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Assessment of heavy metal contamination in three aquaculture fish ponds of urban Kolkata, West-Bengal, India

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Abstract
Water is an important component of living organisms, especially for human beings. This study assessed the metal qualities of three fish ponds in urban Kolkata, West-Bengal between January 2014 to June 2014 with a view to determine the level of contamination of Copper (Cu), Lead (Pb), Cadmium (Cd) and Zinc (Zn) elements in the pond water. It was performed for the water samples by using atomic absorption spectro-photometery (AAS). The average metal concentration was found to be higher in P-3 in comparison to other two ponds P-1 and P-2 This indicates the poor water quality of P-3 in comparison to other ponds. It is a well known fact that the heavy metal ions are potentially toxic to human health as and could be quite detrimental for human life. This study suggests the preventive measures which are to be adopted to control this heavy metal contamination in three aquaculture fish Ponds of urban Kolkata, West-Bengal, India.

Keywords: urban ponds, heavy metal, contamination, aquaculture fish ponds, Kolkata

1. Introduction
Environmental contamination is one of the most important factors responsible for the degradation of surface environments, and heavy metals play a dominant role in this degradation. Pollution of the aquatic environment with heavy metals has become a worldwide problem in recent years. Because heavy metals are the toxic, persistent, non biodegradable and indestructible and most have a toxic effect on organisms (MacFarlane and Burchette, 2000 [19]. Heavy metals are intrinsic, natural constituents of our environment and the term "heavy metals" refers to any metallic elements that have relatively high density and are toxic or poisonous even at low concentration Lenntech (2004) [17]. Heavy metals include Lead (Pb), Cadmium (Cd), Zinc (Zn), Mercury (Hg), Arsenic (As), Silver (Ag), Chromium (Cr), Copper (Cu), Iron (Fe) and the platinum group elements. Heavy metals consists of both essential and non- essential elements and they are known to be of particular significance in ecotoxicology. Some of them such as Fe, Zn, Cu Cr, Ni are essential nutrients required in small amounts for enzymatic biochemical activities (Buss and Robertson, 1976)[9],while others such as Cd, Hg, Pb are potential poisons not even required in small amount but have valuable industrial applications with resultant effect on the environment if not controlled (Owolabi,1992) [22]. However, all metals are toxic if the exposure level is sufficiently high to exceed the tolerance level (Dowdeswell, 1996) [11]. There is no life without water; water is most necessary resources of the all biological lives and their nutrition too. Water quality has become a most important global problem due to increasing human developmental actions. Water pollution is a severe problem as almost 75% of India's surface water resources have been polluted by biological and chemical. Increasing human population and their activities creates more pressure on the provision of safe drinking water especially in developing nations **(**Pattanaik *et al.,* 2012) [25]. Surface water resources like a river and lake pollution is severe and serious problem due to the large amount of pollutants released by urban activities in India (Pani and Mishra, 2000) [23]. The agricultural drainage water containing pesticides and fertilizers and efuents of industrial activities and runoff in addition to sewage efuents enter into the water bodies and sediment with huge quantities of inorganic anions and heavy metals (ECDG, 2000) [12]. Several studies deal with the physicochemical status of water has been done by several

Authors (Rai, 2009; Aladesanmi *et al.,* 2014; Adewumi *et al.,* 2015; Ahmad *et al.,* 2010; Islam *et al.,* 2015) [26, 5, 3, 4, 15]. But, there were no such studies from this region and therefore a study of heavy metal contamination was undertaken in different ponds from Kolkata municipal areas to check the pond water quality with different management practices of these urban ponds.

2. Materials and Methods

2.1 Study Area

The present study was carried out for a period of six months from January 2014 to June 2014. Three ponds with different management practices were selected to make a comparative ecological study among them. The water bodies identified for the present study are situated within the municipal boundary of Kolkata, West Bengal. First pond (P-1), Bibek Nagar Jheel, moderately managed is situated near the Jadavpur railway station with around 8000 m2 area and surrounded by cemented wall. Second pond (P-2), situated at Panchasayar, an earthen well managed pond with 7500 m2 area. The third pond (P-3), namely Baghajatin Park pond is situated near Highland Park, highly unmanaged with 6000 m2 area. The water samples were collected on monthly basis in the early morning (between 7.30 am to 9.30 am) from each pond for heavy metal analysis.

2.2 Sample collection and analysis

The level of contamination of Copper (Cu), Lead (Pb), Cadmium (Cd) and Zinc (Zn) were analyzed. The samples were collected in polyethylene bottles (1.5 litres capacity) which had been thoroughly washed and filled with distilled water, and then taken to the sampling site. The bottles were emptied and rinsed several time with the water to be collected. The sample bottles were covered immediately after collection and the temperature taken. The above said heavy metals have been analyzed using atomic absorption spectrometer as per the standard methods of APHA (1998) [6].

2.3 Statistical analysis

All data presented are expressed as mean ± standard deviation subjected to two way analysis of variance (ANOVA).

3. Results and Discussion

Among heavy metals (lead, zinc, cadmium and copper), the concentration of cadmium was very low compared to lead, zinc and copper in all the three ponds during study period.

3.1 Lead (Pb) concentration

The average value of lead concentration in the water ranged between 0.025 and 0.042 ppm in P-1, 0.011 and 0.036 in P-2 and 0.035 and 0.052 in P-3 (Table 1). On the basis of mean values of lead, P-3 reflected the highest amount (0.052 ppm) followed by P-1(0.042 ppm) and P-2(0.036 ppm) (Fig.1). The heavy metal lead is significantly highest (p<0.05) in the month of March in P-1 but in both P-2 and P-3 it is significantly highest (p<0.05) in the month of May. The maximum permissible concentrations of pb in drinking water as per IS are 0.1 ppm (Awashthi, 2000) [7].

The average values of Pb concentration in all three ponds were found below this limits **(**YeeLing and Nyanti, 2012) [30] .Pb toxicity studies conducted on female animals revealed mostly miscarriages and potent mortality (Taupen *et al.,* 2015) [27]. High Pb concentration in drinking water may result in metallic poisoning that manifests in symptoms such as tiredness, lassitude, slight abdominal discomfort, irritation, and anemia(Cecil *et al.,* 2008) [10]. Pb is a cumulative poison and a possible human carcinogen (Bakare-odunola, 2005) [8]. In comparison with a study where a concentration of 0.1 mg/L had resulted in the development of neurological problems in fetuses and children, the results obtained in this study definitely require urgent attention by the citizenry (Fatoki *et al.,* 2005) [13].

Table 1: Pond wise monthly variation in Pb (ppm)

Month	P1	P2	P3
JAN	0.031 ± 0.001	0.011 ±0.001	0.0365±0.0007
FEB	0.032 ±0.007	0.014 ±0.001	0.0405±0.0007
MAR	0.042 ±0.001	0.0265 ± 0.003	0.0445 ±0.002
APR	0.0405 ±0.0007	0.0315 ±0.002	0.043 ±0.001
MAY	0.041 ±0.004	0.036 ±0.002	0.052 ±0.001
JUNE	0.0255 ±0.016	0.021 ±0.005	0.035 ±0.005

3.2 Zinc (Zn) concentration

The values of zinc varied between 0.05 and 0.15 ppm in P-1, 0.047 and 0.07 ppm in P-2 and 0.059 and 0.17 ppm in P-3 (Table 2). The mean value of zinc was also found to be highest in P-3 (0.17 ppm) followed by P-1 (0.15 ppm) and P-2 (0.07 ppm) (Fig.2). The heavy metal zinc showed significantly highest (p<0.05) in the month of May in both the P-1 and P-2. But there was no significant variation (p>0.05) was found between the months in P-3 during the study period.The permissible concentrations of zinc in drinking water as per IS is 5.0 ppm (Awashthi, 2000) [7]. Average values of all three ponds were found below the permissible limits.This finding clearly indicated water pollution due to municipal wastes, industrial effluents etc. and also agreed with the findings of Moore and Ramamoorthy (1984) [21] and Meade (1989) [20]. Zn is essential to plant and animal physiology, but excessive levels in water can cause problem of bitter, astringent taste and opalescent appearance (Lenntech 2009) [18].

Zn in e-waste is usually in the form of ZnS used in monitor glass. Exposure to this heavy metal may be from burning and dismantling of computer monitors. Direct critical exposure is corrosive to the skin and lungs and ingestion can be very harmful (Adaramodu *et al.,* 2012) [2].

Table 2: Pond wise monthly variation in Zn (ppm)

Month	P1	P2	P3
JAN	0.0825 ± 0.0007	0.0505 ± 0.0007	0.0615± 0.0007
FEB	0.0775 ± 0.002	0.0475± 0.0007	0.059 ±0.001
MAR	0.092± 0.012	0.062 ± 0.004	0.0765± 0.003
APR	0.133 ± 0.015	0.07 ± 0.001	0.1175 ± 0.050
MAY	0.158± 0.002	0.077 ± 0.001	0.1745 ± 0.020
JUNE	0.05 ± 0.002	0.047 ±0.005	0.139 ± 0.074

3.3 Cadmium (Cd) concentration

The values of cadmium varied between 0.004 and 0.025 ppm in P-1, 0.001 and 0.008 ppm in P-2 and 0.006 and 0.016 ppm in P-3 (Table 3). The mean values of cadmium was also found to be highest in P-3 (0.016 ppm) followed by P-1 (0.015 ppm) and P-2 (0.008 ppm) (Fig.3). The cadmium showed maximum significant variation (p<0.05) in the month of May in both the P-2 and P-3. But there was no significant variation (p>0.05) was observed between the months in P-1. The maximum permissible levels of cd in drinking water as per IS are 0.01 ppm. The average value of cd concentrations in P-3 showed the maximum permissible value. Other two ponds showed below the permissible level. The average metal concentration was found to be higher in P-3 in comparison to other two

ponds P-1 and P-2. This indicates the poor water quality of P-3 in comparison to other ponds.

Abel and Green (1981) [1] reported that different wastes of industries and textiles cause serious pollution due to the presence of the heavy metal components like lead. Templeton (1995) [28] has described that the lead entered into the water by wastes of industries. Javed (1999) [16] also reported high concentration of Pb causes metallic ion pollution. According to Who standards, the permissible limit for cadmium in drinking water 0.003mg/l cadmium concentration in all the water samples was lower than the permissible limit ranged from 0.147 -0.187 mg/l [6]. Cadmium has high toxic potential and minute quantities of cadmium are responsible for adverse renal arterial changes in human kidneys. Higher concentration of cadmium causes kidney damage, bronchitis, gastrointestinal disorder and cancer (Hima *et al.* 2007) [14].

Table 3: Pond wise monthly variation in Cd (ppm)

Month	P1	P2	P3
JAN	0.006± 0.004	0.0015± 0.0007	0.006 ±0.001
FEB	0.0045± 0.001	0.002 ± 0.0008	0.0085± 0.002
MAR	0.0065± 0.001	0.0065± 0.002	0.01 ± 0.002
APR	0.012 ± 0.001	0.006 ± 0.002	0.0155± 0.003
MAY	0.0155± 0.002	0.008 ± 0.001	0.016 ± 0.001
JUNE	0.0075± 0.002	0.0015 ± 0.0007	0.0085 ±0.0007

3.4 Copper (Cu) concentration

The average calculated values of copper ranged between 0.022 and 0.038 ppm in P-1, 0.011 and 0.026 ppm in P-2 and 0.023 and 0.038 ppm in P-3 (Table 4). The mean value of cadmium was found to be highest in both P-1 and P-3 which is 0.038 ppm during the month of May (Fig.4). The copper showed no significant variation ($p>0.05$) between the months in P-1 but the significantly highest variation ($p<0.05$) found in the month of May in both P-2 and P-3. The permissible concentration of cu in drinking water as per IS is 0.05 ppm. The average values of all three ponds were below the permissible limits.

This finding clearly indicated water pollution due to industrial effluents and also agreed with the findings of Moore and Ramamoorthy (1984) [21] and Meade (1989) [20]. Abel and Green (1981) [1] reported that different wastes of industries and textiles cause serious pollution due to the presence of the heavy metal salts of copper.It is found in less quantity as an essential element for organisms. Excess of copper in human body is toxic and causes hypertension and produces pathological changes in brain tissues. At lower concentrations, Cu ions cause headache, nausea, vomiting and diarrhoea and at high concentrations, it causes anaemia, gastrointestinal disorder and also leads to liver and kidney malfunctioning in extreme cases. (USEPA, 1999; Neethu Patil and Puttaiah, 2014) [29, 24].

Table 4: Pond wise monthly variation in Cu (ppm)

Month	P1	P2	P3
JAN	0.022 ± 0.001	0.012 ± 0.002	0.026 ± 0.001
FEB	0.025 ± 0.002	0.011 ± 0.001	0.029 ± 0.0007
MAR	0.0315 ± 0.002	0.016 ± 0.002	0.032 ± 0.001
APR	0.0345± 0.0007	0.020 ± 0.0007	0.038 ± 0.001
MAY	0.038 ± 0.009	0.026 ± 0.001	0.0385± 0.0007
JUNE	0.031 ± 0.0004	0.015 ± 0.002	0.023 ± 0.003

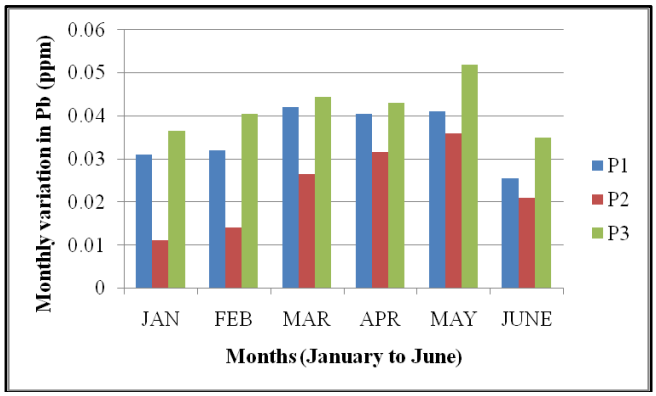

Fig 1: Pond wise monthly variation in Pb (ppm)

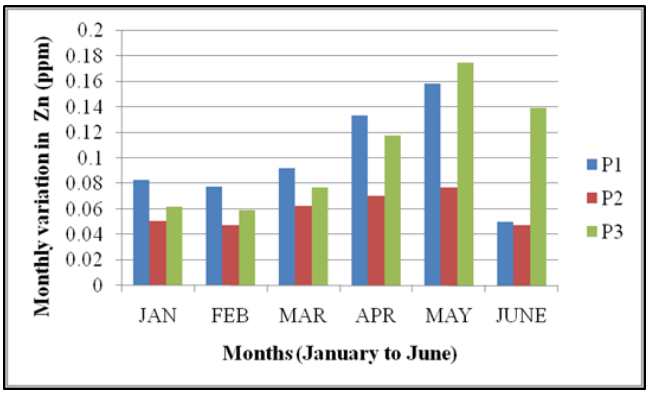

Fig 2: Pond wise monthly variation in Zn (ppm)

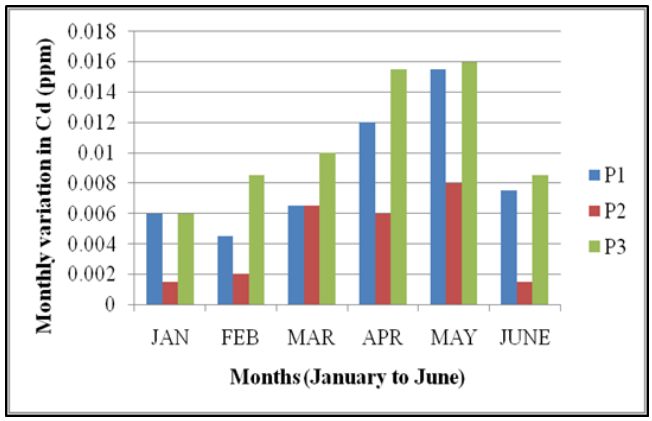

Fig 3: Pond wise monthly variation in Cd (ppm)

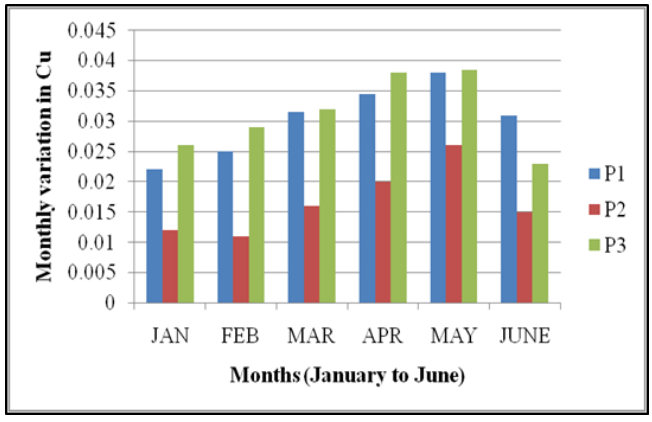

Fig 4: Pond wise monthly variation in Cu (ppm)

Several authors have already studied about heavy metal contamination in different water body. But this study shows that the heavy metals of interest though found in measurable quantities are still within safe limits for consumption. Efforts should however be concentrated on ensuring that these concentrations are not exceeded. In view of the importance of fish to diet of man, it is necessary that biological monitoring of the water and fish meant for consumption should be done regularly to ensure continuous safety of food. Safe disposal of domestic sewage and industrial effluents should be practiced and where possible recycled to avoid these metals and other contaminants from going into the environment. Laws enacted to protect our environment should be enforced.

4. Conclusion

Heavy metals, industrial pollutants, in contrast with organic materials cannot be degraded and therefore accumulate in water, soil, bottom sediments and living organisms. Water contamination with heavy metals is a very important problem in the current world. Occurrence of toxic metals in pond, ditch and river water affect the lives of local people that depend upon these water sources for their daily requirements. Consumption of such aquatic food stuff enriched with toxic metals may cause serious health hazards through food chain magnification. In recent years, also found some heavy metals have carcinogenic, teratogenic, mutagenic effect, it is not only affecting the body's immune system, but also may increase the specificity of certain diseases. The study concludes that all the heavy metals (Pb, Cu, Zn and Cd) concentration was maximum in P-3 and minimum in P-2 throughout the study period.The city sewage discharge, agriculture and urban runoff and continuous dumping of waste materials especially sanitary waste are affecting the water quality of these urban water bodies. There is considerable need for better understanding of these small impoundments so that they can be managed effectively.

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