Heavy metals in Tilapia *(Oreochromis sp)* from Padaviya and Huruluwewa reservoirs in Sri Lanka

P. Ekanayaka[1],C.Jayasinghe[1*] and R. Chandrajith[2]

[1]Department of Food Science & Technology, Faculty of Livestock Fisheries and Nurtition, Wayamba University of Sri Lanka, Makandura, Gonawila, Sri Lanka

[2]Department of Geology, Faculty of Science, University of Peradeniya, Peradeniya, Sri Lanka

Abstract

Incidence of chronic Kidney Disease of unknown etiology (CKDu) has significantly increased in the North Central Province (NCP) of Sri Lanka. Tilapia *(Oreochromis* sp*)* is one of the most common fish consumedin CKDu affected regions and is one of the main protein source of their regular diet. The consumption of freshwater fish contaminated with heavy metals isconsidered as a possible causative factor for the onset of CKDu. Scientific evidence of the heavy metal concentration in Tilapia need to be investigated in detail,as the CKDuis now becoming a national health issue in Sri Lanka. The aim of thisstudy was to determine the heavy metal concentration in fresh Tilapia collected from Padaviya and Huruluwewa reservoirs in the North Central Province. Scaled, degutted, washed Tilapia were freeze dried, microwave digested and samples analyzed for heavy metals by Inductively Coupled Plasma Mass Spectrometry (ICP-MS). Dietary essential metals, Fe (16 – 11 mg/kg), Zn (13 – 16 mg/kg), Mn (2.3 mg/kg –1.0 mg/kg) concentrations were higher in raw Tilapia from both Padaviya and Huruluwewa reservoirscompared with other metals elements Cr, Co, Ni, Cu, As, Mo, Ag, Cd, Hg and Pb studied. Toxic heavy metals, Pb, Hg, Cd and As concentrations in Tilapia from Padaviya reservoir were 152 µg/kg, 42 µg/kg, 11 µg/kg and 6.6 µg/kg, respectively, compared with 111 µg/kg, 86 µg/kg, 8.8 µg/kg and 0.66 µg/kg of the above elements from Tilapia from the Huruluwewa reservoir. Mn, Co and Cd concentrations were significantly ($P < 0.05$) higher in Tilapia caught from Padaviya compared to Huruluwewa. All the above values are significantly lower than the FAO recommended limits for fish. Results conclude that Tilapia from Padaviya and Huruluwewa reservoirs do not possestoxic levels ofheavy metals. However, periodical studies are further needed.

Keywords: chronic kidney disease, heavy metals, inductively coupled plasma mass spectrometry

---

**Corresponding author:cvljayasinghe@gmail.com*

Introduction

Fish may contain heavy metals in hgh concentrations when the aquatic environment is contaminated. Metals can enter the body via the food chain and causes evere damage to humans when the concentration reaches a toxicological thresholds. Lead (Pb), cadmium (Cd), arsenic (As) and mercury (Hg) are considered as non-essential since such elements are not involved with any functionalities of the human body but can cause harmful effects (Andre *et al.* 2005). Cobalt (Co), copper (Cu), manganese (Mn), molybdenum, iron (Fe) and zinc (Zn) are essential nutrients for humans but becometoxic if ingested in large quantities (Silva and Shimizu, 2004).

Tilapia (*Oreochromis* sp)is one of the important fish in the inland fish production of Sri Lanka and account for 58.4 % of the reservoir fishery catches (MOFAR, 2014). Bioaccumulation of heavy metals in Tilapia (*Oreochromis* sp) which is the uptake and sequestration of contaminants by an organisms from their ambient environment has become a great concern

worldwide as freshwater resources are becoming increasingly polluted (Suhaimi *et al.* 2006). The NCP contributed approximately 37 % of the total inland fish production (NARA, 2009).

Recently, Chronic Kidney Disease of unknown etiology (CKDu) has been reported extensively in the NCP of Sri Lanka especially in the Anuradhapura district. Consumption of Tilapia that is contaminated with heavy metals (especially Cd) was considered as a significant factor in the aetiology of the CKDu, the incidence of which reached a peak in Anuradhapura in last few years and most cases were from the Padaviya, Medawachchiya and Kebithigollewa divisional areas (Bandara *et al.* 2010; Jinadasa *et al.* 2013). This focus of this study was to investigate the heavy metal concentration in Tilapia in the Padaviya and Huruluwewa reservoirs and compare these levels with the FAO standards.

Materials and methods

Tilapia samples (whole fish N = 28) with same growth similar size (Total length 218 ± 4.9 mm, Standard length 189 ± 7.4 mm) and similar weight (203 ± 8.0 g) were collected from the Padaviya and Huruluwew areservoirs. Tilapia samples were scaled, degutted, sliced using a plastic dissecting tool and washed with deionized water to remove extraneous matters. Samples were homogenized to obtain a mince. 10 g of each mince was kept in sterile vials containers, labeled and died in a in freeze dryer (Alpha i-2 LD Plus, Germany) for 48 hours, and digested using accelerated microwave system (Mars 6, CEM, Matthews, USA). The digested samples were analyzed using inductively coupled plasma mass spectrophotometer (Thermo Scientific iCAPQc, Bremen, Germany) against aqueous standards. Discriptive analyses were carried out with MS Excel 2007 and SPSS 13.0.

Results

Thirteen heavy metals; Fe, Zn, Mn, Cr, Co, Ni, Cu, As, Mo, Ag, Cd, Hg and Pb were detected. Dietary essential metals, Fe (16 – 11 mg/kg), Zn (13 – 16 mg/kg), Mn (2.3-1.0 mg/kg) concentrations were higher in raw Tilapia caught from both reservoirs compared with other metals elements. Toxic heavy metals, Pb, Hg, Cd and As concentrations in Tilapia from Padaviya reservoir were 152 µg/kg, 42 µg/kg, 11 µg/kg and 6.6 µg/kg, respectively, compared with 111 µg/kg, 86 µg/kg, 8.8 µg/kg and 0.66 µg/kg of the above elements from Tilapia from the Huruluwewa . The order of metal element accumulation in Tilapia in Padaviya reservoir was Fe>Zn>Mn>Cu>Cr>Ni>Pb>Co>Mo>Hg>Ag>Cd>As while Huruluweva reservoir was Zn>Fe>Mn>Ni>Cu>Cr>>Pb>Hg>Co>Mo>Ag>As>Cd.

Table 1. Heavy metal concentration of Tilapia in Padaviya and Huruluweva reservoirs.

	Concentration (µg/kg)		P Value
	Padaviya	Huruluwewa	
Cr	454 ± 58	430 ± 195	0.917
Mn	2281 ± 201	955 ± 20	0.022
Fe	16467 ± 1756	11401 ± 746	0.117
Co	10 1± 9	58 ± 5.5	0.05
Ni	330±90	654 ± 255	0.353
Cu	657±47	566 ± 32	0.251
Zn	13674 ± 3180	16415 ± 464	0.483
As	12.8±0.7	8.8 ± 0.7	0.096
Mo	74 ± 4	42.4 ± 20.3	0.268
Cd	17.5 ± 2.5	0.7 ± 0.6	0.024
Hg	42 ± 7	86 ± 3 0	0.283
Pb	152 ± 28	110 ± 8	0.296

Mean concentrations of HM ± SE. n = 2 ($P < 0.05$)

Discussion

Each selected sampling site has been received different types of pollutants from different sources of pollution. When selecting the sampling sites for this study following criteria were considered; size of the reservoir, degree of anthropogenic activities related to the reservoir and reported CKDu patients in the area and fish consumption degree of that areas. Both reservoirs were large scale reservoirs, which covers lager area for the agricultural practices by irrigating. Anthropogenic activities of both areas were the same in general. But specially, degree of kidney disease patients reported was different in both catchment areas. According to Dr. Asanga Ranasinghe, Director of the Provincial Renal Disease Prevention Unit of Anuradhapura General Hospital, around 17,000 people who have been affected with CKDu were reported in the North Central province by the end of 2013 and the province's monthly death rate average as of the end of 2013 due to renal failure was 19. Especially in Padaviya area 2653 patients were recorded which high risk is and in Huruluwewa reservoir area recorded numbers of patients were 274 which is low risk.

Cu, Fe and Zn are essential elements and are regulated by physiological mechanisms in most organisms. However, they show toxic effects when organisms are exposed to levels higher than normally required (Biney *et al.* 1994). In this study, Fe concentration in Padaviya reservoir raw fish is between 14.7-18.2 mg/kg and Fe concentration in Huruluwewa reservoir fish is between 10.6-12.2 mg/kg.But there is no significant difference between Fe concentration in both reservoirs ($P > 0.05$).

Non-essential heavy metals such as Pb, Hg, As and Cd cab be accumulated in fish tissues and is harmful to human health even in trace level. The accumulation of Pb in the edible muscle of Tilapia fish collected from Padaviya and Huruluwewa reservoirs ranged from 124 µg/k to 180

µg/kg and from 102 µg/kg to 119 µg/kg, respectively. The accumulation of Pb was not significantly different (P > 0.00) between the two reservoirs.

Conclusion

Most toxic heavy metal concentrations in the Tilapia were in the order of Pb>Hg >Cd>As in the Padaviya reservoir and Pb> Hg>As>Cd in the Huruluwewa. These levels are below the FAO standards. Based on the heavy metal concentrations, the consumption of Tilapia from these reservoirs do not pose a threat to human health.

References

Andre, L.O.D.S., Paulo, R.G.B., Silvana, D.J., and Josino, C.M. 2005. Dietary intake and health effects of selected toxic elements. *Brazilian journal of plant physiology,* **17:** 79-93.

Bandara, J. M. R. S., Senevirathna, D. M. A. N., Dasanayake, D. M. R. S. B., Herath, V., Bandara, J.M. R. P., Abeysekara, T. and Rajapaksha, K. H. 2010. Chronic renal failure among farm families in cascade irrigation systems in Sri Lanka associated with elevated dietary cadmium levels in rice and freshwater fish (Tilapia). *Environmental Geochemistry and Health*, **30(5):** 465–478

Biney, C.A., Calamari, A.T.D., Kaba, N., Naeve, H. & Saad, M.A.H. 1994. Review of Heavy metals in the African Aquatic Environment. *Ecotoxicology and Environmental Safety*. **28**: 134-159.

NARA. 2009. Sri Lanka fisheries yearbook, Colombo, Sri Lanka: NARA.

Silva, E.I.L. and Shimizu, A. 2004. Concentrations of Trace Metals in the Flesh of Nine Fish Species Found in a hydropower reservoir in Sri Lanka. *Asian Fisheries Science.***17**: 377-384.

MOFAR. 2014. Fisheries statistics. Colombo: Ministry of Fisheries and Aquatic Resources, Sri Lanka.

Jinadasa, B., Subasinghe, M., Thayalan, K., Wickramasinghe, I., and de Silva, M., 2013. Trace Metal Contents in Muscle Tissues of Inland Fish Species in the North central Province of Sri Lanka. *Ceylon Journal of Science (Bio. Sci.),* ***42*****(2):**79 - 86.

Suhaimi, F., Wong, S.P., Lee, V. L. L., and Low, L. K. 2006. Heavy metals in fish and shellfish found in local wet markets. *SingaporeJournal of Primaryl industries*, **32:** 1-18.