



# PROCEEDINGS



## *First National Symposium*

### **The Potential Health and Environmental Impacts of Exposure to Hazardous Natural and Man-made Chemicals and Their Proper Management**

*23 November 2012*

Organized by  
***Centre for Environmental Justice / Friends of the Earth Sri Lanka***

in association with the  
***Department of Zoology, University of Sri Jayewardenepura***

financial support





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***Published by***  
**Centre for Environmental Justice/Friends of the Earth Sri Lanka**  
20A, Kuruppu Road, Colombo 08, Sri Lanka

Tel/Fax: 0094112683282 email: info@ejustice.lk  
website: www.ejustice.lk

ISBN 978-955-0498-02-4

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***Cover Photo:***

Kidney medical clinics conducted by CEJ and the Public Health Inspectors at Padaviya, Anuradhapura

***Report compilation and Design:***

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# acknowledgments

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Centre for Environmental Justice thank all the authors and researchers and their institutions for sharing the valuable research work conducted by them. We also thank Prof. Pathmalal Manage of the Department of Zoology, University of Sri Jayewardenepura for leading this initiative. We thank Ms. Shireen Samarasuriya and Ms. Dinali Jayasinghe of the Small Grant Programme operate under the UNDP Global Environmental Facility for providing financial support for this work. We also thank Dilena Pathragoda, Chalani Rubasinghe and other CEJ staff for their valuable contributions.

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*The mission of the Centre for Environmental Justice is to protect the equal environmental rights of the people and promote ecological sustainability by supporting ecologically sound community activities.*

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# Preface

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While writing this preface, a news broke in the media was finding pesticide residues in “Kohila” (*Lasia spinosa*) curry in the Parliament canteen. This is a day today occurrence for the people in Sri Lanka and in many other countries. Some fish found in Negombo lagoon are not eatable due to the kerosine smell comes from the curry after cooking them. Some fish found in Sri Lanka comes from the ocean contains high levels of mercury according to the researchers. Farmers purposely add chemicals to the crops after harvesting in order to keep them long. There are many other chemical related stories.

World has produced over 150,000 chemicals and they ends up in the animal and human body through the food chain, creating both environmental and health problems. Many such chemicals are categorised as carcinogenic, endocrine disruptive chemicals or highly hazardous. While many of these chemicals itself are dangerous, the chemical residues or heavy metals contained cause severe dangers to the life on earth.

These chemical related issues and research findings are mostly unknown to the public although many such researches are happening in the country. It is our pleasure to organise the first Symposium on “The Potential Health and Environmental Impacts of Exposure to Hazardous Natural and Man-made Chemicals and their Proper Management” in collaboration with the Department of Zoology, University of Sri Jayewardenepura and the Centre for Environmental Justice. This is the first joined attempt by a civil society organisation and an academic institute to bring such research to the public domain. We encourage the researchers around the country to publish their research work on this subject.

The research works submitted to this symposium make great contribution to the citizens of Sri Lanka to understand the environment around them. Some research presented in this symposium shows the accumulation of trace heavy metal in the fish samples collected from Anuradhapura and Polonnaruwa District, availability of high levels of Mercury in skin whitening creams found in Sri Lanka, availability of high levels of perfluorooctanesulfonate (PFOS) in fish samples, availability of deadly PCB in the welding plants etc.

The outcome of this symposium has given an insight into the pollution problems of Sri Lanka and the possible way out. This is the time that we have to work on programs for curbing the pollution in different disciplines, through the net work that we have formed in this symposium. This symposium and this proceeding volume are the fruits of untiring and unrelenting efforts of the Centre for Environmental Justice members and Department of Zoology, University of Sri Jayewardenepura. The financial assistance to conduct this symposium was provided by the Small Grant Programme under UNDP/GEF and the preparation of this volume has been generously provided by the symposium committee.

## **Editorial Committee**

*19 November 2012*





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# Session I



# ACCUMULATION OF TOXIC AND ESSENTIAL TRACE METALS IN FOUR FISH SPECIES FROM ANURADAPURA DISTRICT, SRI LANKA.

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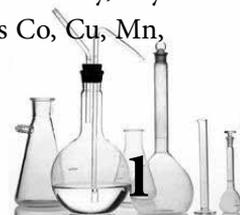
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## 1 INTRODUCTION

Sri Lanka has one of the highest densities of reservoirs in the world and about two percent of the area of Sri Lanka is covered with reservoirs (Fernando, 2000). Most of the reservoirs of Sri Lanka are located in the dry zone and most of these are used for fresh water aquaculture. Reservoir fish are the main source of animal protein of the rural people living in the dry zone of the country (Allinson et al., 2008). Among those reservoir fish Tilapia is the main Sri Lankan inland fish which contributes in large amount for the inland fish production.

In recent years, high incidence of chronic kidney disease (CKD) has been reported from the North Central and Eastern provinces of Sri Lanka. The worst hit areas are Anuradhapura and Polonnaruwa along with Trincomalee, Girandurukotte and Ampara, especially in areas bordering the North Central province (NCP). With the CKD reaching crisis level in NCP, consumption of Tilapia fish contaminated with heavy metals (especially Cadmium) was considered as a factor for the CKD. Chronic cadmium exposure has been linked to renal damage, hypertension, and cardiovascular effects. The leaching of heavy metals from agricultural chemicals in to water sources consider as a factor for the contamination of fish with heavy metals. Though the incidence of CKD is increasing, the exact cause of the disease is not known to any degree of certainty. With the above assumption consumption of fresh water fishes, especially Tilapia was reduced in the NCP. It was indirectly affect to the reservoir based fish industry of NCP of Sri Lanka.

The natural aquatic systems may extensively be contaminated with heavy metals released from domestic, industrial and other man-made activities (Vinodini and Narayan, 2008). Fish may easily absorbed pollutant from the ambient water and from their food and then deposit them in the tissue through the effect of bioconcentration, bioaccumulation and the food chain process. In this regard, heavy metals have long been recognized as an important pollutant due to their toxicity and ability to accumulate in aquatic organisms (Sofia, 2005). Heavy metals such as Pb, Cd, As and Hg are non-essential and considered as harmful elements. Because of this non-essentiality, any concentration of Pb, Cd or Hg in food is considered too high. Trace metals such as Co, Cu, Mn,

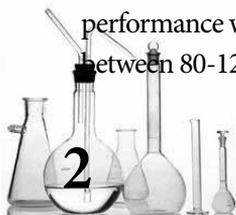


Mo, and Zn is essential nutrients for organisms including humans but is toxic if consumed in large quantities (Silva and Shimizu, 2004). Humans as consumers of seafood and freshwater food may be affected by consuming them. The effects include chronic and acute disease. Fish are often at the top of aquatic food chain and may concentrate large amounts of some metals from the water. Contamination of fish therefore of particular concern to both the fisheries industries and public. Therefore, determination of heavy metal levels of fish is tremendously important for the health of human beings. Therefore present study was planned to determine the concentration of heavy metals (Cd, Hg, Pb, As, Cu, Zn, Co, Cr and Fe) in four commercially important freshwater fish species, which are common in reservoirs of Anuradhapura district namely Tilapia (*Oreochromis spp.*), Stinging catfish/Hunga (*Heteropneustes fossilis*), Bar Eyed Goby/Weligouwa (*Glossogobius giuris*) and Snakehead Murrel / Loolla (*Channa striata*). Metal concentrations of fish muscle were also compared with the national and international standards for food and human health.

## 2 METHODOLOGY

Studies were conducted from the fish samples collected from six reservoirs; Rajanganaya, Wilachchiya, Thuruwila, Padawiya, Kalawewa, and Kumbichchiyankulama of Anuradhapura district, NCP of Sri Lanka. Fish samples [(*Oreochromis spp.*), (*Heteropneustes fossilis*), (*Glossogobius giuris*) and (*Channa striata*)] were collected from the commercial landings of Rajanganaya, Wilachchiya, Thuruwila, Padawiya, Kalawewa, and Kumbichchiyankulama reservoirs during October to November 2009. They were packed in polythene bags and transported to the laboratory in an insulated box with crushed ice. In the laboratory, fish were cleaned and their total length, standard length and total weight were recorded. Then muscle of fish were separated using plastic dissecting instrument and oven dried at 105°C to a constant weight to determine moisture content [AOAC official methods 950.46 (2000)]. Then dried samples were powdered using a mortar and pestle and packed in air tight bags until further analysis. Protein content of each samples were analysed using heating digestion unit (VELP, DK 6) and Semi automatic steam distilling unit (UDK 132), according to the AOAC, "Official methods of analysis", method 981.10.

For the determination of metals, oven dried fish sample was pre-digested with conc.HNO<sub>3</sub> (65%AR) and it was digested under pressure in a closed vessel heated by microwaves using a microwave digester (model- Mars CEM XP 1500 plus). Then digested fish samples were transferred to grade "A" 100 mL volumetric flask and made up to the mark with deionized water. Each sample was analysed in duplicate. Two reagent blanks and two spiked samples were done with each batch. Spectra AA Varian atomic absorption spectrometer (AAS-240 FS) from Varian with graphite tube atomizer (Varian GTA) was used for Pb, Cd, Co and Cr determination. Vapor generation accessory (Varian VGA 77) with closed end cell was used for Hg determination. Varian VGA 77 with opened end cell was used for As determination. AAS-240 FS was used for Zn, Cu and Fe determination. All statistical analysis was conducted using Microsoft Excel 2007 version and Statistical Package for Social Sciences (SPSS 17.0). One way analysis of variance (ANOVA) was used to assess whether metal concentrations varied significantly among fish species. Analytical procedure performance was maintained throughout the analysis period. The spiked recovery limits were maintained between 80-120%.



### 3 RESULTS AND DISCUSSION

Average length, weight, moisture content and protein content of fish samples are shown in table 1 and the mean concentrations of Hg, As, Pb, Cd, Cr, Co, Zn, Cu and Fe of fish samples are shown in table 2. The highest mean Hg and Cd levels (0.1651 mg/kg and 0.0125 mg/kg) were recorded from *Channa striata* collected from Padawiya reservoir. Cadmium was not recorded from *Channa striata* collected from Wilacchiya and Kumicchiyankulama reservoirs. Arsenic was not recorded from *Oreochromis sp.*, *H. fossilis*, and *Channa striata*. The highest mean As value (0.0062 mg/kg) was recorded from *Glossogobius giuris* collected from Rajanganaya reservoir. The highest mean Pb value (0.0361 mg/kg) was recorded from *Oreochromis spp.* collected from Wilacchiya reservoirs. The highest mean Zn and Cu levels (4.7573 mg/kg and 0.6918 mg/kg) were recorded from *H. fossilis* collected from Wilacchiya reservoir. The highest mean Fe level (6.9516 mg/kg) was recorded from the same species collected from Rajanganaya reservoir.

**Table 1. Average total length, weight, moisture content and protein content of fish (wet wt. basis)**

Species	Length(cm)	Weight(g)	Moisture%	Protein%
<i>Oreochromis spp.</i>	22.7±4.2	252.29±155.84	81.43	15.90
<i>Heteropneustes fossilis</i>	24.4±2.8	97.57±31.18	82.88	17.50
<i>Glossogobius giuris</i>	21.7±3.1	87.97±40.27	80.94	14.74
<i>Channa striata</i>	43.0±6.8	824.55±350.22	77.10	19.56

Results are presented as mean ± standard deviation.

**Table 2. Metal concentrations in fish (mg/kg; wet wt basis)**

Metal	<i>Oreochromis spp.</i>	<i>Heteropneustes fossilis</i>	<i>Glossogobius giuris</i>	<i>Channa striata</i>
Hg	0.0089±0.0047	0.0414±0.0276	0.0404±0.0346	0.1183±0.0559
As	n.d	n.d	0.0040±0.0029	n.d
Pb	0.0147±0.0178	0.0101±0.0131	0.0119±0.0128	0.0048±0.0097
Cd	0.0007±0.0006	0.0008±0.0004	0.0003±0.0004	0.0031±0.0063
Cr	0.0112±0.0202	0.0089±0.0121	0.0090±0.0119	n.d
Co	0.0124±0.0135	0.0075±0.0056	0.0012±0.0017	0.0015±0.0012
Zn	3.2693±0.6248	4.4591±0.5838	3.2289±0.4325	3.3629±0.3232
Cu	0.4191±0.2120	0.6236±0.2038	0.2243±0.1553	n.d
Fe	1.9410±1.3843	6.2052±1.1793	2.6698±1.8280	0.3842±0.7683

Results are presented as mean ± standard deviation,  
n.d – not detected.



Metal concentration of fish samples decreased in the sequence for *Oreochromis spp.* as Zn>Fe>Cu>Pb>Co>Cr>Hg>Cd>As, for *H. fossilis* as Fe>Zn>Cu>Hg>Pb>Cr>Co>Cd>As, For *Glossogobius giuris* as Zn>Fe>Cu>Hg> Pb>Cr>As>Co>Cd, for *Channa striata* as Zn>Fe>Hg> Pb>Cd>Co>Cu=Cr=As. The highest Cr, Co and Pb concentrations were recorded in *Oreochromis spp.*, and highest Zn, Cu and Fe concentrations were recorded from *H. fossilis*. The highest hg and Cd concentrations were recorded from *Glossogobius giuris*. All the recorded values were lower than the established maximum allowable limits for heavy metals in Sri Lanka, WHO standards, Australian food standards and EU standards.

Bandara et al. (2007) reported the average weekly intake of Cd in residents in region irrigated with a reservoir carrying heavy levels of Cd in sediments, and in the fish reared in Thuruwila and Karapikkada reservoirs, is higher the maximum contaminated level of 0.007mg/Kg body weight., purely based on rice and fish intake in the average meal. He also reported to Lakbima newspaper, that staples such as rice, grains, vegetables and curd produced in the NCP contained Cd deposits and this is believed to be the reason for severe renal failure cases among those living in the NCP (Gunasekara, 2010). In 2008, the per capita fish supply was 17.6 kg and as recommended by the Medical Research Institute (MRI) the minimum required level of per capita fish consumption for healthy life is established as 21 kg (NARA,2008). According to that the weekly intake of fish in Sri Lanka, can be calculated as approximately 410 g per person. Hence, *Oreochromis spp.* recorded the highest Cd concentration among species, the maximum weekly intake of Cd was calculated to *Oreochromis spp.* Therefore the maximum weekly intake of Cd via fish in this study was 0.001 mg/Kg body wt./week. It was well below the Provisional Tolerable Weekly Intake (PTWI) established by Joint FAO/WHO Expert Committee on Food Additives. Therefore, present study indicates that there is no risk of intake of Cd from freshwater fish from Anuradhapura district.

According to the established PTWI values for Hg, Pb, Cd, As, Cu, Zn and Fe, a 50 kg person should not exceed the 0.25 mg of Hg/week, 1.25 mg of Pb/week, 0.350 mg of Cd/week, 0.75 mg of As/week, 350 mg of Cu/week and 280 mg of Fe/week. By considering the highest mean value of each metal in this study, the maximum weekly intake for Hg (0.049 mg/kg body wt./week), Pb (0.006 mg/kg body wt./week), As (0.002 mg/kg body wt./week), Zn (1.828 mg/kg body wt./week), Cu (0.256 mg/kg body wt./week) and Fe (2.544 mg/kg body wt./week) were also well below the PTWI established by Joint FAO/WHO Expert Committee on Food Additives. Therefore, *Oreochromis spp.*, *Heteropneustes fossilis*, *Glossogobius giuris* and *Channa striata* can be consumed without exceeding recommended PTWI values for Hg, Pb, Cd, As Cu, Zn and Fe.

#### 4 CONCLUSION & RECOMMENDATIONS

The highest Cr, Co and Pb concentrations were recorded in *Oreochromis spp.* and the highest Zn, Cu and Fe concentrations were recorded in *H. fossilis*. The highest Hg and Cd concentrations were recorded in *Channa striata*. Arsenic was recorded only from *Glossogobius giuris* among selected species. All the metal concentrations of fish were lower regulations made by the ministry of Fisher-



ies & Aquatic Resource in Sri Lanka than (Fisheries & Aquatic Resource Act, No 2 of 1996), maximum level allowed in food as recommended by the World Health Organization (WHO, 1989), EU standards (Commission Regulation (EC) No 1881/2006 of 19 December 2006) and Australian food standards (Anon, 1987). The weekly intake of Hg, Pb, Cd, As, Cu, Zn and Fe by consuming *Oreochromis spp.*, *H. fossilis*, *Channa striata* and *Glossogobius giuris* was well below the established PTWI limits for Hg, Pb, Cd, As, Cu, Zn and Fe by Joint WHO /FAO Expert Committee on Food Additives (JECFA). Therefore by consuming *Oreochromis spp.*, *H. fossilis*, *Channa striata* and *Glossogobius giuris*, the weekly protein requirement can be fulfilled without exceeding maximum allowable limits for Hg, Pb, Cd, As, Cu, Zn and Fe. Therefore, the fish from this region, in general, are safe for human consumption. In view of the importance of fish to diet of people, it is important to monitor regularly the levels of contaminants of fish to ensure continuous safety of food.

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# ENVIRONMENTAL CONTAMINATION AND ITS ASSOCIATION WITH CHRONIC KIDNEY DISEASE OF UNKNOWN ETIOLOGY IN NORTH CENTRAL REGION OF SRI LANKA

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## ABSTRACT

*High prevalence of Chronic Kidney diseases of unknown etiology (CKDue) observed in the North Central region of Sri Lanka has become an environmental health issue of national concern in Sri Lanka. In many studies, trace metals in the environment have been identified as a major geo-environmental factor contributing to the etiology of renal damage. Therefore 40 water samples collected from both affected area (n=35) in the North Central region of Sri Lanka and reference areas (n=5) were analyzed for physico-chemical parameters and heavy metals. The physico-chemical parameters – total dissolved solids, alkalinity, hardness and calcium were higher in groundwater (dug well and tube well) samples than the water samples collected from tanks, municipal supply, springs and river. The fluoride levels of groundwater in the dry zone are higher, in the range of 0.4 to 1.7 ppm as compared to those of the wet zone, in the range of 0.3 to 0.9 ppm. Heavy metals were not detected in the water samples which indicates that heavy metals in drinking water are not related to CKDue in Sri Lanka.*

*Key words – Chronic Kidney disease of unknown etiology, Sri lanka, Water, Heavy Metals*

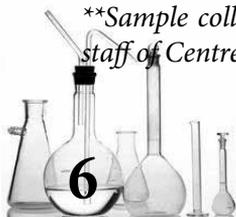
## 1 INTRODUCTION

High prevalence of Chronic Kidney Disease (CKD) has become an environmental health issue of national concern in Sri Lanka. The symptoms of Chronic Kidney Disease (CKD) in North Central Province of Sri Lanka, were found to be very different from the known risk factors of diabetes, hypertension or glomerulonephritis and hence it was termed as CKDue. High prevalence of CKDue is observed mainly in the in two main districts of the North Central Province — Anuradhapura and Polonnaruwa divisions of Anuradhapura (approx. 3500) Medawachchiya (approx. 2500 cases presently), Girandurukotte (approx. 1500 cases presently), Mahiyaganaya (approx. 800 cases presently), Padaviya (approx. 1800 cases presently), Medirigiriya (approx. 800 cases presently), Hingurakgoda (approx. 2000), Dehiattakandiya (approx. 400 cases presently), Nikawewa (approx.

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*\*.The Authors are the staff of the Pollution Monitoring Laboratory of the Centre for Science and Environment, India.*

*\*\*Sample collection, local information research and interviews were conducted and assisted by the staff of Centre for Environmental Justice, Sri Lanka.*



400 cases presently) and Kabithigollawa.. The prevalence is now spreading to the adjoining districts of North Western province, Uva province, Eastern province, Central province and the Northern province<sup>1</sup>.

Epidemiological data indicates that all the high prevalent areas are clustered around reservoirs of the irrigation system. Low prevalence of the disease was noted in communities who consume water from natural springs for drinking<sup>2</sup>. The disease mostly affects young males from low socio-economic farming communities; patients presented with non-specific symptoms, mild proteinuria and had bilateral echogenic small kidneys on ultrasound examination. The occurrence is mainly amongst males of age group 30–60 years engaged in agriculture.

The disease process appears to mainly affect the proximal tubules and the interstitium giving rise to characteristic, recognizable histopathological and clinical features. Clinically, the disease is characterized by tubular proteinuria, usually b2-microglobulinuria, and the absence of hypertension and edema. The histological appearance of the disease is 'tubulointerstitial' that can commonly be observed in toxic nephropathies<sup>3</sup>.

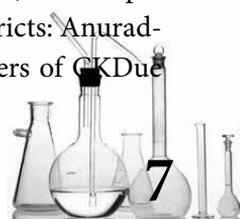
A study by Fonseka (et al) indicated that arsenic associated with elevated levels of hardness could reasonably be one of the potential causes of CKD<sup>4</sup>. The presence of high levels of fluoride<sup>5</sup>, widespread use of agrochemicals, exposure to cadmium was through the food chain<sup>6</sup>, lead and uranium in soil and water are postulated as contributory factors. In some studies, cyanobacterial toxins<sup>2</sup>, use of herbal/ayurvedic medicines<sup>7</sup>, illicit liquor<sup>8</sup>, smoking and snakebite are some other factors that have been considered<sup>9</sup>. Up to now, there is no unequivocal evidence to recognize the possible environmental causative factors that could lead to a nephrotoxins responsible for the disease.

Recently a new theory has been proposed and Arsenic is considered to be the main causative factor of CKD<sup>4</sup>. According to Jayasumana et al<sup>10</sup>, the calcium content in the hard water combines with the arsenic found in fertilizers and pesticides, forms calcium arsenate crystals and the crystals are bound to arsenic transporters in the liver and transport to kidneys.

In Sri Lanka, the quality of drinking water is at the base of all theories linked with CKD<sup>4</sup>. In many studies, trace metals (especially arsenic) in the environment have been identified as a major geo-environmental factor contributing to the etiology of renal damage. The focus of the study, therefore, was to analyze drinking water quality for physico-chemical parameters and heavy metals in affected and unaffected regions.

## 2 METHODOLOGY

During the study, water samples (n=35) from ground water (dug well and tube well), municipal supply, tank, river and springs were collected from the affected areas of the two districts: Anuradhapura and Polonnaruwa in the North Central Province of Sri Lanka, high numbers of CKD<sup>4</sup>



cases have been observed in. In order to compare the results of water quality in the endemic regions, five water samples were taken from Kandy area (n=5). Kandy in Central Province, which falls in the wet zone, was used as reference area as there were no reports of CKD due from here.

The 40 water samples collected from both affected area (n=35) and reference areas (n=5) have the following source-wise categorization: well water (n=28; 23 dug well and 5 tube well), tank water (n=4; Ampara, Padaviya, Minneriya and Konduwatwana Tank), municipal supply (n=4), river (n=1) and spring (n=3).

The well water samples were collected from the centre of the well and at about a depth of three feet from water surface in clean plastic bottles. During sample collection, CKD due positive patients and their family members were interviewed and data on age, occupation, and source of drinking water and family history were recorded. All the water samples were analyzed for physico-chemical parameters and heavy metals.

The physico-chemical parameters in water samples—pH, hardness, TDS, conductivity, alkalinity, calcium, magnesium, sulphate, chloride and fluoride—were analyzed using standard methodology provided by American Public Health Association (APHA 1985) 11

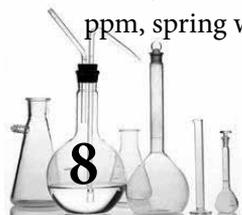
For heavy metals in water samples—lead, cadmium and chromium—samples were prepared by EPA method 3010 for aqueous and extracted samples analyzed by Flame Atomic Absorption Spectrophotometry (FLAA). Detection limit for lead was 0.01 ppm, cadmium 0.01 ppm, and chromium 0.02 ppm. Arsenic in water samples was analyzed using standard methodology prescribed by Environment Protection Agency, EPA method 7060A –Graphite Furnace Atomic Absorption Spectrometry (GFAA). Detection limit for arsenic was 0.002 ppm.

### 3 RESULTS AND DISCUSSION

The results of the physico-chemical parameters and heavy metals analyzed in the water samples (n=40)—groundwater (n=28), tank water (n=4), municipal supply (n=4), spring (n=3) and river water (n=1)—collected from the endemic and non endemic areas (Table 1).

In the present study the Sri Lanka standards for potable water prescribed in SLS 614: 1983 were used for the comparison of the water quality parameters in the CKD due affected and unaffected areas.

Under SLS 614: 1983 the maximum desirable level for TDS is 500 ppm and the maximum permissible level is 2000 ppm. In 40 water samples collected, TDS was detected at a mean level 363 ppm in dug wells; 306 ppm in tube wells; tank water was 192.3 ppm followed by municipal water 97.5 ppm, spring water 57.2 ppm and river water 34 ppm (Table 3 ).



The mean TDS level in all water samples (n=35) of the affected area was 271.3 ppm as compared to 113.2 ppm in the reference area (n=5). None of the samples exceeded the maximum desirable level of 500 ppm (Table 4)

Under SLS 614: 1983 the maximum desirable level for hardness is 250 ppm and the maximum permissible level is 600 ppm. In 40 water samples collected, hardness was detected at a mean level of 291.5 ppm in tank water, 258 ppm in dug wells; 246 ppm in tube wells; followed by municipal water 155 ppm, spring water 93 ppm and river water 59.7 ppm (Table 3). The mean hardness level in all water samples (n=35) of the affected area was 225.8 ppm as compared to 136 ppm in the reference area (n=5). (Table 4) The groundwater of Sri Lanka is divided into 4 categories- calcium, magnesium, sodium /potassium and non-dominant action type. Calcium type of water is distributed in the northern and north central region <sup>12</sup>.

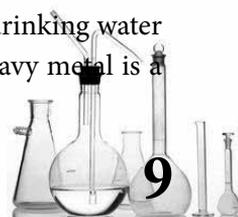
Under SLS 614: 1983 the maximum desirable level for calcium is 100 ppm and the maximum permissible level is 240 ppm. In 40 water samples collected, calcium was detected at a mean level 86 ppm in dug wells, 62 ppm in tube wells, 66 ppm in tank water followed by municipal water 52 ppm, spring water 16 ppm and river water 20 ppm (see Table 3). The mean calcium level in all water samples (n=35) of the affected area was 70.7 ppm as compared to 43.2 ppm in the reference area (n=5) (Table 4). None of the water samples exceeded the maximum desirable levels.

Under SLS 614: 1983 the maximum desirable level for alkalinity is 200 ppm and the maximum permissible level is 400 ppm. In 40 water samples collected, alkalinity was detected at a mean level 131 ppm in dug wells, 96 ppm in tube wells, 72.5 ppm in tank water followed by municipal water 22.5 ppm, spring water 16.7 ppm and river water 10 ppm (Table 2). The mean alkalinity level in all water samples (n=35) of the affected area was 95 ppm as compared to 26 ppm in the reference area (n=5). All the samples were well within the maximum desirable levels.

Under SLS 614: 1983 the maximum desirable level for fluoride is 0.6 ppm and the maximum permissible level is 1.5 ppm. 40 water samples collected, fluoride was detected at a mean level 1 ppm in dug wells, 1 ppm in tube wells, 0.7 ppm in tank water followed by municipal water 0.5 ppm, spring water 0.4 ppm and river water 0.5 ppm. The mean fluoride level in all water samples (n=35) of the affected area was 0.8 ppm as compared to 0.5 ppm in the reference area (n=5).

The other parameters tested were for pH, chloride, sulphate and magnesium. In all the 40 water samples, these parameters were found to be within the maximum desirable levels prescribed for drinking water under SLS 614: 1983. The results of pH, chloride, sulphate and magnesium are given in Table 2.

Cadmium, arsenic, chromium and lead were not detected in drinking water samples collected either from the affected area or reference area, indicating that these heavy metals in drinking water is not a contributing factor for CKD due in Sri Lanka, as also reported earlier<sup>1</sup>. If heavy metal is a causative factor of CKD due, then its source is different than drinking water.



## 4 CONCLUSION

Total Dissolved Solids exceeded the maximum desirable levels of 500 ppm in 6 out of 40 samples—5 dug well water and 1 tube well water, all in the affected areas. Hardness exceeded the maximum desirable levels of 250 ppm in 14 out of 40 samples—11 dug well water and 3 tube well water. 1 tube well water sample, which exceeded the maximum desirable levels, was from the reference area. Calcium exceeded the maximum desirable levels of 100 ppm in 9 out of 40 samples—7 dug well water and 2 tube well water, all from the affected areas. Alkalinity exceeded the maximum desirable levels of 200 ppm in the 5 out of 40 samples—4 dug well water and 1 tube well water, all from the affected areas. Fluoride levels exceeded the maximum desirable levels of 0.6ppm in 22 out of 40 samples—15 dug well water, 5 tube well water, 1 municipal supply and 1 tank water sample. 1 tube well water sample, which exceeded the maximum desirable levels, was from the reference area. One tube well water sample from Polonnaruwa exceeded the maximum permissible levels of 1.5 ppm.

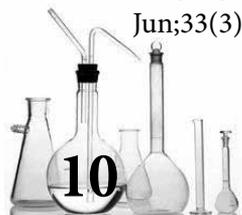
The physico-chemical parameters --TDS, alkalinity, hardness and calcium were higher in ground-water (dug well and tube well) samples than the water samples collected from tanks, municipal supply, springs and river(Table 3). People in the affected areas of Ampara, Badulla, Polonnaruwa and Anuradhapura district were consuming water directly from these dug wells and tube wells (Table 4).Not all households have access to water filters.

The results also indicate that maximum number of groundwater samples exceeded the maximum desirable level of fluoride. The study shows that fluoride levels of groundwater in the dry zone are higher, in the range of 0.4 to 1.7 ppm as compared to those of the wet zone that is in the range of 0.3 to 0.9 ppm. Though the fluoride levels, in all but one sample, is within the maximum permissible levels prescribed in SLS 614: 1983, studies have shown that fluoride at these low levels over a long period of time is a possible risk factor responsible for kidney diseases.

It can be safely concluded that: People in the affected areas are drinking relatively poor quality water than those in the unaffected areas. The spring, river water and municipal water are of comparatively better quality (based on the parameters tested)than dug well and tube well water. Heavy metals in drinking water are not related to CKD due in Sri Lanka. If heavy metal is responsible, then there is a different source for it than drinking water and that should be explored.

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# PREPARATION AND CHARACTERIZATION OF DIMENSIONALLY STABLE ANODE FOR DEGRADATION OF CHLORPYRIFOS IN WATER

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## 1 INTRODUCTION

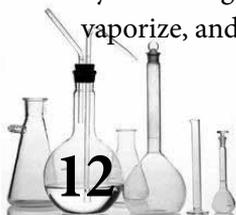
Pesticides have been recognized as one of the major organic pollutant in water streams because of their increasing use in agriculture. Chlorpyrifos (CP) is one of the most widely used organophosphate pesticides in agricultural pest control and in households as a termiticide. It is now one of the top commercial insecticides in Sri Lanka. Excessive exposure to chlorpyrifos may cause poisoning and hence affect the central nervous system, cardiovascular system and respiratory system. In addition, it acts as a skin and eye irritant (Tang et al., 2012). As a consequence, the use of chlorpyrifos has been vastly restricted in United States (U.S.) and in some European countries. However, Sri Lanka has been imported 317.43mt (Statistical data, Office of the registrar of pesticides) of chlorpyrifos to the country in the year 2008. As such, treating chlorpyrifos-contaminated water is of very high importance.

In recent years, the electrochemical degradation of organic compounds becomes an emerging technology due to factors such as in-situ chemical generation, ease in process control and high efficiency. This study therefore, addresses electrochemical degradation of chlorpyrifos by developing the anode material. Among the possible electrode materials, a dimensionally stable anode (DSA) was developed in order to mineralize chlorpyrifos in chlorine free environment. Although the electrochemical degradation of chlorpyrifos has given considerable attention, the use of DSA like Ti/IrO<sub>2</sub> for that has never attempted before. The major objectives of this study are to investigate the efficiency in degradation and electrochemical properties of the developed anode.

## 2 METHODOLOGY

### DSA preparation

Titanium plates with a dimension of 10mm x 10mm x 2.5mm i.e., an effective geometric area of 2.5 cm<sup>2</sup> were used as substrates. Prior to the dip coating, electrode was sandblasted and pretreated using 5% (w/w) oxalic acid solution for 10 min and 37% (w/w) HCl acid for 5 min, respectively. The substrate was then dried at 100 °C. The precursor solution for depositing IrO<sub>2</sub> was prepared by dissolving 0.56g of IrCl<sub>3</sub>.3H<sub>2</sub>O in 4.6 ml ethanol, air dried in 80°C for 5 min to allow solvents to vaporize, and then calcinated in an oven at 450°C for 10 min. This process was repeated until final



coating load of 1 mg/cm<sup>2</sup>. Finally it was post backed at 500°C in muffle furnace for 1 h (Fockedeey et al., 2002).

### Electrochemical degradation of Chlorpyrifos

The chemical oxygen demand (COD) for the degradation of chlorpyrifos was determined by the dichromate method(410.4) (Pisal, 2010).The Ti/ IrO<sub>2</sub> electrode described above as an anode and a Ti plate as a cathode was set at distance of 1.0 cm. The operating current density was 20 mAcm<sup>-2</sup>. The appropriate amount of samples was collected during 6 hours and absorbance was measured by using UV-visible(Shimadzu, UV- 2450) spectrophotometer.

### Determination of current efficiency

The instantaneous current efficiency (ICE) for the anodic oxidation of chlorpyrifos was calculated using the following expression (Sun et al., 2012).

$$ICE = \frac{[(COD)_t - (COD)_{(t+\Delta t)}]FV}{FV/8I\Delta t}$$

Where (COD)<sub>t</sub> and (COD)<sub>t+Δt</sub> are the initial chemical oxygen demand (gO<sub>2</sub> m<sup>-3</sup>) at time t and t+Δt (s) respectively. I is the applied current (A), F is the Faraday constant (Cmol<sup>-1</sup>) and V is the volume of the electrolyte (m<sup>3</sup>).

### Cyclic Voltammetry

Cyclic Voltammetry (CV) was operated for the electrodes using potentiostat galvanostat equipment (Autolab PGSTAT128N). The electrode under study was used as the working electrode (WE), and Ag/AgCl electrode was used as the reference electrode (RE). Range of voltage scan was from -2.5 to 2.5 V at the scan rate of 0.1 V/s. The Na<sub>2</sub>SO<sub>4</sub> (10 g/L) was used as the electrolyte.

## 3 RESULTS AND DISCUSSION

The electrochemical oxidation of chlorpyrifos was carried out with two electrolytes. N<sub>a</sub>2C<sub>o</sub>3 was used as OH<sup>0</sup> radical scavenger. According to Figure 1, it was found that prepared Ti/ IrO<sub>2</sub> electrode could mineralize chlorpyrifos up to 65.1% in sulphate medium and 58.7 % in carbonate medium after the electrolysis time of 6 hours. COD concentration was also reduced from 183.16 mg/L to 64.28 mg/Lin sulphate medium and from 134.36 mg/L to 54.60 mg/Lin carbonate medium. Consequently, it is clear that OH<sup>0</sup> radical is generated in Na<sub>2</sub>SO<sub>4</sub> electrolyte and the generated radical is scavenged by Na<sub>2</sub>CO<sub>3</sub> reducing the removal efficiency.



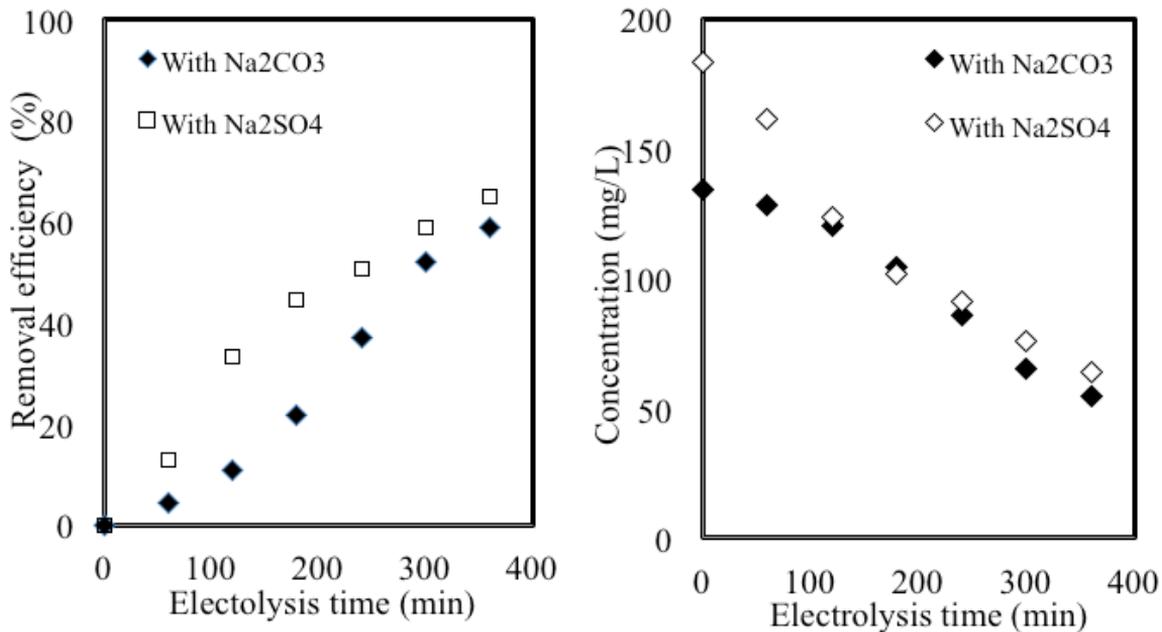


Figure 1: (a) Variation of COD removal percentage with electrolysis time (b) Variation of COD concentration during electrolysis time, on Ti/IrO<sub>2</sub> anode in Na<sub>2</sub>SO<sub>4</sub> and Na<sub>2</sub>CO<sub>3</sub> electrolytes. Current density = 20 mA/cm<sup>2</sup>, Reaction time = 6h, [CP] = 1 mg/L and temperature = 25°C

Figure 2 shows the instantaneous current efficiency (ICE) during electrochemical degradation of chlorpyrifos. The value of ICE was relatively high in the initial period of reaction, and then decreases dramatically with the increase of electrolysis time.

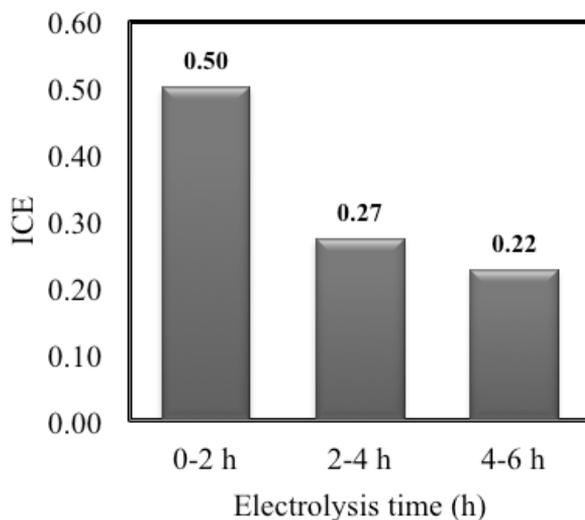


Figure 2: Change in ICE with respect to electrolysis time on Ti/IrO<sub>2</sub> anode for the degradation of 1 mg/L chlorpyrifos solution. Electrolyte= 10 g/L of Na<sub>2</sub>SO<sub>4</sub>, Current density = 20 mA/cm<sup>2</sup>, Reaction time = 6h

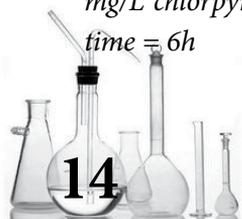


Figure 3 shows the CV diagrams obtained for the Ti/IrO<sub>2</sub> anode and uncoated electrode. It shows a considerable difference in electrochemically active surface area. According to the CV diagrams, it was found that the anodic charge increased from 29.8 mC to 149.67 mC after the development of Ti/IrO<sub>2</sub> anode. This finding further confirms the increment in electrochemically active surface area because of the coating layer applied on the substrate. Such increment is important to generate a greater amount of OH<sup>•</sup> radicals.

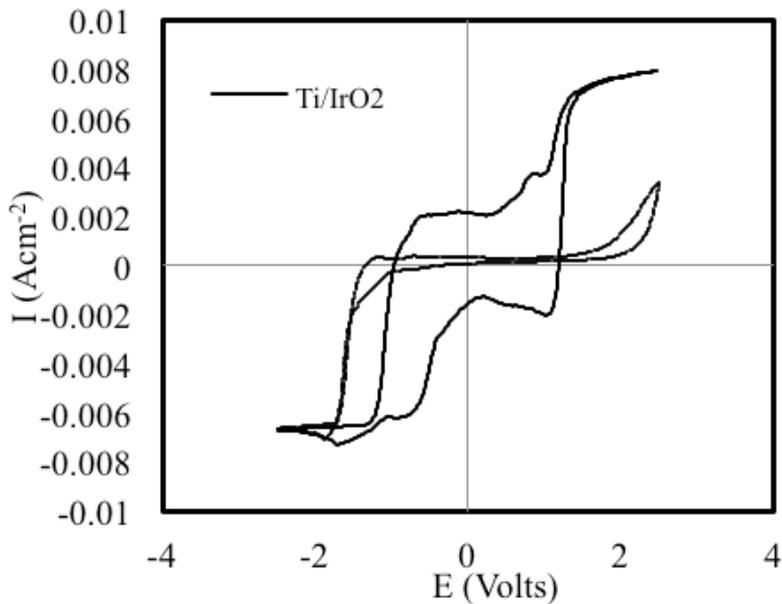


Figure 3: Cyclic voltammograms of (a) Ti/IrO<sub>2</sub> anode (b) Ti substrate. Scan range = 2.5 V to -2.5 V, Scan rate = 0.1 V, Electrolyte = 0.5M of Na<sub>2</sub>SO<sub>4</sub>, Geometrical area of electrode = 2.6 cm<sup>2</sup>, Reference electrode = Ag/AgCl

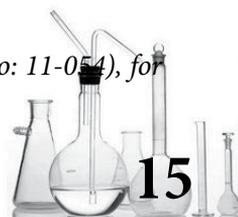
This fact indicates that Ti/IrO<sub>2</sub> can be successfully used for the treatment of effluents containing chlorpyrifos in chlorine free environment.

#### 4 CONCLUSIONS

Since wastewater contains considerable amounts of organic pollutants, electrochemical technology can be applied to treat such water. By using developed Ti/IrO<sub>2</sub> anode chlorpyrifos can be mineralized up to 65.1% in Na<sub>2</sub>SO<sub>4</sub> as electrolyte. It was found that the anodic charge increased from 29.8 mC to 149.67 mC for the developed Ti/IrO<sub>2</sub> anode. Indeed, surface coating affects the oxidant generation. However, further study should be conducted to improve the stability of this anode by adding secondary oxide and optimized it.

#### Acknowledgements

The authors wish to thank the National Research council (NRC) - Sri Lanka (Grant no: 11-054), for the financial support.



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# GLOBAL OCCURRENCE OF TOXIGENIC CYANOBACTERIA, THEIR ENVIRONMENTAL AND HEALTH EFFECTS

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## 1 INTRODUCTION

Water is a precious resource subject to a host of extreme environmental pressures which can affect water quality (Tarczynska et al., 2001). The presence of cyanobacteria (blue-green algae) in surface water is of increasing concern in the world (Klöhn and Hagemann, 2010). In addition to apparently changing ecosystem structure and function, cyanobacterial blooms require the special attention of environmental agencies and public or water authorities because they have been shown to present a range of serious risks to both human and animal health (Marsalek and Blaha, 2004) because, algal blooms have become a global problem as a result of continuous growth of population and increasing water demand (Wu et al., 2010b). Eutrophication of the freshwater bodies due to appearance of cyanobacterial blooms as a result of global warming (Tarczynska et al., 2001; Yoshida et al., 2003) and with intensification of agriculture resulting in enhanced fertilizer content of surface run-off and with increased sewage input into surface waters, “blooming” of cyanobacteria have become a worldwide problem for the supply of safe drinking water (Eiler and Bertilsson, 2004; Torokne et al., 2007).

In particular, cyanobacterial blooms can impose strong physiological, chemical and biological impacts on the biogeochemical properties and function of water systems (Paerl et al., 2001) and this problem can become serious when these cyanobacteria release potent water soluble toxins (Ahmed et al., 2008). Cyanobacteria naturally produce deleterious compounds, called cyanotoxins, due to cell death or lysis during cyanobacterial blooms and may persist in the surrounding water for some time, usually for some days up to weeks (Jones and Orr, 1994; Rapala et al., 1994; Tsuji et al., 1994).

The toxins have been grouped in to hepatotoxins, neurotoxins and lipopolysaccharide endotoxins according to their mode of action (Paerl et al., 2001) and the toxins of freshwater cyanobacteria are classified into two groups, neurotoxins and hepatotoxins, which include cyclic- peptide microcystins and nodularin (Frank, 2002; Gupta et al., 2003). Microcystins are the most abundant group of cyanotoxins, and other cyanotoxins include anatoxin-a, anatoxin-as, aplysiatoxin, cylindrospermopsin, domoic acid, nodularin R and saxitoxin which are produced by various genera of cyanobacteria, the principal species being *Microcystis* sp. (Carmichael, 1992; Gremberghe, et al., 2009; Hitzfeld et al., 2000; Schatz et al., 2007) and others are *Anabaena* sp., *Planktothrix* sp. etc (Yoshida et al., 2003). But the filamentous cyanobacteria from the genus *Planktothrix*, including *P. agardhii* and *P. rubescens*, are one of the most important microcystins (MCs) producers in freshwaters of the temperate climatic zone (Kurmayer et al., 2004; Christiansen et al., 2006).

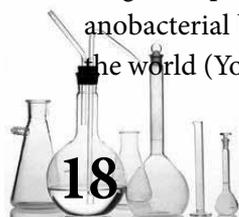


Cyanobacterial growth leading to blooms along with toxin formation and their fatalities to livestock, pets, wild animals, aquatic animals, birds and human are known worldwide (Feitz et al., 1999). Exposure to toxins may be direct such as drinking water, recreational activity or indirect, from fish, shellfish or from plants irrigated with water containing algal toxins (Jones and Orr, 1994). Health effects can occur when surface scum or water containing high level of microcystin are swallowed, through contact with skin while swimming, wading or showering or by airborne droplets while staying nearby ponds or reservoirs contaminated with toxins (Mankiewicz-boczek et al, 2011). Acute exposure to these toxins has been responsible for human and animal fatalities, whereas, chronic exposure has been shown to be responsible for primary liver cancer and neuro toxicity in epidemiological studies (Rapala et al., 1994). This data led the WHO to establish a guideline of  $1 \mu\text{g l}^{-1}$  as a maximum concentration of *microcystin-LR* (MC-LR) in drinking water; in addition the International Agency for Research on Cancer (IARC) classified microcystin as a carcinogen (WHO, 1998).

Scarcity of natural surface water sources, such as rivers, ponds, reservoirs and lakes, has forced many parts of the dry zone in Sri Lanka to choose irrigation water tanks as the source for drinking water supply schemes (Jayatissa et al., 2006). Surface runoff drains to irrigation tanks, which are generally shallow, through cultivated areas and therefore the water is rich in nutrients and causes rapid growth of algae and cyanobacteria. These algal and cyanobacterial blooms can cause several problems, depending on the species and their concentration (Pathmalal & Piyasiri, 1999). Out of more than 150 genera of cyanobacteria around 41 species are known to produce toxins in addition to cell wall LPS endotoxins. Production of toxin is highly variable both within and between blooms and potency can vary over time for an individual bloom.

In Sri Lanka, there were some records about sudden fish and cattle deaths attributed to the presence of toxic cyanobacterial blooms (Jayatissa et al., 2006; Pathmalal,1999) and recently some researchers have highlighted but not confirmed the effect of cyanotoxins on chronic renal disease in the north central province in Sri Lanka. Manage et al. (2010) recorded that the hepatotoxic effect of the *Microcystis aeruginosa* on Wister rats in vitro. A research conducted by the department of Zoology, University of Sri Jayewardenepura revealed that the contamination level of microcystins-LR in some drinking, irrigation and aesthetic water bodies in Sri Lanka ranged between 2-  $10 \mu\text{g/l}$  (Sethunge and Manage, 2010) and these values were much higher than the WHO recommended value of  $1.0 \mu\text{g/l}$  for drinking and recreational water quality standards (WHO, 1998).

Also, an insignificant relationship between cyanobacteria and cyanotoxin microcystin-LR contamination was found suggesting the importance of molecular screening of toxigenic cyanobacteria in water bodies to ascertain the potential health impact. This is essential if public health is to be safeguarded since providing safe drinking water is one of the most critical factors to guarantee long-term population health. Temporal changes in microcystin producing and non-producing cyanobacterial blooms, mainly *Microcystis sp.* were reported in water bodies from different parts of the world (Yoshida et al., 2007). Though several research groups have recently reported the occur-



rence of toxic and non-toxic strains of *Microcystis* in water bodies (Vezie et al., 1998; Neumann et al., 2000; Baker et al., 2002), the factors determining their relative abundance and the relationship between them are poorly understood (Schatz et al., 2005).

Cyanobacterial blooms are not always toxic. Our research group in the University of Sri Jayewardenepura revealed that even high cyanobacteria density was not given high concentration of microcystin-LR though low density of cyanobacteria was given considerable concentration of microcystin-LR confirming that diverse genotypes of cyanobacteria are responsible to produce microcystin toxins. Hence, at the same sampling point, it is possible to find toxic and nontoxic strains of the same species of cyanobacteria. Cyanobacterial toxin concentration is apparently influenced by many factors such as the composition of the phytoplankton community, stage of growth of the cyanobacterial population, and domination of toxic species of cyanobacteria (Tarczynska et al., 2001). Therefore the exact identification of strain of cyanobacteria or strain of *Microcystis* is essential prior to predict whether they are toxic or non toxic. *Microcystis* species have been traditionally identified on the basis of morphological features, such as cell arrangement in colonies and characteristics of mucilage around the colonies (Yoshida et al., 2003).

However, even if cyanobacteria show more morphological diversity than other bacterial groups, the discrimination at the species level is often problematic (Zwart et al., 2005). Morphological features are futile when separating the toxic and non-toxic strains, because both are having similar external morphological features as they are subpopulations of a same species. Therefore it is important to apply molecular biological techniques for the identification of these different *Microcystis* and other cyanobacterial genotypic strains (Yoshida et al., 2003). This matter is same for Sri Lanka and therefore, molecular characterization of toxic and non toxic cyanobacterial species in Sri Lanka has been started.

Genetic differentiation of *Microcystis* colonies based on rRNA internal transcribed spacer (ITS) sequences provides an adequate basis for recognition of microcystin producers. Consequently, ecological studies of toxic and nontoxic cyanobacteria are now possible through studies of rRNA ITS genotypic diversity in isolated cultures or colonies and in natural communities (Ingmar et al., 2004).

## 2 METHODOLOGY

Batch cultures of cyanobacteria were prepared in solid and liquid culture media using the fresh algae samples collected from eleven (11) water bodies. BG 11 liquid medium and the BG 11 agar solid medium were selected as the most suitable culture medium to maintain the cyanobacterial cultures. Selected cyanobacterial colonies or cells were isolated from batch cultures to prepare monocultures by dilution method.



### 3 RESULTS AND DISCUSSION

In the presentation we discuss about toxigenic cyanobacteria and their use for monitoring of cyanotoxins for safe drinking water supply.

Table 1. Species composition and number of isolated cyanobacterial strains from water bodies different water bodies

Reservoir	District	Most common species	Number of Isolates
Boralesgamuwa	Colombo	<i>M. aeruginosa</i> , <i>Microcystis spp.</i> , <i>Merismopedia spp.</i>	10
Beira		<i>M. aeruginosa</i>	3
Labugama		N/R	N/R
Kalatuwawa		N/R	N/R
Jayanthiwewa	Ampara	<i>Microcystis spp.</i>	12
Kondawatuwana		<i>M.aeruginosa</i> , <i>Cylindrosmermopsis</i>	2
Weeragoda		N/R	3
Sagama		N/R	N/R
Parakrama Samudraya	Polonnaruwa	<i>M. aeruginosa</i>	1
Minneriya Wewa		N/R	N/R
Giritale Reservoir		<i>M.aeruginosa</i> , <i>M. wesenbergii</i>	12
Tissa Wewa		N/R	N/R
Nuwara Wewa		<i>M. aeruginosa</i>	1
Thuruwila		N/R	N/R
Eluwankulama	Puttalam	N/R	N/R
Kala Oya		N/R	N/R
Ridiyagama Tank	Ambalanthota	N/R	N/R
Kandy Lake	Kandy	<i>M. aeruginosa</i> , <i>M. wesenbergii</i>	5
Janaranjana Reservoir	Trincomalee	N/R	6
Kantale Tank		N/R	2
Kantale Podi Wewa		<i>M. aeruginosa</i>	3
Mahaweli River		N/R	N/R
Hot Water Springs		N/R	N/R
Adithyamalay	Bataloa	<i>Microcystis spp.</i>	2
Unnichchi		<i>Microcystis spp.</i>	4



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# THE MERCURY CONTAMINATION IN SOME SELECTED WHITENING CREAM SAMPLES FOUND IN THE LOCAL MARKET

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*Centre for Environmental Justice*

## 1 INTRODUCTION

Mercury is one of the primary toxic metals of concern in cosmetics. The toxicity depends on the type of mercury exposed. The most hazardous form is the organic or the Methyl mercury. But all forms of mercury are absorbed through skin and tend to accumulate in the body due to lipophilic property of the chemicals<sup>1,3</sup>. Contamination of mercury in blood can cause allergic reactions, skin irritation, or adverse effects on the nervous system<sup>3</sup>. Clinical symptoms of over exposure to mercury include tremors, weakness, memory loss, dermatitis and impaired kidney function<sup>4</sup>. Despite of all these health issues mercury is used in whitening treatments such as whitening creams, soaps and ointments<sup>2</sup>. The mercury in whitening creams function as the inhibitor of melanin formation<sup>2</sup> and the products are popular among the people with a dark complexion disregard of the gender or the country they live. Whitening cosmetic products are popular all over the world including Sri Lanka. Some survey has highlighted that some of these whitening products are available in populated as well as very rural areas of Sri Lanka..

According to the US food and Drug Administration (FDA), the concentration of mercury compounds as cosmetic ingredients is limited to eye area and not allowed to increase concentrations of mercury more than 65ppm [parts per million (0.0065 percent)] and their metal (about 100 ppm or 0.01 percent phenylmercuric acetate or nitrate) is permitted only if no other effect. All other cosmetics containing mercury is contaminated and subject to regulatory action unless it occurs in less than 1 ppm (0.0001 percent) as metal and its presence is unavoidable under conditions of good manufacturing practice<sup>3</sup>.

However, in Sri Lanka, under the SLS 743: for Skin creams and lotions, the specifications for raw materials and adjuncts are given under SLS 457: Part 2: Raw materials and adjuncts other than dyes, pigments and colour additives generally not recognized as safe.

Accordingly;

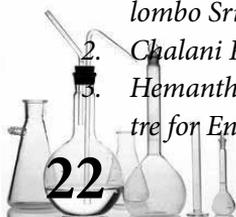
- Mercury and its compounds are listed under the Appendix A of “GNRAS” list.
- “GNRAS” list indicates; “ingredients which are generally not recognized as safe and

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which shall not be permissible either in any amount or in amounts exceeding those specifically laid down for cosmetics.

- It is further elaborated in Appendix C: Part 1: The list of preservatives which cosmetic products may contain subject to the restrictions and conditions laid down. Here the description gives “Thiomersal (INN) can contain the maximum concentration of Hg remains fixed at 0.007% (70ppm), only for eye make-up and eye make-up remover.
- SLS 457: Part 2: Clause 4 indicates that “GNRAS” list shall be updated with the latest relevant WHO publications and EEC council directives and amendments there under.
- SLS 457: Part 1: colouring agents, pigments and colour additives generally recognized as safe, indicates that, silver shall confirm to be having Mercury not more than 1mg/kg.

It is always a best practice to check whether the product contains an ingredients list and mercury is not listed in it. Mercury can be indicated as, “calomel,” “mercuric,” “mercurous chloride” or “mercurio,” “mercuric oxide,” “mercuric sulphide (vermilion)” 6,2.

The aim of this study was to analyze the amount of Mercury in Skin whitening creams and thereby to reveal the intentional exposure to this toxic chemical just for the sake of changing the natural beauty.

## 2 METHODOLOGY

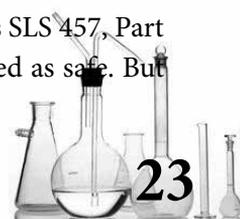
An initial survey was carried out in order to find the brands already detected for mercury in world-wide surveys. In addition a list of products was taken by the verbal conversation with users. Sampling was done for total of 16 whitening cream products from the local market stores in Colombo and Negombo where most of the customers visit.

Sample containers were cleaned and labelled with four digit code number. 50g of each sample was collected in which some included several cream containers. This was done as a preliminary survey only to understand the contamination level. Sent for analysis to the SGS (Société Générale de Surveillance) Lanka (Pvt) Ltd and SGS India (Pvt) Ltd for testing the level of mercury and Lead using the Atomic Absorption Spectrometry (AAS). The least detection level for Mercury is 0.02ppm and for Lead 0.05ppm.

## 3 RESULTS AND DISCUSSION

No warning label was found on the label or information leaflet. Most of the samples were imported items where language is not English (either Mandarin or Thai languages).

Mercury was detected in 9 out of 16 samples (Table 1). The Sri Lanka Standard institution’s standard SLS 743 pertaining for Skin cream and lotions in its provisions for raw materials SLS 457, Part 1, lists Mercury and its compounds as a substance which is generally not recognized as safe. But the levels detected in cream samples falls between 0.06- 30167.66ppm.



Four whitening cream products show relatively higher concentrations of mercury (Fig.1). and they are imported products.

The remaining five products in which Mercury was detected, relatively low levels were observed (Fig .2). Out of these samples three are produced in Sri Lanka, two are imported.

It was also seen that the Mercury concentration differs with the sample of the same product. Of C032 and C033, in 35ml sample products obtained in which the batch number is not indicated but the date of manufacture and expiry are the same, one was detected for 1.92ppm of mercury while the other was not detected (<0.02ppm) [Table 1].

Considering the levels given for tolerable daily intake by the WHO (World Health Organization), the 2 µg/kg body weight/day for total mercury<sup>5</sup> all the samples contain hazardous levels of mercury in them. It is worth considering that cosmetics are not the only source of exposure.

Lead was detected in only one sample to a concentration of 33.27ppm while the rest was recorded as not detected (<0.05ppm).

*Table 1. Concentrations of Mercury and Lead in the whitening cream samples.*

<b>Cosmetic product</b>	<b>Sample No.</b>	<b>Level of Mercury(mg/kg)</b>	<b>Level of Lead (mg/kg)</b>
XIN JIAOLI 10 WHITENING SP. RE2	CA04	1506.52	<0.05
XIN JIAOLI 10 WHITENING SP. RE2	CB04	1218.53	<0.05
PAI MEI WHITENING SPOT CRM	C007	30167.66	<0.05
CAIKE GINSENGWHITEN CREAM	C008	19699.1	<0.05
LOREAL WHITE PERFECT DAY	C012	<0.02	<0.05
EMAMI FAIR AND HANDSOM	C014	<0.02	<0.05
FAIR N LOVELY C.FAIRNESS C.	C019	<0.02	33.27
THAI ROSE WHITENING CREAM	C023	4.17	<0.05
FAIREVER FAIRNESS CREAM	C024	0.45	<0.05
EVE FAIRNESS	C030	25.46	<0.05
VASELINE HELTHY WHITE (BCD3:49)	C031	<0.02	<0.05
NATURE SECRETS MULBERRY FAIRNESS CREAM	C032	1.92	<0.05
NATURE SECRETS MULBERRY FAIRNESS CREAM	C033	<0.02	<0.05
VASELINE HELTHY WHITE (BCD3:48)	C034	<0.02	<0.05
JANET AYURVEDA FAIR & NATURAL	C020	<0.02	<0.05
OLAY WHITE RADIANCE	C006	0.06	<0.05



Figure 1. Products in which high levels of Mercury were detected

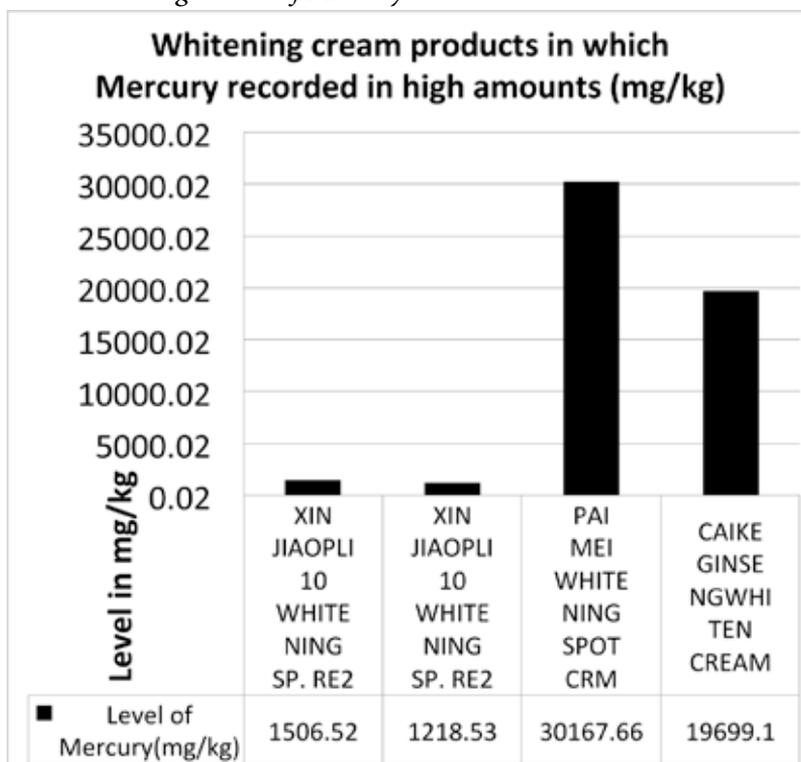
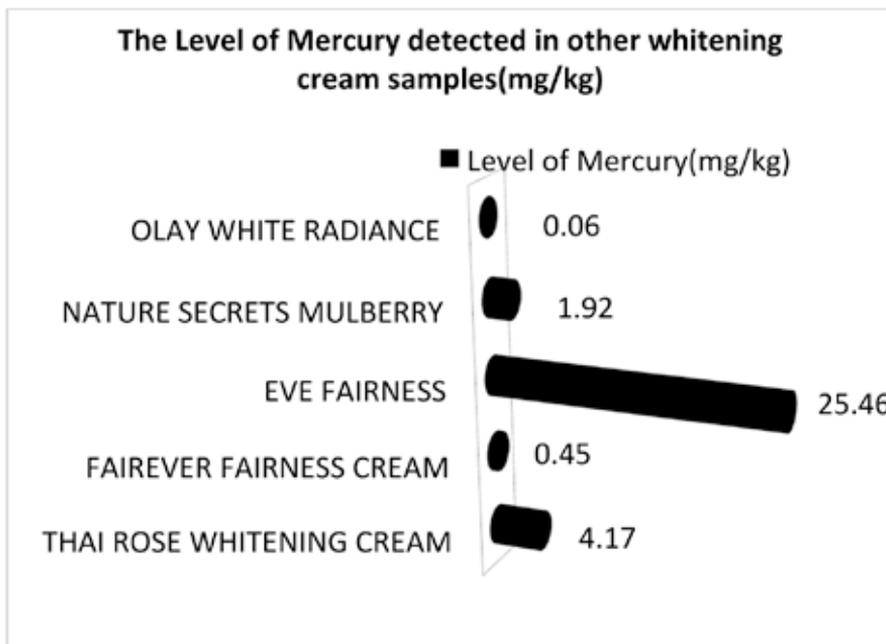


Figure 2. Concentration levels of Mercury in other tested whitening products



#### 4 CONCLUSION/ RECOMENDATIONS

It is evident that whitening cream products in the local market can contain dangerous amounts of mercury. This can be varying with the sample batch.

It is necessary to bring out mandatory standards, for type of mercury and the permissible level to be included in the cosmetic product. The consumer must always check for the product for the list of ingredients.

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# ENVIRONMENTAL IMPACT AND USE OF AGROCHEMICALS IN CATTLE FEED AND ITS EFFECT ON MILK IN MAGASTOTA, NUWARA ELIYA, SRI LANKA

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## 1 INTRODUCTION

Agrochemical contamination of feedstuffs is one of a greatest challenge which caused by the environmental pollution due to industrialization, hence the occurrence of Agrochemicals in foods of animal and plant origin has been a matter of considerable concern in recent years (Jayakody J A L,2006). Pesticides which widely used in agriculture can find their way into food chains in a number of ways via the pollution of ecosystems. As a food product milk is widely consumed within all civilizations and age groups, can be easily polluted by various agrochemicals or pollutants such as herbicides, pesticides, dioxins and heavy metals (David J, Geoffrey M,1996).

The objective of this study was to investigate milk from dairy cows, fed mainly with feedstuffs which contaminated from agrochemical residues. Due to insufficiency of grazing lands in up country, people tend to feed animals with crop residues which contaminated with Agro chemicals and certain compounds may find their way into milk indirectly through dairy animals as residues of agrochemicals on feedstuffs and drinking water (Fischer W.J. et. al, 2011).

Sprayed agrochemicals reach destinations other than their target species, including non-target species, air, water and soil. Agrochemical drift occurs when they suspended in the air as particles are carried by wind to other areas, potentially contaminating them. These compounds are sources of soil and ground water contamination and some are persistent organic pollutants which soluble in lipids and will hence are stored in adipose tissue or secreted with the milk fat. Consequently, reliable analytical methods are required to determine pesticide residues in foods.

Forty cattle farms from Magastota area, Nuwara Eliya, Sri Lanka was selected and a field survey was carried out to estimate the used agrochemical types, their usage and their role of contamination. Ten farms out of Forty were selected randomly to collect milk samples to analyze agrochemical residues using Gas Chromatography, UV visible Spectroscopy and with a manual method. The amount of residues found in the milk samples were below the maximum residue levels (MRL) for



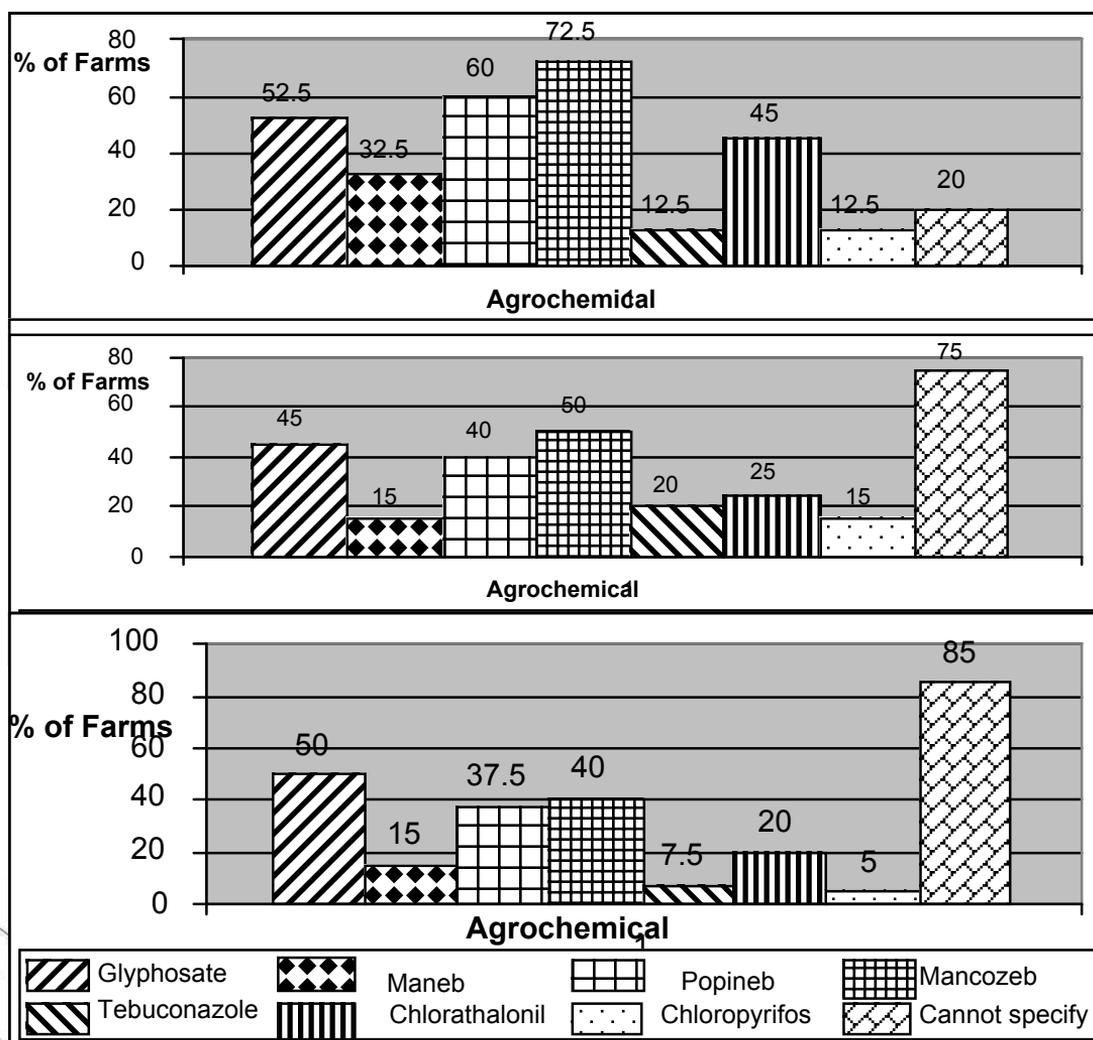
all investigated agrochemicals, which means that there is a risk of low level from agrochemical contamination causing a risk to the human health and needs further research. The goal of this research is identification and confirmation of pollution which occurred in farms, grazing areas and water sources which occurred via agrochemical contamination and quantitative estimation of identified agrochemical residues in raw bovine milk samples in Magastota area, Nuwara Eliya.

## 2 METHODOLOGY

### Study location:

Magastota Area, Nuwara Eliya was selected to the study and 40 farmers were selected randomly to collect data. A field survey which based on pre tested questionnaire was carried out to determine the types and sources of contaminations which have an impact to the milk industry of the area.

### Sample collection and sample analysis:



Ten Milk farmers out of forty were randomly selected to collect the milk samples. Several Agrochemicals were identified as major contaminants in the area and three of them were selected to analyze because of their role in application near farm, grazing area and water sources. Finally the milk samples were analyzed with two replicates for the presence of above agro chemical residues by Gas Chromatography and UV visible spectrometry and CIPAC handbook method.

### **Analytical milk sample preparation from laboratory sample**

For this the frozen laboratory sample was thawed, mixed, comminuted and reduced to the analytical sample of appropriate weight (Their H.P, Kirchhoff J. 1987)

## **3 RESULTS AND DISCUSSION**

All the selected 40 farms in Magastota area use crossbred animals for milk production. Majority of 67% of farmers have Jersey crosses and other 33% have Friesian crosses. Major crops in the area were Vegetables and tea. Also 45% of farms were surrounded by vegetable cultivations and 10% of farms were surrounded by tea cultivation. Rest 45% was surrounded by both crops. Most farmers, actually a 72%, carry out semi intensive rearing in their gardens, roadsides and tea lands rather than intensive rearing of 28%. Considering about the other management practices, regular cleaning of animals done before milking and water is provided adlibitum.

When considering about Magastota area, Nuwara Eliya, feeding of crop residues and providing of contaminated fountain water was recognized as the major causes for contamination via the survey. Farmers provide grass, poonac, rice bran and crop residues as feed and tap or fountain water as drinking water for their animals. In the case of crop residues, it was provided freshly with the contaminants. No treatments done to remove the contaminants even washing. Majority of 57% provide Carrot leaves thoroughly as crop residue because some other residues as Cabbage and Leeks are causing loose motion conditions to animals. Thus 43% of farmers provide miscellaneous crop residues to their animals because of lower availability of carrot leaves comparing to other residues.

Survey results revealed that the agro chemicals were mainly sprayed as form of aerosols and mainly as foliar applications. As per the topography of the area the applied pesticides were washed away to nearby lake and the pasture lands. As mentioned above the farmers do the semi intensive rearing of animals in lakeside, roadside, tea land, gardens and forest (27.5, 45, 42.5, 62.5 and 10 % respectively). Also farmers who rear their animals intensively practice cut and fed system for grass from those areas. Mancozeb, Propineb, Glyphosate, Chlorothalonil, Maneb, Chloropyrifos and Tebuconazole were recognized as major agrochemical contaminants in the area. Propineb, Chlorothalonil and Tebuconazole were selected to analyze because of their role in application near farms, grazing areas and water sources (Fig 1). Pesticides were applied heavily because of the moist environment and elevated pest and disease problems. The analysis of other agrochemicals wasn't



done because of practical problems in determination. Poisoning and Mastitis can be seen in the area and can observe less tick problems and other diseases comparing to other districts, because of the mild climate. Most farmers have the problem of low fat content in milk.

Concerning about the quantification of residues the status of concentrations of all three agrochemical residues was below 0.04 mg/kg (Table 1). The residue levels of tested Agrochemicals are lower than the MRLs. But as the chromatograms there are signals for other unidentified agrochemicals which mean that there is a risk of presence of other agrochemicals in milk. So means that there is a risk of low level from investigated agrochemicals but not from others. This area needs further research because of presence of other agrochemicals.

Table 1: Summary of determination of agrochemicals which present in the milk samples

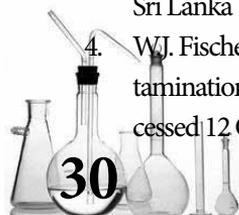
Agro Chemical	Amount	Method	MRL
Chlorothalonil	< 0.04 mg/kg	Gas Chromatography	0.05 mg/kg
Tebuconazole	< 0.04 mg/kg	Gas Chromatography	0.05 mg/kg
Propineb	< 0.04 mg/kg	Spectroscopy and CIPAC	0.2 mg/kg

#### 4 CONCLUSION

In this study the identification and confirmation of agrochemical contamination which occurred in farms, grazing areas and water sources was estimated and quantitative estimation of identified agrochemical residues in raw bovine milk samples was done in Magastota area, Nuwara Eliya. Mancozeb, Propineb, Glyphosate, Chlorothalonil, Maneb, Chloropyrifos and Tebuconazole were recognized as major agrochemical contaminants in the area. Feeding of contaminated crop residues and pasture and providing of contaminated water was recognized as the sources of contamination by the field survey. The residue levels of milk samples for Propineb, Tebuconazole and Chlorothalonil are lesser than 0.04 mg/kg which is lower than Maximum Residue Levels of 0.2 mg/kg, 0.05 mg/kg and 0.05 mg/kg respectively and this milk from Magastota, presents low human health risks. But there is a risk from other unidentified agrochemicals which present in the milk samples. The milk which produced in Magastota area, Nuwara Eliya is safe to consume but supplementary investigations should be done within this subject in future because of other unidentified agrochemicals.

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# ESTIMATION OF AMMONIA EMISSION FROM BROILER AND LAYER LITTERS UNDER HOT-HUMID SMALL FARMING CONDITIONS IN SRI LANKA

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## 1 INTRODUCTION

Ammonia generated by animal industries including poultry litter is a key agricultural air emission component and of increasing concern. Ammonia is formed due to the break down of nitrogenous wastes (undigested proteins and excretory uric acid) in poultry manure by microorganisms. High NH<sub>3</sub> levels in poultry houses are responsible for a number of disease conditions, reduce growth rate, feed efficiency and egg production in poultry. High NH<sub>3</sub> levels in poultry facility on the health and welfare of the workers in poultry houses are also a concern (Moore et al., 1996). It is recommended that air of the poultry house should not contain more than 25-50 ppm (Miles et al., 2004).

High environmental temperature levels and Physio-chemical characters of the litter such as high moisture and pH conditions increase the NH<sub>3</sub> emission rate (Coufal et al., 2006). Having hot-humid environmental conditions NH<sub>3</sub> emission rates of poultry litters in Sri Lanka, particularly those managed less intensively can assume to be high. Objective of this study was to estimate the NH<sub>3</sub> emission rates of broiler and layer type litters under small and medium scale farming conditions of Sri Lanka.

## 2 METHODOLOGY

Litter samples were collected from small and medium scale layer (n=21) and broilers (n=11) farms in Matara District of the Southern Sri Lanka. Farms those managed less than 100 and 101-1000 birds at a given time regarded small and medium scale farms, respectively. Paddy husk was the litter material of all farms. All farms used bell shape drinkers. Three representative samples taken from each farm were analyzed for moisture and pH. Litter samples were incubated for five hours and the emitted NH<sub>3</sub> was trapped with boric acid and then titrated with HCl to determine the NH<sub>3</sub> emissions. Ammonia emission was computed as mg/kg of dry litter/hr. Data were analyzed using t test.

## 3 RESULTS AND DISCUSSION

Physio-chemical properties and the NH<sub>3</sub> emission rates of layer and broiler type litter were significantly different (Table 1). Importantly emission of NH<sub>3</sub> from broiler type litter was almost three



times higher than that of layer type litter.  $\text{NH}_3$  emission from layer types farms varied widely from undetectable levels (4 farms) to 80 mg/Kg/hr. In contrast the  $\text{NH}_3$  emission rates of broiler litters varied within a narrow range from 19-86mg/kg/hr. Higher litter pH and moisture levels increased the emission of  $\text{NH}_3$  from poultry litter (Coufal et al., 2006). Higher litter pH and moisture levels of the broiler litter compared to the respective values of layer type litter could be more conducive for the formation of  $\text{NH}_3$ . Particularly, moisture content of the broiler litter were substantially higher than the optimum level; 30% that minimize the  $\text{NH}_3$  emission. Since litter pH normally exceeds 8 (Coufal et al., 2006) maintenance of optimum litter moisture content is recommended to reduce  $\text{NH}_3$  emission from small/medium scale poultry operations.

Table 1. Physio-chemical properties and ammonia emission rates of broiler and layer type litters

Litter character	Type of litter		Probability
	Layer	Broiler	
pH	7.5±0.09	8.2±0.13	***
Moisture (%)	39.3±1.3	56.8±2.1	***
Bulk density (g/cm <sup>3</sup> )	0.34±0.01	0.26±0.02	***
Ammonia emission (mg/kg DM/hr)	18.9±3	52.8±4.6	***

It was observed that one litter is used without disposing for over two years in layer type poultry management. In contrast, broiler litters are disposed every 35-42 days. This may be the reason for higher bulk density of layer type litter. High compactness of the layer type litter may also be a reason for lower  $\text{NH}_3$  emission from layer litters.

Atapattu et al. (2006) reported that 0.28 kg of litter is produced per kg of broiler live weight. Assuming that 52.8 mg of  $\text{NH}_3$  is emitted per Kg of dry litter throughout the whole 42 days of production cycle, it was calculated that  $\text{NH}_3$  emission per Kg of broiler live weight could be as high as 15 g.

Since many of the ammonia emission rates reported in literature gives the ammonia levels in poultry house air, no attempt is made to compare the values observed with those in literature. Timmer et al. (2005) reported that the minimum threshold of  $\text{NH}_3$  sense to human nose was 50 ppm. Strong  $\text{NH}_3$  odour was common in many farms indicating that unacceptable level of  $\text{NH}_3$  in those farms.

#### 4 CONCLUSIONS

It was concluded that  $\text{NH}_3$  emission rate of broiler litter is higher than that of layer litter. Attention should be given to improve the litter management conditions of small and medium scale poultry farming condition to reduce the ammonia emission from those operations.



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# SCIENTIFIC ANALYSIS OF TRADITIONAL WATER PURIFICATION METHODS IN SRI LANKA

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## ABSTRACT:

Today millions of people suffer from water scarcity, especially drinking water in many parts of the world. Therefore, water purification and water conservation is very important. There are advance technological methods available for water purification and however, access to advanced water purification methods are limited due to high cost especially in the developing countries. Traditional knowledge have been successfully applied over centuries by local communities. The present study was carried out to find the possibility and efficiency of traditional water purification methods. In this study we used several traditional ingredients. Treated water was measured for physico-chemical and microbiological parameters by the standard methods. The results showed that traditional water purifying methods can be effectively used for water treatment. Among the tested materials *Vitex negundo* leaves had significant efficiency for water purification up to SLS standards. Literature survey shows that *Vitex negundo* leaves has been used for water purification in number of countries in Asia, Africa and Latin America.

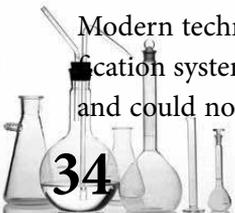
*Keywords: Water purification, Sri Lanka,*

## 1 INTRODUCTION

Water pollution is a major environmental crisis in the world. It is known fact that 75% of the planet earth is covered with water. However, only 3% of freshwater is available in the world<sup>[1]</sup> for consumption. Most of this freshwater is trapped in glaciers and only a little amount (1%) of freshwater is available for living beings for their needs. Due to accelerated development freshwater is getting polluted from recent years. Every day 300,000 children die due to lack of safe access to water and poor sanitation<sup>[2]</sup>. Therefore, purifying polluted water and conserving the existing sources is of importance to the world in order to supply enough pure water to keep a healthy life.

Other than natural disasters such as storms, earthquakes etc, global warming is an added danger to the water crisis. Unpredictable weather conditions and natural disasters enhance the problem of lacking clean water. The first 48 hours after a natural disaster has been declared as the most critical period and the basic need on that period is clean drinking water<sup>[3]</sup>.

Modern technologies have invented many methods of water purification. But almost every purification system is based on chemical or physical treatments. Most of these methods are expensive and could not be access most part of the world. Therefore, a natural and environmental friendly



approach is needed for water purification and conservation as providing safe drinking water is a global challenge in near future.

There are many traditional ways of water purification around the world. They are eco-friendly and human-friendly. People have used those methods for hundreds of years and have proved extremely positive results. But this precious knowledge is disappearing due to lack of transfer of traditional knowledge. Scientific researches on traditional water purifying methods are very rare. But some fields related to these methods have already been studied. A.B Olayemi & R.O Alabi of Department of Biological Science, University of Ilorin, Nigeria had conducted a research on Traditional Water Purification Using *Moringa oleifera* seeds in 1994.

Several Indian researchers had conducted researches about substances which used in traditional water purifying methods. But they had not done scientific scaling to submit the applications of those substances. Thus, the main objective of the present study was spread of the traditional wisdom of water purification through traditional knowledge and giving scientific evidences for their successful application. Also, we aim to give a natural approach to water purification instead of chemical and physical methods.

## 2 METHODOLOGY

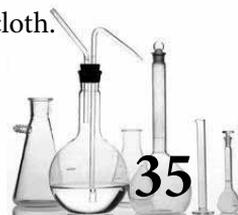
Among fourteen (14) traditional water purifying methods identified, four (4) methods were selected to be tested in the laboratory level. The methodology included identifying methods which local communities living in the rural areas have been used, through the interviews and conduct scientific analysis of such methods.

Material required for the selected methods were collected and samples were sealed and stored in a dry place to avoid direct sunlight between 26°C-30°C. All samples were monitored daily for any fungal infection or hydration.

Contaminated water was collected from Kelani River, which flows in the boarder of the Colombo city. Kelani river is the source for the Colombo water utility and many people living along the river is used for their day by day consumption.

One sample had been sent to the SGS laboratory in Colombo to conduct quantitative analysis of the selected drinking water quality parameters before applying traditional methods. Following traditional water purifying methods were applied to other samples separately.

***Strychnos potatorum* seeds (Ingini)**- Dried *Strychnos potatorum* seeds were mildly crushed and chopped in to 5mm pieces. Then 100mg of the crushed seeds added to one of the contaminated water samples (Sample 2). After 24 hours water was filtered through a clean cotton cloth.



**Moringa oleifera seeds (Murunga)**- *Moringa oleifera* seeds were sundried and grinded in to a powder. 100mg of powder was mixed with a contaminated water sample (Sample 3). After 24 hours water was separated by decantation and it was filtered using a clean cotton cloth.

**Vitex negundo leaves (Nika)**- *Vitex negundo* leaves were sundried. Then dried leaves was filled in to a water container with contaminated water sample (Sample 6). After 24 hours water was separated by decantation and filtered using a clean cotton cloth.

**Zinc Chloride crystals (Zinnakkaram)** - 50mg of crushed Zinc Chloride crystals were added in to another contaminated water sample (Sample 5). After 24 hours water was filtered through a clean cotton cloth.

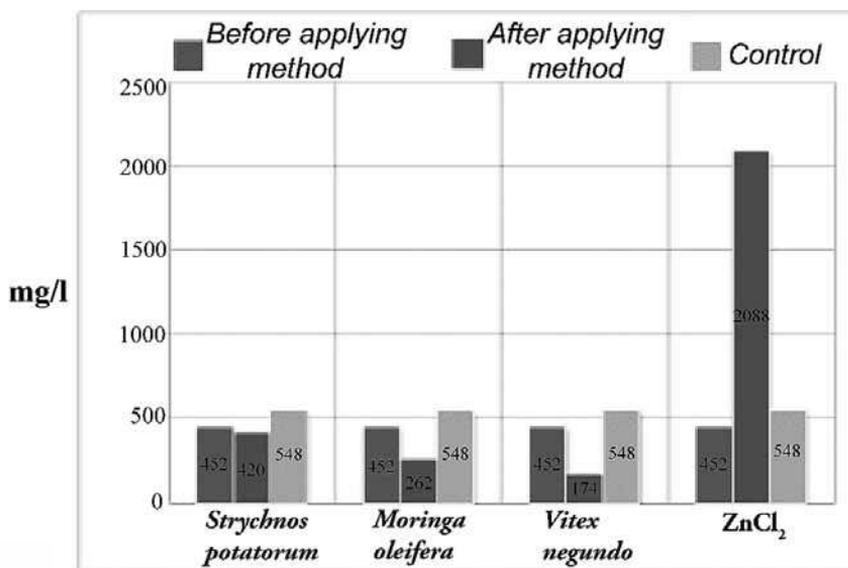
One contaminated water sample had been set as a control and it was also filtered using a cotton cloth after 24 hours. Finally all four samples were sent to the laboratory and tests were conducted for quantative analysis on selected parameters<sup>[4]</sup> i.e Total Solids, Turbidity, pH, Total Coliforms were measured for each sample.

### 3 RESULTS AND DISCUSSION

Tests were conducted by the Société Générale de Surveillance (SGS) laboratory in Sri Lanka according to international standards. The results are given in fig. 1.

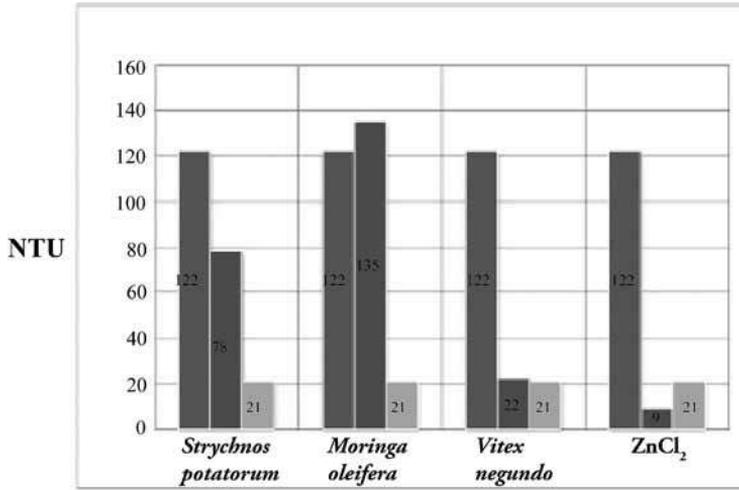
#### Total Solids

Figure.1- Effects on Total Solids by methods.



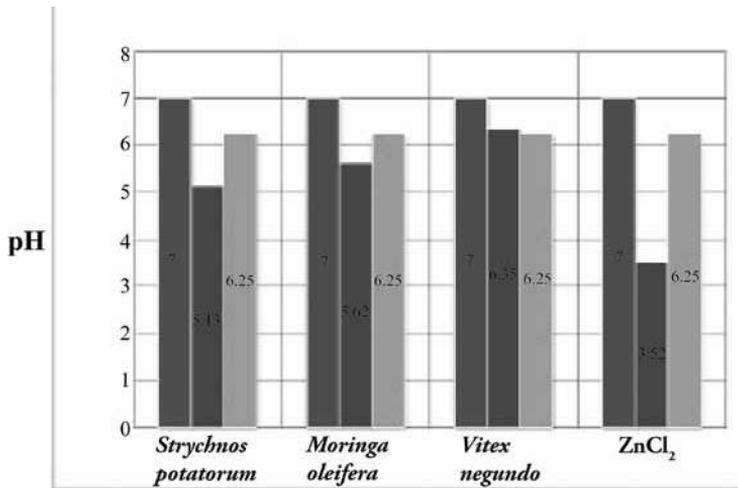
## Turbidity

Figure 2- Effects on Turbidity by methods.



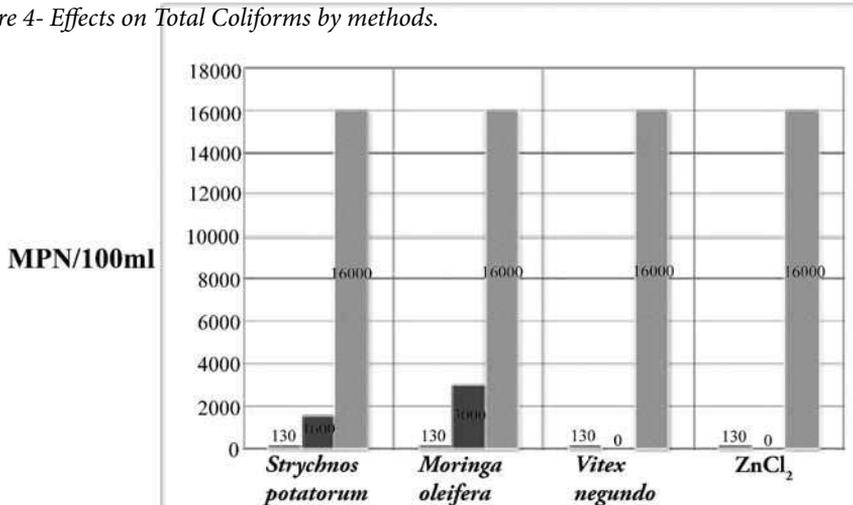
## pH Level

Figure 3- Effects on pH by methods.



## Total Coliforms

Figure 4- Effects on Total Coliforms by methods.



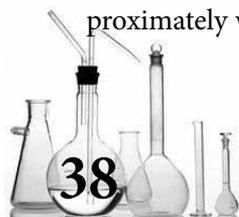
Fourteen traditional water purifying methods were found during the survey. Only four methods were selected considering facts: i.e wide distribution and easy to find, easy to apply, widely practiced by people and take less time for purification. Among them use of *Garcinia indica*, (Goraka) *Capsicum annuum* (Chilli) and *Elettaria cardamomum* (Cardamom) was rejected because those methods are not widely practiced. Methods based on *Curcuma longa* (Turmeric), *Osbeckia aspera* (Bovitiya) and *Phyllanthus embilica* (Nelli) was rejected due to its limited distribution. *Nymphaea odorata* (Water Lily) was not selected because that method is not easy to apply. Methods on coal and seashells were also not selected because they are long-term applications. Copper was rejected because that method is not widely practiced and takes comparatively long time. All the water purifying methods had been applied in 28°C and under standard pressure (1atm). Changes of the selected parameters that caused by methods, vary in a significant range.

Analysis in TS measurements shows that *Strychnos potatorum* seeds have caused a minor reduction (7.07%) in TS level. *Moringa oleifera* seeds have caused a significant reduction (42.03%) in TS and *Vitex negundo* leaves has caused the most effective reduction, which is presented as 65.92% in TS. The method based on  $ZnCl_2$ , TS level has increased from 361.94%, which is very high from the standard TS level in clean drinking water. Use of *Vitex negundo* leaves can reduce TS level significantly and bring it to the standard level. TS level in the control was increased from 19.46% within 24 hours. Flocculation and the addition of dry weight of grown bacterial colonies could be reasons for it.

*Strychnos potatorum* seeds have reduced turbidity significantly while *Moringa oleifera* seeds have increased (10.65%) the turbidity. *Vitex negundo* leaves reduced turbidity very significantly to 81.96% and  $ZnCl_2$  had the most effective reduction (92.62%) of turbidity. Somehow the control shows a reduction (82.78%) of turbidity of its own. However, *Vitex negundo* has effectively reduced turbidity and  $ZnCl_2$  gives the best results. Thus, among the methods  $ZnCl_2$  has brought turbidity of water almost to the drinking water standards.

In the method based on *Strychnos potatorum* seeds, pH has decreased to 5.13 and *Moringa oleifera* seed powder has caused a reduction to 5.62. *Vitex negundo* leaves has increased the pH level to 6.35 and close to the pH value in drinking water standards. So it doesn't contribute largely to the variation of pH level.  $ZnCl_2$  has made a major move to the acidic side and it has decreased the pH level to 3.52.

All the traditional water purifying methods have displayed good results in controlling total *coliforms*. Coliform is an indicator for the availability of bacteria which is tested in order to find out whether water is contaminated from microbes; belonging to Enterobacteriaceae family, such as *E.coli*. Raw water sample had *Coliforms* which was counted as 130 MPN/100ml. In the control, within 24 hours population of the bacterial colony was increased in to 16,000 MPN/100ml, approximately with a replication time of 3.4 hours. *Strychnos potatorum* seeds and *Moringa oleifera*



seed powder have controlled the growth of *Coliform* colony significantly. After 24 hours bacterial population in the water sample, which was treated with *Strychnos potatorum* seeds was 1,600 MPN/100ml, approximately with a replication time of 6.85 hours. *Moringa oleifera* seed powder has controlled the bacterial population in 3,000 MPN/100ml, approximately with a replication time of 5.33 hours. *Vitex negundo* leaves and ZnCl<sub>2</sub> crystals have eliminated the entire *Coliform* population in water. So those two methods are efficient in removing microbes from untreated water. Comparison of the four methods is given below. (Table.2)

Table.2- Effectiveness of traditional water purifying methods to bring water to drinking Water Standards.

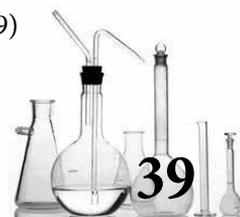
Methods \ Parameters	Total Solids	Turbidity	pH	Total Coliforms	
<i>Strychnos potatorum</i> seeds	⊘	⊘	⊗	⊘	
<i>Moringa oleifera</i> seeds	⊕	⊗	⊗	⊘	Efficient-⊕
<i>Vitex negundo</i> leaves	⊕	⊕	⊘	⊕	Significant-⊘
ZnCl <sub>2</sub> crystals	⊗	⊕	⊗	⊕	Minimal or Deficient-⊗

#### 4. CONCLUSIONS

Among traditional water purifying methods dried *Vitex negundo* leaves is the best way to reduce TS in untreated water and bring it to the standard level. Method based on ZnCl<sub>2</sub> crystals is the best way among those methods to decrease turbidity to drinking water standards level. All the methods reduce pH level. All methods, especially ZnCl<sub>2</sub> crystals could reduce the pH level in water. *Strychnos potatorum* seeds and *Moringa oleifera* seed powder have the ability of controlling the growth of *Coliform* population. Dried *Vitex negundo* leaves and ZnCl<sub>2</sub> crystals have the ability of eliminating the entire *Coliform* population in contaminated water. Considering test results and analyzes, dried *Vitex negundo* leaves is the overall best method to purify water according to drinking water standards.

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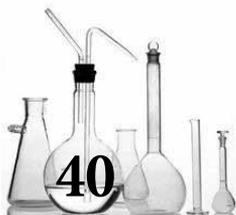
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# Session II



# ACCUMULATION OF Pd, Cd, Cr, Zn and Cu IN DIFFERENT BODY PARTS OF SOME COMMON EDIBLE FRESH WATER FISH SPECIES FROM THREE RESERVIORS OF POLONNARUWA DISTRICT

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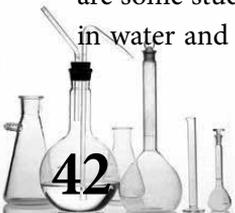
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## 1 INTRODUCTION

Accumulation of trace elements in aquatic organisms is one of the most striking effects of pollution in aquatic system (Abdallah, 2008). The contamination of freshwaters with a wide range of pollutants has become a matter of concern over the last few decades (Vinodhani & Narayan, 2008). Metals are natural components of the aquatic ecosystem (Indrajith et al., 2008). The natural aquatic systems may extensively be contaminated with heavy metals released from domestic, industries, agricultural and other man made activities (Vinodhani & Narayan 2008). Many heavy metals and their compounds have been found toxic, while some are also subjected to bioaccumulation and biomagnifications (Kumar et al., 2010).

Heavy metal contaminations in inland water bodies can be monitored by measuring the metal levels in sediment, water, & resident biota especially fish (Senarathne & Pathirathne, 2007). Some heavy metals such as Pb & Cd are biologically non essential metals that can be toxic to biota even at very low levels. High concentrations of some essential trace metals such as Cr, Cu, & Zn may become toxic at concentrations exceeding the limits which are required (Senarathne & Pathirathne, 2007). Heavy metals are considered as critical contaminants of aquatic ecosystems, due to their high potential to enter and accumulate in food chains. Fish are commonly situated at the top of the food chain and, therefore, they can accumulate large amounts of some metals and fish are also considered as one of the most susceptible aquatic organisms to toxic substances present in water (Jaricet al., 2010). Fish are widely used to evaluate the health of aquatic ecosystems because pollutants build up in the food chain and are responsible for adverse effects and death in the aquatic systems (Vinodhani & Narayan, 2008). Humans who consume significant amount of fish contaminated with toxic heavy metals may also be at risk. Little information is available on heavy metal levels in food species found in inland water bodies in Sri Lanka (Senarathne and Pathirathne, 2007). It is important to determine the heavy metal levels in commercial food fish in order to evaluate the possible risk of fish consumption (Indrajith et al., 2008). According to statistics from Ministry of health, it was found that some unbelievable cases were recorded regarding Chronic Renal Disease (CKD) in North Central Province and some other provinces in Sri Lanka. There are some hypotheses for the CKD and heavy metal (As, Cd, Pb and Al) is considered as one of them. There are some studies have been conducted by some scientists in quantitative analysis of heavy metals in water and some edible fish species. Such studies have not given much more information and



bioaccumulation and biomagnifications of heavy metals via food chain. Thus, the present study was carried out to determination of heavy metal concentration in water, sediment, phytoplankton, zooplankton and some fish species commonly consume by people in the study area. In this paper, special attention has been given for the analyses heavy metals in some part of fish such as head, mussel and skin to give more information of the contaminated levels of metals in different body parts of fish species. This may help to take some precautionary actions regarding health issues in heavy metal pollution.

The present study determined the selected heavy metals (Pb, Cd, Cr, Cu & Zn) in some commercially important freshwater fish species which are common in Minneriya wewa, Parakrama Samudraya & Kaudulla wewa at Polonnaruwa District. Fish species selected for the study was based on the results obtained by interviewing people in the study arean on eating preference of fish body parts (head region, after remove sin, with skin of fish etc) in their day to day fish consumption.

## 2 METHODOLOGY

Studies were conducted from the fish samples collected from there reservoirs namely Minneriyawewa, Parakrama Samudraya & Kaudullawewa at Polonnaruwa District. Edible fish samples (*Labeo rohita*, *Oreochromis mossambicus*, *Oreochromis niloticus*, *Etroplus suratensis*, *Heteropneustes fossilis*, *Oligolepsis acutipennis*, *Puntius dorsalis*) were purchased from the commercial fisherman's at the lake itself during October 2011 to March 2012. Collected fish samples were wrapped using cleaned polyethylene bags and kept in ice box during the transportation and kept at the laboratory freezer until analysis. Fish samples were removed from deep freezer and allowed to thaw and morphological features such as fork length, standard length, fork legnth and weight were measured and identification done following fresh water fish identification key. Each sample, Knife, scissors, chopping board etc were washed several times from distilled water and hands were cleaned by distilled water and then 90% alcohol to avoid any contamination. Then, all fins, scales and internal body parts (digestive system, gills etc) were removed and separated into acid washed cleaned Petri dish.

Each sample was separated to 'skin', 'head' and 'muscles' with bones into pre-cleaned Petri dishes and labeled and were kept in an oven at 120°C for 24 hours until a constant weight was obtained. The dried samples were grounded using acid washed motar and pestle and weighted 1.0g using electric balance (Stanton OB 152). The 1.0 g sample was digested in Kjeldhal apparatus using conc. HNO<sub>3</sub> and conc.H<sub>2</sub>O<sub>2</sub> (1:1 V/V) until dissolution. Then the aliquate was transferred in to 50ml of volumetric flask and volume up to the mark. The sample was analyzed by AAS. Statistical analysis was conducted using Microsoft Excel 2007 version & Statistical Package for Social Sciences (SPSS 17.0).

## 3 RESULTS AND DISCUSSION

The biometry of the fish samples collected from three reservoirs was summarized in Table 1 and mean metal concentrations of different parts of fish species of three reservoirs are shown in figures.

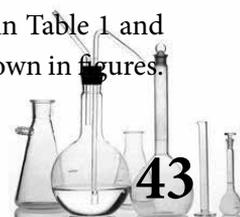


Table 1. Biometry of the fish samples collected from three reservoirs

Fish type	Mean length (cm)	Standard deviation (cm)	Mean fork length (cm)	Mean weight (g)
<b>MINNERIYA WEWA</b>				
<i>Labeorohita</i>	20.83 ± 0.76		24.66 ± 0.76	195.8 ± 10.01
<i>Oreochromismossambicus</i>	13.35 ± 0.50		16.65 ± 0.64	95.18 ± 15.39
<i>Oreochrominiloticus</i>	12.42 ± 0.40		15.95 ± 0.71	86.95 ± 15.60
<i>Etroplussuratensis</i>	12.66 ± 2.25		16.02 ± 2.20	123.32 ± 45.51
<i>Heteropneustesfossilis</i>	19.1 ± 1.6		20.66 ± 1.43	71.36 ± 14.67
<i>Oligolepsisacutipennis</i>	16.25 ± 1.0		20.4 ± 2.38	101.27 ± 39.11
<i>Puntiusdorsalis</i>	9.6 ± 2.5		12.67 ± 2.94	37.82 ± 23.93
<b>PARAKRAMA SAMUDRAYA</b>				
<i>O.mossambicus</i>	14.44 ± 0.64		18.26 ± 3.17	120.72 ± 52.06
<i>O.niloticus</i>	15.52 ± 0.85		19.68 ± 4.31	181.8 ± 83.99
<b>KAUDULLA WEWA</b>				
<i>O.mossambicus</i>	16.75 ± 0.76		20.48 ± 1.66	202.05 ± 48.99
<i>O.niloticus</i>	16.02 ± 0.85		19.8 ± 1.21	157.42 ± 30.50
<i>Etroplussuratensis</i>	14.16 ± 1.35		17.7 ± 1.47	161.46 ± 37.45

Results are presented as mean ± standard deviation

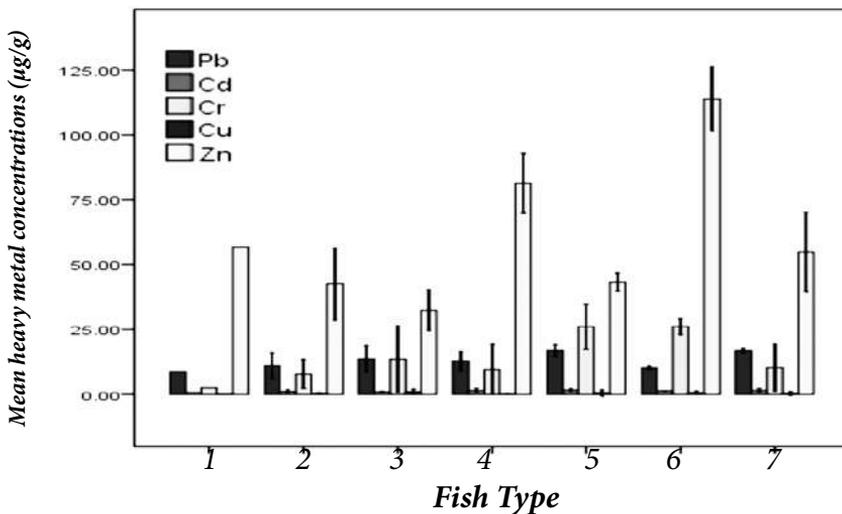


Fig.1. Mean heavy metal concentrations ( $\mu\text{g/g}$ ) in head part of different fish varieties in Minneriya Wewa. (1 *Labeorohita*, 2 *Oreochromis mossambicus*, 3 *Oreochromis niloticus*, 4 *Etroplus suratensis*, 5 *Oligolepisa cutipennis*, 6 *Puntius dorsalis*, 7 *Heteropneustes fossilis*)



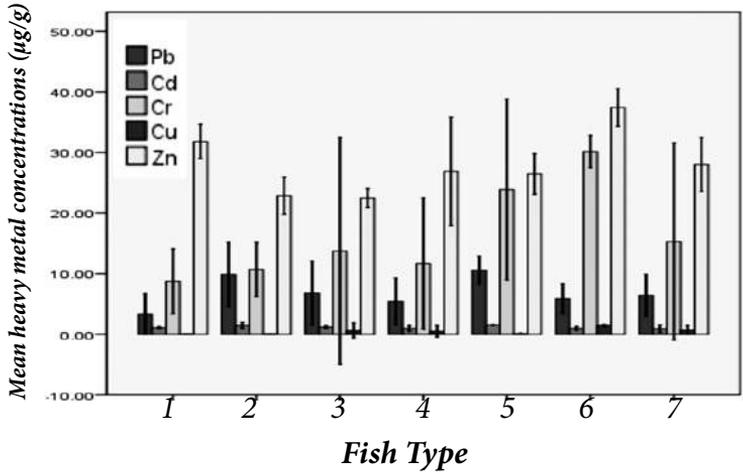


Fig.2. Mean heavy metal concentrations ( $\mu\text{g/g}$ ) in muscle part of different fish in Minneriya Wewa. (1 *Labeorohita*, 2 *Oreochromis mossambicus*, 3 *Oreochromis niloticus*, 4 *Eetroplus suratensis*, 5 *Oligolepisa cutipennis*, 6 *Puntius dorsalis*, 7 *Heteropneustes fossils*)

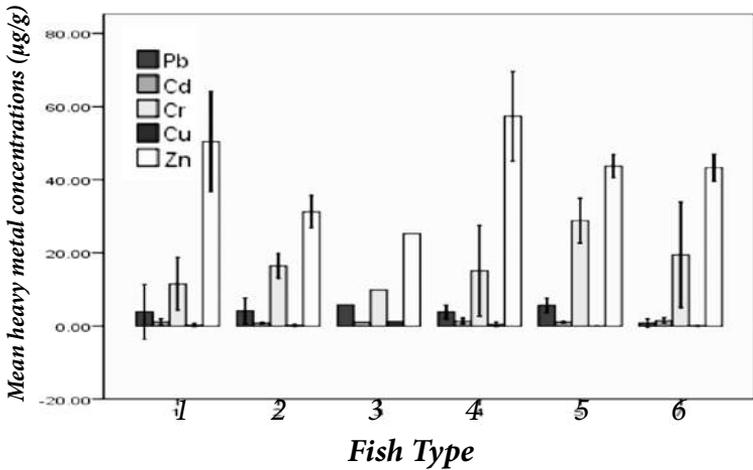


Fig.3. Mean heavy metal concentrations ( $\mu\text{g/g}$ ) in Skin of different fish varieties in Minneriya Wewa. (1 *Labeorohita*, 2 *Oreochromis mossambicus*, 3 *Oreochromis niloticus*, 4 *Eetropluss uratensis*, 5 *Oligolepisa cutipennis*, 6 *Puntius dorsalis*, 7 *Heteropneustes fossils*)



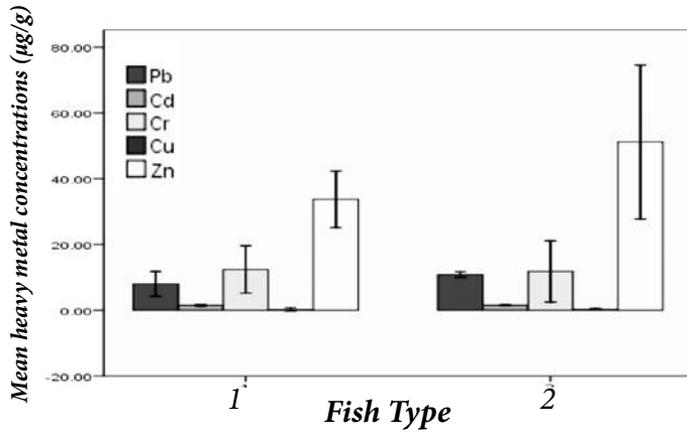


Fig.4. Mean heavy metal concentrations ( $\mu\text{g/g}$ ) in head part of different fish varieties in Parakrama samudraya. (1 *Oreochromis mossambicus*, 2 *Oreochromis niloticus*,)

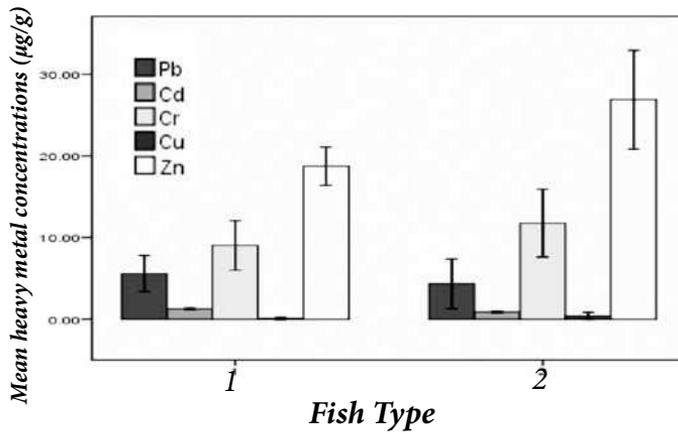
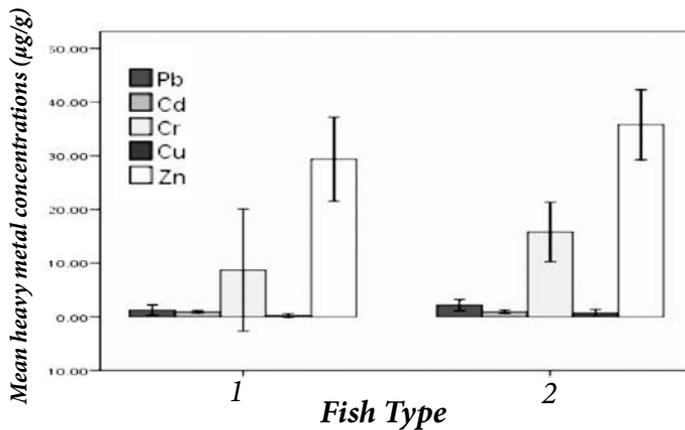


Fig.5. Mean heavy metal concentrations ( $\mu\text{g/g}$ ) in muscle part of different fish varieties in Parakrama Samudraya. (1 *Oreochromis mossambicus*, 2 *Oreochromis niloticus*)



avy metal concentrations ( $\mu\text{g/g}$ ) in skin of different fish varieties in Parakrama *Oreochromis mossambicus*, 2 *Oreochromis niloticus*,)



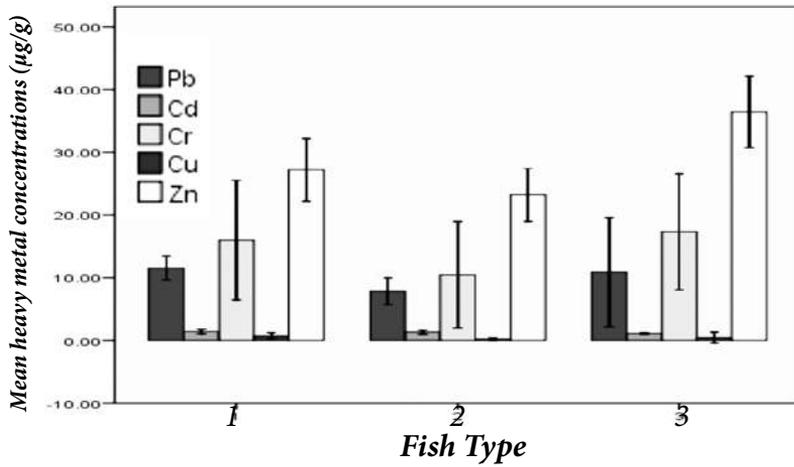


Fig.7. Mean Heavy metal ( $\mu\text{g/g}$ ) in head part of different fish varieties in Kaudulla Wewa. (1 *Oreochromis mossambicus*, 2 *Oreochromis niloticus*, 3 *Etroplus suratensis*)

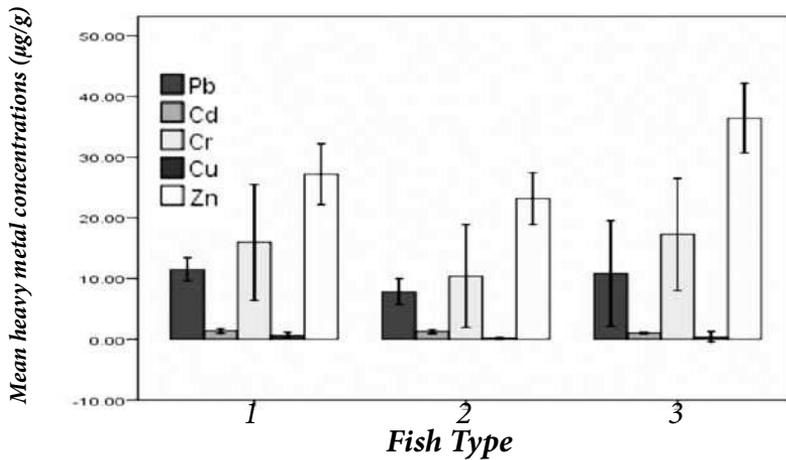


Fig.8. Mean heavy metal concentrations( $\mu\text{g/g}$ ) in muscle part of different fish varieties in Kaudulla Wewa. (1 *Oreochromis mossambicus*, 2 *Oreochromis niloticus*, 3 *Etroplus suratensis*)

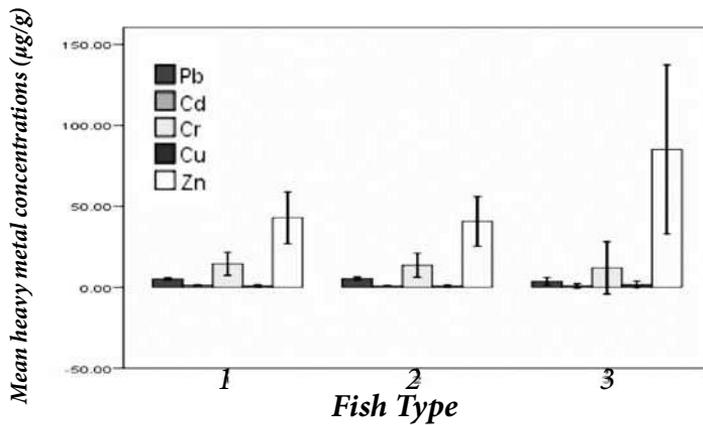


Fig. 9. Mean heavy metal concentrations ( $\mu\text{g/g}$ ) in skin of fish varieties in Kaudulla Wewa (1 *Oreochromis mossambicus*, 2 *Oreochromis niloticus*, 3 *Etroplus suratensis*)



Pb and Cd are non essential elements which are accumulated in human tissues and harmful to human health (Senarathne et al., 2007). The highest amount of Pb recorded from the head part of the *Oligolepisa cutipennis* in Minneriya Wewa, which contained  $16.17 \pm 1.92 \mu\text{g/g}$ , where as the maximum level of Cd ( $1.68 \pm 0.54 \mu\text{g/g}$ ) was recorded from the head part of *Heteropneustes fossilis*. Both Pb and Cd were highly accumulated in the head region compared with skin and muscle of the collected fish from Minneriya wewa, Parakrama Samudraya and Kaudulla Wewa. The maximum allowable levels of Pb and Cd in the fish for human consumption specified by the European Union are 0.2 and  $0.05 \mu\text{g/g}$  wet weight respectively (Senarathne & Pathirathne, 2007). All the Pb and Cd levels that detected in head, muscle and skin of all the fish in three reservoirs exceeded this maximum levels in fish for human consumption specialized by the European Union. According to the median international standards for foods, the tolerable levels for Pb and Cd in foods are 2.0 and  $0.3 \mu\text{g/g}$  respectively (Senarathne & Pathirathne, 2007). Pb and Cd levels in the head, muscle and skin of all the fish that collected from Minneriya Wewa, Parakrama Samudraya and Kaudulla Wewa exceeded this international standard for Pb and Cd. Hence, heavy consumption of these fish varieties, especially head part may pose a health risk for fish consumers.

Cr, Cu and Zn are non essential elements and are regulated by physiological mechanisms in most organisms; however occurrence of excessive levels of them is regarded as potential hazards which can endanger both animal and human health (Indrajith et al., 2008). The highest amount of Cr level detected in muscle of the *Puntius dorsalis* in Minneriya wewa, which contained  $30.15 \pm 2.31 \mu\text{g/g}$ . The Cr levels that detected in head, muscle and skin in all the fish of three reservoirs were exceeded the maximum permissible level for Cr except the skin of *O. mossambicus* in Parakrama Samudraya. The median international standard level of Cr is  $1.0 \mu\text{g/g}$  in food for human consumption (Senarathne & Pathirathne, 2007).

The least concentrated metal was Cu for the three parts of fish in three reservoirs. The highest amount of Cu detected in head part of the *Etroplus suratensis* ( $2.18 \pm 1.90 \mu\text{g/g}$ ) in Kaudulla wewa. The median international standard level of Cu is  $20 \mu\text{g/g}$  in food for human consumption (Senarathne & Pathirathne, 2007). All the Cu levels that detected in head, muscle and skin of all fish species in three reservoirs not exceeded than the permissible level.

The most abundant metal was Zn for the three parts of fish in three reservoirs. Highest amount of Zn detected head part of *Puntius dorsalis* which contained  $113.93 \pm 10.55 \mu\text{g/g}$ . According to the median international standard, maximum permissible level of Zn is  $45 \mu\text{g/g}$  in food for human consumption. This limit was exceeded the head part of the *Etroplus suratensis* ( $81.46 \pm 9.95$ ), *Puntius dorsalis* ( $113.93 \pm 10.55$ ), *Heteropneustes fossilis* ( $55.0 \pm 10.76$ ) in Minneriya Wewa, *O. niloticus* ( $48.9 \pm 24.27$ ) in Parakrama Samudraya. In addition, head and skin parts of *Etroplus suratensis* in Kaudulla wewa exceed the permissible level,  $107.0 \pm 26.16$  and  $85.14 \pm 45.18 \mu\text{g/g}$  respectively. Zn levels of mussel of all the fish collected in three reservoirs not exceed than the permissible level.



## 4 CONCLUSIONS AND RECOMMENDATIONS

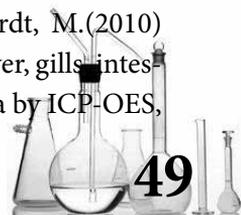
The study confirm that Zn is the most abundant metal in all fish species in three reservoirs and least concentrated metal is Cu. Metal accumulation pattern of head, muscle and skin of all the fish species collected from Minneriya Wewa, Parakrama Samudraya and Kaudulla Wewa follow same order: Zn>Cr>Pb>Cd>Cu. The levels of non essential metals, Pb and Cd are highly accumulated in the head part of the fish species collected from three reservoirs ( Head> Muscle> Skin) and all the concentrations exceed the food safety limits specialized by International Authorities. The results show that consumption of Head part of fish species in these reservoirs may pose a health risks to the consumers due to the accumulation of high level of Pb and Cd.

The essential metal for animals, Zn, is abundantly can be seen in head part of all the fish species in three reservoirs. All the five metals (Pb, Cd, Cr, Cu, Zn) are highly accumulated in the head part of the *Oreochromis mossambicus*, *Oreochromis niloticus* and *Etroplus suratensis* in Kaudulla Wewa.

It is very important to monitor heavy metals in the food fish species in reservoirs of Polonnaruwa District and it's better to recommend avoiding consumption of head part of edible fish species inhabiting to these reservoirs.

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# COLOR AND COD REMOVAL FROM TEXTILE WASTE WATER CONTAINING REACTIVE DYES USING COAGULATION AND FENTON'S OXIDATION

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## 1. INTRODUCTION

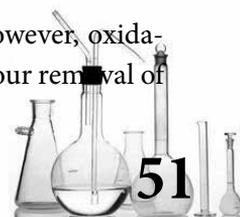
Wastewaters originated from textile industry contain various pollutants including organic matter, dyes and its by products, and various chemicals depending on the forms of dyes and way of processing. There are various types of textile dyes and they are structurally different. Reactive dyes are the most commonly used dye group among more than 10,000 dyes applied in textile industry. Discharge of dyes on open environment without treatment is undesirable not only for aesthetic reasons but also toxic to living beings in aquatic resources. Therefore treatment of textile wastewater (TWW) is essential before discharge to environment.

The biological, physical and chemical treatment technologies are the major TWW treatment methods available in the world. However, the most of the textile factories prefer to use combination of above treatment methods since colour and chemical oxygen demand (COD) removal are effective than when a single treatment method is used. Even though biological treatment approaches are more effective and economical in municipal wastewater treatment, the colour removal are very poor in TWW treatment (Shyh-Fang et al.,1999). Therefore, the textile industries urgently need to install advanced treatment facilities to reduce color to meet more stringent discharge standards.

Textile industry is one of the largest water consuming industries in Sri Lanka (Abeyrathne et al., 2001). Therefore, it is necessary to follow strict treatment regulations and technologies to avoid the bad impact imposed on environment due to release of untreated TWW.

The removal of particles can be achieved through number of methods such as coagulation, sedimentation, flocculation, filtration, etc. At the same time, biological, advanced oxidation, adsorption and membrane processes are used for the removal of organic compounds. In coagulation, Aluminium Sulphate ( $Al_2(SO_4)_3 \cdot nH_2O$ ) is used as more famous and effective coagulant (Boon et al.,2000). AS is presently the most widely used coagulant and it is extensively used in the drinking water and wastewater treatment, due to its proven performance in treating water and wastewater of different characteristics and its low cost.

Colour removal can also be achieved through these processes at certain degree, however, oxidation processes such as Fenton's Oxidation (FO) has been shown better results on colour removal of



TWW (Parag and Aniruddha, 2004). Many chemical treatment processes have been used extensively to treat textile wastewaters. Most of the studies, such as chemical precipitation, adsorption by activated carbon, photo catalytic oxidation, ozonation and Fenton's oxidation focused on color removal (Sureyya et al., 2004).

In this study, we attempted to optimize the COD and colour removal in synthetic textile wastewater (STWW) having coffee brown colour (six types of reactive dyes are mixed in certain proportions to get the colour) by coagulation and FO processes under laboratory conditions.

## 2. METHODOLOGY

### 2.1. Textile wastewater preparation

Reactive dye was obtained from a nearby cotton textile industry in southern province of Sri Lanka. Six types of reactive dyes are mixed in certain proportions to prepare the required dye mixture to obtain coffee brown colour. Initially, 1000 mg/L dye solution was prepared and used for the study and it was further diluted where necessary.

### 2.2 Chemicals used

Commercial grade AS was used as a coagulant. Ferrous Sulphate ( $\text{FeSO}_4$ ), hydrogen peroxide ( $\text{H}_2\text{O}_2$ ) (30%), NaOH and  $\text{H}_2\text{SO}_4$  (for pH adjustment) used in this study were in analytical grade.

### 2.3 Analytical methods

Colour removal was determined using the reduction in maximum absorbance (585 nm) before and after treatment with coagulant and FO processes. COD was determined by digestion with  $\text{H}_2\text{SO}_4$  presence of  $\text{K}_2\text{Cr}_2\text{O}_7$ .

### 2.4. Experimental procedure

The treatment of STWW was performed in batch wise in beakers. In coagulation, six levels of AS concentration (25, 50, 100, 150, 200 and 250 mg/L) were used to find out the effective concentration for the maximum COD removals of STWW while keeping the other parameters constant. After coagulation COD and colour removal were determined.

The treated STWW by coagulation were used for FO for removal of COD and Colour. The effective doses of  $\text{H}_2\text{O}_2$  and  $\text{FeSO}_4$  were determined by using different concentration of those chemicals ( $\text{H}_2\text{O}_2$ : 50, 100, 150, 200, 250 mg/L;  $\text{FeSO}_4$ : 5, 10, 15, 20, 25 mg/L) while keeping the other parameters constant. The reaction and settling times in each experiment were kept constant.



### 3. RESULTS AND DISCUSSION

#### 3.1. The effect of coagulation on COD and colour removal

The COD removals of STWW at different AS levels are shown in Figure 1. It is apparent that with the increase of coagulant dose, COD removals have been increased, and then decreased. The maximum COD level was observed at 150 mg/L of AS concentration. Chemical oxygen demand in treated water is about ~15 mg/L at 150 mg/L of AS concentration. Colour removal by coagulation is quite poor. Maximum colour removal was noted at 150 mg/L of AS concentration

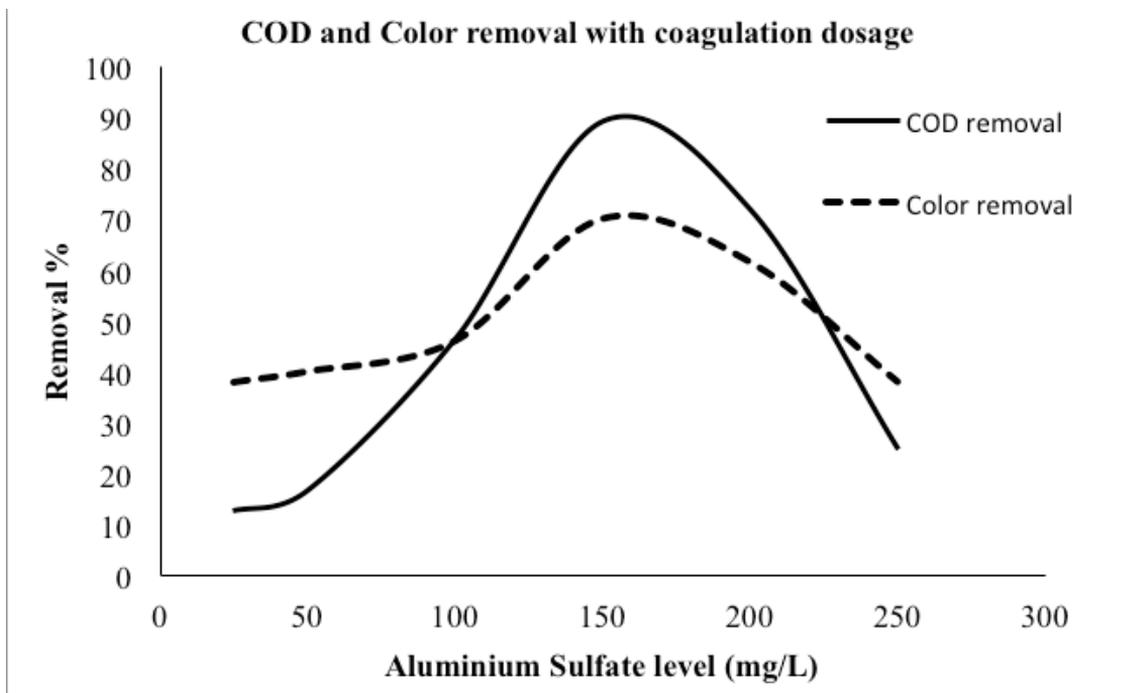


Figure 1: COD and colour removal of STWW at different doses of AS (1000 mg/L dye concentration)

#### 3.2. Efficiency of COD and colour removal at different levels of H<sub>2</sub>O<sub>2</sub>

COD and colour removal at different level of H<sub>2</sub>O<sub>2</sub> are given in table 1. COD and color removal efficiency were increased with the increased H<sub>2</sub>O<sub>2</sub> concentrations. At 250 mg/L H<sub>2</sub>O<sub>2</sub> level, COD and colour removal was 65% and 97%, respectively. However, it was noted that at increased levels of H<sub>2</sub>O<sub>2</sub>, COD removal efficiency was decreased.

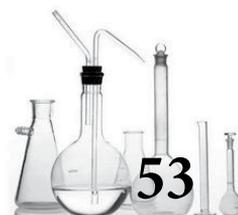


Table 1: COD and Color removal at different levels of H<sub>2</sub>O<sub>2</sub> (AS: 150 mg/L; FeSO<sub>4</sub>: 20 mg/L; pH: 3.0)

H <sub>2</sub> O <sub>2</sub> Level (mg/L)	COD in Treated STWW (mg/L)	COD Removal (%)	Color Removal (%)
		(%)	
50	189.63	55	61
100	159.51	58	63
150	152.21	60	75
200	114.29	70	93
250	132.92	65	97

### 3.3. Efficiency of COD and colour removal at different levels of FeSO<sub>4</sub>

The effect of FeSO<sub>4</sub> concentration on COD and colour removal efficiency for 1000 mg/L of reactive dye mixture is given in Table 2. The maximum COD removal (68%) was obtained at 20mg/L of FeSO<sub>4</sub> and 250 mg/L of H<sub>2</sub>O<sub>2</sub> levels. pH (3.0) and temperature (30°C) were kept constant during all experiments where Fenton's oxidation process was practiced.

COD removal efficiency was decreased at higher concentration of FeSO<sub>4</sub>. A same phenomenon has observed by several authors (Süreyya et al., 2004). They have explained the reduction of COD removal with increased FeSO<sub>4</sub> concentration as redox reactions. Hydroxyl radicals react with Fe<sup>2+</sup> and forms Fe<sup>3+</sup>. The formed Fe<sup>3+</sup> can react with H<sub>2</sub>O<sub>2</sub> as well as with hydroperoxy radicals with regeneration of Fe<sup>2+</sup> in the solution resulting in decrease in COD removal.

Table 2: COD and Color removal at different levels of FeSO<sub>4</sub> (AS: 150 mg/L; H<sub>2</sub>O<sub>2</sub>:250 mg/L; pH: 3.0)

FeSO <sub>4</sub> Level (mg/L)	COD in Treated STWW (mg/L)	COD removal (%)	Color removal (%)
5	140.52	63	91
10	159.51	58	93
15	186.09	51	95
20	197.49	48	98
25	216.47	43	96

## 4. CONCLUSION

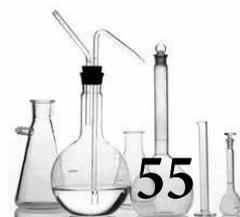
The higher colour and COD removals were observed in this study. The main responsible process for the removal of COD is coagulation with AS, which colour removal was poor. Over 97 % of col-



our was removed by both coagulation and FO process in STWW. Final COD in treated STWW is very low (less 250 mg/L). It can be concluded that coagulation and FO can effectively be used for the removal of COD and colour of textile wastewater. However, degraded products of dyes were not determined in this study. Therefore, it is necessary to investigate the degraded product after coagulation and FO of STWW to avoid the possible toxic effect on aquatic environment before dispose to the environment.

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# ACCUMULATION OF ZENOBIOTIC CHEMICALS IN SOME EDIBLE FISH SPECIES IN SRI LANKA

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## 1 INTRODUCTION

Fluorochemicals comes under zenbiotic category and perfluorooctane sulfonate (PFOS) is known to be the end-stage of the metabolite of fluorochemicals produced using perfluorooctanesulfonyl-fluoride (POSF) as a precursor<sup>1</sup>. POSF-based fluorochemicals have been used in wide variety of industrial and consumer products, including protective coatings for carpets, apparel, paper coatings, herbicide, greases and lubricants, adhesives, paint, polish, insecticide formulations, surfactants<sup>2</sup> and also used as a surfactant in fire fighting foams<sup>3</sup>. Perfluorooctane sulfonate (PFOS) is a persistent and bioaccumulative perfluorinated acid detectable in human and wild life worldwide that has alerted scientists to examine the environmental fate of other fluorinated organic contaminants<sup>4</sup>. Since these compounds are highly bioaccumulative, consumption of contaminated foods is considered to be the main route of exposure to human and wildlife<sup>5</sup>.

Accumulation of persistent organic pollutants (POPs) in aquatic biota, wildlife and human sera from Sri Lankan samples were recorded (Grurge & Tanabe 2001). Only one report is available on human contamination of fluorinated organic compounds (FOCs) in Sri Lanka (Guruge 2005) and there are no any reports available on FOCs contamination in Sri Lankan fishes, where fish is an important protein source of diet in Sri Lankan. Thus, the present study provides detailed information on the accumulation of perfluorooctane sulfonate (PFOS) and perfluorooctanoate (PFOA) compounds in some edible freshwater fish, coastal fishes, shrimps and bivalves collected from Sri Lanka.

## 2 MATERIALS AND METHODS

### Sample Collection and Storage

Nine species of marine fish; *Pomadasya hasta*, *Siganus virgatus*, *Lisa parsia*, *Lutjanus quinquelin-eatus*, *Monodactylus argenus*, *Lutjanus russelli*, *Lutrinus harak*, *Lutrinus leutjan*, *Arius subro-stratus*; two species of marine invertebrates, *Penius monodon* and *Mytelus sp.* were collected from fish catch of the Negambo lagoon and Negambo coast. Six species of freshwater fish; *Ctenophar-yngodon idella*, *Tilapia nilotica*, *Clarius sp.* *Hyporhampus limbatus*, *Trichogaster pectoralis*, *Channa straita* and were collected from local fisherman in various regions from Sri Lanka. All fish samples



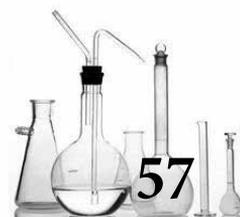
were frozen immediately after collection and remained frozen until time of processing. Invertebrate fresh samples of shrimp and *Mytilus* sp. were collected from Negombo lagoon at depths of 90-120cm. Greater than 60 individual were frozen as composite samples. Greater than 60 individual invertebrates (*Penius monodon* and *Mytelus* sp.) were processed as composites of whole individuals after removing the exoskeleton, whereas all other fish samples were homogenized, as described in “Sample preparation”, and stored at -20 °C in sealed polypropylene bags lined with clean aluminum foil which rinsed with acetone and hexane.

## Sample preparation

The invertebrates (*Penius monodon* and *Mytelus* sp.) were processed as composites of whole individuals, where as all the other fish samples analyzed represented individual whole fish homogenates. Composite invertebrate samples of *Penius monodon* (total weight of soft tissue = 50.2 g, mean total length 8.5cm, individual per composite, n = 41 ), *Mytelus* (mean fish weight < 65g; total weight of soft tissue = 79g, individuals per composite ; n = 8; mean fish weight > 65g; total weight of soft tissue = 152g, individuals per composite ; n = 12) were prepared by rinsing each individual in distilled water and combining them in steel beakers by cutting each of them into small pieces with clean scissors . The contents of each beaker were then homogenized using a Polytron homogenizer. Pooled homogenates were then frozen until analysis in clean 50ml polypropylene tubes and these were analyzed in triplicate by sub sampling .

## Analysis

Samples were analyzed for 10 FOCs: perfluorohexanesulfonate (PFHxS), perfluorooctanesulfonate (PFOS), perfluorohexanoic acid ( PFHxA), perfluoroheptanoic acid (PFHpA) ,perfluorooctanoic acid ( PFOA ), perfluorononanoic acid ( PENA ), perfluorodecanoic acid ( PFDA ) ,perfluoroundecanoic acid (PFUnDA ), perfluorododecanoic acid and ( PFDOoDA ), perfluorooctanesulfonylamide (PFOSA). All fish samples homogenates were thawed at room temperature and stirred before subsampling. A subsample of 0.5g homogenates was placed in a 15 ml plastic (polypropylene) centrifuge tube with 5ml of distilled water and a 1ml aliquot of the sample homogenate (in triplicate) was extracted by an ion-pairing method, which described elsewhere 7,8,13. One ml of aliquot was mixed with 1 ml of 0.5 M tetra-n-butylammonium hydrogen sulfate solution and 2 ml of buffer (pH 10,1.25 M) in a poly propylene (PP) tube. The sample mixture was extracted with 5 ml of methyl tert -butyl ether (MTBE) by shaking vigorously for 20 min followed by centrifugation to isolate the organic phase. The MTBE supernatant (4 ml) was collected in a separate polypropylene tube, and this extraction process was repeated once more, combining the 5ml of MTBE supernatants. The MTBE was blown to dryness under high-purity nitrogen gas, and the analytes were taken up in 0.5 ml of 100% methanol. The concentrates were then filtered through 0.2µm nylon filters into polypropylene vials for analysis.



Detail instrumental analysis and quantification was described elsewhere (8,14). Analysis of FOCs was performed using a high performance liquid chromatograph-tandem mass spectrometer (HPLC-MS/MS), comprising an Agilent Hp1100 liquid chromatograph interfaced with a Micromass® (Beverly, MA,USA) Quattro Ultima Pt mass spectrometer operated in the electrospray negative ionization (ESNI) mode 3,5. A 10µl aliquot of the sample extract was injected into a guard column (XDB-C8, Agilent Technologies, CA) connected sequentially to a Betasil C18 column (Termo Hypersil-Keystone, Bellefonte, PA) with 2mM ammonium acetate/methanol as mobile phase, starting at 10% methanol.

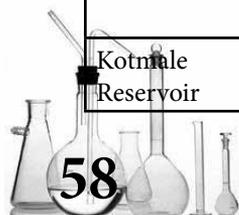
### 3 RESULTS AND DISCUSSION

#### Quality control

Biometry of samples is shown in table 1. Procedural recovery and blank tests were carried out to determine the precision of the extraction and analytical protocol. An instrumental blank response was always present for PFOA and PFOSA, which made quantification of analytes difficult in most samples. The accuracies of the analyses were determined by use of matrix spikes. Mean recoveries of PFOS, PFHxS, PFOSA, PFDODA, PFUnDA, PFDA, PFNA, PFOA, PFHpA, PFHxA, and spiked into homogenized fish muscle (n = 4) prior to extraction were given in table 2. The matrix-spike studies suggest that the data are quantitatively acceptable. Concentrations were not adjusted for the purity of standards or recovery. The concentration less than LOQ was considered as zero for calculate mean concentrations, thus the mean values will diverse from the actual values. Moreover, to reduce the high background levels, all accessible PTFE tubs and solvent inlet filter were used. Additionally suitable PP tubes and septa were selected after thorough blank checking. Details of analytical improvements to eliminate contamination sources have been discussed elsewhere (14 ).

Table 1. Biometry of fish and invertebrates collected from Sri Lanka

Location	Species	Sam- ple No. (n)	Mean body length (cm)	Mean body- weight (g)
Negombo lagoon	<i>Pomadasya hasta</i> (Grunter)	5	17.4 (15-20)	91.2 (56-145)
	<i>Siganus virgatus</i> (Rabbit fish)	5	14.4 (13.5-15)	44.4 (35-54)
	<i>Lisa parsia</i> (Mullet)	5	19.8 (15-22)	88.2 (45-117)
	<i>Penius monodon</i> (Shrimp)	41	8.5	50.2*
	<i>Mytelus sp</i> (Mussel) Wt <65g	8	16.5 (16-17)	79*
	<i>Mytelus sp</i> (Mussel) Wt >65g	12	16	152*
Negombo Coast	<i>Lutjanus quinquelineatus</i> (Five lined snapper)	2	15	102
	<i>Monodactylus argenlus</i> (Silver moonny)	2	14.5	102
	<i>Lutjanus russelli</i> (Russells snapper)	2	15	73
	<i>Lethrinus harak</i> (Thumbprint emperor)	2	24	51.5
Kotmale Reservoir	<i>Luthrinus leutjan</i> (Pinkear emperor)	2	25	100



Polonnaruwa	<i>Arius subrostratus</i> (Shorenose catfish)	2	17	22.6
Bolgoda Lake	<i>Ctenopharyngodon idella</i> (Carp)	4	23.6	225
	<i>Tilapia nilotic</i>	5	21	90
	<i>Tilapia nilotic</i>	3	21.3	265
Bolgoda Canal	<i>Tilapia nilotic</i>	5	21.4	176
	<i>Clarius sp.</i> (Catfish)	5	18.6	52.8
	<i>Hyporhamphus limbatus</i> (Moralla)	5	17.5	31.6
	<i>Tilapia nilotic</i>	3	18.5	137
	<i>Trichogaster pectoralis</i> (Snakeskin gurami)	2	17.5	80
	<i>Channa straita</i> (Snake head)	2	18.5	63.5

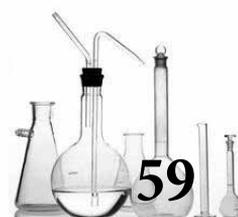
\* Total weight of soft tissues

Table 2. Procedural and matrix recoveries (%; mean±SD) for individual PFCs through the analytical procedure

	(n)	PFOS	PF-HxS	PFO-SA	PF-DoDA	PFUn-DA	PFDA	PFNA	PFOA	PFH-pA	PF-HxA
LOQ		<10	<2	<2	<10	<10	<10	<10	<10	<10	<10
Blank	4	<10	<2	2	<10	<10	<10	<10	49	<10	<10
Pro. Rec.	4	91± 1	94± 2	89± 2	98± 3	88± 6	98± 4	92± 3	95± 3	88± 6	92± 4

Recoveries (%; mean±SD) for PFCs spiked into homogenized fish muscle through the analytical procedure

The highest concentration of PFOS was recorded in the marine/ brackish water fish snake head as 12370 pg/g while in freshwater thilapia was 11220 pg/g. The mean concentration of PFOS in *Mytilus* was less than 10 pg/g or undetectable. The concentrations of PFHxS and PFO-SA were considerably higher (178 and 183pg/g) to that of PFOS concentration in *Mytilus sp.* The mean concentration of PFO-SA was high in the marine fish *Lutrinus leutjan* (231pg/g). Also, considerable concentration of PFHxS (310 pg/g) was detected only in *Siganus virgatus*. The detection frequency of PFOS was 75% while PFO-SA was 50%. The accumulation of FOCs was found in human body fluids<sup>6</sup>, suggesting that FOCs pollution in Sri Lanka aquatic environment may be widespread. In this study 13 species of fish and two species of invertebrates from 4 locations were investigated. To our knowledge, this is the first report documenting the extent of FOCs contamination in edible fish from Sri Lanka. Thus, present study provides evidence for the current background concentration of fishes in Sri Lanka. The current levels of FOCs concentrations in fishes were considerably lower compared to the concentrations recorded those in fish in other countries.<sup>4</sup>

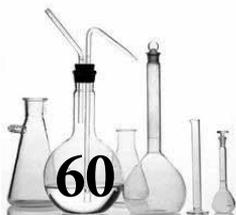


## 4 ACKNOWLEDGEMENTS

*This study was partially funded by a Grant-in Aid to Dr. KSG and Dr. NY by the Environmental Ministry of Japan.*

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# ELECTROCHEMICAL TREATMENT FOR PHENOL/PHENOLIC HAZARDOUS CHEMICALS IN WATER

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## 1 INTRODUCTION

Hazardous natural and manmade chemicals have been a global environmental issue, when discharge them directly or indirectly into the water bodies without proper treatment. Even in Sri Lanka, they have created impacts on our economy, health and ecology.

Phenolic compounds are known as one of such hazardous chemicals due to their high toxicity, high oxygen demand and low bio degradability (Kingsland et al., 2006). Since they have potential to impact on our health and ecology even at low concentration, the phenolic contaminated water treatment has received more attention. Hence, various techniques have been widely investigated. Among those technologies, electrochemical methods have gained more attention due to factors such as in-situ chemical generation, ease in process control and high efficiency (Daidai et al., 2007; Fan et al., 2001). An important factor for the application of electrochemical treatment is the anode material. However, little attention is paid towards the development of anode materials for specific contaminants such phenols. Therefore, the aim of this study is to develop an anode for the electrochemical treatment of water contaminated with phenol.

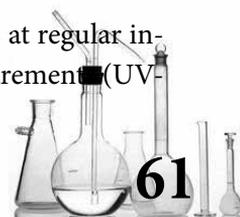
## 2 METHODOLOGY

### Development of electrodes

In the pre treatment process, substrate was mechanically treated by using sand paper to increase the adhesiveness of the surface followed by a chemical pre treatment process. Chemical pre treatment was done with 5% (w/w) oxalic acid solution and 37% (w/w) HCl acid prior to the coating process (geometrical area of one electrode was ~1 cm<sup>2</sup>). Finally, the substrate was sonicated in distilled water and dried at 100 °C (Feng and Johnson, 1991). The anode was developed with rare metal oxide coatings using the dip coating process followed by calcinations steps (Min et al., 2007).

### Detection of phenol removal

The phenol removal during the electrolysis was measured by obtaining the samples at regular intervals (1 h). Determination of phenol was done using the Uv-vis absorbance measurement (UV-2450- Shimadzu, Japan) at wave length of 270nm.



## Qualitative analysis of hydroxyl radical

Hydroxyl radical generation at electrodes was investigated with 4-nitroso-N,N-dimethylaniline (RNO) due to its selective reaction with  $\text{OH}^\bullet$  radicals, electrochemical inertness and the easy color determination towards bleaching at the presence of hydroxyl radicals (Comninellis, 1994; Jeong et al., 2006).  $2 \times 10^{-5}$  M RNO and 10g/L  $\text{Na}_2\text{SO}_4$  solution was electrochemically treated at a constant current density of 20  $\text{mA}/\text{cm}^2$ . The colour bleaching was monitored through absorbance readings at 440 nm wave length.

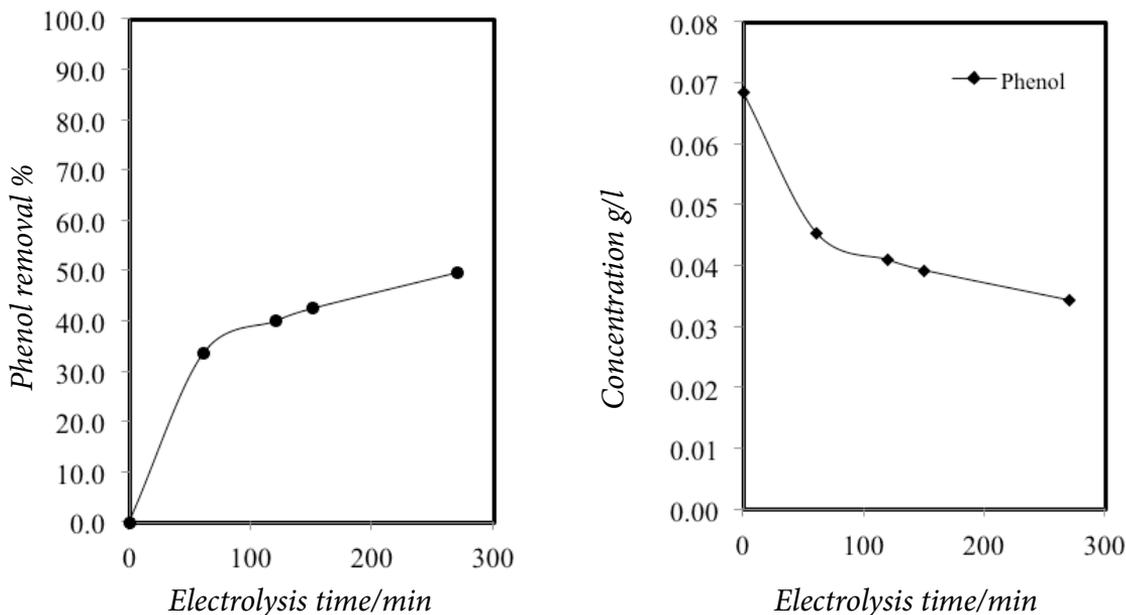


Figure 01: (a) Phenol removal percentage with Steel/ $\text{IrO}_2$ - $\text{Sb}_2\text{O}_3$  anode in  $\text{Na}_2\text{SO}_4$  electrolyte. (b) Electrochemical degradation of 7mg/L phenol as a function of time. Notations: volume per test = 50ml, applied current = 20mA, anode area =  $1.126\text{cm}^2$ , pH = 11.27

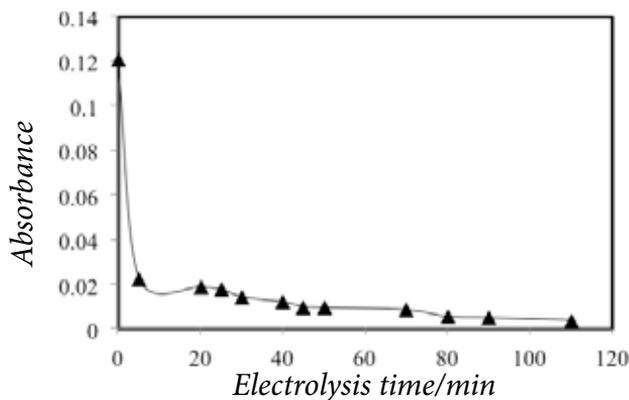
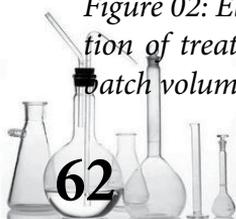


Figure 02: Electrochemical bleaching of  $2 \times 10^{-5}$  M RNO in 10g/L  $\text{Na}_2\text{SO}_4$  solution as a function of treatment time. Notation: current density = 19  $\text{mA}/\text{cm}^2$ , anode area =  $1.126\text{cm}^2$ , batch volume = 50ml



### 3 RESULTS AND DISCUSSION

This section discusses the investigation on electrochemical oxidation of water contaminated with phenol.

#### Removal of phenol from chloride-free electrolytes:

Figure 01 shows the removal percentage and the variation of concentration of phenol during the electrolysis with  $\text{Na}_2\text{SO}_4$  as supporting electrolyte. Phenol removal efficiency of 49.8% was achieved after 270 min of electrolysis time. At a  $20\text{mA}/\text{cm}^2$  of current density with  $10\text{g}/\text{L}$   $\text{Na}_2\text{SO}_4$  as the supporting electrolyte the phenol concentration decreased with the electrolysis time.

#### Generation of oxidants

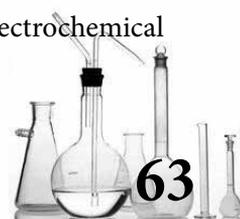
In electrochemical oxidation, electrochemically generated chlorine would be the mostly studied oxidant. However, reactions of organic compounds such as phenol with chlorine result in more toxic intermediates. In order to avoid such situations,  $\text{OH}^\bullet$  radical is promoted as the major oxidant in this study. Free radical production during the electrolysis was observed by using RNO. Figure 02 shows the rapid decrease of absorbance during first 10 minutes showing the generation of hydroxyl radicals.

### 4 CONCLUSIONS AND RECOMMENDATIONS

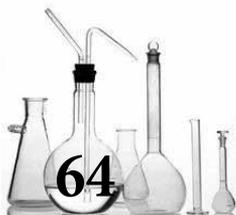
The above finding reveals that the electrochemical technologies can be used to treat organic compounds in water. Suitable electrode materials with optimized conditions will determine the best degradation capacity under success of oxidant generation. It will help to prevent potential negative health and environmental effects of exposure to these chemicals.

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# MANAGEMENT OF THE KALATUWAWA RESERVOIR TO IMPROVE WATER QUALITY

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## 1 INTRODUCTION

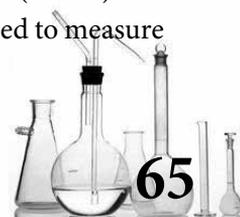
Metals and other inorganic toxic substances management of reservoirs is aimed at the protection of human health and aquatic life from impacts caused by the release of toxic substances to surface waters. These reservoirs and lakes hold important fresh water ecosystems of the globe, in which a great number of species, including human beings interact with each other. Therefore special care must be taken when releasing substances in to the reservoir because of the unique physical and chemical characteristics of confined water. Metal and other inorganic substances are retained longer in both water and sediments than in flowing surface water which increases the risk of exposure of toxicants in terms of concentration and duration to both aquatic organisms and humans who depend on drinking water and food from reservoir.

The presence of metals and other inorganic substances in reservoir is attributable to both natural processes and human activities. Metals enter the reservoir as a result of natural physical and chemical processes such as weathering and leaching of soil and rocks. Ammonia and other inorganic toxic substances are released due to decomposition of organic matters. Therefore the reservoir management is important tool to improve the water quality – sediment removal can be used to reduce the release of accumulated metals and inorganic substances in to the water column.

## 2 METHODOLOGY

This study is basically to investigate the water quality variation in the reservoir from year 2000 to 2012 and also from top to the bottom of the reservoir within different valve positions to minimize the chemical usage and reduce the operational cost. Water samples were collected to analyze basic physical and chemical parameters from year 2000 to 2012 but significant changes have been observed for ammonia, iron and colour. Therefore these parameters are considered for the analysis of the data because of their important of the treatment processes.

In this investigation water samples were collected in cleaned acid-washed plastic bottles to analyze basic physical and chemical parameters. Sediment samples were collected in occasionally to analyze Lead (as Pb ), Cadmium (as Cd) , Chromium (as Cr) , Zinc (as Zn), Manganese (as Mn) and Iron (as Fe) levels. Flame Atomic absorption spectrometer Varian 240 FSAAS was used to measure



the Lead (as Pb), Cadmium (as Cd), Chromium (as Cr), Zinc (as Zn), Manganese (as Mn) and Iron (as Fe) levels in water and sediment samples. A series of standard solutions were prepared for each metal ion using above standard solutions and directly aspirated to the atomic absorption spectrometer and absorbance measured. Using these readings constructed the calibration graph, from these graphs read the sample concentration according to the absorbance given by the instrument for the each sample. Lovibond Nessleriser was used to measure the colour in Hazen units. DR 5000 Spectrophotometer and Orion pH meter were used to measure the ammonia and pH in water.

### 3 RESULTS AND DISCUSSION

Monthly variations of ammonia levels from year 2000 to 2012 in Kalatuwawa reservoir are plotted in graph 01 and the range of the measured ammonia levels were  $0.06 \text{ mg/dm}^3$  to  $0.64 \text{ mg/dm}^3$ . Variations of ammonia levels in different depths are plotted in graph 4 and the highest concentration of ammonia  $1.92 \text{ mg/dm}^3$  was reported at the bottom of the lake in year 2012. Ammonia is toxic to fish and the ratio of ammonium to ammonia is known to be dependent on pH.

In the chlorination of raw water containing ammonia, virtually no free residual chlorine is obtained until the ammonia has been oxidized. Rather the chlorine reacts with ammonia to form monochloramine, dichloramine and trichloramine – combine chlorine. Therefore high chlorine dosage is required for disinfection process.

Presently chlorine requirement for the treatment plant is 240 kg/day but removal of the sediment this requirement can be reduced to half.

Monthly variations of iron levels from year 2000 to 2012 in Kalatuwawa reservoir are plotted in graph 02 and the range of the measured iron levels were  $0.17 \text{ mg/dm}^3$  to  $2.0 \text{ mg/dm}^3$ . Variations of iron levels in different depths are plotted in graph 5 and the highest concentration of iron  $12 \text{ mg/dm}^3$  was reported at the bottom of the lake.

Therefore high iron content raw water should be treated by aeration and filtration prior to human consumption. Pre chlorination dosage requirement is high to oxidize Fe (II) into Fe (III) and with the removal of high iron containing sediment also minimize the chlorine demand.

Iron is an essential element for human. It is contained in a number of biologically significant proteins: hemoglobin and cytochrome, and also in many oxidation-reduction enzymes. Iron ingested in large quantities results in a condition known as hemochromatosis – normal regulatory mechanisms do not operate effectively.

Monthly variations of colour from year 2000 to 2012 are plotted in graph 3. The colour level varies



from 6 Hz – 30 Hz from year 2000 to 2012. Variations of colour levels in different depths are plotted in graph 6 and the highest level of colour 90 Hz was reported at the bottom of the reservoir due to organic matter in the sediment.

Excessive colour needs to be removed to make water suitable for general and industrial applications. The colour is used here to mean “apparent colour” which is due to substances in solution and also that is due to suspended matter. In some highly coloured water, colour is contributed principally by colloidal or suspended material. Therefore apparent colour varies according to turbidity.

Measurement of pH is one of the most important and frequently used tests in water. Practically every phase of water supply and water treatment, acid - base neutralization, water softening, precipitation, coagulation, disinfection and corrosion control are all pH dependents. At a given temperature the intensity of the acid or basic character of a solution is indicated by pH or hydrogen ion activity. Kalatuwawa reservoir has reported pH range from 6.0 – 6.8 throughout the years.

Heavy metals are the most significant toxic substances in lakes. Therefore the sampling were done for the measurement of cadmium (as Cd), chromium (as Cr), lead (as Pb), zinc (as Zn), manganese (as Mn) and iron (as Fe) concentrations in lake sediments and water and the values are given for the sediment in mg/kg dry weight, for the water in mg/dm<sup>3</sup>. Reservoir sediment reported high Zn level (136.7 mg/kg) and manganese (349.3 mg/kg) and iron but heavy metals such as Pb, Cr and Cd were not detected in sediment as well as water.

#### 4 CONCLUSIONS

Toxic heavy metals such as Cd, Cr, and Pb were not detected in sediment samples but Fe, Mn and Zn in sediment is significant. It does not endanger aquatic life and use of drinking water but more treatment chemicals – chlorine – is required to oxidize the contaminants.

The metal content of the sediment is indicative of the degree of pollution. It serves as a source of solubilization into water depending physico-chemical circumstance such as pH.

Soluble metal concentration for Cd, Cr and Pb were not detected in source water. Therefore no such toxic metal contamination in drinking water.

High concentration of ammonia with low pH value to the ionized form of ammonia (NH<sub>4</sub><sup>+</sup>) which is not acute toxic to the fish which means death of fish were not observed in the reservoir.

In the chlorination of raw water containing ammonia, virtually no free residual chlorine is obtained until the ammonia has been oxidized. Rather the chlorine reacts with ammonia to form monochloramine, dichloramine and trichloramine – combine chlorine. Therefore high chlorine dosage is required for disinfection process. With considering the above facts following recommendation can be given



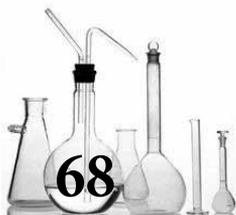
Sediment removal is proposed to reduce the release of accumulated metals – Zn, Mn, Fe - and ammonia and other contaminant to the water column. This method may be quite effective as a means of reducing the reservoir toxic substances.

Catchment protection and management minimize the loading of organic matter to the reservoir

- Control an adequate buffer zone around the reservoir, remove leaves dropping trees, shrubs and weeds from the buffer zone, maintain short grass in the immediate runoff area, replace shoreline silt with gravel, steepen the shoreline for aquatic weed control and control the pollution sources such as agriculture, timber cutting, industry and accidental.

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# CONTAMINATION STATUS OF MICROCYSTIN-LR AND THEIR DESTRUCTION BY MICROBES

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## 1 INTRODUCTION

Microcystins (MCs), a large family of cyclic heptapeptides produced by a group of cyanobacteria, such as *Microcystis sp.*, *Anabaena sp.*, *Planktothrixm sp.* (*Oscillatoria*), *Nostoc sp.*, and *Hapalosiphon sp.* (Carmichael.,1992; Imanishi and Harada., 2004). Microcystin contamination in drinking water supplies is an emerging concern as conventional water treatment processes such as coagulation; flocculation, chlorination and filtration have failed to reduce microcystins (Lawton et al., 1999). An important concern is that chronic exposure to low concentrations of MCs in drinking water may promote tumour growth in the human liver (Falconer., 1991; Matsushima et al., 1992). Currently, drinking water supplies all over the world have been contaminated with MCs, posing a threat to public health. For example, in 1996, more than 50 hemodialysis patients in Caruaru, Brazil, died because the water used for dialysis was contaminated with MCs (Jochimsen et al.,1998;Pouria et al., 1998). Some advanced water treatment technologies like activated carbon adsorption and ozone oxidation have been shown to be successful in removal of MCs from drinking water (Jones et al., 1993). Implementation of such advanced technologies is more critical in developing countries like Sri Lanka where technology and funds are very challenging to science. One of the most exciting areas that hold promise for a successful cost effective solution is harnessing microbes to render water safe and recent years we have demonstrated that there is greater diversity of microbes capable of degrading microcystins. Recently it has been documented that the use of slow sand filters and biofilms which exploit the use of selected biodegrading bacteria to complement the natural microbial flora of the filter for improved removal, providing a low cost solution for the provision of safe potable water (Babica et al., 2005; Bourne et al., 2006; Ho et al., 2006). Thus, the objectives of this proposed study was to determine the contamination status of water bodies by Microcystin-LR and screening of bacterial isolates for most effective water treatment for microcystin degradation.

## 2 MATERIAL AND METHODS

Surface water samples (10cm below) were collected from Beire Lake, Kandy lake, Boralessgamuwa lake, Kasbewa lake, Kotmale, Victoria, Randenigala and Rantabe reservoirs, Maha-abagaswewa, Tissawewa, Abankattuwa, Girithale wewa, Kaudule wewa, Parakkrama samudra, Udawalawe tank, Chandrika wewa, Kondawatuwana, Kantale wewa, Weeragoda, Wahalkada, Jayanthi wewa, Nuwara wewa, Kala oya, Eluwankulama, Ridiagama Labugama and Kalatuwawa reservoirs in to 1 L sterile

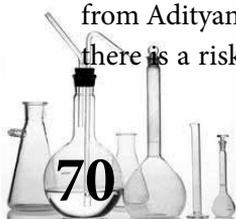


lized glass bottles and were transferred to the laboratory kept in ice and stored at 4°C overnight until analysis. Identification and enumeration of cyanobacteria was done using standard methods (Prescott,1970; Manage.,2009). Phyco-chemical parameters like pH, conductivity, temperature, total nitrate concentration, total phosphate concentration, total hardness, and alkalinity were measured according to the standard methods (Silva et al.,1996). Microcystin-LR was measured using ImmunoStrip which is an on-site screening tool to determine the presence of microcystins in freshwater (agida, USA). The ImmunoStrip method quantifies a range of contamination of microcystin-LR and thereafter the level should be precisely confirmed by HPLC methods. The ImmunoStrip has been formatted using antibody fragment developed and has standardized using a well established laboratory method HPLC PDA diode array. To screen microcystin degrading bacteria from natural water, enrichment experiments were carried out by spiking known concentration of microcystin variants as a sole carbon source for the bacteria in the filtered water (0.8µm). Samples were kept in a flask shaker (100 x rpm) at 25°C. After 14 days of rotary incubation one millilitre aliquots were removed from the flask and bacteria will be cultured according to the pour plate methodology.

### 3 RESULTS AND DISCUSSION

Water quality parameters of all reservoirs were within the acceptable levels and some deviations were detected for total nitrate (TN) and total phosphate (TP) concentrations for Beire lake (TN-1.31±0.01mg/l, TP-1.78±0.21mg/l), Kondawatuwana tank (TN-1.45±0.11 mg/l, TP-2.09±0.48mg/l), Boralasgamuwake (TN-1.63±0.47mg/l, TP-2.10±0.32mg/l), Jayanthi wewa (TN -1.98±0.05mg/l, TP -1.76±0.62mg/l). *Cyanobacterium M. aeruginosa* was the dominant cyanobacteria recorded most of water bodies except Kondawatuwana and Kantale reservoirs where *Cylindrospermopsis sp.* was the dominant species. *Cylindrospermopsis sp.* produce cylindropermopsin which is a neurotoxin.

Algae scum samples collected from some recreational and irrigation tanks showed greater contamination (more than 15 µg/L) of microcystin-LR. More than 170 bacteria were isolated from enrichment experiments for different water bodies for microcystin degradation studies. Seven bacteria strains from Nuwara wewa, two bacteria strains from Tissa wewa, six bacteria strains from Wahalkada tank in Anuradhapura district and seven bacteria strains from Girithale tank, four bacteria strains from Parakrama samudraya from Polonnaruwa district was isolated. Eight bacteria strains from Kondawatuwana, seventeen bacteria strains from Jayanthi wewa from Ampara district, twenty six bacteria strains from Boralasgamuwa lake, six bacteria strains from the Colombo Beirae lake, ten bacteria strains from Kalatuwawa, and twelve strains from Labugama were isolated. In Trincomalee district, eighteen bacteria strains from Kantale tank, twelve bacteria strains from Mahaweli river intake, twelve bacteria strains from Janaranjan tank were isolated. Fourteen bacteria strains were isolated from Unnichi reservoir and twelve bacteria strains were isolated from Adityamalia in Batticaloa district. The contamination levels of microcystin-LR showed that there is a risk in future as most these water bodies used for recreational, irrigation and drinking



purposes. The immu-strip assay only provides contamination range and qualitative methods are recommended to predict the impact of microcystin on human health. Microcystin degradation experiments are in progress for water treatment solution.

Table 1. Dominant cyanobacteria and microcystin contamination level of the water bodies.

Reservoir/ Water body/ Tank	Dominant Cyano- bacteria	Microcystin-LR $\mu\text{g/L}$ (Immuno strip detec- tion)	Risk category
Beire Lake	<i>M. aeruginosa</i>	Greater than 15	<b>High risk</b>
Cylindropermopsis			
Kandy Lake			
Boralesgamuwa lake			
Kesbawa lake			
Kondawatuwana tank			
Kantale tank			
Randenigala	<i>M. aeruginosa</i>	0 to 15	Low to moderate risk
Rantambe			
Maha-abagaswewa			
Nuwara wewa			
Wahalkada			
Jayanthi wewa			
Tissawewa			
Girithale wewa			
Abankattuwa			
Kaudule wewa			
Ridiagama reservoir			
Victoria			
Parakrama samudra			
Udwalawe irrigation tank			
Chandrika wewa			
Labugama			
Kalatuwawa			
Kala oya			
Eluwankulama tank			



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# OPTIMIZATION OF ELECTRODE MATERIAL FOR ELECTROCHEMICAL DENITRIFICATION IN CHLORIDE FREE ENVIRONMENT

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## 1. INTRODUCTION

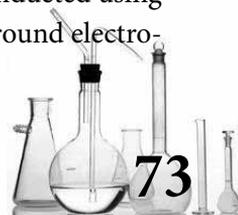
The use of synthetic fertilizers is a common practice in agricultural countries like Sri Lanka. The increased use of nitrogen – based fertilizers has been reported to lead the elevated amount of nitrate in groundwater. Nitrate is a known culprit behind methamoglobinemia and as well it can be carcinogenic. In accordance with World Health organization (WHO), maximum limit of 50 mg/L NO<sup>3-</sup> (15 mg/ L NO<sub>3</sub><sup>-</sup> for infants) in drinking water is permitted <sup>[1]</sup>.

Among other denitrification technologies like physiochemical and biological methods, electrochemical denitrification is an attractive technology since it is easy to operate and maintain. In addition, by careful development of material, electrochemical denitrification can offer high efficiencies at lower energy cost. However, most of the reported studies are based on commercially available electrode materials. Also, electrochemically generated Chlorine is used to oxidize byproducts of nitrate reduction and hence confined to electrolytes with chloride ions.

In this study the attention is paid on the development of novel electrode materials considering the electrode properties pertaining to a higher degree of nitrate removal in Chloride free environment. Cathode material is developed using Copper as main coating material. Optimization of cathode material has done by statistical based experimental design <sup>[2]</sup>. Nitrate reduction has accomplished using the developed cathode in chloride free environment with oxide of rare earth metal (IrO<sub>2</sub>), as anode.

## 2. MATERIALS AND METHODS

Copper metal was electrodeposited on pre- treated Titanium substrate [3]. The Ti/ IrO<sub>2</sub> anode was prepared by thermal decomposition of IrCl<sub>3</sub>.3H<sub>2</sub>O (Acros organics, 53.56%) metal precursor in isopropanol (Fisher Scientific, 99.9%) <sup>[3]</sup>. The nitrate reduction experiments were conducted using electrolytes which contain 20 mg / dm<sup>3</sup> NO<sub>3</sub><sup>-</sup> - N using 0.1 M NaClO<sub>4</sub> as the background electro-



lyte [4]. The applied current density was 0.050 A/ cm<sup>2</sup> and the electrolytic tank contained 25 ml of the electrolyte. The nitrate content was analyzed using Sodium-Salicylate method.

In the step of optimization of cathode material, a statistical based response surface modeling methodology was used to examine the dependence of surface area on the fabrication parameters. The experiment was performed using three independent parameters current density, plating duration and copper concentration. These variables were simultaneously changed at highest (+1) and lowest (-1) levels. The range for variables were 0.01 A/cm<sup>2</sup> – 0.04 A/cm<sup>2</sup> , 0.5 h – 3 h, 0.2 M -1.0M for current density, plating duration and copper concentration respectively. The experimental design and response surface were designed using Minitab 16 software with Box-Behnken design. Anodic charge which represents the electrochemically active surface area of the electrodes was measured using Metrohm Autolab PGSTAT 128N.

### 3. RESULTS

#### 3.1 Nitrate removal efficiency of the Ti/ Cu cathode with Ti/ IrO<sub>2</sub> as anode.

Electrochemical experiments were performed under galvanostatic conditions (0.050 A/ cm<sup>2</sup>) using 20 mg / dm<sup>3</sup> NO<sub>3</sub><sup>-</sup> - N solution for two hours.

Results shown in Table 01 indicate that 69.84% of nitrate is removed by using Ti / IrO<sub>2</sub> as anode material with Ti/Cu cathode.

Table 01:- Percentage removal of nitrate by Ti / Cu electrode with Ti / IrO<sub>2</sub> as anode

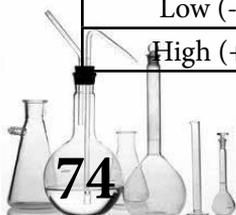
Solution	Absorbance	Concentration (mg / dm <sup>3</sup> )
Initial	0.710	20.714
Final	0.210	6.247

#### 3.2 Statistical based experimental design

Using Box- Behnken design experiment was designed statistically by Minitab 16 software.

Table 02:- Factors and levels of the experimental design

Level	Factor I	Applied current (mA) Factor II	Plating duration (hrs) Factor III	CuSO <sub>4</sub> •5H <sub>2</sub> O Concentration (M)
Low (-1)		20	0.5	0.2
High (+1)		80	3	1.0



Anodic charge values were obtained by cyclic voltammetry for the fifteen electrodes fabricated according to the corresponding parameters obtained through the Box- Behnken design.

Table 03:- Experimental design of copper electroplating

Experiment	Virtual level of factors			Level of factors			Anodic charge (C)
	I	II	III	I (mA)	II (hrs)	III (M)	
1	-1	-1	0	20	0.50	0.6	0.752206
2	0	+1	-1	50	3.00	0.2	0.981741
3	+1	0	-1	80	1.75	0.2	0.86809
4	0	0	0	50	1.75	0.6	0.096996
5	-1	+1	0	20	3.00	0.6	0.62947
6	-1	0	-1	20	1.75	0.2	0.466897
7	-1	0	+1	20	1.75	1.0	0.188488
8	0	0	0	50	1.75	0.6	0.628675
9	+1	0	+1	80	1.75	1.0	0.252341
10	0	+1	+1	50	3.00	1.0	0.526127
11	+1	+1	0	80	3.00	0.6	0.247660
12	0	-1	-1	50	0.50	0.2	0.549255
13	0	-1	+1	50	0.50	1.0	0.261500
14	+1	-1	0	80	0.50	0.6	0.601092
15	0	0	0	50	1.75	0.6	0.118963

#### 4. DISCUSSION

During this electrochemical process, reduction of nitrate to byproducts such as nitrite and ammonium ion is occurred at the cathode. Anodic oxidation is used to oxidize these byproducts back to nitrate.

The efficient removal of nitrate is generally represented by the electrodes with higher anodic charge, since highest anodic charge indicates the highest electrochemically active surface area of the electrodes. All three parameters, Current density, Plating duration and copper concentration play significant role in nitrate reduction by Cu/ Ti cathode. In accordance with the results obtained, high current densities and long plating durations increase the surface area while higher copper concentrations decreases that of the electrodes. An increase of copper concentration has produced nuclei with a coarser texture and lower population density in turn increase the surface area. Moreover, higher current density increases mass transfer rate which leads to higher surface area.



## 5. CONCLUSION

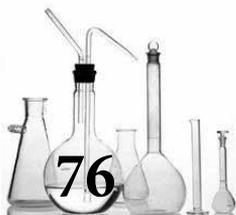
Current density, Plating duration and copper concentration play significant role in the electroplating of copper on Titanium substrate. Higher current densities, higher plating durations and lower copper concentration produce electrodes with higher surface area.

### **Acknowledgement:**

*Authors acknowledge the National Science Foundation Sri Lanka for funding this research (RG/BS/11/01). In addition, the authors acknowledge the National Research Council Sri Lanka for providing the Autolab PGSTAT 128N equipment (NRC/11/054).*

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# PCB SCREENING STUDY IN WELDING PLANTS IN BADULLA DISTRICT

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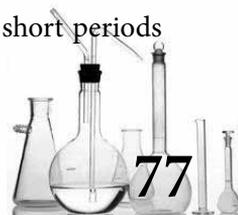
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## 1 INTRODUCTION

Persistent organic pollutants (POPs) are organic compounds of natural or anthropogenic origin that resist photolytic, chemical and biological degradation. They are characterized by low water solubility and high lipid solubility, resulting in bioaccumulation in fatty tissues of living organisms. POPs are semi-volatile and, therefore, able to move long distances in the atmosphere, and are also transported in the environment in low concentrations by movement of fresh and marine waters, resulting in a wide-spread distribution across the earth, including regions where they have never been used and thus, may cause a long range of detrimental environmental and health effects. Persistent organic pollutants (POPs) are grouped on the basis of a common characteristic, i.e. persistence in the environment, longer than that required for their intended use. The 12 POPs, all are chlorinated compounds, are the pesticides aldrin, chlordane, DDT, dieldrin, endrin, heptachlor, mirex and toxaphene; the industrial chemicals and hexachlorobenzene which is also a pesticides; and the unintended by-products of combustion and industrial processes, polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans, numbering 210 congeners, were never produced commercially, and have no intended use. None of the nine chlorinated hydrocarbon pesticides is presently recommended for the use in agriculture.

Polychlorinated biphenyls (PCBs) have been widely using of its important aspects such as, excellent electrical and insulating abilities. PCBs become very popular since 1930s. For many years, PCBs were considered to be almost non toxic, since there were very few reports of illness even among industrial workers who were exposed to fairly large amounts. In 1978, the Environmental Protection Agency (EPA) began to impose bans on PCB manufacturing and sale and on most PCB uses. PCBs were used mainly in electrical transformers and capacitors, heat transformers systems and hydraulic systems. They were also used in inks and carbonless copy paper and for a verity of other purposes, but the EPA ban now prohibits almost all these other uses. Nowadays, PCBs are found mostly in transformers and capacitors. These may be contained in industrial equipment (such as Welding Equipments), medical equipment (such As X-ray machines) and household appliance (such as refrigerators and microwave ovens).

PCBs are very stable in the environment and have accumulated in sediments, organic soils and biota (especially fish). Animals that ate food containing large amount of PCBs for short periods



of time had mild live damage and some died. Liver disease being the cause of death in a significant number of exposed people. Acute exposure to PCBs ash also caused chloracne, a chemically induced acneform eruption. Human fetal exposures of PCBs are associated with neural and developmental changes, lower psychomotor scores, short-term memory and spatial learning effects, and long-term effects on intellectual function. Neurological dysfunction had been associated with perinatal PCB exposure in several Dutch studies. Parental exposure to PCBs may impair immune responses to infection as suggested by a 20-fold higher incidence of infectious diseases and ear infections in a study of Inuit infants with high PCB exposure compared to individuals in a lesser exposed population. (WFPHA, 2000).

Waste substance and articles containing or contaminated with PCB and PTCs and PBB are included as a waste stream (waste stream 23) in schedule 1 of the regulation No.1 of 1990, of the National Environment Act, as amended by Gazette Extraordinary No 595/16 of 1990. Under this regulation, no person shall collect, transport, store, recover, recycle or dispose waste containing or contaminated with PCBs or establish any site or their disposal, except under the authority or a license issued by CEA. Though, it has known that PCBs released into the environment by unauthorized human activities especially through welding plants.

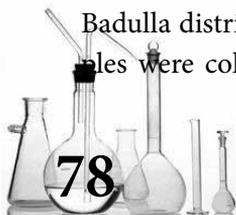
Thus, the study was focused to detect PCBs contamination in welding plants which were used by welders in Baddula district as selected areas. Also, special attention was given on PCBs positive welding plants and how the welders get the coolant agent for their plants. The result of this screening data will help further, to improve the country inventory of the contamination of PCBs.

According to the available data, 48% of the transformers manufactured on or before 1986 are contaminated with PCBs. That is 1060 transformers of an estimated 2210 number which were manufactured before 1986. This contaminated quantity represents 5.78% of the 18,308 transformers in the year 2005. Under the national Environment Act, standards have been proposed for inland water bodies. Proposed maximum acceptable levels of organic micro-pollutants in 'inland waters where fisheries and aquatic life are to be protected' give a limit of 1 nano grams per liter of PCB (total) as the maximum acceptable level. Thus, it is important to screen and detect level of PCBs contamination in ground level and the present work was carried out to find PCBs contamination in welding plants which are one of the important ways to get release PCBs into the natural environment via human activities. The objectives are to screen the welding plants that contaminated with PCBs positive oil as coolant agent in Budulla district.

### 3 MATERIALS AND METHODS

#### 3.1 Study area

Badulla district which located in Uva province was selected as the study area for sampling. Samples were collected from twelve Pradesiya Saba Divisions within the Badulla District namely,



Walimada, Uva Paranagama, Ella, Bandarawella, Mahiyanganaya, Meegahakiwula, Ridimaliyadha, Soranatota, Kandekatiya, Badulla, Haldumulla, Haputale, Haliela. In addition to that six samples were collected from Colombo district based on the information given by the welders who buy coolant for their welding plants.

### 3.2 Sampling

Sampling was performed for a period of three months from August 2007 to November 2007. 5ml welding coolant oil sample was collected from running welding plant and transferred into cleaned plastic bottles, sealed and labeled at the site with a reference. Total of six samples, five from Colombo and one from ELK ARC (PVT) Ltd, Nugegoda were collected .

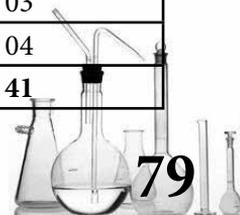
At the same time a questionnaire was given to collect information regarding the way to get coolant oil to the welders. Collected samples were sent to the Industrial Technology Institute (ITI) for analysis. 37 samples out of 69 collected were process for analysis.

## 4 RESULTS AND DISCUSSION

PCB was screened for positive or negative by the method and instructions given by the manufactures (BEXSIL CLOR-N-OIL 50 PCB Screening). After screening, 20 samples were detected as PCB positive. Out of 20 positive samples 4 samples were selected for GC analysis based on Screening test (PCB positive). Analysis of samples were restricted according to the funds available.

*Table1. Divisions of Budulla district where samples were collected.*

	<b>PRADESIYASBA DIVITIONS</b>	<b>No of samples col- lected</b>	<b>No of samples tested</b>
01	Walimada	09	03
02	Uva Paranagama	07	03
03	Ella	05	03
04	Bandarawela	09	03
05	Mahiyanganaya	03	03
06	Meegahakiwula	08	03
07	Rididimaliyadha	03	03
08	Soranatota	02	02
09	kandekatiya	02	02
10	Badulla	07	03
11	Haldumulla	05	03
12	Haputale	03	03
13	Haliela	06	03
	Colombo	06	04
<b>Total</b>		<b>75</b>	<b>41</b>



37 samples were tested for PCBs. Out of 37 samples 26 samples (70%) were collected from refilled welding plants and 11 samples (30%) were collected from new welding plants. Twelve samples (46%) out of 26 refilled welding plants contained more than 50ppm PCBs and the rest was negative (54%). Six samples (55%) were positive for more than 50ppm PCBs out of 11 samples tested for new welding plants. Five samples from 11 were negative (45).

According to the information given in the questionnaire most of welders stated that they punched coolant oil from some places where Panchikawatta and Kelaniya (Addresses were not given). Also, welder's purchase welding plant from Elk arc (PVT) Limited company. Thus, we collected coolant oil from such places and analyzed. It was found that the oil collected from the Elk arc (pvt) Limited company also was positive for PCBs.

## 5 CONCLUSION

The results obtained from the present survey revealed that the contamination of PCBs in welding plants were considerably high. It is important to highlight that the sample collected from the welding plant manufacture company was also contaminated with PCBs and there is a high possibility to get the contaminated coolant to welders via new plants. Discussion made with the company revealed that the coolant oil for welding plants was perched from the electricity board through the tender procedure. Thus, the present survey recommends carrying out a detail study to confirm the way to get the PCBs contaminates coolant oil to welders.

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# STUDY ON EXPOSURE TO POLYCHLORINATED BIPHENYLS (PCBS) AND ITS HEALTH EFFECTS AMONG WELDERS IN THE KALUTARA DISTRICT

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## 1. INTRODUCTION

Polychlorinated biphenyls (PCBs) are a subset of synthetic organic chemicals known as chlorinated hydrocarbons. This class of chemicals includes all compounds with a biphenyl structure (i.e. two benzene rings linked together) that have been chlorinated to varying degree. Theoretically, a total of 209 possible PCB congeners exist, but only about 130 of these are likely to occur in commercial products.

These compounds are chemically stable, have good insulating properties and do not degrade appreciably over time or with exposure to high temperature. Since these compounds use as coolants and insulating fluids (dielectric fluids) for transformers and capacitors, in heat transfer in hydraulic systems, and as link solvents in carbonless paper copy.

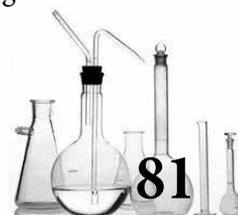
PCBs bio-accumulate in fatty tissues is believed to be responsible for a wide variety of health effects. Acute exposure to high levels of PCBs have been associated with skin rashes, itching and burning, eye irritation, skin and fingernail pigmentation changes, disturbances in liver.

The objectives of the study is to describe the exposure to polychlorinated biphenyls (PCBs) and its health effects among welders in the Kalutara district.

## 3 METHODOLOGY

### 3. 1 Study population

The study population consisted of all workers employed in the 63 welding workshops that were selected for testing of PCBs previously. Since health effects of PCB exposure would manifest only after several years of exposure, it was decided to select the welding worker with highest duration of experience out of the participants fulfilling the eligibility criteria in each work setting.



### 3.2 Study instruments

Three data collection instruments were used for the study:

1. Interviewer administered questionnaire
2. Checklist to record examination findings and information from medical records
3. Observation schedule to record practices in the workplace

### 3.3 Data collection process

The selected welding workshops were visited and the potential participants were identified. Participants were given the information sheet. Verbal consent was obtained prior to collecting information and subjecting them to medical examination. Data collection was done during 1st January 2010 to 28<sup>th</sup> February 2010.

### 3.4 Data entry and statistical analysis

All data collected was entered using SPSS and statistical analysis was done to achieve the specific objectives listed above. Data was analyzed using standard descriptive methods and statistical tests.

## 4. RESULT AND DISCUSSION

These welding workshops are small (less than 10 employees) or medium scale enterprises or micro household businesses that are based on self-employment activities. They contribute to the informal sector in Sri Lanka where 63% of the work force is employed. Employment in the informal sector contributes a lower level of education. It is also observed that insecure, unsafe, unprotected, low quality, low paying, labour intensive, non-standard employment practices dominate in the informal sector.

Sixty two percent of welders (n=39) in the study sample were in the age group of 35 – 49 years and 57% (n=36) educated between grades 9-11 only. Over 80% worked for more than 5 working days per week and for more than eight hours a day. Sixty eight point two percent (n= 43) of the workers have been working in the current occupation for less than 10 years and were welders in their previous occupation too. Twenty seven percent of the work places (n=17) were home based.

Except in the case of one worker the rest used transformer oil as coolant oil in their welding plants. Transformer oil is a cheap substitute and is freely available. The reason given by the workers for using transformer oil as a coolant was that it was the only oil available to be used for this purpose. Transformer oil is removed from damaged or discarded transformers that are stockpiled in the Ceylon Electricity Board (CEB) yard. The frequency of filling the welding plant with transformer oil was done once a year or once in two years or even with a lesser frequency. No protective gear



were used by the workers during this operation which made it clear that exposure to and contamination from PCBs could be possible. All except one had no knowledge on health effects of PCB contaminated transformer oil.

Among the health problems reported by the workers, eye problems were the highest reported with Hyperopia (62.2%) and Myopia (18.9%) being the commonest eye problems. These two conditions are caused by visual defects in the eye. In the present sample 5.4% complained of redness of the eye while 8.1% complained of excessive tearing. These symptoms may be a result of eye irritation which is related to PCB exposure. However, this condition was not observed in the present sample of welders which may be related to their relatively high use of hand shields (97.3%) as protective gear.

Skin problems were also common in this sample of welders with 28.6% having skin rashes and 17.5% having discoloration of the skin. Skin rashes have been identified in the literature as a health effect of acute exposure to PCBs. The commonest site of the skin rash being the hands of the welders suggests chemical handling as the possible cause. According to the literature hyper pigmentation of the skin is also reported as a health problem of acute PCB exposure. In the present study 17.5% having hyper pigmentation of skin which was mainly distributed in the back and the neck regions may be a result of PCB exposure. Malignancies and liver disease were also two conditions that have been highlighted as health effects of PCBs in the literature (3). The present study however did not have the facilities to test for liver function due to resource constraints. Malignancies and clinical liver disease were not detected in the present sample which could be due to the 'healthy worker' bias where the diseased persons have left the employment. However, there was a high prevalence of anorexia (7.9%) and weight loss (11.1%) in the sample which could be due to undetected liver dysfunction or malignancies. The present study assessed pregnancy outcomes in the families of the 63 welders which revealed a still birth rate of 1.7% (95% CI 0 - 4.9) and an abortion rate of 6.8% (95% CI 0.6 - 13.0).

The present study identified developmental delays among 2.8% (95% CI 0 - 5.9) of the children of welders. The rate of congenital defects was 0.9% in the present sample and there were 4.7% who had current health problems which were identified as respiratory problems. According to these findings health effects PCB exposure among the children of the welders seems unlikely in this sample.

## 6 CONCLUSIONS AND RECOMMENDATIONS

### 6.1 Conclusions

This study clearly shows that transformer oil is used as coolant oil in welding plants. The possibility of exposure and self contamination among welders and cross contamination of their families



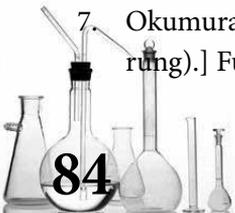
and the environment are high due to lack of knowledge on the properties and toxic effects of the PCB contaminated transformer oil. Poor personal hygiene practices and not wearing personal protective equipment during refilling of welding plants with coolant oil and during maintenance operations and incorrect storage and disposal of the oil may subject the workers, their families and the environment to exposure and contamination. The eye and skin problems being the commonest health problems seen among the participants could be due to PCB exposure. Substandard health, safety and welfare facilities prevailing in these work places contribute to the situation further.

## 6.2 Recommendations

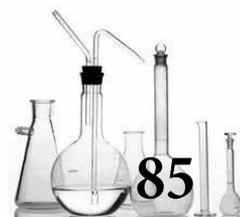
1. To compile an island-wide inventory of PCB equipment and equipment likely to contain PCB both in the formal and informal sectors and to label and register these equipment in order to indicate to those handling them their toxicity and specific control measures to be adopted.
2. Small and medium scale Industrial sector to be made aware of the issues related to PCBs. To conduct educational programmes to employees likely to handle PCB equipment and equipment likely to contain PCB, particularly in small and medium scale enterprises and those self employed in household businesses on toxicity, control use, protection and disposal.
3. Implement management actions identified in the National Implementation Plan under the Stockholm Convention on POPs for Sri Lanka prepared by the Persistent Organic Pollutants (POPs) Project, Ministry of Environment.
4. To adopt appropriate environmentally sound waste management systems for the use, storage and disposal of PCB equipment
5. To conduct cohort studies on occupational exposure to PCBs.

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ISSN 975-955-0438-02-4



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