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Bioaccumulation of Trace Metals in *Cyprinus carpio* (Common Carp) from Bomuruella Reservoir, Nuwara-Eliya

N. D. Hettige[1, #], K. A. W. S. Weerasekara[1], S. A. M. Azmy[1], W. D. N. Wickramarachchi[1] and B. K. K. K. Jinadasa[2]

[1]Environmental Studies Division,
National Aquatic Resource Research and Development Agency (NARA),
Crow Island, Colombo 15, Sri Lanka

[2]Institute of Post-Harvest Technology,
National Aquatic Resource Research and Development Agency,
Colombo 15, Sri Lanka

[#] Corresponding Author:
Email: nadeeshahettige7@gmail.com

ABSTRACT

Currently, an aquatic ecosystem of Sri Lanka is faced with acute environmental problems due to trace metal pollution. Bomburuella is one of reservoirs situated in Nuwara-Eliya District, Sri Lanka. Trace metal pollution of this reservoir has taking placed due to various anthropogenic activities. Therefore, it is very important to determine the cause for bioaccumulation of trace metals in fish tissues. The aim of this study was to determine the levels of selected trace metals in the tissues of fish species (Cyprinus carpio/Common Carp). Samples were analyzed using Atomic Absorption Spectroscopy (AAS) to determine selected trace metals namely mercury (Hg), lead (Pb) and cadmium (Cd). Results revealed that, the mean concentration of trace metal namely Hg, Pb and Cd recorded as 0.56 ± 0.15 mg/kg, <Limit of Detection (LOD) and 0.03 ± 0.00 mg/kg whereas Hg and Cd concentration of the fish sample in the reservoir were ranging from 0.44 to 0.73 mg/kg and 0.02 to 0.03 mg/kg respectively. However concentration of Pb was less than limits of detection (0.52 mg/kg). The detected average concentration of Cd in fish tissue was below the standard limits (<0.05 mg/kg) defined by European Union for (Commission Regulation (EC) No 1881/2006 of 19 December 2006) and lower regulations made by the ministry of Fisheries & Aquatic Resource in Sri Lanka (fish product export regulation No 1528/7, 2007 in Fisheries and Aquatic Resource Act, No 2 of 1996). However, concentration of Hg was above the standard limits (>0.50 mg/kg).

KEYWORDS: *Anthropogenic and aquatic, Cyprinus carpio, Pollution*

Introduction

Pollution of the aquatic environment by inorganic chemicals has been considered a major threat to the aquatic organisms including fishes (Akan *et al.*, 2012).

Contaminations of trace metals in inland water bodies can be determined using the metal levels in water; sediments and resident biota especially using fish species (Senarathne and Pathirathne, 2007). Currently, trace metal pollution in aquatic ecosystems is one of the growing problems worldwide and it has been increasing at an alarming rate (Ogoyi *et al.*, 2011). Therefore, it is necessary to identify proper mitigation measures in order to reduce the threats that it may impose on the health of ecosystems.

Metals, including trace metals occur in small amount naturally in water bodies. In addition, trace metals are released into aquatic environment through naturally processes and anthropogenic activities. However, anthropogenic activities have led to increased contamination of the environment due to the use of toxic metals in industrial processes. Trace metals such as Hg and Cd can be categorized as non-essential metals that are toxic to animals and human even at very low concentrations (Wright and Welbourn, 2002). However, trace metal such as Pb is included in between essentials and non-essentials metals (Valavanidis and Vlachogianni, 2012).

Accumulation of trace metals in fish species in aquatic ecosystem is a serious problem which earns more attention due to their toxicity. Brahmbhatt *et al.*, (2012) stated that, "Bioaccumulation" is a process which accumulates metal by living cells which is dependent on the metabolic activity of the cell. Bioaccumulation of trace metals can affect the whole food chain resulting high concentration in fish that could affect the human health. As such the fish in water bodies can be used as bio indicators for assessing pollution levels (Desta *et al.*, 2012).

Bomburuella is one of reservoirs situated in Nuwara-Eliya District; Sri Lanka and it act as a very important water resource for various purposes namely fishing, agricultural activities, drinking, cleaning and washing purposes by those who live in the surrounding area and in the downstream area. However, Jayasinghe *et al.*, 2011 stated that, deterioration of this reservoir has taking placed due to some anthropogenic activities.

Since distribution of the marine fish for the people live in the hill country is poor it is necessary to develop inland fishing industry to cater their protein demand. However, the prevailing water pollution condition may bring some negative effect on the fish yield of the reservoir and the contaminated fish may harmful to people of all ages. Studies on bioaccumulation of trace metals in inland fishes in different water bodies have been done by many researches in Sri Lanka. However, there is lack of research studies on heavy metal accumulation in fishes in Bomburuella reservoir. Therefore, it is very important to determine the trace metals concentration in the fishes to study the bioaccumulation.

The aim of this study was to determine the levels of selected trace metals namely Hg, Pb and Cd in the tissues of fish species (*Cyprinus carpio/* Common Carp).

Methodology

The Study Area

Bomuruella Reservoir (Latitude 06°57'N; Longitude 80°48'E) in Nuwara-Eliya District in the Central Province of Sri Lanka was chosen for this study (Figure 1).

Figure 1: Map of Bomuruella reservoir

The reservoir covers approximately an area of 14.6 ha. Major land use types in the reservoir catchment area were identified as 58% of intermediate zone with secondary forest , 27% of scrub land, 6% of land use for crop land is and 9% of tea cultivation.

Sample Analysis

Fish samples were collected from Bomburuella reservoir with the help of local fishermen for the three month period from March to June 2014. After collection, total length, standard length and total weight of the fish were recorded. Fish samples were packed in polythene bags in an insulated box with crushed ice and transported to the laboratory.

All the glassware and plastic ware were cleaned following standards procedures. Muscle of fish sample was separated using dissecting kit and it was measured as initial weight. Then it was dried to constant weight at 105 °C. Dried sample was ground, using porcelain mortar and a pestle.

The ground fish tissue sample was digested with conc. HNO3 (65%, AR). The samples were boiled slowly and then evaporated on a hot plate in a fume hood chamber. Digestion was continued until the liquor becomes clear. Digested sample was diluted to 100 mL volumetric flask with deionized water. Vapor generation accessory (Varian VGA 77) with closed end cell was used for Hg determination. Spectra AA Varian atomic absorption spectrometer (AAS-240 FS) from Varian with graphite tube atomizer (GTA - 120) was used for Cd and Pb determination.

The accuracy of the analytical procedure was continued throughout the analysis period by following ways. Total Hg, Cd, and spiked samples (for Pb) were routinely treated and analyzed in the same manner as the samples, using certified quality control material (canned fish muscle, T/07194 and canned crab meat, T/07192QC) from Food Analysis Performance Assessment Scheme (FAPAS, Sand Hutton, York, UK) (Table 1). The analytical chemical laboratory at NARA has participated in the proficiency testing programme of the FAPAS for total Hg and Cd within the same period, with satisfactory results (the Z value for Hg; 0.0, and Cd; - 0.3), Proficiency Testing Report 07215, July - Aug. 2014. The limit of detection (LOD) was evaluated using an average field blank, derived from sample field blanks, and three times its standards deviation. The limit of quantification (LOQ) was 3 × LOD.

Table 1: Quality control material for selected trace metals

	Metal	**Hg (µg/kg)**	**Cd(µg/kg)**	**Pb (µg/kg)**
T - 07192QC	Assign value	95.68	5.62	-
	Determined value	94.47 ± 14.05	5.9 ± 1.02	-
	% recovery	98.73	101.40	
T - 07194QC	Assign value	141	4.99	-
	Determined value	155 ± 17.2	5.5 ± 0.7	-
	% recovery	110.07	110.22	-
Spiked sample	% recovery	-	-	86.57

Data analysis was conducted using the Microsoft Excel 2007 version.

Results and Discussion

Fish sample (*Cyprinus carpio*) use to analyze was shown in Figure 2.

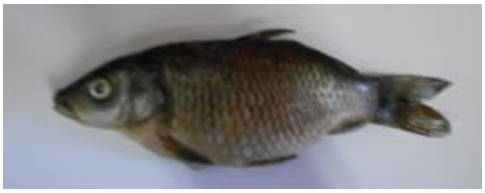

Figure 2: Fish sample (*Cyprinus carpio*)

Average total length, standard length, and total weight of fish samples are shown in Table 2, whereas Table 3 indicates the concentration of trace metals in fish tissues.

Table 2: Average total length, standard length and total weight of fish sample (*Cyprinus carpio*)

Description	Min	Max	Average (± SD)
Total length (cm)	13.00	21.00	16.00 ± 4.36
Standard length (cm)	9.50	16.50	12.33 ± 3.69
Weight (g)	13.20	135.06	62.8 ± 63.97

Table 3: Concentration of trace metals in analysed fish tissues

	Minimum	Maximum	Average (± SD)	Limit of Detection (LOD)
Hg (mg/kg)	0.44	0.73	0.56 ± 0.15	0.07
Pb (mg/kg)	< LOD	< LOD	< LOD	0.52
Cd (mg/kg)	0.02	0.03	0.03 ± 0.00	0.0063

Age of fish, lipid content in the tissue and mode of feeding are affected to the accumulation of trace metals in fishes and the discharge of industrial wastes containing toxic trace metals into water bodies may have significant effects on aquatic organisms including fishes (Eneji *et al.*, 2011). Therefore, these factors would be reasons for the concentration of trace metals in fishes.

The mean concentration of trace metal namely Hg, Pb and Cd recorded as 0.56 ± 0.15 mg/kg, less than LOD and 0.03 ± 0.00 mg/kg whereas Hg and Cd concentration of the fish sample in the reservoir were ranging from 0.44 to 0.73 mg/kg and 0.02 to 0.03 mg/kg respectively. However concentration of Pb was less than the limits of detection. Trace metal concentrations in Fish tissues were decreased in the sequence Hg > Cd.

Lead is a non-essential element and it can be accumulated in higher concentrations in aquatic organisms due to discharge of industrial, sewage and agricultural wastes (Nzeve *et al.*, 2014). Metal pollution from mercury Hg can be happened due to natural and anthropogenic activities. Up to 150 tons of Hg are released because of degassing from the earth's crust and 8 -10 tones from industrial and urban activities (Valavanidis and Vlachogianni, 2012). Cadmium is released to an aquatic ecosystem due to discharge of batteries and other electronics, fertilizers and plastics etc (Naeve, 1994).

Composition of Municipal Solid Waste (MSW) in Nuwara-Eliya city is consisted with short-term biodegradable and long term biodegradable. According to the findings of Wijewardane *et al.*, (2012), `Moon plains' engineered landfill site which belongs to Nuwara-Eliya municipal council (MC) which receives approximately 22 tons of waste per day.

According to the literature review (Jayasinghe *et al.*, 2011) and the discussions made with the people of the vicinity, it is possible to leachate trace metals from the landfill, which is located above the reservoir and also through treatment outlet of the landfill which is directly connected to the reservoir. Further, there is a possibility to contaminate reservoir water with clinical waste dumping from Nuwara Eliya hospital to the vicinity of the reservoir.

Therefore these sources could be considered as most possible reason for the addition of trace metals to the reservoir. Bioaccumulation of trace metals in fishes through food chain has become a matter of great concern in public health.

Results revealed that, average concentration of Cd in fish tissues were below the standard limits (<0.05 mg/kg) defined by European Union (EU) for (Commission Regulation (EC) No 1881/2006 of 19 December 2006) and lower regulations made by the ministry of Fisheries & Aquatic Resource in Sri Lanka (fish product export regulation No 1528/7, 2007 in Fisheries and Aquatic Resource Act, No 2 of 1996). However, concentration of Hg was above the standard limits (>0.50 mg/kg) refer to the above standards.

Mercury increases in fish through the food chain by consuming small plankton and through nonfood source such as underwater sediments. Fish concentrate Hg in their bodies, often in the form of methyl mercury, which has been identified as highly toxic organic compound. If these food sources are utilized by fishes, there is a possibility of bioaccumulation and finally to cause negative impacts on human health. This toxic compound in fish can be created health issues for pregnant women, nursing mothers and young children (Stokes and Wren, 1987).

Conclusions

The detected average concentration of Cd in fish tissue was below the standard limits (<0.05 mg/kg) defined by European Union (2006) and lower regulations made by the ministry of Fisheries & Aquatic Resource in Sri Lanka (fish product export regulation No 1528/7,2007 in Fisheries and Aquatic Resource Act, No 2 of 1996). An average concentration of Hg in fish tissue was above the standard limits (>0.50 mg/kg) refer to the above standards.

Hence, it can be concluded that these metals could have negatively impact on the health of consumers of fish from Bomburuella reservoir.

Recommendations

Proper monitoring programs should be initiated for identification of water pollutant sources. Rules and regulations should be implemented to minimize the pollution from anthropogenic activities. Further studies in space and time are also suggested to obtain clear picture of the bioaccumulation of trace metals in the reservoir.

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