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Assessment of trace metals in fish species of urban rivers in Bangladesh and health implications

Md Saiful Islam[a,b,*], Md Kawser Ahmed[c], Md Habibullah-Al-Mamun[a,d], Shigeki Masunaga[a]

[a] Graduate School of Environment and Information Sciences, Yokohama National University, 79-7 Tokiwadai, Hodogaya-ku, Yokohama, Kanagawa 240-8501, Japan
[b] Department of Soil Science, Patuakhali Science and Technology University, Dumki, Patuakhali 8602, Bangladesh
[c] Department of Oceanography, University of Dhaka, Dhaka 1000, Bangladesh
[d] Department of Fisheries, University of Dhaka, Dhaka 1000, Bangladesh

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ABSTRACT

Levels of six metals i.e. chromium (Cr), nickel (Ni), copper (Cu), arsenic (As), cadmium (Cd) and lead (Pb) in three fish species (*Channa punctatus*, *Heteropneustes fossilis* and *Trichogaster fasciata*) from three urban rivers in Bangladesh were measured. Concentrations of Cr, Ni, Cu, As, Cd and Pb in fish species were 0.75–4.8, 0.14–3.1, 1.1–7.2, 0.091–0.53, 0.007–0.13, and 0.052–2.7 mg/kg ww, respectively. The analyzed metals were significantly different between species and seasons ($p < 0.05$). The target hazard quotients (THQs) and carcinogenic risk (CR) for individual metal showed that As and Pb in muscle was particularly hazardous and potential risk for the low, medium and high fish consumer in Bangladesh. Some of the trace metals' concentrations are higher than the recommended value, which suggest that the water and fish of these rivers are not completely safe for human health.

1. Introduction

Contaminations of aquatic ecosystems with trace metals have been receiving worldwide attention especially in developing countries like Bangladesh and have become a challenge for the world scientists (Islam et al., 2014a; Ghaedi et al., 2008). Metals and metalloids from natural and anthropogenic sources can enter the aquatic environment and pose serious threat because of their toxicity, long persistence, bioaccumulation and biomagnifications in the food chain (Islam et al., 2014a). Therefore, trace metals have been widely studied for their toxic effects and bio-accumulation in food chains (Tao et al., 2012). The rapid development of industry and agriculture has resulted the increasing trend of metal pollution, which has a significant hazardous impacts for invertebrates, fish and human (Yi et al., 2011). Studies have shown that urban and industrial development contributes metal contamination in water environment and aquatic organisms (Tao et al., 2012; Islam et al., 2014a). Many industries have been set up in and around Dhaka City during the last decades and the number of new industries are continually increasing. As a direct

* *Corresponding author at*: Graduate School of Environment and Information Sciences, Yokohama National University, 79-7 Tokiwadai, Hodogaya-ku, Yokohama, Kanagawa 240-8501, Japan. Tel.: +88 01717372057.
E-mail addresses: islam-md.saiful-nj@ynu.jp, saiful@pstu.ac.bd (M.S. Islam).

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consequence, the amount of untreated wastewater being discharged into the adjacent rivers (Turag, Buriganga and Shitalakha) of the city and is increasing day by day. That is why, in the lean flow period of dry season (November to May), the water quality of these rivers can reach much lower than required for the sustainability of aquatic life, therefore, posing a severe threat to the aquatic ecosystem (Ahmad et al., 2010). Besides, these rivers are increasingly being polluted with the city's thousands of industrial units and sewerage lines that are continuously dumping huge volumes of toxic wastes into these rivers (Ahmad et al., 2010; Islam et al., 2014a). Over exploitation, mismanagement and improperly treated industrial effluents from more than thousand industries were continuously discharged into the surrounding rivers of Dhaka city, which brings a great challenge for the ecosystem balance.

Large number of different types of water bodies both inland and marine makes Bangladesh one of the most suitable countries of the world for freshwater aquaculture. The freshwater inland aquaculture production in Bangladesh is the second highest in the world after China (FAO, 2006). The total annual fish production is estimated at 2.90 million tons in 2010-11 (Bangladesh fiscal year: 1 July–30 June), of which 1.35 million tons (46.62%) are obtained from inland aquaculture, 1.02 million tons (35.53%) from inland capture fisheries, and 0.52 million tons (17.85%) from marine fisheries (DOF, 2011). Fish is an important part of human diet as well as a good indicator of environmental contamination by a number of substances, including trace metals. Fish has been considered as the top of the food chain in the aquatic ecosystems (Zhao et al., 2012). In Bangladesh, fish farming is currently one of the most important sector of the national economy. Within the overall agro-based economy of the country, the contribution of fish production has been considered to hold good promise for creating jobs, earning foreign currency and supplying protein. About 97% of the inland fish production is marketed internally for domestic consumption while the remaining 3% is exported (Hasan, 2001). Daily consumption of fish for adult residents are 71.84, 87.16 and 127.4 g for low, medium and high fish consumers. Among these consumer groups, the average consumption is 95.47, 668 and 2864 g for daily, weekly and monthly basis. Fish being an aquatic animal are exposed severely to metal pollution. Essentially, fish assimilate metals by ingestion of particulate material suspended in water, ingestion of food, ion-exchange of dissolved metals across lipophilic membranes, e.g., the gills, and adsorption on tissue and membrane surfaces (Ahmed et al., 2014). However, trace metals pollution in fish has become an important worldwide concern, not only because of the threat to fish, but also the health risks associated with consumption. For example, lead causes renal failure and liver damage (Lee et al., 2011). Moreover, prolonged exposure to lead will result in coma, mental retardation and even death (Al-Busaidi et al., 2011). Cadmium injures the kidney and causes symptoms of chronic toxicity, including impaired kidney function, poor reproductive capacity, hypertension, tumors and hepatic dysfunction (Rahman and Islam, 2010; Al-Busaidi et al., 2011). Chromium and Cu causes nephritis, anuria and extensive lesions in the kidney (Rahman and Islam, 2010). The nature of effects can be toxic (acute, chronic or sub-chronic), neurotoxic, carcinogenic, mutagenic or teratogenic (European Union, 2002). Therefore, trace metal contamination in fishes is increasing global attention.

In Bangladesh few studies have been conducted on the concentration of trace metals in water, sediments, fish and other aquatic animals of some rivers (Ahmad et al., 2010; Rahman et al., 2012; Islam et al., 2014a). Although no detailed study on trace metals concentration in the studied fish species have been conducted so far and metal toxicity data severely insufficient to accomplish the risk assessment. Accordingly, there is a need for detailed information in order to achieve health risk assessment for the fish consumers in Bangladesh. Therefore, the present study aimed to evaluate the concentration of Cr, Ni, Cu, As, Cd, and Pb in water and three mostly consumed fish species and to assess the human health risk due to fish consumption.

2. Materials and methods

2.1. Study area

This study focused on three major rivers "Turag, Buriganga and Shitalakha" around Dhaka City, Bangladesh (Fig. 1). The Basic information of sampling sites are presented in Table S1. The bank of these rivers has turned into unplanned industrial areas. The metropolitan area of Dhaka is about 815.8 km^2 and located at the center of Bangladesh. The Dhaka City is one of the most densely populated in the world, home to approximately twelve million people of which less than 25% are served by sewage treatment facility (Ahmad et al., 2010; Islam et al., 2014a). These rivers are used as a convenient means for disposing of domestic raw sewage as well as untreated industrial waste effluents from surrounding habitation and nearby industrial belt. No information is available regarding the levels of trace metals in water and fish species of these rivers. Therefore, these rivers have been selected for the present study.

2.2. Sample collection and preparation

The sampling was conducted during February–March 2012 (winter) and August–September 2012 (summer), respectively. About 36 water samples were collected from three different rivers. Immediately after collection, water samples were transferred into acid cleaned 100 mL polypropylene bottles and stored in refrigerator in the department of Fisheries, University of Dhaka, Bangladesh. About 54 samples of three mostly consumable fish species – spotted snakehead (*Channa punctatus*), stinging catfish (*Heteropneustes fossilis*) and banded gourami (*Trichogaster fasciata*) were collected from the same sites of water sample. Immediately after collection, fish samples were transported to the Department of Fisheries, Dhaka University, Bangladesh. After transportation to the laboratory, non-edible parts were removed with the help of a steam cleaned stainless steel knife. The edible portion (muscle tissues) of the fish samples were then washed with distilled water and cut into small pieces (2–3 cm) using the cleaned knife over a clean polyethylene sheet. After cutting, the samples were then freeze dried about 48 h until the constant weight was attained. The processed samples were brought to Yokohama National University, Japan for chemical analysis.