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Full Length Research Paper

The use of heavy metals load as an indicator of the suitability of the water and fish of Ibiekuma Stream for domestic and consumption purposes

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The levels of Cd, Cr, Cu, Pb and Zn in the water and fish from Ibiekuma Stream, Ekpoma, Nigeria were determined at two locations (Upstream and Downstream) in order to ascertain their suitability for consumption and other domestic uses. Atomic Absorption Spectrophotometry was used to measure the metal levels. Seasonal (dry and wet seasons) levels were also determined. The results showed Zn mean levels were highest with 1.12 ± 0.51 mg/l in water and 45.5 ± 7.46 mg/kg in fish. Minimum levels were 0.005 ± 0.002 mg/l (Cd and Pb) in water and 0.70 ± 0.22 mg/kg (Cd) in fish. Pb was not detected in fish. Spatially, upstream location levels were generally higher than downstream levels for all the metals in both water and fish. Dry season levels were also generally higher for all samples and at both locations. The consumption of the fishes of the stream requires stringent precautionary measures because of the high levels of Cr and Cu which exceeded limits in food fish and could therefore pose some health risks. It was also observed that all metal levels in water were within drinking water limits and global background levels for surface fresh water. The implication of these findings is that the water of the stream could be used for drinking and other domestic purposes.

Key words: Atomic Absorption Spectrophotometry, heavy metals, water, fish, Ibiekuma Stream.

INTRODUCTION

The risks to health posed by the use of contaminated water and food have been well documented (WHO, 1972; FEPA, 2003). Various researchers have also reported that heavy metals are a major toxicant in contaminated water (Manahann, 1994; Ukpebor et al, 2005; Asonye et al, 2007) and food fish (Kurland et al, 1960; Shimizu, 1972; CIFA, 1994; Idodo-Umeh, 2002). Heavy metals today have a great ecological significance due to their toxicity and cumulative behaviour (Purvez, 1985). They are non-biodegradable and undergo a global eco-biological cycle in which natural waters are the main pathways (CIFA, 1994; Ukpebor et al, 2005).

Heavy metal intake in humans is through three main sources: inhaled air, drinking water and food (Miroslav and Vladimir, 1999). When metallic toxicants find their way into the body, they attack the proteins notably the enzymes. According to Ademoroti, (1996), the points of attack are the enzyme sulphur atoms and also the free amino (-NH_2) and carboxyl (-COOH) groups, if found in proteins. Once in the human system their toxic effects are cumulative and cause slow poisoning of the system over a period of time (Nriagu, 1988; Ukpebor et al., 2005). When enzymes and proteins in cell membranes in the body are attacked by the heavy metals and they interfere with the working order of the body system, the combined result of this attack leads to a variety of health problems ranging from cancer to heart diseases. The health problems associated with some heavy metals have been documented (WHO, 1972).

Cadmium (Cd) is a natural element in the earth's crust occurring in combination with zinc. Besides its natural occurrence, elevated Cd levels in air and dust in urban areas may be associated with emissions from burning of fuel (oil and coal), household wastes and motor vehicles (Shaheen, 1975; Manahann, 1994). Cd poisoning, results in deadly itai-itai disease, with symptoms of softening bones, body shrinkage and slow painful death (Ademoroti, 1996). Lead (Pb), a widespread contaminant gets into man through diet and inhalation. Its toxicity effects in humans include nausea, abdominal pains, uncoordinated body movement, stupor eventually producing coma and death (Fell, 1984).

The other metals analyzed in this study are copper (Cu), chromium (Cr) and zinc (Zn). These are essential trace metals required for maintenance of physiological functions. They however, exhibit toxic effects in excessively high concentrations. Acute toxicity of Cu results in hypotension, coma and death (Asonye et al., 2007). Cu has been reported to cause hemolytic anemia in man (Manzer and Schreiner, 1970). Cr is a known contaminant in aquatic environment (NAS, 1974), a vital component for the glucose tolerant factor (WHO, 1988). Though among the least toxic of the heavy metals, its toxicity damages the liver, lungs and causes organ hemorrhages (WHO, 1988; O'Flaherty, 1995). Zn is a ubiquitous essential element. Luckily, Zn does not accumulate with continued exposure; rather body content is modulated by homeostatic mechanisms that act mainly on absorption and liver levels (Walshe et al., 1990).

In Nigeria, heavy metals have been implicated in the upsurge of liver and kidney diseases, believed responsible for a high proportion of mortality caused by kidney and liver morbidity (Ndiokwere, 2004). Heavy metal intake have also been reported to be due essentially to drinking contaminated water and ingestion of contaminated food from the use of untreated surface waters (Idodo-Umeh, 2002; FEPA, 2003; Asonye et al., 2007).

In Ekpoma, Edo State, Nigeria, the Ibiekuma Stream is the main natural surface water and is the major source of potable water supply on which the population of the town and adjoining communities depend for drinking and other domestic uses. Although a local taboo prohibits fishing and consumption of the fishes of this stream by the inhabitants, there is evidence of poaching. With increasing cosmopolitan nature of the town and the accompanying influx of non-indigenes, together with the current onslaught of Christian religion on the traditional/cultural beliefs of the people, it is doubtful if the prohibition will last long. Besides, there is overriding desire for a cheap source of animal protein, which the fishes of this stream can provide.

The health risks associated with heavy metal poisoning in man and animal systems are of concern to environmentalists and government agencies and underscores the need for continuous research with a view to ameliorating the problems of environmental pollution by heavy metals. It is against this general background that this investigation was conducted. The specific objectives were to determine the levels of Cd, Cu, Cr, Pb and Zn in the water and fish of the stream; compare these levels with recommended WHO limits for drinking water and food fish, to ascertain the suitability of the stream for drinking, domestic and consumption purposes. The choice of the fish, *Parachanna obscura*, is based on the fact that it is very common in the stream and relished by the people.

MATERIALS AND METHODS

Sampling location

Ibiekuma Stream is a perennial First Order Rain Forest stream in Ekpoma, Southern Nigeria (Lat. 6.00°N, 6.06°S and Long. 6.00°E, 6.05°W). It drains Southern Ekpoma in a West-East direction and joins the Okhuo River further South before emptying into Ossiomon River, South East of Benin City. Samples were collected from two different locations. One from within the Ambrose Ali University campus designated upstream and the other from a rural setting 2 km further South which was designated downstream.

Sample collection, preparation and analysis

Water and fish samples were collected for this study. Samples were collected at the two main seasons in Nigeria: Wet and Dry Seasons for a total of eight months with sampling being done bimonthly. All samples were collected in pre-cleaned polythene bottles and bags. The glasswares were washed with concentrated trioxonitrate (V) acid and rinsed with distilled water (Ukpebor et al., 2007). All chemicals used were of analytical grade.

Water

Water samples were treated using concentrated nitric acid to preserve them and then refrigerated at 4°C until analysis. Water samples were not subjected to further treatment and were aspirated directly into the flames of an AAS-Solar 960 Unicam Series for metal determination.

Fish

Random fish samples of the fish were collected using a combination of traps, gill nets of various mesh sizes and baited hooks and lines. The fish samples were ice-packed and transported to the Laboratory. In the Laboratory, they were oven-dried to constant weight at 105°C and then ground to powder. 1 g of each fish powder was digested using a mixture of perchloric acid, concentrated nitric and sulphuric acids in a ratio 1:5:1 (Sreedevi et al., 1992) until colourless liquids were obtained. The total volume of each sample was made up to 20 ml with distilled water. The heavy metal concentrations of the resulting solution were determined using an AAS-Solar Unicam Series in air- acetylene flame.

RESULTS AND DISCUSSION

In the water samples collected from both upstream and downstream sampling locations in wet season, Zn recorded the highest mean concentration of 1.02 ± 0.41 mg/l (upstream location). The least mean concentration of 0.005 ± 0.002 mg/l was recorded for Cd and Pb (downstream location). In fish, Zn recorded the highest metal concentration of 36.2 ± 8.42 mg/kg at the upstream location. Cu followed with a mean concentration of 15.8 ± 3.22 mg/kg at the upstream location. Cd concentration was the least with 0.70 ± 0.22 mg/kg at the downstream location. Pb was not detected (ND) in fish samples from both locations during this season (Tables 1 and 2).

In the dry season, Zn also recorded the highest mean concentration among the metals. Zn values in water at the upstream location was 1.12 ± 0.51 mg/l, while at the downstream location, the value was 1.05 ± 0.34 mg/l. The metal with the least value was Pb with a low mean value of 0.007 ± 0.004 mg/l at the downstream location.

Table 1. Mean concentrations of heavy metals in water and fish obtained at the sampling stations in wet season.

Specimen	Location	Heavy metal concntration				
		Cd	Cr	Cu	Pb	Zn
Water (mg/l)	Upstream	0.006±0.002	0.008±0.003	0.003±0.02	0.005±0.003	1.02±0.41
	Downstream	0.005±0.002	0.005±0.004	0.02±0.01	0.005±0.002	0.85±0.21
Fish (mg/kg)	Upstream	0.95 ± 0.08	*5.1 ±1.39	*15.8 ±3.22	ND	36.2 ± 8.42
	Downstream	0.70 ±0.22	*3.6 ±1.64	*8.6 ±1.86	ND	34.5 ± 6.22

Table 2. Mean concentrations of heavy metals in water and fish obtained at the sampling stations in dry season.

Specimen	Location	Heavy metal concntration				
		Cd	Cr	Cu	Pb	Zn
Water (mg/l)	Upstream	0.01 ± 0.004	0.02 ± 0.01	0.05 ± 0.03	0.009±0.002	1.12 ± 0.51
	Downstream	0.008±0.004	0.01 ± 0.003	0.037 ± 0.03	0.007±0.004	1.05 ± 0.34
Fish (mg/kg)	Upstream	1.65 ± 0.76	*5.3 ±2.45	*19.0 ±5.22	ND	45.5 ± 7.46
	Downstream	1.15 ± 0.42	*4.8 ±1.62	*13.6 ±4.82	ND	36.6 ± 6.86

*Concentration above WHO recommended limit in food fish.

Table 3. Recommended Limits in drinking water and fish (WHO, 1972) and estimated global background levels of dissolved metals in freshwater (Borg, 1984).

Sample	Cd	Cr	Cu	Pb	Zn
Drinking water (mg/l)	0.05	0.05	1.0	0.05	5.0
Fish (mg/kg)	2.0	0.15	1-3	2.0	75
Background levels in freshwater (mg/l)	0.005 - 0.05	0.1 - 0.5	0.5 - 3.0	0.05 - 0.5	0.5 - 5.0

In the fish samples, the highest Zn mean value was 45.5 ± 7.46 mg/kg (upstream location), while the metal with the least mean value was Cd with a low value of 1.15 ± 0.42 mg/kg at the downstream location.

In both wet and dry season, the concentrations of all the metals investigated were higher at the upstream location than at the downstream location. The spatial variations in the data obtained are apparent from the fish samples collected in the dry season. These were a mean upstream value of 45.5 ± 7.46 mg/kg and a mean downstream value of 36.6 ± 6.86 mg/kg. A similar trend was observed in the water samples collected from the two stations. The differences observed in the data suggested that metal concentrations decreased as dilution took place away from the pollution source upstream. Similar observation has been reported in Ikpoba River (Ogbeibu and Ezeunara, 2002) and Kabul River, Pakistan (Khan et al., 1999).

Seasonal variations were also observed in the data collected. Higher values were obtained in the dry season than in the wet season (Tables 1 and 2). This situation is expected in view of the reduction in pollution in the wet season arising from increased dilution and water flow. It is to be noted that the river is at its highest volume and flow in the wet season.

Another striking observation in the data generated was the higher levels of heavy metals in fish in comparison to the levels in water. The observation indicated metal bioaccumulation in the fish. Fish have been reported to have the ability to concentrate metals in their bodies from the surrounding medium or food either by absorption or ingestion (Forstner and Wittman, 1981; Ademoroti, 1996). The concentration of a metal in a fish is the product of an equilibrium between the concentration of the metal in its environment and its rate of ingestion and excretion (NWSCA, 1985). Additionally, bio-magnification could have enhanced metal accumulation in this fish. Bio-magnification is a cumulative increase in the concentration of persistent metals in successive higher levels of the food chain (Porter et al., 1975; Forstner and Wittman, 1981). The fish, *P. obscura* is a voracious carnivore (Reed et al., 1967; Idodo-Umeh, 2003). It is conceivable that metals were bio-magnified along the food chain, as the fish preys on lower organisms in the ecosystem.

The levels of all the metals recorded in water in this study were below WHO (1972) recommended limits in drinking water and within the estimated global background levels of dissolved metals in freshwater (Borg, 1984; Table 3). Consequently, it could be inferred that the water of this stream can be used for domestic purposes like washing of clothes, cars, etc. and also for drinking as the levels of these metals could not pose any health hazards for now.

The results of the analysis of the fish samples showed that the levels of Cd, and Zn were within WHO recommended limits in food fish. Pb was not detected in the fish samples. Thus it could be inferred that Cd, Zn and Pb in fish posed no health hazard. However, the levels of Cr and Cu in fish exceeded WHO limits. As far as Cr and Cu are concerned, Ibiekuma Stream fish could be said to be unfit for human consumption. Zn, Cr and Cu are, however essential trace metals in the aquatic environment (Bryan, 1976). Their supply in sufficient concentrations results in optimum conditions, though oversupply results in toxic effects.

Conclusion

The results obtained from this investigation indicate that the water from Ibiekuma Stream with regards to these heavy metals can be utilized for drinking and other domestic purposes like washing of clothes, cars, etc. The consumption of the fishes of the stream requires stringent precautionary measures because of the high levels of Cr and Cu which exceeded limits in food fish and could therefore pose some health risks.

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