The Open University of Sri Lanka

OUSL JOURNAL

Volume 9 2015

Published by The Open University of Sri Lanka, Nawala, Nugegoda, Sri Lanka.

The OUSL Journal is a peer-reviewed journal, published annually by The Open University of Sri Lanka (OUSL).

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Subscription Rates

Local: Rs. 200.00; Foreign: US $ 20.00 (Inclusive of postage)

Local cheque should be crossed and made payable to the "The Open University of Sri Lanka" and should be addressed to the Librarian/OUSL.

Printed at The Open University Press
ISSN 1880-3621

The Open University of Sri Lanka

OUSL Journal

Volume 9
2015

OUSL Journal
Volume 9 2015

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Published Annually by The Open University of Sri Lanka (OUSL)

Editorial

This is the ninth Volume of the OUSL Journal, the Journal of the Open University of Sri Lanka. The articles published in this issue cover research on photochemistry, health science, emotional Intelligence on job performance, zoology, transport, phytoremediation and English literature.

Increasing drug resistance of pathogens and negative consequences of antibiotic usage has made scientists search for alternative medicines from plant materials found in nature. Sivagnanasundaram and Karunanayake, in their article, investigate the antimicrobial and phytochemical properties of *Artocarpus heterophyllus* and *Artocarpus altilis* leaf and stem bark extracts. Phytochemical screening confirms the presence of phytosterols, anthraquinone, terpenoids, phenols, glycosides, flavonoids and diterpenes, which are known to possess antimicrobial properties.

The Southern Expressway is the first expressway built in Sri Lanka and plays a vital role linking other major roads in Sri Lanka. The Expressway provides motorists a hassle free safe journey at a uniform speed throughout their journey offering advantages on fuel consumption and reduced travel time. Kumari *et.al,* in their paper titled "Future impact of current toll-gates on the capacity of Southern Expressway", investigate the efficiency of manually operated toll gates along the Southern Expressway and the impact on the capacity of interchanges which may finally limit the expressway potential in the future. Findings suggest that, even at present, Kottawa and Pinnaduwa interchanges do not operate satisfactorily during long weekends and festive seasons. The study recommends suitable off ramp lengths after considering the existing queue lengths and deceleration lengths. It also suggests introducing an electronic toll collection system with automatic coin machines or touch and go systems or systems operated through transponders *etc.,* in order to improve the service rate at toll gates.

Leaders who have high emotional intelligence (EI) are more likely to achieve greater success at the workplace. EI is the ability to monitor one's own and others' feelings and emotions, to discriminate among them and to use this information to guide one's thinking and

actions. In other words, it is the capacity for recognizing one's own feelings and those of others to motivate all involved. Job satisfaction refers to the collection of positive feeling and affective responses associated with the job. S. Praveena, in her paper, investigates whether there is any significant relationship between EI and job performance of bank managers in Sri Lanka. Her findings confirm that higher levels of EI of bank mangers lead to higher levels of job performance and job satisfaction. EI is recognized as one of the most critical skills that managers should possess nowadays.

Diyawanna Oya is a man-made ancient canal system located in Sri Jayewardenepura, which is the present administrative Capital of Sri Lanka. Zooplankton is a microscopic organism, which drifts or floats freely in freshwater bodies. As a result of rapid development taking place in Sri Jayewardenepura, most of the natural aquatic habitats are disturbed, restored, restructured or altered. Ruwini Perera, in her paper, investigates the variation of diversity, abundance and density of zooplankton present in a selected branch of Diyawanna Oya and its correlation with some environmental parameters. The results revealed that there was a significant variation of zooplankton species composition, diversity, their abundance and density during February to July 2003 and also among six sampling stations of Diyawanna Oya.

All over the world, mechanical ventilation is one of the most frequently used life supportive technique in Intensive Care Units (ICUs) which facilitates the gas exchange to the lung in impaired breathing situations. Marasinghe *et al.* studied the experiences of mechanically ventilated patients in the ICUs of the National Hospital of Sri Lanka, the Teaching Hospital in Peradeniya and the District General Hospital in Nuwara Eliya. It was found that patients faced negative experiences such as pain, dependency, fear and anxiety, thirst, noise level, cold environment and nightmares. Patients expressed moderate to high levels of distress in trying to communicate their needs during mechanical ventilation.

Rapid urbanization, industrialization and over use of fertilizers in agricultural practices have resulted in serious environmental pollution in Sri Lanka. Textile, paper, tannery, metal finishing, food

and beverage industries and agricultural runoff contribute most to water pollution. Phytoremediation involves the removal of pollutants from water and soil using plant materials. Thayaparan *et al*, in their paper, looks at the phytoremediation potential of *Lemna minor* for the removal of Cr(VI) and the time required for significant absorption of Cr(VI). They found that maximum uptake of Cr(VI) (5.8×10^3 µg/g dry weight) was at 8 mg/L in ambient solutions. However, the bio-concentration factor (BCF) decreased with increasing chromium concentration in the solution. The BCF was 1000 for chromium up to 3 mg/L. These results suggest that *Lemna minor* could be used to remove Cr(VI) from waterways.

Folktales that Henry Parker collected from the southern villagers of Sri Lanka in the late nineteenth century narrate a real-life experience of a person or a historical, religious or heroic event which took place many years ago. Lal Medawattegedera, in his article titled "We Must Make Men: constructions of masculinities and femininities in Parker's Village Folk Tales of Ceylon", analyzes the gender aspects of these Sinhala folktales published by Henry Parker. Medawattegedera concludes that Parker's folktales are sites where gender tensions are played out, where the feminine gender becomes a site against which the male proves his validity and superiority.

This year we have succeeded in publishing two Volumes of the OUSL Journal because of the positive response we have received from our readers. We look forward to publish your current research findings in our next volume.

Professor K. Sarath D. Perera
Editor-in-Chief

OUSL Journal (2015)
Vol. 9, (pp. 1-17)

Phytochemical Screening and Antimicrobial Activity of *Artocarpus heterophyllus* and *Artocarpus altilis* Leaf and Stem Bark Extracts

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Abstract

Increasing drug resistance of pathogens and negative consequences of antibiotic usage has led to the search for alternative medicines from nature. Many plants have been exploited to cure infectious diseases from time immemorial. The present investigation evaluated the antimicrobial and phytochemical properties of *Artocarpus heterophyllus i.e.* Jack fruit (Kos in Sinhala) and *Artocarpus altilis i.e.* Bread fruit (Dhel in Sinhala) leaf and stem bark extracts. Hexane, dichloromethane and ethanol were used as extraction solvents and test organisms were *Escherichia coli*, *Micrococcus luteus*, *Aspergillus niger* and *Trichoderma* sp. A disc diffusion test was adopted to test the susceptibility of the selected microbes to the extracts while Minimum inhibitory concentration (MIC) was determined using serial dilution of extracts. Phytochemical screening was carried out by specific chemical identification tests. Bioassay data were statistically analyzed using two-way ANOVA (SPSS 20 at 95% confidence level). Ethanolic stem bark extracts (30mg/ml) of *A.heterophyllus* and *A.altilis* possessed significant antibacterial activity against *Escherichia coli* with 9.50 ± 0.44 mm and 7.49 ± 0.28 mm inhibition zone radii respectively. Dichloromethane extracts of leaf and stem bark showed lesser antibacterial activity against both of the bacteria with inhibition zones of 3.00 ± 0.34 mm to 5.66 ± 0.16 mm while hexane extracts did not show any antibacterial activity. Antifungal activity on the other hand was not detected in any of the extracts. Bacterial antibiotic tetracycline and fungal antibiotic ketoconazole which were used as positive controls were more effective even at 1/10 concentration compared to all the plant extracts tested. Phytochemical screening confirmed the presence of phytosterols, anthraquinone, terpenoids, phenols, glycosides, flavonoids and diterpenes in both of the trees. These results confirm the potential antibacterial activity of *A.heterophyllus* and *A.altilis*

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stem barks and the presence of medicinally important phytochemicals in aerial parts of the plants.

Keywords: Artocarpus heterophyllus, Artocarpus altilis, Antimicrobial, Phytochemical, Plant extracts, ethnomedicinal

Introduction

According to the World health organization (2012) the evolving public health threat of antimicrobial resistance is driven by both appropriate and inappropriate use of anti-infective medicines. Kumaraswamy *et al.* (2008) state that the biochemical molecules of plant origin appear to be a suitable alternative to overcome the problems caused by antibiotic resistant pathogens.

A wide range of plants express complex mixtures of secondary metabolites within each species (Arguedas & Coley, 2005). Phenols, terpenoids, flavonoids, glycosides, tannins, alkaloids, steroids, saponins and resins are some important phytochemicals found in plants (Tiwari *et al.* 2011). An estimated 74% of pharmacologically active plant derived components were discovered after following up on ethnomedicinal use. Thus, medicinal plants can be regarded as the richest bio-resource of drugs of modern medicine, folk medicine and chemical entities or templates for synthetic drugs (Joshual & Takudzwa, 2013). Further, the discovery of medically important metabolites in common and abundant plants would minimize over exploitation of well known, rare medicinal plants.

Sri Lanka is recognized as a biodiversity hotspot as a great variety of flora and fauna inhabit the wide range of natural ecosystems found within the country (Pethiyagoda, 2005). In Sri Lanka, *Artocarpus heterophyllus* (Jack)and *Artocarpus altilis* (Dhel) fruits are a popular food among the locals. *A.heterophyllus* bark and fruit are medicinally used to treat sprains, fractures, diabetes and are also used for laxative effect of abdomen and to increase the breast milk production in nursing mothers (Fernando, 2003). Almost all the parts of *A.heterophyllus* and *A.altilis* are utilized to treat several infections and other ailments in the Caribbean islands, Polynesian islands, Taiwan, Malaya, Java, and Borneo (Deivanai and Bhore 2010; Jitendra *et al.* (2014). However, the usage of *A.heterophyllus* and *A.altilis* to treat infections has not been reported in Sri Lanka.

Satish *et al.* (2008) conducted an antimicrobial assay to test the efficacy of leaf extracts of 46 plants including *A.heterophyllus*

against 14 pathogenic bacteria including *E.coli*. Aqueous extract of *A.heterophyllys* leaf didn't inhibit any of the test pathogens. Another study showed that the silver nanoparticles synthesized using an aqueous leaf extract of *A.heterophyllus* as a reducing agent, increased the inhibitory effect of six antibiotics against *Salmonella paratyphi* and *Klebsiella pneumonia.* In addition, it was reported that, among the 54 chemical components of the aqueous leaf extract, 37.4% were alcohols and 32.2% were carboxylic acids (Thirumurugan *et al*. 2010).

Kuete *et al.* (2011) tested the effectiveness of crude methanolic extract of *Artocarpus communis* (Synonym for *A.altilis*) stem bark and terpenoids and flavonoids isolated from the bark against selected bacteria and fungi. Lowest MIC value recorded for crude extract against *E.coli* was 64 µg/ml. Lowest MIC value of 32 µg/ml was recorded for one flavonoid compound against *P.aeruginosa* which was more effective than the antibiotic chloramphenicol (64 µg/ml). Raman *et al*. (2012) and Mohanty and Pradhan (2014) reported that the methanolic and ethanolic leaf extracts of *A.altilis* were highly effective against some selected gram negative and gram positive bacteria including *E.coli* and *M.luteus* while the aqueous extracts (100 mg/ml, 10 µl per disc) were found to be the least effective.

Binumol & Sajitha (2013) state that the methanolic extracts of *A.heterophyllus* bark and *Artocarpus communis* leaf and bark extracts showed effectiveness against *Bacillus subtilis* and *Pseudomonas fluorescens* while aqueous extracts did not show considerable activity against test organisms. Mbaeyi Nwaoha & Onwuka (2014) investigated the antimicrobial properties and phytochemical composition of *A.altilis* leaf extracts using ethanol, n hexane and water. The ethanol extracts (at MIC 5 mg/ml) were more effective against bacteria including *E.coli* and fungi including *A.niger* compared to the other solvents. n hexane extracts inhibited all the test organisms (at MIC 8 mg/ml) while water extracts didn't inhibit any of the test organisms.

In addition to the antimicrobial activity of *A.heterophyllus*, anti inflammatory, anti oxidant, anti cholinergic, anti diabetic, immune modulatory effect, inhibition of protease, oestrogen regulation and inhibition of melanin biosynthesis have also been reported through several pharmacological research investigations of the plant parts (Jitendra *et al.* 2014). *A.altilis* has been found to exhibit antitubercular, antiplasmodial, antiatherogenic, antioxidant, antiausteric, antihypertensive, antihelmintic and skin lightening effects (Sikarwar *et al*. 2014).

Although many studies have focused on the antibacterial activity of *A.heterophyllus* and *A.altilis* extracts, little attention has been given to antifungal activity. Further, while *A.heterophyllus* (Jak fruit) and *A.altilis* (Bread fruit) (Moraceae) are very common trees in Sri Lanka and popular as a source of food, their antimicrobial potential has not yet been locally utilized.

Therefore, the present study was conducted to examine the antifungal activity of *A. heterophyllus* and *A.altilis* in addition to its antibacterial activity, and to ascertain the phytochemical constitution of these two trees which are extensively grown throughout Sri Lanka.

Methodology

Aseptic techniques and universal lab safety protocols were followed throughout all experiments.

Plant Collection

Healthy fresh leaves and bark of both *A.heterophyllus* and *A.altilis* were collected from Colombo and Kalutara districts of Sri Lanka, cleaned, surface sterilized using 70% ethanol, washed with distilled water and allowed to shade dry for seven days at room temperature. Dried plant material was cut into small pieces and ground using an electric grinder (JENCONS-Osterizer) to obtain small sized material (approximately 2-4 mm in size) as reported by Karthy *et al.* (2009).

Plant Extraction

Extracts were prepared by maceration of the powdered samples (10 g each) in 100 ml of 95% ethanol, 99% dichloromethane or 99% hexane (A/R Grade) with intermittent shaking (mrc, TS-400 orbital shaker) for three days at room temperature. Extracts were filtered using Whatman grade 1 filter paper and were concentrated by rotary evaporator (IKA® RV 05 basic) at 45°C. Concentrated extracts were weighed to find the extraction efficiency on dry weight basis. All the twelve extracts were stored at 4°C until further use as described by Karthy *et al.* (2009).

Extraction efficiency was calculated as follows;
Extraction efficiency % = (Final dry weight of extract / Initial weight of dried plant material) x 100 (Shilpakar *et al.* 2011).

Microbial Cultures

Escherichia coli, Micrococcus luteus and fungal strains *Aspergillus niger* and *Trichoderma sp* were obtained as stock cultures from the Department of Botany, The Open University of Sri Lanka.Streaking of bacterial cultures was done and pure cultures were obtained from single colony isolation and were stored in Nutrient agar (NA) while pure cultures of fungi were obtained from a single spore isolate obtained from a spread plate. These were stored in Potato Dextrose Agar (PDA) and were stored at 4°C until further use (Kuete *et al.* 2011). Sub culturing of bacteria and fungi was done at two weeks intervals.

Antimicrobial Assay

Agar disc diffusion test was adopted to test the antimicrobial activity of extracts as described by Hasan *et al.* (2009). Stock solutions of extracts were prepared in 30 mg/ml concentration by dissolving dried plant extract in its respective extraction solvent. 3 mg/ml stock solutions of antibacterial antibiotic tetracycline and antifungal antibiotic ketoconazole were prepared using sterile distilled water and served as positive controls.

Sterile discs (Whatman grade 1 filter paper, each 6mm diameter discs) were separately loaded with 50 µl of plant extracts, positive control (Antibiotics Tetracycline against bacteria and Ketoconazole against fungi) and extraction solvents which served as negative control (95% Ethanol, 99% dichloromethane and 99% hexane). All discs treated as above were left to dry overnight under sterile conditions and then placed in spread plates prepared from bacterial cell or fungal spore suspensions.

Bacterial cell suspensions were prepared from 24 hour cultures of bacteria by diluting a small amount of inocula in sterile distilled water. Turbidity was compared to match the 0.5 Mcfarland standard (approximately 1.5×10^8 cfu/ml) ensuring that the cell concentration of the microbial suspension used to prepare each spread plate would be approximately 1.5×10^8 cfu/ml (Tiga, 2011).

Fungal spore suspensions were prepared by flooding 7 day old fungal culture plates with sterile distilled water dislodging the spores with a sterile glass rod and filtering through muslin cloth. Total number of fungal spores in the suspension was counted using a

haemocytometer (NEUBAUER improved HBG) and was adjusted to 1 x 10^6 spores/ml by diluting the suspension (Rana *et al.* 2011).

Preparation of Culture Plates

NA and PDA were used to culture bacteria and fungi respectively. Spread plates of the microorganisms were prepared using 100 µl of microbial suspension prepared as indicated above. Discs treated as described above were transferred to the agar plates after the microbial suspension had been absorbed onto the agar. Plates were incubated at 37°C, 24 h and 25°C, 72 h for bacteria and fungi respectively. After the incubation period, radii of the clear zones were measured as described by Hasan *et al.* (2009). The Bio assay was repeated three times and mean values were obtained.

Determination of MIC

MIC was determined using the serial agar dilution method (Hasan *et al.* 2009). The extracts which showed good activity in the antimicrobial assay were selected to determine the MIC. Serial dilutions (0.5, 1, 2 and 3 mg/ml) of each selected extract were prepared using sterile distilled water. Appropriate amounts of Nutrient broth (5 ml) and selected 24 hours old standardized bacterial suspensions (10 µl) were added to each of the extract dilutions and the whole set up was incubated at 37°C, 24 h. The tube with the lowest concentration which showed no visible growth was considered as the MIC for that particular microbe.

Statistical Analysis

Results of the bio assay were represented as mean ± SD of three replicates in each test. An analysis of variance (Two – way ANOVA) with type III sums of squares was performed using SPSS 20 software at 95% confidence interval.

Phytochemical Screening

Presence or absence of selected phytochemicals: phytosterols, anthraquinones, terpenoids, phenols, glycosides, flavanoids, diterpenes, tannins and alkaloids in each extract was determined by performing qualitative chemical tests as described by Tiwari *et al.* (2011), Shilpakar *et al.* (2011) and Sasidharan *et al.* (2011).

Results

Extraction Efficiency (on Dry Weight Basis)

Extraction efficiency was higher in leaf extracts compared to the bark extracts except the hexane extract of *A.heteophyllus* in which bark extraction efficiency was higher than that of the leaf. Highest extraction efficiency of 22.88% was obtained in ethanolic leaf extract of *A.heterophyllus* whereas least extraction efficiency of 0.84% was obtained in ethanolic bark extract of *A.altilis* (Table 1).

Table 1. *Percentage (%) Extraction efficiency of A.heterophyllus and A.altilis leaf and stem bark by different extraction solvents (on dry weight basis)*

	95% Ethanol	**99% Dichloromethane**	**99% Hexane**
A.*heterophyllus*			
Leaf	22.88	12.17	5.29
Bark	5.17	3.98	9.54
A.altilis			
Leaf	7.98	8.89	18.62
Bark	0.84	8.30	15.04

Antimicrobial Assay

Highest inhibition zone radius of 9.50 ± 0.44 mm was found in the ethanol extract of *A.heterophyllus* bark against *E.coli* followed by the ethanolic extract of *A.altilis* bark (7.49 ± 0.28 mm) against *E.coli*. Dichloromethane extracts showed moderate activity against test bacteria, the exception being the dichloromethane leaf extract of *A.heterophyllus* against *M.luteus* where no inhibition was noted. None of the hexane extracts of both trees showed any activity against tested bacteria. Tetracycline was generally more effective (except ethanolic extract of *A. altilis* bark against *E. coli*) against both *E.coli* and *M.luteus* than the plant extracts even at $1/10^{th}$ concentration (Table 2).

Table 2. *Mean inhibition zone radius ± SD in mm of A.heterophyllus and A.altilis leaf and stem bark extracts against E.coli and M.luteus*

Treatment		*E.coli*			*M.luteus*		
		95% ETOH	**99% DM**	**99% HEX**	**95% ETOH**	**99% DM**	**99% HEX**
A.heterophyllus (Each disc was loaded with 50 µl of 30 mg/ml concentrated extract)	**Leaf**	0.00	3.89 ± 0.20	0.00	0.00	0.00	0.00
	Bark	9.50 ± 0.44	4.33 ± 0.29	0.00	0.00	3.00 ± 0.34	0.00
A.altilis (Each disc was loaded with 50 µl of 30 mg/ml concentrated extract)	**Leaf**	0.00	3.33 ± 0.33	0.00	4.16 ± 0.16	4.49 ± 0.28	0.00
	Bark	7.49 ± 0.28	5.66 ± 0.16	0.00	5.44 ± 0.53	4.16 ± 0.16	0.00
Solvent (50 µl) (Negative control)		0.00	0.00	0.00	0.00	0.00	0.00
Tetracycline (3 mg/ml, 50 µl) (Positive control)		6.78 ± 0.25	7.00 ± 0.00	6.95 ± 0.21	6.72 ± 0.35	6.89 ± 0.10	6.72 ± 0.26

ETOH = Ethanol, DM = Dichloromethane, HEX = Hexane, SD = Standard deviation

None of the extracts of *A.heterophyllus* and *A.altilis* showed any antifungal activity against *A.niger* or *Trichoderma* sp. Antifungal antibiotic ketoconazole was effective against both of the fungi, while negative control solvents did not inhibit fungi.

Minimum Inhibitory Concentration (MIC)

The four extracts which showed the highest inhibition zone radius in the disc diffusion test were selected for the MIC determination test. Ethanolic bark extracts of *A.heterophyllus* and *A.altilis* inhibited *E.coli* in all concentrations tested. Dichloromethane bark extract of *A.altilis* inhibited *E.coli* in 2 mg/ml and 3 mg/ml concentrations.

Ethanolic bark extract of *A.altilis* inhibited *M.luteus* in all concentrations except 0.5 mg/ml (Table 3).

Table 3. *Presence or absence of visible microbial growth in treatment tubes as an indication of the MIC of selected extracts*

Concentrations Extracts	**0.5 mg/ml**	**1 mg/ml**	**2 mg/ml**	**3 mg/ml**
Ethanol – *A.heterophyllus* bark against *E.coli*	**----**	-	-	-
Ethanol – *A.altils* bark against *E.coli*	**----**	-	-	-
Dichloromethane – *A.altils* bark against *E.coli*	+	+	**----**	-
Ethanol – *A.altils* bark against *M.luteus*	+	**----**	-	-
Positive control – Tetracycline	----	-	-	-

(-) – Growth absent, (+) – Growth present, (**----**) – Growth absent
(Minimum inhibitory concentration of particular extract according to tested concentrations in present study)

Phytochemical Analysis

All the extracts of *A.heterophyllus* showed the presence of phytosterols and terpenoids. Anthraquinone was present in all the bark extracts. Flavonoids were present only in ethanolic extracts of leaves and bark. Phenols and glycosides were present only in ethanolic leaf extract and ethanol and dichloromethane extracts of bark. Diterpenes were present only in ethanolic leaf extract while tannins and alkaloids were absent in all the extracts of *A.heterophyllus* (Table 4).

In *A.altilis* all the bark extracts and ethanolic leaf extract showed the presence of phytosterols. Anthraquinone was present in all the leaf extracts and absent in bark extracts. Terpenoids were present in hexane extracts of leaves and bark and dichloromethane extract of leaf. Phenols were present only in ethanol and dichloromethane extracts of leaves. Flavonoids and diterpenes were present only in ethanolic extracts of leaves and bark. Glycosides were present in

ethanolic leaf and bark extract and dichloromethane leaf extract. Tannins and alkaloids were absent in all the extracts (Table 4).

Table 4. *Phytochemical screening of A.heterophyllus* and *A.altilis leaves and stem bark extracted using different solvents*

Treatment / **Phytochemicals**	**Leaves**						**Barks**					
	95% ETOH		**99% DM**		**99% HEX**		**95% ETOH**		**99% DM**		**99% HEX**	
	A.h	A.a	A.h	A.a	A.h	A.a	A.h	A.a	A.h	A.a	A.h	A.a
Phytosterols	+	+	+	-	+	-	+	+	+	+	+	+
Anthraquinone	-	+	-	+	-	+	+	-	+	-	+	-
Terpenoids	+	-	+	+	+	+	+	-	+	-	+	+
Phenols	+	+	-	+	-	-	+	-	+	-	-	-
Glycosides	+	+	-	+	-	-	+	+	+	-	-	-
Flavonoids	+	+	-	-	-	-	+	+	-	-	-	-
Diterpenes	+	+	-	-	-	-	-	+	-	-	-	-
Tannins	-	-	-	-	-	-	-	-	-	-	-	-
Alkaloids	-	-	-	-	-	-	-	-	-	-	-	-

A.h – *A.heterophylus*, A.a – *A.altilis*, (+) – Present, (-) – Absent, ETOH – Ethanol, DM – Dichloromethane, HEX – Hexane

Discussion

Extraction efficiency was high in leaf extracts compared to bark extracts except in *A.heterophyllus* hexane extracts, in which the extraction efficiency of bark was 9.54% and leaf was only 5.29% (Table 1). Leaves are thinner and less complex than the bark. Therefore, compared to bark extraction, solvents could penetrate more easily and dissolve more of the phytochemicals in leaves. The highest extraction efficiency was found in the ethanolic extract of *A.heterophyllus* leaf (22.88%) (Table 1). Franco *et al.* (2008) report that ethanol is preferred by many researchers since it poses less toxicity and higher extraction yield. Rahmoun *et al.* (2014) state that extraction yield increases with the increasing polarity of the solvent which is in agreement with the present results.

Although investigations on antimicrobial activity of *A.heterophyllus* and *A.altilis* aqueous extracts were carried out by Binumol & Sajitha (2013), Mbaeyi Nwaoha & Onwuka, (2014), Raman *et al.* (2012) and Satish et al. (2008), none of the reports recommended the use of water as an extraction solvent as little or no antimicrobial activity was seen in any of the investigations. Since the literature available up to date reiterate about very little or no antimicrobial activity of aqueous extracts of both the plants, using distilled water as an extraction solvent and thereby investigating the antimicrobial potential of aqueous extracts were omitted in the present study even though working with the aqueous extracts is less expensive and more environmentally friendly than the use of other extraction solvents.

Both *A.heterophyllus* and *A.alilis* bark showed significant antimicrobial activity against the gram negative bacterium tested. Ethanolic bark extracts of *A.heterophyllus* (9.50 ± 0.44 mm) and *A.altilis* (7.49 ± 0.28 mm) strongly exerted significant antimicrobial activity against *E.coli* which is a gram negative bacterium. But ethanolic leaf extracts of both plants failed to inhibit *E.coli* (Table 2). Similar finding related to bark extract has been reported by Kuete *et al.* (2011) and Binumol & Sajitha (2013), in which methanolic extract of *Artocarpus communis* (now known as *A.altilis*) stem bark and some isolated compounds (Terpenoids and Flavonoids) were effective against *E.coli* and methanolic bark extracts of both plants were effective against *P.fluorescens* (gram negative) *and B.subtilis* (gram positive) respectively. Efficient extraction by high polar ethanol and presence of bio active phytochemicals in the stem bark being stated as the reasons for this notable higher antimicrobial activity.

Contrary to the present findings, Raman *et al.* (2012), Mbaeyi Nwaoha & Onwuka, (2014) and Binumol & Sajitha (2013) reported the antimicrobial activity of *A.heterophyllus* and *A.altilis* methanolic and ethanolic leaf extracts against certain gram positive and gram negative bacteria including *E.coli*. This difference between literature and the present study regardless of the phytochemistry of leaf extracts, may be due to the result of inadequate usage of extracts in the bioassay (≈ 1.5 mg/disc).

Among all the extracts tested, only the dichloromethane bark extract of *A.heterophyllus* was effective against *M.luteus*. However in *A.altilis*, ethanol and dichloromethane leaf and bark extracts showed considerable activity against *M.luteus* (Table 2). Similar findings have been reported by Raman *et al.* (2012). All the dichloromethane

extracts except *A.heterophyllus* leaf extract have inhibited *E.coli* and *M.luteus* at a considerable level (Table 2). Omar *et al.*, 2013 reported that stigmasterol isolated from the dichloromethane twig extract of *A.altilis* was effective against *S.aureus*. Leaf extracts of *A.altilis* obtained using some other medium polar solvents such as chloroform and ethyl acetate have also shown good antimicrobial activity against bacteria including *E.coli* and *M.luteus* (Mohanty & Pradhan, 2014; Raman *et al.* 2012). As such it seems probable that the medium polar solvents effectively extract bioactive phyto-chemicals.

All the n-hexane extracts (≈ 1.5 mg/disc) of both of the plants did not show any antimicrobial activity against *E.coli* or *M.luteus* (Table 2). Results indicate that, hexane is significantly ineffective compared to the other medium and high polar extraction solvents in extracting bioactive compounds. It appears that hexane failed to extract bioactive phytochemicals although hexane showed good extraction efficiency (Table 1). However, one report by Mbaeyi Nwaoha & Onwuka (2014) state that n hexane extract of *A.altilis* leaf inhibited *E.coli* and further Omar *et al.* (2013) stated cycloartenyl acetate isolated from hexane twig extract of *A.altilis* inhibited *S.aureus*. So it is possible that higher concentrations of crude hexane extracts could inhibit bacteria.

None of the extracts showed antifungal activity against *A.niger* and *Trichoderma* sp at the concentrations tested in the present study. Mbaeyi Nwaoha & Onwuka (2014) reported that ethanolic leaf extract of *A.altilis* inhibited *A.niger* at 6 mg/ml MIC while n hexane inhibited at 8 mg/ml MIC. Kuete *et al.* (2011) and Raman *et al.* (2012) found that methanolic and ethanolic leaf extracts of *A.altilis* were effective against *Candida* sp *and Mucor* sp. The reason behind the absence of antifungal activity may be due to inefficient extraction of antifungal phytochemicals or inadequate dosage of the extracts. Since all the replicates showed no antifungal activity and only one publication (Mbaeyi Nwaoha & Onwuka (2014) states antifungal activity of *A.altilis* leaves at higher dosage (MIC of ethanolic extract was 5 mg/ml and MIC of n hexane extract was 8 mg/ml against *A,niger*), it is not possible to conclude on the antifungal activity of *A.heterophyllus* and *A.altilis*.

Antibiotics tetracycline and ketoconazole (≈ 0.15 mg/ disc) were more effective than any of the tested plant extracts against bacteria and fungi respectively. Use of an equal amount of antibiotics as plant extracts resulted in very large zones of inhibition in the very first trial of this present study. As the main objective of this study

was to investigate and compare the antimicrobial activity of *A.heterophyllus* and *A.altilis* trees, the concentration of antibiotics was reduced to $1/10^{th}$ of the concentration of plant extracts and considered only as a positive control. This reduction in concentration further provided the plant extracts sufficient space to show their inhibitory effect.

Kuete *et al*. (2011) reported that the phytochemicals are classified as antimicrobials on the basis of MIC in the range of 100-1000 mg/ml. According to Rios & Recio (2005) quantities lower than 1 mg/ml for extracts and quantities lower than 0.1 mg/ml for isolated compounds are considered noteworthy. In the present study ethanolic bark extracts of *A.heterophyllus* and *A.altilis* inhibited *E.coli* at MIC 0.5 mg/ml (Table 4). Kuete *et al*. (2011) reported that the lowest MIC of methanolic bark extract of *A.communis* against *E.coli* was 64 µg/ml.

According to Mbaeyi Nwaoha & Onwuka (2014) ethanolic leaf extract of *A.altilis* showed inhibition of *E.coli* and *A.niger* at MIC 6 mg/ml. This further supports the statement that, stem barks of *A.heterophyllus* and *A.altilis* (MIC at 0.5-1 mg/ml, Table 3) are more effective than leaves.

Previous reports on phytochemical screening of *A.heterophyllus* leaf showed the presence of flavanoids, terpenoids, steroids, phenols, glycosides and saponins while stem bark showed all the above stated phytochemicals and in addition alkaloids and tannins. Meanwhile *A.altilis* leaves showed the presence of alkaloids, flavanoids, glycosides, steroids, saponins, tannins, and stem barks showed the presence of flavanoids, glycosides, terpenoids, tannins, steroids and anthraquinones (Binumol & Sajitha, 2013; Kute *et al*. 2011; Mbaeyi Nwaoha & Onwuka, 2014; Raaman *et al*. 2014; Raman *et al*. 2012).

When comparing the plants *A.heterophyllus* and *A.altilis*, all the tested phytochemicals were present in both of the plants. But interestingly anthraquinones were present only in *A.heterophyllus* bark but in *A.altilis* those were present only in the leaves. Further, the present results are in agreement with the findings of Mohanty & Pradhan (2014) and Amponsah *et al*. (2014) hence proves the phytochemical diversity of secondary metabolites in both of the tested plants.

Although the presence of tannins and alkaloids have been reported in both of the plants (Amponsah *et al*. 2014; Binumol & Sajitha, 2013; Elevitch & Manner, 2006; Mbaeyi Nwaoha & Onwuka, 2014;

Mohanty & Pradhan, 2013; Raman *et al.* 2012) tests for tannin and alkaloids gave negative results in all the extracts in the present study (Table 4).

Conclusion

Results of the present in vitro antimicrobial assay and MIC test revealed the antibacterial potentiality of stem barks of *A.heterophyllus* and *A.altilis* which reiterate the broad spectrum of antibacterial activity of both of the plant extracts against gram negative and gram positive bacteria. The most effective of the extraction solvents proved to be ethanol, followed by dichloromethane, and hexane was found to be the least effective of the tested solvents. The antimicrobial activity of extracts was further supported by the presence of phenols, terpenoids, flavonoids, anthraquinone, phytosterols, glycosides and diterpenes in the extracts which are known to possess antimicrobial properties. Therefore, the present investigation draws attention to the phytochemistry and the antimicrobial properties of both *A.heterophyllus* and *A.altilis* by providing supportive data to indicate that the isolation, characterization and ethnomedicinal in vivo investigations of phytochemicals from *A.heterophylus* and *A.altilis* could act as a platform to formulate promising antimicrobials against pathogens.

References

Amponsah, I. K., Annan, K., Koffuor, G. A., Sarkodie, J. A., Umerie, I. J., & Osei wusu, S. (2014). Anti-inflammatory and antioxidant properties of the ethanolic stem bark extract of *Artocarpus altilis* (Parkinson) Fosberg (Moraceae). Der Pharmacia Lettre, 6(3), 211-217.

Arguedas, T. B., & Coley, P. D. (2005). Phenotypic variation and spatial structure of secondary chemistry in a natural population of a tropical tree species. OIKOS, 108, 410-420.

Binumol, M. & Sajitha, T. (2013). Phytochemical and antibacterial activity of *Artocarpus heterophyllus* Lam. and *Artocarpus communis* Forst. on *Bacillus subtilis* and *Pseudomonas fluorescens*. International Journal of Scientific & Engineering Research, 4, 1766-1784.

Deivanai, S., & Bhore, S. J. (2010). Bread fruit (*Artocarpus altilis* Fosb.) – An underutilized and neglected fruit plant species. Middle East journal of Scientific research, 6(5), 418-428.

Elevitch, C. R. & Manner, H. I. (2006). *Artocarpus heterophyllus (Jackfruit).* Retrieved from https://retirenicaragua.files.wordpress.com/2012/05/a-heterophyllus-jackfruit1.pdf (Accessed 26 on Nov.2014).

Fernando, S. (2003). Herbal food and medicines in Sri Lanka. New Delhi. (Original work published in 1982).

Franco, D., Sineiro, J., Rubilar, M., Sanchez, M., Jerez, M., Pinel, M., Nunez, M. J. (2008). Polyphenols from plant materials: extraction and antioxidant power. Electronic journal of environmental, agricultural and food Chemistry, 7(8), 3210-3216.

Hasan, M. F., Das, R., Khan, A., Hossain, M. S., & Rahman, M. (2009). The Determination of Antibacterial and Antifungal Activities of *Polygonum hydropiper* (L.) Root Extract. Advances in Biological Research, 3, 53-56.

Jitendra, R., Kalpana, S., Shweta, S., Kumar, M. S., & Manish, B. (2014). *Artocarpus heterophyllus* (jackfruit) potential unexplored in dentistry- an overview. Universal journal of Pharmacy, 3(1), 50-55.

Joshual, M. & Takudzwa, M. (2013). Antibacterial properties of *Mangifera indica* on *Staphylococcus aureus*. African journal of clinical and experimental microbiology, 14, 62-74.

Karthy, E. S., Ranjitha, P., Mohankumar, A. (2009). Antimicrobial potential of plant seed extracts against multidrug resistant methicillin resistant *Staphylococcus aureus* (MDR-MRSA). International Journal of Biology, 1, 34-40.

Kuete, V., Ango, P. Y., Fotso, G. W., Kapche, G. D. W. F., Dzoyem, J. P., Wouking, & Abeghas, B. M. (2011). Antimicrobial activities of the methanolic extract and compounds from *Artocarpus communis* (Moraceae). BMC Complementary and Alternative Medicine, 11, 1-5.

Kumaraswamy, M. V., Kavitha, H. U., & Satish, S. (2008). antibacterial evaluation and phytochemical analysis of *Betula*

utilis D. Don against some human pathogenic bacteria. World Journal of Agricultural Sciences, 4(5), 661-664.

Nwaoha, I. E. M., & Onwuka, C. P. (2014). Comparative evaluation of antimicrobial properties and phytochemical composition of *A.altilis* leaves using ethanol, n hexane and water. African journal of Microbiology research, 8(37), 3409-3421.

Mohanty, M. & Pradhan, C. (2014). Phytoconstituent analysis and comparative bioefficacy assessment of breadfruit fruit and leaf extracts for antipathogenic potentiality. American journal of phytomedicine and clinical therapeutics, 2(1), 77-87.

Omar, M. N., Muzammil, A., Khan, N. T., Zahid, M. & Kamal, T. (2013). Isolation and identification of bioactive compounds from twigs of *Artocarpus altilis*. Merit Research Journal of Environmental Science and Toxicology, 1, 147-155.

Pethiyagoda, R. (2005). Exploring Sri Lanka's biodiversity. The raffles bulletin of Zoology, 12, 1-4.

Rahmoun, N. M., Ziane, H. & Boucherit Otmani, Z. (2014). Antibacterial and antifungal screening of four medicinal plants. Journal of Coastal Life Medicine, 2(12), 975-979.

Raaman, N., Sivaraj, C. & Tenzing. (2014). Antioxidant activites and phytochemical analysis of methanol extract of leaves of *Artocarpus heterophyllus* Lam. International Journal of Pharmacy and Pharmaceutical Sciences, 6, 289-293.

Raman, V., Sudhahar, D. & Anandarajagopal, K. (2012). Preliminary phytochemical investigation and screening of antimicrobial activity of leaf extracts of *Artocarpus altilis*. Asian journal of Biological and Life Sciences, 1(2), 104-107.

Rana, I. S., Rana, A. S. & Rajak, R. C. (2011). Evaluation of antifungal activity in essential oil of the *Syzygium aromaticum* (L.) by extraction, purification and analysis of its main component eugenol. Brazilian Journal of Microbiology, 42, 1269-1277.

Rios, J. L. & Recio, M. C. (2005). Medicinal plants and antimicrobial activity. Journal of Ethnopharmacology, 100, 80–84.

Sasidharan, S., Chen, Y., Saravanan, D., Sundram, K. M. & Yoga Latha, L. (2011). Extraction, isolation and characterization of bioactive compounds from plants' extracts. African Journal of Traditional, Complementary and Alternative medicines, 8, 1.

Satish, S., Raghavendra, M. P. & Raveesha, K. A. (2008). Evaluation of the antimicrobial potential of some plants against human pathogenic bacteria. Advances in Biological Research, 2, 44.

Shilpakar, A., Gaire, B. P., Sunar, C. B., Lamichhane, R. & Neupane, S. (2009). Phytochemical screening and analysis of antibacterial and antioxidant activity of *Ficus auriculata*, Lour. stem bark. (Bachelor's thesis). Retrieved from http://www.researchgate.net/profile/Bhakta_Gaire/publication/221677460Phytochemical_screening_and_analysis_of_antibacterial_and_antioxidant_activity_of_Ficus_auriculata_%28Lour.%29_Stem_Bark/links/0922b4f5ed8b5bf060000000 Accessed on 25 Nov. 2014).

Sikarwar, S. M., Hui, B, J., Subramaniam, K., Valeisamy, B., Yean, L. K. & Balaji, K. (2014). A Review on *Artocarpus altilis* (Parkinson) Fosberg (breadfruit). Journal of Applied Pharmaceutical Science, 4 (08), 091-097.

Thirumurugan, A., Tomy, N. A., Jai ganesh, R. & Gobikrishnan, S. (2010). Biological reduction of silver nanoparticles using plant leaf extracts and its effect on increased antimicrobial activity against clinically isolated organism. Der Pharma Chemica, *2*, 279-284.

Tiga, S. (2011). Characterization and identification of some medically important bacterial isolates. (Master's dissertation). Retrieved, http://ethesis.nitrkl.ac.in/2435/1/Suman_Thesis_final.pdf. (Accessed on 12 Nov. 2014).

Tiwari, P., Kumar, B., Kaur, M., Kaur, G. & Kaur, H. (2011). Phytochemical screening and Extraction: A Review. International Pharmaceutica Sciencia, 1, 98-106.

World health organization. (2012). The evolving threat of antimicrobial resistance options for action. Retrieved from http://whqlibdoc.who.int/publications/2012/9789241503181_eng.pdf (Accessed 29 on Nov.2014).

Received: 30-4-2015 Revised: 6-8-2015 Accepted: 7-9-2015

OUSL Journal (2015)
Vol. 9, (pp. 19-40)

Future Impact of Current Toll-Gates on the Capacity of the Southern Expressway

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Abstract

The Southern Expressway plays a vital role in national road network in Sri Lanka. Vehicles on Expressways can travel at uniform speeds throughout their journey offering advantages on fuel consumption and reduced travel time. The expressways ensure a hassle free safe journey due to the minimum obstructions to the traffic.

At present, all the interchanges along the Southern Expressway operate with manually operated toll gates. The efficiency of current toll gates was studied for the existing exit ramp lengths and it investigated whether their current efficiencies are sufficient for higher vehicle volume of the future traffic. To investigate the current toll gate efficiency on the capacity of 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 of the Southern Expressway. 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 were found. Simultaneously the analysis was carried-out for a different number of gates.

Finally, maximum queue lengths and longest individual delays were compared with existing ramp lengths, and shortcomings were identified. By using suitable growth rates for the Southern

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Expressway, future traffic conditions were predicted. Subsequently, by using the maximum vehicular queue lengths, individual delays that could occur in the future were computed. Hence, these values were used to analyze the effect of the capacity of Southern Expressway due to the present toll gate arrangement. Therefore, it was able to recommend suitable off ramp lengths considering queue lengths and deceleration lengths. Recommendations were also proposed for future improvements to the service rates at toll gates.

Keywords: Southern Expressway, Service time, Service rate, Toll gates, Maximum queue length, Exit ramp length

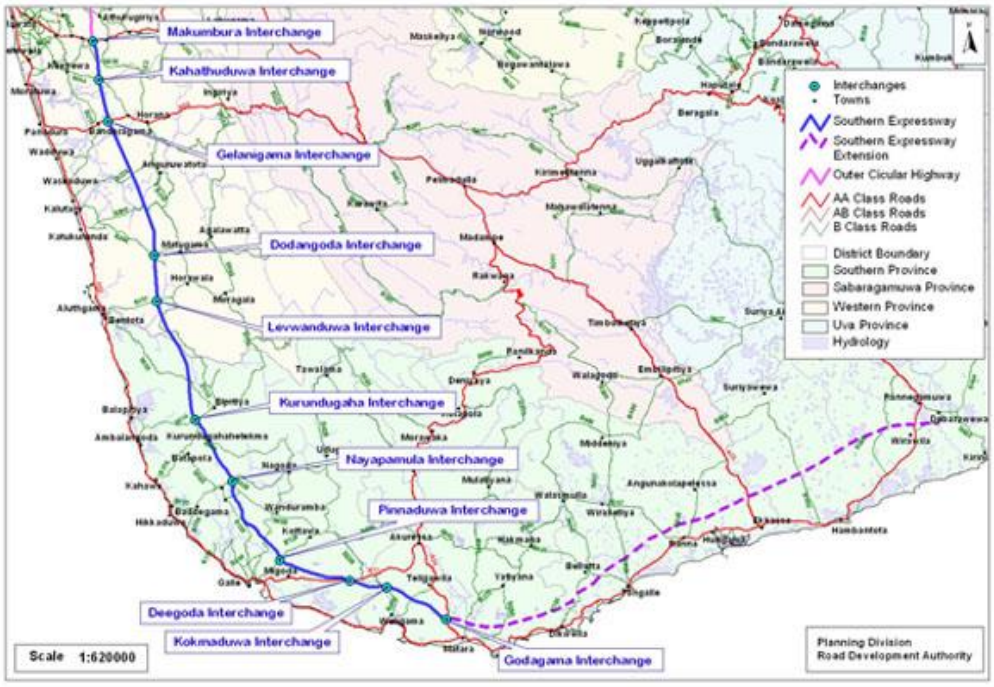
Introduction

The Southern Expressway is the first expressway to be built in Sri Lanka and it is an important link of the proposed expressway network. It traverses from Kottawa to Matara (126 km) and the construction of the section from Kottawa to Pinnaduwa (Galle) was completed and operates as a dual carriageway expressway with 4-lane facility when the study was conducted in 2013. Expressways have many advantages such as; reduced travel time, reduced traffic congestion, reduced transport delay costs, reduced fuel costs, attract private sector investors and thereby contribute to expand the job market and develop fisheries, agriculture, industries in the region, expand tourism presently confined to the coastal belt along Colombo-Galle-Matara, and enhance the value of land and property.

In the Southern Expressway (between Kottawa and Galle) there are eight interchanges namely; Kottawa (Makumbura), Kahathuduwa, Gelanigama, Dodangoda, Welipanna, Kurundugahahatakma, Baddegama, and Pinnaduwa (Galle).

Problem Identification

With the increase in traffic in the future, the possible formation of traffic queues at entry or exit points during congested periods can cause a considerable time delay and may result in the reduction of highway performance. Southern Expressway has shortened the journey time from Galle to Colombo to one hour. At present, since manually operated toll gates are installed and with increased traffic, it is intended to observe whether their efficiency is adequate to handle higher vehicle volumes.



(Source: www:rda:gov:lk/supported/expressways/stdp:htlm)

Figure 1. Southern Expressway

At present, the traffic at the toll booths is not very heavy, but in future, with the increase of vehicles, the traffic at the booths could be a problem. Traffic delay in a toll plaza is caused by time taken due to the manual operated method adopted in paying user fee. Hence the long queues that could occur at exit ramps may cause safety threat to the vehicles travelling along the expressway if vehicles at toll booths heads-up along the exit ramps and enter the expressway. Therefore, in here, it studies the present toll gates operation and observes whether it could cope with future traffic needs at a meaningful level of service and investigates whether the capacity is adequate to meet this demand.

Aim of the Study

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 Southern Expressway. It consists of investigating the present condition in interchanges, and to develop recommendations for future implementation (including traffic engineering, geometric consideration and benefit evaluations). 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 a reduction in the capacity of the expressway.

Strategies

To achieve the aims of this project, 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 interchanges.
- Existing procedure of paying of user fee in toll gates and the toll gate operation was studied.
- Peak day/peak hour was identified for each interchange.
- The critical exit ramps of the expressway by considering exit ramp distances and traffic volume, were identified.
- 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, the effects of the capacity of Southern Expressway due to present toll gates in interchanges, were analyzed.
- Suitable off ramp lengths considering queue length and deceleration lengths were recommended and future improvements to the service rates at toll gates are suggested.

Methodology

Graph of Time *vs* Cumulative Vehicle at Ramp

Figure 2 illustrates the curve of Time vs. Cumulative Number of Vehicle and how it effects with service rate. The two curves shown in the Figure 2 is related arrival and service rates (Mannering and Washburn, 2004).

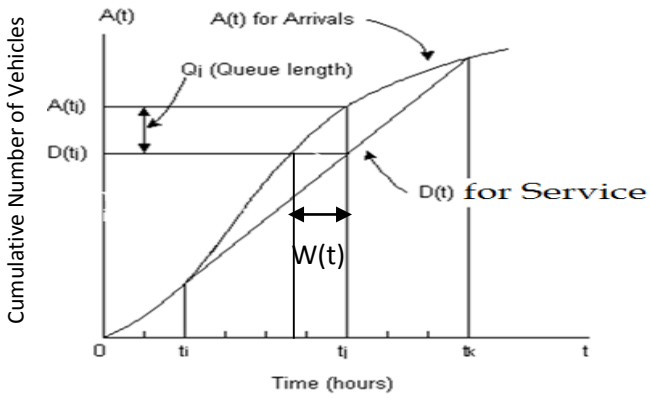


Figure 2. Graph of Cumulative Number of Vehicle vs. Time

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 entry of the vehicle into the toll booth until the exit of the vehicle from the toll booth.

Service rate - The number of vehicles serves in unit time

Field Data

The Southern Expressway consists of eight interchanges between Kottawa and Pinnaduwa including the two at the ends. They are of the following types:

Kottawa (Makumbura)	Grade separated
Kahathuduwa	Diamond (conventional)
Gelanigama	Partial cloverleaf
Dodangoda	Diamond (conventional)
Welipanna	Diamond (conventional)
Kurundugahahatakma	Partial cloverleaf (modified)
Baddegama	Diamond (conventional)
Pinnaduwa (Galle)	Mixed diamond- cloverleaf

(Source: RDA, www.rda.gov.lk/supported/expressways/stdp.htlm)

Adopted Procedure in Paying 'User Fee'

When a driver enters the expressway, a ticket is issued to him/her at the entry toll gate of the interchange. The ticket displays the type of the vehicle (vehicle category), date, time and name of the interchange which the vehicle entered. Driver has to handover the ticket to the exit toll gate, and he/she will be informed of the user fee. A receipt will be issued for the payment of the user fee.

Due to the manual transaction, the operator has to monitor the entrance ticket details. Also, the user takes time to pay for the usage. Therefore, it takes time at exit toll gates compared with other advanced tolling methods. It was especially experienced when paying of fines for over speeding or any other negligence of road rules, causing further delay at exit gates.

Present Condition of Entry and Exit Gates

It is not the same number of entry and exit gates that have been constructed in each interchange for the two directions. At present, only a few gates are operating due to lack of traffic. The gate details and exit ramp lengths are tabulated in Table 1.

Table 1. Number of entry and exit gates and exit ramp lengths of interchanges

Interchange	Number of toll gates (total in both direction)				Exit Ramp	Exit Ramp length (m)
	Constructed		Currently operating			
	Entry	Exit	Entry	Exit		
Kottawa (Makumbura)	05	08	02	03	Ramp 1 – From Galle	197
Kahathuduwa	04	04	02	02	Ramp 1 – From Galle	106
					Ramp 2 - From Colombo	96
Gelanigama	04	04	02	02	Ramp 1 – From Galle	181
					Ramp 2 - From Colombo	187
Dodangoda	04	04	02	02	Ramp 1 – From Galle	93
					Ramp 2 - From Colombo	134
Welipanna	04	04	02	02	Ramp 1 – From Galle	73
					Ramp 2 - From Colombo	69
Kurundugaha hatakma	04	04	02	02	Ramp 1 – From Galle	45
					Ramp 2 - From Colombo	134
Baddegama	04	04	02	02	Ramp 1 – From Galle	154
					Ramp 2 - From Colombo	90
Pinnaduwa (Galle)	02	02	01	02	Ramp 1 – From Galle	378

(Source: Expressway Operation Maintenance and Management Division - RDA)

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 seventeen exit ramps between Kottawa and Pinnaduwa, critical exit ramps were identified using 'weight factor' as described below.

Method adopted for computation of 'weight factor' is based on ramp length, and peak hour volume. By observing traffic data during a

period of one week, peak hour volumes for each interchange were identified. Then weight factor is obtained by dividing the peak hour volume of each exit ramp by the measured ramp length. The number of toll gates was considered when queue length exceeded the off ramp length.

$$\text{Weight factor} = \frac{\text{Peak hour volume (veh/hr)}}{\text{Ramp length (m)}}$$

Table 2. 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 2, seven critical exit ramps were selected to conduct the detailed surveys. Exit ramps consisting 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 (see Table 2).

Selection of field survey days (as per data collected from RDA)

Prior to conducting traffic survey at the interchanges, probable peak days and peak hours for exit ramps were identified according to collected data from Expressway Operation Management and

Maintenance division of RDA. These traffic survey days and time periods are as shown in Table 3.

Table 3. The peak hour ranges for each critical exit ramps

Interchange	Day	Date	Time period (hrs)
Kottawa	Monday (Poya day)	25.03.2013-26.03.2013	16:00-06:00
Kahathuduwa	Sunday	07.04.2013	17:00-21:00
Galenigama	Sunday	21.04.2013	16:00-19:00
Dodangoda	Sunday	21.04.2013	11:00-17:00
Welipanna	Sunday	28.04.2013	11:00-17:00
Kurundugahahetakma	Sunday	28.04.2013	13:00-17:00
Pinnaduwa	Saturday	04.05.2013	09:00-17:00

Present Condition of Toll Gates Considering Average Service Time

Separate surveys were conducted for each and every gate operating in critical exit ramps. The survey durations are as indicated in Table 3. The purpose of the survey was to obtain the average service time in each toll gate according to the exit ramps.

Table 4. 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	
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**

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 was 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 4.

Average Length for Vehicle Categories

Traffic on interchanges is mixed in nature. Therefore, several categories (according to Southern Expressway Operation Maintenance and Management division) were selected to calculate queue lengths. Average lengths of vehicles are as shown in Table 5.

Table 5. Average vehicle length

Vehicle category	Description	Average length (m)
A	Car, utility vehicles, light good vehicles	4.92
B	Medium/ large buses, larger lorries/ trucks	10.9
C	3 Axels vehicle	12.5
D	More than 3 Axels vehicle	16

(*Source: Washington States Department of Transportation, 2011)*

Four wheel drive jeeps, small trucks with design on a car frame and vans come under utility vehicles and light good vehicles.

The average length of car (4.92 m) was selected for all the vehicles included in category 'A'. It was selected based on the highest composition according to field survey data. The average length of a large bus (10.9 m) was selected for all the vehicles included in category 'B'. It was selected based on the highest composition according to field survey data.

Traffic Volume Data up to 2080 Using Trend Curves

Trend curves were drawn up to year 2080 according to predicted vehicle growth rates for Southern Expressway from RDA. The obtained values are given in Table 6.

Table 6. Predicted vehicle growth

Interchange	Vehicle category	Predicted vehicle growth (%)													
		2017	2022	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070	2075	2080
Kottawa, Kahathuduwa, Galanigama	Car, utility vehicles, light good vehicles (A)	6.3	5.1	3.6	4.1	3.95	3.8	3.7	3.6	3.5	3.45	3.4	3.3	3.25	3.2
	M/L buses, L lorries/ trucks (B)	2.9	2.3	2.1	2.21	2.19	2.12	2.11	2.1	2.0	2.04	2.01	2	1.99	1.95
	3 Axels vehicle (C)	2.9	2.3	2.1	2.05	1.93	1.8	1.7	1.6	1.5	2.06	1.32	1.22	1.15	1.11
	More than 3 Axels vehicle (D)	6.3	6.5	3.8	4.21	3.82	3.5	3.25	2.95	2.7	2.5	2.25	2.05	1.86	1.7
Dodangoda Welipanna, Kurunduga hahatakma, Baddegama Pinnaduwa	Car, utility veh., light good veh. (A)	11.2	9.8	6.8	8.2	8.1	8	7.9	7.8	7.8	7.7	7.6	7.58	7.56	7.5
	M/L buses, L lorries/ trucks (B)	5.2	4.5	3.9	4.41	4.46	4.5	4.51	4.52	4.5	4.55	4.58	4.59	4.59	4.6
	3 Axels vehicle (C)	11.3	12.5	7.3	9	8.6	8.3	8.1	7.9	2.6	7.3	7.1	6.9	6.65	6.4
	More than 3 Axels vehicle (D)	11.3	12.5	7.3	8.9	8.6	8.3	8.1	7.8	7.6	7.4	7.1	6.9	6.7	6.45

Data Analysis

Traffic Volume Forecast of Southern Expressway

Traffic volume forecast data were used to calculate the annual traffic growth rates for vehicle categories. And the equation which was used to calculate the future traffic demand was stated below (Mannering and Kilareski, 1998).

$(\text{Peak hour volume})_{future} = (\text{Peak hour volume})_{present} \times (1+g)^n$
g = Annual growth rate
n = Number of year

Above equation and relevant annual traffic growth rates were used to calculate the peak hour volume in coming years.

Example: Sample calculation for Kottawa interchange at 2017 (*i.e.* 4 years from 2013)

$$(\text{Peak hour volume})_{2017} = (\text{Peak hour volume})_{2013} \times (1+g)^n$$
$$(\text{Peak hour volume})_{2017} = 554 \times (1+0.063)^4 = 704 \text{ veh/hr}$$

Calculated vehicle growth over the years for Kottawa interchange is tabulated below in Table 7. The same procedure was followed to calculate vehicle growth for other interchanges as well.

Table 7. Vehicle growth at Kottawa interchange over the years

Time	Cumulative Number of Vehicles														
	Pres	2017	2022	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070	2075	2080
16:00-16:05	25	32	41	45	55	66	80	96	114	135	160	189	222	260	304
16:05-16:10	51	64	82	91	111	134	160	191	228	269	318	375	440	515	602
16:10-16:15	80	101	129	143	174	211	253	303	360	427	504	595	698	818	956
16:15-16:20	119	151	192	213	260	314	377	451	537	636	752	887	1041	1220	1425
16:20-16:25	163	207	263	292	356	431	517	619	737	873	1033	1218	1430	1676	1958
16:25-16:30	215	273	348	386	470	569	684	818	974	1154	1365	1611	1892	2216	2591
16:30-16:35	263	334	425	472	575	696	836	1000	1190	1410	1669	1968	2311	2708	3166
16:35-16:40	311	395	504	559	681	824	991	1185	1411	1673	1979	2335	2743	3214	3757
16:40-16:45	371	471	601	667	813	984	1183	1415	1686	1998	2365	2791	3278	3841	4491
16:45-16:50	429	545	696	772	941	1140	1370	1640	1954	2316	2741	3235	3801	4454	5208
16:50-16:55	494	628	802	890	1085	1314	1580	1892	2254	2673	3163	3734	4387	5142	6013
16:55-17:00	554	704	900	999	1219	1476	1776	2126	2533	3005	3557	4199	4934	5783	6764
17:00-17:05	624	793	1014	1126	1373	1663	2001	2395	2854	3386	4007	4731	5559	6517	7622

In order to identify the efficiency of current toll gates for present and future conditions, the following study methodology was adopted.

- Service rate when operating a different number of toll gates. (Service rate denotes the rate at which vehicles are being served in a system. In here service rate depends on the number of toll booths and average service time.)

As indicated in Banks (2010), service rate when operating of different number of toll gates;

Service rate = [1 vehicle × 60 × No. of toll booths × Time interval for arrival rate (veh/min)] / Average service time

- According to the queuing analysis graph of time vs. cumulative number of vehicles, following terms are indicated.
  - Number of vehicle in queue
  - Individual delay time

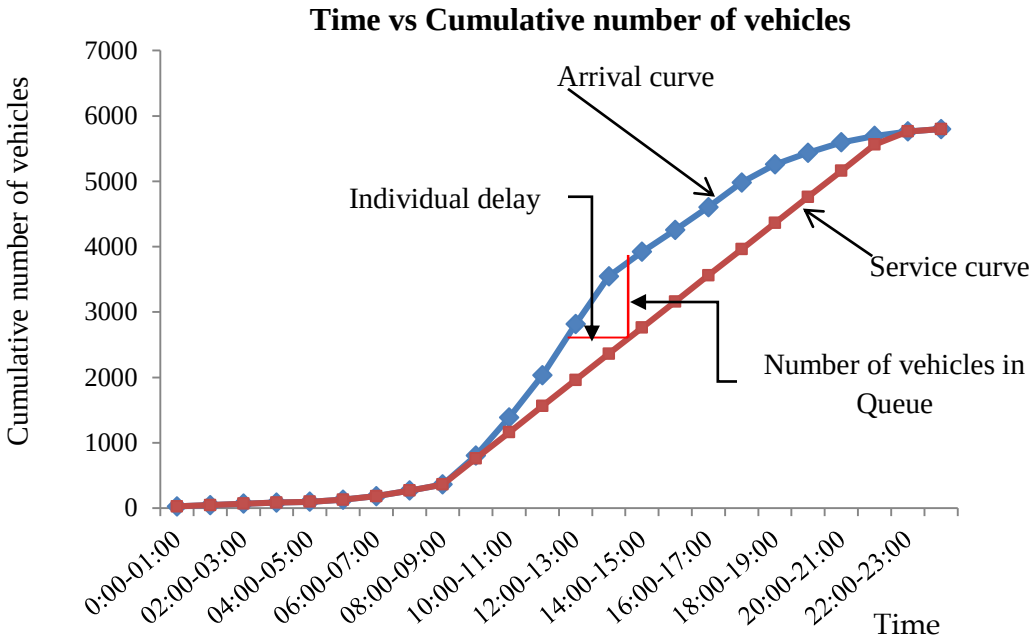


Figure 3. Graph of time vs. cumulative number of vehicles

Critical exit ramps were evaluated to see whether they could handle the present traffic flow according to the traffic survey results. Figure 3 illustrates variation of time vs. cumulative number of vehicles at Pinnaduwa. In here, these two curves represent arrival curve and service curve. Arrival curve was plotted according to the 5 minutes time interval during the peak hours at each exit ramp. Service rates were calculated for different number of toll gates when operating at exit ramps. Service curve was plotted according to the number of toll gates in operating. Vertical length between these two curves indicates

the number of vehicles in queue and horizontal difference indicates individual delay.

Service Rate, When Operating Different Number of Toll Gates for 5 Minute Arrival Rate

Service rate = [1vehicle × 60 × No. of toll booths × Time interval for arrival rate (veh/min)] / Average service time

Sample calculation for service rate when operating one toll gate only;

Service rate = [1 × 60 s × 1 × 5 s] / 18 s/veh
= 16.67 veh/5 min

Service rate increases due to the number of gates operating in exit ramps. Table 8 shows service rates for 5 minutes time duration for a different number of toll gates.

Kottawa interchange has the most number of exit gates. It has eight exit gates. It is observed that more vehicles can be served when the number of toll gates increase. When operating one gate, seventeen vehicles can be served in 5 minutes. As observed in Table 8 with the increase of number of gates, number of vehicles served in exit ramps too increases.

Table 8. Service rates

Number of toll gates	Service rate (veh / 5 min)
1	16.67
2	33.33
3	50
4	66.67
5	83.33
6	100
7	116.67
8	133.33

Analysis of Maximum Queue Length and Individual Delay Time Up to Year 2080 when Operated Different Number of Toll Gates

Sample 1 - Maximum queue length and maximum individual delay at Kottawa interchange

Survey data were used to obtain the cumulative number of vehicles. Arrival curve was obtained when plotting cumulative number of vehicles against time. Service curves were also plotted according to the number of gates in service and it varies with time. For the purpose of identification of future traffic, arrival curves were also plotted according to predicted vehicle growth.

Kottawa Interchange–Exit Ramp (exit of vehicles arriving from Galle)–When one gate is operating

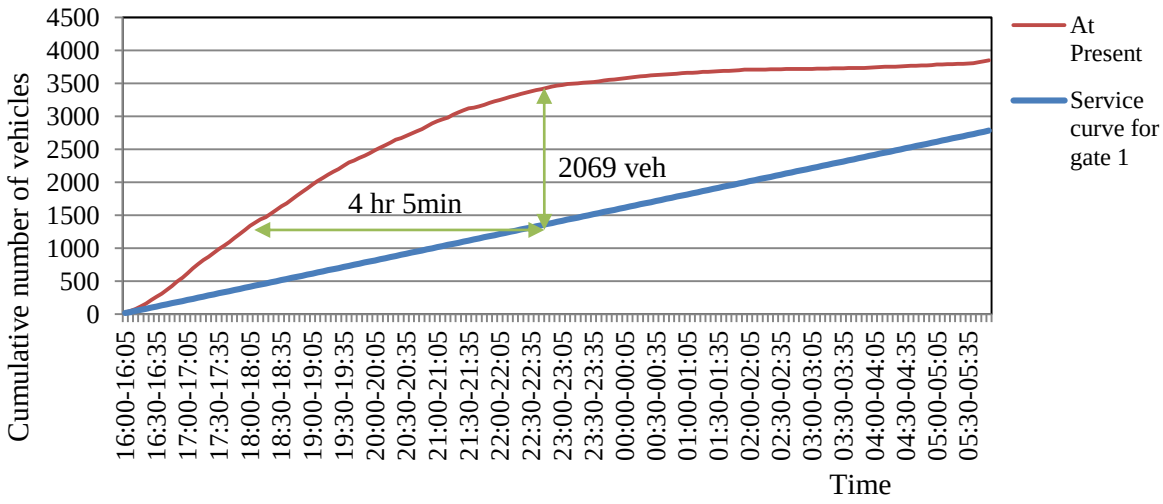


Figure 4. The graph of time vs. cumulative number of vehicles when only one gate is on operation at Kottawa Interchange

The total length of the queue at a specified time, expressed by the number of vehicles, is given for the particular exit ramp from the vertical length between arrival and departure curves. It shows the longest vehicle queue at manual system when only one gate is in operation. The longest vehicle queue occurs at time 22:50 hrs consisting of 2069 vehicles.

Sample Calculation for Present Condition When Only One Gate is on Operation at Kottawa Interchange

For the calculation of maximum longest queue for that particular exit ramp, average vehicle length according to the anticipated vehicle composition was found. One meter gap in between two successive vehicles was assumed.

Maximum no. of vehicle in queue at present = 2069 veh

Average vehicle length = ∑(Percentage composition for vehicle category × Average length of vehicle category)

Average vehicle length = (92.43% × Average length of category A) + (4.91% x Average length of category B) + (1.56% × Average length of category C) + (1.1% × Average length of category D)
= (92.43% × 4.92 m) + (4.91% × 10.9 m) + (1.56% × 12.5 m) + (1.1% × 16 m)
= 5.45 m

Gap between two successive vehicles = 1 m
Maximum queue length at present = Maximum No. of vehicle in queue at present × (Average vehicle length + Gap between successive vehicle)
= 2069 × (5.45 + 1) m
= 13345 m
Longest individual delay = 4 hr 5 min

At present it was found that 13345 m queue length is the longest queue length if only one gate at Kottawa exit ramp is in operation. When the operating gates are increased the queue length will decrease proportionally. Since critical exit ramp length of Kottawa interchange is only 197 m, it will be insufficient even with more gates operating at present service rates.

The same procedure was followed in obtaining maximum queue length and longest individual delay for each interchange when operating at different number of toll gates up to 2080 for critical exit ramps at interchanges.

Deceleration Lane Length

Exit ramp design based on the assumption that vehicles exiting from a freeway have adequate space to decelerate to the ramp's limiting design speed feature (typically a horizontal curve) after clearing the through traffic lane. The length provided between the freeway departure point and the ramp's limiting design speed feature should be at least as long as the distance needed to accomplish the appropriate deceleration which is governed by the speed of traffic on the through lane and the speed to be attained on the ramp.

Calculation of Minimum Deceleration Lane Length for Exit Ramps

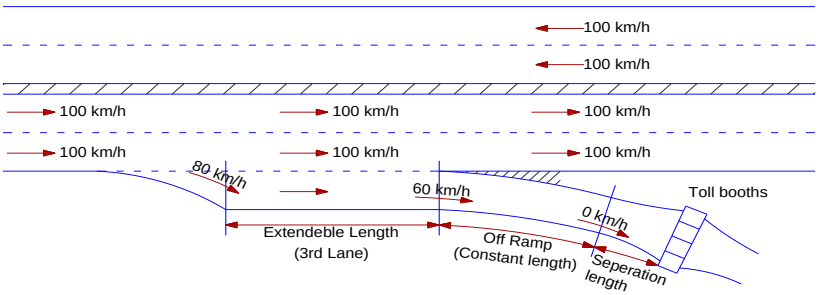


Figure 5. Deceleration lane of off ramp

Lower limit of highway design speed = 80 kmph
Design speed of off ramps = 60 kmph

The recommended minimum deceleration lane length for an off ramp is 255 ft (77.7 m) when vehicle travels at 80 kmph to become 60 kmph and once it reaches that speed the vehicle needs further 300 ft (91.4 m) lane length to stop the vehicle. Those values are clearly indicated in Table 9 considering highway design speed of the Southern Expressway.

Also it needs to provide deceleration lane length to the end of the anticipated queue at the off ramps. In here minimum deceleration length was considered as per Washington State Department of Transportation (WSDOT) Design manual 2011.

Table 9. Minimum Deceleration Lane Length

Highway Design Speed (mph)	Highway Design Speed (kmph)	Minimum deceleration lane length (ft) for ramp design speed (mph)											
		0	15	20	25	30	35	37.5	40	45	50	60	70
30	48	235	200	170	140								
35	56	280	250	210	185	150							
37.5	60	300											
40	64	320	295	265	235	185	155						
45	72	385	350	325	295	250	220		155				
50	80	435	405	385	355	315	285	255	225	175			
55	88	480	455	440	410	380	350		285	235	180		
60	96	530	500	480	460	430	405		350	300	240		
65	104	570	540	520	500	470	440		390	340	280	185	
70	112	615	590	570	550	520	490		440	390	340	240	
80	128	735	710	690	670	640	610		555	510	465	360	265
		0	24	32	40	48	56	60	64	72	80	96	112
		Minimum deceleration lane length (ft) for ramp design speed (kmph)											

(Source: WSDOT Design Manual 2011 – Chapter 1360)

Minimum deceleration lane length to achieve 60 km/h (ramp design speed), when vehicle travels lower highway design speed of 80 km/h for exit ramps is;

Minimum deceleration lane length = 255 ft (78 m)

Minimum deceleration lane length, once the vehicle achieves 60 km/h (i.e. ramp design speed) to stop the vehicle.

Minimum deceleration lane length = 300 ft

Total Minimum deceleration lane length = 255 ft + 300 ft

= 555 ft (170 m)

Therefore, total minimum deceleration lane length should be 170 m for all exit ramps.

The calculated minimum deceleration lane length for an off ramp is 170 meters. Exsisting ramp length of Kahathuduwa ramp 1 (from Galle) and ramp 2 (from Colombo), Dodangoga ramp 1 (from Galle) and ramp 2 (from Colombo), Welipanna ramp 1 (from Galle) and ramp 2 (from Colombo), Kurundugahahatakma ramp 1 (from Galle) and ramp 2 (from Colombo), Baddegama ramp 1 (from Galle) and ramp 2 (from Colombo) are respectively 106m, 96m, 93m, 134m, 73m, 69m, 45m, 134m, 154m, and 90m. Therefore, Table 10 highlights the exit ramps which do not satisfy the minimum deceleration lane length of 170 meter requirement according to WSDOT design Manual 2011.

Table 10. Comparison of minimum deceleration lane length and existing exit ramp lengths

Interchange	Exit ramps	Ramp length (m)	Minimum deceleration lane length
Kottawa	Ramp 1 – From Galle	197	(Satisfy)
Kahathuduwa	Ramp 1 – From Galle	**106**	(Do not satisfy)
	Ramp 2 - From Colombo	**96**	(Do not satisfy)
Galenigama	Ramp 1 – From Galle	181	(Satisfy)
	Ramp 2 - From Colombo	187	(Satisfy)
Dodangoda	Ramp 1 – From Galle	**93**	(Do not satisfy)
	Ramp 2 - From Colombo	**134**	(Do not satisfy)
Welipanna	Ramp 1 – From Galle	**73**	(Do not satisfy)
	Ramp 2 - From Colombo	**69**	(Do not satisfy)
Kurundugahahathakma	Ramp 1 – From Galle	**45**	(Do not satisfy)
	Ramp 2 - From Colombo	**134**	(Do not satisfy)
Baddegama	Ramp 1 – From Galle	**154**	(Do not satisfy)
	Ramp 2 - From Colombo	**90**	(Satisfy)
Pinnaduwa	Ramp 1 –From Colombo	378	

Table 11. Results and Proposals

Interchange	Direction	Failure reason at year			Proposals
		Longest individual delay at year	Maximum queue length	Minimum deceleration length (169.04m according to WSDOT)	
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 not enough	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 not enough	Ramp length has to improve from now
	Ramp 2 - From Colombo	2040	2040		
Welipanna	Ramp 1 – From Galle			Existing ramp length not enough	Ramp length has to improve from now
	Ramp 2 - From Colombo	2045	2045		
Kurundugahahatakma	Ramp 1 – From Galle	2060	2050	Existing ramp length not enough	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

Conclusions and Recommendation

Southern Expressway will be directly influenced by additional traffic that would generate due to the anticipated rapid development of the Southern part of Sri Lanka. As seen from the study results, even at present, Kottawa and Pinnaduwa interchanges do not operate satisfactorily during long weekends and festive seasons. This study checked the effect of current toll gates on the free flow of the Southern Expressway. In fact, this study was conducted before commissioning the stretch from Pinnaduwa to Matara, and it is anticipated that the Pinnaduwa exit conditions will improve once the new stretch starts to operate.

It could be observed how each interchange dealt with maximum queue length, individual delay and minimum deceleration lane length. Table 11 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 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. As an example, proposed layout plan for Kurundugahahatakma interchange shown in Figure 5. Table 11 shows that queue lengths will exceed the critical exit ramps in years 2034, 2075, 2050, 2040, 2045, 2050 and 2030 for the Kottawa (from Galle), Kahathuduwa (from Galle), Galenigama (from Galle), Dodangoda (from Colombo), Welipanna (from Colombo), Kurundugahahatakma (from Galle) and Pinnaduwa (from Colombo) interchanges respectively. Due to the spillback of the traffic queues from off ramps, capacity reduction of expressway is visible by bottlenecking the expressway.

The maximum individual delay of 10 minute duration exceeded in years 2035, 2075, 2060, 2040, 2045, 2060, 2030 for the Kottawa (from Galle), Kahathuduwa (from Galle), Galenigama (from Galle), Dodangoda (from Colombo), Welipanna (from Colombo), Kurundugahahatakma (from Galle) and Pinnaduwa (from Colombo) interchanges respectively.

Hence, the capacity of the Southern Expressway will get affected due to the inadequacy at toll gates unless the number of toll gates is increased or the efficiency of the toll collecting systems is improved, thus improving the efficiency of the toll gates which is more practical. Due to the operational procedure of electronic toll collection systems such as; automatic coin machines, touch and go systems, systems operated through transponders *etc*. the queue length and individual delay can be reduced. The service rates and operational procedure for above mentioned systems are indicated in Table 12. The last column of Table 12 presents the study proposals for toll gates.

Table 12. Comparison of toll collection systems

Toll collection system	Service time (s)	Operational procedure
Manual toll collection system	18	Cash toll is received by the collector. The collector, who also dispenses change, may accept and sell scrip, tickets, coupons, making an entry of the vehicle in the system and issuing receipt to the patron. The processing time is highest, due to manual intervention
Automated coin machine	5.20	These machines accept both coins and tokens issued by the operating agency. Depending on the toll rate, the use of automated coin or token collection instead of manual collection reduces transaction and processing time as well as the operating cost.
Touch and go system	3.50	The drivers are provided with a prepaid or postpaid card in which the driver and vehicle details are been stored. And the driver comes to the entrance has the card and the machine reads the card information and sends it to the network. And the gate is then opened. Also at the exit, when the driver touches the machine with the card, the machine takes necessary action to deduct the required amount of money.
Electronic toll collection system	1.12	Most systems use the radio frequency transmitter and the transponder in the vehicle for identification for the billing process of electronic toll collection. It is mostly dealt by banks, and the billing process can follow a post-pay over a prepaid model.

(Source: www.researchgate.net)

Therefore, one of the tolling systems above described can be introduced to minimize the queue length and individual delay.

References

Banks, J. H. (2010), "*Introduction to Transportation Engineering*", 2nd Edition, Tata McGraw-Hill, New Delhi, India.

Mannering, F. L. and Washburn, S. S. (2004),*'Principles of Highway Engineering and Traffic Analysis*', 3rd edition, John Viley & Sons, Inc, USA.

Mannaring, F. L. and Kilareski, W. P. (1998) "*Principals of Highway Engineering and Traffic Analysis*", 2nd Edition

Washington State Department of Transportation (2011), *Design Manual*, Washington, US.

www.rda.gov.lk/supported/expressways/stdp.htlm

www.researchgate.net

Received: 5-4-2015 Revised: 14-9-2015 Accepted: 15-9-2015

OUSL Journal (2015)
Vol. 9, (pp. 41-59)

Emotional Intelligence on Job Performance of Bank Managers in Sri Lanka

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Abstract

Present day organizations realize that traditional intelligence or Intelligence Quotient (IQ) is not sufficient for developing job performance, work-related behaviour and career advancements of leaders in organizations. The literature suggests that Emotional Intelligence (EI) plays a vital role in the success of managers in the workplace. Hence, the purpose of this study was to investigate the effect of Emotional Intelligence on the job performance of bank managers in Sri Lanka, in order to narrow the research gap.

Based on the previous literature showing the relationships among the variables, a conceptual model was developed. The study adopted already validated research instruments. The model was empirically tested by collecting data from bank managers in Sri Lanka. A total of two hundred commercial bank managers were selected for the study using the Convenience Sampling Technique and one hundred and sixty three usable questionnaires were returned. The model was tested with the measurement model and the structural model analysis by using the Partial Least Square technique (PLS). The measurement model analysis was used to establish the item reliability, internal consistency reliability, convergent validity, and discriminant validity and the structural model analysis was used to test the model fit.

The structural model analysis results provided the support for all three hypotheses formulated in this study. Thus, the higher the levels of emotional intelligence of bank mangers the higher the levels of job performance and higher the levels of job satisfaction. This study provides future directions for further research as well.

Keywords: Emotional intelligence, job performance, job satisfaction, measurement model, structural model

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Introduction

Leaders who have high Emotional Intelligence competencies are more likely than less emotionally intelligent leaders to achieve success in the workplace (Goleman, 1998; San & O'Higgins, 2012). In today's competitive world, the non-cognitive skill of Emotional Intelligence of managers is the instrument in enhancing their work-related behaviours and their job performance and success, which ultimately leads to organizational success (Goleman, 1998; Derman, 1999; Groves, McEnrue, & Shen, 2008).

Emotional intelligence provides positive consequences for employees at all levels. Especially it determines the leaders' success in organizations (Groves *et al.*, 2008). Emotional Intelligence is considered twice as important as technical skills and intellectual intelligence for all jobs at all levels (Goleman, 1998). Further Goleman suggested the importance of emotional intelligence for leaders as without it, a person can have the best training in the world, an incisive, analytical mind, and an endless supply of smart ideas, but she/he still won't make a great leader. Further he stated that among star performers with average areas in senior leadership positions, nearly ninety percent of the differences in their profiles were attributable to emotional intelligence factors rather than cognitive abilities.

The banking sector is one of the foremost sectors in any country to boost the economy of any country. Similarly, the banking sector of Sri Lanka is one of the leading sectors in the financial sector and it plays a vital role in the country's development. Compared to the last few decades, new banks are emerging day by day thereby increasing competition among the banks, leading the existing banks to rethink their existing strategies, policies, systems, structures, resources *etc.* Gaining sustainable competitive advantage through organizational employees could be considered as the best strategy since one of the most important strategic resources in any organization is the human resource. In this regard, organizations must consider the competent employees in achieving success through the people. Many researchers have argued that organizations benefit from having emotionally intelligent employees at the workplace. Emotional Intelligence is proved to be a necessity for successful performance and career development (Kunnanatt, 2008) and for enhancing employee outcomes including job satisfaction, organizational commitment, career commitment, and job involvement (Carmeli,2003; San & O'Higgins, 2012).

If managers and employees develop their Emotional Intelligence, they will both benefit. EI enhances employee cooperation, increases motivation, productivity, and profits (Johnson & Julie, 1999). Further, these scholars pointed out that managers will have a work force willing to engage with passion and employees will have managers who are receptive and open to their needs. How the Emotional Intelligence training programmes influenced quality of service provided by the employees must be taken into consideration. According to the study of Mina and Melika (2011), it was proved that service employees in the banking sector can be trained in EI by means of tailored programmes designed to enhance perceived service quality among bank customers.

Studies on investigating the impact of Emotional Intelligence on Job Performance are lacking, and therefore, the literature is deficient in several aspects. In reviewing the literature, it was found that there were few studies conducted on emotional intelligence in Asia. However, studying the impact of Emotional Intelligence on enhancing performance and employees' outcomes provides a valuable input to the organization in order to identify the right skills and competencies that should be possessed by leaders and managers (Carmeli, 2003; Johnson & Julie, 1999; Mina & Melika, 2011).

Sri Lankan commercial banks today have become much more demanding as well as complex and ambiguous places of work. The managers are expected to show their worth in creating conditions in which people can deliver the best results necessitating mastery of a set of new key competencies which includes emotional intelligence and related competencies. However, in the Sri Lankan context, the construct of Emotional Intelligence has only been studied with limited constructs such as organizational learning (Dissanayaka, Janadari & Chathurani, 2010) and Job Satisfaction (Kappagoda, 2011). However, there is still a need to fill the empirical gap in studying the impact of Emotional Intelligence on Job Performance of managers in the banking industry in Sri Lanka since there were no studies found in testing the relationships between these constructs.

Thus, the research problem of this study is to investigate whether there is a significant relationship between Emotional Intelligence and Job Performance in Sri Lanka.

Scope of the study

The current study focused on commercial bank managers in Sri Lanka and four banks are namely, Hatton National Bank, Commercial Bank PLC, People's Bank, and Bank of Ceylon. Two hundred managers were selected using convenience sampling method, representing each province on a proportionate basis.

The objectives of the present study are; to investigate the effect of Emotional Intelligence on Job Performance of managers in the banking sector in Sri Lanka; to investigate the effect of Emotional Intelligence on Job Satisfaction of managers in the banking sector in Sri Lanka; and to investigate the effect of Job Satisfaction on Job Performance of managers in the banking sector in Sri Lanka.

Literature review

Emotional Intelligence and Job Satisfaction

Emotional Intelligence is the ability to monitor one's own and others' feelings and emotions, to discriminate among them and to use this information to guide one's thinking and actions, and it is the capacity for recognizing our own feelings and those of others, for motivating ourselves, and for managing emotions well in ourselves and in our relationships (Salovey & Mayer, 1989; Goleman, 1998). Job Satisfaction refers to the collection of positive feelings and affective responses associated with the job (Spector, 1997; Robbins & Coulter, 2002; Robbins & Judge, 2009).

Previous studies proved that there is a positive and significant relationship between Emotional Intelligence and Job Satisfaction (Wong & Law, 2002; Grandy, 2000). Fisher (2003) found that the emotions in the work place affect Job Satisfaction. Furthermore, he identified constructs of Emotional Intelligence such as interpersonal relations which immediately affect job satisfaction, other than salary and chance of promotion. Carmeli (2003) also found that emotional intelligence has a significant positive effect on job satisfaction by taking a sample of senior managers employed as chief financial officers in the local government authorities in Israel.

Employees who rated their leaders as more emotionally intelligent and effective were satisfied with work (Nowak, 2006). Another study found that leader member exchange mediated the relationship between the follower Emotional Intelligence and both turnover intention and Job Satisfaction (Jordan & Troth, 2011.

San and O'Higgins (2012) tested the influences of managers' Emotional Intelligence, leadership styles, and employee outcomes with a sample of three hundred and twenty three managers and their subordinate employees using the Wong Emotional Intelligence Scale. Results showed that managers' transformational leadership style fully mediated the relationship between managers' emotional intelligence and employee job satisfaction. Thus, based on the above justification, the following hypothesis is proposed:

H_1: Higher the level of Emotional Intelligence, higher the level of Job Satisfaction of bank managers

Job Satisfaction and Job Performance

Job Satisfaction is one of the most prominent variables in the field of organizational behaviour and management since it has been frequently tested in several areas from time to time (Pfeffer, 1994; Fisher, 2003; Robbins & Judge, 2009). More and more organizations consider Job Satisfaction as a factor in order to retain their employees within the organization (Robbins & Judge, 2009).

Luthans (1995) found that there is a significant negative relationship between Job Satisfaction and absenteeism. Also Job Satisfaction has been tested with job performance and a positive relationship was found between the two variables (Fisher, 2003). Moreover, research finding proved that satisfied employees effectively perform their tasks and jobs in terms of higher level of performance and productivity (Fisher, 2003). Thus, based on the above justification the following hypothesis is proposed:

H_2: Higher the level of Job Satisfaction, higher the level of Job Performance of bank managers

Emotional Intelligence and Job Performance

Dries and Pepermans (2007) conducted a study to reveal Emotional Intelligence and identify the high potential managers. In this study, fifty one high potential and fifty one regular managers were selected as the sample. The results showed that there is a higher level of Emotional Intelligence elements such as assertiveness, independence, optimism, and social responsibility revealed in high potential managers compared to regular

managers. Also it was found that high potential managers showed a higher level of job performance.

Also it was found that Emotional Intelligence of employees leads to enhance the financial position of the organization. Executives who possessed higher levels of empathy, self-regard, reality testing, and problem solving were more likely to yield high profit-earning companies (Stein *et al.*, 2009). Similarly, another study showed that emotional intelligence of government employees within public organizations has had an impact on Job Performance similar to that in private organizations (Hsi-An & Susanto, 2010). Thus, based on the above justification the following hypothesis is proposed:

H_3: Higher the level of Emotional Intelligence, higher the level of Job Performance of bank managers

Theoretical Framework

Emotional Intelligence plays an important role in the success of senior managers in the workplace in order to develop positive work attitudes, behaviour, and outcomes including better performance at the workplace. (Carmeli, 2003). Carmeli empirically examined the extent to which senior managers with a high Emotional Intelligence employed in public sector organizations developed employee outcomes. The results indicated that Emotional Intelligence augments positive work attitudes, altruistic behaviour, and work outcomes in the workplace**.**

Emotional Intelligence can make the difference between good and poor leaders (Carmeli, 2003). Leaders with high Emotional Intelligence skills are well satisfied with their work (Nowack, 2006). Individuals with high Emotional Intelligence experience continuous positive moods and feelings that generate higher levels of satisfaction and well-being compared to individuals who experience anger, depression and disappointment (Carmeli, 2003; Derman, 1999; Stein *et al.*, 2009). Emotionally intelligent mangers develop emotional attachment to their organizations and even more to their career, and mangers with high Emotional Intelligence often get extremely involved in challenging and complex situations, and they try to get highly involved in their jobs (Carmeli, 2003; Dries & Pepermans, 2007).

Based on the literature review, it was clear that there are significant relationships among constructs identified for this

study. Emotional Intelligence has a significant positive effect on Job Performance (Carmeli, 2003; Dries & Pepermans, 2007; Stein *et al.*, 2009).

In addition to these relationships among the constructs, the job satisfaction was taken as mediator between Emotional Intelligence and Job Performance. Previous studies supported the relationship between these constructs. Emotional Intelligence had a significant positive effect on Job Satisfaction (Carmeli, 2003; Jordan & Troth, 2011; San and O'Higgins, 2012) and Job satisfaction had a favourable effect on Job Performance (Luthans, 1995; Fisher, 2003).

Therefore, based on the previous studies, the conceptual model for this study was developed. The conceptual model is shown in Figure 1.

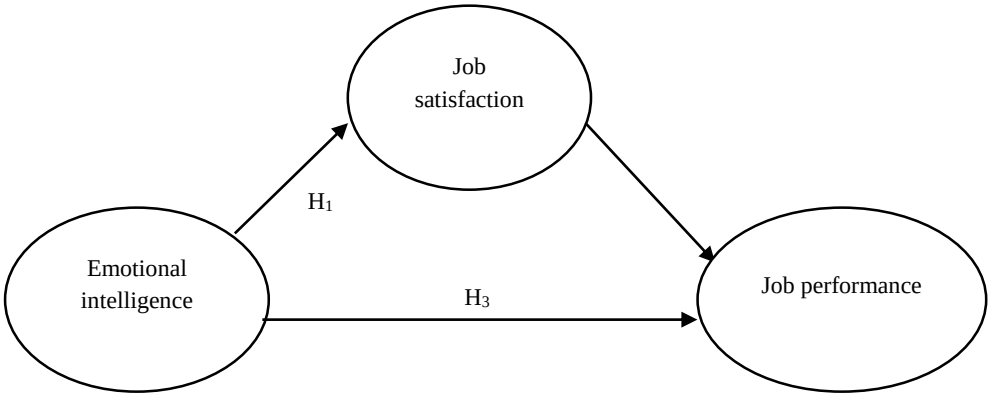

Figure1. Theoretical framework

Methodology

Overall Approach to Research

The type of investigation was a correlational study, the extent of researcher interference was minimal, the study setting was non contrived (natural) and the time horizon was cross sectional, and the unit of analysis was individual.

Population and Sample

The population for this study was commercial bank managers. Four commercial banks were selected for this study; Hatton National Bank, Commercial Bank PLC, People's Bank, and Bank

of Ceylon. Two hundred managers were selected using convenience sampling method, representing each province on a proportionate basis.

Data Collection

In this study, an empirical survey was carried out using a self-administered questionnaire on a seven-point Likert scale (1 = strongly agree, 7 = strongly disagree), whereby respondents were asked to give their agreement or disagreement. The response rate was 81.5%.

Survey Instrument Development

Emotional Intelligence:

The current study adopted the self-report of EI of Schutte (1998) including 33 Likert-type scale items in order to measure the emotional intelligence traits of managers. However, factor loadings eliminated 7 items.

Job Satisfaction:

This study adopted a 6-item measurement developed by Tsui, Egan, and O'Reilly (1992). This study modified items from the question format to statements as a result of consultation regarding these items with selected managers. Factor loadings eliminated one item.

Job Performance:

The current study adopted a 4-item measurement developed by Perarce & Porter (1986) and it has been used in the study of Carmeli (2003). Factor leading accepted all items.

Approach to Data Analysis

Statistical Package for Social Science (SPSS) version 20.0 and SmartPLS version 2.0 (Ringle, Christian Wende, Will & Alexander, 2005) were the statistical tools used in the current study.

Findings

Descriptive Analysis

Research constructs of emotional intelligence, job satisfaction and job performance were analyzed through mean and its respective standard deviation using the SPSS version 20.0 and they showed higher levels of mean values as shown in Table 1.

Table 1. Descriptive statistics of research constructs

Constructs	N	Mean	Standard Deviation
Emotional Intelligence	163	5.66	0.951
Job Satisfaction	163	5.69	1.009
Job performance	163	5.63	0.895

Measurement Model Analysis

The data collected was analyzed using Smart-PLS version 2.0 software. The reliability was tested as a measurement model analysis in this research. Particularly, factor loadings (item reliability) and internal consistency reliability were examined. According to factor loadings, the majority of items were acceptable as the item loadings were above the threshold value of 0.70 (Hair *et al.*, 2011).

However the factor loadings of 07 items of emotional intelligence and 01 item of job satisfaction were below the threshold value of 0.70. The factor loadings for all items were above the threshold value (0.70) when the measurement model analysis was carried out for the third time.

Structural Model Analysis

The model's explanatory power was assessed by the coefficient of determination, R^2 and it is 0.824 for the "job performance" construct. This means that the two constructs (emotional intelligence and job satisfaction) explained a substantial proportion (82.4%) of the variance in job performance, since $R^2 >$ 0.75 (Hair *et al.*, 2011).

The strength of the cause-effect relationships was assessed through the path coefficient values (β) and bootstrapping was used to test the significance of structural paths using t-Statistics (Hair

et al., 2011; Wong, 2013). The path coefficients suggested that emotional intelligence has the strongest effect on job performance (0.8816), followed by job satisfaction (0.7513). Thus all the hypothesized path relationships between the constructs were statistically significant. Thus, it is concluded that all the hypothesized path relationships between the constructs: emotional intelligence and job satisfaction (β = 0.6894, p = 0.0000); job satisfaction and job performance (β = 0.7513, p = 0.0000); and emotional intelligence and job performance (β = 0.8816, p = 0.0010) were statistically significant.

The Figure 2 shows the conceptual model along with its path coefficients and the statistical significant levels where the statistical significant level was set at 95% ($p < 0.05$).

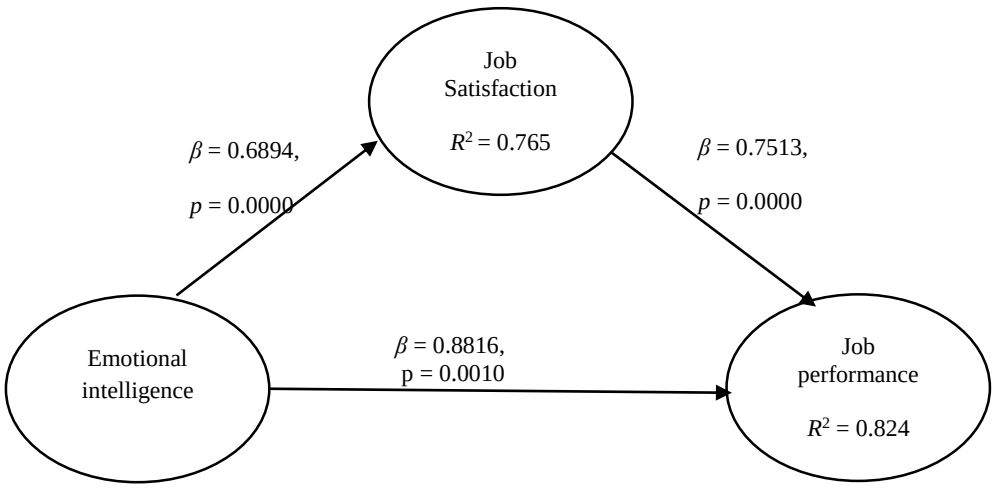

Figure 2. Structural model of the study

Hypotheses Testing

As shown in Table 2, the hypotheses were tested using the path coefficients (β) indicating the strength of the cause-effect relationships between the research constructs. The bootstrapping procedure was used to assess the significance of path coefficient values (β). The statistical significance was tested at 95% ($p < 0.05$) confidence level.

Hypotheses	Path coefficient (β)	*p* value	Supported/ Not supported
Hypothesis 1: Emotional intelligence -> Job satisfaction	0.6894	0.0000	Supported
Hypothesis 2: Job satisfaction -> Job performance	0.7513	0.0000	Supported
Hypothesis 3: Emotional intelligence ->Job performance	0.8816	0.0010	Supported

Table 2: Research hypotheses testing

H_1: Higher the level of emotional intelligence, higher the level of job satisfaction of bank managers

As shown in Table 2, the emotional intelligence affected job satisfaction of bank managers (p = 0.0000) with a larger effect size (β = 0.6894) since emotional intelligence was positively and significantly related to job satisfaction of bank managers (β = 0.6894, p < 0.05), supporting H_1. This indicated that the bank managers with higher levels of emotional intelligence are likely to display higher job satisfaction in the workplace.

H_2: Higher the level of job satisfaction, higher the level of job performance of bank managers

As per Table 2, job satisfaction positively affected the job performance of bank managers (p = 0.0000) with a larger effect size (β = 0.7513) since job satisfaction was positively and significantly related to job performance of bank managers (β = 0.7513, p < 0.0000), supporting H_2. This indicated that the bank managers with higher levels of job satisfaction are likely to display higher job performance in the workplace.

H_3: Higher the level of emotional intelligence, higher the level of job performance of bank managers

As shown in Table 2, emotional intelligence positively affected the job performance of bank managers (p = 0.0010) with a larger effect size (β = 0.8816) since job satisfaction was positively and significantly related to organizational commitment of bank managers (β = 0.8816, p < 0.05), supporting H_3. This indicated

that the bank managers with a higher level of emotional intelligence are likely to display higher job performance in the workplace.

Discussion

The major purpose of the study was to examine the extent to which one of the most important managerial skills viz. emotional intelligence leads to job performance of bank managers employed in a financial sector setting.

The first finding of the current study indicates that emotionally intelligent managers are likely to display higher job satisfaction in the workplace. This finding coincided with the earlier findings. Employees with high emotional intelligence experience continuous positive moods and feelings that generate higher levels of satisfaction and well-being compared to individuals who experience feelings and moods such as depression and anger (Carmeli, 2003). Also older managers with a higher level of adaptability were able to perceive higher levels of job satisfaction (Stewart, 2008).

Emotional Intelligence led to job satisfaction among high school English teachers, Anari (2011). Sri Lankan studies also supported that the managers with a higher level of emotional intelligence lead to perceive the job satisfaction of their subordinates. A higher level of emotional intelligence of school principals increased the level of job satisfaction of teachers (Kappagoda, 2011). Hence, it was concluded that higher levels of emotional intelligence of bank managers are likely to display a higher level of job satisfaction in Sri Lanka.

The second finding of the current study shows that the managers with a higher level of job satisfaction are likely to display higher job performance in the workplace. Job satisfaction has been tested with job performance, and a positive relationship was found between the two variables (Fisher, 2003). Moreover, Research findings proved that satisfied employees effectively perform their tasks and jobs in terms of a higher level of performance and productivity (Fisher, 2003). Hence, it was concluded that higher levels of job satisfaction of bank managers are likely to display a higher level of job performance in Sri Lanka.

The last finding of the current study shows that the emotionally intelligent managers are likely to display a higher job performance

in the workplace. One study showed that emotional intelligence of government employees within public organizations has had an impact on job performance similar to that in private organizations (Hsi-An & Susanto, 2010). Hence, it was concluded that higher levels of emotional intelligence of bank managers are likely to display a higher level of job performance in Sri Lanka.

Conclusion

The current study investigated whether there is any significant relationship between emotional intelligence and job performance of bank managers in Sri Lanka. The findings concluded that higher levels of emotional intelligence of bank mangers lead to higher levels of job performance as well as to job satisfaction at the workplace. Further, it was concluded that job satisfaction of bank managers lead to enhance their job performance. Hence, emotional intelligence can be recognized as one of the most critical skills that managers should possess in present day organizations.

Implications of the Study

The current study narrowed the empirical gap by exploring the role of emotional intelligence on threefold work-related attitude of managers. The findings showed that the managers with a higher level of emotional intelligence in the banking sector can develop higher levels of job satisfaction and job performance at the workplace

Limitations of the Study

Although this study delivered a new model, implications for theory and practice, there were a few inherent limitations in this study. One limitation is that only job performance and job satisfaction were considered in the study. Apart from these, there are other variables which could also be studied on the grounds of emotional intelligence. Another limitation is the current study explored the role of emotional intelligence only among selected bank managers in Sri Lanka. The reliability of data depended on the respondents' understanding and perceptions as given in the self-reported data, which is also a limitation.

Future Research Direction

Even though the current study narrowed the empirical gap as well as provided new findings and insights based on the conceptual model developed in this study, it still provides a pathway for future research. First, the objective of the current study was to explore the role of emotional intelligence among bank managers in Sri Lanka. Therefore, it did not include other managerial level and non-managerial level employees at different organizations in Sri Lanka. Also, future studies may focus on exploring the emotional intelligence among for-profit as well as for not-for-profit organizations. The current study used a relatively new measure of self-report of emotional intelligence items and it showed a higher level of reliability and validity for most of the items. It would be valuable to conduct a future study which compares results of the current study with those that used other acceptable measures of emotional intelligence.

References

Akintayo D. I. & Babalola, S. S. (2012). The impact of emotional intelligent on workers' behaviour in industrial organizations. African Journal, 4 (2).

Allen, N. J. & Meyer, J. P. (1990). The measurement and antecedents of affective, continuance and normative commitment to the organization. Journal of Occupational Psychology, 63, 1-18.

Anari, N. N. (2012). Teachers: emotional intelligence, job satisfaction, and organizational commitment. Journal of Workplace Learning, 24(4), 256 – 269.

Buchanan, B. (1974). Building organization commitment: The socialization of managers in work organizations. Administrative Science Quarterly, 22, 533-546.

Carmeli, A. (2003). The relationship between emotional intelligence and work attitudes, behavior, and outcomes: An examination among senior managers. Journal of Managerial Psychology, 18(8), 788-813.

Chang, L., Shih, C. & Lin, S. (2010). The mediating role of psychological empowerment on job satisfaction and organizational commitment for school health nurses: A cross-sectional questionnaire survey. International Journal of Nursing Studies, 47(4): 247-276.

Chin, C.H. (2006). A Study of Relationship between Work Values, Job Involvement, and Organizational Commitment among Tiwananees Nurses. Unpublished dissertation, Queensland University of Technology.

Derman, J. (1999). The relationship between the emotional intelligence of family member managers and business success in family business. Dissertation Abstracts International, 55: 2397.

Dissanayaka ,D. R., Janadari, M. P. N. & Chathurani , R. A. I. (2010). Role of Emotional Intelligence in Organizational Learning: An Empirical Study Based on Banking Sector in Sri Lanka.proceeding of the 2nd International conference on business and information, Kelnaiya, Sri Lanka.

Dries, N., & Pepermans, R. (2007). Using emotional intelligence to identify high potential: Meta competency perspective. Leadership and Organizational Development Journal, 28(8), 749-770.

Fisher, C. (2003). Why do lay people believe that satisfaction and performance are correlated? Possible sources of a commonsense theory. Journal of Organizational Behavior, 24(3), 753-771.

Gardner, H. (1983). Frames of mind: The theory of multiple intelligences. New York: Basic Books.

Goleman, D. (1995). *Emotional Intelligence*: Why It Can Matter More than IQ. New York: Bantam Books.

Goleman, D. (1998). *Working with Emotional Intelligence*. New York: Bantam Books.

Groves, K. S., McEnrue, M. P & Shen, W. (2008). Developing and measuring the emotional intelligence of leaders. Journal of Management Development, 27(2), 225-250.

Guleryuz, K., Guney, S., Aydin, E.M., & Asan, O. (2008). The mediating effect of job satisfaction between emotional intelligence and organizational commitment of nurses: a questionnaire survey. International Journal of Nursing Studies, 45(11), 1625-1635.

Hair, J. F., Ringle, C.M & Sarstedt.M. (2011). PLS-SEM: Indeed a Silver Bullet. Journal of Marketing Theory and Practice 19(2): 139-151

Hsi-An,S. & Susanto,E. (2010). Conflict management styles, emotional intelligence, and job performance in public organizations. International Journal of Conflict Management, 21(2), 147 – 168.

Johnson, P. R. & Julie, I, (1999). Organizational benefits of having emotionally intelligent managers and employees. Journal of Workplace Learning, 11(3), 84-88.

Jordan, P. J. & Troth, A. C. (2011). Emotional intelligence and leader member exchange: The relationship with employee turnover intentions and job satisfaction. Leadership Organizational Development Journal 32(3), 260-280.

Jordan, P. J. & Troth, A. C. (2011). Emotional intelligence and leader member exchange: The relationship with employee turnover intentions and job satisfaction. Leadership Organizational Development Journal 32(3), 260-280.

Kanungo, R. N. (1982). Measurement of job and work involvement. Journal of Applied Psychology. 67(3), 341-349.

Kappagoda, S. (2011). Managers' Emotional Intelligence and its impact on Non - Managerial Employees' Job Satisfaction in the Banking Sector in Sri Lanka. Proceedings of international conference on MTIM, University of Rajarata.

Kappagoda, S. (2013). Emotional intelligence of the managers in the banking sector in Sri Lanka. Proceeding of International journal of research in commerce, IT & Management, 3(6).

Kunnanatt, J. T. (2008). Emotional intelligence: theory and description: A competency model for interpersonal effectiveness. Career Development International, 13(7), 614-629.

Lodahl T. M. & Kejner M. (1965). The definition and measurement of job involvement. Journal of Applied Psychology, 49, 24-33.

Luthans, F. (1995). *Organizational behavior*. 7th ed. McGraw-Hill.
Mayer, J. D. & Salovey, P. (1997). What is emotional intelligence? In: Salovey, P. & Sluyter, D.J. (Eds.) Emotional Development and Emotional Intelligence. New York: Basic Books.

Mayer, J. D., Roberts,R. D. & Barsade, S. G. (2008). Human Abilities: Emotional Intelligence. Annual Review of Psychology, 59: 507-536.

Meyer, J. & Allen, N. (1991). A three-component conceptualization of organizational commitment. Human Resource Management Review, 1, 61-89.

Meyer, J. & Allen, N. (1997). Commitment in the workplace. Thousand Oaks, CA: SAGE Publications.

Mina, B. & Melika, S. (2011). Effects of an emotional intelligence training program on service quality of bank branches. Managing Service Quality, 21(5), 552 -567.

Mowday, R.T., Porter, L.W. & Stress, R.M. (1982). Employee organization linkages: The psychology of commitment, absenteeism and turnover. San Diego: Academic Press.

Najafpour, E. (2008). An investigation of the relationship between emotional intelligence and job involvement in a Penang manufacturing company. Unpublished dissertation Universiti Sains Malaysia.

Nowack, K. (2006). Emotional Intelligence and Employee Engagement: Creating a Psychologically Healthy Workplace. Leadership.

O'Reilly, C. A. & Chatman, J. (1986). Organizational commitment and psychological attachment: the effects of compliance, identification and internalization on pro-social behaviour. Journal of Applied Psychology, 71(3): 492-499.

Paullay, I., Alliger, G. & Stone-Romero, E. (1994). Construct validation of two instruments designed to measure job

involvement and work centrality. Journal of Applied Psychology, 79, 224-248.

Pfeffer, J. (1994). Competitive advantage through people: Unleashing the power of the work force. Boston: Harvard Business School Press.

Porter, L. W., Steers, R. M., Mowday, R. T. & Boulian, P. V. (1974). Organizational Commitment, Job Satisfaction, and Turnover among Psychiatric Technicians. Journal of Applied Psychology, 59, 603-609.

Ringle., Christian,M., Wende, Will, S. & Alexander. (2005). SmartPLS Release 2.0 (beta). Retrieved November 02, 2014, 2011, http://www.smartpls.de.

Robbins, S. P. & Coulter, M. (2002). *Management*, 7th ed. Upper saddle River: Prince Hall International.

Robbins, S. P. & Judge, T. A. (2009). *Organizational Behavior*, 13th Ed. Prentice-Hall Inc.

Salovey, P. & Mayer, J. D. (1990). Emotional intelligence. Imagination, Cognition and Personality, 9(3), 185-211.

San, L. C. & O'Higgins, E. R. E. (2012). Enhancing employee outcomes: The interrelated influences of managers' emotional intelligence and leadership style. Leadership & Organization Development Journal, 33(2) 149 – 174.

Sarboland, K. (2012). Assessment of the Relationship between Emotional Intelligence and Organizational Commitment of Employees: A Case Study of Tax Affairs Offices. Iran Journal of Basic Applied Sciences, 2(5), 5164-5168.

Schutte, N. S., Malouff, J. M., Hall, L. E., Haggerty, D. J., Cooper, J. T., Golden, C. J. & Durkheim, L. (1998). Development and validation of a measure of emotional intelligence. Personality and Individual Differences, 25, 167-177.

Spector, P. (1997). Job Satisfaction: Application, Assessment, Causes and Consequences. London: Sage Publications.

Stein, S. J., Jeremy, A. P. P. & Gill Sitarenios, Y. (2009). Emotional intelligence of leaders: a profile of top executives.

Leadership & Organization Development Journal, 30(1), 87-101.

Stewart, G. L. (2008). The relationship of emotional intelligence to job satisfaction and organization satisfaction. (Unpublished Dissertation), Regent University.

Tsui, A.S., Egan, T.D. and O'Reilly III, C. A. (1992). Being different: Relational demography and organizational attachment. Administrative Science Quarterly, 37, 549-579.

Uygur, A. & Kilic, G. (2009). A study into organizational commitment and job involvement: An application towards the personnel in the central organization for Ministry of Health in Turky. Ozean Journal of Applied Sciences, 2(1), 113-125.

Yang, F. H. & Chang, C. C. (2008). Emotional labour, job satisfaction and organizational commitment amongst clinical nurses: A questionnaire survey. International Journal of Nursing Studies, 45(6), 879-887.

Received: 9-4-2015 Revised: 6-8-2015 Accepted: 16-8-2015

OUSL Journal (2015)
Vol. 9, (pp. 61-81)

A Preliminary Study on the Variation of Zooplankton Diversity, Abundance and Density in a Selected Branch of Diyawanna Oya Canal System

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Abstract

Zooplankton make the secondary level in aquatic ecosystems and provide a ready source of food for secondary consumers. Hence any fluctuation in their population will directly affect the food webs, and eventually the whole ecological system. This study was carried out along a main branch of Diyawanna Oya, during the period of February to July, 2003. The objectives of the study were to find out the variation in diversity, abundance and density of zooplankton present in a selected branch of Diyawanna Oya and their correlation with some environmental parameters. Zooplankton & water samples were collected monthly from six stations representing both edges and the middle of the canal. During the study, 39 species of rotifers, 9 species of cladocerans, 6 species of copepods, 5 species of ostracods, some larval stages of malacostracans, 2 species of large protozoans and one Tardigrade species were recorded. There was a significant monthly variation in the average density of zooplankton. It was positively correlated with the flow rate (r = 0.81), depth (r = 0.47) and temperature (r = 0.58) of water. And there was a significant variation in density and abundance among six sampling stations. Density values of stations were positively correlated with DO level (r = 0.72) while it was negatively correlated with total alkalinity (r = -0.78), total hardness (r = -0.67) and conductivity (r = -0.6). The highest average density of zooplankton was recorded from Kotte whereas the least was from Torrington. Additionally, the possibility of ousing Lacane sp., Philodina sp. and Moina micrura taxa as indicators was also noted.

Keywords: Zooplankton, Diyawanna Oya, environmental parameters, correlation, indicators

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Introduction

Diyawanna Oya canal system with its surrounding environment is one of the precious assets which exist in the Colombo metropolitan of Sri Lanka. The system has added economical, historical, environmental and recreational value to the capital of Sri Lanka. In order to maintain the good health of this water body, it is important to monitor the status of water quality by measuring any changes in abiotic or biotic factors regularly. Therefore several local authorities plus some government agencies such as Land Reclamation and Development Cooperation (SLLRC) and Urban Development Authority (UDA) are in-charge of its proper maintenance and development. Recent studies have proven that some Zooplankton species and their dimensions can be used as indicators in monitoring water quality (Haberman and Haldna, 2014). Thus, the current study can be considered as a preliminary study that mainly focusses on Zooplankton diversity and their distribution in Diyawanna Oya Canal system. It can also be used as a baseline survey on the status of the canal system particularly on zooplankton, prior to the initiation of development activities around the area.

Sampling process of this study was carried out in 2003. Soon after, due to the speedy development taken place in Sri Jayawardenapura, Kotte urban area, most of the natural aquatic habitats were disturbed, restored, restructured or altered. Though zooplankton have short life spans and can regenerate within a short period of time, it would be worth keeping track on pre and after records on environmental status of the canal system to monitor the extent to which development has affected the environment.

Zooplankton are microscopic organisms, which drift or float freely in any water column. They mostly live in the pelagic zone of oceans, seas, or in freshwater bodies. Freshwater zooplankton play a major role as primary consumers in lower trophic levels of most aquatic food chains and food webs. They are also involved in nutrient cycling and affect the density of phytoplankton in water bodies. Zooplankton are also one of the most important nutrient rich food sources for fish fry and for some adult fishes that live in aquatic systems (Battish,1992). The main taxonomic groups of zooplankton in fresh water bodies are Crustacea (Cladocera, Copepoda, Ostracoda), Rotifera, Gastrotrichs and Protozoa.

According to Fernando (1974), Sri Lanka has no natural lakes, yet over 10,000 'Lakes' have been constructed for irrigation of rice fields,

water storage, for drinking and for the generation of hydroelectric power. They have been colonized by zooplankton via the rivers and have a relatively rich fauna except for typical lake species. Zooplankton in these man-made lakes are poor in species diversity and they are also poor in littoral and benthic animals. According to Fernando (1974), zooplankton community in low country shallow lakes is diverse in species composition. However, in the up country reservoirs, the zooplankton species are few that results in a very low fish production in these lakes.

Most common taxa of zooplankton in Sri Lanka are Rotifera, Cladocera, Copepoda and Ostracoda. Around 140 Rotifera species belonging to 42 genera have been recorded from Sri Lanka (Rajapaksa & Fernando, 1984). Species of both limnetic and littoral forms were among them. The planktonic Rotifers of Sri Lanka are mainly represented by the members of 7 families known as Brachionidae, Asplanchnidae, Synchaetidae, Hexarthridae, Conochilide, Filinidae and Collothecidae. Their species diversity is lower in the limnetic habitats than in the littoral (Rajapaksa and Fernando, 1984).

The composition of the Cladocera in Sri Lanka is typically tropical with few *Daphnia* and *Ceriodaphnia* species, which are the dominant species in the temperate zone (Fernando, 1980a). About 68 species of Cladocera belonging to 7 families (Sididae, Daphnidae, Bosminidae, Monidae, Macrothricidae, Chydoridae and Leptodoridae) have been recorded from Sri Lanka (Rajapaksa and Fernando, 1984).

Twenty-seven species of Copepods belonging to 3 groups are recorded from the freshwater habitats of Sri Lanka. They compose 13 species of Cyclopoids, 11 species of Calanoids and 3 species of Harpacticoids (Rajapaksa and Fernando, 1984). Two species of Gastrotricha were recorded by Fernando & Mendis in 1962.

A few species of Osrtracoda occur as zooplankton. Most of the recorded species in Sri Lanka are benthic, some occur among the aquatic vegetation (Rajapaksa and Fernando, 1984).

Description of the Study Area

Diyawanna Oya is a man-made canal system which is located in the left bank of the lower valley of Kelani River in the Colombo district, Western province of Sri Lanka, within the ranges of latitudes 6 52' 55" - 6 55' 45" N and longitudes 79 52' 35" - 79 55' 15" E.

The canal system functions as the main drainage system of Colombo city. Since its elevation is closer to the sea level and flow rate depends on the storm water, water body becomes stagnant or slow moving during the dry period. As a result, industrial and domestic waste disposed to the water body does not flush away easily. Eventually it generates many health hazards to the public who live in the surrounding area. The major catchment areas of this system are the low-lying marshlands known as Kolonnawa marsh, Heen-ela marsh and Kotte marsh. These are also important as major flood detention zones in the city of Colombo (Wetland Site Report, 1995). Total land area that covers those marshy areas was around 400 ha. Out of them Kolonnawa is the largest marsh (214.3 ha) while Heen-ela is the smallest (87.7 ha). Figure 1 illustrates the study area, which includes a main canal (Diyawanna-Wellawatta canal), 6 sampling stations, and two marshes namely Kotte (KM) and Heen marsh (HM).

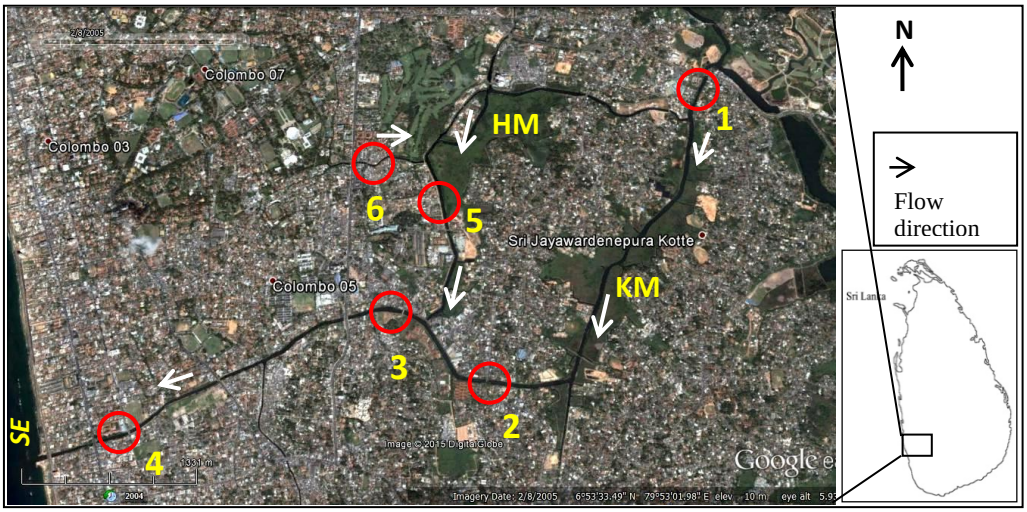


Figure 1. Site map of the study area : Diyawanna Oya Canal system and six sampling stations. *(1. Kotte , 2. Nawala , 3. OUSL, 4. Wellawatta, 5. Kirimandala Mw., 6. Torrington, KM - Kotte Marsh, HM – Heen Marsh)*

The depth of these canals reduces or fluctuates due to the heavy soil erosion and sedimentation of silt during the rainy season. Therefore to control bank erosion, most of the banks are covered with stone

barriers & wire meshes known as 'gabions'. The average depth of the canals is about 1.5 meters. Canal system often clogs with floating weeds & dumps (polythene, plastics & domestic wastes). It has been found that 43.5% of the families in the study area dump their household garbage into the marsh (Wetland Site Report, 1995).

The main objectives of the study were to find out the variation of zooplankton species diversity, density and abundance along a main branch of Diyawanna Oya. Another objective is to find out if there is any correlation between density variation and some environmental parameters recorded during the study.

Materials and Methods

Sampling Site:

Six sampling stations were selected, which were different from one another in respect of human influences and environmental factors. Selection procedure was mainly focused on the presence of marshes, industries and human settlements. Kotte and Nawala stations were the least populated areas, where as Torrington consisted of large numbers of settlements. OUSL station was heavily affected by industrial wastes while Right bank of Kirimandala Mawatha station was affected by Nitrogen rich discharges, released by some food factories. Wellawatta station was located in an urbanized area, which was also affected by seawater intrusion. The easy access to the sampling point was also considered when selecting these sampling stations.

Sampling Method:

Zooplankton were collected from all six stations once a month, during the period of February to July 2003 using a conical plankton tow net with 100μm mesh size and 0.30m mouth diameter. It was towed horizontally between surface and 0.5m depth for about 20 meters distance along the canal, both in two banks and from the middle of the canal using a non-mechanized boat. The volume of water filtered through the net was approximately 1.413 m^3 (1413 Litters). At the same time some environmental parameters such as temperature, flow rate and water level were measured on the spot. Additionally, water samples were collected for further analysis of DO, pH, Conductivity, Alkalinity and Cl^- concentration. Preserved plankton samples were analyzed at the laboratory by using the light microscope. Identification of zooplankton was done using keys and some illustrated guides authored by Fernando & Mendis (1962),

Fernando (1963,1969 & 1974), Chengalath & Fernando (1974,1974), Fernando (1984), Neale (1984), Battish (1992), Edmondson (1959), Dole-Olivier et al., (2000), Ricci & Balsamo(2000) and Barnes (1998).

Results

Species Diversity of Zooplankton in Diyawanna Oya

Among zooplankton, thirty-nine (39) species of rotifers, nine (9) species of cladocerans, six (6) species of copepods, five (5) species of ostracods, some larval stages of malacostracans, one (1) species of Branchiopods, two (2) large protozoans and one (1) tardigrade species were recorded. Among rotifers *Brachionus falcatus*, *Lecane bulla* and *Philodina* sp. were the most abundant. *Ceriodaphnia cornuta, Diaphanasoma excisum* and *Moina micrura* were the most abundant cladoceran species.

The checklist of zooplankton recorded during the study has been given in Table 1.

Variation of Zooplankton Diversity within Six Sampling Stations

It was revealed that Nawala station, which is nourished with water coming from Kotte marsh, had the highest zooplankton species richness while Torrington which was heavily influenced by human activities had shown the lowest. The graph below (Fig. 2) illustrates the pattern of variation of zooplankton diversity (species richness) among six sampling stations. Further to Shanon-Wiener Diversity Index, Kotte station has scored the highest value of 3.36 where as Nawala, OUSL, Wellawatta, Kirimandala Mw. and Torrington stations area 3.27, 2.98, 2.79, 2.85 and 0.82 respectively.

Table 1. Checklist of zooplankton taxa & their total number of occurrence during the study (N = Number of Occurrence)

Taxonomy	**N**	***Taxonomy***	**N**
		Phylum Arthropoda	
Phylum Rotifera		***Class Crustacea***	
Order Ploimida		***Order Cladocera***	
Brachionus angularis	5	*Diaphanasoma excisum*	36
Brachionus calyciflorus	32	*Ceriodaphnia cornuta*	49
Brachionus caudatus	16	*Monia micrura*	43
Brachionus donneri	12	*Bosminopsis dietersi*	34
Brachionus falcatus	44	*Oxyurella sinhalensis*	3
Brachionus forficula	4	*Psedochydorus globosus*	1
Brachionus patulus	13	*Macrothrix triserialis*	18
B. quadridentatus	9	*Euryalona orientalis*	14
Platyias quadricornis	11	*Ladigia acanthocercoides*	4
Keratella tropica	14	***Sub class Copepoda***	
Lecane bulla	44	***Order Cyclopoida***	
Lecane quadridentata	4	**Mesocyclops sp.*	66
Lecane ungulata	3	**Thermocyclops crassus*	51
Lecane sp1	10	*nauplii stage 1*	86
Lecane sp2	1	*nauplii stage 2*	61
Lecane sp3	5	***Order Calanoida***	
Lecane sp4	5	*Phyllodiaptomus sp.*	50
Lecane sp5	2	*Eudiaptomus sp.*	41
Lecane sp6	32	*nauplii stage 1*	62
Philodina sp.	68	*nauplii stage 2*	37
Asplanchna brightwelli	18	***Order Herpactocoida***	
Euchlanis dilatata	28	*sp.1*	2
Trichocera cylindrica	2	***Class Ostracoda***	
Trichocera chattoni	14	***Order Podocopida***	
Lepadella patella	1	***Super Family :Cypridoidae***	
Scaridium longicaudum	1	*sp.1*	
Testudinella patina	19	*sp.2*	1
Filinia sp.1	3	*sp.3*	17
Filinia sp.2	3	***Class Malacostraca***	1
Macrochaetus collinsi	1	*crab nauplii 1*	
Macrochaetus sericus	2	*crab nauplii 2*	1
Trichotria tetractis	1	*crab nauplii 3*	4
Sinantherina spinosa	7	***Insecta***	4
Sinantherina semibullata	33	*Odonata nymphs*	
Cephalodella giba	14	***Protozoa***	9
Hexarthra mira	30	*Arcella sp.*	
Mytillina sp.	1	*Centropyxis sp.*	22
		phylum Tardigrada	10
		sp.1	8

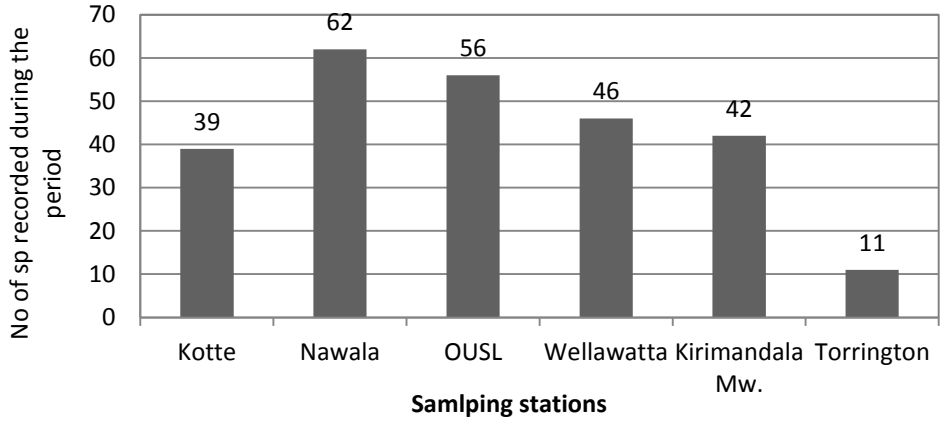


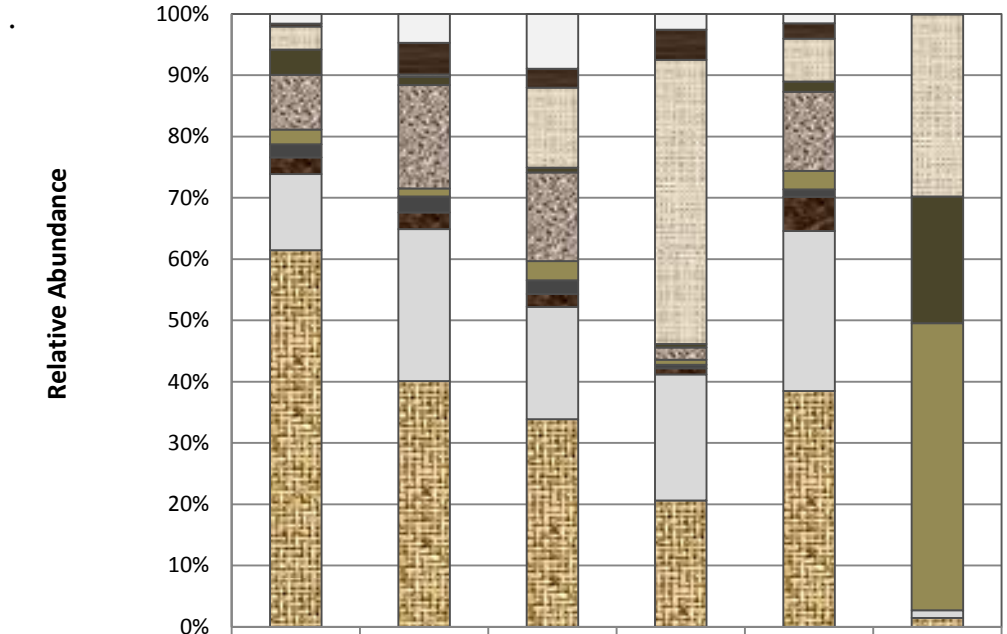
Figure 2. Variation of zooplankton diversity (species richness) among six sampling stations

Relative Abundance of Some Major Taxonomic Groups of Zooplankton

Figure 3 shows the variation of relative abundance (%) of 10 frequently recorded zooplankton taxa in six sampling stations during the study period. The abundance values (no of individuals per cubic meter) of those taxa for each and every station have been given in the graph. According to the graph, except for Torrington, Copepod adult and nauplii have been the most abundant taxa (over 40%) in almost all stations. For Torrington it was *Moina micrura,* which is a cladoceran species and showed the relative abundance around 50%. Though Wellawata showed relative abundance more than 40% as a total figure for copepod adults and nauplii, the most dominant taxa for the station was *philodina* sp which is a Rotifer species.

Variation of Zooplankton Density

There was a significant monthly and spatial (station wise) variation of zooplankton density in Diyawanna Oya. According to Figure 4 the highest zooplankton density was recorded in March, 2003 whereas the lowest was in July, 2003. When considering the average density variation of the six stations, Kotte station has recorded the highest zooplankton density while Torrington has shown the lowest (see Figure 5).



	KOTTE	NAWALA	OUSL	WELLA.	KIRIMA.	TORING
B. falcatus	393	566	943	205	159	0
Lecane sp.	126	625	325	389	260	1
Philodina sp.	943	43	1378	3698	728	407
Hexarthra sp.	1037	167	80	47	174	283
Ceriodaphnia sp.	2263	2029	1524	157	1337	0
Moina micrura	597	157	335	67	315	641
Bosminopsis sp.	550	314	236	47	126	0
Diaphanasoma sp.	676	331	220	79	581	0
Copepoda	3143	2987	1934	1642	2710	18
Copepod nauplii	15508	4834	3571	1642	3997	20

Sampling stations and abundance values (no. of ind/m^3)

Figure 3. Variation of relative abundance of ten frequently occurred zooplankton taxa in six sampling stations and their abundance values (individuals per cubic meter).

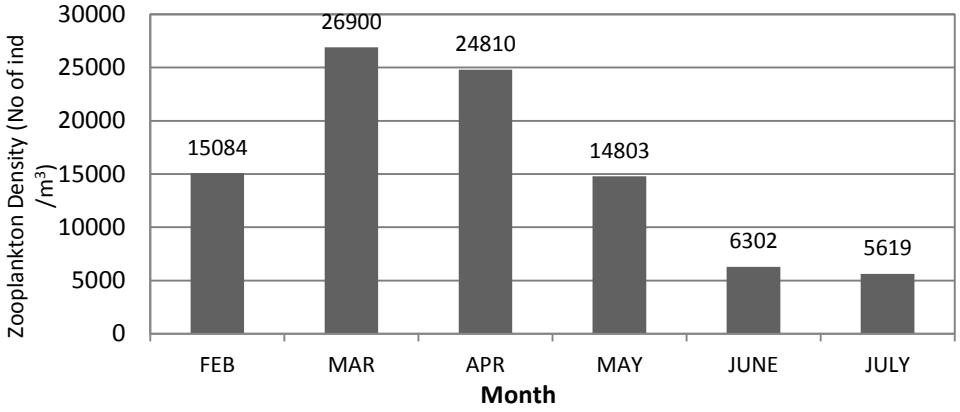


Figure 4. Monthly variation of zooplankton density in Diyawanna Oya (Feb-July 2003)

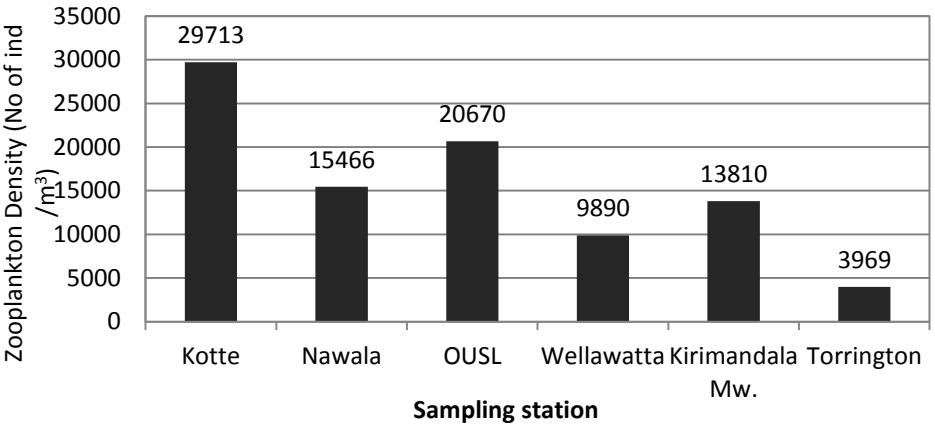


Figure 5. Variation of zooplankton density among six sampling stations during the study period

Correlation Between Monthly Variations of Zooplankton Density and Some Environmental Parameters

Environmental parameter readings obtained from six stations were averaged and tabulated (Table 2) on monthly basis. Highest values recorded for each parameter are highlighted in the table. The highest rainfall was recorded in the month of May. Highest air and water temperature values were recorded in April. Chloride ion concentration was significantly high in both February and July. Dissolved Oxygen content of water has shown a peak value in March and secondly in June.

Monthly variation of overall zooplankton density of Diyawanna Oya was positively correlated with flow rate (r = 0.81), water temperature (r = 0.58), depth (r = 0.47) and dissolved oxygen content (0.26). Graphs in figure 6 have illustrated the pattern of monthly variation of zooplankton density and above mentioned environmental parameters together with their correlation values (r).

Table 2. Monthly variation of some environmental parameters of the study area, Diyawanna Oya (overall view) during the period of Feb – July, 2003.

	Parameter	Feb	Mar	Apr	May	Jun	Jul
1.	Rain fall (mm)	89.3	164	95.9	284.8	181.6	185.7
2.	Air temp (C^o)	31.4	32.33	33.2	33	32.5	31.8
3.	Water temp (C^o)	30.75	31.75	31.88	31.6	31.25	31
4.	Flow rate (ms^{-1})	0.1116	0.1496	0.1573	0.1046	0.0530	0.0762
5.	Water level (m)	0.23	0.35	0.32	0.29	0.37	0.37
6.	Average depth (m)	0.773	0.779	0.733	0.755	0.742	0.700
7.	pH value	6.57	7.35	6.41	6.18	6.65	6.58
8.	Tot. Hardness ($m.mol.l^{-1}$)	0.00031	0.00026	0.00027	0.00028	0.00028	0.00029
9.	Tot. Alkalinity ($m.mol.l^{-1}$)	0.00036	0.00028	0.00022	0.00024	0.00019	0.00023
10.	Cl^- concentration (mgl^{-1})	112.65	45.26	72.42	50.04	64.12	111.90
11.	DO level ($mgdm^{-3}$)	3.12	3.55	2.38	1.45	3.03	2.05

Table 3. Average values of some environmental parameters recorded from six sampling stations of Diyawanna Oya (Feb – July, 2003).

	Location	Mean flow rate (ms^{-1})	Mean water level (m)	mean Depth (m)	pH value	Conductivity (Ms)	DO level ($mgdm^{-3}$)	Cl^- cocent-ration (mgl^{-1})	Alkalinity ($m.mol.l^{-1}$)	Hardness ($m.mol.l^{-1}$)
1.	Kotte	0.0241	0.41	0.645	6.40	65.45	5.47	43.50	0.00019	0.00019
2.	Nawala	0.0957	0.37	0.830	6.64	70.25	2.93	62.11	0.00022	0.00024
3.	OUSL	0.1284	0.34	0.837	6.81	86.40	1.83	88.01	0.00022	0.00031
4.	Wellawatta	0.3059	0.18	0.611	6.61	115.33	2.20	130.76	0.00030	0.00033
5.	Kirimand.Mw.	0.0822	0.32	0.631	6.54	90.33	2.87	65.38	0.00026	0.00028
6.	Torrington	0.0161	0.31	0.928	6.74	96.25	0.29	66.64	0.00035	0.00034

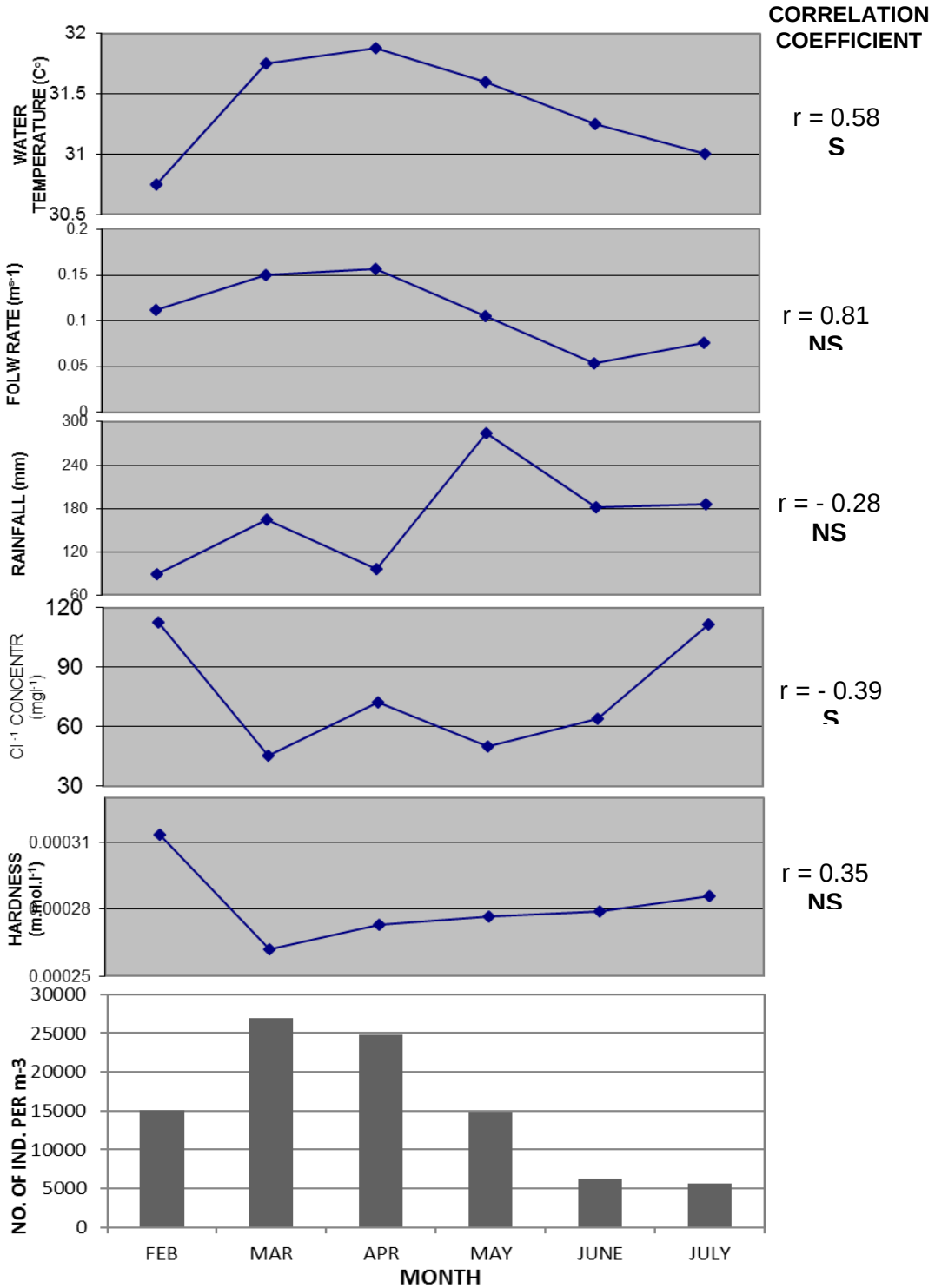


Figure 6. Monthly variation of zooplankton density (No. of ind. /m^3) and its correlation with some environmental parameters recorded from the study area, Diyawanna Oya

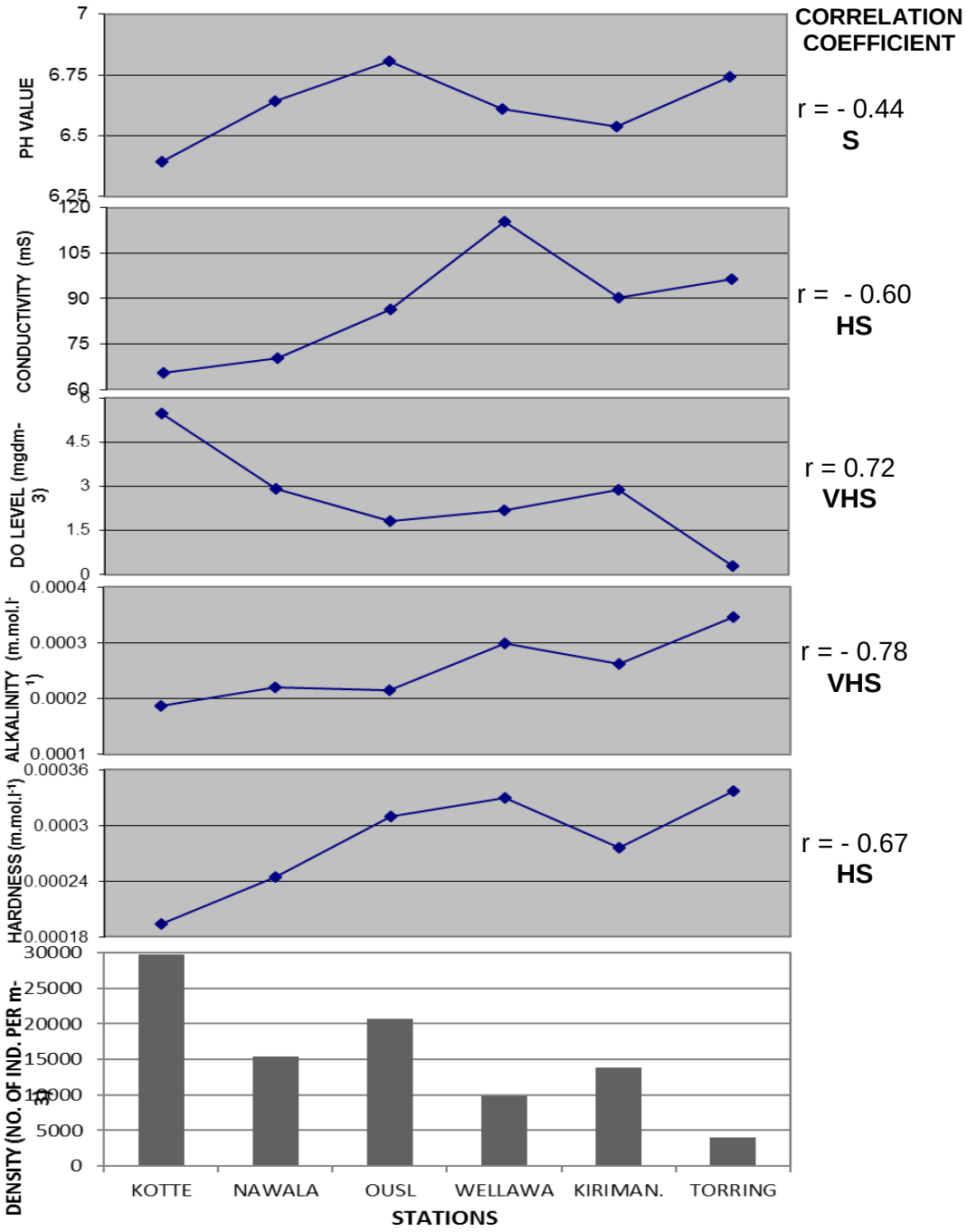


Figure 7. Variation of average zooplankton density (No. of ind. /m^3) in six sampling stations and its correlation (r value) with some environmental parameters recorded from the study area.

Table 4 has given the statistically analysed correlation coefficient values (r) and their level of significance for each and every relationship. Flow rate has shown a Very High Significant Positive Correlation (VHS) with the density variation while water temperature and depth have shown a Significant Correlation (S). Though Dissolved Oxygen Content has showed a positive correlation, it was not a significant relationship.

Table 4. Correlation coefficient (r) between density and some environmental parameters. [VHS – Very High Significant Correlation (r>0.70), HS – High Significant Correlation (r>0.6/<0.74), S – Significant Correlation (r>0.35/<0.59), NS – No Significant Correlation (r<0.35)]

	Relationship	Monthly variation	Significance	Spatial Variation	Significance
1	Density- Depth	0.47	S	-0.29	NS
2	Density - Flow rate	**0.81**	**VHS**	-0.19	NS
3	Density - rainfall	-0.28	NS	_	_
4	Density - Air Temp.	0.32	NS	_	_
5	Density –Water Temp.	0.58	S	_	_
6	Density – Conduct.	0.03	NS	**-0.6**	**HS**
7	Density - pH	0.32	NS	-0.44	S
8	Density - Hardness	0.35	S	**-0.67**	**HS**
9	Density - Alkalinity	0.23	NS	**-0.78**	**VHS**
10	Density - Cl^-	-0.39	S	-0.36	S
11	Density - DO	0.26	NS	**0.72**	**VHS**

Correlation Between Zooplankton Density Variation in Six Sampling Stations and Environmental Parameters

Environmental parameter values obtained from six sampling stations during the study were averaged and given in Table 3. As per values given in the table flow rate, conductivity and Chloride ion concentration values recorded in Wellawatta station were considerably higher than all other stations. A remarkable average Dissolved Oxygen value (5.47 $mgdm^{-3}$) was reported from Kotte station.

When considering their correlation with zooplankton density variation in six stations, it has shown a Very High Significant (VHS) positive correlation with dissolved oxygen (r = 0.72), Very High Significant (VHS) negative correlation with total alkalinity (r= - 0.78), and High Significant (HS) negative correlation with both total

hardness (r = - 0.67) and conductivity (r = - 0.6). Graphs in fig. 7 illustrate clearly the pattern of zooplankton density variation in six sampling stations with some environmental parameter values.

Discussion

Overall zooplankton community in Diyawanna Oya study area was composed of Rotifers (39 species) that represented the highest diversity, Cladocerans (9), Copepods (6), Ostracods (5), Protozoans (2) and some larval forms and minor groups (Tardigrata). Similar results were obtained in Prakrama Samudra by Fernando & Rajapaksa in 1983. They have recorded 32 species of Rotifers, 7 species of Cladocerans, 6 species of Copepods and 4 species of Protozoans etc. Correspondingly in Bolgoda Lake, Wignarajah & Amarasiriwardana (1983) have found that the highest number of species belonged to Phylum Rotifera, and others (Copepoda, Cladocera and Ostracoda) were with lower numbers. From a study conducted in Vortsjarv Lake, Central Estonia in the growing season, has identified 54 metazooplankton species that include with 29 Rotifers, 17 Cladocerans, and 8 copepods have been identified (Haberman & Haldna, 2014) . Another investigation on limnological features and zooplankton assemblage study performed in Funil Reservoir, Rio de Jeneiro, Brazil by Branco e*t al.* (2002) recorded parallel results for zooplankton composition as in 21 Rotifer species, 6 Cladocerans, 3 Copepods and some testate amoeba varieties.

From a recent study carried out by Wickramasinghe, et al. (2012) in Kotte and Kolonnawa wetland, has revealed a total of 12 taxa of zooplankton that composed of 8 Rotifers, 3 Copepods and 1 Cladoceran species. Though their abundance is aligned with this study, their species richness is poor than what we have recorded in 2003. Causes behind above contrast would be due to the drastic changes which happened in wetland land use pattern and the canal system with the development activities commenced in the area by 2005 or may be due the method used for zooplankton sampling. As in this study approximately 1413 Litters of freshwater were filtered through the plankton net to collect zooplankton while it was only 10 Litters by Wickramasinghe, et al. (2012). This hypothesis is further assisted by the study carried out in Lakes of the Northern Coast of Rio Grande do Sul state, Brazil on zooplankton and water quality by Pedrozo & Rocha (2005), where they have filtered 300 litters of water using a suction pump and plankton nets. From that study, 62 taxa were identified, which consisted of by 40 Rotifera taxa, 15 Cladocera

taxa and 7 Copepoda taxa, showing comparatively a high species richness of zooplankton.

Additionally, some studies were carried out in Beira Lake, which were also a part of the Colombo canal system but not directly connected with Diyawanna Oya by several other researchers. It is noteworthy that zooplankton diversity in Beira Lake was relatively lesser than common inland freshwater habitats. During the study conducted by Kamaladasa & Jayatunga (2007) only a total of 10 zooplankton species were found from both South and East Beira Lakes. Among them there were 6 Rotifers, 3 Cladocerans and 1 Copepod species. According to the records of hydro biological investigations done by Costa & De Silva (1969) *Brachionus* sp., *Keratella* sp., *Diaphanosoma* sp., *Diaptomus* sp., Cyclops sp., and crustacean nauplii were the most notable of the Zooplankton, with copepod cyclopoidea.

In the present study, there was a remarkable variation of species diversity within the sampling stations. Higher diversity index values were recorded from Kotte and Nawala, which were influenced by Kotte and Heen marshes. Some species like *Hexartha* sp., *Diaphanasoma* sp. and *Ceriodaphnia* sp. were also commonly found from these stations. However, the most common taxa in Kotte were Copepod adults and nauplii throughout the study period. On the other hand, Torrington which was the least diverse station and heavily affected by domestic pollutants, was the station where *Moina micrura* and *Philodina* sp were the most abundant species recorded. *Moina micrura* is considered which is of the “tolerant” or “benefited” by the organic contamination in the system (Pedrozo & Rocha, 2005). Therefore, high abundance of *Moina micrura* can be an indicator of high level of organic pollution.

Overall density of zooplankton had fluctuated outstandingly throughout the study period. Higher values were obtained just before the commencement of the rainy season. Similar results have been obtained for Rotifer species by Costa & De Silva (1978) in Beira Lake. The maximum number of Rotifers was recorded in the drier months (June and July) or before the monsoon period. According to the observation of Wignarajah & Amarasiriwardena (1983) in Bolgoda Lake, only the populations of nauplii showed peaks with the monsoonal periods, while the rest of the zooplankton population showed higher fluctuations with peaks during the inter-monsoonal periods. The reason behind this is perhaps the ability of Copepods for movement against water flow with their body size and biomass which is comparatively higher and much favourable to withstand

heavy storm water movements which take place in monsoon than other zooplankton groups.

Variation of zooplankton density has shown a significant negative correlation with Chloride ion concentration (Cl^-) level during the study period. This may be due to the inflow of saline water through canals upwardly during the high tidal season probably by June onwards. Wallawatta, OUSL and Nawala were the stations that are directly subjected to this situation. In the months of June and July, density and abundance of zooplankton in these stations had fluctuated. Interestingly the abundance of *Lacane* sp. has increased during these months. Hence, there is opportunity of considering *Lacane* sp. as an indicator of high Cl ion concentration or saline water intrusion.

Monthly variation of zooplankton density had positively correlated with the Flow rate, DO level and water temperature during the six months study period. Mean flow rate, DO values and water temperature were higher in March and April while they were lower in later months. As noted by Schöll & Kiss (2008) the ability of some zooplankton taxa (rotifers) to reproduce in waters with high flow velocities (above 0.4 m/s) is very low, or indeed nil. Lower flow rates in later months may be a result of stagnation of water by obstructing freshwater runoff to the sea and rising of sea water level in the high tidal season. This could have also caused low DO content in water due to lessening of water movements. Temperature was declined due to the variation of weather in the monsoon period, which also has shown some significant positive correlation with density variation in six month. Branco (2002) revealed that some Rotifer taxa such as *Brachionus calyciflorus* and *Euchlanis dilatata* were associated with increasing of water temperature. As per Matsumura-Tundisi et al.(1990) cited by Pedrozo & Rocha (2005) Rotifers are opportunistic organisms whose densities change with temperature in a short time, some of them can adapt to a fast population growth during favourable seasons. Similarly, in the month of February and April, there was a higher density of *Brachionus calyciflorus* and *B. falcatus* mostly with eggs in OUSL and Nawala stations. These were the months, which also recorded high temperatures, and lower rain falls during the study period.

Average density values of zooplankton within six sampling stations also have shown a dramatic variation within the study. It reported a high significant positive correlation with DO level ($r = 0.72$). The highest density of zooplankton as well as the highest DO value were recorded from Kotte station, which is associated with Kotte and

Kolonawa marshes plus the main Diyawanna Oya Lake. In contrast, the lowest density of zooplankton was recorded from Torrington, which also showed lowest average DO value. In some occasions it was noted that there was no fluctuation in that water body. The major reason is that the water column had to be flowed through low elevated area to higher. In such months DO levels were recorded as zero (February, April and May). However, DO values were increased in later months caused by heavy rains, indicating that there is a significant positive correlation between DO level and rain fall. Wickramasinghe, et al. (2012) has observed a similar kind of situation in the study conducted in Kotte and Kolonnawa wetlands. Wickramasinghe has reported a clear differentiation of the density of taxa in flowing and stagnated habitats.

Total alkalinity and hardness of water showed highly significant negative correlation with zooplankton density variation among stations. Torrington, which contained the highest total hardness and total alkalinity values recorded the lowest density of zooplankton. Wallawatta, Kirimandala Mawatha and OUSL stations also obtained highervalues for these environmental characteristics. When considering the species abundance, in stations like Wallawatta and Kirimandala Mawatha, the most commonly occurred species during the period were *Philodina* sp. and Copepod adult stages. From this study, these species can be considered as tolerant species, which are able to withstand such unfavourable conditions.

The study revealed that conductivity, pH and Cl^- concentrations were negatively correlated with density variation along stations. Wallawatta, which is located close to the outfall to the sea, had the highest value of Cl^- concentration and conductivity. This condition is more preferable for planktonic crustaceans like Copepods. As per the results, Wellawatta station was mostly abundant with higher densities of Copepod and some Rotifer sp. such as *Philodina* sp., *Lecane bulla* and *Lecane ungulata*.

Conclusion

From this study, it was revealed that there was a significant variation of zooplankton species composition, diversity, their abundance and density in the period of February to July 2003 and also among six sampling stations of Diyawanna Oya. Some Rotiferan and Cladoceran taxa like *Lacane* sp., *Philodina* sp. and *Moina micrura,* have shown some indicator properties that can be used to monitor some environmental changes of the canal system. Further studies should be carried out based on this hypothesis for better

results. Flow rate had shown a very highly significant (VHS) positive correlation with the monthly variation of zooplankton density. There was a highly significant (VHS) positive correlation between DO content and average density variation of zooplankton in six sampling stations. Simultaneously, there was a high significant (HS) negative correlation with alkalinity, hardness and conductivity. The situation may have been changed by now as the canal system had gone through a rapid development process within the last few years by improving the condition of the canals as well as changes in land use in the surrounding. Also a boat service for visitors and daily passengers was established by the government. There after the canal system was occupied with plenty of mechanical boats. As a result, it may have affected by the effluents released out to the water by the boats. The canal system provides livelihoods and food sources for the community which lives around. Also it plays a major role in balancing the environmental health of Colombo metropolitan, which is the capital city of Sri Lanka. Thus, it is vital to pay more attention on proper maintenance of the canal system considering its ecological value as well as the historical and socio-economical values.

Acknowledgements

The author wishes to express her sincere thank to Dr (Mrs) W. P. N. Chandrananda for her valuable guidance. Also the author highly appreciates the constructive comments and suggestions made by the anonymous reviewers to improve the manuscript.

References

Battish, S. K. (1992). Fresh Water Zooplankton of India. Oxford & IBH Publishing Co. Pvt. Ltd. New Delhi.

Branco, C. W. C., Rocha, M. I. A., Pinto, G. F. S., Gômara, G. A. & De Filippo, R. (2002). Limnological features of Funil Reservoir (R.J., Brazil) and indicator properties ofrotifers and cladocerans of the zooplankton community. *Lakes & Reservoirs: Research and Management*, 7, 87-92.

Costa, H. H. & De Silva, S. S. (1969). Hydrobiology of Colombo (Beira) Lake, I Diurnal variations in Temperature, hydro chemical factors and zooplankton. Bulletin Fisheries Research station, Ceylon, 20(2), 141-149.

Costa, H. H. & De Silva, S. S. (1978). The hydrology of Colombo (Beira) Lake, III : Seasonal fluctuations of plankton. Spolia Zey., 32, 35-53.

Dole-Olivier, M. J. et al. (2000). Lotic microcrustacea. Blackwell science Ltd. Freshwater Biology, 44, 63-91.

Fernando, C. H. (1974). A guide to the freshwater fauna of Ceylon. Supplement 4. Bulletin of the freshwater fisheries research station Ceylon, 25(1& 2), 27-81.

Fernando, C. H. & Rajapaksa, R. (1983). Some remarks on long term and seasonal changes in the zooplankton of Parakrama Samudra. In F. Schiemer (ed), Limnology of Parakrama Samudra, Sri Lanka, Dr W Junk Publishers.

Haberman, J & Haldna, M. (2014). Indices of zooplankton community as valuable tools in assessing the trophic state and water quality of eutrophic lakes: long term study of Lake Vortsjarv. *Journal of Limnology, 73(2)*, 263-273. doi:http://dx.doi.org/10.4081/jlimnol.2014.828

Kamaladasa, A. I. & Jayatunga, Y. N. A. (2007). Composition, density and distribution of zooplankton in south west and east lakes of Beira Lake soon after the restoration of South West Lake. *Ceylon Journal of Science (Biological Sciences),* 36(1), 1-7.

Mendis A. S. & Fernando, C. H. (1962). A guide to the freshwater fauna of Ceylon. bull. Fisheries research station Ceylon.

Neale, J. W. (1984). The freshwater Ostracoda. In C. H. Fernando (ed), Ecology and biogeography in Sri Lanka, Dr Junk Publishers.

Pedrozo, C. De S. & Rocha, O. (2005). Zooplankton and water quality of lakes of the Northern Coast of Rio Grande do Sul State, Brazil. *Acta Limnol. Bras., 17(4),* 445-464.

Rajapaksa, R. & Fernando, C. H. (1984). Freshwater zooplankton. In C.H. Fernando (ed), Ecology and biogeography in Sri Lanka, Dr Junk Publishers.

Ricci, C. & Balsamo, M. (2000). The biology and ecology of lotic rotifer and gastrotrichs. *Freshwater Biology, 44*, 15-28.

Schöll, K. & Kiss, A., (2008), Spatial and temporal distribution patterns of zooplankton assemblages (Rotifera, Cladocera, Copepoda) in the

water bodies of the Gemenc floodplain (Duna-Dráva National Park, Hungary). *Opuscula Zoologica Budapest, 39*, 65–76.

Wetland Site Report - Colombo Flood Detention Areas. (1995). Wetland Conservation Project, Sri Lanka, Central Environmental Authority.

Wickramasinghe, D. D., Abeygunawardena,R. & Hettiarachchi, M. (2012). Community structure of zooplankton in two different habitats of Kotte Kolonnawa Wetland, Sri Lanka. *International Journal of Environmental Sciences, 3(3),* 965-975.

Wignarajah, S. and Amarasiriwardana, P. (1983). Some aspects of the limnology of Bolgada Lake II, Sri Lanka: 1 composition and seasonal fluctuation of zooplankton. *Journal of Nal. Sc. Coun. Sri Lanka. 11(2)*, 255-268.

Received: 21-4-2015 Revised: 31-8-2015 Accepted: 17-9-2015

OUSL Journal (2015)
Vol. 9, (pp. 83-96)

An Exploration of Patients' Experiences of Mechanical Ventilation

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Abstract

Mechanical ventilation is a part of the most frequently used technological treatments in Intensive Care Units (ICU) which facilitates the gas exchange to the lung in impaired breathing situations. However, it is a stressful and frustrating experience for patients. Therefore, the aim of this study is to explore the experiences of mechanical ventilation of patients admitted to ICUs in the National Hospital of Sri Lanka, the Teaching Hospital in Peradeniya and the District General Hospital in Nuwara-Eliya.

The purposive sample of 15 mechanically ventilated patients was recruited for this phenomenological study to collect the data during one month by using semi structured interviews. Data was analyzed by thematic analysis method. A total of 11 sub themes and three main themes were identified. All these themes are reflections of intra personal, extra personal and interpersonal experiences of the patients. The feeling of inner suffering such as pain, dependency, fear and anxiety, thirst, noise level, cold environment and nightmares were identified while on mechanical ventilation. Further, the body intolerances such as feelings of congested secretions, experiences of suctioning, inspiration by ambu and chest physiotherapy were reported. Patients further noted that an inability to speak, diverse way of communication and inability to express feelings as being more stressful and frustrating. Mechanically ventilated patients tolerate many stressors during mechanical ventilation at moderate to high levels of distress. Hence exploring experiences of mechanical ventilated patients can be used to provide them with better care that will reduce their stressors when they are on a ventilator.

Keywords; Patients' experiences, mechanical ventilation, ventilator

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Introduction

Mechanical ventilation is a supportive therapy which facilitates the gas exchange of the lung with the use of mechanical apparatus when there are impaired breathing situations of the patients. It is the most widely used life supportive technique in Intensive Care Units (ICUs) in hospitals all over the world (Brochard, 2003). Despite the dramatic development in technology of the mechanical ventilator, it is still described as a stressful and frustrating experience for patients (Granja et al., 2005). Since the early days, the use of the mechanical ventilator named as the iron lung machine, to the modernized ventilator, studies have been conducted on patients' experiences of mechanical ventilation. Many of them highlighted that experiences of mechanically ventilated patients are very stressful. While on the mechanical ventilator most patients were conscious, but paralyzed with medicine. Therefore, mechanically ventilated patients undergo various experiences, including pain, lack of peace, fear, anxiety, lack of sleep, feeling tense, and the inability to speak or communicate, which are unique to each (Arabi & Tavakol, 2009; Guttormson, 2011; Rotondi *et al.*, 2002).

According to the literature, there had been many studies on intrapersonal, extra-personal, and interpersonal experiences of patients in ICU. A phenomenological study conducted by Arabi and Tavakol (2009) in Iran, found some of intra personal experiences such as coping with the present condition, changes in self-image, loneliness, pain and lack of peace, nightmares, unfamiliar environment and changes in physiological needs. The authors concluded that the mechanically ventilated patients' experiences were unpleasant (Tavakol, 2009).

A prospective cohort study of Rotondi *et al*, (2002) revealed that two third of the sample were strongly associated with experience of pain, fear, anxiety, and lack of sleep and feeling tense. A phenomenological study conducted by Lykkegaard, and Delmar (2013), unveiled that dependency had been a difficult experience related to mechanical ventilation. Moreover, Johansson, Bergbom and Lindahl (2012), indicated the need to reduce disturbing and unexpected sound and noise around the critically ill. Furthermore, Granja *et al.*, (2005) conducted a study in ten Portuguese ICUs. The result revealed that 64% of patients experienced pain and 51% of patients reported bad experience of dreams and nightmares.

Many studies done worldwide on mechanical ventilated patients highlighted that their discomfort and extra-personal experience are

more extensive. The study of Arabi and Tavakol (2009) indicated that their extra personal experience includes difficulties with suctioning, change in position, chest physiotherapy, personal health, and change in sleep pattern, weaning, inspiration by ambu, and vital dependency to intra venous medication as important. Studies from both developing countries and developed countries stated extra-personal experiences as stressful. Granja, *et al.*, (2005) found that 81% of patients reported that tracheal tube aspiration is more stressful and 75% of patients reported difficulties about the nasal tube.

Interpersonal experiences include communication deprivation, communication by writing, one-way verbal communication and touch which the patients experienced toward physicians, nurses and their accompanying persons (Arabi & Tavakol, 2009; Khalaila *et al*; 2011; Patak, *et al.*, 2005).

Communicating with others is a main difficulty with ventilated patients and a cross sectional correlation study conducted by Khalaila *et al*, (2011) found that fear and anger were presented in relation to difficulty in communication. The authors have concluded that patients treated with mechanical ventilation experienced a moderate to extreme level of psycho emotional distress because they cannot speak and communicate their needs. Further, Patak, *et al.*, (2005) conducted a study and found that 62% of patients reported a high level of frustration in communicating their needs while being mechanically ventilated. Rotondi *et al.* (2002) and Tosun et al. (2009) reported the inability to communicate and the difficulty to be understood had been described as uncomfortable stressful experiences of ventilated patients.

The literature provided important insight into the patients' experiences of mechanical ventilation in relation to most of the countries. However, in the Sri Lankan context, literature related to patients' experiences of mechanical ventilation has not been identified. As Sri Lanka is a developing country with limited resources and specific cultural groups, their experiences of mechanical ventilation may be significant. Therefore, it is of paramount importance to explore the patients' experiences on this phenomenon and how they perceive and discuss their experiences related to mechanical ventilation in relation to the Sri Lankan context.

Methodology

A descriptive phenomenological method exploratory descriptive was utilized in this study to explore the patients' lived experiences of mechanical ventilation. Since this qualitative approach is important to understand how people make sense of their experiences (Merriam, 2009), it was used as a powerful tool to understand subjective experiences (Hancock *et al.*, 1998) of mechanically ventilated patients and gaining their insights (Lester, 2007). It is also important to recognize how people perceive and talk about their experiences (Marriam, 2009). Since the aim of this research is to explore the patients' experiences of mechanical ventilation, a qualitative research approach rather than a quantitative research method has been selected to explore the meaning, actions and interpretations of the patients' experiences of mechanical ventilation in relation to the Sri Lankan context.

Study Settings and Participants

The study was carried out in ICUs of three hospitals, namely the National Hospital of Sri Lanka, Teaching Hospital in Peradeniya and District General Hospital in Nuwaraeliya. These units have a nurse to patient ratio of one to one and all units use modern ventilators such as Centiva, Bennett 760, Bennett 840 and Newport. The purposive sample of 15 mechanically ventilated patients was recruited to collect the data during a one-month period which included eight females and seven male participants. All the participants were above 18 years and below 65 years old, who were mechanically ventilated patients for a minimum of 24 hours. Their ability to orient a person, place, time and the ability to speak Sinhala, Tamil or English languages were considered. Willingness to discuss feelings; competency and ability to sign an informed consent were also considered in this study as they were able to share their experiences related to mechanical ventilation. Any patient who had a tracheostomy or who was hemo-dynamically unstable at the time of the interview was excluded from the study.

Ethical Consideration

Ethical approval for the study was granted by the Ethical Review Committee of the National Hospital of Sri Lanka and Ethics Review Committee of the Faculty of Medicine at the University of Peradeniya and administrative clearance was also obtained from the relevant authorities. The patients were informed that their participation was completely voluntary and the ability to withdraw from their

participation at any time without any consequences was left open. All participants were kept fully informed of the purposes, benefits, potential risks of the study before taking their informed consent.

Data Collection

Data was collected through face to face interviews conducted by co-authors based on a pre- formulated topic guide. Rice and Ezzy (1999) pointed out that a guided theme list or inventory of topics helps to cover all relevant issues that are required for investigating. On the other hand, this theme list did not have direct questions but it acted as a reminder regarding the topics that needed to be considered while interviewing. Supplementary questions such as "What; How; and Can you….." were added in order to encourage participants to describe their experiences in depth (Burns & Grove, 2005). Fifteen participants were interviewed in their mother tongue individually. Every interview lasted for 40 to 50 minutes on average and was recorded on audio tapes with the prior permissions of the participants.

Data Analysis

The interviews were recorded on audio files, transcribed to verbatim, and de-contextualized to a text for analysis. Data analysis was made according to the method of qualitative thematic analysis described by Hycner, (1985). For this, several steps of Braun and Clarke (2006) have been followed such as being familiar with the data, extracting keywords, generate initial codes, clustering them to units of same meaning searching for themes, reviewing themes, defining and naming themes and producing the report. To maintain trustworthiness of the study data, the four steps credibility, transferability, dependability and conformability of the evaluative criteria model highlighted by Guba and Lincoln (1985) were utilized.

Findings

In the process of analysis, through the participants' experiences, three major themes were identified as "feeling of inner suffering", "body intolerance", and "disrupted interactions" from overall generated eleven sub themes. It was presented as a model which illustrates the patients' experiences of mechanical ventilation (Figure1).

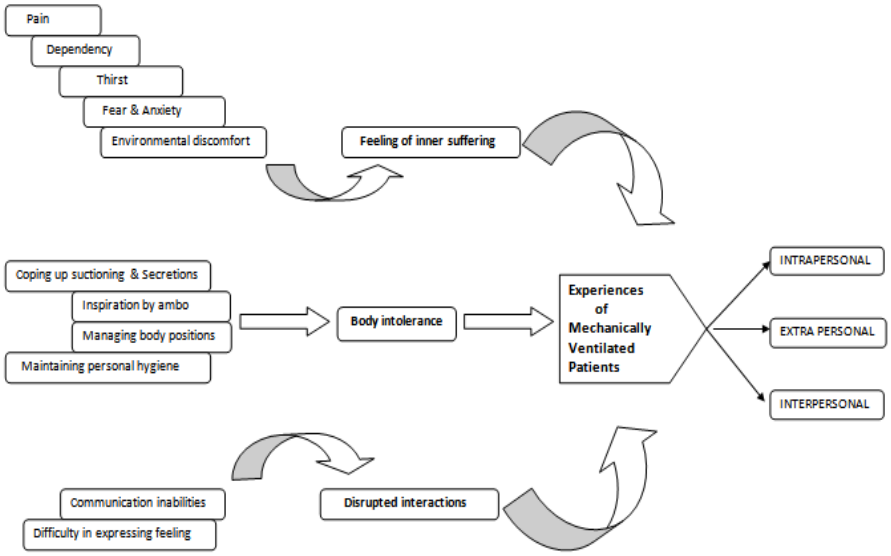

Figure 1. Mechanically ventilated patients' experiences and its influences upon them

Feeling of Inner Suffering

Even the main purpose of utilizing therapeutic support of the mechanical ventilator is to ensure the survival of the patient from life threatening conditions, while on the ventilator the majority of the patients are conscious, so that they can hear, feel everything which they are facing, except an inability to express their feelings and emotions. According to the participants, they had experiences of pain during mechanical ventilation and some had a sore throat due to the inserted endotracheal tube into the airway. Back pain was also a common discomfort due to the inability of moving their body for a longer period. Participant I highlighted that as;

> *It was pricking like a mass of iron strings. When the tube was removed, I sort of regained life. When turning to this side, it pricks. When on supine position, it is ok. I was unable to turn, it was unbearable. The back was irritating. I just obeyed the instructions to turn. I continued to turn as instructed, even though it pricked* (Interview 09, participant I).

While on the mechanical ventilator, most patients are kept physically paralyzed so that it is limiting their activities of daily

living. Further, it was highlighted that they cannot do activities without any other persons' support.

> *There was a back pain. Do you remember Miss, I asked you to help me with a pillow at the back. A severe pain came; I couldn't turn* (Interview 06, participant F).

It is a universal truth that patients, who undergo unfamiliar therapy, commonly confront the feelings of fear and anxiety. This was also relevant to mechanically ventilated patients and they also encountered fear and anxiety as a major difficulty. This escalates with the lack of ability to express their feelings and emotions. Such feelings related to their fear and anxiety were expressed as follows;

> *I am waiting to see the face of the little one. I saw the elder daughter. I want to see the younger daughter too. How many days were they without me? I remembered all my children. I was afraid and disappointed. When the tube was taken away it was comfortable and I was happy* (Interview 09, participant I).

While on the mechanical ventilator, it is difficult to take food and drink since the apparatus invades the whole mouth cavity of the patient. With this circumstance mechanically ventilated patients mainly endure the feeling of thirst as they do not have the ability to drink water while connected to the mechanical ventilator. They expressed this feeling of thirst as a major problem.

> *Thirst was there, I had an unquenchable thirst. I wanted to drink a pot of cold water. I felt like drinking cold water first. Lips were dry and when they wet my lips, it was so comforting* (Interview 04, participant D).

The environment of an ICU where patients are kept mechanically ventilated is an unruffled place with less human interactions. However, due to the devices that are used to maintain lives of critically ill patients, it is surrounded with electronic noises most of the time all over the day. This is an ear –splitting situation for the patients who are conscious but kept on a bed alone without interaction with their relatives. Therefore, almost all participants described that the noise in the ICU as a bad experience and that they cannot sleep properly. Nightmares were common among some patients. Nevertheless, they highlighted that those sounds of alarms negatively affected their comfort. Participants also commented on the cold environment as unbearable.

> *The alarm was bit irritable. It was intolerable at times. The AC was also unbearable. I have phlegm, that's why I think* (Interview 04, participant D).
> *I couldn't sleep from the day I came. If I sleep, I feel as if the tube is going in; going in and getting stuck inside. I couldn't sleep troubled by that fear* (Interview 09, participant I).

Patients expressed their feelings about the cold environment. All ICU are generally air conditioned. However most of the time patients cannot tolerate the cold as they are always exposed to cold temperature continuously. One of the patient highlighted that he had secretions due to the air conditioned environment.

> *The* air condition *was unbearable. I felt very severe cold but I cannot communicate and feeling very sad. I think I have phlegm, because of this severe cold.* (Interview 07, participant G).

All these common endeavors disclose the major concept or the theme of "feeling of inner suffering" and this reveals the participants intrapersonal suffering while on the mechanical ventilator.

Body Intolerance

Under the mechanical ventilator support, patients cannot spit out secretions and saliva and it is congesting within their air way and the mouth cavity. This has to be removed with the help of others.
Some participants expressed that the feelings of congested secretions and experience of suctioning was painful and irritating whereas some had positive feeling on inspiration by ambo apparatus and chest physiotherapy.

> *The tube is painful. I felt, I had committed grave sins. I was almost dying. I thought, it was ok to die. When phlegm was removed, I felt a piece was going in. I questioned the existence of God. If they gave me air, it was ok. I felt like throwing the tube away (Interview 09, participant I).*

> *I felt unable to breath, but when phlegm was removed, it was comfortable (Interview 08, participant H).*

> *When Phlegm came out, that pressing on the chest was ok (Interview 06, participant F).*

With the restricted activities, mechanically ventilated patients have to depend on others, especially on the nurses who are providing care for them. When the caring nurse is away from the patient they have to wait to change their position, and to fulfill essential needs like

maintaining personal hygiene. This was accepted by the participants as a difficult for them.

> *Alas! I was unable to turn; I needed another person's help to turn. It was difficult move my body alone* (Interview 02, participant B).

These incidents emphasized the extra personal experiences as their "body intolerance" happened due to the external environment. It was revealed that the external environment of the patient also influenced the mechanically ventilated patients.

Disrupted Interactions

While in the ventilator, patients cannot also talk and communicate with others due to the inserted mouth piece which helps them to breathe in and out. Even though this is essential for their life saving, all participants reported communication difficulties as moderate to extremely stressful. Participants were worried about their inability to speak, not being_understood and reported that they communicated with others by using hands.

> *By hitting the bar of the bed, I tried to communicate as I couldn't talk with these machines. Most of the time nurses cannot understand what I want to tell. When feel the barrier to communicate, it was severe stress (*Interview 01, participant A).

Participants also worried about the inability to express their feelings. They highlighted that it was a big problem and a negative experience related to mechanical ventilation.

> *I couldn't communicate; I just enjoyed looking at the faces of my loved ones. It was a very sad situation* (Interview 07, participant D).

Likely, through the analysis of participants' feelings, it can be seen that the patients who were in a mechanical ventilator encountered a very unpleasant experience.

Findings of the present study reveal that the patients had different experiences of mechanical ventilation during their ventilated period. Most of them had experienced stress and suffering due to various reasons. Findings shows patient's intrapersonal experiences like pain, dependency, thirst, fear and anxiety as the most common experiences of ventilated patients. Further, noise level, cold environment and nightmares were other unpleasant experiences of mechanically ventilated patients. Secretions and suction, inspiration

by ambu and chest physiotherapy were extra personal experiences most of the mechanically ventilated patients faced. Inability to speak, way of communicate and express feelings was an important interpersonal experience of mechanically ventilated patients.

Discussion

The findings of the present study identified that the patients had many experiences of mechanical ventilation during their ventilated period. In the process of analysis, three major themes were identified as feeling of inner suffering, body intolerance, and disrupted interactions from overall generated eleven sub themes.

Participants expressed that experiences related to mechanical ventilation negatively affected their comfort during mechanical ventilation. The study revealed that the participants had experiences of pain and sore throat related to the endotracheal tube and they pointed out back pain due to the inability to move their body. Both Sri Lankan and some Iranian patients complained of pain in throat and general pain (Arabi & Tavakol, 2009). It may be due to the lack of changing position (Tosun et al., 2009). Dependency is reported as the most important source of stress in mechanical ventilation in this study as well as other studies (Lykkegaard & Delmar, 2013; Tosun *et al.*, 2009). It may be due to the patients' inability to convey their real feelings with an endotracheal tube and their lack of experience in nursing care management.

Moreover, participants expressed that the fear and anxiety were other stressful factors during mechanical ventilation. Similar results were found in the studies of Chlan and Savik (2011), Eng, Hassan, Saidi and Zulkfli (2008), and Patak, *et al.* (2004). It could be due to the fact that nurses and other health care workers neglect the patients' communication efforts (Patak, *et al.*, 2004). In the study, the patients expressed their feelings about noise level and cold environment in the ICU as being more stressful, same as in Sweden (Johansson, Bergbom & Lindahl, 2012). It might be due to the unfamiliar environment. Moreover, nightmares were highlighted as the most discomforting factor not only in Sri Lanka but also in Iran (Arabi & Tavakol, 2009). It might be due to the fear of patients and not receiving enough information about their conditions by health care workers.

The study revealed that the experiences occurred due to the functions carried out by others or extra personally in relation to mechanical ventilation such as feelings of congested secretions,

experiences of suctioning, inspiration by ambu and chest physiotherapy. Participants reported that such experiences were both positive and negative. In the study of Arabi and Tavakol (2009) that suctioning was difficult and stressful for the ventilated patients. Participants expressed that feelings of secretions and experience of suctioning were painful and irritating as reported both in Sri Lanka and in Netherlands (Leur, Zwaveling, Loef & Schans, 2003; Tosun *et al.*, 2009). Furthermore, participants had both positive and negative experiences about the inspiration by ambu and chest physiotherapy same as in Iran (Arabi & Tavakol, 2009). They disclosed that the procedure was helpful and provided relief in the sense that it made their breathing easier after the secretions had been removed. While others expressed that the procedure of removing secretions produced pain and discomfort and therefore, they would rather not have it (Arabi & Tavakol, 2009; Rotondi *et al.*, 2002). This may be due to the air hunger and fear of the participants (Rotondi *et al.*, 2002).

The study has found the communication barrier as a major problem for mechanically ventilated patients. Participants further noted the inability to speak, diverse ways of communication and inability to express feelings as being more stressful and frustrating. Participants highlighted the inability to speak and not being understood as stressful or difficult same as in Portugal (Granja *et al.*, 2005). It might have happened due to health care workers being sometimes too busy and do not spend sufficient time attempting to understand patients' modes of communication (Patak, *et al.*, 2004).

When considering the overall present study findings, participants had stressful and frustrating intra personal, extra personal and interpersonal experiences during mechanical ventilation. Participants expressed unpleasant and uncomfortable feelings while receiving mechanical ventilation.

Conclusions

The findings of this study focused to determine the experiences of patients on mechanical ventilation in ICUs. It has shown that they were associated with negative experiences with mechanical ventilation. Pain, dependency, fear and anxiety, thirst, noise level, cold environment and fear from sleep were described as uncomfortable and stressful intrapersonal experiences which patients suffered during mechanical ventilation. Furthermore, participants showed feeling of clogged secretion and difficulties with

airway suction, inspiration by ambu, and chest physiotherapy as moderately discomforting. Participants expressed moderate to high levels of distress in trying to communicate their needs during mechanical ventilation. Understanding the real lived experiences of the patients leads to expand the knowledge of the health care workers, especially nurses and it will help to minimize patients' unpleasant experiences while they are on a ventilator.

Acknowledgements

We would like to express our deepest appreciation for all those who participated in this study including the participants, researchers and the supervisors. A special gratitude goes to the Ethical Review Board of the National Hospital of Sri Lanka and the Ethics Review Committee at the Faculty of Medicine at the University of Peradeniya.

References

Arabi, A., & Tavakol, K. (2009). Patient's experiences of mechanical ventilation. Iranian Journal of Nursing and Midwifery Research, 14(2).

Boyce, C., & Neale, P. (2006). *Conducting in-depth interviews: A guide for designing and conducting in-depth interviews for evaluation input* (pp. 3-7). Watertown, MA: Pathfinder International.

Brochard, L. (2003). Mechanical ventilation: invasive versus noninvasive. European Respiratory Journal, 22 (47 suppl), 31s-37s.

Braun, V. & Clarke, V. (2006). Using thematic analysis in psychology. Qualitative Research in Psychology. 3: 77-101

Burns, N. & Grove, S.K. (2005). *The practice of nursing research: conduct, critique, and utilization.*(5th ed.). St Louis: Elsevier Saunders.

Chlan, L., & Savik, K. (2011). Patterns of anxiety in critically ill patients receiving mechanical ventilatory support. Nursing research, 60(3 Suppl), S50.

Ho, S. E., Hassan, H., Saidi, S., & Zulkfli, S. (2008). Recollections Expressed by Mechanically Ventilated Patients of Intensive Care Unit (ICU), Hospital Universiti Kebangsaan Malaysia (HUKM). Medicine & Health, 3(1), 46-53.

Granja, C., Lopes, A., Moreira, S., Dias, C., Costa-Pereira, A., & Carneiro, A. (2005). Patients' recollections of experiences in the intensive care unit may affect their quality of life. Critical Care, 9(2), R96.

Guba, E. G. (1981). Criteria for assessing the trustworthiness of naturalistic inquiries. *ECTJ*, 29(2), 75-91.

Guttormson, J. L. (2011). *Patients' recall and evaluation of Mechanical Ventilation: Impact of Sedation* (Doctoral dissertation, University of Minnesota).

Hancock, B., Ockleford, E., & Windridge, K. (1998). *An introduction to qualitative research.* Nottingham: Trent focus group.

Hycner, R. H. (1985). Some guidelines for the phenomenological analysis of interview data. Human studies, 8(3), 279-303.

Johansson, L., Bergbom, I., & Lindahl, B. (2012). Meanings of being critically ill in a sound-intensive ICU patient room-A phenomenological hermeneutical study. *The open nursing journal*, *6*, 108

Khalaila, R., Zbidat, W., Anwar, K., Bayya, A., Linton, D. M., & Sviri, S. (2011). Communication difficulties and psychoemotional distress in patients receiving mechanical ventilation. American Journal of Critical Care, 20(6), 470-479.

Lester, S. (2007). An Introduction to phenomenological research. Retrieved from http://www.sld.demon.co.uk/resmethy.pdf

Van de Leur, J. P., Zwaveling, J. H., Loef, B. G., & Van der Schans, C. P. (2003). Patient recollection of airway suctioning in the ICU: routine versus a minimally invasive procedure. Intensive care medicine, 29(3), 433-436.

Lincoln,Y. S., & Guba, E. G. (1985). Naturalistic inquiry. Beverly Hills, Calif: Sage.

Lykkegaard, K., & Delmar, C. (2013). A threat to the understanding of oneself Intensive care patients' experiences of dependency. Int. J Qualitative Stud Health Well-being, 2013; 8: 20934.

Merriam, S. (2009). *Qualitative research: A guide to design and implementation*. San Francisco, CA: Jossey-Bass.

Patak, L., Gawlinski, A., Fung, N. I., Doering, L., & Berg, J. (2004). Patients' reports of health care practitioner interventions that are related to communication during mechanical ventilation. *Heart & Lung:* The Journal of Acute and Critical Care, 33(5), 308-320.

Rice, L., & Ezzy, D. (1999). *Qualitative research methods: A health focus*. South Melbourne: Oxford Press.

Rotondi, A. J., Chelluri, L., Sirio, C., Mendelsohn, A., Schulz, R., Belle, S., & Pinsky, M. R. (2002). Patients' recollections of stressful experiences while receiving prolonged mechanical ventilation in an intensive care unit*. Critical care medicine, 30(4), 746-752.

Tosun, N., Ayla, Y. A. V. A., Ünver, V., Akbayrak, N., & Hatipoğlu, S. (2009). Experience of Patients on Prolonged Mechanical Ventilation: A Phenomenological Study. Turkiye Klinikleri Journal of Medical Sciences, 29(3), 648-658.

Received: 20-5-2015 Revised: 29-9-2015 Accepted: 06-10-2015

OUSL Journal (2015)
Vol. 9, (pp. 97-111)

Phytoremediation Potential of *Lemna minor* for Removal of Cr(VI) in Aqueous Solution at the Optimum Nutrient Strength

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Abstract

Toxic heavy metal pollution of water and soil is a major environmental concern for which conventional remediation approaches do not provide an appropriate solution. Phytoremediation, which involves removal of pollutants from water and soil through plants, is of low cost and environmentally friendly. In this study, the phytoremediation potential of *Lemna minor* for the uptake of Cr(VI) at the optimum nutrient strength for Cr(VI) uptake was investigated. Capacity assessment for chromium absorption by *Lemna minor* was carried out for 7 days at different levels of chromium concentrations. The time required for significant absorption of chromium was estimated in a time course experiment by growing *Lemna minor* in 3 mg/L chromium solution in which the plant showed no toxicity. Plant samples were harvested at 24 hour intervals for 5 days and wet weight was obtained to determine relative growth; the dried samples were analyzed for chromium using Atomic absorption spectrophotometer. Plant growth decreased significantly with increasing concentration of chromium in the nutrient solution and chlorophyll content (greenness) was also affected. Maximum uptake of chromium (5.8×10^3 µg/g dw) was at 8 mg/L in ambient solution. However, the bio-concentration factor (BCF) decreased with increasing chromium in the ambient solution. The BCF was 1000 for chromium up to 3 mg/L. In the time course experiment, growth of *Lemna minor* and chromium accumulation increased significantly with time up to the 3rd day (3119 µg/g dw). These results suggest that *Lemna minor* is an extreme accumulator of chromium and could be considered for chromium (VI) removal from waterways.

Keywords: Phytoremediation, *Lemna minor*, chromium (VI).

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Introduction

Rapid urbanization, industrialization and over use of fertilizers in agricultural practices have resulted in serious environmental pollution in Sri Lanka. Textile, paper, tannery, metal finishing food and beverage industries and agricultural runoff contribute most to water pollution. There are standards for discharge of effluent in Sri Lanka. However, effluents are discharged into shore waters, lagoons and estuaries with little or no treatment (CZMP 2004).

Contamination of aquatic systems by heavy metals is a serious environmental concern. Heavy metals, unlike organic pollutants, are not degraded by chemical or biological processes. Thus, they persist a long time in the environment and pose a serious health hazard on living organisms. Chromium is one such contaminant released into the environment due to its heavy use in the dyes and pigments, textile, electroplating, wood processing and tanning industries. In nature chromium exists in two stable oxidation states, trivalent and hexavalent. Chromium is biologically inactive in the metallic state. Organisms weakly absorb trivalent chromium, but Cr (VI) is more toxic and highly soluble in water (Chandra and Kulshreshtha, 2004) and it is very harmful to human health as it is carcinogenic. Chronic chromium toxicity causes cancer in the respiratory tract and lungs (Zayed and Terry 2003).

Traditional technologies such as chemical reduction, precipitation and ion exchange to remove heavy metals are often ineffective or very expensive. Phytoremediation has been accepted widely for its potential to clean up polluted sites. It can be defined as the use of plants to remove or sequester hazardous contaminants from media such as soil, water and air. Plants species are selected for phytoremediation based on their potential to accumulate metals, their growth and yield and depth of their root zone. This ability can be used to remove heavy metals in the contaminated sites. Advantages of phytoremediation over traditional treatments include lower cost, ease of monitoring plants, and possibility of the recovery and re-use of valuable metals (phytomining); it is also environmentally friendly.

Aquatic plants are known to absorb and accumulate heavy metals (Kamel 2013 and Aisien *et.al*. 2010). In this study *Lemna minor* which is a floating aquatic plant covering the surface of a water body as a mat, was investigated, for its ability to remove chromium from aqueous medium. It has an average lifespan of 5-6 weeks and a production rate of 0.45 fronds per day, doubling its mass in 2-3

days (Isaksson *et al.* 2007). Its small size and rapid growth rate make it a potentially useful tool for phytoremediation.

Materials and Methodology

Stock chromium solution (1000 mg/L) was prepared by dissolving Analytical Reagent grade $K_2Cr_2O_7$ in distilled water. Hoagland nutrient solution was prepared according to Hoagland and Arnon (1950). Total chromium content in the effluent was determined by using Atomic Absorption Spectrophotometer (GBC 932AB plus). The pH of the test solution was adjusted to pH 6 which is the optimal pH for growth of *Lemna minor* (Isaksson *et al.* 2007) using conc. HNO_3 and conc. NH_4OH. The pH meter (OHAUS -STARTER 3000 bench pH meter) was used to measure the pH of the solution.

Lemna minor was collected from Boralesgamuwa Lake, Kesbewa Lake, Attidiya marshy land and Diyawanna Oya in the Colombo district. Plants were rinsed with tap water to remove any epiphytes and insect larvae growing on the plants. Plants were acclimatized for 3-7 days in the green house in a large fiber glass tank containing fresh water.

Optimum nutrient strength

In order to find the optimum strength of nutrient solution for the uptake of chromium by *Lemna minor*, the aquatic plants were grown in solutions of varying concentration of chromium at different strengths of Hoagland nutrient medium**.** The experiment was carried out for eight days (Zayed et al. 1998). One experimental set-up with zero metal concentration served as control. Aged water (about 25 ml) was added to compensate for water loss through plant transpiration and evaporation. During the experiment morphological changes were observed. After 8 days of hydroponic culture, the plants were harvested, rinsed twice in distilled water for two minutes, in 20 mM EDTA solution for five minutes and then finally rinsed twice with distilled water for two minutes to remove any Cr on the plant surface (Gothberg *et al.* 2004).

The plant biomass was air dried for six hours and oven-dried at 60 ^{o}C for 24 hours (Radojevic and Baskin, 1999) and ground using a mortar and pestle. The ground samples were placed in clean glass bottles and dried again for 24 hours at 60 ^{o}C. After drying, the bottles were sealed and allowed to stand in a dry and cool place. The powdered plant biomass was dried in a crucible at 105 ^{o}C to

constant weight and prepared for analysis for Cr by acid digestion according to Hoenig *et al.* 1998.

Absorption capacity assessment

Test solutions containing different concentrations of Cr(VI) at the optimum strength of 10% of Hoagland nutrient medium as found in the previous experiment were prepared. Black plastic basins were filled with 2-liter test solutions. The pH of the solution was maintained as 5.8 – 6.0. The aquatic plants were carefully blotted on filter paper and their initial wet weight was recorded and introduced into the test solution. The experiment was run in triplicate for seven days (Leblebici and Aksoy 2011). One experimental set-up with zero metal concentration served as control. Aged water (about 25 ml) was added every day to compensate for water loss through plant transpiration and evaporation. After seven days, the plants were harvested and rinsed as described previously to remove any Cr on the plant surface.

The Relative growth (R.G) of the plant species was calculated as follows (Lu *et al.* 2004).

$$R.G = \frac{\text{Final wet weight}}{\text{Initial wet weight}}$$

Bio Concentration Factor (BCF) which is a useful parameter (Lu *et al.* 2004) to evaluate the potential of plants for accumulating metals was calculated as follows.

$$BCF = \frac{\text{Concentration of metal in plant tissue}}{\text{Initial concentration of metal in external solution}}$$

The plant biomass was prepared for Cr analysis by acid digestion according to Hoenig *et al.* (1998).

Time course experiment

The aquatic species were collected from the fresh water- holding tank and their initial wet weight was recorded. From the capacity assessment experiment it was found that *L. minor* had the capacity to accumulate large quantities of Cr in solutions containing Cr (VI) of initial concentration up to 3.01 mg/L without showing any toxicity symptoms. The plants were cultured in 500 ml of 3.01 mg/L Cr(VI) solution containing10% of Hoagland nutrient solution for five days as the plants started to show chlorosis on the 5th day in the experiment to determine the optimum nutrient strength. The pH of

the test solution was 5.9-6.2. The experiment was run in triplicate. One experimental set up with zero metal concentration served as control. The Aged water was added every day to maintain water level. Plant biomass and test solution in each experimental set up were withdrawn at 24 hours intervals for five days, for analysis.

The data obtained (in three replications) was analyzed by one – way analysis of variance (ANOVA) to determine the significance of differences between the pairs of means. The differences were statistically significant when P-value was less than 0.05. Tukey 95% Simultaneous confidence intervals test was done to determine which mean values were significantly different from the others.

Results and Discussion

Optimum nutrient strength

The morphological change observed during the experiment is given in Table 1. With increasing external Cr concentrations, toxicity effects such as chlorosis on *L. minor* appeared at lower nutrient strength rather than at the higher nutrient strength. Chlorosis appeared in *Lemna minor* on the 2nd day in 12 mg/L Cr concentration at 10% nutrient level, while at 75% nutrient level in the same Cr concentration, there were no toxicity symptoms in *Lemna minor* throughout the experiment. Similarly, *L. minor* treated with 5 mg/L at 10% nutrient strength showed the toxic symptoms on the 5th day of the experiment, while the plants exposed to the same concentration but at 75% nutrient strength were normal and fresh up to 5 days. A similar observation has been reported in water spinach by Gothberg *et al.* (2004).

Table 1. Morphological change in *L.minor* grown in different strengths of Hoagland nutrient with varying concentration of chromium

Cr concentration (mg/L)	Strength of Hoagland nutrient solution			
	10% Nutrient	25% Nutrient	50% Nutrient	75% Nutrient
Control	None	None	None	None
1	None	None	None	None
2	None	None	None	None
3	None	None	None	None
4	None	None	None	None

5	Chlorosis started on 5th	None	None	None
6	Chlorosis started on 4th	Chlorosis started on	None	None
9	Chlorosis started on 3rd	Chlorosis started on	Chlorosis started on 4th	None
12	Chlorosis started on 2nd	Chlorosis started on	Chlorosis started on 4th	None
15	Chlorosis started on	Chlorosis started on	Chlorosis started on 4th	Chlorosis started on 4th

Uptake of chromium by *Lemna minor* in different strengths of Hoagland nutrient solution with varying concentration of chromium is given in Figure 1.

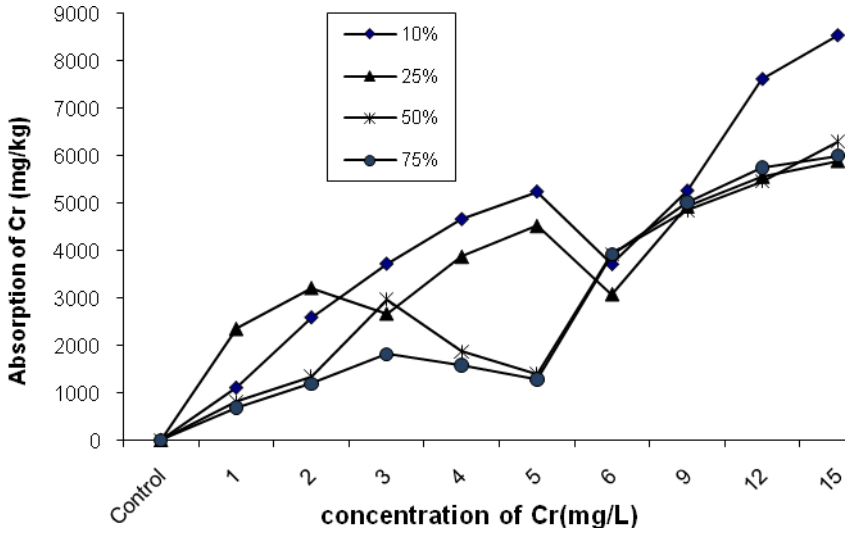

Figure 1. Absorption of chromium by *L. minor* in different strengths of Hoagland nutrient solution with varying concentration of Cr after 8 days of hydroponic culture.

In chromium treated *L. minor*, the concentration of Cr in the biomass increased with decreasing ambient nutrient strength (Figure 1). *Lemna minor* showed high absorption of chromium at

10% nutrient level. The plants grown in a controlled set up did not show any chromium in its tissue.

The metal uptake in plants varies considerably. In a nutrient-enriched environment, due to competition between the metal ion and the cations in the nutrients for the uptake sites, the uptake of metal ion under investigation may decrease (Greger M., 1999). On the other hand, a generous availability of nutrients promotes plant growth, which in turn creates an increasing number of uptake sites for metal in the plants, thus encouraging uptake; however, the extent of metal absorption by plants depends on the relative responses of metal uptake and growth rate.

The metal uptake by *L. minor* at a particular metal concentration decreased with increasing nutrient strength. Previous studies (Greger *et al.* 1991) also showed the influence of nutrient enrichment on the uptake of toxic metals by plants. The Cd uptake rate in *E. crassipes* was much higher in deionized water than in 50% Hoagland nutrient solution (O'Keeffe *et al.*1984). The Cd net uptake in the roots of sugar beet (*Beta vulgaris L.)* was greater when the nutrient concentration was minimal, rather than optimal (Greger *et al.* 1991). The strength of the external nutrient solution is of importance for the accumulation and toxicity of heavy metals in water spinach (Gothberg *et al.* 2004).

The nutrient strength of 10% was considered the optimum strength for Cr uptake and had been used for the rest of the experiments.

Absorption capacity

The most obvious initial effect of heavy metal stress is manifested as change in plant growth. The initial wet weight of *L. minor* was about 3.6 g and metal concentrations in the test solution were 1 to 8 mg/L. *L. minor* plants in control grew at a higher rate so that after 7 days, its RG was 3.99 while the relative growth of plants in the Cr test solutions were in the range of 0.79- 2.48. The relative growth significantly decreased ($P \leq 0.05$) with increasing Cr in the test solution. Goswami and Majumdar (2015) reported a significant reduction in specific growth rate of *Lemna minor* with increase in Cr(VI) concentration in ambient solution.

At the end of the experiment period (after 7 days) Cr(VI) caused a distinct limitation of *Lemna*'s growth compared to the control (Table 2). Similar effects had been observed in *Azolla caroliniana* by Bennicelli *et al.* (2004). In this study it was observed that Cr(VI)

caused inhibition of *Azolla caroliniana* biomass growth by 20-27 %. Arrora *et al*. (2004) also observed inhibited growth of three *Azolla* spp. (*A. microphylla*, *A. filiculoides* and *A. pinnata*) by Ni and Cd. Khosravi *et al*. (2005) had further reported that the presence of Pb, Cd, Ni and Zn caused an inhibition of biomass growth by 25%, 42%, 31% and 17% respectively in comparison to the weight of *Azolla* in control experiment, in which there was no heavy metal present.

Table 2. Percentage relative growth of *L.minor* in different concentrations of chromium

Initial concentration of Cr solution (mg/L)	Average relative growth	% R.G compared to control
0.0	3.99	--
0.79	2.48	62
1.85	1.42	36
3.01	1.09	27
4.31	0.91	22
6.72	0.80	20
8.32	0.79	20

The highest relative growth of 2.48 was observed in 0.79 mg/L solution. It appeared that low concentration of Cr did not affect plant growth. Higher doses of Cr (*i.e*. above 4 mg/L) limited the relative growth by more than 70%.

Cr Uptake by *L. minor*

In general there was an increase in total Cr in the plant biomass as the Cr concentrations in the feed solution increased (Control plant showed absorption of 0.16 mg Cr/kg DW which was presumably present in the plants at the time of sampling). Uptake of chromium by *L. minor* in different concentrations of chromium is shown in Figure 2.

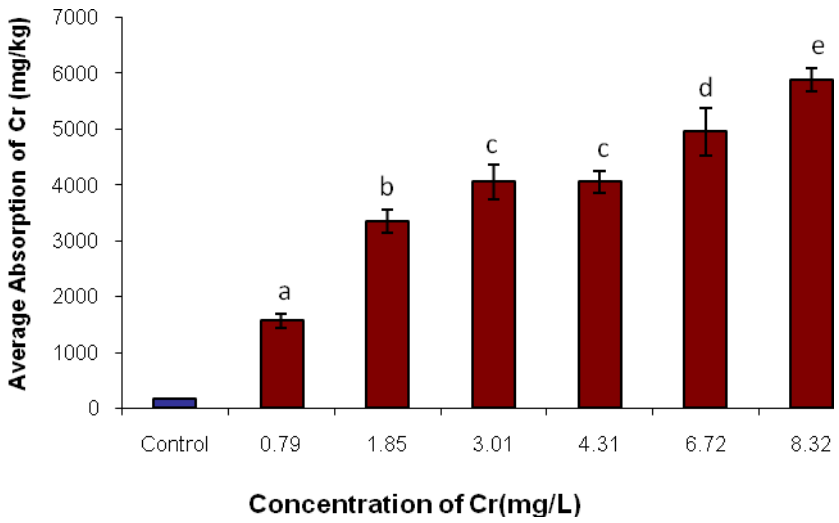

Figure 2. Uptake of Cr by *L. minor* with different concentrations (Error bars are standard deviations)

Mean values of absorption denoted by the different letters significantly differ at P≤ 0.05 by Tukey's 95% simultaneous confidence intervals. The absorption of chromium by *L. minor* increased significantly (P ≤ 0.05) when concentration of chromium was increased. After the experiment, control plants showed a very low Cr concentration (160 mg/kg). Plants treated with 8 mg/L, accumulated the highest level of metal and these plants did not survive. It appeared that this concentration was very toxic to *L. minor*. However, plants showed toxicity symptoms such as complete chlorosis or whiteness and transparency of fronds after 4.31 mg/L Cr concentration.

Several studies have been reported on the effects of chromium on aquatic plants. Roots of water hyacinth showed an accumulation of 18.92 µmol (g dry tissue wt^{-1}) Cr (Chandra and Kulshreshtha, 2004).Under experimental conditions, duckweed *(Lemna minor)* accumulated 2.87g Cr/kg (Zayed *et al.*1998). In *Bacopa monnieri* and *Scirpus lacustris,* accumulation of 1600 and 739 µg Cr/g DW respectively has been reported when exposed to 5 mg/L Cr for 168 hours in solution culture (Chandra and Kulshreshtha, 2004).

Bio Concentration Factor (BCF) is a useful parameter to evaluate the potential of the plants in accumulating metals and this value is

calculated on a dry weight basis. Ambient metal concentration in water is a major factor influencing the metal uptake efficiency. The variation of BCF of *L. minor* for chromium with varying concentration of chromium is shown in Figure 3. Mean values of BCF denoted by the different letters significantly differ at $P \leq 0.05$ by Tukey's 95% simultaneous confidence intervals. The BCF values decreased significantly ($P \leq 0.05$) with increasing concentration of the feed solution. The maximum BCF value for Cr was 1978. However BCF value was more than 1000 for Cr concentration up to 3.01 mg/L and BCF decreased to 701 in 8.32 mg/L Cr solutions (Figure 3). In general, when the metal concentration in the feed solution increases, the amount of metal accumulating in plant increases, whereas, the BCF value decreases (Lu *et al.* 2004). Similar results were reported (Jain et al 1990) wherein BCF values for water velvet (*Azolla pinnata*) and *L. minor* treated with Pb and Zn gradually decreased with increasing metal concentration in feed solution. Zhu *et al.* (1999) also reported that BCF of water hyacinth were very high for Cd, Cu, Cr and Se at low external concentration. Zayed *et al.* (1998) reported that *L. minor* bio concentrated the six elements Cu, Se, Pb, Cd, Ni and Cr to different levels at low supply concentrations compared with those at high supply concentrations.

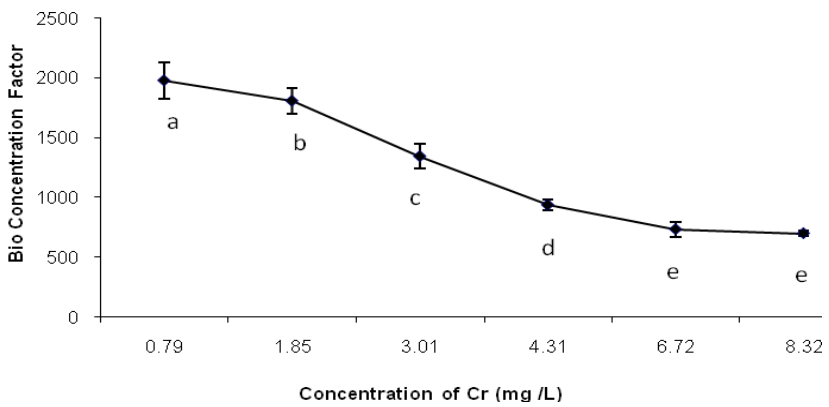

Figure 3. Bio Concentration Factor of *L. minor* for chromium (Error bars are standard deviations)

In terms of phytoremediation, a good accumulator should have the ability to concentrate the elements in its tissue, for example, a BCF of more than 1000 (Zayed et al 1998). According to this arbitrary criterion, *Lemna minor* can be considered as an extreme

accumulator of Cr at low external concentration (up to 3.01 mg/L). Phytotoxicity of chromium in an aquatic environment has not been studied in detail. In aquatic species, namely, *Myriophyllum spicatum*- the maximum increase in shoot length was found at 50 µg/L Cr. *Lemna minor* showed relatively greater tolerance to chromium. However, an inhibition of growth in *Spirodella* and *Lemna* species was found at 0.02 mmol and 0.00002 mmol Cr concentrations, respectively. The effective concentrations (EC-50) for some aquatic species have been reported: *Lemna minor*, 5.0 mg/L, 14 days. *L. paucicostata*, 1.0 mg/L, 20 days; *M. spicatum*, 1.9 mg/L , 20 days; *Spirodela polyrrhiza*, 50 mg/L , 14 days. Chromium toxicity on biochemical parameters was shown in terms of reduction in photosynthetic rate at 50 µg/L Cr (VI) solutionin *Myriophyllum spicatum*. Decrease in chlorophyll and protein contents were also recorded in *N. indica*, *V. spiralis* and *Alternanthera sesilis* with an increase in chromium concentration (Chandra and Kulshreshtha, 2004). Chromium–induced morphological and ultrastructural changes have been reported in several aquatic vascular plants: In *L. minor* and *Ceratophyllum demersum*, chromium–induced changes in chloroplast fine structure disorganized thylakoids with loss of grain and caused formation of many vesicles in the chloroplast (Chandra and Kulshreshtha, 2004).

Time course Experiment - *Lemna minor* for chromium

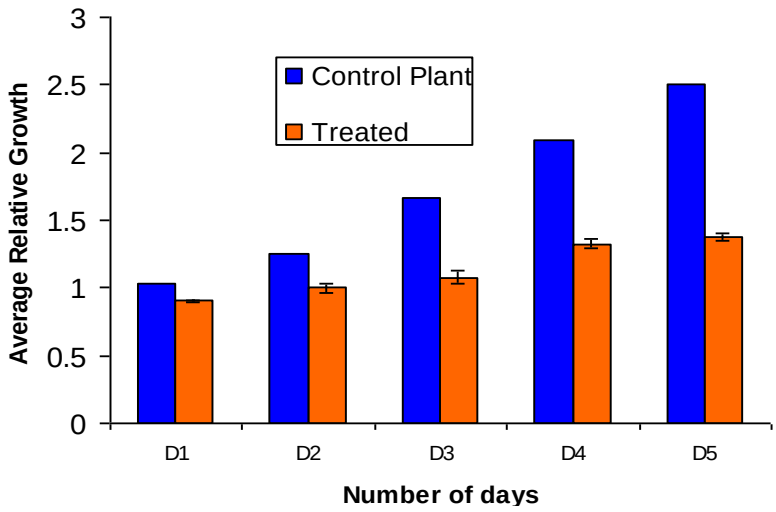

Figure 4. Average relative growth of *L. minor* in chromium solution with time (Error bars are standard deviations)

In the case of *Lemna minor,* the best concentration of chromium was found to be 3.01 mg/L. In this concentration, growth of *Lemna minor* was normal with greater accumulation. Initial fresh weight of *Lemna minor* was 2.6 g. *Lemna minor* was normal and very fresh during the test period. The effect of chromium on relative growth of *Lemna minor* with exposure time is shown in Figure 4.

The relative growth of control plant increased with the passage of time. The average relative growth of chromium-treated plants significantly ($P \leq 0.05$) increased with exposure time. The lowest value of relative growth was observed to be 0.90 on Day 1. Relative growth reached its maximum (1.37) on Day 5.

The variation of uptake as given by mean values of absorption of chromium by *Lemna minor* with exposure time is shown in Figure 5 (Control plants showed absorption of 0.02×10^3 mg/kg of Cr). The uptake denoted by the different letters significantly differs at $P \leq 0.05$ by Tukey's 95% simultaneous confidence intervals.

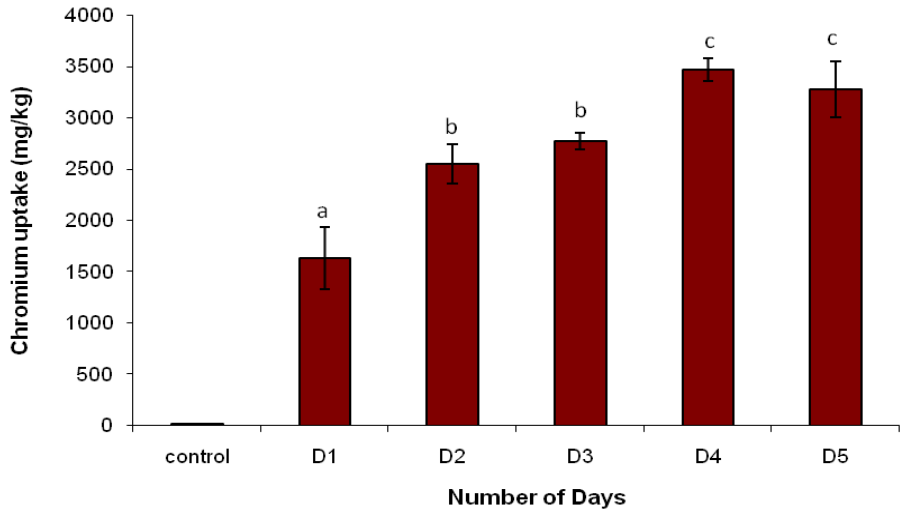

Figure 5. Uptake of chromium by *L. minor* with time. (Error bars are standard deviations)

The results revealed that under the experimental condition, the accumulation of chromium increased significantly ($P \leq 0.05$) when the exposure time was increased. In this study *Lemna minor* accumulated highest chromium concentration (3.46×10^3 mg/kg DW) when exposed to 3.01 mg/L chromium on Day 4. According to the Tukey's test, at $P \leq 0.05$, the difference between the absorption

means on Day 4 and Day 5 was not significant, *i.e.* the removal efficiency on Day 4 and 5 are almost the same. This shows that maximum absorption can be achieved by Day 4.

Conclusion

The strength of external nutrient solution is important for accumulation and toxicity of metals in *Lemna minor.* 10% nutrient strength was found to provide the optimum condition for Cr uptake. *L.minor* has the capacity to accumulate large quantities of Cr(VI) and also the ability to grow in solutions containing Cr(VI) with the initial concentration up to 3 mg/L within 7 days, although its growth was inhibited by 64% relative to *Lemna* plants that were not exposed to Cr(VI) (control). *Lemna minor* has the ability to bio-concentrate 3460 mg Cr(VI) /kg DW from a solution with an initial concentration of about 3 mg/L within 4 days.

References

Aisien. F. A., Faleys, O., and Aisien, E. T. 2010. Phytoremediation of heavy metals in aqueous solution. Leonardo Journal of Sciences, issue 17, 37-46.

Arrora, A., Sood, A. and Singh, P. K. (2004). Hyper accumulators of cadmium and nickel by *Azolla* sp. Indian Journal of Plant Physiology, 9(3), 302-304

Bennicili, R., Stepniecoska, Z., Banach, A., Szajnocha, K. and Ostrowski, J. (2004). The ability of *Azolla caroliniana* to remove heavy metals (Hg(II), Cr(III), and Cr(VI) from municipal waste water. Chemosphere, 55, 141-146.

Chandra, P. and Kulshreshtha, K. (2004). Chromium accumulation and toxicity in aquatic vascular plants. The Botanical Review, 70(3), 313-380.

Coastal Zone Management Plan (CZMP) 2004: The Gazette of the Democratic Socialist Republic of Sri Lanka 2004.

Goswami and Majumder (2015). Potential of *Lemna minor* in Ni and Cr removal from aqueous solution. Pollution, 1 (4): 373-385.

Gothberg, A., Greger, M., Holm, K. and Bengtsson, B. E. (2004). Influence of nutrient levels on uptake and effects of mercury,

cadmium and lead in water spinach. J. Environ. Qual. 33, 1247-1255.

Greger, M., (1999), Metal availability and bioconcentration in plants in: Heavy metal stress in plants-from molecules to ecosystems, Springer, Berlin.

Greger, M. E., Brammer, S., Lindberg, G. L. and Idestan, A. J. (1991). Uptake and physiological effects of cadmium in sugar beet (Beta vulgaris) related to mineral provision. J. Exp. Bot. 42: 729-737.

Hoagland, D. R., and Arnon, D. I. (1950). The water-culture method for growing plants without soil. Berkeley, Calif.:University of California, College of Agriculture, Agricultural Experiment Station.

Hoenig, M., Baeten, H., Vanhentenrijk, S., Vassileva, E. and Quevauviier, Ph. (1998). Critical discussion on the need for an efficient mineralization procedure for the analysis of plant material by atomic spectrometric methods. Analytica Chimica Acta, 358, 85-94.

Isaksson, R., Balogh, S .J. and Farris, M. A. (2007). Accumulation of mercury by the aquatic plant *Lemna minor*. International Journal of Environmental studies, 64(2): 189-194.

Kamel, A. K., (2013). Phytoremediation potentiality of aquatic macrophytes in heavy metal contaminated water of El – Temsah Lake, Ismailia, Egypt. Middle – East Journal of Scientific Research 14(12): 1555-1568.

Khosravi, M., Ganji, T., and Rakhshaee, R. (2005). Toxic effect of Pb, Cd, Ni, and Zn on *Azolla filiculoides* in the international Anzali wetland. International Journal of Environmental Science and Technology, 2(1), 35-40.

Leblebici, Z., and Aksoy, A. (2011). Growth and Lead Accumulation capacity of *Lemna minor* and *Spirodela polrhiza* (Lemnaceae): Interaction with nutrient enrichment. Water, Air and Soil Pollution: 214:175-184.

Lu, X., Kruatrachue, M., Pokethiyook, P. and Homyok, K. (2004). Removal of cadmium and zinc by water hayacinth, *Eichhornia crassipes*. Science Asia 30, 93-103.

O'Keefe, D. H., Hardy, J. K. and Rao, R. A.,(1984), Cadmium uptake by the water hyacinth: Effects of solution factors, environmental pollution (Series A), 34, 133-147.

Radojevic, M. and Baskin, V. N. (1999). *Practical environmental analysis*. The Royal Society of Chemistry, Cambridge, UK.

Zayed, A., Gowthman, S. and Terry, N. (1998). Phytoaccumulation of trace elements by wetland plants: I. Duckweed. *J. Environ. Qual. 27*: 715-21.

Zayed, A., and Terry, N.(2003). Chromium in the environment: factors effecting biological remediation. Plant and soil, 249, 139-256.

Zhu, Y. L., Zayed, A. M., Qian, J. H., de Souza, M. and Terry, N. (1999). Phytoremediation of trace elements by wetland plant II: water hyacinth. *J. Environ. Qual. 28,*339-44.

Received: 30-4-2015 Revised: 02-11-2015 Accepted: 04-11-2015

OUSL Journal (2015)
Vol. 9, (pp. 113-131)

"We Must Make Men"[1]: Constructions of Masculinities and Femininities in Parker's Village Folk Tales of Ceylon

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Abstract

Prior to the advent of print capitalism, people of ancient Sri Lanka used folklore -- 'folktale' is one of the various forms of folklore – to create and recreate the sense of a larger nation with a political hierarchy and moral order. Scholar, Michael Roberts (2002), associates the creation of nationalism in Sri Lanka with pre-modern forms of visual (*e.g.*, wall paintings) and oral modes (e.g., storytelling) of communication. Folklorists in Sri Lanka have positioned folk tales – and folklore - as a national heritage. The present research adds a gender dimension to the already existing scholarship on Sri Lankan folktales, by analyzing a sample of folk tales for modalities of gender creation – both masculine and feminine. This research will re-read the folk tales in the sample, for acts of gender, with careful attention paid to gendered functions, performance, engagements and positioning in the tales. This is a preliminary study related to a larger study and it attempts to fill an existing scholarly gap in the study of gender dimensions of folk tales in Sri Lanka.

Introduction

Scholarly studies in folklore have identified the term 'folktale' as one of the various forms of folklore--myths, legends, folksongs, proverbs, riddles, games, dances, chain letters and autograph book verse, etc, being the other forms. A folktale that engages a reader/listener, either in print or oral mode, could be one of the many versions or variations of the same story that could also exist in other spaces, cultures or nations. Most of the folktales that Henry Parker collected from southern villagers of Sri Lanka in the late nineteenth century are also told (in re-adopted forms) in Punjab, Kashmir, Africa, and

[1]*After creating the earth, this was God Vishnu's first thought. Quoted from The Making of the Great Earth (LPSLT 01), the first tale in Parker's Village Folk Tales of Ceylon, Volume I.*

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the Middle East. Thus, tracing the origin of a folktale or the socio-historical context of its creation would be problematic. Regardless of their indeterminate origins, a folktale, wherever it is narrated, heard and enjoyed would be about people's "real-life experience" Wickramasinghe (1945), or would help to vent out "anxieties" Dundes (1980); they would entertain people with "exciting events", "heroic deeds," "arouse interest in history" and "provide models for religious and ethical perfection" Deigh (1989). Folktales also have gender dimensions. Andalusian folktales and Japanese folktales (particularly Animal-Wife tales) are biased towards the male sex (Brandes, 1982; Kobayashi, 2015). The present study wishes to foreground and analyze the gender aspects in a sample of Sinhala folktales collected and later transcribed into written form by a colonial officer in late nineteenth century Ceylon - Sri Lanka, H. Parker, under the title *Village Folk Tales of Ceylon.* In keeping with the accepted norms of folkloristics this study has classified the tales under scrutiny into Tale Types (see Appendix I) and Episodic Structures (see Appendix II)[2]. From these episodic structures the gender-specific behavior has been analyzed and interrogated with respect to the thematics of the tale. *Part I* of the *Volume I* of *Village Folk Tales of Ceylon*, where Parker lists 37 folktales under the sub-heading, *Stories of the Cultivating Caste and the Vaeddas,* form the basis for this paper, which is the preliminary initiative of a larger study of the same nature, involving all three volumes of Parker's tales.

Theoretical framework

Though Sinhala folklore has attracted scholarly attention in Sri Lanka (Disanayaka, 2012; Ratnapala, 1991; Wickramasinghe, 1970; Wijesekera, 1987; Vitharana 1993,) there have been no extensive studies, gender-related or otherwise, on Parker's folktales, which easily forms the biggest collection of tales ever collected in the south of the country, which prompted Ratnapala (1991) to position Parker's folktales as the "only worthwhile collection of folktales available to us in any language". However, there is one unpublished conference paper by Fernando (2002), titled *Representation of Women in the Folktales of H. Parker*, where the females in Parker's tales have come under focus for their presence/absence in the tales alongside males, and for their character attributes.

[2] *The present paper is part of a larger study where all 266 folktales of Parker listed in the three volumes would be given Tale Type Indexes, and their Episodic Structures written down.*

Fernando locates the number of male and female characters in all the tales of Parker and tables them for easy reference: in *Volume I*, there are 78 males against 43 females; *Volume II*, 115 males for 87 females; *Volume III* 98 to 78. Taken in total, this table shows that, in all three volumes, the male characters have a presence that is sixteen percent (16%) higher than female characters. Fernando thus argues that women have an "inferior status" within the folktales. One immediate shortcoming of his counting-character method is that he has not defined whether his male/female 'characters' are primary (protagonists of the plot), secondary (aid the main protagonist/s in the plot) or neutral (are merely present in the plot). At the same time, there are characters in the tales who assume gender disguises to avoid danger; there are animals and super natural beings that operate with a gendered identity; there are females and males who appear in the tales in groups (eg: seven sisters and seven brothers); and, there are females who die and are reborn in the same tale as females. Fernando has not identified or acknowledged these complexities of characterization in his gender count. At the same time, he does not question the statistical insignificance of the difference between the presence of male and female characters (16 %). Perhaps, a difference of 30% and above could be an adequate percentage to base the kind of conclusion that he has arrived at.

Fernando also surveys the character attributes of females in the stories. A summary of these attributes would be as follows: female is the guardian of the household, she lacks intelligence and is greedy, she is cunning and dishonest, she is unfaithful, she is beaten by men, marriage is her ultimate aspiration in life though she is free to choose her husband; in some of the tales, she is also portrayed as being wise, bold and daring. These attributes lead Fernando to conclude that Parker's folktales promote patriarchal ideology and are not conducive to female liberation. As interesting and as ground breaking as his paper is, as far as Parker's folktales are concerned, Fernando's analysis requires further probing and raises more questions. Take for instance, his observations on marriage: "woman's ultimate aspiration is marriage" and women are "free to choose their husbands." Does that mean that 'marriage' for a female in the folktales is a self-determining and autonomous bond? If she has 'an inferior status' across the folktales, what would be her status in a 'marriage'? What about the women who are 'bold,' and 'daring'? Do these 'ideal' females imitate such qualities only to reinforce the superiority of the male gender? Though the present study is not as large as Fernando's to interrogate these questions comprehensively, they will form its backdrop as this study

undertakes its own reading of both the masculine and feminine gender in the tales.

Summarized observations on Parker, and the *Village Folk Tales of Ceylon*

Parker has collected a total of 266 folktales and arranged them under three categories: a) Stories of the Cultivating Caste and Vaeddas b) Stories of the Lower Castes (namely, Tom-Tom Beaters, Durayas, Rodiyas and Kinnaras) c) stories from the Western Province and India. His categorization is not without problems: Parker does inform the reader whether a tale listed under the category *cultivating castes*, is a tale told of or told by a member of that caste; Vaedda is not a caste category; and his categorization (c) is based on geography. Parker does not seem to find his caste categorization problematic, nor does he explain where he obtained his understanding of Sinhala caste classifications. In a personal anecdote, recorded in Volume I of *Village Folk Tales* titled *The Foolishness of the Tom-Tom Beaters,* Parker encourages existing cultural stereotypes about this caste with a story about how he convinced a tom-tom beater that rats were born out of eggs. Parker uses this anecdote as the starting point for his stories listed under tom-tom beaters, all of which, he says are based on the "foolish doings" (Parker 238) of the drummers. All this could be interpreted as Parker's seeming neutrality with regard to, as well as his complicity in upholding, the Sinhala caste system as well as cultural stereotypes about particular castes.

The colonial mindset of Parker, who as a colonial official was duty-bound to uphold the British civilization and culture, is evident in his *Introduction* to *Village Folk Tales of Ceylon*. Here, Parker evinces little respect for native cultures and implicitly justifies the 'noble' British colonizing mission by presenting the 'natives' as illiterate, ignorant and superstitious.

Parker's other major work, *Ancient Ceylon,* and his *Introduction* to *Village Folk Tales of Ceylon,* also demonstrate his gendered worldview. He restricts description of females in 'ancient Ceylon' to just three sketchy paragraphs in his 695-page book *Ancient Ceylon*. Parker does not find 'objectionable' some of the gendered social, cultural and labor practices that he found in Ceylon. In defense of Parker, it could be argued that there was no requirement for him to be more enlightened on gender than the majority of his countrymen of the time. What is relevant to the present study is the obvious gender dimensions and the obvious gender dynamics in the tales he chose to compile but which escape commentary on his part.

The majority of the tales Parker has collected have been written down (in Sinhala) by the narrator and the villagers employed by Parker to collect them. He himself has written down a few stories as they were narrated to him. The stories that appear in the print form "are practically literal translations of the written Sinhalese originals, perhaps it may be thought in some respects, too literal. " [3] Parker has not recorded the context in which the stories were narrated, the gender of the teller/listener of the stories which are essential requirements for collecting of folktales.

Findings

Representation of men and women

Female as a 'threat' and male as a caste-marked category

Parker's first tale in *Volume I* is titled *The Making of the Great Earth* (Tale Index LPSLT 01) where three male gods – *Vishnu*, *Saman* and *Rahu* -- create the earth and its first gendered beings, *Brahmana* and a female; *Brahmana* is created first, given breath by the gods and he converses with his creators. On the penultimate paragraph of this tale, *Brahmana* is asked to create a female for his "assistance" (Parker 41), as if she is a mere afterthought of this all-male creation project. The first male on the newly formed earth is not a neutral entity – he is marked by caste; and in the caste hierarchy of Sri Lanka he occupies the top-most rung, his identification, *Brahamana,* carries connotations of religious leaning and exceptional learning.[4] This tale endorses inter-gender bias (male is created first, female, later for his assistance) and intra-gender bias (the first male is from a valorized caste, therefore, his presence implies a hierarchy in the male order), thus reinforcing the superiority of a particular type of male and inferiority of females; it draws the gods, valorized and venerated by people of Sri Lanka up-to-date, into its discriminatory project. Parker also features two other creation tales, with questionable gender representations, in the long foot notes to this story. In the tale *Servant Maid & the Sky* (LPSLT 02), a working class female (*servant maid*) sets in motion the events that created the present state of affairs on the earth. In the beginning, the sky touched the rooftops and stars lit up houses with their light. A female servant brings chaos into this world with a reckless act: annoyed with the clouds frequently obstructing the broom, she hits the sky with it. Shamed by this affront, the sky separates from the

[3] Quoted from the Introduction to Village Folk Tales of Ceylon, H Parker page 26
[4] Interview with Prof. J.B. Disanayaka, 24th March 2015

earth. Female aggression is pushed to the forefront of the story: culturally, a female expressing her annoyance with a broom is considered an insulting act.[5] The question is: how would the sky react if the offender is a male (servant)? Impulsive female aggression and the absence of males (there are no males in this story!) seem to have contributed to a disagreeable state of affairs. In the third creation tale (LPSLT 03: *God Sakra & Jackfruit*), social division of labor is stressed when God Sakra uses a female as a cook (assistant?) to teach men in the newly formed earth how to eat Jack Fruit, thus relegating the female to a passive agent in a grand male project.

All three creation tales suspend linear, historical or "profane time" Davies (1995) and return to the beginning of events or "sacred time" Davies (1995). Suspension of 'profane time' and return to mythical 'sacred time,' Davies suggests[6], is a reaction to a threat faced by primitive 'men.' This argument offers an alternative reading of the creation tales: the urgent need to valorize a *Brahmana* male over females and other males in the tale *The Making of the Great Earth,* could be understood as a response to a 'threat': a threat from females? - and from low caste males?; in the other two creation tales, the act of representing the females in the negative (as an architect of chaos and a passive entity) lends itself to the interpretation that males feared females. Why would a select group of males (cultivators and vaeddas) seem to fear females, and males from the lower castes? Or, what is the pragmatic impulse that could have prompted these males to create inter/ intra gender hierarchy? A possible answer could be the human need for perfection. A human being's need for 'perfection,' argues Coupe (2007), creates "powerfully imaginative stories" and "systematic violence" Coupe (2007). The 'systematic violence' inflicted upon females in the tales help buttress the male gender. The female body becomes the fertile space in which the male gender gives itself identity. The low-caste males are the fodder with which the Brahmana nourishes his caste purity - all by 'himself' Brahmana is nothing. Though the creation tales seemingly carry the idea of the superiority of particular males, they concurrently transmit the anxieties and fears of those males.

Parker's ordering of these three tales - as the first tales in a collection whose scope is national ('Ancient Ceylon') – is

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[5] One of the Prime Ministerial candidates at the recently concluded Parliamentary Elections urged females to use the 'elapatha' (a type of broom used to sweep a smaller area, usually a toilet), if his main opposition candidate came to their houses seeking votes.

[6] He quotes from Mircea Eliade's text, The Myth of the Eternal Return

questionable. The act of placing creation tales with obvious gender bias at the beginning of the book, and not elsewhere, attests to Parkers seeming participation in the gendered and caste-based worldviews that percolate the tales.

Depiction of marriage

Marriage is an obvious site where gender relationships are played out. In the folktales under study, heteronormative marriage (the only form of marriage found in the tales) finds many different modes of representation. In the tale, *The Golden Kaekiri Fruit* (LPSLT 13), a woman boldly asks a widowed male: "What indeed! Why don't you invite me?" (Parker 117) - a suggestion that she wants to be his wife, to which he replies "Ha. Stop here" (Parker 117). This is the model of marriage practiced by the cultivators found in the tales: marriage is female initiated, lacks emotional dialogue or sensual element, is simple and practical. At the same time, for these females, marriage is a claustrophobic affair located inside the house and defined by household duties; males hold power over them, can beat them for a fault and also vent their frustrations upon them.

To illustrate the above, seven sisters go in search of male partners in the tale *Tamarind Tikka* (LPSLT 07) and marry seven cultivating males. However, the initiative taken by these females is not reflected in their post-married life: their lives are confined to their houses and the river; they only engage in household tasks and violently punish their only sister-in-law for failing in her household duties; they abandon their homes immediately after their husbands are killed in a revenge attack by the main protagonist, Tamarind Tikka. In the tale *The White Turtle* (LPSLT 22) two sisters seeking marriage partners declare their purpose as: "We are going to a country where they give to eat and to wear" (Parker 102). This declaration is also used by a male who seeks employment in the tale *The Prince and the Yakka* (LPSLT 14), thus suggesting that marriage holds practical concerns for a female. This is possibly, the reason why six out of the seven sisters in *Tamarind Tikka* abandon their houses and run away the moment their husbands are killed. Despite the static nature of married life and its shortcomings for the females, they still actively seek marriages in the tales. One possible reading of this tendency is that marriage, for a female, is a means of employment or livelihood. Since females to a great extent do not engage in the production of wealth (by cultivating, animal rearing, robbing, engaging in trade) they need marriage to have access to wealth – and, therefore, basic needs of life. Thus, the female hunts for marriage (like hunting for a

job), asserts the conditions of employment (food and clothes), performs defined duties (household chores), and deserts her employer the moment he dies. In a marriage, one act that females stage-manage for their own benefit is an illness. When a female suffering from an illness demands a food item as part of the cure, her husband responds immediately, even if that demand is cruel and, at times, impossible. Females in the tales frequently use an illness as an occasion to seek revenge or harm another female. In *The Golden Kaekiri Fruit,* Mahage makes cruel demands of her husband, which results in the violent death of the daughter of his first marriage. In the tale *The White Turtle,* a female regularly urges her two husbands (she killed her sister and married her husband as well, particularly because they were wealthy) to bring her desired food items while feigning illnesses. Both males oblige. Seemingly, this manipulative act to achieve an objective could be seen/read as agency for females. But, within the tales, such acts are represented in the negative and the manipulator is usually punished in the end – both females in the tales quoted above meet with violent ends.

Depictions of aristocratic/royal women

In the tales involving the royal princes and princesses, marriages, far from being practical and mundane, also offer a sensual take. Males and females of this class usually fall in love after an act of voyeurism at a bathing place. In the tale, *The Turtle Dove* (LPSLT 07), a princess falls in love with a prince at a bathing place. She informs her father about her chosen prince and the father arranges the marriage. A princess gets physically attracted to a prince at a bathing place in the tale *The Prince and the Yakka.* Thus the river and the bathing place become a site of sensuality, and marriage is usually initiated by females.

In the tale *The Glass Princess,* a royal prince sends his sword to represent him at a marriage ceremony with a choice for the selected princess – she could marry the sword and come to him or she could refuse to do so. The princess opts to marry the sword with the reasoning: "Even a deaf man or a lame man would be good enough for me. Therefore I must be married." (Parker 50). This statement suggests that marriage, even for a royal princess, is a mandatory act and emotional compatibility might not matter in some cases. The princes in some of the tales marry more than one female and such practices are considered natural since none of the princesses in the tales object to that practice. The father of a princess usually sets an exchange value for a princess, as in the tale *The Prince and the Princess* (LPSLT 11*),* where the king demands a well full of gold from the prince who seeks his daughter's hand. The father of the princess

in *The Glass Princess* (LPSLT 20) sets next-to-impossible tasks for suitors who seek the hand of his beautiful daughter, thus suggesting that a prince seeking a partner needs to overcome the economic and physical obstacles placed by potential fathers-in-laws. A prince would also have to be vigilant against other males (usually princes and, in some cases, low caste males who are pretenders to the throne) who would kill him in order to possess his wife. Such destructive acts are usually neutralized through pre-emptive action initiated by princesses. The alert and expeditious princess in *The Prince and the Princess* (herself riding a horse and carrying a sword) kills the horse of a kinnara man who attempts to kidnap her and also causes a diversion to escape from four vaeddas who pursue her for the same purpose. Later, this princess disguised as a male teacher, orders his (her) students to kill both these parties, thus indirectly participating in the death of males – males who are beneath her class. This is the first instance in the tales where a female engages in an indirect act of killing males to protect her family. The princess in *The Glass Princess* helps her husband overcome two parties (his brothers and a vaedda) who attempt to kill him and abduct her. Thus, unlike the cultivator's wives, the royal wives are won by their husbands with heroic efforts involving economic costs and physical toil. Even such hard-won happiness has to be regularly protected from other males who would attempt to possess their wives – and the initiatives of undermining such males are usually taken by the wives. The royal wives, unlike the wives of the cultivators, play a participatory role in their marriages, particularly when it comes to defending their husbands. However, their participation in this act of self-defense, is stage-managed: they can neutralize a threat from low caste males even by inflicting indirect physical/verbal harm; but if the offender is a male from her own class, they can only evade him. Thus, the marriage of royal princesses involves female bodies being objectified as economic entities with exchange values, usually regulated by males. Male bodies are subject to acts of voyeurism, which sets off the events leading to this exchange. A female usually takes the initiative to protect her marriage from other males, though she would allow another female to enter her marriage as another partner of her husband. However, a female wielding a sword, riding a horse and taking pre-emptive action to protect a polygamous husband is not a female with agency, rather 'she' is a 'female' created by males to stage-manage a male dominated world. 'She' only idealizes the male gender and reinforces its superiority, and, therefore, need not exist in the 'real' world beyond the text.

Females absorbing male frustrations

The female of the cultivating family could also find herself as an absorber of male frustration as in the case of Nagul Munna, the eponymous chena cultivator, who suffers a series of misfortunes while cultivating a chena: his chena partner is killed in a fire and the devastating nature of the fire makes the villagers think that Nagul Munna has died. He, thereafter, makes a living by acting as a devil and kills other men in order to prolong his devil-act. When he is finally caught, he holds his wife responsible for all his misfortunes and kills her. Her death comes in the penultimate paragraph of the story as a mater-of-fact event. The story does not dwell on the aftermath of her death or suggest a penalty for this crime.

Punishment of women for violating accepted codes of behavior

Matalange Loku Appu, a dim-witted inefficient cultivator, convinces gullible tom-tom beaters to beat up older women in their village with a particular club and imprison them in a room in order to convert them to younger females. The tom-tom beaters end up killing many women in their village (they repeat this act twice using the different sides of the club) and the tale treats their deaths as a part of a comic act. No remorse or penalty is suggested in the tale. Both the above tales suggest that female lives are expendable in fictitious spaces created for (male?) entertainment.

Another tale that endorses a gender stereotype with regard to females is the tale *The Faithless Princess* (LPSLT 16), where God Sakra intervenes in the affairs of a prince who refuses to marry because he holds the opinion that "women are faithless" (Parker 145). God Sakra creates a female out of his own body in order to convince this prince to marry. This female, however, becomes a free agent of her own destiny when she engages in an illegitimate affair with a supernatural being (*a nagaya*) and attempts to kill the prince. The prince beheads her with the help of another female – his sister. This female's pursuit of her own destiny, only reinforces the gender stereotype ascribed to her kind by her husband – faithlessness.

Illicit affairs are also found in cultivating families in the tales. In the tale *The Millet Trader* (LPSLT 06) cooking, which is the primary labor ascribed to the females in the tales, becomes a symbolic act of engagement between the female and her secret lover. This lover comes to her house in the night when her husband is guarding the chena. She cooks and keeps the best food for him, and he consumes the food in darkness. Thus, the act of feeding in darkness becomes a symbolic act for love and sensuality. Though females take lovers in

the tales, the cultivating men do not follow that trend, possibly a suggestion that the males are serious and consistent in their relationships. Infidelity usually carries harsh punishments, and in this tale the woman is beaten by the man. In the *Gamarala's Cakes* (LPSLT 39) a woman engages in affairs with two lovers, and feeds them rice cakes in the night when her husband guards the Chena. Her immediate neighbor is aware of her infidelities and tells Gamarala, the chief protagonist in the tale, that the best way to eat cakes is to pretend to be her lover. Thus, cooking and consuming of food appear to be a trope or a euphemism for sexual acts within the tales, allowing females powerful influence over that sphere.

Caste issues

Females do not tolerate insults by males of lower castes. In *Millet Trader* the eponymous trader is insulted by his host's wife as he attempts to disrupt her meeting with her lover. "Be off! Be off! Rodiya!" (Parker 65) she thus chases him away.[7] The trader does not challenge her, but takes his revenge by informing the husband of her infidelity. A princess in the tale *The Turtle Dove* insults and threatens the anti-hero of the tale, a shrewd and untrustworthy hettiya who lustfully asks her to share a meal with him. The male does not respond to her insults.

Masculinity is inscribed into caste and ethnicity in the sample of tales under scrutiny. Low caste males are depicted in a negative light in the tales told by cultivators. Matalange Loku Appu, a destructive and dim-witted man deceives tom-tom beaters into believing that it is possible to convert older females into younger ones using a club. The gullible drummers trust him twice before realizing their folly. The victims then kidnap Matalange Loku Appu and force him into a sack to be drowned in a river. While carrying the sack, their attention is diverted by the beating of drums in the jungle. During that short respite, Matalange Loku Appu tells a curious passerby, a "Muhammadan trader in clothes" (Parker 100), that he is forcibly taken to be made King. The trader willingly exchanges places with Matalange Loku Appu, only to be thrown into the river by the unsuspecting tom-tom beaters. The protagonist steals all the clothes of the trader and convinces the tom-tom beaters that he obtained the clothes from the bottom of the river. The tom-tom beaters then

[7] It is difficult to ascertain from the tale whether the Millet Trader who is thus insulted is a man from the Rodi caste. He is possibly not, because he cheats a lot of cultivators and become rich in the end. Such happy endings are usually not granted to low caste people in the tales of cultivators.

ask him to throw them into the river in the same fashion; he obliges willingly and confiscates all their belongings. In a similar fashion, Tamarind Tikka, who is taken to be drowned by his uncles as an act of revenge, tricks a gullible washerman into exchanging places with him in a tied-up sack. The washerman drowns and Tamarind Tikka takes all his clothes. The kinnara man and four vaeddas who attempt to forcibly kidnap a princess in *The Prince and the Princess* are ambushed and killed violently. A hettiya (man from the trading caste) in the tale *The Turtle Dove* is untrustworthy, shrewd and cruel. "Tambi-elder-brother" (Parker 207) suffers serious head injuries by an inadvertent act of Gamarala in the tale *Gamarala's Cakes*. In the tales *The Jackal Devata* (LPSLT 28) *a*nd *The Kinnara and the Parrot* (LPSLT 26), an animal and birds show more intelligence than tom-tom beaters as they outsmart the low caste men. The tales absorb caste and ethnic tensions into their thematics. Males marked by low caste or a different ethnic label are systematically bound to stereotypes. They usually sow chaos in the tales and are made to experience violent deaths, dire financial loss or humiliation

If low caste males are represented as those lacking common sense and intelligence, some of the female characters too are portrayed in a similar light. The Millet Trader entices a woman to elope with him with the promise that the millet in his village taste better. He steals all her valuables. She finds it difficult to trace him because of his name -- *Pereda*, meaning day-before-yesterday. When she complains to her husband about the theft and the name of the thief, he beats her up with the assumption that she is a liar – if something was stolen day-before-yesterday how come she did not tell him day-before-yesterday? The trader deceives another woman, who is grieving the loss of her daughter, by pretending to have come from the world of the dead. He asks for all her jewellery so that he could marry her daughter in that world. The woman obliges.

There are females who contrast with these stereotyped characters as well. The Glass Princess possesses beauty, magic (she can fly, take any disguise, has access to rare medicine) and can use a sword to defend herself. She can even predict events and thus foils an attempt by the prince's brothers to kill the prince and abduct her. She also uses her magical powers to rescue the prince from a vaedda who attempts the same feat as the prince's brothers. She plays a significant role in the happiness and political power that her prince obtains in the end. The princess in the tale *The Prince and the Princess* fights lone battles with a king, a kinnara and vaeddas to be with her prince who lacks initiative, energy and who is lazy. She is

the only princess who indirectly kills males – all of whom are of lower castes. However, both these strong female characters serve a male agenda. Both princesses perform typically male tasks like riding horses, using swords, only to save and restore power to a male. However, the Gamarala's wife, in the tale *Gamarala's Cakes,* known as Gama Mahage, transcends other females in the tales in terms of her independent acts. When Gamarala demands that she cook cakes, she ignores him. When he asks her again, she cooks them, but their sons eat them. Gama Mahage, when the husband confronts her about the cakes, pushes him and behaves aggressively, prompting him to ask another woman to make cakes for him.

There is social division of labor in the tales. All the females in the tales studied are engaged in household tasks like cooking, sewing, fetching water and drying crops. Males engage in cultivation, trading, teaching, sooth saying, war and theft. This trend is also found in the animal tales, where animals with feminine gender care for the young and occupy the kitchen.

One story (LPSLT 37: *How a Yaka and Man Fought*) alludes to homosexuality. The episodes of the story are couched in subtlety and therefore this analysis would take a closer look at those episodic elements. The story concerns three men who went shooting. One man deliberately separates himself from the others in the jungle without informing them "for a certain purpose" (134). The 'purpose' is obviously to answer a call of nature – and either the narrator of the tale, or Parker had omitted that. In none of the other tales is the concept of answering a call of nature mentioned either as part of a plot or as a natural event. A yaka "seizes" (134) this man (referred to as 'the separated man' hereafter) and "began to push against him" (134). When the others chase the yaka and shoot it they find the separated man's body "having gone quite slimy"; he is also unconscious. When the separated man regains consciousness, after spells uttered by a Yaksa Vedarala (exorcist), he recounts his experience as follows: "A Yaka having come, seizing me pressed against me to roll over to the ground" (135). These acts, strongly point towards an assault of a homosexual nature. Sexuality alluded to in all the tales is heteronormative thus homosexuality would be considered the deviant mode of sexuality. A supernatural being of the repulsive order (yakas are usually associated with destruction in the tales and at times, they are helpful to the human beings) suggestive of sexual encounter being abnormal.

Conclusion

Parker's folktales, just as much as they are aesthetically motivated creations of a culture, are sites where gender tensions are played out. Feminine gender is the marked category in the tales; the female is frequently regulated within the tales, either by crafting her in the negative (faithless), or in the passive mode (assistance), or modeling her on a perfect 'male' in order to idealize the male gender. The modalities of this creation inform the reader more about the male gender than the female. Her negativity/passivity allows the teller of the tale to create a male of the opposite character, a virtuous victim. Her negativity/passivity becomes a site where a 'male' earns his existence, a kind of scaffolding that props 'him' up. Thus, the feminine threat becomes a simulated 'womb' for males, who also need further protection: 'he' needs to protect 'himself' from the deviant types of his own gender – 'males' from low castes and other ethnic groups. Selected females defeat these 'deviant males', who, in that supposedly victorious act, become the protectors (or mothers!) of the chosen 'males.' Village folk tales of Ceylon, thus, are textual sites where the male gender seems to make sense of its own existence by foregrounding itself. They are mirrors the male gender holds up to males' own insecurities. What the males could encounter when they read or listen to the tales are their own fears and frustrations.

Limitations of the present study

This study only considered the 37 tales listed under *Part I* of Volume I of Parker's *Village Folk Tales of Ceylon*. This is the initial part of a larger research to re-read all three volumes of Parker's folktales for gender constructions and therefore might not be fully representative of the gendered constructions found within the tales. This research acknowledges that there could have been 'distortions' in meaning or authorial intentions in the act of 'transliteration' by the compiler of the village folk tales despite his best intentions. This paper does not attempt to discover masculinities and femininities as a subjective or lived experience. Rather it analyses cultural ideas, symbols and narratives that imply and are located in a putative gendered subjectivity and perspective.

References

Collections of Folktales

Parker, H. (2010). Village Folk Tales of Ceylon Vol. 1, II & III. Dehiwela: Tissara Prakasakay Ltd.

Ratnapala, N. (2000). Jana Katha:1. NIE: Colombo.

Secondary Reading Material

Coupe, L. (2007). Myth. Routledge: New York.

Davies, P. (1995). About Time: Einstein's Unfinished Revolution. Penguin: UK.

Dundes, A. (1980). Interpreting Folklore. Bloomington: Indiana University Press.

Fernando, T. A. (2002). Representation of Women in the Folktales of H. Parker. Paper presented at the 8th National Convention on Women's Studies, CENWOR, Colombo, March 23-26.

Obeyesekere, G. (2002). Buddhism, Nationhood and Cultural Identity: The Pre-modern and Pre-Colonial Formations. Colombo: ICES.

Parker, H. (1999). Ancient Ceylon. Asian Educationla Service: New Delhi.

Ratnapala, N. (1991). Folklore of Sri Lanka. The State Printing Corporation: Colombo.

Roberts, M. (2002). Modernist Theory. Trimming the Printed Word: The Instances of Pre-modern Sinhala Society. Colombo: ICES.

Vitharana, V. (1993). Sun and Moon in Sinhala Culture. Educational Publications Department: Colombo.

Weeratunge, N. (2002). Aspects of Ethnicity and Gender among the Rodi of Sri Lanka. Colombo: ICES.

Wickramasinghe, M. (1975). Aspects of Sinhalese Culture. Sarasa (Pvt) Ltd: Colombo.

Wickramasinghe, M. (1968). Jataka Katha Vimasuma. Sarasa (Pvt) Ltd: Colombo.

Wickramasinghe, M. (1948). Landmarks of Sinhalese Literature. Sarasa (Pvt) Ltd: Colombo.

Appendix I

Tale Type Index of Parker's Village Folk Tales of Ceylon – Volume I; Part I: Stories of the Cultivating Caste and Vaeddas

This Tale Type Index is based on Japanese folklorist Koji Inda's Tale Types[8]. LPSLT stands for Lal-Parker-Sri Lankan-Tale. The bold title is the Tale Type – which is "a traditional tae that has an independent existence."[9]. The title of the tale, the region from where it was collected and its relevant volume and page number in Parker's book are given underneath the tale type.

I: Creation Tales 01-03

LPSLT 01: Gods, the Earth, Man and Woman

1: The Making of the Great Earth (NWP) Vol I: 39-41

LPSLT 02: Servant Maid & the Sky

Vol I: 42 (footnotes)

LPSLT 03: God Sakra & Jackfruit

Vol I: 42 (footnotes)

II: Ordinary Folktales

LPSLT 04: Mother rewards and punishes

2: The Sun, Moon and the Great Paddy (NWP) Vol I: 44-45

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12: The Kitul Seeds (NWP) Vol I: 183

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[8] *Kobayashi, F. Japanese Animal-Wife Tales. Peter Lang: New York. 2015. Print.*
[9] *Thompson, S. The Folktale. University of California Press: California, 1977. Print.*

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Example of Episodic Structure of a Tale: This episodic structure is formed by breaking the tale into motifs. A motif is the smallest element in a tale. According to Thompson (1977) there are three types of motifs: actors in the tale, objects in the background and single incidents.

LPSLT 05: Supernatural Help

(3: The Story of Senasura - NWP)

- 1) Senasura affects a cultivator - his cultivation go wrong
- 2) He leaves the village, a friend advices him to combine chena cultivation
- 3) Astrologer tells him that Senasura will haunt him for the rest of his life
- 4) Senasura comes to his house as an old man
- 5) He tells Senasura of his bad luck
- 6) Senasura gives him a book with instructions as to how to pay obeisance to him. He asks the man to pay him obeisance three times a day
- 7) The man becomes prosperous

Received: 30-4-2015 Revised: 03-11-2015 Accepted: 07-11-2015

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For chapters within books:

Campbell, C. (1990). Writing with other's words: using background reading text in academic compositions. B. Kroll (Ed.), Second Language Writing (pp.211-230). Cambridge, England; Cambridge University Press.

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Gunawardena, C., Menon, M., & Naidu, S. (2004). The making of teacher educator, Paper presented at the 3rd Pan-Commonwealth Forum, Dunedin, New Zealand, June 4-9.

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Collis, B. (1998). Implementing innovative teaching across the faculty *via* the www. Paper for the conference "SITE 98", March 1998, Washington, DC. Available Online at: http://education2.edte.utwente.nl/teletophomepage.nsf/papersUKViewform?readform (accessed 19 January 2006).

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