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Copper Contamination of Different Prawn Farms at Shatkhira District

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Abstract

Copper (Cu) contamination of six prawn farms under three upazilas of Satkhira district were evaluated. Total 54 water, sediment and prawn samples were collected from six farms, 18 samples from each category were examined to observe the Cu contamination of water, sediment and prawn. Cu was determined by Atomic Absorption Spectrophotometer at the central laboratory of Bangladesh Agricultural University and toxicity laboratory of Bangladesh Fisheries Research Institute, Mymensingh. The levels of Cu in water sample, sediment sample and samples of prawn species were collected from different surface and ground sources. The concentration of Cu in sediment samples were ranged from 45.3895 to 127.8771 μg^{-1} and the average mean concentration was 76.92101 μg^{-1}. The concentration of Cu in prawn was ranged from 16.1069 to 97.3841 μg^{-1} and the average mean concentration was 51.2342 μg^{-1}. The copper concentration in water ranged from 0.0309 to 0.0702 ppm. Cu concentrations in those samples were higher in sediment than prawn, but very lower concentration was found in water sample. The Cu in sediment samples were present higher amount than allowable limit. So prawn was mostly affected by contaminated water and sediment.

Key words: Copper (Cu), Contamination, Water, Sediment, Prawn

Introduction

Heavy metals are elements having a density greater than 5 in their elemental form and comprise some 38 elements. Cu mostly found in specific absorption sites in the soil. Due to rapid industrialization and urbanization, the pollution load in rivers and open water body has a rapid pace, and numerous investigations have been conducted through out the world to asses the toxic metal concentrations of Cu in various river systems and their impact on aquatic biotope. Human wastes and sewage, and industrial effluents are discharged regularly in the river and other open water body. The resulting eutrophication as well as quality deterioration of open water bodies such as river, beel, lake, channel etc, affecting the biotope and thus their fishery. Almost all metals are toxic at higher concentrations and some are lethal even at lower concentrations, but some heavy metals within limited concentrations are essential for aquatic organisms, plants as well as humans for survival and functioning. Through various food materials, fishes, vegetables, water etc. traces of metals enter into the human body and participates in health hazard activity (Sattar, 1996). Wong et al. (2002) evaluated the levels Cu in different tissues of three species of cultured marine fishes (Epinephelus areolatus, Lutjanus russelli, and Sparus sarba) collected from three fish culture sites in Hong Kong. They found that Cu pollution problems in the fish culture sites were serious, as reflected by the high Cu concentrations recorded in sea water, sediments, and the biomonitor Perna viridis. In general, tissues of all three species contained high concentrations of Cu. Metal concentrations in various tissues varied greatly among species and among fish culture sites. Different tissues showed different capacity for accumulating Cu. On the other hand, liver seemed to be the primary organ for Cu accumulation.

Methodology

1. Description of the study area

The experimental area was Shatkhira district. Water, sediment and prawn samples were collected from six different farms. These farms were situated at three upazilas of Shatkhira district. These upazila were Sadar upazila (Farm A and Farm B), Debhata upazila (Farm C and Farm D) and Kaligonj upazila ((Farm E and Farm F). These samples were also collected to observe the variation of Cu contaminations. Total 54 samples were collected (water sample- 18, sediment sample-18 and prawn sample-18). The analysis of water samples were conducted at Bangladesh Agricultural University and Bangladesh Fisheries Research Institute, Mymensingh during the period from 15 December 2006 to 21 May 2007.

2. Sample collection and preparation

2.1 Sediment

Eighteen sediment samples were collected from different farms at Shatkhira district by Ekman dredge and kept in fresh plastic packets. The samples were shade dried and sieved through 80-mesh after grinding. The sediment sample weighing 1.0 g was transferred into a dry clean digestion vessel. Five (5) ml nitric acid (HNO_3) and 3 ml perchloric acid ($HCHO_4$) were added to the vessel. The digestion vessel was then placed on a heating block and was heated at 120^{o}C temperature to for two hours and 180^{o}C for one hour. The digest was cooled, filtered

through Whatman No. 42 filter paper and diluted to 50 ml with de-ionized water into plastic bottle.

In next step, 1g sediment sample was taken in digestion tube and 17 ml Triacid mixture (14 ml HNO_3: 2ml $HClO_4$: 1 ml H_2SO_4) was added. The content was initially heated strongly at 150°C for 2 hours. The digestion material (colorless or faint color of content) was from passed through Whatman 42 filter paper, washed with 2% HNO_3 solution and made to 50 ml volume. The concentration in the sample was calculated as follows:

$$\text{Metal concentration in sample (ppm)} = \frac{\text{Concentration observed (ppm) X Final volume (ml)}}{\text{Weight of sediment (g)}}$$

The collected sediment samples were put into the individual polythene bag with definite markings. Finally these were brought to the Bangladesh Fisheries Research Institute (BFRI).

2.2 Water

Water samples were collected in 100 ml plastic bottles previously cleaned with dilute hydrochloric acid followed by the distilled water (1.1). After collection of wetland water samples, all bottles were brought to the laboratory. The water samples were filtered with filter paper (Whatman No. 1) to remove undesirable solid and suspended materials. Then fifteen water samples were transferred to another 100 ml plastic bottles which contained 10 ml 2 M HCl. After preparing 100 ml solution all bottles were sealed immediately to avoid air exposure to air. To provide necessary information for each sample such as date of collection, location, sources of water etc. were recorded in a notebook and each sample collected in a plastic bottle was labeled separately with a unique identification number. Water dissolved metal include the portion that passes through 0.45 µm filter. The freshly collected samples were filtered through Millipore Filtration Assembly, using 0.45 µm membrane filter quickly after sample collection. The set (Millipore Filtration Assembly) were washed beforehand in acid solution of 1:1 HNO_3. The filtrate was then acidified with conc. HNO_3 to make a pH of <2 (conc. HNO_3 - 1.5 to 5 ml is sufficient to bring down the pH to the desired level, depending on the buffering capacity of the sample). Measured volume (10 to 20 ml) of well mixed, acidified sample was then taken in a beaker or conical flask. 5 ml of conc. HNO_3 was added and strongly boiled after adding boiling chips on hot plate till the volume dropped down to about 10 to 20 ml. Addition of HNO_3 and boiling was repeated till solution becomes light colored or clear. Then the volume was raised to desired level after cooling. The sample was than ready for Atomic Absorption Spectrophotometry analysis, whose observed value was calculated as follows:

Metal concentration in sample (ppm) = Observed concentration (ppm) X Concentration factor of the sample

2.3 Prawn

Tissue was taken out from prawn samples. Approximately 50g of sample was drawn out. The collected tissue was immediately kept in ice in a thermos to maintain temperature of about 0°C. From collected tissues3 to 5 g samples were taken out and 25.5 ml of triacid mixture (21 ml HNO_3: 3 ml $HClO_4$: 1.5 ml H_2SO_4) was added. The content were mixed and left over night. Sample was then digested, initially at low temperature and later at 150°C for 2 hours.

The completion of digestion was indicated by almost colorless or light colored material. The brown fumes also cease to exist at completion of digestion. The content was then filtered through Whatman 42 filter paper, washed with 2% HNO_3 and volume made to 25 or 50 ml in polyethylene/ bottles. Then the samples were subjected to analysis by Atomic Absorption Spectrophotometer. Concentration in tissue was calculated by the following formula:

$$\text{Metal concentration in sample (ppm)} = \frac{\text{Concentration observed (ppm) X Final volume of sample (ml)}}{\text{Weight of tissue taken (g)}}$$

3. Determination of heavy metal content

Cu was determined by Atomic Absorption Spectrophotometer (AAS, UNICAM 969) at the central laboratory of Bangladesh Agricultural University and toxicity laboratory of BFRI, Mymensingh (Model AAS, BUCK Scientific) followed the method of Clesceri *et al.* (1989).

4. Statistical analysis

Statistical analyses of the recorded data found from the chemical analysis of samples were done with help of scientific calculator (Casio fx-570W) following the standard procedure as described by Gomez and Gomez (1984). Correlation studies were also computed following the procedure described afforested and authors.

Results and Discussion

Sediment

The contaminated sediment environment (different farms) of Shatkhira region contained copper (Cu) ranged from 45.3895 to 127.8771 μg^{-1} (Table 1 and Fig.1). The mean Cu concentration ranged in farm A

(Sadar upazila) were 70.3436± 8.56 (58.5594-83.6885) μg^{-1}, in farm B (Sadar upazila) were 55.6100± 3.23 (52.574-58.873) μg^{-1}, in farm C (Debhata upazila) were 48.1434±2.76 (45.3895-50.5515) μg^{-1}, in farm D (Debhata upazila) were 102.2359± 11.76 (83.0498-127.877) μg^{-1}, in farm E (Kaligonj upazila) were 108.4543± 9.87 (94.9801-122.348) μg^{-1}, in farm F (Kaligonj upazila) were 76.7388± 7.98 (59.5549-95.5635) μg^{-1}. The average mean concentration was 76.92101 μg^{-1}. The highest concentration was 127.8771 μg^{-1}. The highest concentration was found in sample number D_2 and the lowest concentration was found in sample C_1 (Appendix 7). The computed standard deviation and co-efficient of variation were 25.8156 and 33 %, respectively.

Prawn

The concentration of Cu in prawn of different farms ranged from 16.1069 to 97.3841 μg^{-1}. The mean concentrations of Cu ranged from 20.4908± 2.56 (16.1069-24.1589) μg^{-1}, 54.7174±3.56 (51.2388-58.4905) μg^{-1}, 33.9808±1.43 (32.4414-35.2488) μg^{-1}, 46.1929±1.89 (44.6721-47.1347) μg^{-1}, 66.1799± 2.12 (64.0071-69.2205) μg^{-1}, 85.8433± 6.43 (77.8769-97.3841) μg^{-1} in farm A, B, C, D, E and F, respectively. The mean concentration was 51.2342 μg^{-1}. The highest concentration of 97.3841 μg^{-1} was found in sample F_1 and the lowest concentration 16.1069 μg^{-1} of Cd was found in sample A_1. The calculated standard deviation and co-efficient of variation were 22.2234 and 43.376 %, respectively (Table 1 and Fig 2).

Water

The Cu concentration in water environment ranged from 0.0309 to 0.0702 ppm. The mean Cu concentration ranged in farm A (Sadar upazila) were 0.06453 ± 0.0012 (0.0582-0.0702) μg^{-1}, in farm B (Sadar upazila) were 0.06346± 0.02(0.0605-0.0688) μg^{-1}, in farm C (Debhata upazila) were 0.06373±0.0023 (0.0619-0.0659) μg^{-1}, in farm D (Debhata upazila) were 0.0341 ±.004 μg^{-1} (0.0309-0.0395), in farm E (Kaligonj upazila) were 0.0521± 0.002 (0.0506-0.0536) μg^{-1}, in farm F (Kaligonj upazila) were 0.06006± 0.005 (0.0511-0.0695) μg^{-1}. The highest concentration (0.0702 ppm) were found in sample no.A_1 and the lowest concentration (0.0309 ppm) were found in sample D_1. The average mean concentration was observed 0.0563. The computed standard deviation and co-efficient of variation were 0.01197 and 21.262 %, respectively (Table 1, Fig 3).

Table-1: Cu concentration in various levels of sediments, water and prawn from different farms in Satkhira district (mean±SE and range)

SL. No.	Farms	Sediment (μg^{-1})	Prawn (μg^{-1})	Water (ppm)
1	A (Sadar)	70.3436± 8.56 (58.5594- 83.6885)	20.4908± 2.56 (16.1069-24.1589)	0.06453± 0.0012 (0.0582-0.0702)
2	B (Sadar)	55.6100± 3.23 (52.574-58.873)	54.7174± 3.56 (51.2388-58.4905)	0.06346± 0.02 (0.0605-0.0688)
3	C (Debhata)	48.1434±2.76 (45.3895-50.5515)	33.9808± 1.43 (32.4414-35.2488)	0.06373±0.0023 (0.0619-0.0659)
4	D (Debhata)	102.2359± 11.76 (83.0498-127.877)	46.1929±1.89 (44.6721-47.1347)	0.0341±.004 (0.0309-0.0395)
5	E (Kaligonj)	108.4543± 9.87 (94.9801-122.348)	66.1799± 2.12 (64.0071-69.2205)	0.0521± 0.002 (0.0506-0.0536)
6	F (Kaligonj)	76.7388± 7.98 (59.5549-95.5635)	85.8433± 6.43 (77.8769-97.3841)	0.06006± 0.005 (0.0511-0.0695)
	Mean	76.92101± 13.45	51.2342± 7.78	0.0563± 0.0821
	Maximum	127.8771	97.3841	0.0702
	Minimum	45.3895	16.1069	0.0309
	SD.	25.81559	22.2234	0.01197
	C.V. %	33.021	43.376	21.262

The concentration of Cu in sediment was ranged from 45.3895 to 127.8771 μg^{-1} and the average mean concentration was 76.92101 μg^{-1}. The concentration of Cu in prawn was ranged from 16.1069 to 97.3841 μg^{-1} and the average mean concentration was 51.2342 μg^{-1}. The Cu concentration in water environment ranged from 0.0309 to 0.0702 ppm and the average mean concentration was observed 0.0563 ppm. Cu

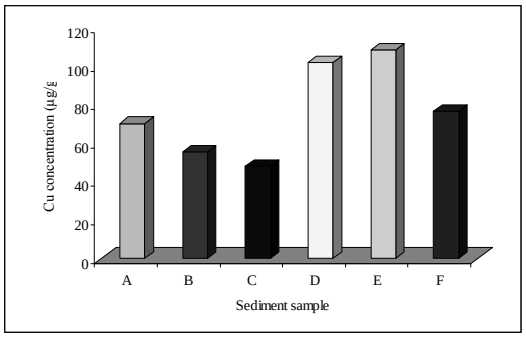

Fig. 1. Cu concentration of sediment in different farms

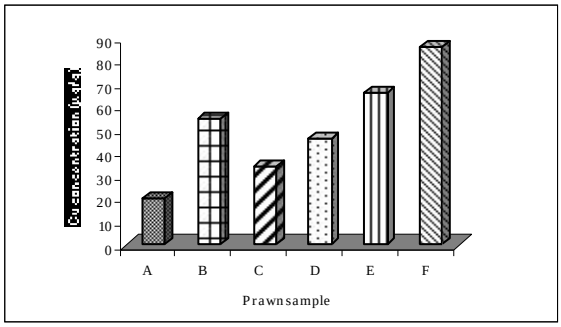

Fig. 2. Cu concentration of prawn in different farms

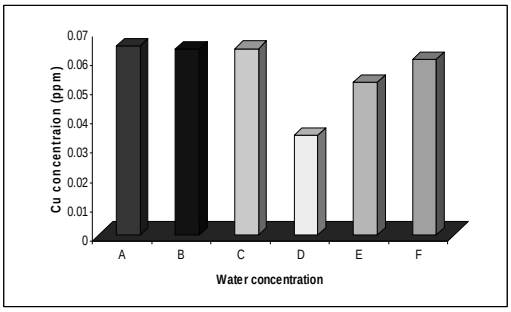

Fig. 3. Cu concentration of water in different farms

concentrations in those samples were higher in sediment than prawn, but very lower concentration was found in water sample. Similar result was found by Davies and Wixon (1995), as the range of Cu 2.0-46.0 μg^{-1} in soil from Missouri. The Cu concentration in the aquatic organism samples ranged from 0.15-77.8 $mgkg^{-1}$ which was found by Ip, *et al.* (2005). The concentration of Cu was found in prawn, crab, shellfish and also fish by Ip *et al.* (2005) ranged from 0.15 to77.8 µg/g, the concentration of Cu in sediment ranged from 15.02 to 205.236 μg^{-1} which was found by Himadri and Kaviraj (2000) and they also found Cu in water environment ranged from 0.02 to 0.125 ppm. Acute toxicity tests of Cu were carried out by Fafioye and Ogunsanwo (2007) on giant prawn (*Macrobrachium rosenbergii*) post larvae. Lethal concentrations at which 50% of the prawn died (LC< sub>50</ sub>) at 96 h was 3.02 mgl^{-1} Cu for *M. rosenbergii*. Cogun *et al.* (2005) were conducted to determine the level of Cu in tissues of fish and prawn and found the highest monthly mean concentrations of Cu was 17.79 in June. The lowest monthly mean concentrations of Cu was 10.33 micro gg^{-1} in January. The highest mean values of Cu 20.0+or-0.5 micro gg^{-1} d.w., was observed in prawn from the HC lagoon (Espericueta *et al.* 2005). Boszke *et al.* (2004) found the concentrations of Cu in sediments was 11.5-88.3 mg $Cukg^{-1}$. WenBin (2003) found the concentrations of Cu in muscle ranged 2.0-6.2 micro gg^{-1} wet weight. The concentrations of Cu in liver were in the range of 16.9-59.1 micro gg^{-1} wet weight. YiChun *et al.* (2001) observed the muscle concentration of Cu ranges was 4.00-7.28 μgg^{-1} wet weight. Cu concentrations of sediment, prawn and water sample of different farms of Satkhira district found in this experiment was similar with above findings.

These findings indicate that dissolved heavy metal, Cu is indeed bioavailable within the aquaculture pond system. Gosavi *et al.* (2004) state that Cu bioaccumulation by algae revealed concentrations recorded in the study are comparable to highly contaminated environments, such as those exposed to urban, industrial and mining pollution. The results of the study indicate that dissolved metal bioavailability in many earthen prawn aquaculture ponds may be higher than previously thought.

Conclusion

The Cu concentrations present in water within the permissible limit but in sediment and prawn body muscle were comparatively higher than allowable limit. Consumption of these prawns will be health hazard for human. Farms water of Satkhira region can safely be used for specific purposes after proper treatment. Routine research work with wide public awareness, government participation and government regulations can save the water and sediment of Satkhira region and then a safe and water environment can be made for future aquaculture.

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