CONCENTRATION OF MERCURY IN FISH FROM NUNGWE BAY OF LAKE VICTORIA: PUBLIC HEALTH IMPLICATION

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SUMMARY

In the present study we investigated accumulation of mercury (Hg) in fish collected from Nungwe bay in Lake Victoria, an area known to be at risk for Hg contamination from Mugusu small-scale gold mine. Fish samples were acid-digested, and levels of Hg determined by atomic absorption spectrophotometer under the cold vapour technique. Total Hg concentration varied with fish species and sizes. While Hg levels in sardine (*Rastrineobola argentea*), furu (*Haplochromines* spp), and lung-fish (*Protopterus aethiopicus*) samples were below the limit of detection, mean total Hg levels for Nile perch (*Lates niloticus*), Tilapia (*Oreochromis niloticus)* and Catfish (*Clarias gariepinus*) were 0.41 ± 0.041, 0.24 ± 0.014, and 0.53 ± 0.17 µg/g respectively. There was a significant positive correlation between total Hg concentration and fish length for Nile perch ($r = 0.5608$ and $P<0.05$). Except for large Nile perch and catfish the average Hg concentration for other sizes were below the safety limits for Canada, Brazil, Finland, Sweden, Japan, the European community and WHO. Based on our results it is suggested that, eating tilapia and average sized Nile perch from Nungwe bay is safe but caution should be exercised for eating catfish and large Nile perch.

INTRODUCTION

The threat of environmental mercury (Hg) exposure to human health has been known for over five decades following the consumption of Hg contaminated fish in Japan (Harada, 1995) and of contaminated grain in Iraq (Bakir *et al.*, 1973). In the aquatic ecosystem, Hg undergoes methylation to its organic form methylmercury (MeHg), which magnifies through the food chain and bioaccummulate in fish (Pak and Bartha, 1998). Therefore, communities, which depend mainly on fish diet, can be easily exposed to large quantities of MeHg. Riverine population of the Amazon Basin which heavily depend on fish consumption for their nutritional needs, have been found to have elevated levels of MeHg in hair and urine (Akagi *et al.*, 1995; Barbosa *et al.*, 1995; 1997; 1998; 2001;

Lebel *et al.*, 1998; Kehrig *et al.*, 1998; Olivero *et al.*, 2002). Tuija and Lodenius (2001) investigated a fishing community around the Tucuru`I water reserve in Parà state Brazil and found that Hg concentration in hair samples were as high as 240 mg/kg, which were considered high enough to cause ill health.

For the last decade, there have been considerable amount of research about environment contamination with Hg in Lake Victoria, Tanzania (Ikingura and Akagi, 1996; Ikingura *et al.*, 1997; LVEMP, 2002; Taylor *et al.*, 2005). These studies have been triggered by concerns about the gold ore processing practices in artisanal gold mines around the lake. The primary gold recovery method used by miners involves crushing of ore followed by amalgamation with Hg. Mugusu Small Scale gold mine, which is found in Geita district, is one of the active mines. It is located ten Kilometres from Nungwe bay of lake Victoria, this bay is known to be at risk for Hg contamination because it is the main draining point for the mine (Ikingura and Akagi, 1996). Increased levels of Hg in Nile perch fish caught from the Nungwe bay have been reported (Machiwa *et al.*, 2003). However, there is no information about Hg concentration in other variety of fish, which are consumed by the local communities. In this paper we report the public health implication of the concentration of Hg in Nile perch (*Lates niloticus*), tilapia (*Oreochromis niloticus*, furu (*Haplochromines* spp), catfish (*Clarias gariepinus*), sardine (*Rastrineobola argentea*) and lung fish (*Protopterus aethiopicus*), and their public health implication.

MATERIALS AND METHODS

Study Area and Fish Sampling

This study was conducted in Nungwe bay of Geita District, Mwanza region in July to November, 2005. Nungwe bay is located approximately 10 km down stream from the Mugusu small scale gold mine. Species of fish were purchased at two landing sites in the bay. A total of 79 specimens of fish were collected. The represented species were Nile perch (n = 33), tilapia (n = 27), catfish (n = 6), sardine (n = 10) and lungfish (n = 3). At collection, the fish were identified, weighed and their length measured. An approximately 100g of muscle tissues were removed from the dorsal area of Nile perch, tilapia, catfish and lungfish, while whole sardines were sampled and individually preserved in a nitric acid washed glass containers with tight caps and kept in a cooler box until brought to the laboratory in the nearby (Mwanza) city, where the samples were frozen to await analysis

Determination of Hg in the samples

Two grams (2 g) of each fish sample was acid-digested by using diluted nitric acid ($HNO3:H_2O$ = 2:1) at 130°C for 2 h. Undissolved particles were filtered off and the solution diluted to 25 ml with deionized water. The concentration of Hg was determined using Atomic Absorption Spectrophotometer (AAS), Varian model Spectra A55 under cold vapour technique after reduction with $SnCl_2$. Acid washed glassware, analytical grade reagents and double distilled water were used in the tissue analysis. In order to check purity of the chemicals used, one chemical blank was run after a very five samples. Analytical quality control was ensured through the analysis of certified reference material DORM-2 (Dogfish muscle) from National Research Counsel Canada, which has 4.64 ± 0.26 µg/g certified level of Hg. The calculated recovery percentage ranged from 96 to 100, which were considered adequate, therefore results of analysed samples was not corrected for recovery.

Data analysis

Data of Hg concentrations in muscles of different species of fish were tested for normality and homogeneity using the Shapiro-Wilkinson test. The differences between Hg concentrations in different species of fish were determined by one-way analysis of variance (ANOVA) (STATISTICA version 6.0). Results were considered significant if p was below 0.05. The relationship between Hg concentration and fish length was done using the general linear regression model. Data were normal log-transformed before analysis to meet the underlying assumptions of the tests; the average values reported are therefore geometric mean ± SEM of wet weight.

RESULTS

Fish Hg Levels

Total Hg concentration ranges in fish from Nungwe bay is shown in Table 1. Hg levels in fish varied with species alimentary habits and sizes of fish. The mean Hg levels were 0.41 ± 0.041, 0.24 ± 0.014, and 0.53 ± 0.17 µg/g Hg for Nile perch, tilapia and catfish respectively. Considering the health effect of MeHg, samples with levels below the limit of detection were assigned 0.2 µg/g value which was the limit of detection, and they were registered in 40%, 46% and 33% of Nile perch, tilapia and catfish samples respectively. All collected specimens of sardine (10), furu (10) and lungfish (3) were below the limit of detection and were not included in calculating MeHg intake. In this study, the relationships among Hg concentrations in fish and total length were evaluated. Total length was preferred to body weight in generating the

relationship between Hg and fish size according to the recommendation in the protocol for environmental and health assessment of Hg released by artisanal and small-scale gold miners (UNIDO, 2004). There was a significant correlation between total Hg concentration and fish length for Nile perch (Figure 1) with r = 0.5608 at P = 0.00068. On the other hand, there was weak and statistically not significant correlation between total length and Hg concentration for tilapia fish (Figure 2) with r = 0.3654 at P = 0.079. Hg levels in large sized Nile perch and tilapia were 0.76 ± 0.05 and 0.29 ± 0.04 µg/g respectively (Table 2).

Table 1. Mean ± SEM of Hg concentrations (wet weight) in the muscles of fish

Type of Fish	N	Mean weight (g) (Range)	Mean Length (cm) (Range)	Mean Hg (µg/g) (Range)
Nile perch	33	620 ± 93.34 (100 - 2000)	33 ± 1.82 (20 - 59)	0.41 ± 0.041 (0.2 - 1.0)
Tilapia	27	484.44 ± 73.02 (120 - 1250)	24.67 ± 1.27 (14.5 - 36.5)	0.24 ± 0.014 (0.2 - 0.53)
Catfish	6	962.5 ± 56.69 (800 - 1200)	43.08 ± 2.39 (36 - 52)	0.533 ± 0.17 (0.2 - 1.25)

Table 2. Mean ± SEM Hg of concentrations (wet weight) in the muscles of different fish according to size from Nungwe bay, Tanzania- 2005

Fish type and category	N	Weight (g)	Length (cm)	Hg (µg/g)
Nile perch (Small)	18	245 ± 35.11	25.2 ± 0.99	0.287 ± 0.029
Nile perch (Medium)	10	776.4 ± 45.63	38.3 ± 0.99	0.47 ± 0.078
Nile perch (Large)	5	1,660 ± 150.33	50.6 ± 2.39	0.76 ± 0.05
Tilapia (Small)	7	167.14 ± 15.54	18.43 ± 0.72	0.22 ± 0.012
Tilapia (medium)	12	309.17 ± 18.88	22.3 ± 0.013	0.28 ± 0.013
Tilapia (Large)	8	1025 ± 70.08	33.7 ± 1.09	0.29 ± 0.04

Catfish (small)	6	962.5 ± 138.85	42.08 ± 2.39	0.533 ± 0.17

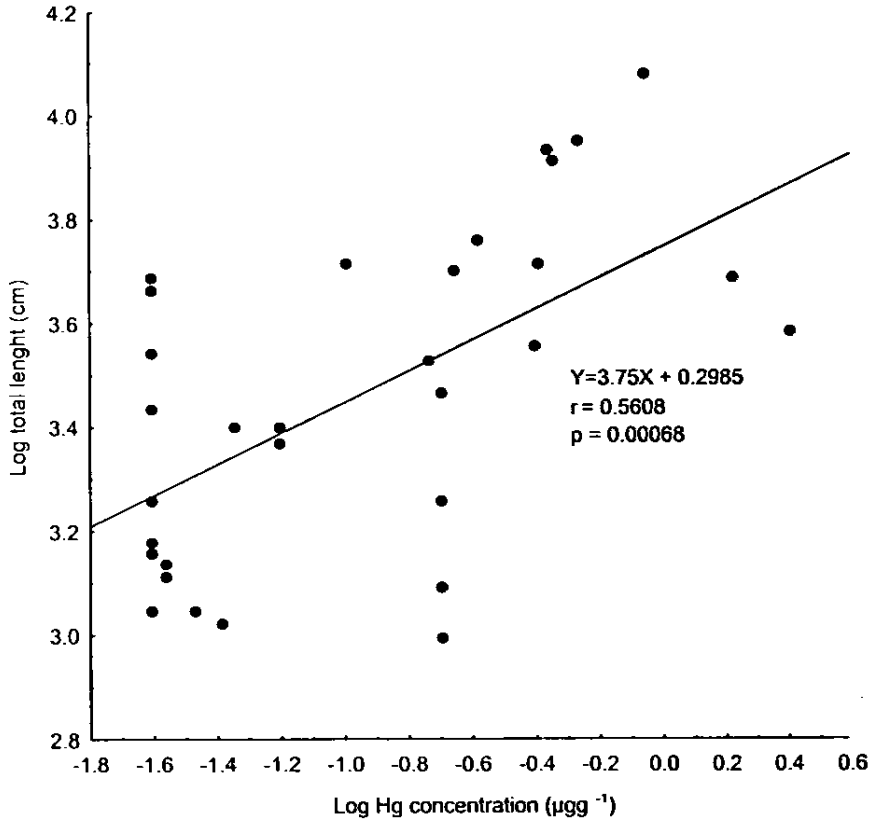

Figure 1. Relationship between Hg concentration and total length of Nile perch fish from Nungwe bay, Tanzania

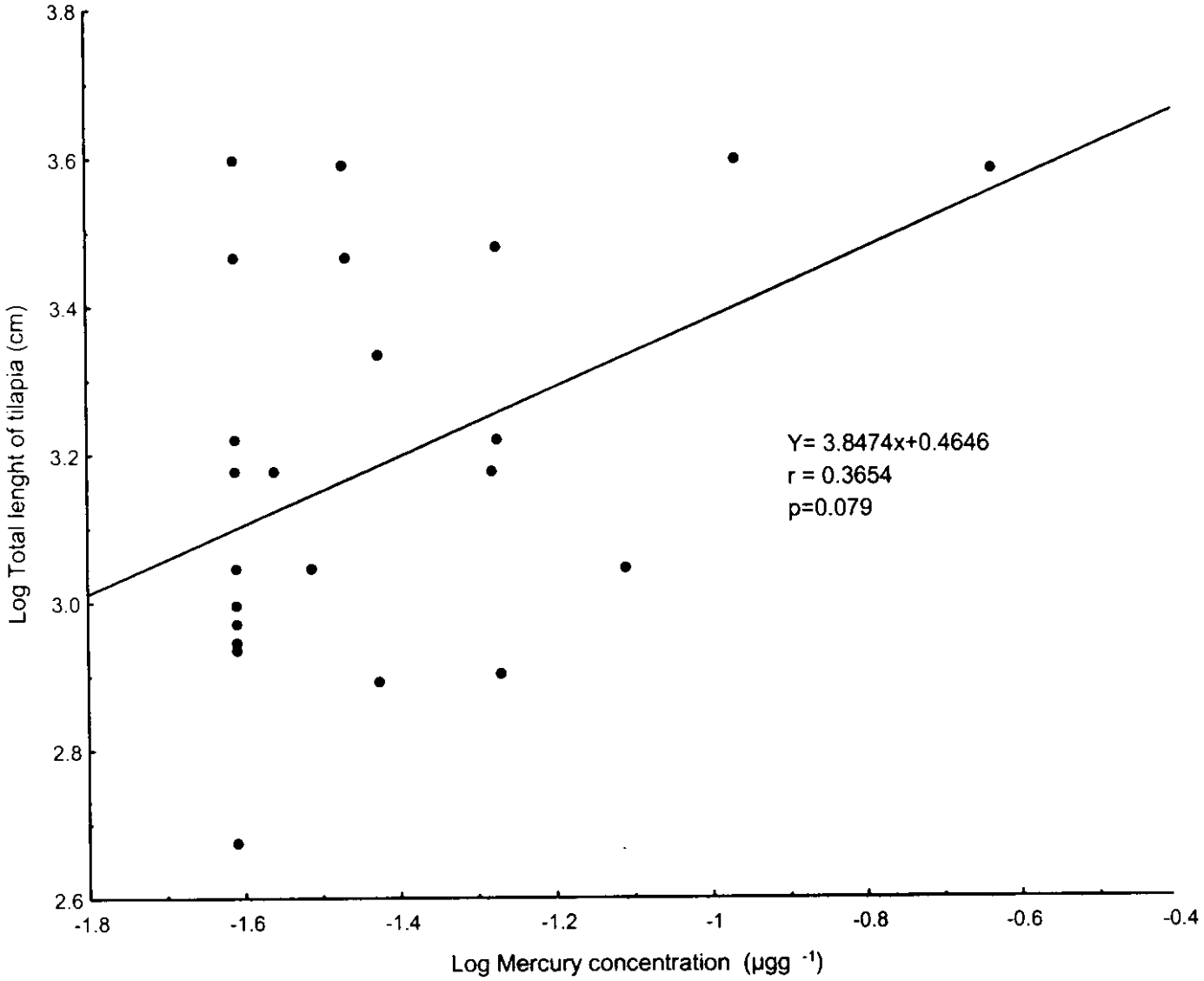

Figure 2. Relationship between Hg concentration and total length of tilapia fish from Nungwe bay, Tanzania

DISCUSSION

Mercury levels in fish varied with type of fish and size. The average levels of Hg decreased in the order of catfish (0.533 ± 0.17 µg/g), Nile perch (0.41 ± 0.041µg/g), and tilapia (0.24 ± 0.014µg/g) (Table 1). The variability of Hg levels among the different species is in accordance with the process of uptake of this metal in fish and the interaction of numerous parameters, either abiotic (water and sediments) or biotic (size, sex, longevity, growth rate, feeding habits, trophic position and habitat). It has been widely documented that benthic feeders show higher total Hg levels in their muscles than pelagic species, confirming the vital process of sedimentation and persistence of metals in the lake sediment (Campbell *et al.*, 2003b). In this context, catfish, a benthic feeder, that leave in close proximity with the upper layer of sediment, showed high levels of Hg than the more pelagic species. Hg

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