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ORIGINAL ARTICLE

Monitoring of trace metals in tissues of *Wallago attu* (lanchi) from the Indus River as an indicator of environmental pollution

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Abstract We aimed to assess the bioaccumulation of selected four trace metals (Cd, Ni, Zn and Co) in four tissues (muscles, skin, gills and liver) of a freshwater fish *Wallago attu* (lanchi) from three different sites (upstream, middle stream and downstream) of the Indus River in Mianwali district of Pakistan. Heavy metal contents in water samples and from different selected tissues of fish were examined by using flame atomic absorption spectrometry. The data were statistically compared to study the effects of the site and fish organs and their interaction on the bioaccumulation pattern of these metals at $P < 0.05$. In *W. attu* the level of cadmium ranged from 0.004 to 0.24; nickel 0.003–0.708; cobalt 0.002–0.768 and zinc 47.4–1147.5 μg/g wet weight. The magnitude of metal bioaccumulation in different organs of fish species had the following order gills > liver > skin > muscle. The order of bioaccumulation of these metals was Ni < Zn < Co < Cd. Heavy metal concentrations were increased during the dry season as compared to the wet season. The results of this study indicate that freshwater fish produced and marketed in Mianwali have concentrations below the standards of FEPA/WHO for these toxic metals.

1. Introduction

Water pollution is an appalling problem, powerful enough to lead the world on the path of destruction. Water is an easy solvent, enabling most pollutants to dissolve in it easily and contaminate it. Organisms and vegetation that survive in water directly suffer the most basic effect of water pollution. Pollution in freshwater ecosystem, particularly, heavy metal contamination may be one of the most important worldwide ecological problems in the future (Virha et al., 2011).

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Pollution of the Indus River by heavy metals is a major problem in Pakistan. Different human activities on land, water and air contribute to the pollution of River Indus in Pakistan (Jabeen and Chaudhry, 2010). The River Ravi is a classic example of pollutants due to dumping of untreated domestic and industrial wastes, resulting in a high level of impurities in water. It is calculated that nearly 48 percent of the overall pollution discharged into the River Indus comes from the River Ravi. Now, the River Ravi is no more a River but a sludge carrier. It is said that pollution has led to the extinction of 42 species of fish. The wastewater discharged into the Ravi flowed to Balloki Headworks from where it ended up as irrigation water for crops in southern Punjab (Mahboob et al., 2014).

The Indus River with 970,000 km^2 drainage basin area is one of the world's major discharge and sediment load River. It is contaminated with industrial and domestic sewage. Rapid industrialization (cement, cotton ginning and pressing, fertilizers and flour mills) has also increased the level of contamination by the release of unrefined waste products into the River Indus. The inhabitants along the bank of River contribute to the pollution by directly throwing domestic sewage and excretory waste products into the River Indus. All these sources of pollution contain toxic heavy metals and other dangerous substances that affect the aquatic system (Jabeen and Chaudhry, 2010).

Environmental pollutants such as metals change genetic, physiological, biochemical and behavioral parameters of fish and other aquatic organisms (Scott and Sloman, 2004). While trace metals are very important for normal physiological processes, abnormally high accumulation can be toxic to aquatic organisms (Uysal et al., 2008). Metals tend to bioaccumulate and cause danger to humans and aquatic environment (Obnasohan et al., 2008). Heavy metals cannot be destroyed through biological degradation and have adverse effects to the aquatic system and eventually to humans, who depend on aquatic products as a source of food (Ashraf, 2005).

In aquatic ecosystem fish can be successfully use as a bio-indicator for heavy metals' pollution. The distribution of metals between different tissues depends on the way of exposure (environmental or dietary) (Alam et al., 2007). From water fish accumulates large amounts of metals which may be toxic for human consumption (Malakootiani et al., 2011). Yousafzai et al. (2010) reported that the level of heavy metal intake in aquatic system causes an extra stress on fish that in turn concentrate metals in metabolically active organs and tissues.

Heavy metals from the industrial sources are constantly released into the aquatic environment (Klavins and Potapovics, 2009) which in turn are accumulated and cause harmful effects on aquatic organisms (Funes et al., 2006). Jabeen and Chaudhry (2010) reported the increased water pollution in the Indus River was due to its reduced water flow which has resulted in the reduction of its natural assimilative ability. They further mentioned that this River receives raw sewage from various sources during its flow through mainly the big cities in the form of untreated industrial wastewater and irrigation returns from the surrounding communities. The increased levels of contaminants from sewage, toxic compounds from industrial discharges and pesticides from irrigation returns have caused a rise in waterborne diseases and decline in the number and diversity of fish and other aquatic species in Indus River. This study was planned in Mianwali district keeping in view the above mentioned reports and scarcity of information on the impact of water pollution on fish in this comparatively less developed region along the stretch of the Indus River. *Wallago attu* has undergone a significant decline due to overexploitation as a food fish throughout its range. Unfortunately, only limited reports are available on this commercially important fish species in the region. The present study was aimed to compare the bioaccumulation and seasonal variation of selected heavy metals in four tissues of *W. attu* and water from three locations of the Indus River in Mianwali District. This information may be used to formulate a strategy for appropriate monitoring and to control freshwater pollutions and the suitability of freshwater fish species in the Indus River.

2. Materials and methods

2.1. Sampling site specifications

Mianwali is located in the Punjab province and is approximately 200 m above the sea level (Fig. 1). This district contains nuclear power plants, Chashma Barrage and the Chashma Hydel power plant. In this district coal, metal and trace element deposit, fire clay, dolomite, gypsum, salts, marble and rocks are excavated for profitable purposes. Maximum temperature of Mianwali ranges about 51 °C during summer season while in winter a minimum of −2 °C is recorded with 250 mm of usual rainfall (Jabeen and Chaudhry, 2010). There are about 259 small to large industries including cement, penicillin, cotton ginning and pressing, drugs and pharmaceuticals, fertilizer, flour, oil and power generation. This study was conducted at three sites Kundian (upstream), Chashma (middle stream) and Kalabagh (downstream) along the stretch of the Indus River in Mianwali, which were 40 km apart from each other. These sites were receiving domestic and municipal wastes and agricultural runoffs. During its course, some pollutants from agricultural runoffs and domestic and municipal wastes enter into the Indus River at CH where water is stored for power generation.

2.2. Water sampling

Water samples were collected from all the sampling sites in polypropylene bottles on a monthly basis from March 2011 to September 2011. Before sample collection, all bottles were washed (with dilute acid and then with River water). All bottles were labeled with date and sampling station for heavy metal analysis. Replicated water samples of about one liter were collected from about 30 cm depth of the surface water from the selected locations. The water samples were preserved in 55% HNO_3 and stored at 4 °C in the refrigerator.

Temperature, pH, and electrical conductivity (EC) of water samples were measured immediately using a temperature probe and a pH and conductivity meter (720 WTW Series 82362 Wellehein, Germany). Dissolved oxygen (DO) and Total Dissolved Solids (TDS) were determined using standard methods as described by (SMEWW, 1989).

Standard methods as described by the AOAC (1990) were followed for the determination of various parameters of these water samples. All chemicals were purchased from Sigma and were of analytical grade. Preserved water samples (100 mL)