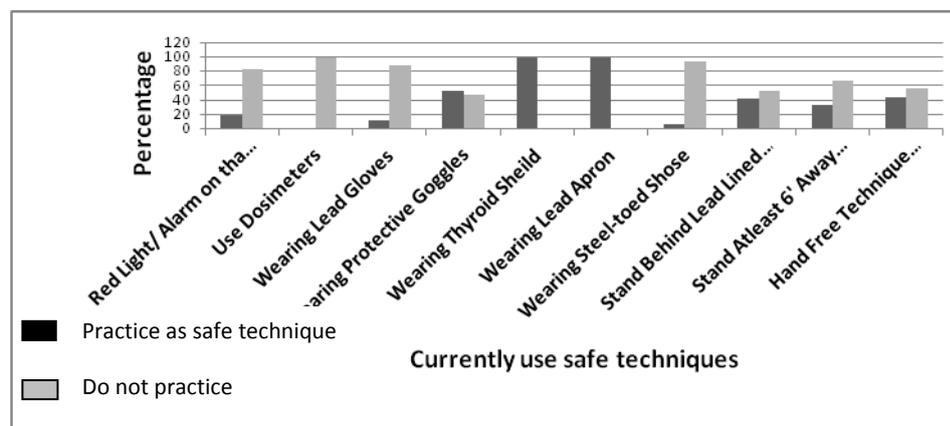
Additionally, it was noted that 99% of nurses were unaware of basic principle of 'As Low As Reasonably Achievable (ALARA)' which as maintain distance from the X-ray source, reduce time of X-ray exposure and shielding. Not only in Sri Lanka but also in Turkey the situation is same (Yurt *et al.*, 2014). Vast majority of nurses (more than 80%) have knowledge of wearing lead apron, thyroid guard and lead lined goggles, red alarm or sign on the door and stand behind lead lined shields as international standard safe techniques to prevent X-ray. Around 60% of nurses are knowledgeable regarding using dosimeters to indicate dosage of personal X-ray exposure, stay away from X-ray beam (at least six feet) and wearing lead lined gloves and use hand free technique from direct X-ray beam as international safety techniques. In contrast, 63% of nurses unaccepted that the wearing steel-toed shoes as standard technique. But nearly half of the sample has lack of knowledge related to some international standard safe techniques for protect themselves, team as well as patients from unnecessary X-ray exposure. Similar finding was pointed out in Kuwait and as well as in Korea (Alotaibi and Saeed, 2006). Sri Lankan nurses do not have basic training program about X-ray safety and it may be one of the reasons for inadequate knowledge regarding some areas.

Based on the result, most of the nurses (82% - 90%) have positive attitudes related to concern of safety of themselves as well as their team members. It was found that 96% nurses have positive attitude towards wearing protective lead shields is important even their family is completed. Results showed that 75%-87% of nurses believed that it is important to wear protective devices while participatine in fluoroscopic surgeries. In contrast 44% of nurses believed that they have not adequate knowledge regarding X-ray safety. The situation of Turkey is also same as Sri Lanka (Yurt *et al.*, 2014). Whereas 92% nurses felt that they need to update their knowledge and attitudes about X-ray safety (Table 1). It is similar to the findings from the study which done in Kuwait and they pointed out nurses were concerned about X-ray and would like to learn more about health risks associated with X-ray (Alotaibi and Saeed, 2006).

Table 1. Nurses' attitudes towards X-ray safety

Statement	Disagree	Neutral	Agree
1. Must be concern all the persons of the team must wear protective lead shields during fluoroscopic surgeries.	2%	14%	84%
2. When see someone without lead apron and a thyroid shield in the theatre must tell to the radiation technician to stop X-ray screening.	3%	8%	89%
3. Must not allow to persons enter to the theatre without protective wearing when using X-ray.	4%	4%	82%
4. When see unnecessarily X-ray screening by X-ray technician without surgeons' order must tell him to stop screening.	3%	7%	90%
5. Wearing protective lead shields by assisting nurse is important during fluoroscopic surgeries.	3%	10%	87%
6. Wearing protective lead shields by circulating nurse is important during fluoroscopic surgeries.	7%	18%	75%
7. Wearing protective lead shields is necessary when my family is completed.	1%	3%	96%
8. I have adequate knowledge regarding X-ray protection.	44%	27%	29%
9. My knowledge regarding X-ray protection must be updated.	4%	4%	92%

In Sri Lanka there is no evidence of use dosimeters to measure X-ray dosage. In contrast, American nurses monitor X-ray exposure by dosimeters (Bahari *et al.*, 2006). Almost all the nurses (99%) use lead aprons and thyroid shields as basic safety techniques. Furthermore 50% of nurses use protective goggles while 50% do not standard of behind lead lined shield. Although 94% not use steel toed shoes, 89% avoid wearing lead gloves and 82% not use red light or alarm. Average amount (58%) does not follow safety techniques for extremities. As well as nearly 70% of them do not uses distance method as stands at least six feet away from direct X-ray beam (Figure 2). In contrast nurses in Korea used protective garments, safe distance and less exposure time as protective measures to limit X-ray exposure (Jung *et al.*, 2013). The overall sample (100%) was accepted that they did not have opportunity to engage in training on X-ray safety. The situation of Turkey is similar (Yurt *et al.*, 2014).

**Figure 2.** Nurses' existing practice of safety techniques

The majority of nurses (72%) identified that heavy weight of the lead apron as a barrier. As well as, more than half of the nurses (54%) face the shortage of protective devices. Whereas 39% of nurses indicated that they dislike using common aprons. Not only in Sri Lanka but

also the situation of United State is also same (Alotaibi and Saeed, 2006). Unfortunately fluoroscopic theatres of NHSL, SJGH and CSTH in Sri Lanka dosimeters are not available. Insufficient equipment, poor use of modern technology, lack of training and lack of knowledge are the barriers for X-ray safety in Sri Lanka. However developed countries have enough safety devices and technology for X-ray safety (Bahari *et al.*, 2006).

CONCLUSIONS / RECOMMENDATIONS

Even though, Sri Lankan nurses have sound knowledge regarding X-ray effects and international standard safe techniques, they do not aware of ALARA principles. Attitudes of X-ray safety among nurses are satisfactory. Practice of safe techniques is very poor. The study revealed that as a developing country insufficient equipment, poor use of modern technology, lack of training and knowledge are the barriers for X-ray safety. Finally this study recommended that to include X-ray safety in for nursing diploma curriculum. As well as nurses already working with fluoroscopy guided surgeries should update their knowledge and attitudes regarding X-ray safety to positive outcome. Authorities should provide adequate amount of safety devices and personal dosimeters to measure personal X-ray exposure level.

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AN EXPLORATION OF THE EXPERIENCES OF PATIENTS WITH LARYNGECTOMY

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INTRODUCTION

Laryngectomy is the surgical removal of part or the whole larynx and surrounding structures. Partial Laryngectomy, supraglottic laryngectomy, hemi-laryngectomy and total laryngectomy are the main types of laryngectomies. Cancer of the larynx is the most common cause for laryngectomy and total laryngectomy is the final solution in most cases (Smeltzer, *et al.*, 2010). Due to this surgery, as a result the patients not only lose a functional part of their body, but they have to live their whole life as a normal person in the society, experiencing a wide range of problems even after completing their treatments.

Patients with total laryngectomy report mainly the functional and psychological difficulties as their experiences (Noonan and Hegarty, 2010). The functional difficulties included alteration in swallowing, excessive secretions, speech difficulties, and weakness of neck muscles, breathing difficulties and altered energy levels. The psychological concerns included descriptions of depression, regrets, and problems with personal resolve. Although patients with laryngectomy live with such experiences, because of the increasing amount of cancer situations in respiratory system, the prevalence of patients with total laryngectomy is increasing all over the world including Sri Lanka. Moreover, there are little or no published studies in Sri Lanka related to this area. Therefore the main purpose of this study was to disclose the experiences of patients with laryngectomy in Sri Lanka. The specific objectives were to identify the physical adjustments with laryngectomy, to discover the psychosocial life of laryngectomized patients, and to explore the factors affecting their psychosocial life.

METHODOLOGY

The study was conducted in the Laryngectomees' Association; the sole community for laryngectomies in the country at the National Hospital of Sri Lanka (NHSL) and it was carried out between December 2013 and January 2014. As the study focus on exploring the day-to-day experiences of participants, to elaborate their fully lived experiences the phenomenological design was used (Basavanthappa, 2007). Purposefully selected 15 laryngectomies who had lost their voice with the surgery and who had more than two years experiences after laryngectomy was recruited for this study. Hence, all of them were using electronic devices for communication. Ethical approval was granted from the ethical approval committee at the NHSL. Written informed consent was obtained from each voluntary participant notifying them of the ability to withdraw from the study at any time without any penalty. Anonymity and confidentiality was assured by securing the information only among the research team and by labeling each patient with a specific code for collected data. Face to face semi structured interviews was conducted for collecting data to maximize the accuracy of the information. A theme list was utilized to guide the interview which lasted for 30 to 45 minutes. Data were analyzed with Hycner's method (Hycner, 1985). According to the steps of transcribing, bracketing and phenomenological reduction of this method, data analysis was carried out to develop common themes. The recorded interviews were transcribed into text with several reviews, clustered, coded according to their common features, and derived sub themes followed with general themes. To maintain the validity of the study, each transcription was reviewed by interviewers to come to an agreement on the extracted themes.

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RESULTS AND DISCUSSION

According to the findings of the study, laryngectomies face various difficulties and these can be categorized into two major facets. Using the generated nine sub themes and two major themes with the analysis process, a model was developed illustrating the laryngectomies' experiences with their new life (Figure 1).

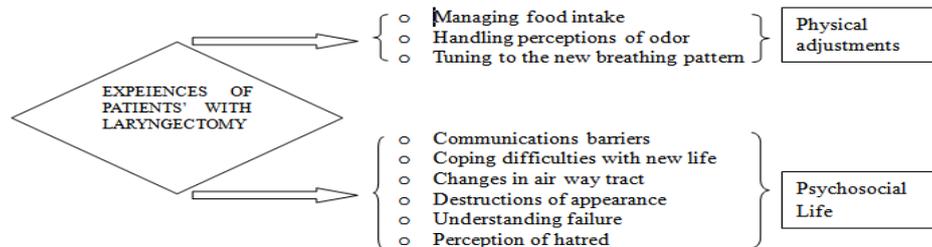


Figure 1. Experiences of Laryngectomy patients.

Physical Adjustments

Whatever the type of laryngectomy that the patients had undergone, all of them experienced physical changes after the surgery such as difficulties of food intake, difficulties in smelling, and especially difficulties in breathing due to loss of the larynx or the vocal tube (Noonan and Hegarty, 2010). Participants of the study highlighted that they have to face various problems with physical changes such as difficulties of swallowing, smelling and breathing after a laryngectomy surgery. However, these were regulated by themselves with time. While such personal changes are often difficult to express, the interviews reflected a variety of personal impacts on this as;

“I often eat rice with much gravy. I want more curry (hodi). I don't like to eat at cafeterias and outside hotels or restaurants. Because if something occurs; I mean cough or respiratory problem it is a big issue. So I drink a milk packet and go home to eat. If the cough starts I can't manage it alone. Need others help” (Participant M).

“After this operation sometimes I don't feel some fragrances such as my perfume or some foods. But I don't worry. Though I can't smell I can do so many things?” (Participant B).

“After one month I could breathe effectively without the help of oxygen machine.... Step by step I used to tolerate and ignore some difficulties like coughing, nasal discharges and high frequency in breathing patterns.”(Participant A).

Similar results were found by Beitler, *et al.* (2010), Berlin, *et al.* (2009), and Noonan and Hergerty (2010).

Psychosocial Life

The function of making sounds is performed by the larynx and the vocal cords. When a person loses parts or all of these structures, it can cause difficulties or they can lose the ability to speak. As a result, communication barriers were the main psychosocial experiences reported, and similar findings were obtained from developed and developing countries (Berlin, *et al.* 2009; Chaves, *et al.* 2012; Green, Matusiewicz, & Borczyk, 2007).

“Nona I can see well. I can here very well. I feel everything as much as you all. But no need to live without my voice” (Participant A).

“I can't express my feelings to my wife as it is. Also I can't go close to my children as I wish. I live with all these sorrows till my death. The biggest sadness was my wife also can't understand me. I have a big fear that I will try to think of suicide again if I

have to face intolerance further. It is only fear I have. I don't like to do so" (Participant A).

Difficulties in coping with new life were also a major psychosocial aspect among laryngectomees due to new communication patterns (Dyer and Powell, 2012). Participant C reported this as;

"Those days I was so aggressive. Even the family members couldn't understand what I say. One day I threw my plate and it was broken. My daughter was also injured with this incident." (Participant H)

Laryngectomees were suffering severe cough, high sputum production and dryness of the respiratory tract when they were coping with new life. Furthermore they were dealing with the problem of coughing and also the problem with their out ward appearance influencing their lifestyle. They always sought to cover it with modifications to their dresses. Similar findings were reported in many studies (Decotte, *et al.* 2010; Nakayama, *et al.* 2010). Participants revealed this situation as;

"I am always covering my neck with this handkerchief and I always bring this papers (showing paper tissues) in my pocket to clean this (showing his neck opening, which is full of secretions)" (Participant N).

"Earlier, always I used to wear trouser and T-shirt. But now I have to use this towel to cover this opening. So I can't wear any types of T-shirts. The neck button is needed to cover the lower part of the neck with this handkerchief. So many things have to think before wear, eat, and go somewhere. This is our Karume....." (Participant E).

Additionally, the impression of the community for chronically ill patients like laryngectomees is bad (Berlin *et al.*, 2009; Chaves *et al.*, 2012). From the interviews of participants' perception of hatred in their current life was revealed as;

"People in my area use some names such as "old man with a hole on the neck" "robot like seeya" and "man speaking with machine". I do not like to go out because of these names". (Participant J.)

"When we talk with this machine young crowd and high class ladies cover their ears with fingers and looks at us like as animals". (Participant C and Participant J)

From the interviewed participants', their experience of difficulties were being understood by others in the society and their hatredness towards them were revealed as;

"Can I speak as they do? But anyone doesn't understand it. It is o.k. if we have any advantage by explaining our difficulties. Nona..... Do you think will they help us with even ten rupees? No never. They just asked for their interest and fun. If we meet on the next day they even don't know who we are. That's the way (Participant B and Participant F).

Most of laryngectomees have a negative impression of society. So they try to hide from the society due to above factors and their special needs such as semisolid food requirements, severe cough during meals and slow oral intake of foods.

CONCLUSIONS/RECOMMENDATIONS

Most laryngectomies are suffering problems with communication, smelling, breathing swallowing and fear of facing the public. The robotic sound comes out from the device that the participants use for communicating with others is the major barrier and the biggest fear for them in facing the public as well as maintaining interrelationship with others. Therefore, developing more versatile speaking devices for low cost is essential. Laryngectomees often complain about a negative attitude of others upon them. Emotional status of the patients appears to be influenced by others' negative attitudes, bad expressions, and these attitudes may have increased their physical symptoms. Similarly, their social activities also seem to be diminishing due to these negative attitudes of the community, which may cause poor quality of life after laryngectomy. Therefore, it is recommended that educational programs be

established through public health nurses and public health inspectors to improve awareness among the general public regarding cancers of the larynx since it will help with early diagnosis of cancer. It is also important to ensure the public awareness on this surgery, its consequents and especially for the benefit of prospective laryngectomy patients, regarding what to expect and how to manage the physical and psychosocial changes after laryngectomy. This will improve their quality of life and will create a harmonious living status for patients with laryngectomy within the society. Moreover, further research on the topic is needed to expand and corroborate the findings of this study, to make better improvements in laryngectomy patients' quality of life, and developing comparatively better speech devices for them.

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MIDWIFERY TRAINED REGISTERED NURSES PERCEPTIONS' OF THEIR ROLE IN MATERNITY CARE TEAMS: A QUALITATIVE STUDY

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INTRODUCTION

In developed countries healthcare professionals such as nurses and midwives have well-established and clearly defined legal and professional boundaries (Sharma *et al.*, 2012). For example in Canada, the College of Registered Nurses of Nova Scotia (CRNNS) and the College of Licensed Practical Nurses of Nova Scotia (CLPNNS) have written guidelines providing a frame work for assigning or delegating tasks and roles to different professional groups within the health care team (CRNNS AND CLPNNS, 2012). The situation is different in many developing countries. For example, in India the role of auxiliary nurse midwives working within hospitals is unclear and poorly defined (Sharma *et al.*, 2012). Even though midwives and nurses play a pivotal role in maternity health care teams, their role and scope of practice is not clearly defined and this can be a contentious issue among multi-professional healthcare teams.

In Sri Lanka, a Midwifery Trained Registered Nurse (MTRN) is a registered nurse with a one-year specialized training in midwifery. In hospitals, MTRNs work with other healthcare professionals such as doctors, midwives and nurses who have not had midwifery training, to provide maternity care. MTRNs' role is not clearly defined in these settings and there are no guidelines for them to follow. There have been frequent conflicts between different healthcare professionals in maternity care units in Sri Lanka and those among MTRNs, non-midwifery trained nurses and midwives, have been particularly severe, leading to trade union actions.

Because MTRNs in Sri Lanka share training pertaining to two professional groups-nurses and midwives, they hold a unique position in the health care team. The ways in which MTRN's perceive their role in maternity care team and how they define their scope of practice has not yet been studied in the Sri Lankan context. To address this knowledge gap, we conducted a study among MTRNs in three tertiary care hospitals in the Western province of Sri Lanka with the aim of describing how they perceive their role in providing intra-natal and post-natal care. .

METHODOLOGY

An explorative qualitative study was conducted using focus group discussions (FGDs) as the method of data collection. FGDs allow in-depth exploration of experiences and perceptions of new topics, and gathers qualitative data that provides insights into the attitudes, perceptions and opinions of participants (Krueger, 1994).

Twenty two MTRNs from selected hospitals participated in the study. Participants were purposively selected. Inclusion criteria specified that participants should have more than four years experience in an intra- natal or a post- natal unit. Three FGDs were conducted by the first author using a semi-structured interview guide. The interview guide was evaluated by two clinical experts in qualitative research. The interview guide consisted of eight open ended questions which were focused on what MTRNs perceive as their role in this setting and their

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experiences in provision of care with other care providers. Six to eight MTRNs participated in each FGD which were about one and half hours in duration. Each FGD was conducted in Sinhala medium and audio recorded with permission of the participants. Note taking was done by a note taker during the each FGD. Data were collected from August 2013 to January 2014.

The audio recordings from the FGDs were transcribed into text, verbatim, in Sinhalese and translated into English. The text was analyzed using conventional qualitative content analysis method as described by Graneheim and Lundman (2004). The transcribed data were coded, similar codes were pooled into categories and eventually themes were generated according to the objective of the study.

Ethical approval for the study was obtained from the Ethics Review Committee (ERC), Faculty of Medical Sciences, University of Sri Jayewardenepura and the ERCs of the relevant hospitals. Permission was also granted from the Ministry of Health for conducting the study.

RESULTS AND DISCUSSION

MTRNs who joined the study were aged between 29 to 55 years and their average duration of nursing and midwifery experience was 17 years and 10 years, respectively. Out of 22 participating MTRNs, 2 were nursing degree holders and the others were nursing diploma holders. The result of the data analysis is presented as three themes: ‘my role: what we have to do’ which refers to the tasks and responsibilities identified and encompassed as their own by the MTRN; ‘overlapping roles’ which refers to the tasks performed by MTRNs as well as others in the team; and ‘role disagreements’ which refers to instances where MTRNs were confused about the role and/or perceived a situation of conflict.

‘My role: what we have to do’

Participants perceived their own role in terms of individual tasks and responsibilities identified by them as specific MTRNs duties. In doing so they placed themselves in an exclusive group described as ‘we’ and ‘us’, that is separate from others such as doctors and midwives in the team. For example, as shown in the excerpts below, MTRNs take on the responsibility of welcoming, explaining and comforting a woman when she arrives in the labour room for the delivery and in the post-natal ward after the delivery of the baby. In being able to recognize these as exclusively as their duties, tasks and functions, MTRNs demonstrate a strong sense of responsibility and belonging.

“After coming into our labour room we take the responsibility of welcoming mother, ensuring safety of the mother, fulfilling her needs, preventing from complications and all”. (FGD-03)

“we insert a canula and explain it to the mother this is inserted to give drugs and saline. Next we auscultate fetal heart sounds and inform the doctor. We monitor fetal heart sounds every fifteen minute. Getting an idea about the condition of the mother, start oxytocin drip according to the prescription.” (FGD-03)

“After the mother and the baby were sent to the postnatal ward, taking over the baby by checking sex of the baby, disc number and checking whether baby has been fed are our responsibilities. After keeping the mother in the bed, bleeding is observed. If it is a forceps or vacuum, antibiotics should be continued. In addition, whether vaginal pack is inserted, If so when it will be removed, we have to give over and document after checking the BHT. If mother does not have any food, we find and offer something to eat and give the baby to the mother for breast feeding again. If the baby is with poor sucking, PHO is informed. Baby’s ticket is kept in the PHO file and maintained”. (FGD-01)

There is an overreaching sense of pride and belonging in the way in which MTRNs showcase their enormous responsibility towards the mother and the baby while describing these tasks.

“Whole responsibility of the mother and the baby, are upon us, whether mother has had her meals, how is the blood pressure? Has the baby been fed, has the baby been examined by doctor, all these tasks are done by us”. (FGD-01)

‘Overlapping roles’

According to the participants there were a set of tasks and duties to be completed by “others”. For the MTRN’s, the others’ roles were not clear and it was not well demarcated from their own roles. Midwives, nurses and doctors tasks and responsibilities were often seen as overlapping with their own. This meant that some of the work done by MTRNs were ‘hidden’ or ‘minimized’ by the overlap with others roles.

“Although we work hard our role is always hidden. We do half of the doctor’s duties, do nurse’s part completely, do more than half of midwife’s duties. But including their (midwives’) name for the delivery means the most important part has been done by them. We have done nothing”. (FGD-02)

MTRNs felt that others accepted MTRNs performing these tasks when everything was in order, however, when ‘something went wrong’ this created problems because they had to bear the sole responsibility for it. MTRNs sensed unfairness in being ‘blamed’ in this manner.

“Things go smoothly as long as there is no problem. When a problem arises, the ball is always passed. Why didn’t you do? At the end the ball is passed to the nurse.” (FGD-02)

“Her (Midwife’s) responsibility is similar to that of a midwifery trained nurse. She can check FHS, deliver the baby, remove urine, and put the CTG”. (FGD-02)

‘Role disagreements’

The third category that emerged was the situations in which the roles were clearly conflicted. MTRNs perceived some situations as being clear disagreements with regards to roles and responsibilities resulting in confusion, frustrations and conflicts. This was of particular significance around their role in the delivery of the baby. Lack of a clear understanding about who is responsible for attending to a delivery created conflicting situations.

“The midwife came and told me why are you doing these things? Don’t you have other work to do like giving injections? This is our duty. This is when problems begin”. (FGD-02)

“One day I went for a delivery. When I was getting ready to perform the delivery, the midwife was doing another delivery. At the moment I was holding the skin to give the epis a midwife came from the antenatal side, pushed me away blaming me aggressively and did the delivery”. (FGD-01)

MTRNs displayed a sense of belonging and esteem when performing roles and responsibilities clearly identified as being their own. However, when their roles overlapped or conflicted with others their contribution was perceived as being ‘minimized’ by others. This was particularly significant when there were failures or break down of processes. Moreover, role disagreements around the time of the delivery and in competing essential tasks means there are implication for patient safety. Lack of clarity with regards to each professional groups’ role meant that opportunities to examine reasons for omissions and and/or break down in processes were often missed.

CONCLUSIONS AND RECOMMENDATIONS

Lack of clarity with regards to each professional group's roles has been reported as a reason for conflict among team members. (Oelke et.al , 2008; Nayanga et al ,2012). This is particularly common in labour rooms because midwives, nurse-midwives and obstetricians are known to compete for professional space around child birth (Sharma et.al. 2012). When different professional groups lacked clarity regarding their own roles and responsibilities it also affected their self-esteem and ability to develop as an individual as well as a team identity in a multi-disciplinary team. Defining Midwifery Trained Registered Nurse's scope of practice and clear delegation of responsibility using written protocols and guidelines will help improve team dynamics within similar maternity care teams.

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CRITICAL CARE NURSES' KNOWLEDGE AND PRACTICES ON ADMINISTERING TOTAL PARENTERAL NUTRITION FOR CRITICALLY ILL PATIENTS IN TWO SELECTED TEACHING HOSPITALS IN SRI LANKA

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INTRODUCTION

Nutrition is a vital requirement of every person and is essential for their survival (Warber, Warber and Simon, 2000). When people become ill, nutrition is the major supportive tool for their healing and recovery process (Eulalia and Dawn, 2013). In that sense, slowed or impaired recovery from illness or surgery is strongly associated with poor nutrition. For wound healing, tissue maintenance, and faster recovery, patients need optimal nutritional intake. If patients become critically ill or have digestive tract problems or have undergone a surgery to remove a part of the digestive organs, the nutrition must be supplied in a different way than the normal oral route. In such situations, nutrition can be supplied via a tube passed to the digestive tract (enteral nutrition) or as an intravenous solution (parenteral nutrition) (Mohammed & Taha, 2014). Parenteral nutrition (PN) is feeding of patients via a line placed over their vein which bypasses usual eating and digestion process (Jain and Teckman, 2014). Total Parenteral Nutrition (TPN) is used for patients who have non functional gastrointestinal tracts (GITs) and are unable to take meals by other routes. TPN provides nutrients such as glucose, amino acids, lipids and added vitamins and dietary minerals which are essential elements for the survival of a person (Thomas, 2010). TPN is mostly used for the patients who are admitted to the critical care units owing to the dependent nature of their diseases. The critical care nurses have a big responsibility in taking care of patients who are admitted to critical care units. The critical care nurse is a licensed nursing professional who is responsible for ensuring optimal care to acutely and critically ill patients and to their families (American Association of Critical-Care Nurses, 2015). As the provision of nutritional support is one of the most important elements of a critical care nurse's caring role, they should have proper knowledge and practice regarding administering TPN. Therefore this study was planned to examine critical care nurses' knowledge and practices regarding administering TPN for critically ill patients in critical care units in teaching hospitals of Anuradhapura and Kurunegala. The study was further guided by the following objectives; to assess the critical care nurses' existing knowledge on TPN administration, to identify critical care nurses' practices on TPN administration and to determine the critical care nurses' perceived barriers in administering TPN for critically ill patients.

METHODOLOGY

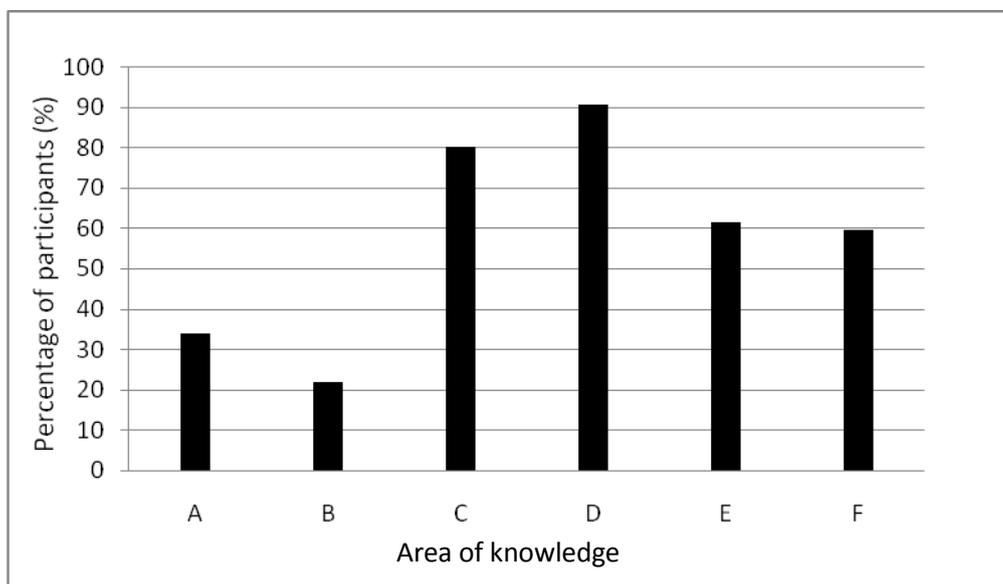
Quantitative approach and descriptive design were used for the study. Using convenient sampling technique, a sample of 150 critical care nurses from eight critical care units of Kurunegala and Anuradhapura Teaching Hospitals in Sri Lanka was obtained for the study. Having a minimum of six months work experience at critical care units was the inclusion criteria. A researcher administered questionnaire was used as the research tool for the data collection. Content validity of the tool was assured by referring to the TPN guideline of North York General Hospital and modifications were done by the supervisor. Reliability of the tool was assured by performing test-retest reliability procedure. Ethical clearance was granted

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from the Ethical Committee of the Teaching Hospital Kurunegala. Written informed consent was obtained from each participant prior to the data collection while assuring voluntary participation. The data analysis was done by using SPSS statistical software. The questionnaire consisted of two parts, part A and part B. Part A consisted of socio-demographic questions and part B consisted of knowledge related questions (section 1) and practices related questions (section 2) on TPN. The knowledge and practices related to each area of TPN administration (6 areas for knowledge and 5 areas for practices) were assessed.

RESULTS AND DISCUSSION

The response rate of the study was 70.7%. In the sample, a majority was females (93.4%). When considering working experience in critical care unit as a nurse, 70.6% of the sample had six months to five years experience, 24.5% had 5-10 years experience while 4.7% had more than ten years experience. When considering the highest level of nursing education amongst participants, 0.9% were graduates, 15.1% were under graduates and 84.0% were diploma holders.

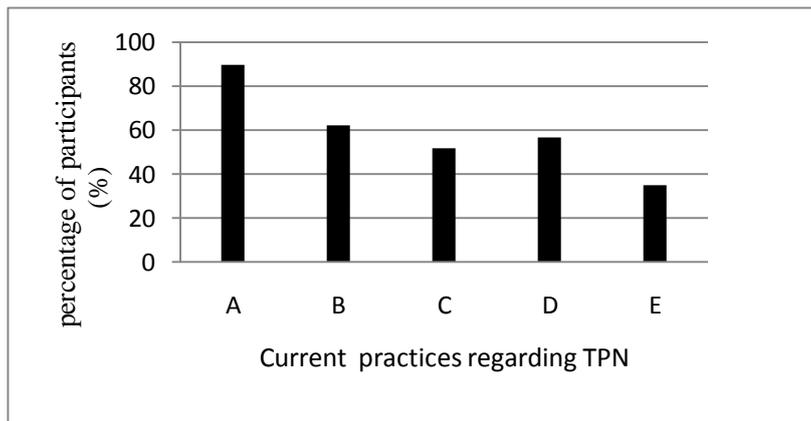


- | | |
|---|---|
| A. Knowledge in identifying correct venous access for Total Parenteral Nutrition (TPN) administration | D. Knowledge on required observations during TPN administration |
| B. Knowledge on required investigations before TPN administration | E. Knowledge on TPN administration related complication |
| C. Knowledge on standard composition of TPN | F. Knowledge on fluid management during TPN administration |

Figure 1. Critical care nurses' existing knowledge regarding TPN administration

The study findings showed a variation in knowledge regarding TPN administration amongst nurses. The majority of the participants knew the required observations during TPN administration. Many participants knew about standard composition of TPN and the complications related to TPN administration. More than half of participants knew about the correct way of fluid management during administration of TPN. But, the majority had insufficient knowledge regarding identification of correct venous access for TPN administration and required investigations before TPN administration as similar to the findings of Mohammed and Taha (2014) and Erdil and Dinc (2000) (Figure 1). In the clinical setting in Sri Lanka, the persons who are mostly involved in identifying correct venous access are medical persons. Thereby, nurses do not have many chances to get involved in this task. Hence, they do not have opportunities to gain hands on experience to identify correct venous access as they do not practice it in clinical setting. This might be a possible reason for their

relatively poor knowledge in this regard.



- A. Hand hygiene during TPN administration D. Correct use of central venous catheter
 B. Use of dedicated intravenous line for TPN administration E. Frequent changing of intravenous infusion set
 C. Maintenance of intravenous catheter site

Figure 2. Critical care nurses' current practices regarding TPN administration

According to the findings, a majority of participants had maintained hand hygiene during TPN administration and a majority had used dedicated intravenous line for TPN administration. Similar results were shown by Daniel et al. (2013) in their study. But, relatively few participants practiced changing the intravenous infusion set frequently. The possible reason may be the lack of resources for frequent changing of intravenous infusion sets which is a common problem in the current health care setting. More than half of the participants had practiced maintenance of intravenous catheter site, which is similar to the findings of Dudrick (2009) (Figure 2).

The results showed that the participants had identified few barriers for TPN administration such as inadequate resources, inadequate knowledge and having a tendency of getting complications during TPN administration. Majority of participants were not satisfied about their present knowledge of TPN.

CONCLUSIONS/RECOMMENDATIONS

The critical care nurses who are working in Anuradhapura and Kurunegala Teaching Hospitals had knowledge and practices in many areas on TPN administration for critically ill patients. But, it was also reported that the critical care nurses lacked in knowledge and practices on some areas. The reported lack of knowledge and practices may be due to lack of educational materials, policies and protocols about TPN and lack of resources in the critical care units. Specifically, as the task of identifying venous access for TPN is not a current practice of nurses, it may be another reason for them to lack in their knowledge. Based on the results, it is recommended to establish written updated protocols and guidelines about TPN to ensure enough knowledge and standardized nursing practice. Further, educational programmes and practical sessions should be implemented on regular basis to update critical care nurses' knowledge regarding the TPN. Moreover, it is important to focus on revising nursing curriculum of basic nursing diploma programme to ensure provision of sufficient knowledge and practice on TPN administration for nursing students. As this study is limited only to critical care units of two Teaching Hospitals, replication of the study in critical care units of other hospitals in Sri Lanka is important to have a wider picture of nurses' knowledge and practices regarding TPN.

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KNOWLEDGE, ATTITUDES AND PRACTICES ON ANTIBIOTIC USE OF A STUDENT POPULATION ATTENDING OPEN UNIVERSITY OF SRI LANKA (OUSL): A DESCRIPTIVE STUDY ON UNDERGRADUATE NURSING STUDENTS

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INTRODUCTION

Antibiotics are drugs used in the treatment of microbial infections. They are substances produced by the microorganisms that are antagonistic to the growth of other microorganisms. The range of antibiotics is wide and selection of the antibiotic depends on the knowledge of the likely or proved pathogens and the factors relevant to the patient (Bennett P. N. and Brown M. J., 2003). According to WHO health reports, antibiotics are the most commonly prescribed and abused drugs for upper respiratory tract infections (URTIs) (World Health Organization, 1988, 1996).

More than 50% of antibiotics in the world are purchased privately without a prescription from pharmacies or street vendors in the informal sector (Cars, O. and Nordberg, P., 2005). In developing countries the use of antibiotics without medical guidance is largely facilitated by inadequate regulation of the distribution and sale of prescription drugs (Byarugaba, D. K., 2004) (Hart CA, *et al.*, 1998).

In the United States of America and Europe, self-medication is practiced particularly for colds and upper respiratory tract symptoms, which are self-limiting and mostly caused by viruses (Grigoryan, L., *et al.*, 2007) (Väänänen M. H., *et al.*, 2006) The emergence and spread of resistance related to the irrational use of antibiotics is a main global public health problem (World Health Organization; 2007).

METHODOLOGY

A descriptive study was conducted to assess the knowledge, attitudes and practices on antibiotic use among the undergraduate students of nursing (Level 05) attending the Faculty of Natural Sciences, OUSL. The study group was already employed nurses at the government sector and they were diploma holders. Data were collected during the year 2013.

The sample size was calculated by considering confidence level: 95%, confidence interval: 5 and population size: 430. Calculated sample size (N) was 203. A pretested interviewer-administered questionnaire was used as the data collection tool and it was given after obtaining informed written consent. (n= number of participants responded)

The data were analyzed using EXCEL version 2010 and each question was analyzed individually. Ethical approval was granted by the Ethical Review Committee of the University of Sri Jayewardenepura, Sri Lanka.

RESULTS AND DISCUSSION

Demographic characteristics

The response rate was 100%. The median age of study participants was 30 years

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(IQR = 27–46 years). Female study participants accounted for 97.5% (n = 203). Majority of nurses (54.18%, n=179) were having income LKR. 21,000.00 to LKR.30, 000.00.

All of the study participants (100%, n= 203) responded that they have heard about antibiotics similar to the findings of Changhua *Chen et al.*, (2005). All the respondents had heard about Methicillin-Resistant *Staphylococcus aureus* (MRSA).

Knowledge on use of Antibiotics

Majority of participants (70.3%, n=199) responded that microbes are used as a natural source of antibiotics. Only 48.6% (n=185) participants knew that antibiotics are needed for hepatitis while 99.5% (n=200) responded that antibiotics should be given to the sore throat caused by bacteria. Participants responded that antibiotics are not required for treatment of common cold (77.4%, n=186) and for every infectious disease (46.4%, n=194). Fifty seven percent of the participants (n=200) responded that antibiotics will not resolve the symptoms of flu and common cold. However common cold (32.0%) and sore throat (20.6%) has been identified as the most frequent indications for the use of self-medicated antibiotics according to Grigoryan L, *et al.*, (2007).

Participants responded for the commonly used antibiotics as Amoxicillin (98.5%, n=203), Penicillin (91.3%, n=184) and Cephalexin (92.0%, n=187). A study done by Grigoryan L, *et al.*, (2007) also found Amoxicillin as a commonly prescribed antibiotic. All participants responded (100%, n=203) that antibiotics should be given at the correct time interval and (100%, n=202) were known that some antibiotics may have side effects. This high level of knowledge may be due to the fact that the study group comprised of already employed nurses.

A majority of participants (81.5%, n=200) responded that antibiotics should be taken for the prescribed time duration. Eighty three percent (n=195) of participants knew that any antibiotic cannot be given to pregnant mothers while 75.6% (n=201) of participants responded that any antibiotic cannot be given to children (below 12 years). These high correct response rates may be due to the study group being already practicing nurses.

Further 99.4% (n=197) of participants responded that inappropriate use of antibiotics may lead to antibiotic resistance and 96.9% of the participants (n=199) responded that frequent administration of antibiotics without a correct cause, can develop resistance to antibiotics. Further the participants responded that the possibility of emergence of antibiotic resistant bacteria can be due to not administering at prescribed intervals (83.8%, n=201) and not administered for the prescribed time period (77.4%, n=195). Similar findings were found in studies done by Spellberg B., *et al.*,(2008) and de Silva N., *et al.* (1995)

Attitudes on use of Antibiotics

The study findings indicated that majority of the sample agreed 90.1% (n=202) that antibiotics should be always prescribed by a physician and 64.9% (n=202) most of the upper respiratory tract infections are self-cured even without the use of antibiotics. Participants showed positive attitudes on completing the antibiotic treatment for the prescribed treatment schedule 89.6% (n= 201) even when symptoms decrease and 57% agreed on same fact in a study done among public in Kuwait (2015).

All participants agreed that 100.0% (n= 203) previous incidence of allergies should be informed to the doctor and 98.5% (n= 203) of respondents agreed that side effects due to antibiotics should be immediately reported to the doctor. However more than half of the participants disagreed on the fact that antibiotics can be used safely without previous consultation of a physician 85.1% (n=201), and correct time intervals is not important when taking antibiotics 92.4% (200). The high correct response rates may be due to the education given to the nurses and their experience. Seventy three percent (n=203) responded that antibiotic resistance is not a problem as there will be new antibiotics produced and are in

contrast to findings in a study done by Lilian M. Abbo., *et al* (2013) where it was responded as 20% by US medical students.

Practices on use of Antibiotics

The findings of the practices on antibiotic use revealed the following (Figure 1).

More than 80% of the participants indicated that antibiotics should be taken at the correct time intervals (87%, n=198) and for prescribed time duration (88%, n=198)

Sixty three percent of the participants (n=109) continued the antibiotic treatment even when symptoms are over and they were taking antibiotics for prescribed by a physician at all times. Similar results were found in a study done on antibiotic resistance and usage by third and fourth year medical students in India by Rekha M.S., *et al.* (2014)

Fifty percent of the participants were often taking antibiotics with previous consultation of a physician, which was 64.29% in study done by Rekha M.S *et al.* (2014). However 44% (n=201) of the participants were reusing antibiotics which they had used in the past, if similar symptoms occurs which can be due to the knowledge and easy access to the medicines for nurses.

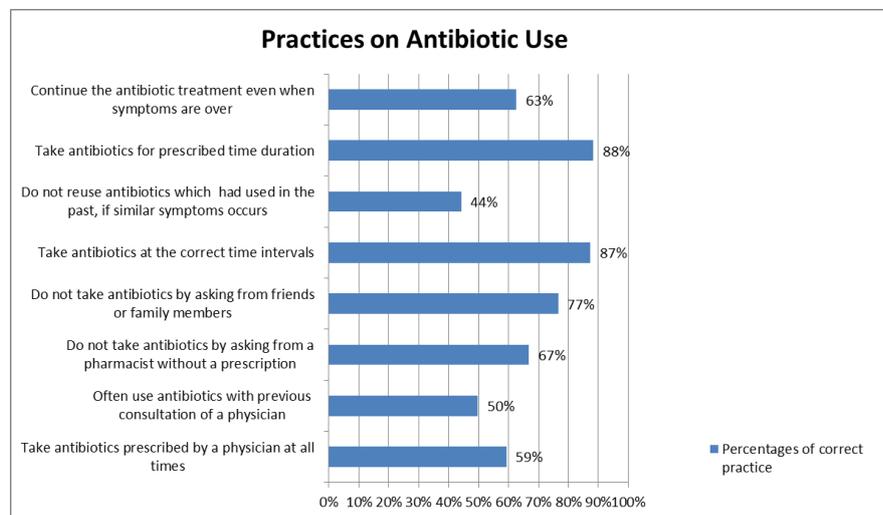


Figure 1. Nurses practices towards Antibiotic Use

CONCLUSIONS / RECOMMENDATIONS

In conclusion, the study results indicated that the majority of nurses' had good level of knowledge regarding antibiotic use, correct time interval (frequency of administration), continuing the treatment for prescribed duration and side effects that might occur due to antibiotics. All the respondents had knowledge on antibiotic resistance due to inappropriate use of antibiotics and use of antibiotics for flu or cold conditions.

The study group had correct practices on continuation of antibiotic treatment for the prescribed duration, frequency and getting prescribed antibiotics always by a physician. Furthermore, it is recommended to compare the knowledge, attitudes and practices of these undergraduates nursing students with some other undergraduate student group.

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KNOWLEDGE AND PRACTICES OF INTENSIVE CARE NURSES ON ENTERAL NUTRITION CARE

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INTRODUCTION

Enteral Nutrition (EN) refers to delivery of comprehensive nutritional feed into stomach, duodenum or jejunum by orally or using a tube (Kerby and Parisian, 2011). Further, EN is the preferred method of nutritional administration for critically ill patients (Escribano *et al.*, 2011) who have increased metabolic states and augmented nutritional needs (Webster and Galley, 2000).

EN should be initiated within first 24 – 48 hours of admission for patients who receive ventilator support and having stable hemodynamic states. In the preparation of EN feeds, specialized formulae are recommended to critically ill patients as formulas are less contaminated compared to handmade feeds (Sullivan *et al.*, 2001). When administering EN, continuous feeding is preferred to intermittent feeding as this method prevents peptic ulcers. With regard to risks associated with EN, incorrect position of feeding tubes and aspiration account the foremost. Aspirations can be minimized by keeping the head of the bed to a minimum of 30° to 45° during administering EN. The only reliable method of ascertaining the placement of feeding tube is radiographic confirmation because the results of using capnography and pH testing have been inconsistent. The assessment of gastric residual volume (GRV) is useful to recognize intolerance to EN. In this aspect, the GRV values greater than 200mL are considered as high in critically ill patients who are in mechanical ventilation. The pro-kinetic agents have been used to promote gastric motility and prevent unnecessary interruptions of feeding. The patency of feeding tube should be maintained by routine water flushes as occlusions are more frequent when administering EN (Bourgault *et al.*, 2007).

Intensive Care Unit (ICU) nurses play a major role in maintaining patients' nutritional status at a desired level which should be closer to the nutritional goals. As the nurses' responsibilities in determining EN volume, tube insertion, administration of feeding and related care are important, the nurses' knowledge and practice related to EN will affect the clinical outcome of the patient. For instance, some nursing practices may contribute to patients being malnourished and hypo-caloric (Kalaldehy, 2011) while accurate nursing practices on EN such as, using prokinetic agents, diminishing feeding rate, measurement of gastric residual volume, maintaining correct patient's position and checking tube placement are important to prevent such consequences related to EN (Kalaldehy, 2009). Thus, the present study was carried out to assess the ICU nurses' knowledge and practices on EN care and to identify the barriers in providing EN care thereby ensuring the desired level of EN care for critically ill patients.

METHODOLOGY

A quantitative descriptive study was conducted in three government and provincial hospitals in Colombo, Ratnapura and Kalutara districts during the month of December 2014. Registered nurses who are having two years working experience in the medical, surgical and neurological ICUs of National Hospital of Sri Lanka (NHSL) and general ICUs of General Hospital, Ratnapura and Base Hospital, Panadura requested to fill in structured and pretested questionnaire regarding knowledge and practices on EN care for critically ill patients. The

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questionnaire was consisted of four parts: demographic and background characteristics, knowledge and practices on EN care and barriers to provide good EN care. A purposive sample of 150 was included in the study. Ethical clearance was granted from the Ethical Review Committee of NHSL. The descriptive analysis of data was performed by using SPSS 16 and the data management tool Microsoft Excel 2007.

RESULTS AND DISCUSSION

The response rate was 92%. Seventy three point nine percent study participants were recruited from NHSL while the remainder was from General Hospital, Ratnapura and Base Hospital, Panadura. Majority of the sample (70.3%) represented from the 26-35 years age group while 94.9% of the participants were females. When considering the type of ICU, majority of the participants (31.2%) works in Medical ICUs. It was observed that nearly 45% of the respondents were experienced for 5 to 10 years as ICU nurses (Table 1).

Table 1. Demographic and background characteristics of participants

Characteristic	Frequency	Percentage %
Age (Years)		
26-35	97	70.3
36-45	28	20.3
>46	13	9.4
Gender		
Male	07	5.1
Female	131	94.9
Affiliated Hospital		
National Hospital of Sri Lanka	102	73.9
General Hospital, Ratnapura	25	18.1
Base Hospital, Panadura	11	8.0
Type of ICU		
Medical	43	31.2
Surgical	32	23.2
Neurological	27	19.6
General	36	26.1
Experience as a ICU Nurse (Years)		
2-4	49	35.5
5-10	62	44.9
>10	27	19.5

The assessment of knowledge on EN revealed the following (Figure 1). Majority of the study participants (89.9%) expressed that aspiration is a major risk accompanied with EN while approximately 83% of participants further mentioned that positioning of head of the bed to a minimum of 30° will reduce the risk of aspiration. A similar result was obtained by Bourgault et al. (2007). Among the study participants, only 39.9% were known

that EN should be initiated within first 24-48 hours of admission. However, this result was contradicted the finding of Gupta *et al.* (2012). With regard to preferred administering method of EN, only 40.1% of the respondents correctly identified continuous feeding. This finding was contrast with Mula, Ncama and Maluwa (2014) study as 68.6% of their study group correctly stated continuous feeding. When considering the preparation of EN feeds, nearly three quarter of participants correctly indicated that specialized formulas should be used for critically ill patients. However, this result was not consistent with Mula, *et al.* (2014) study as only half of their participants expressed the correct measure. About 56% of the respondents correctly knew that it is necessary to check GRV before administering EN. This finding was proven by Mula, *et al.* (2014). All the participants identified the importance of flushing tubes with water to prevent occlusion.

ICU nurses' practices regarding Enteral Nutritional care

According to the findings (Table 2), majority of the study participants always perform the correct practices of elevation of head of the bed to 30° - 45° when feeding (71%), educating patients and their relatives regarding nutritional requirements (100%), discarding unused feeds 06 hours after preparation (90.6%) whereas 79.7% of respondents always incorrectly followed the practice of mixing handmade feeds with specialized formulae when preparing

the feeds. Gupta et al. (2012) indicated a similar finding for the correct practice regarding unused feeds.

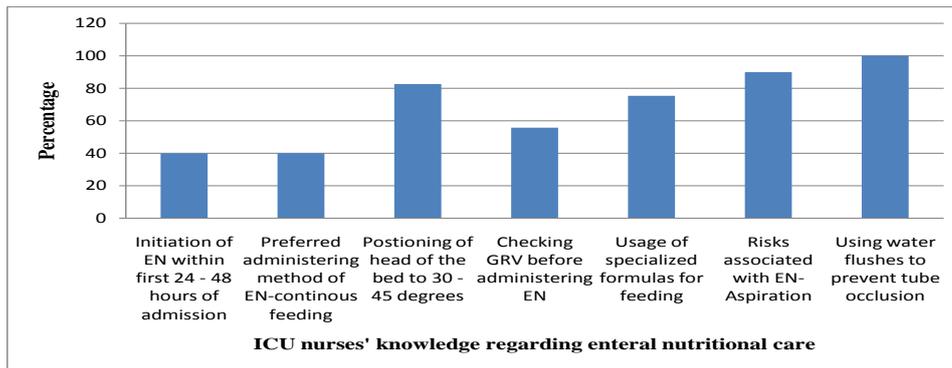


Figure 1. ICU Nurses' knowledge on EN care

It is essential to prepare feeds according to the calorie requirement of patients and to use prokinetic agents in promoting gastric motility all the time. However, 63.8% and 96.4% of the study participants sometimes practice them respectively. Majority of the participants rarely use feeding bags and infusion pumps when feeding (71%) and confirm tube placement by both auscultation and abdominal X ray methods (41.3%). The latter finding was evident by the study conducted in 2012 by Gupta *et al.* About 36% of ICU nurses always followed special diet menus when preparing feeds while 33.3% and 30.4% of the participants followed them sometimes and rarely.

The study findings (Figure 2) revealed that the majority of participants indicated the following barriers will compromise the provision of EN in a desired level. Inadequate dieticians working during weekends and holidays (100%), prioritizing client care activities over EN care (94.9%), unavailability of enteral feeding formulas (73.9%) and inadequate supply of balanced diet (73.9%). However, only 22.5% considered insufficient feeding bags and pumps as a barrier.

Table 2. ICU nurses' practices on EN care

Practice	Always		Sometimes		Rarely	
	N	(%)	N	(%)	N	(%)
Elevate the head of the bed to 30 ⁰ - 45 ⁰ when feeding	98	71.0	40	29.0	0	0.0
Prepare feeds according to the calorie requirement of the client	38	27.5	88	63.8	12	8.7
Follow special diet menus when preparing feeds	50	36.2	46	33.3	42	30.4
Mix handmade feeds and formulas when preparing feeds	110	79.7	17	12.3	11	8.0
Provide health education to clients and their relatives regarding nutritional requirements of the client	138	100.0	0	0.0	0	0.0
Usage of feeding bags and infusion pumps when feeding	12	8.7	28	20.3	98	71.0
Use prokinetic agents to promote gastric motility	05	0.4	133	96.4	0	0.0
Both auscultation and abdominal X ray methods used to confirm tube placement	34	24.6	47	34.0	57	41.3
Unused feed is discarded after 06 hours	125	90.6	13	9.4	0	0.0

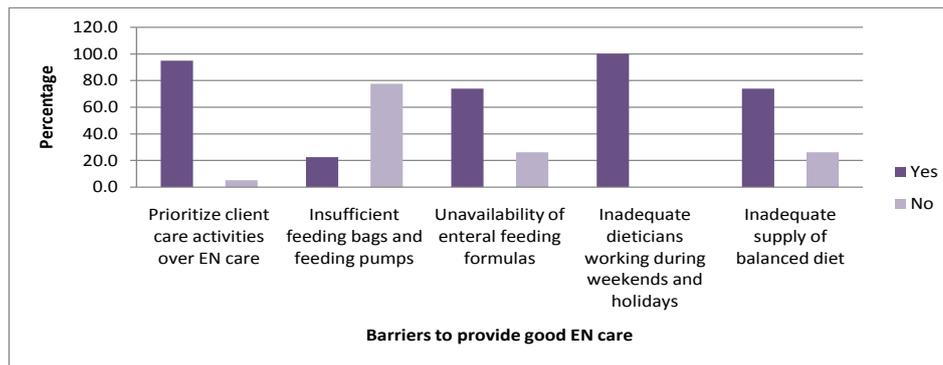


Figure 2. Barriers to provide good EN care

CONCLUSIONS/RECOMMENDATIONS

The study findings suggested that participants' knowledge on EN care is adequate in areas of risk associated with EN, patient positioning and prevention of tube occlusions. However, knowledge on suitable administering method of EN and the time of initiation of EN should be improved. The participants had desirable practices related to elevation of head of the bed when feeding, educate patients and their relatives on nutritional requirements and discard unused feeds. When preparing the feeds the practice of mixing handmade feeds with specialized formulas should be discontinued urgently. Immediate actions should be taken to eliminate the barriers such as inadequate dieticians working during weekends and holidays and prioritizing client care activities over EN care. Further, it is recommended the necessity of increasing the knowledge, improving the practices and eliminating barriers in aspects where there is a deficiency.

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IMPACT OF ULCER HEALING ON HEALTH RELATED QUALITY OF LIFE OF PATIENTS WITH DIABETIC LEG AND FOOT ULCERS

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INTRODUCTION

Complications of Diabetes Mellitus (DM) are known to be the most vital disease-specific determinant of health related quality of life (HRQoL). Diabetic foot ulcers adversely affect quality of life (QoL) and self-esteem of the patients. Common daily activities are restricted due to decreased physical mobility and functional capacities of patients. When compared to diabetic foot ulcer (DFU) patients, both with the general population and those with DM, DFU patients have lower HRQoL. Poorer HRQoL was reported in patients with active ulceration than those who have undergone minor amputation (Hogg *et al.*, 2012) indicating a comparatively better psychological status of mobile amputees than DFU patients. Number of ulcers and severity of ulcers (Valensi *et al.*, 2005) have shown to be associated with impairment in HRQoL. HRQoL has been found to be lower in those living alone, those who are not employed, those with low educational level, and those having at least one complication of DM (Javanbakht *et al.*, 2012; Yekta *et al.*, 2011). Better QoL is reported in men than women with DM but not with diabetic foot ulcers (Javanbakht *et al.*, 2012).

In Sri Lanka, limited studies have reported HRQoL of patients. A recent study which was conducted to establish population norms for HRQoL in healthy individuals in four districts reported lower HRQoL in socioeconomically disadvantaged people (Kularatna *et al.*, 2014). No studies exist in HRQoL of patients with DFU. Therefore, the purpose of the present study was to evaluate HRQoL of patients with diabetic leg and foot ulcers, to examine associations between HRQoL and socio demographic and clinical characteristics, and to compare HRQoL of patients with non-healed vs. healed status of ulcers.

METHODOLOGY

The study is a part of a large descriptive cross-sectional study conducted at the Colombo North Teaching Hospital during the period from June to December 2014. Adult diabetic leg and foot ulcer patients admitted to the surgical wards with wound duration of more than two weeks were recruited purposefully for the study. Acutely ill and those with cognitive impairment were excluded. Data were collected by an interviewer from patients who gave written informed consent. This study was approved by the Ethics Review Committee of University of Sri Jayewardenepura and permission to conduct the study was obtained from hospital authorities.

Data on socio-demographic and clinical characteristics including age, gender, marital status, educational level, duration and family history of DM, duration of ulcer and site of ulcer (foot or leg), history of previous ulceration and amputations were obtained through interviewing the patients. To assess HRQoL, Short form Health Survey (SF-36) questionnaires were completed in respect of 50 patients at baseline and after three months when the ulcer is healed. Scores of each subscale of the SF-36 obtained for patients with a healed ulcer was compared with their own scores obtained when they had the unhealed ulcer to discriminate QoL between non-healed versus healed status. The SF-36 instrument consists of 36 questions that grouped into eight conceptual domains (physical functioning, role limitation due to

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physical health, bodily pain, general health perceptions, vitality, social functioning, role limitation due to emotional problems and mental health). A two-factored model has been developed by aggregating first four domains into physical component score (PCS) and latter four domains into mental component score (MCS). Each question is scored on a scale of a zero to 100 and aggregate percentage scores are calculated for each domain. High scores denote high QoL and low scores denote low QoL. In this study, QoL was measured according to two-factored model; MCS and PCS, eight domains, and aggregated all domains to count total QoL.

Statistical analysis: Demographic and clinical characteristics of the patients were presented using descriptive statistics. Associations between variables were determined using Mann-Whitney U test. Scores of each domain of the SF-36 obtained for patients with a healed ulcer was compared with their own scores obtained when they had the unhealed ulcer using paired t-test. Significance was accepted at alpha <0.05. Data were analyzed using SPSS version 21.

RESULTS AND DISCUSSION

A total of 50 patients were studied. Demographic and clinical characteristics of the patients are shown in Table 1.

Table 1. Demographic and clinical characteristics associated with HRQoL

Variable	Category	n	%
Gender	Men	32	64.0
	Women	18	36.0
Age	≤60	30	60.0
	>60	20	40.0
DM duration	≤10 years	31	62.0
	> 10yrs	19	38.0
Family history of DM	Yes	22	44.0
	No	24	48.0
Ulcer site	Foot	42	84.0
	Leg	8	16.0
Re-ulceration history	Yes	8	16.0
	No	42	84.0

DM, diabetes mellitus; HRQoL, health related quality of life

The scores were low for all eight domains. The scores remained low even when the domains were separated to physical (PCS; 44.73±19.8) and mental (MCS; 53.13±18.7) components. Similarly, previous studies in France (Valensi *et al.*, 2005), Iran (Yekta *et al.*, 2011) have shown poor HRQoL in patients with diabetic ulcers. A Malaysian study (Mazlina *et al.*, 2011) has reported scores similar to our study in physical (PCS; mean 41.05) component, but comparatively higher scores for mental (MCS; mean 63.48) component.

According to the current study, when compared to men, women obtained lower scores for each domain (except role limitation-emotional) as well as for total QoL, PCS and MCS. However, these scores did not show statistically differences except for scores obtained for domains of vitality (p=0.041) (Table 3). Yekta *et al.*, (2011) has also shown significantly higher HRQoL scores in diabetic men compared to diabetic women with no foot ulcers. Likewise, when DFU patients were compared with the general population, DFU patients had lower HRQoL and significant difference was seen on domains of physical functioning, role limitation, physical (Mazlina, *et al.*, 2011) and general health. Present findings also indicated that the scores obtained for vitality were significantly lower in patients who have longer DM duration (>10 years) when compared to scores of patients DM duration of ≤10 years (mean 39.16 vs. 48.44, p=0.025). Similarly, previous findings have shown lower scores for domains of vitality in the sample they studied (Bardage and Isacson, 2001; Trevisol *et al.*, 2011).

Table 2. The scores for eight SF-36 domains, two summary components and overall QoL in the healed vs. non healed status of ulcers of patients

	Non Healed (n=50)		(Healed n=50)		p-value (Paired t-test)
	Mean	SD	Mean	SD	
Physical function	52.18	33.0	66.60	28.4	0.015
Role limitation (physical health)	28.06	39.9	72.44	38.1	<0.0001
Role limitation (emotional problems)	29.93	43.1	78.00	38.7	<0.0001
Vitality	61.73	18.2	80.12	17.2	<0.0001
Mental health	61.93	22.3	84.80	13.1	<0.0001
Social function	48.72	31.8	74.00	25.2	<0.0001
Pain	41.58	24.5	80.00	19.8	<0.0001
General health	44.89	24.7	54.70	15.9	0.004
MCS	53.13	18.7	80.46	16.6	<0.0001
PCS	44.73	22.9	71.04	26.3	<0.0001
Overall QoL	49.04	19.8	75.12	20.5	<0.0001

SD, standard deviation; PCS, physical component score; MCS, mental component score; QoL, quality of life; significant at $\alpha < 0.05$

Scores for role limitation due to physical health (mean 28.06) and role limitation due to emotional problems (mean 29.06) were very low in our study cohort than studies reported elsewhere (Yekta *et al.*, 2011). Role limitation due to physical health was significantly different among patients with history of re-ulceration than those with no history of re-ulceration (mean 10.00 vs. 33.53, $p=0.016$). Role limitation due to emotional health was significantly different in patients with a history of toe amputation than those with no amputation (mean 59.52 vs. 84.79, $p=0.031$) in healed status of ulcer. Previous evidence also indicates that better QoL of patients who have undergone successful minor amputations than those with active ulcerations (Hogg *et al.*, 2012).

When the ulcer site was considered, significantly lower scores were found in patients with leg ulcers compared to the once with foot ulcers across scores of social function (mean 20.31 vs. 54.26, $p=0.004$) and bodily pain (mean 25.00 vs. 44.8, $p=0.030$) indicating poorer health status among patients with leg ulcers. A previous study has reported a negative impact of leg ulceration on QoL of patients without diabetes (Herber *et al.*, 2007). Further, the numbers of ulcers and severity of foot ulcers have shown to be associated with poor HRQoL (Valensi *et al.*, 2005; Yekta *et al.*, 2011).

Comparison of scores of eight SF-36 domains, PCS and MCS and overall QoL of non-healed (scores obtained at baseline) vs. healed status of ulcers showed that mean scores at healed stage were significantly higher ($p < 0.0001$) compared to non-healed stage (Table 3) indicating better HRQoL in healed status of ulcers. In agreeable with this finding, Nabuurs-Franssen *et al.*, (2005) have shown higher HRQoL for patients with healed ulcers than persisting ulcers. Ribu *et al.*, (2007) indicating significant improvement of HRQoL in social functioning and mental health with healing of ulcers. Similarly, another study (Hogg *et al.*, 2012) has reported poorer QoL for patients with active ulcers.

Table 3. Comparison of SF-36 domains, two summary components and overall QoL for gender difference

Gender	Female	Male
Physical function	43.33	57.50
Role (physical)	23.61	30.64
Role (emotional)	79.62	77.08
Vitality	54.16	66.12*
Mental health	56.11	65.32
Social function	40.97	53.22
Bodily pain	34.02	45.96
General health	44.70	45.00
PCS	39.51	47.97
MCS	48.51	55.81
Total QoL	44.01	51.63

PCS, physical component score; MCS, mental component score; QoL, quality of life; * $p=0.041$

CONCLUSIONS/RECOMMENDATIONS

Findings of this study provide useful information to health care workers and researchers regarding HRQoL of patients with diabetic leg and foot ulcers. Diabetic leg and foot ulcers were shown to have a negative impact on HRQoL with both physical health and mental health being affected. Scores of eight domains, total SF-36, PCS and MCS were consistently lower in the study cohort in non-healed status of ulcer. HRQoL was significantly improved when ulcers were healed. HRQoL was worse in women than in men and in patients with leg ulcers compared to those with foot ulcers. This study recommends considering the physical and mental health status when planning, evaluating and managing the patients with diabetic ulcers. Steps should be taken to actively minimize the duration of ulcer healing in order to improve the HRQoL of these patients.

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FACTORS ASSOCIATED WITH FORMULA FEEDING DURING THE PERIOD OF EXCLUSIVE BREAST FEEDING

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INTRODUCTION

Exclusive Breast Feeding (EBF) means infants receive only breast milk and not even water, other liquids, tea, herbal preparations or foods during the first six months of life (during EBF period) with the exception of vitamins, mineral supplements or medicines (World Health Organization (WHO), 2008). Although breast feeding is the best method of nourishing the infants during the first six months of life, some mothers start formula feeding during this period. Helsing and King (1985) defined formula as “powdered animal milk which has been adapted to human needs” (p.237). In general, goat’s, sheep’s and cow’s milk are used in preparation of formula (Henshel and Inch, 1996).

Formula feeding during the EBF period creates many health risks to the baby. Formula feeding increases the risk of death from diarrhea and incidence of acute respiratory tract infections in infants (Victoria *et al.*, 1989; Al-Sharbatti and AlJumma, 2012). Further, WHO (2003) has confirmed that 1.5 million infants who die each year could have been saved if they had been breast fed. In addition, mothers also receive benefits from EBF as it helps to keep space between children and reduce the risk of ovarian and breast cancers (Dhammika and Gunawardhana, 2009). Many factors are associated with early initiation of formula feeding such as mothers’ employment, length of maternity leave, inadequate knowledge on breast feeding, lack of familial and or social support and lack of self confidence in breast feeding (Cameron and Hofvande, 1983; Helsing and King, 1985).

As formula feeding makes many health risks to both the mother and the baby, it is important to identify the factors associated with formula feeding during the period of EBF within Sri Lankan context. The findings of this study will be helpful to take necessary interventions to address the identified factors that are associated with EBF appropriately. Therefore, the purpose of this study is to describe the factors associated with formula feeding during the period of EBF. The specific objectives of the study were to describe mothers’ social, work and health related factors, and their knowledge, attitudes and misconceptions associated with formula feeding during the period of EBF.

METHODOLOGY

Quantitative research approach and descriptive design were used for the study. Data were collected by using a self administered, structured questionnaire. The content validity of the questionnaire was assured by referring to the standard literature and by obtaining expert opinion. The questionnaire was pre- tested for reliability and understandability with five mothers who did not participate in the study. The data analysis was done by using descriptive statistics and data were managed by using Microsoft Excel.

This study was conducted in five medical wards in Lady Ridgeway Hospital for Children (LRH) and two pediatric wards in Colombo South Teaching hospital (CSTH). The sample was taken from the mothers who were admitted to the wards with their children for treatments in LRH and CSTH. Purposive sampling method was used to select a sample of 100 mothers who fed formula for their infants during the period of EBF. Ethical approval was obtained

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from the Ethics Review Committees of LRH and Csth. Voluntary participation was encouraged and written informed consent from each participant was obtained prior to data collection.

RESULTS AND DISCUSSION

The response rate of the study was 98.1%. A majority of the participants were Sinhalese (62.7%) and 18.6% and 11.6% were Tamils and Muslims respectively. Among the participants, majority (42.2%) had studied up to Advanced Level and 63.7% was unemployed. Amongst them, 78.4% fed their babies with both breast milk and formula while 21.6% fed only with formula. Almost half (51.0%) of the participants have had their first baby.

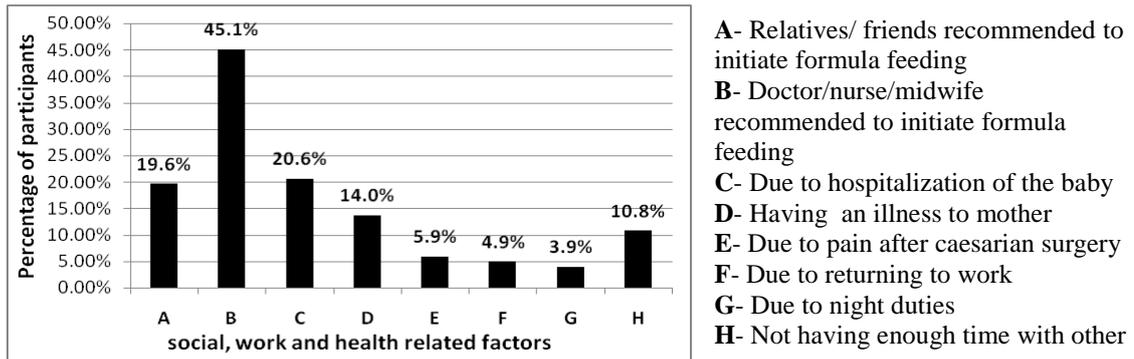


Figure 1. Social, work and health related factors for initiation of formula feeding

A majority of the participants (64.7%) had started formula feeding as they were influenced by others such as doctors, nurses, midwives relatives and friends. Almost 20.5% had started formula feeding during hospitalized period of their infant and they had continued formula feeding afterwards. Among the participants who are employed, only 4.9% had started formula feeding due to returning to work whereas it was 76.7% in the study conducted by Perera, *et al.* (2010). Amongst the other factors, the mother being ill (14.0%) and not having enough time for breast feeding (10.8%) were the reasons for initiation of formula which is similar to the findings revealed in the study of Williams, *et al.* (1993) (Figure 1).

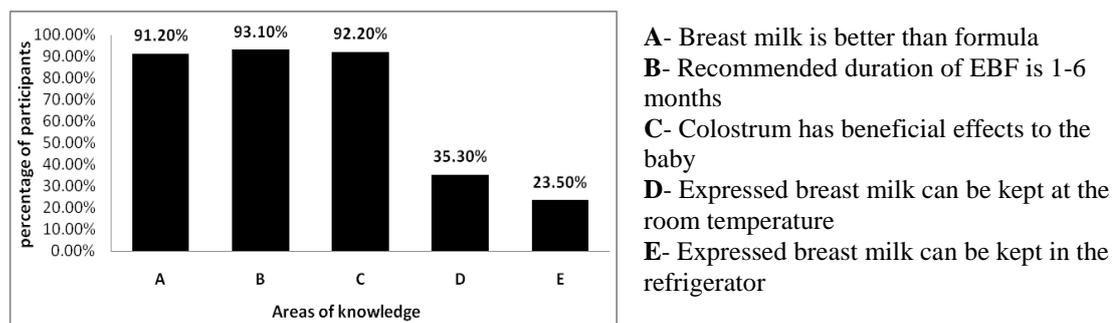


Figure 2. Knowledge on EBF

Most of the participants had adequate knowledge regarding breast feeding although they fed their children with formula feeds. A vast majority (91.2%) agreed that the breast milk is better for their children than formulas and similar finding was observed by Motee, *et al.* (2013). From the sample, 93.1% knew about the recommended duration for EBF which is similar to the findings of Dhammika and Gunawardana (2009). More than half of the sample knew that the baby will acquire some diseases due to formula feeding as identified by Sowden, Marais and Beukes (2009). In addition, the current study showed that most of participants (92.1%) had knowledge regarding the value of colostrum. Only 35.3% and 23.5% of participants knew that the expressed breast milk can be kept at room temperature and refrigerator respectively (Figure 2).

With regard to attitudes on EBF, 98.03% of the participants did not respond to the statement that breast feeding is repulsive. However, it is different from previous studies (Sowden, Marais and Beukes, 2009). Among participants, 46.7% held the attitude that their babies were not satisfying with breast feeding. Some other attitudes regarding initiation of formula feeding were babies' reluctance in sucking (35%) and having flat, inverted nipple or breast engorgement (6.3%). Garbarino *et al.* (2013) in Italy also highlighted similar findings. Among participants, 24.5% stated that they felt embarrassed to breast feed in public places. In contrast Sowden, Marais and Beukes (2009) observed different results (70.9%). Most Muslim mothers (58.3%) indicated that breast feeding in a public place is extremely sensitive to cultural norms and it was a barrier for breast feeding.

There were some misconceptions held by participants who fed formula during the period of EBF. A majority of participants (61.8%) believed that they do have not enough breast milk to feed their babies which is similar to the findings of Garbarino *et al.* (2013). Almost a half of the participants (52.9%) believed that the breast milk is less nutritious when they are not taking nutritious foods during the period of EBF. Similar findings were reported by Bonia *et al.* (2010) and Dhammika and Gunawardana (2009). Among the participants, 34.3% believed that production of breast milk is affected by their age. Only 19.6% believed that their youthful figure will get affected due to breast feeding. Nearly 30% believed that the size and shape of their breast will affect the production of breast milk.

CONCLUSIONS/RECOMMENDATIONS

Most of the participants had given both breast milk and formula milk while few mothers had given only formula feeding for their babies. First time mothers were more likely to have difficulties in establishing breast feeding. The reason may be inexperience and related anxiety of first time mothers. Maternal knowledge about EBF and recommended EBF period (6 months) was adequate but they had inadequate knowledge regarding storage of expressed breast milk. Most of the participants were influenced by the others to feed their babies with formula. Some of the major misconceptions that seem to have affected formula feeding were mothers' belief of insufficient breast milk production and belief that breast milk is less nutritious when they are not taking nutritious foods. Therefore, it is recommended to educate the women on EBF before their delivery, specially on the areas identified by the current study in order to increase their knowledge and eliminate their misconceptions. It is also recommended to take necessary interventions and use strategies to overcome social, work and health related barriers in EBF. Further, replicating this study with a larger sample representing other hospitals and community set-up is also recommended.

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DEVELOPMENT OF AVAILABLE PHOSPHORUS TESTING TOOLKIT FOR FARMERS

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INTRODUCTION

Knowing the level of phosphorus (P) in cropping fields is very important to manage the P level in the soil. Soil test is an important tool of P management for crops. Soil testing provides the soil P level, and helps to determine the optimum amount of P fertilizers required for the crop to be grown. Soil analytical laboratories of the Department of Agriculture (DOA) in Sri Lanka provide the service of soil testing. But this has not been convenient for farmers as they have to travel a long distance to handover the soil samples to the nearest DOA and pay for it. Most of the time the farmers do not get the results of the soil samples before cultivation. Usually the farmers do not tend to do a soil test before cultivation because of those reasons. If there is a rapid and easy method for testing P level in the soil by farmers themselves or with the help of Agricultural Instructors in their area, management of P levels in cropping will be more effective and efficient. Simple and rapid methods of testing have several benefits such as minimizing the time taken for the recommendation, and the need for skills, equipments and chemicals which are used for testing P in soil. This may create more benefits, in turn, for farmers through motivating them to do soil testing without waiting for the analytical report and getting the P level in their soil just before the application of phosphorus fertilizer for the cultivation. This will minimize the wastage while increasing the efficacy of phosphate fertilizers. Therefore, this study was undertaken to develop a new, simple soil phosphorus testing tool kit for farmers so that they could do the testing of available phosphorus in their land before each season and decide on the appropriate phosphorus fertilizer level. This will ultimately reduce soil and water pollution due to excess application of phosphorus fertilizer.

MATERIALS AND METHODS

Soil samples received under the soil testing program of the Agricultural Chemistry division at Horticultural Crops Research and Development Institute, Gannoruwa were used for this study. Seventy five samples were randomly selected for the study. To decide the phosphorus fertilizer application the well established Olsen method (Olsen *et al.*, 1954) is used to extract the available soil P. Further, the majority of the randomly selected soil samples of this study had a pH in the range of 6.5 to 7.2 which represent the mild acidic to basic soil type and the Olsen method was the most suitable method for such soils (Olsen *et al.*, 1954). Extracted P contents in each sample were measured using Murphy and Riley method (1962) which used ammonium vanado molybdate and ascorbic acid as the color development reagent.

Development of a new method for measure the soil phosphorus

Available Phosphorous in soils was extracted using four different methods which were different in their extractant; (1) Morgan's method (0.72 N Sodium Acetate + 0.52 N Acetic Acid solution), (2) Basified distilled water method (Distilled water basified using NaOH and pH adjusted to 8.5), (3) Distilled water only method (pH 4.8), (4) Acetic Acid method (2.5% acetic acid solution). The selected 75 soil samples were used to measure and compare the

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amounts of phosphorus extracted by 4 different extraction methods. For each method, 5 g of air-dried, sieved soil and in order to get colour less filtrate, pinch of (0.1 -0.2 g) P free charcoal were mixed with 50 ml of each extraction solution in a dry and clean plastic bottle. The solution was mixed with hand shaking upside down for 2 minutes and filtered using No. 5 Whatman filter paper. The extracted soil phosphorus was measured by using “Murphy and Riley colorimetric method” (Murphy et al., 1962). Acetic acid extraction method was further simplified as it has given higher r^2 value with Olsen’s method at the results comparison stage. The selected 75 soil samples were used for this method also. Five grams of soil sample and 50 ml of 2.5% acetic acid solution were mixed for 2 minutes with hand, kept it about 3 hours until the supernatant separate. The supernatant was analyzed for phosphorus using “Murphy and Riley colorimetric method” (1962). In this method neither phosphorus free charcoal added nor filter paper used to separate the solution from soil.

RESULTS AND DISCUSSION

Identification of best extraction method

The soil phosphorus contents extracted using the four different extraction methods were measured using the Murphy and Riley colorimetric method and the results were correlated with the Olsen method. The correlations were taken from the Regression analysis.

Among the five new soil P extraction methods the simplified acetic acid method is the simplest method and has the highest correlation (r^2) with the recommended phosphorus extraction method which is the Olsen. The simplify acetic acid method was selected as the simplest method which can be applied for phosphorus test in field level. Simplify acetic acid method was differed from the acetic acid method due to not adding P free charcoal. The extractant used in both methods was same and it gave clear supernatant after 3 hours and supernatant could be separated without using the filtrate. Due to this the step of adding P free charcoal, to get colorless solution, was removed in simplified acetic acid method. The R-square between acetic acid method and simplify acetic acid method was 0.976. It shows there is no significant difference in added P free charcoal or not.

Table 1. Correlation of new extraction methods with Olsen’s method

Method	Correlation with Olsen method (R^2)
Mogan’s method	0.734
Basify distilled water method	0.654
Distilled water method	0.585
Acetic acid method	0.854
Simplify Acetic acid method	0.855

Development of Phosphorus color chart

A color chart was prepared to measure the phosphorus level in the extraction solution. “Murphy and Riley” colorimetric method was used to prepare the color chart. It is a colorimetric method and forms a blue color of which the intensity depends on the concentration of P. The R-square of Olsen’s method and simplify Acetic acid method was 0.855 and linear of regression graph was $y = 0.548x - 5.728$. P content of low phosphorus soil, medium phosphorus soil and high P soil according to the simplify acetic acid method were calculated using this equation (Table 2). Accordingly the low P soil content <2.5 mg/L P, medium P soil content between 6.6 – 10.7 mg/L P and high P soil content > 10.7 mg/L P. These values were used to prepare the color chart (Figure 1).

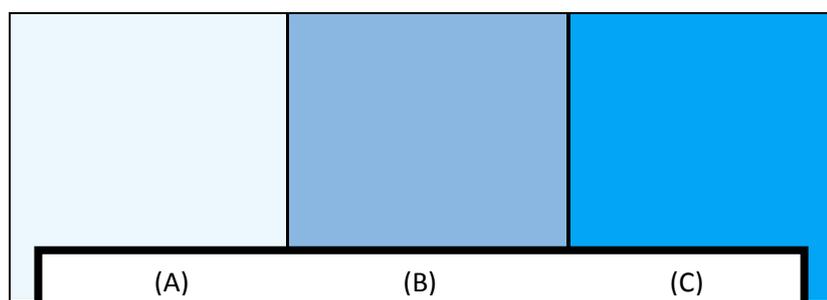
The blue color intensities of 10.7 ppm, 6.6 ppm and 2.5 ppm soil solutions were prepared using P standards of the “Murphy and Riley” colorimetric method and these colors were

captured by camera and these colors were used to prepare the Phosphorus color chart. The color chart consists of 3 different intensities of blue; (A) color shows the blue color intensity of 2.5 mg/L available P extraction, hence it represents the soil which has 2.5 ppm available P soil, (B) color shows the color intensity of 6.6 mg/L available P extraction and (C) color shows the color intensity of 10.7 mg/L available P extraction represent the 6.6 ppm and 10.7 ppm p soil respectively (Table 2).

A color developed sample's phosphorus level can be determined using this color chart. If the blue color intensity of prepared sample is lower than the color "A" it is a low phosphorus soil, the color intensity between "A" and "B" color it is a medium phosphorus soil, the color intensity is between "B" and "C" color it is a high phosphorus soil and higher than "C" color it is extremely high phosphorus soil.

Table 2. Phosphorus content of soil extracted by simplify acetic acid method

	Available P (ppm) according to the simplify acetic acid method	Available P (ppm) according to the Olsen method
Extremely high	>10.7	>30
High	6.6 - 10.7	22.5 – 30
Medium	2.5 - 6.6	15 - 22.5
Low	<2.5	<15



Color	P content
>C	Extremely high P soil
B - C	High P soil
A - B	Medium P soil
< A	Low P soil

Figure 1. Phosphorus color chart developed and the ranges of P content

Development of soil phosphorus testing tool kit for farmers

This tool kit was developed based on the findings of this study (Figure 2). The new soil available phosphorus test can be applied in the field with this tool kit. The tool kit includes distilled water, 2.5% acetic acid solution, mixed reagent, ascorbic acid, a clean glass bottles, the soil P color chart (which has drastic colour differences between classes, so that fairly stable for different sunlight intensities) and also the note of the procedure of new phosphorus testing method. This tool kit is very easy to transport and handle and does not cost more than Rs 200. However, these kits could be given to farmers free of charge or at an affordable price. Soil P can be measured according to the procedure introduced by this study by using this tool kit by the farmers themselves and decide the phosphate fertilizer application.

To get the accurate level of phosphorus, soil sample should consist of fine particles and it should be dry. Wet soil samples can be used to test for phosphorus after allowing them to dry).

Recommended P fertilizer should be applied to the low P soil before the cultivation. There is no need of P fertilizer application to the high or extremely high P soils before the cultivation.

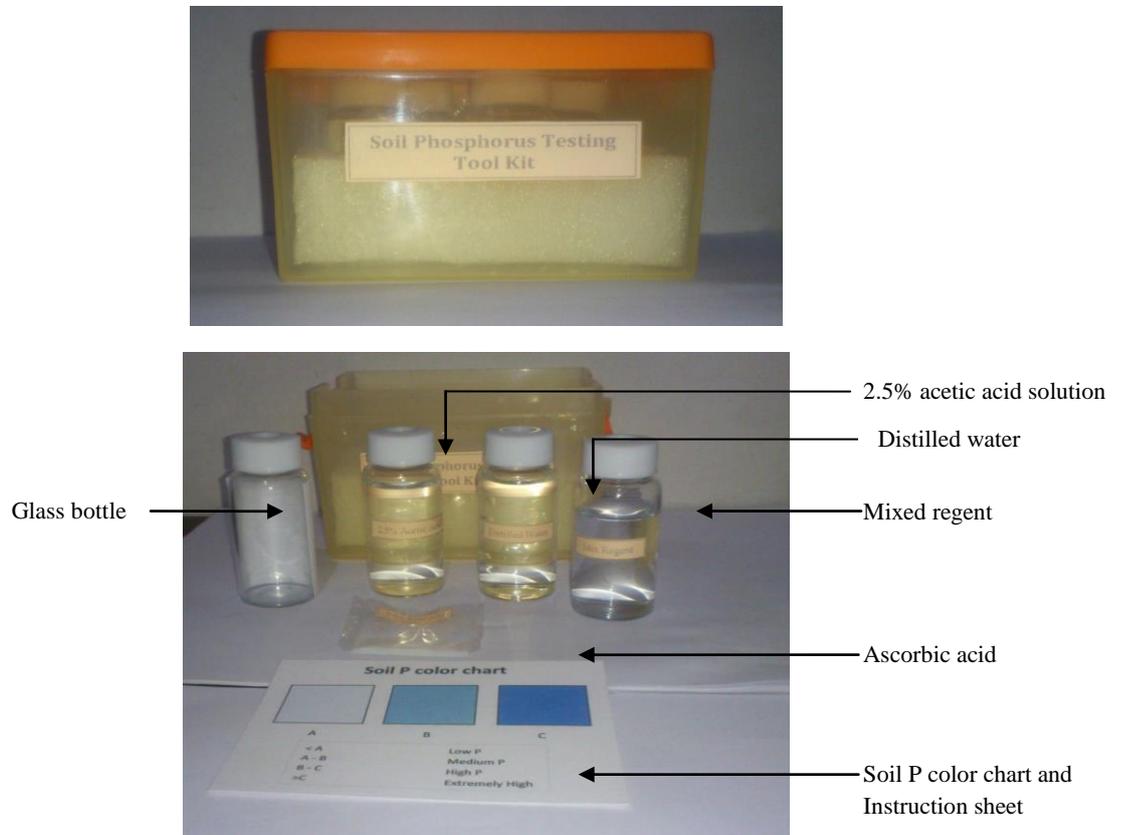


Figure 2. Phosphorus testing tool kit for farmers

CONCLUSION

The simplified acetic acid method which has the best significant correlation with the Olsen method can be introduced to determine the available soil phosphorus. This method is quick, simple and time saving. Measuring of extracted phosphorus is very easy. The introduced phosphorus color chart can be handled easily to measure the extracted phosphorus level, after developing the blue color of the extracted solution. Therefore even farmers can apply this quick method to measure the soil phosphorus in the cultivation lands before the cultivation.

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GLOBAL WARMING INDUCED TEMPERATURE AND WATER STRESS ON MARKETABLE FRUIT QUALITY OF TOMATOES GROWN WITH MULCH

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INTRODUCTION

One of the major global concerns today is the rapidly increasing levels of CO₂ in the atmosphere and its potential to change the world climate. Significant change in climate on a global scale will impact agriculture and consequently affect the world's food supply. Tomato (*Lycopersicon esculentum* Mill.) family Solanaceae, is a very important fruit vegetable in the world. In Sri Lanka it is annually cultivated more than 220ha, producing approximately 3400 metric tons. However, the average productivity of Tomato in Sri Lanka (2 metric tons/ha) is much lower than the world average as the seasonal weather changes affect the average productivity adversely. In the meantime, a shortage in the month of peak rain fall (May and November) and a production glut in the months of harvesting (March to May and September to October) has led to a dichotomy in the distribution of annual tomato production. Protected culture is a remedy for environmental problems of crops cultivation. However, seasonal weather changes affect indoor grown plants adversely. Protected (indoor) culture is predominately used in temperate regions. The quality of tomato fruit for fresh consumption is determined by appearance, (color, shape, size, freedom from physiological disorders, pest and disease attack) firmness, texture, dry matter and organoleptic (flavor) and nutraceutical (health benefit) properties (Dorais et al., 2001). But climate change may have impacts on the quality of marketable fruit tomato. Therefore, this study is designed to identify marketable fruit quality of tomato by cultivating the tomato plants with three types of mulches under induced temperature stress by means of a temperature regulated poly tunnel.

METHODOLOGY

This study was conducted during the period from 2012 to 2014 and an experiment was set up in the agricultural field poly tunnels of the Open University at Nawala, Nugegoda. The research planned to identify the effect of mulch on air temperature and water stress due to climatic changes on dry zone vegetables, with the most popular variety of tomato.

Nursery management was initiated and tomato seedlings were transplanted into individual plastic pots (1 plant in one pot with a diameter of 30 cm and depth of 45 cm). The pots were filled with compost and sandy loam soil mixture, and the two mulching treatments of coir dust and saw dust with control treatment (no mulch) were arranged in a completely randomized design. Two mulches were added until the surface of the compacted soil was below 1.5 cm from the brim. The tomato plants were grown under 3 different conditions, as indicated in Table 1.

The experiment consisted of two factor factorial design, which included three replicates. Pots were arranged according to a completely randomized design (CRD). Water stress and mulches were taken as treatment factors. The general appearance of tomato fruit was evaluated on the basis of color, fruit cracking, size and shape. The results showed that general appearance of tomato fruits was improved significantly at ($P < 0.05$). An analysis of variance (ANOVA) of the result was performed using the statistical program Minitab (version 14, Minitab Inc.).

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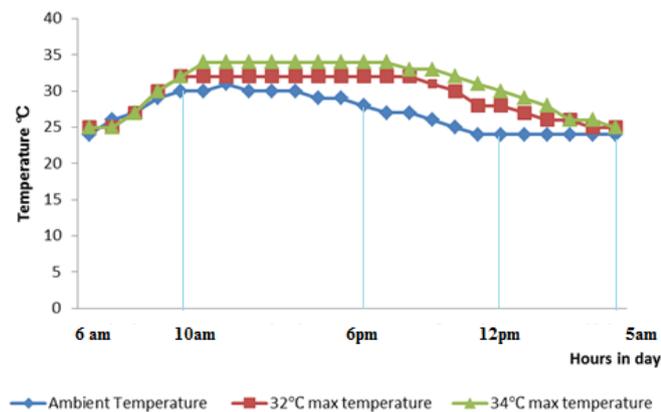
Table 1. Three different environmental conditions imposed

<i>Condition No</i>	<i>Environmental conditions</i>
Condition 1 – Poly tunnel 1	<u>Ambient temperature 32⁰C</u> (i). Providing adequate water to reach the substratum in mulched pots. Mulching-Coir dust and Saw dust (ii). Providing water to fill only up to 50% of the substratum in mulched pots.
Condition 2 – Poly tunnel 2	<u>Ambient temperature 34⁰C</u> (i). Providing adequate water to reach the substratum in mulched pots. Mulching-Coir dust and Saw dust (ii). Providing water to fill only up to 50% of the substratum in mulched pots.
Condition 3 – Open space	<u>Ambient temperature (AT⁰C)</u> (i). Providing adequate water to reach the substratum in mulched pots. Mulching-Coir dust and Saw dust (ii). Providing water to fill only up to 50% of the substratum in mulched pots.

RESULTS AND DISCUSSION

Temperature control in the poly-tunnels

The variation of temperature inside the poly tunnel and the ambient temperature outside over a period of 24 hours was observed as shown below (Figure.1). Even though sensors and exhaust fans were used to maintain the set temperature inside the poly-tunnels, the temperature during the night falls below the maximum temperature set for that particular poly tunnel. However, the temperature maintained inside the poly tunnels was always higher than the ambient temperature; therefore temperature stress was forced on the plants throughout the day.

**Figure 1.** Temperature variation inside and outside the poly tunnel

Effect of Fruit size and shape

High temperature however often results in smaller fruits. (Newton and Sahraoui, 1999). Under ambient temperature with mulching condition in water stress and no water stress (Figure.2a) the average fruit size was larger than the other temperature condition. Under a temperature of 34⁰C with mulch condition and no water stress (Figure 2b) the average size of the fruit was the smallest of all. With a temperature 32⁰C under no mulch condition with no water stress (Figure 2c) the average size of tomato fruit had become smaller than the ambient temperature fruit (Figure 2a). Fruit growth and yield are, like most other developmental processes, primarily dependent on temperature (Heuvelink, 2005). Tomato cultivars differ

greatly in fruit shape and may take the shape of a spherical or oblate or elongated pear. But the fruit peel became rough and a little nib came out of the bottom of the fruit in 34°C temperature condition (Figure 2.d). Therefore, this shows that the temperature stress affects the shape of the fruit.

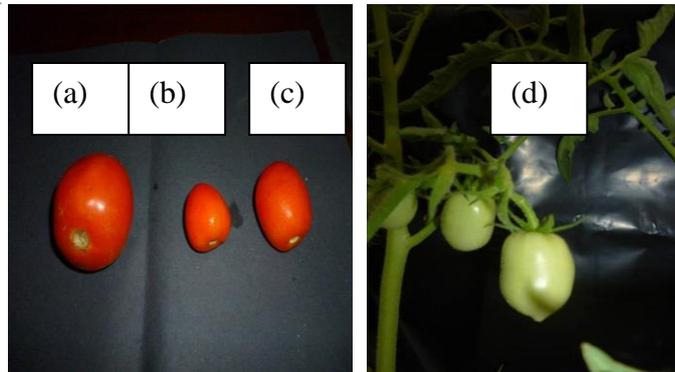


Figure 2. (a) In Ambient temperature with mulching (b) 34°C temperature with mulch condition and no water stress (c) In 32°C temperature under no mulch condition with no water stress (d) In 34°C temperature condition.

Effect on Fruit cracking

Periods of water deficit followed by heavy irrigation or rain have long been associated with the development of growth cracks in tomatoes and other fruits (Frazier & Bower, 1947). Under ambient temperature with coir mulch condition and no water stress (Figure 2.a) the moisture is higher and it makes the fruit crack. So the quality of the fruit becomes worse. In 32°C temperature under the same condition (Figure 2b) the cracks of the fruit are less. But in 32°C temperature without mulch and with water stress condition (Figure .1.3.c) the cracks of the tomato fruits had become worse.



Figure 3. (a) Ambient temperature with coir mulch and no water stress (b) 32°C temperature with coir mulch and no water stress (c) 32°C temperature with out mulch and with water stress

Effect on fruit colour

External colour of tomatoes is the result of both flesh and skin colour. Most consumers prefer the deep, uniform red coloured tomatoes. Colour is an indicator of the stages of ripeness of tomatoes, such as the six classes of tomato ripeness included in the U.S Standards (USDA, 1976). However, red is still the major fruit color for most of the commonly grown varieties. Under 34°C temperature with mulch condition and no water stress, the tomatoes had mixed colour of red and yellow, and the colour of the peel had various shades of yellow. Therefore the temperature stress had affected the colour of the marketable quality of the fruit.

Effect on pest and disease

During first and third seasons tomato plants growing in the poly tunnel were attacked by the Mealy bug and spread very quickly to a few rows of plants in the high temperature poly tunnel. Mealy bugs cause a range of damage symptoms to tomato crops and here adults and nymphs fed on the leaves and stems causing necrotic areas and reduced plant vigour. The pest

also excretes excess sap (honeydew) on which black sooty moulds grew, which led to the reduced quality of the fruit. Researchers have shown that temperature is probably the single most important environmental factor influencing insect behaviour, distribution, development, survival, and reproduction and believe that the effect of temperature on insects largely overwhelms the effects of other environmental factors (Bale et al., 2002).



Figure 3. Mealy Bug attack on tomatoes under temperature stress

CONCLUSIONS

There is a significant individual effect of stress of water, mulching and temperature and a combination of effects on the marketable fruit quality such as fruit colour, cracking condition, size and shape etc. Cracking occurred in 32⁰C and 34⁰C temperatures. But a temperature of 32⁰C with saw dust mulching condition had a significant effect on fruit cracking and the same good condition resulted in other general appearance. Under a temperature of 34⁰C with mulch condition and water stress, tomato fruits were small in size and had pointed bottoms. According to the results there was not much of a difference between the water stress and no water stress treatments as the mulching has resisted the effect of temperature by conserving moisture in the soil under a temperature of 32⁰C. The findings of this study could be an adaptation measure for farmers growing tomatoes if the temperature increases due to global warming. Therefore it is important to identify suitable management options to sustain or ensure the marketable fruit quality under the climate change conditions.

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IMPACT OF DIFFERENT LEAF STANDARDS AND THE INLET DRYING TEMPERATURE ON THE QUALITY CHARACTERISTICS OF LEAFY TYPE OF MADE TEA

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INTRODUCTION

Tea estates are ranked according to the monthly net sale average price and to date average price. Some estates in the same region are at the top of the ranking while others are at the middle or bottom due to the price variation of their net sale average (NSA). One reason for the demand for their tea grades may be good manufacturing practices in addition to maintaining better leaf standards. The leaf standard varies from estate to estate based on the harvesting policy adopted. Usually, 60-65% of good leaves ensure better quality of end product. Also, product consistency has a significant impact on achieving better colour and taste (Samaraweera and Ziyad, 2008). In tea drying, inlet temperature of 190 °-200 °F and exhaust temperature of 120 ° - 130 °F represent the normal range of temperature used in Endless Chain Pressure (ECP) dryer (Jayaratnam and Kirthisinghe, 1974). Most of the low country tea producers increase the drying temperature to a level higher than the recommended level (190°F) with a view to improve the appearance / blackness. However, they do not have a clear idea about the potential impact on liquoring properties of made tea while increasing inlet temperature to a level higher than the recommended level. In this study, an attempt is made to find out whether a correlation exists between the poor leaf standard and high inlet drying temperature levels. Further an attempt is also made to determine/compare the quality of final made tea at both higher inlet temperature levels and at recommended drying temperature levels. The objective of this experiment was to study the impact of different inlet temperatures of the ECP drier on the quality of made tea produced from different leaf standard and to assess the liquoring properties and appearance of leafy type of graded tea organoleptically.

METHODOLOGY

The experiment was conducted at Processing and Technology Division, Tea Research Institute of Sri Lanka at St. Coombs Estate, Talawakelle. The Agro ecological zone of the area is WU3. Tea leaves used for this experiment were collected from factory withering troughs, which were dominated by shoots of TRI 2025 cultivar. The leaf standard of normal estate plucking policy varies from day to day. Three different leaf standards were selected for this study which consisted at 40%, 50% and 60% good leaves (fine plucking). Before the leaves were collected for the experiment, the leaf standard was calculated by picking a leaf sample randomly from the trough and determining the good leaf percentage. If the percentage of the leaves was similar to the experimental standard, the trough was selected for the experiment. In this study, an inlet drying air temperature of 230°F was selected for the treatment while a temperature of 205°F was selected as the control temperature for ECP dryer. The reason for selecting 230°F was that most of the low country tea producers use this temperature. Six

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treatment combinations are shown in Table.1. Plucking tea shoots with more than two leaves during the low cropping season is considered coarse plucking. However, shoots with three leaves and a bud is also accepted as fine plucking during the high cropping season due to the tenderness of the third leaf (Botheju, 2001).The factory trough consisted of a mixture of shoots; bud and two leaves, bud and three leaves, soft banji bud (undeveloped) with two leaves, tender leaves (described as fine leaf plucking) mother leaves/coarse leaves and damaged leaves, called fish leaf plucking or hard plucking (Figure 1).

Table 1. Treatment plan of the experiment

	Leaf standards (%)		
Inlet Temperature	40 (L1)	50 (L2)	60 (L3)
205 ^o F (T1)	L1T1	L2T1	L3T1
230 ^o F (T2)	L1T2	L2T2	L3T2

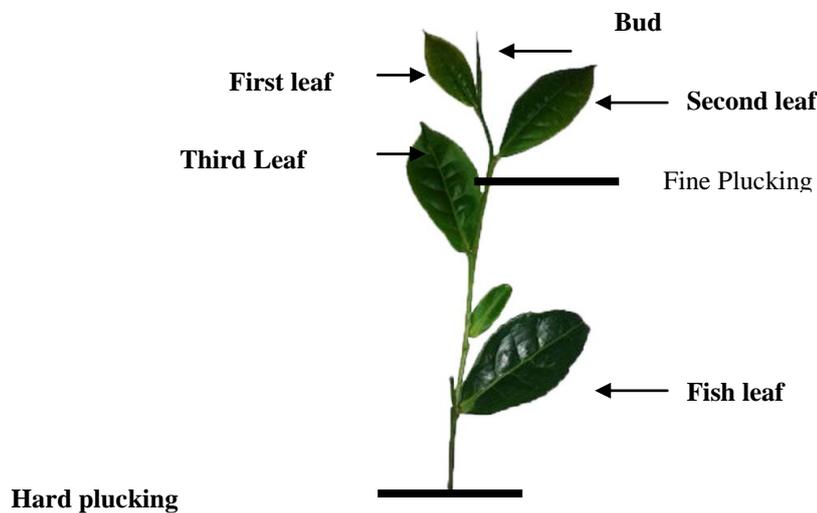


Figure 1. Tea leaves (Tender leaves and coarse leaves)

The experiment was carried out as a 2 factor factorial design (i.e. three different leaf standards and two drying inlet temperatures) with three replicates per each treatment combinations. Plucked leaves were withered on factory withering troughs for 12 – 16 hours until their moisture was reduced to 55% - 57% (Roberts, 2008). Withered leaf samples (50g) drawn from the withering trough in duplicate were used to test the moisture content. After the completion of the withering process, withered leaves were processed separately for treatment samples and control samples using a set of medium sized pilot scale manufacturing machines available at St. Coombs factory. In the process of manufacturing, withered leaves weighing 15 kilo grams were rolled using a single action pilot scale Orthodox roller. After rolling for a period of 30 minutes rolled leaves were discharged and separated to even sized particles (dhool) using a pilot scale oscillatory type roll breaker. A No 4 mesh, fixed to a roll breaker, was used to separate tea dhool. The rolling operation was continued until the big bulk percentage reached to about 32%. Each dhool (1st and 2nd dhool) from the treatment and control samples was spread on clean fermenting trays separately in a height of 5 cm to facilitate fermentation. The humidity level of the fermenting area was maintained using

humidifiers in order to keep the hygrometric difference below 3°F (Samaraweera, 1986). After about a 3 hour fermentation period, fermented dhoos were subjected to drying using an ECP dryer.

Hot air required for drying was generated by using electrical heating elements that have five different power ratings. In this study, drying inlet temperature of air selected for treatment sample was 230°F whilst for the control sample was 205°F. Exhaust air temperature of the dryer outlet was maintained at 135°F. The residence time was approximately 21 minutes. Dried tea from treatment and control samples were graded using hand sieves. Sieve sizes such as No.4, No.5, No.8, No.10, No.12, and No.16 were used to obtain seven different grades; OP, OP1, PEKOE, OPA, FBOP, FBOPF1 and FBOPF. Graded tea samples were sent for tea tasters' evaluation in Colombo and assessed for organoleptic qualities, and the characteristics such as infused leaf color, tea liquor color, strength, quality and flavor were analyzed. Further, liquoring properties and appearance of 126 tea samples produced were also evaluated for organoleptic qualities.

RESULTS AND DISCUSSION

Analysis of variance carried out on the evaluations made by the panel of tasters on the samples manufactured by providing 230°F and 205°F inlet temperatures revealed no significant differences between the control temperature and treatment temperature on the overall quality of the liquor with respect to all the manufactured grades. However, the seven grades, made using 60% good standard of leaves exhibited a trend in increasing the overall quality at a temperature of 205°F when compared to a temperature of 230°F (Figure 2). Therefore, this indicates that there is an advantage of using drying inlet temperature at 205°F to produce tea with better liquoring properties by 60% in standard good leaves.

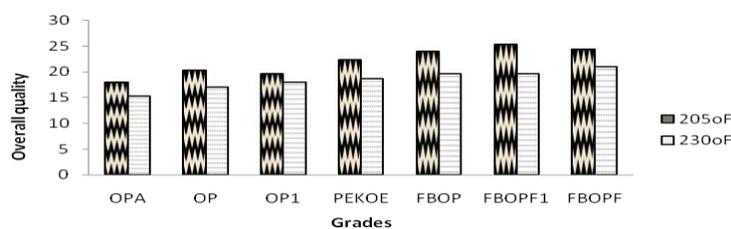


Figure 2. Overall qualities of seven grades at temperatures of 205°F and 230°F at 60% of good leaves standard.

The analysis of variance carried out on the evaluations made by the tasters for the appearance of the made tea samples, showed no significant difference for the grades OP, OP1, and FBOPF1 at a higher inlet temperature for all three leaf standards. However, the appearance of OPA, PEKOE, FBOP and FBOPF grades showed a significant difference of 40% in leaf standard at 230°F inlet temperature as shown in Figure 3. Therefore better appearance can be achieved by maintaining 230°F inlet drying temperature for 40% leaf standards.

CONCLUSIONS/RECOMMENDATIONS

Results revealed that there was no significant difference in liquoring properties of made tea produced at higher drying inlet temperature (230°F) when compared to a temperature of 205°F for the three different leaf standards tested. Therefore overall liquoring quality of made tea has no strong correlation between treatments according to the analysis. However, a trend was observed for tea produced using 60% good leaves (leaf standard) which gave better liquoring properties at 205°F than the higher inlet temperature (230°F). Therefore, when the

leaf standard is good (60%), maintaining a higher inlet temperature for drying has not resulted in any specific advantage in relation to liquor quality. Therefore, it can be concluded that an effective way to reach the final quality of made tea, saving power and energy, is the use of 205^oF inlet drying temperature in the ECP dryer.

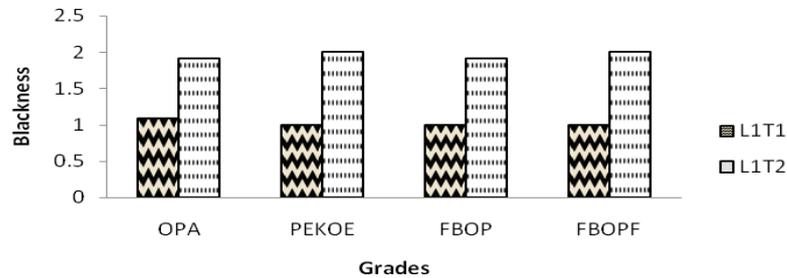


Figure 3. Overall appearances of OPA, PEKOE, FBOP, FBOPF grades at 40% leaf standard with 205^oF and 230^oF

The appearance of OPA, PEKOE, FBOP and FBOPF grades showed a significant difference when the leaf standard was 40% at 230^oF inlet temperature when compared to a temperature of 205^oF. The appearance of OP, OP1 and FBOPF1 grades did not show a significant difference at a higher inlet temperature in relation to all three leaf standards. Therefore, better appearance can be achieved by maintaining a higher inlet drying temperature for leaf standards of 40%.

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EVALUATION OF THE FIRST YEAR PRACTICAL COMPONENT IN BOTANY IN THE B.SC DEGREE PROGRAMME OF OUSL: STUDENT AND STAFF PERCEPTIONS

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INTRODUCTION

Practical work can be recognized as one of students' major support components in the teaching-learning process, especially in science-based disciplines (Emson, 2013). The first year at university is very important for a student as it is the transitional stage from the school setup to an independent tertiary background. The Open Distance Learning (ODL) system is technically different from the conventional system. As a result, students may, relatively, have more adjustment difficulties to the ODL system in their first year.

Laboratory practical classes is a serious challenge for ODL institutions when they offer science-based courses due to their conflict with the "Distance concept" as well as in providing laboratory facilities, relevant equipment, and teaching staff for a large number of students. The advantages of providing distance students with practical work include reinforcing students' motivation towards subject matter, generating a positive attitude towards overall learning, and intensifying interpersonal relationships with tutors and peer groups. Comparatively, a large number of students register for the B.Sc. degree programme at the Open University of Sri Lanka (OUSL) and 50% of them are employed. Hence, it creates laboratory space difficulties, and conflict with education and work norms of students. The first registrants of the B.Sc. programme have to involve themselves in compulsory practical sessions for each subject except for Mathematics. The Department of Botany conducts practical sessions for two of the first year subjects of the degree programme, which are Plant Diversity (05 days) and Organization of Cells and Plant Biochemistry (2 ½ days). This study examines the difficulties and remedial measures that are perceived by students and relevant staff members for the first steps of these practical components.

OBJECTIVES OF THE STUDY

- To quantify the difficulties in practical classes perceived by staff/students.
- To identify the most problematic situations with regard to the practical component.
- To examine the suggestions made by students/staff to improve the practical component.

METHODOLOGY

This study was carried out to evaluate the perceived difficulties and suggestions made by students/staff for the compulsory practical (Botany) components of first year B.Sc. undergraduates, with a piloted questionnaire (Kuruppuarachchi and Gunerathne; 2014). The piloted questionnaire consisted of two major parts. Part I consisted of fifteen items; items 1 to 8 evaluated the students' demographic profile, items 9 to 12 requested students to rank the items provided under personal difficulties, difficulties regarding physical facilities, difficulties encountered in the teaching-learning process, and management difficulties, respectively, and items 13 to 15 mainly investigated a preferable period, time, and evaluation system for practical classes, respectively. Part II of the questionnaire was open-ended to examine the most problematic situations encountered in practical classes and requested suggestions to overcome difficulties.

The piloted questionnaire was randomly administered to students at the Colombo Regional Center (CRC) during the compulsory practical sessions of the Plant Diversity (BOU 1200) and Organization of Cells and Plant Biochemistry (BOU 1101) course units, which represented more than 10% (150) of the target population. The same open-ended questionnaire was distributed

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among the relevant staff members of Department of Botany, which included teachers (08), demonstrators (08), and technical offices (03), to obtain their perceptions. Responses to items 1 to 15 were tabulated using SPSS statistical software, while responses to open-ended questions were classified separately and analyzed using percentages of frequencies. These results were used for descriptive purposes with their calculated response frequency percentages (American Association for Public Opinion Research, 2000).

RESULTS

Characteristics of the sample: The study sample's students' ages spread across 18-23 years (44.7%), 24-29 years (40.91%), and over 30 years (10%). 75.76% of the sample group consisted of females, 85% were unmarried, and 54% were employed. 51.16% of students were from suburban, 26.36% from urban, and 22.48% from rural areas. 50% of the students travelled a distance between 30-120 km, 23.15% more than 120km, and the rest (23.85%) less than 30km.

Difficulties identified and suggestions made to overcome difficulties by the students and the staff included in the samples is summarized in Table 1 and Table 2, below, respectively.

Table 1. Students Perceptions: the most problematic issues in practical classes and suggestions to overcome these

Most problematic issues in practical classes	Response Frequency%	Suggestions made by students	Response Frequency%
Lack of sufficient equipment, chemicals, and laboratory space	56 (29%)	Limit student numbers in a practical group or increase the number of practical sessions	22 (21.35%)
Conflict with work norms (obtaining leave for practical continuously for 05 days)	31 (16.06%)	Increase laboratory facilities	17 (16.5%)
Intolerable, continuous, congested, And heavy workloads	30 (15.54)	Conduct practical classes on weekends in addition to weekdays (Friday and weekends)	17 (16.5%)
Difficulties in practical evaluation, i.e. insufficient time gap for preparing for practical assessment tests	29 (15.02)	Divide 05-day practical classes in to 2 sessions and distribute them over 2 semesters	09 (8.73%)
Less self-experimental facilities due to over crowding	15 (7.77%)	Expand practical classes to other regional centers	09 (8.73%)
Poor teacher-student relationships	11 (5.7%)	Improve self-experiment facilities in the laboratories	07 (6.79%)
Language difficulties	11 (5.7%)	Increase the number of demonstrators, if catering to large numbers of students	06 (5.82%)
Practical overlapping with other academic activities due to the non-flexibility of reserving practical classes	10 (5.2%)	Introduce a flexible and practical reservation system	05 (4.85%)
		Improve the quality and content /sufficient time gaps / Reduce the number of days of practical	11(10.76%)

Table 2. Staff Perceptions: the most problematic issues in practical classes and the suggestions made to overcome these (*Lab staff: Demonstrators, Technical officers; # Teaching staff).

Most problematic issues in practical classes	Response Frequency (total)	Suggestions made by staff	Response Frequency %(total)
*# Insufficient equipment, chemicals, and laboratory space	*15, #07(29.72%)	*# Arrange instruments/specimens/ chemicals in an up to standard manner (eg. clean, prepare, sufficient quantities)	*08, #04 (17.14%)
*# Large numbers of students per group	*07, #07 (18.93%)	*# Increase number of demonstrators, restrict no. of students, increase the number of groups	*07, #06 (18.57%)
*# Insufficient time to prepare for practical due to a continuously heavy workload	*08, #01 (12.17%)	* Recognize that cleaning of laboratory space is very essential	*05 (7.14%)

*# Students unprepared for practical classes have less theoretical knowledge	07, #03 (13.52%)	* Divide 5-day practical classes over 2 sessions over 2 semesters	*05 (7.14%)
* Lab safety is not up to standard	*05 (6.76%)	*# Conduct practical workshops/day schools prior to practical classes for relevant staff/students	*09, #02 (15.7%)
* The number of demonstrators insufficient to conduct practical classes	*02 (2.7%)	*# Improve the reservation and record-maintenance procedure of practical classes	*04, #03 (10%)
# Less commitment, being not well prepared prior to practical classes, and a lack of punctuality of demonstrators and lab staff	#08 (10.8%)	* Effectively schedule timetables (without overlapping and with sufficient breaks between practical classes)	*04 (5.7%)
# Appropriate guidelines not received by students	#03(4.05%)	* Use a separate lab for microbiology	*02(2.8%)
# Discrepancies in conducting practical classes at regional centers	#01 (1.35%)	#Have well-trained laboratory staff or increase staff numbers	*04 (5.7%)
		# Active involvement of senior coordinator at every step	#04 (5.7%)
		#Decentralize practical work	#03(4.28%)

Personal difficulties (Item 9) faced by the students are summarized in Table 3 below:

Table 3. Personal difficulties faced by students

Type of the difficulty	Frequency (%)
Conflict between education and work norms	373(24.6%)
Transport difficulties	341(22.53%),
Accommodation problems	242(15.99%)
Language difficulties	207(13.68%)
Adjustment difficulties for group work	119(7.86%).

Students' perceptions on difficulties due to weaknesses in teaching methodologies (item 11) are summarized in Table 4 below. However, 44.56% (369 students) indicated satisfaction with the current method of how practical

classes are handled.

Table 4. Difficulties faced by students due to weaknesses in teaching methodologies

Type of the difficulty	Frequency (%)
Insufficient guidance from senior coordinators	137(16.54%)
Poor contribution/ guidance from demonstrators	136(16.42%)
Not yet adjusted to ODL methodologies	123(14.85%)
Staff is unfriendly/ poor interrelationships	63(7.6%)

Difficulties faced by students due to weaknesses in management/administrative procedures (Item 12) are summarized in Table 5 below. A smaller percentage of students (13.46%) indicated they were satisfied with the existing practical management system.

Table 5. Difficulties faced by students due to weaknesses in management/administrative procedures

Type of the difficulty	Frequency (%)
Attending practical classes continuously for 5 or 2 ½ days throughout the week	289 (26.46%)
Congested and poor arrangement of the working schedule	274(25.09%),
An improper system to reserve practical classes	179(16.39%)
No prior guidance on the nature and structure of practical classes	116(10.62%)
Insufficient communication with the department	87(7.96%)

The results of frequency tabulation highlighted that in the allocation of marks for the practical component, 27.27% of students preferred it to be only from the submission of a report, 28.08% from the existing spot test system, 24.24% from laboratory practical tests (one hour), and 12.12% from written paper.

DISCUSSION

This study examined the perceptions of first year ODL B.Sc. undergraduates and staff, their responses to difficulties and issues in conducting practical classes, and the suggestions they made for the limited practical sessions of a Botany subject. The results (Tables 01 and Table 02)

revealed that insufficient materials in laboratories are the most problematic factor. The suggestions to overcome this problem were either to improve the physical condition of the laboratory or to allocate a manageable number of students per group. Suggestions made by students and staff to minimize the problem were to limit the number of students per practical group/increase the number of practical sessions (students: 21.35%, staff: 18.57%; see: Tables 1 and 2) and to arrange instruments/specimens/chemical supplies to the required standards (eg, clean, prepared, of sufficient quantity). It was also noted that without the provision of proper training and the increasing of the number of laboratory staff, it would be difficult to improve the conditions of the laboratory. Further, the decentralization of practical work to regional centers could minimize the difficulties faced by the CRC was a suggestion made by teaching staff (4.28%: Table 2). The lack of a practical reservation system for practical classes was recognized as one of the major failures in the conducting of laboratory classes, and introducing a better mechanism for this was considered to minimize this issue (by 10%: Table 2; by 5%: Table 1). Nearly half of the sample population of the study are employed and is required to apply for leave to attend the continuous days of practical classes. This was deemed to create stress and uncertainty among students, was indicated by 16% in open-ended question section of the questionnaire and ranked as a major personal difficulty by students (24.6%). More than 16.5% of students suggested conducting practical classes during weekends, which was demonstrated in the results of a similar survey for continuous assessment tests/CATs (Kurupparachchi and Gunerathne, 2014). This suggestion has been implemented by the Faculty of Natural Science since 2014 for CATs. Therefore, it is impossible to conduct practical classes on weekends due to overlapping with CATs. Students (8.73%: Table 01) and staff (7.14%: Table 02) suggested dividing the continuous 5-day practical classes into 2 sessions to be conducted over 2 semesters, which is a very positive suggestion to overcome the cited issue of “continuous, congested, and heavy workloads”, as well as the problem students have indicated of obtaining leave.

The active involvement of the senior coordinator at every step of the procedure was indicated as being important (by 5.7%) as was the proper scheduling of timetables (without overlaps and with sufficient breaks between practical classes) by senior academics for each course unit.

The results of ranked and weighted items (item 9 and 11) indicated that 44.56% (369) of students have suggested alternatives that are most suitable for handling practical classes. Only a small percentage of 13.46% (147) indicated satisfaction with the existing practical management system (see Tables 3, 4, and 5). Therefore, the results of the study mainly demonstrated that the improvement of the management/administrative system of the laboratory component of the first year Botany subject could enhance the progress of the existing system.

RECOMMENDATIONS

Mainly, the physical and management structure of the laboratory should be improved to create a better laboratory environment. Further, the implementation of an efficient reservations system for practical classes, for the uniform distribution of students among each practical class group, is required. Additionally, the 5-day continuous practical component could be divided into 2 sessions to be conducted over 2 academic semesters of the year. Finally, it is concluded that if the needs of ODL adult learners are catered, by providing a successful facilitating process for teaching-learning, it will upgrade the quality of the degree and better retain students within the programme, which will reduce drop-out rates.

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EXPLORING STUDENT PERSPECTIVES OF ALTERNATIVE ASSESSMENT AT POSTGRADUATE LEVEL STUDY

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INTRODUCTION

The traditional definition of alternative assessment (AA) deals with moving away from multiple choice and restrictive forms of assessment to more creative, instructional, and formative assessment. The value of AA is seen to lie in moving toward a constructivist model of learning where “teaching, learning and assessment” are connected (Anderson, 1998). As shown by McLellen (2004) and Tan (2012), ‘alternative assessment’ encapsulates many terms such as “performance assessment”, “authentic assessment”, and “direct assessment”. Thus, it is best defined by what it is not, namely assessment that focuses only on the product, output, or a measurement. At the Postgraduate Institute of English (PGIE), traditional assessment of that type is not conducted. Yet, there was a sentiment that the way students were being tested was not conducive and was leading to a greater failure and dropout rate.

In particular, in the sociolinguistics component of the postgraduate (PG) level course “Psychosocio context of Teaching/ learning English in Sri Lanka”, which is part of the teaching English as second language PG course, the examiners of traditional pen and paper examination expressed a general dissatisfaction with the standard and quality of answers given by students. This is in contrast to the examiners of the final project of a course, who discovered a much better and more impressive product. Three needs were identified as necessary for better student progress: a need for a training for students to write academically acceptable answers displaying an understanding of theoretical concepts under examination conditions, a need for balanced assessment that is designed to target students’ strengths rather than weaknesses, and a need to facilitate students’ discovery of connections between theory and their practice. In addition, it was mooted that, rather than using the traditional teacher-centered transmission approach to teaching, the facilitation of the self-discovery of knowledge and peer teaching that reflect dialogic learning be encouraged through the use of alternative assessment. In effect, that rather than changing the content, the delivery and assessment of the course be altered.

The proposed changes to assessment were seen as a strategy to both improve the quality of the course and the experience of students. Further, it was also seen as an approach to better prepare students for final evaluations and to reduce the failure rate at final evaluations, without compromising the quality of the course.

McLellen (2004) sums up the key benefits of AA as being that it focuses on holistic thinking and problem-solving skills, as opposed to discrete pieces of information and knowledge, and that it directly informs instruction. It is based on the notion that learning is meaningful, reflective, and self-regulated and that there is a ‘social dimension’ to learning.

The AA in this study is very closely associated with ‘formative assessment’. In the context of the study, AA is not a strange innovation as many of the continuous assessments and even some of the final evaluations involve take home assignments/projects, which in itself are considered alternative assessments. However, OBTs and presentations constitute a different type of AA for this particular context. Thus, in that light, a study of student perspectives is useful to assess the value of its implementation in order to identify areas in this AA that could be improved. The main research question of this study was: How do students perceive alternative assessments such as OBT and group presentations in terms of its value for learning, effectiveness, and its drawbacks?

METHODOLOGY

The AA consisted of replacing a solitary assignment with an OBT and a group presentation assignment.

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The main aim of the OBT was to help students hone their critical thinking and cognitive skills under the pressure of time while maintaining a high level of academic expression. The AA aspect of this assessment is that students are given the area of the test and are expected to prepare adequate reference material to be used during the test.

The main aim of the group presentation was to promote learner autonomy, peer teaching, and peer evaluation. The incorporation of peer assessment is supported by Dochy, Segers, and Sluijsmans (1999) who, based on a critical review of research on the use of self, peer, and co-assessment in higher education, concluded that such assessments make students “more responsible and reflective”. Eight groups of five to six members were allocated two separate topics. Students were asked to peer evaluate the presentation of the topic for which they did not prepare in order to ensure that students would pay attention to both the topics to be explored through student presentations.

Students were then given a questionnaire with open-ended questions via an online anonymous response feedback site in order to ensure anonymity. The queries in the questionnaire sought their views on the suitability of the assessment for PG level study, their assessment of its positive and negative aspects, and suggestions they had for improving the assessment(s). In total, 16 students responded to the questionnaire out of the 41 students who participated in the assessments.

The data from the questionnaires was qualitatively analysed using thematic coding and categorisation as it consisted of a series of open-ended questions.

RESULTS AND DISCUSSION

The responses from the data were first categorized to identify positive and negative perspectives. Within these two broad themes, all the comments of the students were grouped and further analysed for emerging themes. The participants’ responses to the questions have been analysed and presented according to their responses to the OBT assessment and the presentation assessment.

Overall, students had a positive response to the assessments. Analysis of the data revealed that students felt there were direct academic benefits from the OBT while the positive attitude to presentations included benefits such as “improved presentation skills” and the facilitation of networking among the course mates.

Student response to the OBT Assessment

Student perspectives of the OBT assessment comprised 6 major themes. The themes dealt with: time constraints, the effect of facing an OBT for the first time, how it contributed to learning, the ‘fairness’ of the assessment method, the role notes played, and preparation for the OBT.

One overarching theme that was repeated in a majority of the responses was that the time given for the OBT was inadequate. It was highlighted that there was insufficient time to refer books and the given time could not be utilized effectively. One response even highlighted that the limited time duration created exam anxiety. It was additionally pointed out that as the given time was so limited, it was not appropriate to have ‘citation and references’ as a marking criterion.

A more mixed reaction was evident in the responses to facing an OBT for the first time. The main two areas of impact were, firstly, how it made students feel and, secondly, preparation for the OBT (discussed in detail later in this section). While some expressed a sense of excitement at doing an OBT, another stated to being “nervous”. A few respondents also stated that because it was the first time they had done an OBT, they were not adequately prepared for it. One student reported the following:

“as some students had never sat an OBT before, there was general discord after the OBT was completed – because what was expected was not outlined”. On the other hand, others reported it as “really thrilling”, “full of excitement”, and that it “piqued” the interest of the student. Thus, it has been very effective in terms of its ‘novelty effect’ in stimulating interest and motivation in the students.

Another student perspective that emerged from the responses was the ‘learning’ value of the assessment. Students noted that the OBT helped them to “apply theory”, and a number of students

highlighted the fact that they did not have to be limited to ‘memorization’ and it required real understanding and thinking. In this case, the student emphasized that PG level study should not be about memorization. It was also highlighted that the OBT promoted critical thinking skills as well.

It was also emphasized that this test helped students to ‘avoid’ plagiarism and that it was perceived as being a ‘fair assessment’ as it was a way of assessing each student’s individual effort, as it was felt that students could get help for take-home assignments.

According to the students, the provision of students being able to take their notes into the exam for the OBT provided both a positive and negative effect. For some it provided a “sense of security”, but for another it had been a ‘false sense of security’ as the time was inadequate for them to refer to the notes and books and that, in that context, the over reliance on notes had meant they had not sufficiently prepared for the test.

The final major theme to emerge from the students’ responses to the OBT was the issue of preparation for the OBT. On the one hand, students felt prepared because the specific area of the OBT was given well in time, while others felt unprepared because they did not know what an OBT was like. Some even suggested that practice for OBTs should be provided in the day schools.

Student responses to the group presentation assignment

Responses to the presentation were more detailed and prolific, and had a range of responses, which included both positive and negative comments. Overwhelmingly, the comments reflected students’ affective response to working in groups. This dealt with both the advantages and difficulties of group work. The major themes that emerged were the role of peer collaboration in learning, the effect of the assessment on motivation, the extended collegiality effect of the assessment, the perceived benefit for acquiring presentation skills, the practical difficulties and issues with the assignment, and perspectives regarding the contribution of individual members.

Many felt that working in groups helped them to learn more. As one student put it: “everybody can contribute and constructive criticism takes place, and the group goes for the best thing.” Another student pointed out that the assessment demanded an ability to read large amounts, but distill the gist of the readings effectively. Many commented on the positive results of peer interaction on the quality of the final product and on individual learning. An important statement that reveals the potential of this assessment is given below:

“It was really an eye opener. I realized where I was in my studies. I compared myself with my peers. It was really helpful to redesign my learning strategies.”

On the other hand, a student responded that as the presentation had been divided among group members, there was very little sharing of knowledge within the group.

Students reacted positively to peer evaluation and felt that observing peers’ presentations also led them to self-evaluate their own work. However, some observations highlighted that peer marks could be biased and that since peer comments were not distributed to the students themselves, a learning opportunity was lost.

The impact on motivation to complete the assignment is evidenced by such statements as: “intensive study takes place and all work hard because there’s competition between groups”. Another interesting point made, is that even ‘slow learners’, who do not like ‘tests’ in general like this type of assessment.

In relation to further collegial benefits of this assessment, students found that they made new friends who would support them later. It was reported that a good rapport between batch-mates was also developed through the group work assignment.

Many commented on how the task helped them with improving their presentation skills and confidence. However, one student felt that peers/ tutors would be unduly influenced by the presentation itself and not focus sufficiently on the content. Further, one student proposed that as IT skills are needed for the presentation, it can leave students with poor IT skills at a disadvantage.

The practical difficulties with the assignment ranged from the fact that communication between group members was difficult at times due to the geographically-wide distribution of students to the lack of cooperation among group members. Students also noted that dominant personalities at

times produced a detrimental effect on the final presentation. This second issue is, indeed, contentious as one student pointed out “group presentations do not always display the true ability or knowledge of all the group members as sometimes it is the effort of one or two members of the group.” Another student felt there should be a mechanism in place to reward individual group members’ effort.

One final aspect of the assessment with which some students were unhappy was that they were asked to form their own groups. Some felt that individuals could choose groups where they would not have to do any work. Another felt that this created homogenous groups, especially in relation to ‘bright’ students and that a learning opportunity is lost.

CONCLUSIONS

The use of OBTs and presentations in a distance learning context can be problematic due to the fact that students had to be physically present at the university for the assessments. However, in this instance, no student highlighted it as being an issue, and instead they overwhelmingly showed that the time given for the test was inadequate and, thus, defeated the purpose of the test. This was clearly a drawback of the practical aspect of the assessment, but not of the assessment itself.

It is clear that from the students’ perspective, they had engaged with the OBT in terms of ‘thinking’ and, thus, confirmed a key benefit of AA. However, in its practical implementation, more guidance could have been provided to students so that they would not feel unprepared as a result of not comprehending the expectations of the assessment.

Students’ perspectives revealed that there were many advantages and drawbacks to group work. Among the drawbacks highlighted by students was the fact that every group member may not contribute, that ‘weak’ or ‘domineering’ members could have a negative impact on the final presentation, and the practical difficulties of meeting, discussion, and practice. A more serious concern is the value of group tasks when individual members take on discrete aspects of the task and there is very little subsequent discussion. In such a situation, a major benefit of group work, that of co-constructed learning, is completely negated.

Overall, AA at PG level in this study has shown to be effective and has to a greater extent confirmed the premise of existing literature regarding the value of AA. However, for these types of AA to be more successful, student concerns about their implementation, including practical difficulties and mark allocations, needs to be very carefully considered.

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SELF-REFLECTIONS OF STUDENT TEACHERS ON THEIR PRACTICE TEACHING: AN EXPLORATORY STUDY

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INTRODUCTION

In the field of language teaching, there exists a body of knowledge that is drawn from long traditions of theory, research, and practical experience, and the student teachers who enter this specialized field are expected to acquire a solid understanding of the subject if they are to function as effective language teachers (Richards & Bohlke, 2011). In order to equip student teachers with necessary skills and experience, most teacher training programmes include practice teaching sessions under the supervision of a mentor. However, as Loughran (2002) points out, experience alone is not sufficient for a student teacher and reflection on his/her experience is essential if s/he is to become an effective teacher in the future.

Reflective practice is a means of professional development, which is done through a process of self-observation and self-evaluation of one's own teaching, that enables a teacher to identify and explore his/her own practices and beliefs. As John Dewey, the educational philosopher in the late 19th century defined, reflective thinking is active, persistent inquiry of one's own beliefs and actions, which should be combined with intellectual responsibility that takes into consideration the social and moral consequences of those beliefs and actions. According to Dewey (1933), when a teacher attempts to solve his or her problems through reflection, learning takes place.

Based on Schön's (1987) two concepts of reflective teaching (Reflection-in-Action and Reflection-on-Action), Zeichner and Liston (as cited in Bailey, 2012) identify five dimensions of reflection. The first two dimensions, Rapid reflection and Repair, are Reflection-in-Action that occur while teaching, and the other three, namely, Review, Research, and Re-theorizing and Reformulating are grouped as Reflection-on-Action, which occurs after teaching. A recent study by Toom, Husu, and Patrikainen (2014) analyzed reflective episodes according to their deductive and inductive dimensions, together with their static and dynamic features. These researchers note that student teachers can reflect beyond solely practical issues on teaching and articulate multiple concerns about practice, and also learn both from theory and from practice as a result of reflection.

In a survey that investigated language teachers' views on reflective teaching, Springer and Bailey (as cited in Bailey, 2012) found that statements related to appeal were rated higher than statements related to experience on reflective teaching. Bailey(2012) claims that "these respondents are open to the various ideas of how to carry out reflective pedagogy, even if they had not had personal experience with the particular procedures" (p. 26). Bailey (*ibid*) shows that even though reflective teaching has a few disadvantages, such as "discovering uncomfortable information of our own work", the advantages of it outweigh the disadvantages (p. 27). McKay (2000) studied five Japanese teacher trainees' reflections during their teaching practicum for a MA TESOL. The findings showed that teacher trainees were concerned about their lack of knowledge of English and the uncertainty of the methods used.

The study presented in this paper is part of a wider research project that aims to look in-depth at the kind of learning experiences gained by student teachers during the course of their

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teaching practicum of the BA in English and English Language Teaching at the Open University of Sri Lanka. The aim of these practice teaching sessions is to assist student teachers to achieve the relevant competencies in relation to English Language teaching. University academic staff members supervise the teaching practice sessions and give feedback and assess the performance of these novice teachers. In addition, students also engage in peer assessment of their teaching sessions, which provides informal, but, nevertheless, valuable feedback regarding their teaching performance.

The present study attempted to answer the following research questions:

What are the main areas focused on in the self-reflection reports of the teacher trainees?

To what extent do student teachers engage in critical self-reflection when writing their self-reflection reports?

METHODOLOGY

The data collected for the present study were qualitative in nature and took the form of written reflections generated by nineteen student teachers during their practice teaching sessions. In this exploratory study, the student teachers were asked to reflect on one of the lessons that they had taught and to write a report that presented their reflections on the teaching in which they had engaged. Prior categories were not prescribed and it can, therefore, be assumed that the reflections relate to what the student teachers thought were the most salient aspects in relation to their teaching. The qualitative data that were gathered through the written reflections were coded for broad themes and categories that provide insight into what the student teachers felt were the most important aspects of their teaching during the course of a single lesson.

RESULTS AND DISCUSSION

The content analysis of the teachers' self reflections revealed a range of issues that were captured in eleven categories. These categories were related to diverse aspects on which student teachers had reflected in relation to the teaching in which they had engaged. Some of the categories were related to the student teacher's macro level reflections on the overall effectiveness of the lessons they had taught (self evaluation, lesson plans, and student engagement with lessons), as well as more micro level reflections on the components of the lessons (problems and self repair, activities, and materials). Student teachers also commented on the effects of the feedback that they had received that, in some cases, were translated to future plans and improvement. It is important to note that the student teachers also commented on their affective response to the classroom situation, which is an important, but sometimes undervalued and overlooked factor in relation to teaching.

Major Categories Identified in Student Self Reflection Reports

Several major categories were identified in the student self-reflection reports that gave insights into the dominant concerns of the student teachers. Some of the categories identified were linked to the content and delivery of the lesson prepared by the student teachers, which included reflections on *lesson plans* (evaluations of effectiveness of lesson plans and ability to execute lesson plans), *activities and materials* (appropriateness for age group and cultural context), *assessment* (effectiveness of tasks chosen for assessment), and *problems and solutions* (eg, self-monitoring and repair). Other categories were related to more general pedagogical issues that impinged on the lesson, which included *time management* and *classroom management* (dealing with mixed ability groups and questioning strategies).

Comments relating to *self-evaluation* (overall achievement in relation to lessons as well as micro level achievements in relation particular aspects of lesson) indicate that students self-monitor their teaching in terms of the overall success of the lesson and its individual components. The identified categories also shed light on the sources of feedback used by the student learners to aid self-evaluation, which included *peer comments* and *examiner's comments*. It is also important to note that students' self-reflections also included comments on *affective states/emotions* they experienced during the lesson that can impinge on the successful delivery of the lesson. The importance of the practice teaching component and its implications for future teaching was indicated by the category of comments that related to *plans for future improvement*.

The categories thus generated relate to a whole gamut of issues that were of importance to teaching. However, the findings revealed that the reflections on which individual teachers tended to focus were limited to three to four areas only.

Critical Reflection

The reports of the student teachers were also analyzed for evidence of critical reflection. It was found that some of these reports were mainly surface descriptions of the sequence of events that took place in the classroom and that there was no evidence of reflection. The reports showed no evidence of reflecting on issues regarding putting theory into practice.

CONCLUSIONS/RECOMMENDATIONS

The results revealed that students' reflections consisted of multiple areas that were cognizant with previous studies that have shown that teachers do not focus only on practical issues, but on multiple concerns that are salient for their teaching (Toom, Husu & Patrikainen, 2014). The study also showed that critical self-reflection was absent in most of the reports. It is expected that the categories identified in this study would help to create a framework to help student teachers engage in reflective practice systematically, which would enable their future professional development. Given the fact that some student teachers tended to focus on only a few areas and that their reflections did not go beyond mere descriptions of what happened, it is hoped that providing a more comprehensive framework for reflection would promote deeper and more extensive self reflections that would enhance their future teaching. This exploratory study also reveals the importance of praxizing (Sharkey, 2009) in order to develop student teachers' conceptual knowledge of theories and practices in language teaching and the necessity to provide them with more opportunities to try out and critically evaluate the theories and principles in language teaching in a variety of contexts.

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THE CONTRIBUTION OF INTERNATIONAL COMPUTER DRIVING LICENSE (ICDL) TRAINING OF SECONDARY SCHOOL TEACHERS TO CLASSROOM TEACHING LEARNING

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INTRODUCTION

Before the introduction of Information and Communication Technology (ICT) there were no remarkable changes in the teaching-learning process. Just as much as there were revolutionary changes brought about by modern technology in areas such as economics, politics, cultivation, and the arts, the impact of ICT on education has been equally profound and of historic significance. Naturally, ICT has offered teachers and students a giant leap forward that has been unequalled by any other phenomenon, barring the printing press. ICT is seen as a way to promote educational change and to improve the skills of learners and prepare them for the global economy and information society (Butcher, 2011). It makes education more child-centered by providing many alternative paths, with a variety of resources, so that learning can take place in accordance to the learner's study performance (Abbas and Ayo, 2013). The fact remains that ICT involves a combination of a range of continuously evolving technologies, such as desktop, notebook, and handheld computers, digital cameras, local area networking, Bluetooth, the internet, cloud computing, the World Wide Web, streaming, and DVDs. Of these, the computer is the most outstanding, and it is of vital relevance to every field of education. Computer applications in education provide student-centered learning instead of teacher-centered learning, and learning becomes based on the constructivist approach, which creates motivation in the teaching-learning process with the help of computer technology (Forcier, 1996).

One approach to ensure that teachers have the necessary fundamental skills to support ICT instruction in primary and secondary schools is to require International Computer Driving License (ICDL) training and certification. The Ministry of Education in Sri Lanka urges all teachers to receive ICDL training, regardless of the subject they teach. The ICDL, which is known as the European Computer Driving License (ECDL) within the European Union, is a certification that attests to basic proficiency in the use of certain types of software and/or computer systems (Csapo, 2002). The ICDL/ECDL is the world's largest computer certification programme, with more than 9 million candidates applying for certification in 148 countries (ECDL Foundation, 2009). Since the Ministry of Education recognizes the need to ensure that teachers have fundamental ICT skills in order to facilitate integrating ICT into classroom teaching, it considers ICDL training as an effective in-service training approach that allows teachers to acquire fundamental ICT skills, as this program aims to improve teachers' ICT proficiency at three levels: ICT skills, pedagogical skills, and curriculum training. Therefore, the main purpose of this study is to evaluate how ICDL training contributes to classroom teaching and learning.

Objectives

01. To evaluate the contribution of ICDL training to use ICT in the teaching learning process.
02. To assess the usage of computer technology by those who have undergone ICDL training.

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03. To identify the ICT skills, which are gained through ICDL training, that are the most likely to be transferred to the classroom setting.
04. To find out for which purposes computer technology is used by teachers after ICDL training.
05. To find out how often teachers implement computer-based activities in the target class after ICDL training.

METHODOLOGY

The study followed quantitative and qualitative research techniques, which included questionnaires, observations, and interviews. Quantitative techniques, such as the use of percentages, tables, and charts, and qualitative techniques were used for data analysis. A survey was the basic research method used in this study. 848 secondary school teachers have qualified in ICDL training in the Badulla district between 2008 and 2013 under EKSP project. From these 848 secondary school teachers in the Badulla district, a sample of 85 teachers were selected, which represented 10% each of Sinhala-, Tamil-, and English-medium teachers. 45 teachers out of 465 Sinhala-medium teachers, 25 teachers out of 241 Tamil-medium teachers, and 15 teachers out of 142 English-medium teachers, were randomly selected. The total sample consisted of 85 secondary school teachers who followed the ICDL training under the EKSP project, so that it would be large enough to ensure the validity of results and small enough for the study to be completed within the given period of time.

RESULTS AND DISCUSSIONS

The majority of the ICDL participants (69%) stated that the ICDL training increased their understanding of the way in which ICT can be integrated into the classroom, while 60% of the participants stated that they felt more confident about integrating ICT into their classroom teaching after completing the ICDL training and certification process. While 61% of the participants stated that the ICDL training they received was sufficient to use computers in teaching, 56% of the participants stated that their teaching is more student-centered after ICDL training. However, only 51% of participants stated that they could transfer the skills that were provided in the ICDL training to the classroom, while 54% of participants stated that the ICDL training received was sufficient to prepare learning materials. On the other hand, a large number of the participants (75%) stated that they needed more knowledge and practice on computer technology to use computers effectively in the teaching-learning process. Only 49% of participants stated that the ICDL training taught them to use various ICT software applications to solve future education or research problems. At the interview, 65% of the participants stated that their expectation was to pass the ICDL certification exam and they felt that the short period of time given to learn ICDL was insufficient. They further stated that they obtained some skills only to pass the examination within a short period of time.

A majority of participants (59%) stated that they were using computer technology in the teaching-learning process, while 41% of teachers do not use computer technology in the teaching-learning process. Several reasons were given by the teachers for not using computer technology in the teaching learning process, which included the inadequacy of computer facilities in the school, problems of paying electricity bills, a lack of electricity facilities, difficulty of covering the the workload in syllabi, and a dislike of students towards the use of ICT in the teaching process.

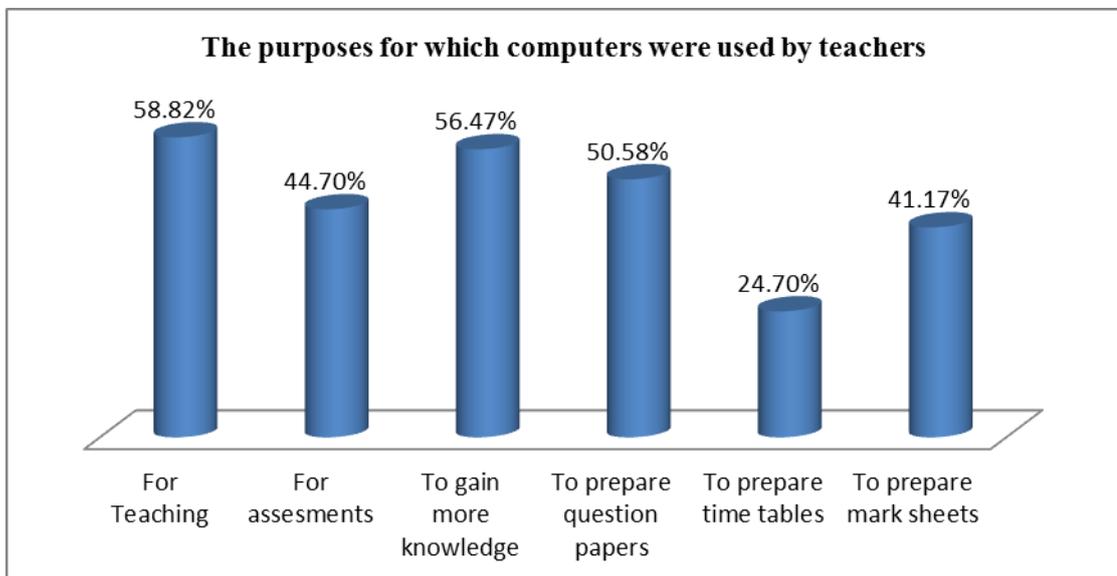
One interviewee noted the difficulties as follows:

“When I was teaching at (x) school with computer facilities, I was able to use computer technology in the teaching-learning process, but after my transfer to this school (y), I have been unable to use

computer technology because of the inadequacy of computer facilities.

However, most of the teachers who do not use computers have given first preference to difficulties in covering the syllabi and the inadequacy of computer facilities. A large number of ICDL participants (86%) stated that they would like to transfer presentation (MS PowerPoint) skills, while 61% of ICDL participants stated that they would like to transfer Word-processing skills. Only 52% of participants stated that they would like to transfer the internet skills that were gained through the ICDL training to the classroom setting. 22% of participants stated that they would like to transfer database skills, while 33% of participants indicated that they would like to transfer the spreadsheets skills that were gained through the ICDL training. The collated data indicates that the majority of teachers would like to transfer the presentation skills they gained through the ICDL training to the classroom setting.

Many teachers (59%) in the sample indicated that they used computer technology directly in their teaching. Only 45% of teachers stated that they used computer technology for assessment purposes. 56% of the teachers stated that they use computer technology to gain more knowledge, while 51% stated they used these skills to prepare question papers.



The collated data indicated that, in terms of internet browsing and usage on a daily basis, only 22% of teachers used it to collect information to prepare lessons, while 8% used it to collect learning material, 11% used it to prepare presentations for lessons, 7% used it to prepare exercises and tasks for students, 7% used it to browse material on the school's website, and 15% used it to search for online professional development opportunities.

CONCLUSIONS AND RECOMMENDATIONS

The findings indicate that even though ICDL training has increased teachers' understanding of the importance of ICT in the educational system and the usefulness of the ICDL training, a majority of teachers disagreed that the ICDL training had given them the full range of capabilities of the software applications that were covered by the ICDL certification. A majority of the teachers felt that the ICDL training they had received had increased their understanding of the way in which ICT could be integrated into the classroom and that it had increased their confidence in integrating ICT into their classroom teaching, but only a moderate number of teachers stated that the ICDL training provided them with skills that they can transfer to the classroom that enable them to prepare computer-based learning materials. Only a minority of the teachers could use various ICT software applications to solve future education problems and a large number of teachers still needed more computer training

courses to use computer technology in the classroom and to solve future education and research problems. The findings indicated that only a very low number of teachers used computer technology every day for internet browsing to collect information to prepare lessons and learning material, to prepare presentations for lessons and exercises for students, to download/upload/browse material from the school's website, to use as a virtual learning environment/learning platform, and to search for online professional development opportunities.

This study recommends the following:

01. Plan to provide multiple incentives, such as reducing workloads, recognizing and rewarding in faculty evaluations, increasing research allocations to encourage the use of ICT in teaching, and compensating those who provide educational/technological assistance to others.
02. Guide teachers who followed ICDL training to prepare lessons, ensuring the effective management of time.
03. Make arrangements for zonal directors who inspect teachers to inspect those who had followed ICDL to note whether they use what they had learnt, provided they are given sufficient equipment.
04. Consider the ICDL training as one phase toward ICT literacy in Sri Lankan schools.
05. Enroll teachers completing this program in more courses first or more specific courses that are aimed at introducing the same into classrooms. (For eg, only some teachers were trained in International Pedagogical ICT License (IPICT) after the ICDL training, but most teachers are not trained in it).
06. Maintain continuous training for a school-centered approach to handle fast-changing computer technology, which would maintain the learning process beyond short courses, and its extension into regular school and classroom life is needed.

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DRAWING COMPOSITION TECHNIQUES PRACTICED IN KANDYAN AND SOUTHERN SCHOOL ART MURALS, SRI LANKA

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INTRODUCTION

The evolution of art in Sri Lanka shows the pattern of cultural development throughout the history. Sri Lankan art styles belong to different time periods such as Classical school art style, Late Classical school art style, Gampola and Kotte period art style, Central Kandyan school art style, Provincial Kandyan school art style, Southern school art style and Modern transition school art style (Bandaranayke, 2006). These arts are treasured in temple murals in Sri Lanka. In comparison to other art styles, Central Kandyan and Southern school art styles preserve more evidences and remain in good condition and are accessible for studies.

Mural paintings belonging to Central Kandyan school art style were widely developed during the kingship of Kirithi Sri Rajashimha (1747-1782 AD) of the Kingdom of Kandy (Karunarathne, 1999). Central Kandyan school art style was initially adopted in temple murals around the city of Kandy and later they became popular in the other areas of Sri Lanka as well. Central Kandyan school art style shows the continuation of traditional art practices in Sri Lanka. Southern school art style was gradually coming out in temple murals belonging to Southern coastal areas of Sri Lanka during the 19th Century. It shows a clear relationship with Central Kandyan school art style. Southern school art style shows more tendencies to practices of contemporary western art (Bandaranayke, 2006).

Mural painting was used in Central Kandyan and Southern school art styles to visually communicate Buddhist Philosophy. These drawing styles are focussed on communicating ideas or messages through murals. Buddhist *Jathaka* stories and Buddha's life stories were mainly the subjects of drawings in both art styles. The total appearance of the art looks like a decoration. Figure graphics were artistically and symbolically developed based on natural figure forms and it was composed in drawing panel to make communication (Chutiwongs, *et al*, 1993^A, Chutiwongs, *et al*, 1993^B).

Composition of the drawing is one of the main areas that need to be consciously practiced for creating visual communication through murals. Central Kandyan and Southern school art styles were commonly composed figures into narrow horizontal bands. Those bands were set inside the temple shrine room walls. Miniature figures, tiny decorative motifs, repeated standard size figures and motifs were made attractive to read the paintings (Charles, 1993). This study is undertaken to determine whether in the Central Kandyan and Southern school art styles which communicate ideas through mural paintings, drawing composition techniques have been consciously practiced to build up visual communication. For this purpose the paper examines the different composition techniques which were practiced in Central Kandyan and Southern school art styles and analyses the effectiveness of the those drawing composition techniques to build up the visual communication.

METHODOLOGY

This is a qualitative research based on the style of drawing techniques that are found in traditional Sri Lankan murals. The research is based on the hypothesis that the way of practicing drawing composition techniques can be used to develop visual communication. Studies of evolution of Sri Lankan art styles, Central Kandyan art and Southern art styles were conducted through literature reviews and visual examination of the primary data by

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visiting temple murals located in Central, Southern and Western Provinces of Sri Lanka. Two case studies were undertaken to perform in-depth studies on Central Kandyan art and Southern art styles. Mural paintings belonging to the Central Kandyan art style were analysed through mural paintings belonging to Gangaramaya temple, Lewalla, Kandy. Mural paintings belonging to the Southern School art style were analysed in-depth by studying the Subodharamaya temple murals, Karagampitiya, Dehiwella.

Analysis of the study was conducted through deriving different drawing composition techniques that were used to compose figures into drawing panels and the methods that used to make separation in-between drawings without disturbing the smooth continuation in the drawing style. Line drawings of selected mural paintings were developed to perform a detailed analysis on the drawing techniques practiced in Central Kandyan and Southern art styles.

RESULTS AND DISCUSSION

The whole appearance of the drawing panels belonging to Central Kandyan and Southern School art styles look like a systematic, detailed decoration. Figures and graphics were used in miniature form to compose drawings into narrow horizontal bands. Figures look two dimensional, short, rigid and deviate from the natural figure proportions. Limited and selective colours are practiced. Line is used as a main highlighting feature in the drawings. Main highlighting incidents of the story were continuously drawn on horizontal drawing panels from one end to another.

Central Kandyan and Southern school art styles were used in different composition techniques to compose figures to create incidence of the story as well as to make separation between incidence without disturbing the story narration techniques.

Figures are composed, creating a line

Figures are composed forming a line in a drawing panel. Repetition, alternation and gradation techniques were used to add interest to the drawing through changing the figure type, clothing and distance among the figures. Figure 1 illustrates the way of using these techniques to compose figures into a painting.

Figures are composed, creating a focal point

Figure forms and graphics are used to create a focal point in a drawing. Three types of techniques were used to create a focal point. These are changing the size of figures, changing the figure proportions and setting separate backdrops. Figure 2 shows the way of setting focal point as considering the figures in the line. Figure 3 illustrates the focal point arrangement with different levels in drawing.

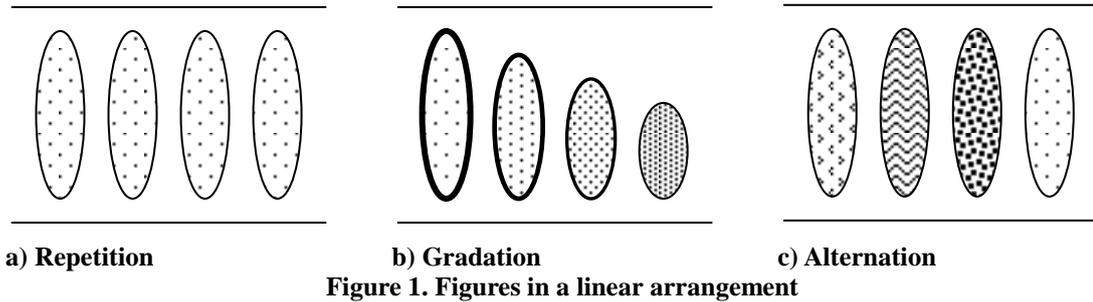
Figures are composed, creating levels

The space of the drawing plane was horizontally divided into two or three parts and figures were composed considering the levels in drawing. Horizontal lines and figure placement of considering different levels in drawing create the illusion of depth in the drawing. However, the size of figures and figure proportions show deviation to show depth. Figure 3 shows the different practices of figure placement, creating foreground, midground and background in drawings.

Different artistic applications were practiced at drawing to make interchanges between the incidents of the story. It is highly affected to make smooth continuation among drawings and make whole appearance as a decoration. Five types of drawing interchanging techniques are discussed below which were derived through the analysis.

Changing figure orientation

Repeating figure forms were set in different directions to show the separation between incidence. Separation was highlighted through the repetition of the figures. Figure 4 illustrates the sense of that technique practiced in drawing.



a) Repetition

b) Gradation

c) Alternation

Figure 1. Figures in a linear arrangement

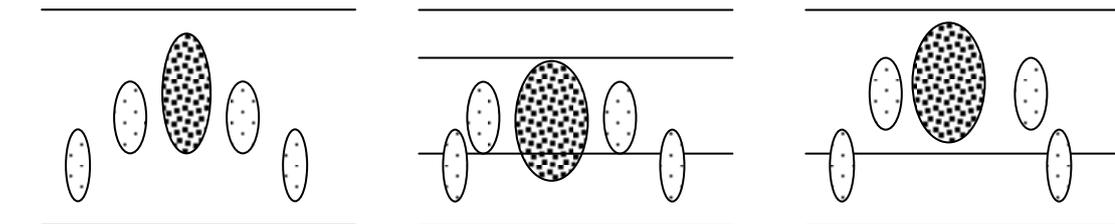


Figure 2. Triadic figure arrangement

Figure 3. Layer separation with horizontal lines

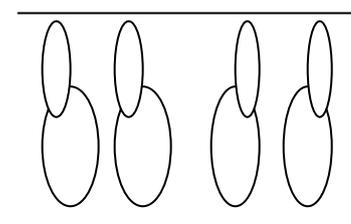


Figure 4. Changing figure orientation

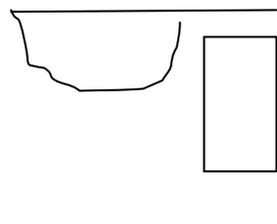


Figure 5. Setting separate windows

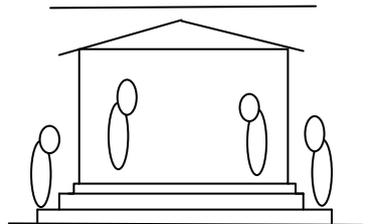


Figure 6. Setting architectural forms

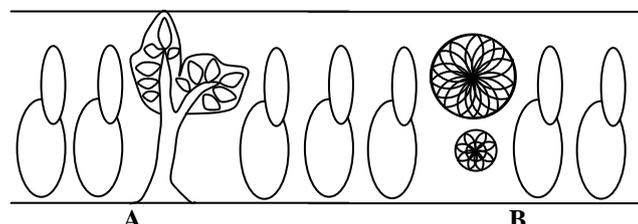


Figure 7. Setting figure graphics

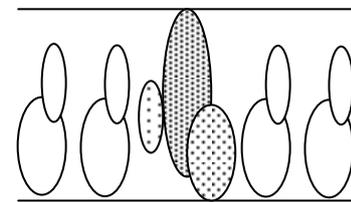


Figure 8. Unrelated incidents

Border arrangements to create the window space

Clear decorative lines and shapes were used as border or windows to highlight the incidents in the drawing. Borders make a clear separation between the incidents. Shapes like window spaces were used to show parallel worlds or coincident to the main story events. Figure 5 illustrates the inorganic and organic forms of window spaces created in drawings.

Setting architectural forms

Architectural forms were used to compose figures into drawing effect to highlight the incidents. It makes a clear separation among other incidence. Figure 6 illustrates the sectional view of the house and the way of composing figures to create a focal point. Likewise sectional view of the palaces, preaching halls, caves were commonly practiced in Central Kandyan and Southern school art styles.

Setting figure graphics

Artistic figure graphics were used in both art styles to make separation among the incidents as

well as to add interest in art. Figure graphics were used to create symbolic communication and to add pleasing effect to the drawing. Natural forms of flowers, trees, rivers, rocks and animals were commonly used to develop these graphical forms. Southern school art style was used to create natural figure forms as well as imaginations to create figure graphics as flower lines, hell, etc.:. Figure 7 illustrates the way of applying symbolic forms in drawings to make separation among incidents.

Setting unrelated incidents to the main story

Incidents that are unrelated to the main story events were inserted in between drawings to make the separation. This practice is commonly visible in Southern school art style. These types of incidents represent the events of day-to-day life style contemporaries to that period. Figure 8 illustrates this.

CONCLUSIONS AND RECOMMENDATIONS

Composition of the drawing techniques related to the Central Kandyan and Southern school art styles were examined and analysed in this work to find possibilities to make effective communication. Nine different techniques of composition were identified in drawings related to figures composed in the drawing panels to create an incident and to separate the incidents. Three types of composing techniques, creation of lines, focal points and levels, were identified as the means that have been used to create incidents. five types of interchanging techniques, namely, change of figure orientation, border arrangement to setting separate window in the picture plane, using architectural forms, using figure graphics and unfamiliar incidents to the main story were identified as that have been used in the drawings.

These techniques are effected to make clear understanding of the story narration and visually communicate the ideas. Central Kandyan and Southern school art styles consciously practiced drawing composition techniques to develop visual communication through mural paintings. The outcomes of this research, identification of drawing techniques used in Kandyan and Souther art styles, can be used to develop visual communication systems that can be practised in different fields with the aid of new technological advancements.

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PRODUCTION OF HIGH QUALITY GRANULAR ACTIVATED CARBON FROM COIR AT LOW COST FOR ELECTRONICS DEVICES

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INTRODUCTION

The activated charcoal of choice for a diverse variety of applications is derived from lignocellulosic materials. Currently Activated carbon is even more extensively used as a sorbent of molecular and ionic species in the liquid phase (Madhava, 2004). Commercial water treatment processes and domestic water filters make use of Activated carbon, as it effectively sorbs a large number of hazardous inorganic and organic compounds (Harris, 1999), (Marsh, and Rodriguez-Reinoso, 2006). The other area of manufacturing industry and research where Activated carbon plays an important role is electrochemical double layer capacitors (EDLCs) frequently referred to as super capacitors or ultra-capacitors (Viswanathan. *et al*, 2009). Here again Activated carbon is generally superior to other forms with respect to capacitance as well as charge discharge characteristics. Consequently, commercial super capacitor manufacturers prefer Activated carbon for the electrode fabrication.

Coir is bio mass separated from coconut husk during extraction of coconut fruit, due to porous structural organic nature that generally contain lignin, cellulose, hemicellulose, pectin, wax matters and ash: which would be ideal to prepare activate carbon.

Scouring would enhance the absorbency of the powder without appreciable loss in strength and help to increase the hydrophilic property of the powder. The main objective of scouring of coir fibre powder is to improve the porosity level by removing all types of hydrophobic matters present in the coir fibre powder, while causing minimum damage to the coir fibre powder.

The present work reports on the production of activated carbon from natural vegetable fibre, namely Bristol coir fibre. These raw materials abundant in Sri Lanka, have a low ash content and low cost in comparison with man-made fibres. In this research bristle coir fibres powder is subjected to alkaline bio- scouring. Using KOH by one step pyrolysis and characterized for activity level and morphology.

METHODOLOGY

Materials

The bristle coir fibres were scoured in solution of 0.15 M of NaOH with added pectin of 2 g and Teepol (2 g) dissolved in 800 ml of water. The temperature was maintained at 45 °C. The liquor ratio was maintained at 1:50 and the pH level at 9.2. Thirty minutes after the scouring treatment the fibre were washed with distilled water and dried at 100 °C for three hours and were stored in desiccators. A sample of a scoured bristle coir fiber weighing 10 g was subjected to Ball Milling (Model: Fritsch supreme line Pulverisette 7). It ran at 600 rpm for 10 minutes to produce micro level coir particles.

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Methods

Then 0.1 M of Potassium Hydroxide (KOH) was used to treat the coir particles for activation. After this the coir particles were fed into a tube furnace with a constant heating rate of $20\text{ }^{\circ}\text{Cmin}^{-1}$ until the temperature reached range of values between $380\text{ }^{\circ}\text{C}$ to $450\text{ }^{\circ}\text{C}$. At a selected temperature between $380\text{ }^{\circ}\text{C}$ to $450\text{ }^{\circ}\text{C}$ the samples were kept inside the tube furnace for 15 minutes in a nitrogen flow.

After activation, the mixture was removed from the furnace and was allowed to cool to room temperature. In order to determine the activity level of the coir carbon, iodine number was determined according to the standard test method ASTM D 4607.

RESULTS AND DISCUSSION

Figure 1 shows the weight loss in Granular Activated Carbon (GAC) at different temperatures. It is found that the weight losses increase steadily until $400\text{ }^{\circ}\text{C}$ and it is clearly seen that there is a rapid increment in weight loss after the $400\text{ }^{\circ}\text{C}$. This may be due to the formation of ash producing CO_2 reducing the carbon amount.

The amount of iodine absorbed in milligrams per gram of carbon at a residual iodine concentration of 0.02 M is known as the iodine number.

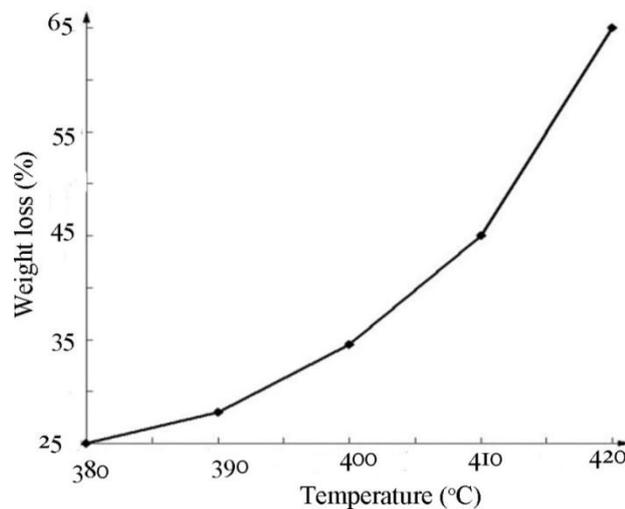


Figure 1. Weight loss vs. activity temperature

Figure 2 shows the variation of surface area estimated from iodine number for the produced activated carbon with various temperature profiles after alkali activation. The highest activity level was obtained at the temperature of $400\text{ }^{\circ}\text{C}$. When further increment, pores may have got damaged and thus reducing the activity level of the GAC producing CO_2 rapidly increasing the weight loss. It should be mentioned that the activation by maintaining slow heating rates facilitates to produce high quality activated carbon from coir for various purposes at low cost.

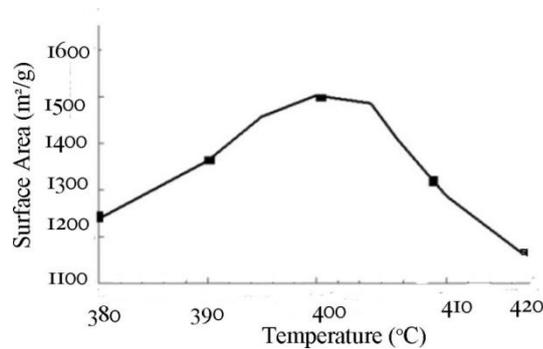
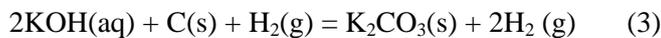
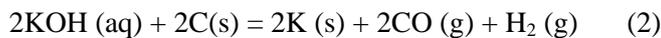
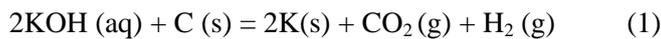


Figure 2. Surface area vs. activity temperature

Most experiments on alkali activation of carbon are conducted in the absence of oxygen, and observations of hydrogen liberation conclude that intercalation of alkali metals in carbon phase contributes to the activation process (Marsh, and Rodriguez- Reinoso, 2006). In the absence of oxygen, carbon and KOH could react to yield K, H₂, CO, CO₂, and K₂CO₃ via the reactions given below or, other reactions generating the same products.



Reactions given above are endogenic and the rate facilitates if the gaseous products are removed from the reaction phase (i.e., heating in a current of N₂). Under identical conditions, KOH is more effective, to produce material of higher surface area as shown in the SEM micrograph in figure 3. It should be mentioned that the SEM micrographs for activated carbon using KOH clearly show the micro-crystals of GAC.

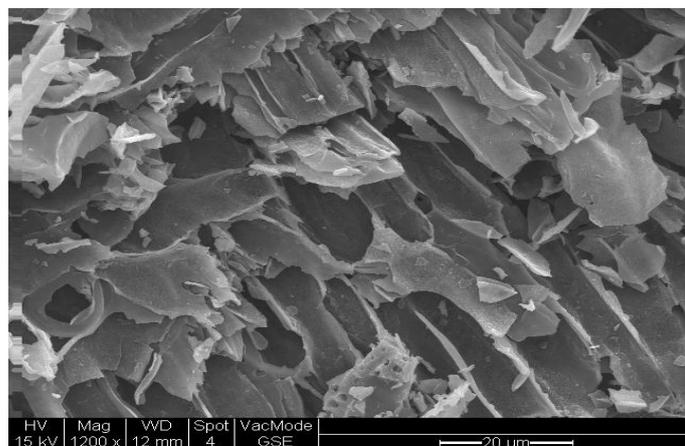


Figure 3. SEM micrograph of activated carbon of coir fibre powder

Pores in activated charcoal are generally classified on basis of pore diameter d as micro ($d < 2$ nm), meso ($5 \text{ nm} < d < 50 \text{ nm}$) and macro ($d > 50 \text{ nm}$). Pore distribution in coconut charcoal is populated more densely in the micro and meso regions. Macro pores of average diameter $\sim 1.3 \mu\text{m}$ are clearly seen in the SEM picture of the GAC sample. Pores smaller than $\sim 20 \text{ nm}$ are not clearly distinguishable in the SEM pictures and the larger fraction porosity originates from such pores.

CONCLUSIONS/RECOMMENDATIONS

The method found to produce activated carbon from coir fibre after alkali activation is significant due to low cost in comparison to the presently available two step activated carbon production. This finding of low cost method to produce activated carbon, that increases the pore size distribution will be favorable for super capacitor, solar cell application's, and hugely subsidizes to the production of activated carbon from coir fibres in Sri Lanka,

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ELASTIC PROPERTIES OF COMPRESSION BANDAGES USED FOR THE TREATMENT OF LOWER LIMB VENUS DISORDERS

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INTRODUCTION

Compression therapy has been used for many years in the treatment of edema and other venous disorders of the lower limb. Wearing compression grants increased healing rates of venous leg ulcers compared with no compression (O'Meara et al, 2008 and Nelson E.A. et al, 2008).

Any effective compression system must be able to generate three distinctive interface pressure levels between the compression material and the leg. These three key pressures are the resting pressure (pressure sustained upon application of compression bandage – also known as supine pressure), the load pressure (pressure during standing) and the working pressure (pressure during walking). To promote pumping of blood upwards these three pressures are in a relationship with low resting pressure, high load pressure and highest working pressure. To achieve these three levels of pressures the compression material must be provided with some characteristics of which elasticity and stiffness are the most important (Partch H., 2005). We can assume that a good bandage must have a low elastic modulus before lock-out but a high modulus after lock-out with a narrow lock-out range.

Presently two types of textile materials, hosiery and bandages are used for compression therapy. Compression bandages appear as simple and the most common compression device which is cheaper in comparison to hosiery. Bandages function as multi-layer systems where compression generating layers are combined with padding. The properties and characteristics of the compression generating layer (elastic bandage layer) are the most important, which determine the interface pressure levels.

Lack of knowledge of the elastic properties of the bandages causes difficulties while application. The interface pressures achieved vary enormously depending on the skill and the experience of the bandager. The present paper studies the elastic properties of some bandages available in the Sri Lankan market with the objective of helping the selection of correct bandage type to achieve a required resting pressure as well as to enable the estimation of working and standing pressures.

METHODOLOGY

Ten (10) different bandages available in the Sri Lankan market were selected for the investigation. All the important fabric structural parameters were first analyzed. Tinus Oleson Tensile Strength Tester available in the research laboratory of the Department of Textile and Apparel Technology was used for testing of the tensile behaviour. The machine was set for a loading rate of 100 mm/min, and the gauge length was 10cm. All the samples were subjected to a tensile load of 10 N per cm width under a preload of 0.1N. The tests were performed under standard atmospheric conditions ($65\pm 2\%$ relative humidity and $27^0\pm 2^0\text{C}$ temperature), and the samples were conditioned for 48 hours before testing. 5 K BS 4952; 2.4. Extension & Recovery [Variable Setting] software was adopted for the evaluation. Ten specimens were tested from each type of bandage.

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RESULTS AND DISCUSSION

Typical Load/Elongation behavior

Figure 1 displays 1.5 cycles of the tensile loading and recovery curve of a bandage. It displays a very low elastic modulus up to an extension of 150mm (Load 3.75 N). The constant modulus in this linear region is about 0.025 N/mm. Thereafter the modulus increases rapidly to reach 3.66 N/mm at an elongation of 185mm. Beyond this elongation any further change of modulus is hardly observed. The recovery of the extension takes a different path (bottom curve). It shows clearly that a bandage which is being stretched produces higher tensions than when it is relaxed from a higher tension. This behaviour of the textile material definitely affects the compression produced by it on the limb when limb dimensions change.

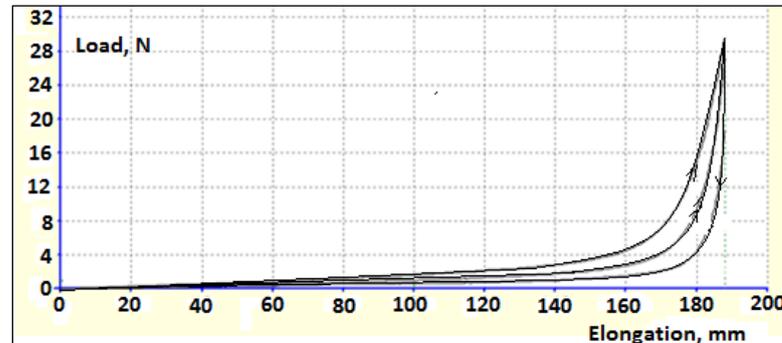


Figure 1. Load / elongation behavior of a bandage with cotton covered spandex and cotton in warp and 100% cotton weft

In the second cycle of loading (Centre curve), the initial modulus is lower than that of the first cycle of loading, and the modulus towards the maximum extension is higher than that of the first cycle of loading. This clearly indicates that when a bandage is subjected to repeated extensions, the tension generated as well as the compression applied on the limb is different. The region in which the modulus varies rapidly is known as lock-out region. The bandage is usually stretched to have an extension in this range during application.

Comparison of different bandages

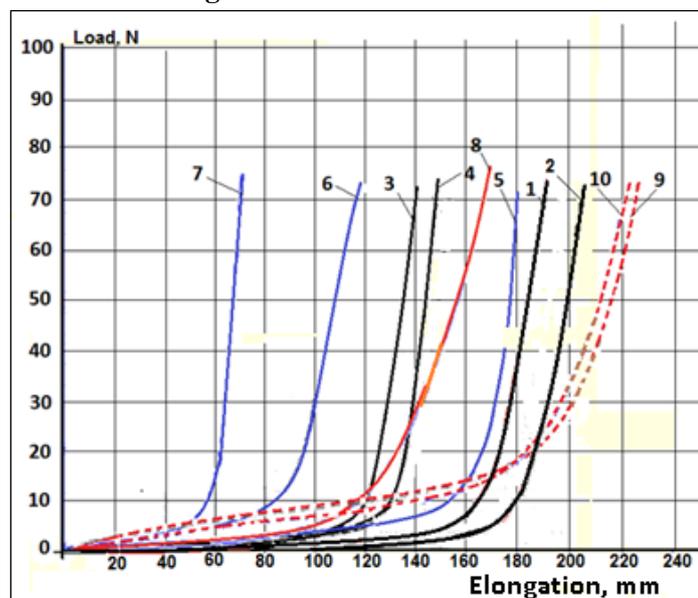


Figure 2. Load Elongation curves of ten different bandages

Figure 2 shows load/elongation curves of 10 bandages, which are designed to use as compression layer of multi-component bandage systems. All the curves have shapes similar to the loading curve illustrated in the Figure 1. The variation of material and the fabric structure

does not have a significant effect on the shape of the curve except in the cases of warp-knitted bandages (9 & 10). However the amount of extensions recorded for application tensions in the range of 8 to 10 N is very much different.

Comparison of bandages 5, 6, and 7 with 100% covered spandex yarns in warp

Table 1 shows important structural features and elastic properties of these bandages. The counts of warp and weft yarns of the bandage fabrics were not determined due to the difficulty of removing of threads from the fabrics without causing permanent stretch and damage.

Bandage 7 has the lowest percentage elongation of 70mm (70%) at a load of 10 N/cm. Its lock-out region is very narrow (From 50mm to 65mm elongation). Bandage six (06) has the second lowest total elongation of 115mm. It has a wider lock-out region than bandage 7 (from 70mm to 100mm elongation). Bandage no. 5 has a very much higher total elongation (about 180 mm) and the width of the lock-out region is about 30% elongation (from 145mm to 175mm), which is similar to bandage 6.

Elastic modulus before and after lock out regions are also different for the three different bandages. Increased amount of spandex in warp must have increased the elastic modulus and decreased the elongation, but it appears that this can be opposed by changing weft density.

Table 1. Important elastic properties of bandages with 100% covered spandex yarns in warp

Bandage No & Weave	Warp Yarn and Warp sett, 1/cm	Weft yarn and weft sett, 1/ cm	Total Elongation at 10 cN/cm, mm or %	Elastic modulus before and (after) lock-out, N/mm
5. Plain weave	Cotton covered spandex, 11	Cotton, 24	180	0.042 , (1.9)
6. Plain weave	Nylon covered spandex, 17	Cotton, 12	115	0.075, (2.68)
7. Plain weave	Cotton covered Spandex, 9	Cotton, 12 double wefts	70	0.097, (8.50)

Comparison of woven bandages with two different types of warp yarns

Table 2. Important elastic properties of bandages with two types of warp yarns

Bandage and Weave	Warp Yarn and Warp sett, 1/cm	Weft yarn and weft sett, 1/ cm	Total Elongation at 10 cN/cm, mm or %	Elastic modulus before and (after) lock-out, N/mm	Crimp of non-elastic warp, %
01. Plain	1. Cotton, 12 2. Cotton covered spandex, 4	Cotton, 24	190	0.018 (5.04)	212
02. Plain	1. Cotton, 8 2. Cotton covered Spandex, 5	Cotton, 25	205	0.021 (4.65)	141
03. Plain	1. Cotton, 11 2. Nylon covered spandex, 4	Cotton, 17	140	0.030 (5.0)	176
04. Plain	1. Cotton, 8 2. Cotton covered spandex, 5	Cotton, 16	150	0.035 (5.5)	169

There are four bandages each with two different types of warp yarns (Table2). The curves 3 and 4 have similar shape. The bandages 3 and 4 have different warp yarns and warp densities but are very much the same in weft yarn type and density. Though the bandages have different elastic warps, they exhibit similar load/elongation behaviour. Both the bandages have approximately equal crimp of the non-stretch warp. The crimp of the non- elastic warp depends on the extent to which the elastic warp is stretched during weaving as well as on the weft density. The similar warp crimp values show that both the bandages had been woven under similar conditions. bandage 3 has a total elongation of 140 mm compared to a total elongation of 150mm of bandage 4 . Total elongation of these bandages lie between the

elongations of bandages with 100% elastic warp (bandages 6 & 7) and bandages with leno and warp knitted structures (8, 9, and 10).

Bandages 1 and 2 have almost the same load/elongation behaviour. These two have almost same weft density but they are different in warp. Bandage 1 has a higher amount of total warp density but a lesser percentage of elastomeric yarns. The total extension of bandage 1 is little smaller (190mm) than that of bandage 2 (205mm). Lesser total warp density (13 against 16 1/cm) allows bandage 2 to elongate easier than bandage 1 and the higher amount of elastic yarn (5 against 4) has no significant effect. The difference in crimp of the non-stretch warp yarns has no significant effect on the total elongation.

Characteristics of bandages with warp knitted structures

Each of the two warp-knitted bandages (9 and 10) has three different warps. The amount of Spandex is less in comparison to low-stretch filament yarns (6 out of 27 and 6 out of 28). These two bandages exhibit the highest total elongation values (bandage 9 -226mm and bandage 10 -222mm). The lesser amount of stretch yarns allow the fabric to stretch easily, and the warp knitted structure applies a lesser resistance against deformation.

Both these bandages also have very large lock-out regions (Bandage 9, 170mm – 225mm and bandage 10, 150mm -210mm). Further, they have higher modulus before lock-out, which allows them to produce higher application tensions.

Leno-woven bandage

Leno-woven bandage has a load-elongation curve similar to those of woven bandages with elastomeric yarns but with a wider lock-out range. The elastic modulus is relatively low after the lock-out region as in the case of warp-knitted structures.

CONCLUSIONS

- Elastic modulus of the fabrics before lock-out increases with increasing amount of elastomeric yarns if there are only elastomeric yarns.
- In fabrics with two types of warp, non-stretch yarns do not significantly affect the load/elongation behavior before lock-out if they have a high percentage crimp.
- Beyond lock-out region the amount of non-stretch yarns as well as the warp and weft densities affects the elastic modulus.
- In fabrics with both stretch and non-stretch yarns, the crimp of non-stretch yarns affects the total elongation, elastic modulus before lock-out and the width of the lock-out region.
- Woven fabrics are the best because they have a low elastic modulus before lock-out and a very high modulus after lock-out with a narrow lock-out range.
- Warp knitted structures are more suitable for achieving high application tensions but difficult to apply due to too wide lock-out region and too high total elongation.
- Leno-woven bandages are suitable for conditions which require average load/elongations between woven and warp knitted structures.

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PREPARATION OF RADIATION GRAFTED CELLULOSE BASED BIODEGRADABLE SUPER ABSORBENT POLYMER (SAP) FOR THE APPLICATIONS OF AGRICULTURE

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INTRODUCTION

Grafting can be defined as a polymer modification where a different monomer is attached to an existing polymer through a covalent attachment irreversibly. Grafting is a free radical process, which can be initiated chemically, photo-chemically or by using ionizing radiation. Ionizing radiation is used for radiation grafting. It has several advantages over conventional grafting methods such as that it can be done at room temperature, high efficiency, high purity, being environmental friendly, simple, accurate, easy to control and a clean process (Yatender et al., 2014).

Ionizing radiation is a type of radiation composed of particles/photons that individually carry enough kinetic energy to liberate an electron from an atom or a molecule with which it interacts, e.g. gamma radiation, X-rays, beta and alpha particles or machine accelerated particles. Ionization radiation sources are of two types, one is radioactive sources which emit radiation due to their nuclear instability e.g. alpha, beta, gamma radiations and the other, machine generated radiation e.g. electron beam, cyclotrons. Gamma rays are more popular in the world. It initiates radiation grafting polymerization process. Radiation grafting is a promising technology having several potential applications. It can be performed using three common methods; i) Grafting by simultaneous or mutual irradiation (polymer backbone and monomer are simultaneously irradiated using electron beam or gamma rays under vacuum or an inert gas environment) ii) Grafting initiated by pre-irradiation in vacuum or inert atmosphere and iii) Grafting initiated by per oxidation (pre-irradiation in air) (Yatender et al., 2014).

Different countries practiced to develop radiation grafted material for industrial application and environment preservation such as radiation grafted materials for water purification, fuel cell membrane, energy storage in battery cells and Super Absorbent Polymers (SAP) for agricultural application using these three grafting techniques. This paper discusses development of radiation grafted SAP for agricultural application.

Super Absorbent Polymers (SAPs) are highly swollen, hydrophilic polymer networks capable of absorbing large amounts of water or saline solution (Lu et al., 2003). These substances can hold 100-1000g of water per dry gram of SAP (Ramazani-Harandi *et al.*, 2006). SAP is having the possibility of being applied in a wide range of industries such as agricultural, medicinal, environmental, horticultural etc. Cellulose based biomaterials could be used as raw materials for developing SAP with high biodegradability, having high strength after absorbing water, having less water soluble components, strong water retaining ability and mould proofing ability (Czaja et al., 2007). Most agricultural residues such as corn stove, wheat straw, rice straw and bagasse which are referred to as lignocellulosic materials are rich in cellulose fibers.

The present study is focused on synthesizing Sri Lankan SAP from bagasse cellulose. Additionally acrylic Acid (AA) and cellulose grafting by mutual grafting using N,N-MethyleneBisAcrylamide (MBA) as a cross linker. This SAP is employed for the application

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in the agricultural field to overcome problems of water scarcity in dry zone and difficulty of continuous watering in urban areas.

OBJECTIVES

General objective is,

To develop biodegradable cellulose based “Sri Lankan SAP” by gamma irradiation process.

Specific objectives are,

To evaluate the amount of cellulose available in bagasse

To develop and characterize the Sri Lankan SAP

METHODOLOGY

Cellulose was prepared by using alkaline pretreatment method as described by Feng et al., (2010) and its percentage determined using chlorinated method as described in Google book, (2004). SAP was prepared using a setup as shown in figure 1. A Certain amount of the cross-linker N’N- MethyleneBisAcrymide (MBA), Acrylic acid and 5 mol/L NaOH solution were mixed and kept in an ice bath for neutralization prior to use. 1.0 g of bagasse cellulose and 50 ml of de- ionized water were added to the vacuum flask and stirred for 15 minutes at 60⁰C. Blend in the ice bath was added to the media and continuously stirred for 5 minute at the same condition. Media was quickly transferred to a glass container and nitrogen gas was bubbled for a few minutes and quickly sealed. Sealed product was placed in the gamma cell and irradiated under a dose of 20 kGy. The final product was cut in to small pieces and dried at 105 °C until a constant weight was observed. Un-grafted cellulose samples as well as grafted SAP were Fourier Transform Infra-Red (FT-IR) spectroscopy analyzed and grafted SAP was subjected to analysis in a Scanning Electronic Microscope (SEM) for morphological characteristics. Swelling ratio was determined by immersing 1 g of SAP in a 200 - mesh sieve pouch in 250 ml of Tap water kept overnight. The swelling ratio (Q) was calculated using the formula, $Q (g/g) = (m_1 - m_0) / m_0$ (Where m_0 and m_1 are the weights of the dry and swollen SAP respectively). Biodegradability was measured by embedding nylon cloth wrapped around 100 g of water absorbed SAP to a depth of 10 cm in pots filled with sandy loam soil. This was repeated three times and each sample was weighed at 14 days intervals until total degradation was attained. The percentage of biodegradability was calculated using the formula; $(m_s - m_d) / m_s \times 100\%$ (Where m_s the weight of the un-degraded SAP and m_d is the weight of the biodegraded SAP).

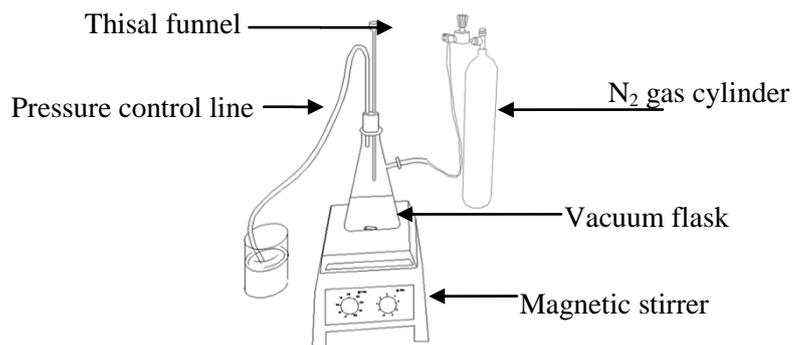


Figure 1. Setup of instrument for mixing chemicals

RESULTS AND DISCUSSION

According to the result of cellulose determination, 83% cellulose was in the bagasse after alkaline pretreatment. Swelling ratio was 1:310 in tap water. According to FTIR results un-grafted cellulose (Figure 2) shows that the main characteristic peaks of cellulose are at 1162.1 cm^{-1} , 1070.7 cm^{-1} (pyran structure) 3483.2 cm^{-1} and 3427.1 cm^{-1} (O-H Structure) and 2927 cm^{-1} (C-H stretch). The small peaks at 1637.6 cm^{-1} 1458.4 cm^{-1} result from -C=O stretching and amorphous cellulose, respectively. The absorption band at 1378.7 cm^{-1} and 897.8 cm^{-1} are

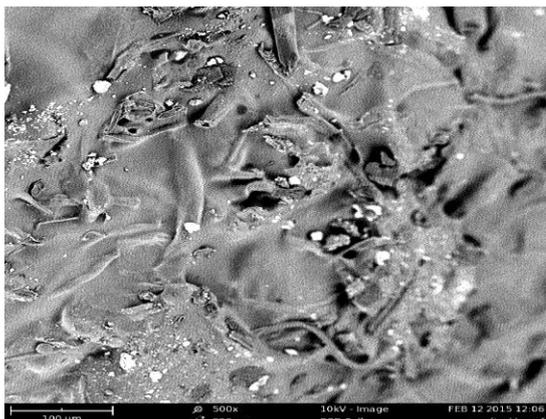


Figure 4. SEM diagram

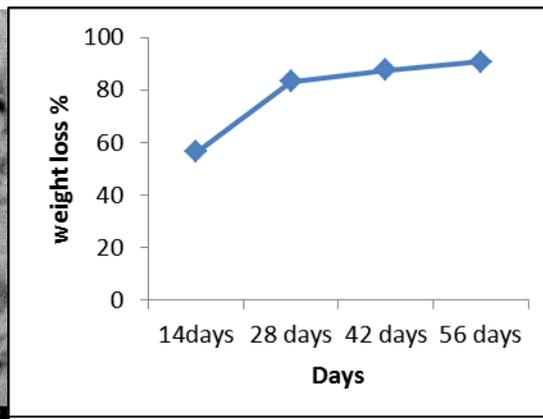


Figure 5. Variation of biodegradability

CONCLUSIONS

Superabsorbent polymer was prepared by graft polymerization of acrylic acid onto the chain of cellulose from mutual grafting. The grafted product had a porous structure and swelled 310 times on its own dry weight with tap water. It degraded successfully after 70 days at 29^oC soil and 32^oC atmospheric temperatures in sandy loam soil.

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ALGEBRA – THE MATHS TEACHER EDUCATIONAL GAME

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INTRODUCTION

In Sri Lankan school curriculum Mathematics is one of the core subjects taught from year one to year 11. In *GCE (O/L)* passing mathematics is essential to pass the exam. Yet, students consider mathematics as one of the most difficult subjects in the curricula. This is clearly evident when term results for mathematics are analyzed because majority of marks obtained falls in the 1st percentile compared to other three percentiles. *GCE (O/L)* results prove this argument further. Table 1 indicates the Passing/Failure rate in mathematics for several consecutive years.

Table 1. *GCE (O/L)* Mathematics answer sheet Analysis

Year	2009	2010	2011	2012	2013
Pass (A+B+C+S) %	50.8	60.37	55.33	52.18	51.44
Weak %	49.2	39.63	44.67	47.82	48.56

Source: *GCE (O/L) Evaluation Report for 32 Mathematics (Relevant Year)* published by Research and Development Branch, National Evaluation and Testing Service, Department of Exam, Sri Lanka.

It was widely discussed that this low performance (approximately 45% weak) is due to the fact that students have not internalized the theories and basic mathematics concepts in their primary education. The teachers play a vital role to resolve this issue in classrooms but most of the children struggle with answering mathematical problems. One commonly believed fact is that the time allocated for the mathematics subject at school time table is insufficient to cover the given syllabus. Then the teachers are compelled to teach in an accelerated speed at the expense of quality and pace of teaching. As a result, slow learners and weak students are negatively affected.

At present, apart from traditional learning modes/materials, there are lots of other supporting material on the web such as tutorials, virtual class rooms, MOOCS, video lectures etc. All these are for passive learning and do not consider the level of knowledge of the learner. Since almost all these are in English language the language barrier becomes a hindrance for utilizing these materials effectively. In addition some of the tailor made software tools for learning becomes difficult for usage due to technical and licensing limitations.

At present computer has become a household item and young children are so keen on playing computer games. By considering all these facts this paper proposes to develop a software tool in the form of a game to teach mathematics.

METHODOLOGY

Algebra - The Maths Teacher Educational Game will be a personalized and an intelligent educational game for *GCE (O/L)* students. Students can use the Maths Teacher game to learn algebraic concepts in *GCE (O/L)* syllabus in the form of an intelligent game. The game can be played in two modes namely *Learning* mode and the *Challenging* mode. Mathematical

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objects in the game are designed considering the Sri Lankan education standards, Bloom's Revised Taxonomy and theories of child psychology with an additional Sinhala interface. Questions at each level will be selected through Game engine considering both user game adjustment (*user rating value*) and player performance (*Core rated value*) along with the stages of the Bloom's Taxonomy.

Initially the user has to register with the system and can select a user rating value. This value reflects the player's own judgment about his/her level of performance in mathematics. The game environment will be automatically adjusted according to the player performances and current rating. The *jMonkey* game engine will be used for system development to harness the power of java to generate a platform independent output. The overall design of the system is given in figure 1.

Core rated value	Level	Resemble grade
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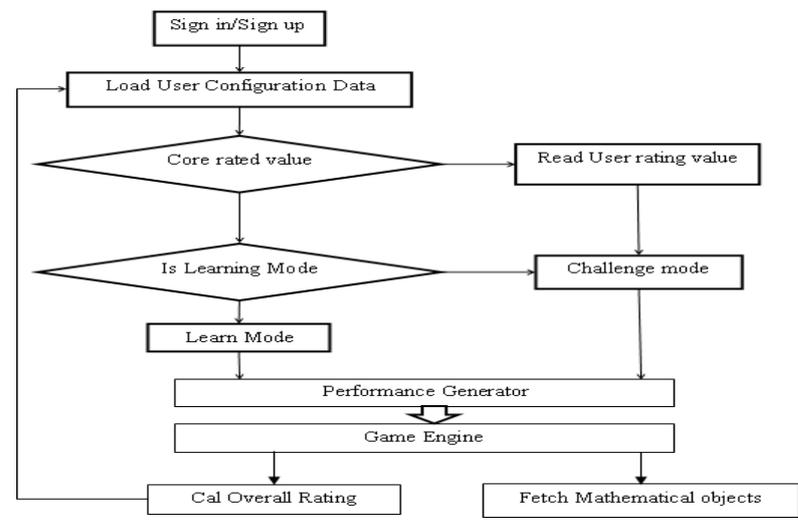


Figure 1. Overall system design

FRONT END OF THE SYSTEM

The game is operated in two layers, i.e., front end layer and the back end layer. The front end layer handles screen play and fetches final results such as the answer given for each question; time consumed per each question etc, and feed them to the back end layer. The front end is designed using *jMonkey* game engine and 3D arts, entities, scenes and textures are designed using *Blender interface*. The front end contains all user screens, interfaces and game environment. The main task of the front end is to make screen play as a game for the set of questions generated by the back end. After completing an activity a summary report will be generated. Soon after finishing each session front end will send list of activity responses, session summary and core rated value or user rated value to the back end and wait for next session or activity.

Game Engine -BACK END

The Back end is the heart of the learning system where all the processing takes place. It is triggered by front end data and at the back end these data are being analyzed by performance generator and game engine to fetch next task. If the user is a new user then the performance level of the user and the corresponding stage of the Blooms taxonomy have to be acquired before starting the game. The main module is categorized into 5 levels namely, Level0, Level1, Level2, Level3 and Level4 to resemble the activity *remembering* of all grades, up to grade 3, 6, 9 and 11 respectively. The Level will be selected considering the user rating values or core rated value of the user. Initially user rating value is set to 0 and core rated value is basically based on the criteria given in Table2.

Table 2. Game level layout

0	0	All grade Uses Remembering
1 - 25	1	grade \leq 3
26 - 50	2	grade \leq 6
51 - 75	3	grade \leq 9
76 - 100	4	grade \leq 11

PLAYING THE GAME

If a player is in the *Learning* mode the lessons are fetched by game engine based on the user level. Previous activity responses and current rate of performance will be considered to offer next lesson task i.e. if user has low performance in a particular category next lesson will include more on the same category. If a user has answered correctly for all the questions in a particular level then that is considered as the best performance for that level and the next lesson questions will be from Bloom's upper stage. Once a level is completed the system calculates the core rate value for each user.

In the *Challenge* mode the game engine initially finds the user level and the stage in the Bloom's taxonomy. For each level initially, five (05) questions will be randomly selected from the question bank. For each level, the first criteria for performance generation is the number of correct answers given and the second criteria is the average time taken to give an answer. Time band is divided into 5 groups, 0-25, 26-50, 51-75, 76-100 or more as a percentage. For each question the allocated time limit is inbuilt and shown to the user. When the time limit is approaching the user is alarmed. If all the questions in a particular level is completed within the given time period the core rated value of the user is increased and allowed to go to next stage of the Bloom's taxonomy. In the same manner if there are less than two correct answers in a particular level the core rated value is decreased. Yet, the stage in the Bloom's taxonomy is not decreased but the user will be given another two levels that comprise of questions where the user answers are wrong. The purpose of doing this is to make him thorough in the weak areas before moving to the next stage in the Bloom's taxonomy. The game playing cycle is given in Figure 2.

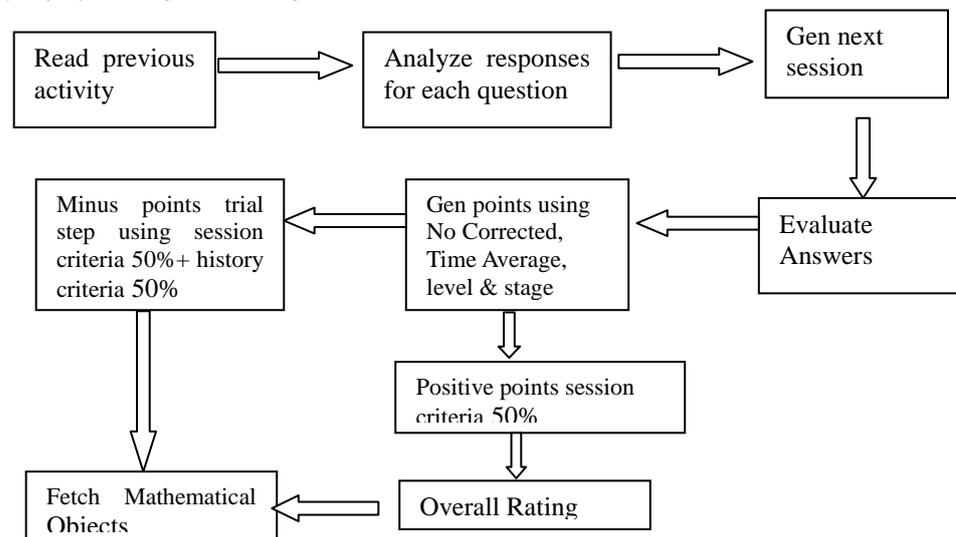


Figure 2. Working cycle of a Game

The game engine will consist of a rule based comprising of game playing rules, level offering criteria (as shown in table 2), rules for generating the core rated values, rules for getting feedback and question selection criteria are stored in the knowledgebase. Table 3 shows the criteria for calculating the core rated values. Hence the game will provide a personalized and intelligent learning environment.

Table 2. Level Acquisition based on Bloom's Revised Taxonomy

bStage	Bloom's Stages	Level 0	Level 1	Level 2	Level 3	Level 4
1	Remembering	Uses	01-05	26-30	51-55	76-80
2	Understanding	Remembering, No points granted.	06-10	31-35	56-60	81-85
3	Applying		11-15	36-40	61-65	86-90
4	Analyzing		16-20	41-45	66-70	91-95
5	Evaluation & Creating		21-25	46-50	71-75	96-100

RESULTS AND DISCUSSION

All the events played are stored for report generation. The reports will comprise of performance statistics presented in different formats with icons for capturing more attention. Since O/L students are mature enough to identify and address their own weaknesses the report generated will give them a good insight to identify the areas that they need to pay more attention.

The entire learning process is designed as a game to maintain the motivation of the users. Though there are many mathematical games on the web the advantage in this game is that the user is taken in a learning process according to the knowledge level of the user. Designing of the questions according to Bloom's taxonomy is a very systematic approach in guiding a learner to attain higher level skills such as application and synthesis. Finally the user can get an insight on his level of knowledge by the report generated. The additional Sinhala interface definitely will be an added advantage in the local context.

CONCLUSIONS/RECOMMENDATIONS

The *Maths Teacher* game provides the users with a novel experience for learning algebraic concepts in O/L mathematics in a user friendly environment with a carefully guided learning process for achieving higher knowledge level capabilities. The report on performance can be used to get an insight into the level of performance of the user. The system can be further improved in two obvious ways. The first improvement can be to develop a mobile app to enable accessing at anytime/anywhere. Secondly the web application can be enhanced for multiplayer facility to connect all into a single game environment which will lead player's morale high as well as high interactivity. Though the game is developed as a prototype system to learn algebra in O/L mathematics curricula the framework can be easily extended to a full fledged learning system that covers the whole GCE (O/L) syllabus.

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AN EMPIRICAL ANALYSIS OF SRI LANKAN EXCHANGE RATE CHANGES BY USING MARKOV CHAIN MODEL

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INTRODUCTION

In the globalization era, the economic interdependence of the countries around the globe increases; it becomes necessary to understand the nature of exchange rate movements and its significant impact on countries performance with the rest of the world. Exchange rate plays a vital role in international trade and investment as they effect on prices of goods and services worldwide. An exchange rate is the price of one currency in terms of another currency. Therefore, movements in rate of exchange can have a significant impact on a particular country and its trading partners. Given the open, small and more import dependent nature of Sri Lankan economy will easily affected by exchange rate fluctuations. Further, forecasting the rate of exchange is very important to assess the benefits and risks attached to international as well as Sri Lankan business environment. However, the empirical studies on this topic have been increasingly evolved in recent literature. Few studies (Hooper and Marquez, 1995; Bernard and Jensen, 2004) provide evidences related to exchange rate movements and its effect on trade flows. Still predicting the exchange rate movement is an unresolved issue in finance literature. This study is tried to fill this gap by analyzing exchange rate movement of Sri Lankan rupee – with world leading currencies (US dollar, Euro, British pound) price changes by employing Markov chain model. Thus, the main purpose of this study is to determine the propensity of increasing and decreasing the exchange rate. Doubleday *et al.* (2011) have analyzed stock market price trends by determining probabilities of the market transitions between various states. Deju Zhang *et al.* (2009) have studied on forecasting the China's stock market trend based on Markov chain model approach. In Markov chain the outcome of an experiment depends only on the outcome of the previous experiment. Exchange rate also follows a random walk implies that the exchange rate changes are as independent of one another as the gain and losses. If we go through the application of Markov chain model, it will be useful to focus on understanding the usage of exchange rate. The exchange rate is used when simply converting one currency to another or for engaging in speculation or trading in the foreign exchange market. In this study the following objective was considered, to construct the two and four state Markov chain model for the movement of exchange rate data. Further, in order to estimate the transition probability matrix, the average transition periods and the prediction of the long run distribution for the exchange rate movement were used by the developed model.

METHODOLOGY

Data for this research were retrieved from secondary source published by www.exchangerates.org.uk. Based on the availability and consistency of the data, daily exchange rate value of Sri Lankan rupees (LKR) versus world leading currencies: US dollar, Euro, British pound was collected. It covers the recent time period from 6th October 2009 to 24th November 2014 amounting to 1876 days. This study focuses on analysis of exchange rate using a discrete time stochastic model, namely a Markov chain. A stochastic process is a family of random variables $\{X(t), t \in T\}$, where the parameter “ t ” is running over a suitable index set T . The conditional distribution of $X(t_n)$ for given values of $X(t_1), X(t_2), \dots, X(t_{n-1})$ dependence only on $X(t_{n-1})$ is called Markov dependents. A discrete or continuous parameter stochastic process display the property of Markov dependents is called Markov process. A special kind of Markov process is a Markov chain. The discrete state space Markov process is called Markov chain. The conditional probability $P(X_{n+1} = j | X_n = i) = p_{ij}$ is called the first step transition probability. For a

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finite state Markov chain $\{X_n\}$ the transition probability p_{ij} can be represented by a matrix which is called transition probability matrix. With these transition probabilities, a $k \times k$ matrix, $P = (p_{ij})$, called the first step transition probability matrix of the Markov chain.

$$P = (p_{ij}) = \begin{bmatrix} p_{11} & p_{12} & \cdots & p_{1k} \\ p_{21} & p_{22} & \cdots & p_{2k} \\ \vdots & \vdots & \ddots & \vdots \\ p_{k1} & p_{k2} & \cdots & p_{kk} \end{bmatrix}$$

Each row of P is the probability distribution relating to a transition from state i to state j and with the following properties: $0 \leq p_{ij} \leq 1$ for all, i, j and $\sum_{j=1}^k p_{ij} = 1$, for all i .

A Markov chain is to have a steady state probability distribution if there exists a vector π such that given a transition probability matrix P : $\pi = \pi P$.

If all states of a chain communicate and are not periodic, then the chain is said to be ergodic.

If a finite Markov chain is ergodic then

$$\lim_{n \rightarrow \infty} P^n = \begin{bmatrix} \pi_1 & \pi_2 & \cdots & \pi_k \\ \pi_1 & \pi_2 & \cdots & \pi_k \\ \vdots & \vdots & \ddots & \vdots \\ \pi_1 & \pi_2 & \cdots & \pi_k \end{bmatrix}$$

where $\pi = (\pi_1, \pi_2, \dots, \pi_k)$ with $0 < \pi_j < 1$ and $\sum_{j=1}^k \pi_j = 1$.

This steady state probability vector π can be viewed as the unique distribution of a random variable in the long-run. Also mean recurrent times m_{jj} are obtained by $m_{jj} = 1/\pi_j$, for every j .

MODEL CONSTRUCTION

The data were arranged into two models of analysis such as two, four state Markov chain model and each study will be considered separately. Let Y_n be the rupees of exchange rate on n^{th} day. Then the random variable D_n denoted by: $D_n = Y_n - Y_{n-1}$.

Case-1: Each day was classified as indicating exchange rate rupee higher or lower than the previous day for the financial market, considering the movement from a category of jump up or jump down on a day to a category of jump up or jump down the next, thus letting classification of two states, namely:

State 1 (jump up): Today's exchange rate rupee is greater than the exchange rate rupee of the previous day

State 2 (jump down): Today's exchange rate rupee is less than or equal to exchange rate rupee of the previous day

A sequence of daily changes on the state of the system may be able to form a binary random variable X_n denoted by

$$X_n = \begin{cases} 1, & \text{if } D_n > 0, \\ 2, & \text{if } D_n \leq 0. \end{cases}$$

Therefore above random variable $\{X_n\}$ is known as a Markov chain with state space $\{1, 2\}$.

Case-2: Based on the case-1 model, jump up and jump down were each partitioned into two subcategories each, namely, small and large. Transitions for this case possessed of moving from a category of jump up or jump down one day to a category of jump up or jump down the next, namely:

State 1: Large jump up (jump up greater than or equal to " a " rupees)

State 2: Small jump up (jump up between 0 and " a " rupees)

State 3: Small jump down (jump down less than or equal 0 and greater than " $-a$ " rupees)

State 4: Large jump down (jump down less than or equal to " $-a$ " rupees)

In this case state of the system denote the random variable X_n as

$$X_n = \begin{cases} 1, & \text{if } D_n \geq a, \\ 2, & \text{if } a > D_n > 0, \\ 3, & \text{if } 0 \geq D_n > -a, \\ 4, & \text{if } D_n \leq -a. \end{cases}$$

transitioning to a state of small jump down than the other states. The third row vector indicates that there is a greater chance of transitioning to a state small jump up than other states. If a given day is in large jump down state, there is a better chance of transitioning to a state of large jump up than other states. Further, steady state probability π is expressed as exchange rate movement among states is, after long days; consist of the following proportions in each category: 15.74 % in the state-1, 33.24 % in the state-2, 36.50 % in the state-3 and 14.51 % in the state-4. Finally, the average return period of the corresponding states 1, 2, 3, and 4 are [6.3532, 3.0084, 2.7397, 6.8918] days respectively.

Table 1. The matrix and vector estimators of the Euro and British pound currencies

Euro	State	1	2	State	1	2	3	4
	1	[0.4725	0.5275]	1	[0.2233	0.2642	0.2987	0.2138]
	2	[0.4791	0.5209]	2	[0.1623	0.3019	0.3874	0.1483]
	$\pi =$	[0.4760,	0.5240]	3	[0.1456	0.3498	0.3769	0.1276]
	$m =$	[2.1008,	1.9084]	4	[0.1830	0.2618	0.3060	0.2492]
			$a = 0.5546$	$\pi =$	[0.1703,	0.3057,	0.3548,	0.1692]
				$m =$	[5.8720,	3.2712,	2.8185,	5.9102]
British pound	State	1	2	State	1	2	3	4
	1	[0.4725	0.5275]	1	[0.2290	0.2522	0.3333	0.1855]
	2	[0.4417	0.5583]	2	[0.1654	0.3012	0.3720	0.1614]
	$\pi =$	[0.4557,	0.5443]	3	[0.1599	0.2767	0.3977	0.1657]
	$m =$	[2.1944,	1.8372]	4	[0.2202	0.2324	0.3456	0.2018]
			$a = 0.6101$	$\pi =$	[0.1847,	0.2711,	0.3698,	0.1745]
				$m =$	[5.4142,	3.6887,	2.7042,	5.7306]

CONCLUSIONS

In this study, daily exchange rate movement of Sri Lankan rupee with respect to US dollar, Pound sterling and Euro is empirically investigated by using a Markov chain model. The findings revealed that the daily exchange rate movement pattern will show a great propensity to have small jump up and small jump down for each currency in the four state models. Further, the result shows that the pattern of exchange rate movement is similar against both currencies such as Euro and British pound. The movement/fluctuation of exchange rate is generally subject to an exposure to various economic factors, for example, GDP of the country, interest rate, foreign capital flows, inflation and so on. However, still, there is no unique model can accurately predict all these changes and their impacts on daily exchange rate movement. Thus, Markov model also no exception. The model described here is used only to predict pattern of exchange rate movement. The same Markov chain frame-work can be further formulated to forecast amounts of exchange rate value too. Finally, the results of this study will definitely helpful for investors and policy makers and enable to design the exchange rate policy appropriately in the country.

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