A Study on the Determination of Heavy Metals in Freshwater Aquaculture Ponds of Mymensingh

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Abstract

Levels of copper (Cu), zinc (Zn), led (Pb), cadmium (Cd) and chromium (Cr) were determined in the waters of a fish farm in Mymensingh district, Bangladesh by Atomic Absorption Spectrophotometer. Metals were found to be present in varied concentrations: Cu (0.02–0.1 mg/L), Zn (0.055–0.072 mg/L), Pb (0.039–0.066 mg/L), Cd (0.014–0.29 mg/L) and Cr (0.13–0.23 mg/L). The results signify that levels of Cd slightly exceeded and Cr in water was almost 1 order of magnitude higher than the values stated by ADB (Asian Development Bank, 1994); EPA (Environment Protection Agency, 2002); WHO (World Health Organisation, 1993); WPCL (Water Pollution Control Legislation, 2004) and USPH (United State Public Health). In general, the rank order of heavy metals was Cr > Pb > Cu > Zn > Cd. This suggests that water of the investigated fish ponds is contaminated with metals and in turn, fish of that aquaculture farm could be harmful to human health.

Keywords: Heavy Metal; Freshwater; Bangladesh.

Introduction

Heavy metals can cause great harm to the aquatic environment, as metals are not perishable. Moreover, metals are harmful to organisms (MacFarlane and Burchett, 2000). "Heavy metals" is a general collective term, which applies to the group of metals and metalloids with atomic density greater than 4 g/cm 3 or 5 times or more greater than water (Duruibe, et al., 2007), and 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. Moreover, they are also known as trace elements because they occur in minute concentrations in biological systems.

Heavy metal concentrations in aquatic ecosystems are usually monitored by measuring their concentrations in water, sediment and biota (Camusso et al., 1995). Though heavy metals generally present in low levels in water but achieve significant concentrations in sediments and biota (Namminga and Wilhm, 1976). Heavy metal cannot be despoiled, hence they are deposited, assimilated or integrated into water, sediment and aquatic biota, causing pollution

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of heavy metal in all parts of the environment. Fish accumulate heavy metals directly from water and diet, and pollutant residues may eventually attain concentrations hundreds or thousands of times higher than those measured in the water, sediment and food (Osman et al., 2007; Goodwin et al., 2003; Labonne et al., 2001).

In Mymensingh district, freshwater aquaculture is widely practiced under improved traditional farming system where different fish species such as koi (Anabas testudineus), Shing (Heteropneustes fossilis), Magur (Clarius batrachus), Silver carp (Hypothalmicthys molitrix); Tilapia (Tilapia mossumbica), Rui (Labeo rohita) and Pangus (Pangasius pangasius) are cultured in the fish farm for 120 days to 300 days depending on the prices and demand of fish market. In a single culture cycle, a stocking density of 40-45 fish/decimal and a feeding regime 150-250 kg/decimal is followed with regular water exchange. In spite of overwhelming importance of heavy metals in freshwater aquaculture pond, some scientific work has been conducted to determine the heavy metals in freshwater fish farm that deal with sediment, feed, fish tissue and water of aquaculture (Ahmad et al. 2010; Flowra et al. 2014; Sarker et al. 2016). But there needs more precious study especially in freshwater fish farms of Mymensingh region in Bangladesh, which supply a significant amount of fish in the country. Therefore, the present study was accomplished with a view to know the heavy metal concentrations in some freshwater aquaculture ponds and compared to different international standards.

Materials and Methods

Sample Collection

The present study was conducted in 21 ponds and triplicate water samples were collected from 7 different freshwater aquaculture ponds of Talukdar fish farm located at Shambhuganj Guripur Upazila of Mymensingh, district in Bangladesh. The research work was carried out in the month of October 2015 following the sampling techniques as outlined by Sincero and Sincero, 2004.

Preparation of Sample

The water samples were acidified immediately with 2ml of HNO3 per litre of water and preserved in a refrigerator at 4˚C for laboratory analysis and samples were taken to the Bangladesh Agricultural Research Institute (BARI), Gazipur.

Analysis of Heavy Metals

1 ml of water sample were taken and 5 ml of a di-acid mixture (5ml conc. HNO3: 1ml 60 per cent HClO4) were added to each sample in a boiling flask. The entire mixture was kept in a digestion chamber for 2 hours at 180˚C and then the solution is filtered. The stock solution was ready to determine the heavy metal analysis. It was passed through the nebuliser in the Spectrophotometer and reading were shown in the monitor of a computer attached with it. The concentration of Cu, Zn, Pb, Cd and Cr in water samples were calculated by the following formula:

Heavy Metal Concentration = (ppm conc. Observed *final volume of sample in ml) /
(water sample was taken in ml.)

Results

Metal contents ranged over following intervals: Cu: 0.02-0.10 mg/L, Zn: 0.01- .072 mg/L, Pb 0.039 – 0.068 mg/L, Cd: 0.002- 0.029 mg/L and Cr: 0.123-0.23 mg/L (Table 1). In the present study, the rank of heavy metals concentration in water was as:

Cr > Pb > Cu > Zn > Cd

Cu concentration in water samples ranged 0.008-0.1 mg/L (Table 1), but a high concentration of these elements in the water is toxic. The highest value of Cu was recorded in pond-1 and the lowest value was found in the pond-5 (Table 1). The mean value of copper was varied from 0.013±0.007 (Pond-5) to 0.06±0.04 mg/L (Pond-1).

Table 1: Heavy metal concentrations (mg/L) in water samples from aquaculture fish farm (Mean ± SD)

Pond No	Cu	Zn	Pb	Cd	Cr
1	0.06 ± 0.040	0.064±0.009	0.049±0.011	0.023±0.008	0.173±0.045
2	024±0.010	0.035±0.007	0.051±0.009	0.017±0.009	0.176±0.036
3	025±0.0110	0.028±0.01	0.057±0.012	0.016±0.01	0.188±0.04
4	03±0.013	0.03±0.011	0.041±0.005	0.012±0.009	0.156±0.056
5	0.013±0.007	0.025±0.013	0.051±0.011	0.014±0.009	0.193±0.048
6	0.029±0.013	0.029±0.015	0.051±0.009	0.014±0.008	0.179±0.038
7	0.026±0.008	0.033±0.025	0.057±0.013	0.014±0.007	0.183±0.04

The concentration of zinc (Zn) in twenty-one water samples ranged from 0.01 to 0.072 mg/L (Table 1). The lowest value was obtained from pond-7 (0.01) and the highest from pond-1 (0.072) (Table 1). In pond-5 the highest mean value of Zinc (Zn) was 0.064 ± 0.009 mg/L and in pond-1, the lowest mean value of Zinc (Zn) was 0.025±0.013 mg/L.

Lead (Pb) in the water was in the range of 0.037-0.068 mg/L (Table 1). The lowest mean value was obtained from pond-4 and the highest from pond-7. The mean value of lead was varied from 0.041±0.005 (Pond-4) to 0.057±0.012 mg/l (Pond-7) (Table 1).

The concentration of cadmium (Cd) in water samples ranged from 0.002 to 0.029 mg/L. The lowest concentration was obtained from pond-4 with a value of 0.002 mg/L and the highest from pond-1 with a value of 0.029 mg/L. The mean value of cadmium (Cd) was varied from 0.012±0.009 (Pond-4) to 0.023±0.008 mg/L (Pond-1) (Table 1).

The concentration of chromium (Cr) in water samples ranged from 0.13 to)) 0.23 mg/L. The lowest concentration was obtained from pond-1 with a value of 0.002 mg/L and the highest from pond-3 with a value of 0.23 mg/L. The mean value of chromium (Cr) was varied from 0.156±0.056 (Pond-4) to 0.193±0.048 mg/L (Pond-1) (Table 1).

Discussion

Cu

Copper is an essential element that is carefully regulated by physiological mechanisms in most organisms. Cu is a useful element for our biological helps to produce blood cells and strengthening bones. But, an excess of Cu can cause health problem (Demirezen and Uruc, 2006). The mean value of Cu was varied from 0.013± 0.007mg/L (Pond 5) to 0.06±0.4mg/L (pond 1) which were in the permissible limit (EPA, 2002). Among the total 21 samples, all of the samples were found within the recommended limit. Flowra et al. (2012) found the mean concentration of Cu was varied from 0.05±0.02 to 1.79±0.88mg/L in the water of some ponds in Rajshahi, values that are higher than the present study. Kundu et al. (2017) found the mean value of Cu in the fish (Tilapia) samples was 21.13±1.44mg/L, values that are higher than the present study. Das et al. (2017) found that the concentration of Cu in sediment was 13.00-23.20mg/kg, which was higher than the present findings.

Zn

Zn is vital for human health. It helps macronutrients disintegrating in food and healing wounds (Demirezen and Uruc, 2006). The mean value of zinc (Zn) was varied from 0.025±0.013 mg/L to 0.064±0.009 mg/L which were in the range of fish culture (ADB, 1994). Similar observation for Zn was reported by Rahman et al. (2012) in Bangshi river water, Bangladesh. Considering all the value Zn concentration in all of the samples was within a suitable range for all purposes. Sarker et al. (2016) found that the mean value of Zn in the sediment of Mymensingh district was 208±31.388mg/kg, which was higher than the present study.

Pb

Lead is a non-essential element and it is well documented that lead can cause neurotoxicity, nephrotoxicity and many other adverse health effects. The mean value of Pb in the study varied from 0.041±0.005mg/L (Pond-4) to 0.057±0.012 mg/L (Pond-7) which was under the limit of fishing water (ADB, 1994). Kundu et al. (2017) found that the mean value of Pd in the fish (Tilapia) samples were varied from 9.92±3.57 to 14.83±1.336mg/Kg which was higher than the present study. Sarker et al. (2016) found that the mean value of Pb in sediment was 14.845±1.995 mg/Kg which was higher than the present study as well. Das et al. (2017) examined the value of Pb in sediment was varied from 6.43-8.65mg/Kg. The mean value of lead (Pb) was varied from 0.14±0.12 to 4.92±1.66 mg/L in the water of some urban ponds in Rajshahi (Flowra et al. 2014), which was much higher than the present study.

Cd

An industrial process such as smelting or electroplating or electroplating and the addition of fertilisation can increase the concentration of Cd in the pond (environment). The mean concentration of Cd was varied from 0.012±0.009mg/L (pond-4) to 0.023±0.008mg/L (pond-1). In only one was slightly exceed with the standard value as described by ADB (1994), EPA (2002) and WPCL (2004). The run-off and waste materials from land and agriculture might be a potential source for Cd concentration. However, the Cd in the observed samples were found between 9.43±0.37 to 9.84±0.55mg/kg (Kundu et al. 2017). Sarker et al.

(2016) found Cd concentration in the sediment samples was 0.009±0.001mg/Kg which was lower than the present study.

Cr

The mean value of chromium (Cr) was varied from 0.156±0.056 (Pond-4) to 0.193±0.048 mg/L (Pond-5) which were almost 1 order of magnitude higher than the findings described by EPA (2002), WHO (1993) and WPCL (2004). Considering this limit, Cr concentration in all of the samples was not within a suitable range for all purposes; which was slightly higher than the polluted category (Cr>0.05 mg/L). Fish feed might be a potential source for higher Cr concentration. Das et al. (2017) found the Cr concentration which was ranged from 7.32 to 15.41mg/Kg in sediment samples. Similarly, Sarker et al. (2016) found the Cr concentration in sediment samples was 63.054±6.922mg/Kg, which was higher than the present study.

Correlation Matrix

Correlations among heavy metals may reflect the origin and migration of these elements (Suresh et al., 2011). Metals with a positive correlation are possibly from the same pollutant sources (Üstün, 2009; Mansouri et al., 2011). Table 2 showed the correlation between metals, where significant positive correlation ($p < 0.05$) were found between Cu-Zn (0.94); Cu-Cd (0.78); Zn-Cd (0.91); and Pb-Cr (0.82) in water.

Table 2: Pearson's correlation coefficients among heavy metals concentration (mg/L).
** Values >0.05 or < - 0.05 are significantly correlated.*

	Cu	Zn	Pb	Cd	Cr
Cu	1				
Zn	0.94209*	1			
Pb	-0.24154	-0.14389	1		
Cd	0.78946*	0.90526*	-0.11993	1	
Cr	-0.44303	-0.28366	0.82088*	0.037018	1

Conclusion

Research work was conducted to evaluate the heavy metals concentrations in water samples collected from the aquaculture fish farm in Mymensingh. The present study has shown that the concentrations of heavy metals in water samples were varied and sometimes it is slightly polluted and dangerous for the aquatic ecosystem and human health but most water samples were not dangerous. In respect of Cu, Zn, Pb and Cd contents, all water samples under the study area could safely be applied for long term fish culture without any harmful effect but in case of Cr, some samples were not within the permissible limit. From the results of the present investigation, it might be concluded that the quality of water in the study area is in general good for utilisation in fish culture & other purposes. Measures should be taken to regulate the water quality determining parameters. It is recommended that further research should be done on the levels of other heavy metals in the water in order to monitor and prevent it from reaching high levels that make them toxic to living organisms.

Conflict of Interest

The authors declare that there is no conflict of interest.

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