Evaluation of Heavy metal contamination in Water, Sediment and Fish (*Mystus gulio*) from Vattakkayal, a part of Ashtamudi Lake, South India

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ABSTRACT

The major objective of the present study is to investigate the accumulation of heavy metals (iron, copper, chromium, cadmium and lead) in water, sediment and in the fish Mystus gulio from Vattakkayal, a part of Astamudi lake, the Ramsar site in Kerala. The results obtained showed that the metals Fe, Cu, and Cr were accumulated in fish at high concentration than those accumulated in water, while the concentration of metals Cd and Pb were recorded low values. Bio-concentration Factor (BCF) of heavy metals in sediments were determined and found that Fe, Cr, Cu and Pb were accumulated at higher concentration than Cd. The concentration of heavy metals in the Vattakkayal exceeds the WHO maximum standard permissible limits. The presence of increased amounts of heavy metals in the water body may have a direct impact on the health of humans as well as aquatic animals. If this lake is not protected from this hazardous situation, the lake as well as the dependent living organisms will be subjected to heavy metal toxicity. Hence it is recommended to implement necessary legislative measures by the authorities to conserve Vattakayal, the part of the Ashtamudi lake, one of the Ramsar sites.

***Key words*:** *Bio-concentration factor, Fish, Heavy metal, Pollution, Vattakkayal*

1. INTRODUCTION

Water is one of the most valuable natural resources. The biological and toxic roles of metals have been studied extensively in recent years. Fishes accumulate toxic chemicals such as heavy metals directly from water; diet and contaminant residues may eventually reach and accumulate in fish body. When larger animals feed on these contaminated organisms, the toxins are taken into their bodies, moving up the food chain with increasing concentrations in a process known as biomagnification[1].

If the water is polluted with heavy metals, fish growth may be inhibited. Inhibition of growth is one of the most distinct symptoms of toxication of metals on fish larvae. Heavy metals in water are particularly dangerous for fish juveniles and may considerably reduce the size of fish populations or even cause extinction of entire fish population in polluted reservoirs. Heavy metals reduce survival and growth of fish larvae[2]. They also cause behavioral anomalies such as impaired locomotors performance resulting in increased susceptibility to predators or structural damages. A study on the heavy metal pollution in fish is a direct indicator on the quality of food and availability of fishes in future respectively. The major objective of the present work is to investigate the accumulation of heavy metals (iron, copper, chromium, cadmium and lead) in water, sediment and muscle tissue of the fish *Mystus gulio* from Vattakkayal, a part of Astamudi lake.

2. MATERIALS AND METHODS

2.1 Study Area

Vattakkayal, a part of Ashtamudi lake in Kollam district, Kerala, South India is selected as the study area. Vattakkayal is located at 8°55'3" North latitude and 76°32'57" East longitude, and is about 9 kms away from Kollam Railway Station and located in the Sakthikulangara Panchayat. The Vattakkayal occupies an area of about 37 acres. The existing land use of the area consists of water bodies surrounded by marshy vacant land. Previously this low lying vacant land was used for paddy cultivation and the water body is enriched with fishes and aquatic life in abundance. At present this kayal is with weeds like water hyacinth as the water body receives nutrients due to the disposal of domestic wastes, drainage water, wastes from nearby factories etc. and is also subjected to many ecological problems. The Vattakkayal also get polluted with waste water discharged from neighboring fish processing unit, ice plants and freezing plants entering into it through a channel of Kattakkal kayal connected to it.

2.2 Collection

Water, sediment and the fish samples were collected from five selected stations of Vattakkayal in the pre monsoon, monsoon and post monsoon seasons during the period February 2013 to January 2014 for estimating the heavy metals residues. Water, sediment and fish samples were collected during pre monsoon, monsoon, and post monsoon seasons in cleaned and dried plastic bottles for the analysis of heavy metals Fe, Cr, Cu, Cd and Pb. The fish species, *Mystus gulio* of uniform length were also collected in different seasons and were transported in ice box to the laboratory, where samples of muscle tissue taken were sorted for analysis.

2.3 Methodology

The concentrations of heavy metals in the acid digested water, sediment and muscle samples were determined following standard procedures[3,4,5] using Atomic Absorption Spectrophotometer (Thermo Electron Corporation, S. Series AA Spectrometer with Gravities furnace, UK). The concentration of heavy metals in water was expressed as mg/l, for sediments and fish muscle as mg kg^{-1}.

2.3.1 Bioconcentration Factor

Bioconcentration Factor (BCF) was calculated using the formula,

$$BCF = CB/CW,$$

Where, CB = Chemical concentration in organism/sediment; CW = Chemical concentration in water (mass of chemical/L), CB usually expressed in units of mass of chemical per kg of organism[6].

3. RESULTS

The results of heavy metal content in water are given in Table 1. The concentration of heavy metal in water sample during the three seasons studied ranged from 0.01 to 4.641 mg l^{-1} lead, 0. 22 to1.124 mg l^{-1} cadmium, 0.08 to 0.45 mg l^{-1} copper, 1.17-13.84 mg l^{-1} iron and 1.17 to 13.84 mg l^{-1} chromium. Mean value for heavy metal concentrations in water is in the order: Fe > Pb > Cr > Cd > Cu in pre monsoon, Fe > Cd >Pb > Cu > Cr in monsoon and Fe > Pb > Cd > Cr > Cu in post monsoon season.

Table 1: Heavy metal content in water samples (Data were presented in table as mean± SD of five samples)

Heavy metals	Pre monsoon	Monsoon	Post monsoon
Iron (mg l^{-1})	8.24±3.20	2.17±1.00	5.36±2.45
Lead (mg l^{-1})	4.37±0.18	0.19±0.06	1.72±1.36
Chromium (mg l^{-1})	0.93±0.22	0.03±0.04	0.77±0.27
Copper (mg l^{-1})	0.25±0.10	0.14±0.09	0.31±0.16
Cadmium (mg l^{-1})	0.73±0.30	0.24±0.01	0.88±0.30

The concentration of heavy metals Fe, Pb Cr, Cu and Cd in sediments are given in Table 2. The sediment analysis showed that the values of lead ranged from 2.3 to 32.82 mg kg^{-1}; cadmium, from 1.32 mg $kg^{-1}$to 13.75 mg kg^{-1}, copper from 0.54 mg kg^{-1} to 6.99 mg kg^{-1}, iron from 50.25 mg kg^{-1} to 3865 mg kg^{-1} and chromium from 7.1 mg $kg^{-1}$to 44.05 mg kg^{-1}. Mean value for heavy metal concentrations in the lake sediments is in the sequence: Fe > Pb> Cr > Cd > Cu in pre monsoon, Fe > Cr > Pb> Cd> Cu > in monsoon, and Fe > Cr> Pb > Cd > Cu Cd >in post monsoon season.

Table 2: Heavy metal content in sediment samples (Data were presented in table as mean± SD of five samples)

Heavy metals	Pre monsoon	Monsoon	Post monsoon
Iron (mg kg^{-1})	955.75±1096.49	1388.15±1415.37	151.43±115.51
Lead (mg kg^{-1})	24.96±7.78	12.5±9.64	13.47±9.41
Chromium (mg kg^{-1})	23.22±5.08	23.675±14.37	28.11±13.19
Copper (mg kg^{-1})	2.994±2.54	2.3335±1.44	3.2095±2.08
Cadmium (mg kg^{-1})	10.615±7.13	7.855±10.01	1.855±1.11

Analysis of heavy metal residues in the muscles of *Mystus gulio* showed that lead content ranged from 0.5 mg kg^{-1} to 1.3 mg kg^{-1}, cadmium content ranged from 0.2 mg kg^{-1} to 1.5 mg kg^{-1}, copper content ranged from 0.4 - 2.2 mg kg^{-1}, iron content ranged from 26 - 116 mg kg^{-1} and chromium content ranged from 0.2- 3.1 mg kg^{-1}. Heavy metal concentrations in the muscles were in the order: Fe > Cr > Cu > Pb> Cd during pre monsoon, Fe > Pb Cu > Cr =Cd during monsoon, and Fe >Pb =Cu > Cr>Cd during post monsoon season.

Table 3: Heavy metal content in fish muscle tissue (Data were presented in table as mean± SD of five samples)

Heavy metals	Pre monsoon	Monsoon	Post monsoon
Iron (mg kg^{-1})	116.6±0.12	26±0.02	45.6±0.33
Lead (mg kg^{-1})	1.3±0.05	0.5±0.24	0.7±0.12
Chromium (mg kg^{-1})	3.1±0.22	0.2±0.31	0.5±0.23
Copper (mg kg^{-1})	2.2±0.24	0.4±0.11	0.7±0.24
Cadmium (mg kg^{-1})	0.5±0.02	0.2±0.12	0.3±0.23

Bioconcentration Factor

The accumulation pattern of heavy metals in sediment and fish organs were determined based on the Bio-concentration Factor, and the BCF values determined are given in Table 4. Bio-concentration Factor (BCF) in fish refers to the uptake of metals from water *via* respiratory surface and or skin. The results obtained showed that, the metals Fe, Cu, and Cr were accumulated in fish at high concentration than those accumulated in water. The metals Cd and Pb recorded low values. Bio concentration Factor (BCF) in sediment showed that Fe, Cr Cu and Pb were accumulated at higher concentration than Cd.

Table 4: Bio concentration factor of sediment and fish collected from Vattakkayal (Values are mean ± SD)

Heavy metals	Mean value of heavy metal concentration			Bio concentration factor	
	Water(mg l^{-1})	Sediment (mg kg^{-1})	Fish(mg kg^{-1})	Sediment	Fish
Iron	5.26±3.9	831.77±108	62.73±47.66	158.09	11.92
Lead	2.09±1.93	31.85±68.95	0.83±0.41	8.-9	0.39
Chromium	0.58±044	40±59.12	1.26±1.59	42.93	2.16
Copper	0.23±1.35	2.84±15.9	1.1±.96	11.96	4.62
Cadmium	0.624±0.36	6.77±7.60	0.33±0.15	10.84	0.52

4. DISCUSSION

Heavy metals are non-biodegradable metals and do not break down in the environment. Fish may easily absorb pollutants from the ambient water and deposit them in the tissue through the process of bio-accumulation, this may lead to chronic and acute diseases. Fish surviving at highly polluted areas accumulate higher levels of heavy metals than those surviving in less polluted areas of the same lake[7].

In the present study the presence of heavy metals in the muscle of fishes from the Vattakkayal showed that it is accumulating in the body of fishes from the pollutants getting in the water body by different anthropogenic activities

like waste water disposal from nearby hotels, domestic activities. The maximum permissible concentration of lead, copper and iron in water according to WHO standards[8] is 0.1 mg l^{-1}; whereas for chromium is 0.01 mg l^{-1} and for cadmium is 0.005 mg l^{-1}. All the heavy metals determined in water showed high values than the standard permissible limits except for copper, which was within the standard limit.

The highest level of iron was found in the tissues of *M. gulio* and it may be due to the presence of various organic and inorganic compounds present in the water body. Heavy metal concentration in muscle tissues of various fishes were reported earlier by several investigators [9,10,11]. Heavy metals concentration in the muscle tissue of *M. gulio* was higher than that in water and sediments, and the results are in agreement with the previous studies on heavy metals in fishes reported by many authors[12,13,14].

Fishes are considered as bio-monitors of aquatic ecosystem for estimation of heavy metal pollution and risk potential for human consumption[15]. Heavy metal pollution in water bodies has become a matter of great concern over the last few decades, not only because of the threat to public water supplies, but also the hazards to human consumption of fishery resources. Heavy metal contamination in water and its uptake by fishes is a direct consequence of urban and industrial pollution[16]. Previous studies by Seethal *et al.*[17] also showed deterioration of fish diversity in Vattakayal, apart of Ashtamudi lake.

Bioconcentration Factor (BCF) in sediment showed that Fe, Cr Cu and Pb were accumulated at higher concentration than Cd. It is known that sediment is a sink of contaminants particularly heavy metals which entered aquatic ecosystem. Bio-concentration factor of sediment and fish showed that the heavy metals are accumulated in sediment and fish at a higher rate than water. The results obtained showed that, the metals Fe, Cu, and Cr were accumulated in fish at high concentration than those accumulated in water. The metals Cd and Pb recorded low values. This could be explained by the fact that, iron and copper are essential elements in the bodies of living organisms and has an important role in different physiological processes. The bioaccumulation might be attributed to the different uptake, metabolism and detoxification of metals in fish[18].

5. CONCLUSION

The study revealed that the water, sediments and fishes of Vattakayal were contaminated with heavy metals Fe, Cr, Cu, Cd and Pb. The presence of increased amounts of heavy metals in the water and sediments of Vattakayal may have a direct impact on the health of aquatic animals as well as of humans. The fish species, *Mystus Gulio* are highly delicious, and have great demand in the market. The main consumers of these fishes are the local residents of this region. Consumption of the fishes intoxicated with heavy metals by human beings may cause accumulation of the toxic metals like cadmium, chromium and lead in human organs through the process of bioaccumulation. It will create severe health hazards to human beings. Also, a potential deterioration of the water quality will be in future, depending on the increasing anthropogenic activities and agricultural development in this region. The study recommends for the implementation of necessary legislative measures by the authorities to conserve Vattakayal, the part of the Ashtamudi lake, one of the Ramsar sites.

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