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Assessment of metal bioaccumulation in *Mastacembelus armatus* (eel) and exposure evaluation in human

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ABSTRACT

Present study deals with the physico-chemical and metal (Cr, Mn, Fe, Co, Ni, Cu, Zn, Cd and Pb) quantification in river Ganga water and bioaccumulation of metals in vital organs (gill, liver and muscle) of *Mastacembelus armatus*. River water quality indicated that industrial effluents may be prime source of metal pollution in river Ganga. Higher organosomatic index in fish samples from downstream revealed the impact of higher metal concentration on vital organs. Metal pollution index was found highest in gill followed by muscle and least in liver. Metal concentration in muscle was compared with the FAO permissible guidelines which revealed that concentration of Cr, Cu and Cd were many folds higher than the permissible guidelines. Effective ingestive dose was calculated to assess the adverse impact caused by dietary exposure of studied metals and it was found that concentration of Cr, Cd and Pb was higher than the permissible concentration given by USEPA.

1. Introduction

Wastewater discharged from anthropogenic activities carry higher concentration of metals which ultimately is being released into aquatic ecosystem (Suthar et al., 2009). Metals are believed to be persistent pollutants as their degradation rate is too slow while half life period is too long (Chabukdhara and Nema, 2012; Jain, 2004; Kelepertzis et al., 2012). The hazardous effects of higher concentration of toxic metals have been extensively documented in previous reports (Christensen, 1995; Goyer, 2004; Jarup, 2003). Metals may enter into biotic components through direct or indirect exposure and get accumulated in the vital organs of aquatic organisms. Through food chain and web, metals are transferred and magnified from one trophic level to another.

Fishes are the excellent bio-indicator of metal pollution load in aquatic ecosystem because it is situated on higher trophic level in an aquatic ecosystem. Additionally, fish is a vital component of non-vegetarian diet which provides high quality protein, amino acid (lysine, sulfur containing amino acids, etc.), iodine, calcium, trace elements (Mn, Fe, Cu, Zn, Se, etc.), vitamins and omega-3-polyunsaturated fatty acid (Ashwani and Ashok, 2006; Mishra and Mohanty, 2008; Rani and Sivaraj, 2010; Qiu et al., 2011). Fish can be exposed directly or indirectly to metal in the environment. Metal accumulation in gill indicates the concentration of metal in water while metal concentration in liver signifies long term metal storage. Muscle is considered as inactive metal accumulation site (Alhashemi et al., 2011; Yilmaz, 2003; Pandey et al., 2014). Metal toxicity adversely affects the metabolism of the fish. It has been very well established in earlier studies that hyper bioaccumulation of metals in vital organs of the fish causes histopathological alterations, significant change in hematology, blood glucose, muscle glycogen and biomolecules (Fatima et al., 2014; Fatima et al., 2015; Javed and Usmani, 2013, 2015a,b; Javed et al., 2015, 2016a,b,c).

Ever rising pollution in river Ganga, the National River of India, has attracted the attention of scientific community worldwide. Anthropogenic activities like agriculture run off, discharge of untreated effluents are responsible for metal pollution (Pandey et al., 2014). Therefore, the aim of the present study was to quantify the trace metals (viz. Cr, Mn, Fe, Co, Ni, Cu, Zn, Cd and Pb) in river water vis-à-vis in fish samples collected from the river Ganga. *Mastacembelus armatus* species has been selected as the test organism in the present work because it is an important constituent of non-vegetarian diet of the people living in Indo-Gangetic plain. Besides this, it forms large fraction of fish population in river. *M. arma-*

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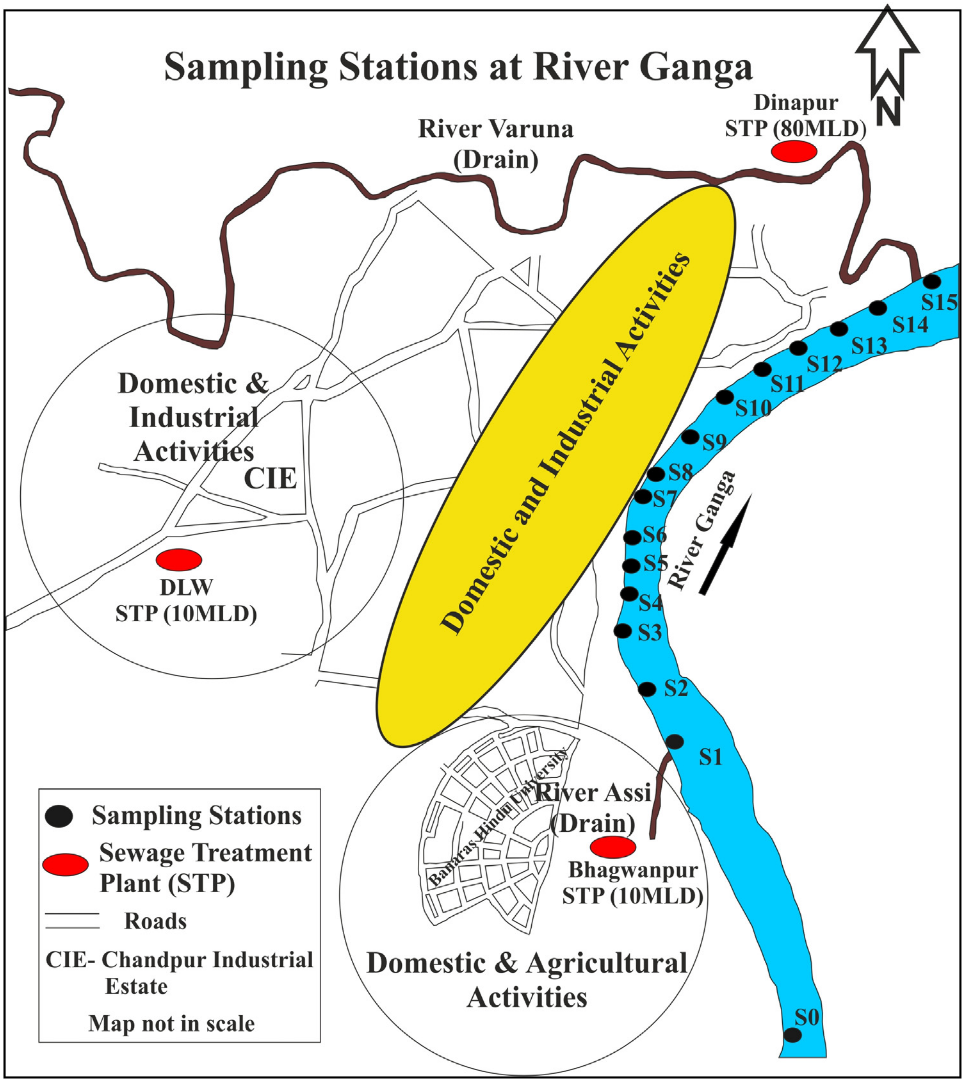

Fig. 1. Sampling stations (Adapted from Pandey et al., 2014).

tus (Eel; also known as Bam) is a nocturnal, carnivorous, bottom dweller and burrower fish having snake like body with no pelvic fins. It may attain a maximum length of 90 cm. It feeds upon insects, molluscs, crustaceans, larva, and small fishes etc. Effective ingestive dose (EID) for heavy metals in human by the consumption of metal accumulated fish has been also calculated as discussed elsewhere (Alhashemi et al., 2012).

2. Materials and method

2.1. Study region

Varanasi (25° 16′ 55″ N 82° 57′ 23″ E, 76 m amsl) is situated at the left bank of the river Ganga. Over 7000 micro, small and large scale registered industries (locomotive and metal works; textile, dye and glass industries) are situated in and around Varanasi city which discharge effluents having high concentration of heavy metals (DIP, 2014). Owing to unavailability of metal removing technologies these industries continuously discharge metals bearing effluents in the aqueous environment (Tripathi et al., 1991).

2.2. Sampling and analysis

Samples of river water were collected from sixteen sampling stations from S0 (Shooltankeshwar) to S15 (Varuna-Ganga confluence) (Fig. 1). The length of entire sampling stretch was 20 km (S0–S1 10 km; S1-S15 10 km). S0 was reference site at upstream of the river as least anthropogenic activities were found over there. Water samples were collected in PTFE bottles following standard protocols (APHA, 2005) and immediately carried to laboratory under low temperature (4 °C). Non-acidified samples were used to assess physical parameters while acidified samples were used to evaluate metal concentration in river water using flame Atomic Absorption Spectrophotometer (AAS) (AAnalyst 800-Perkin Elmer).

Five samples each of *M. armatus* were collected from reference (S0) and downstream site (S8) with the help of professional fishermen using traditional net practice method. Homogeneity in weight and length of the fish samples was tried to be maintained throughout the sampling. Fish samples were transferred to the laboratory in river water. Anaesthetized fish samples were dissected to get gill, liver and muscle (mid-abdomen) tissues. Acid digestion ($HNO_3 + H_2SO_4 + HClO_4$ v/v) of tissues was done in Teflon vessels for 60–120 min on hot plate (125–140 °C) to get a clear solution (ASTM, 2011). Final volume (100 ml) of digested samples was made up using Millipore water and metal analysis was done by flame