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Assessing the health of marine and lacustrine wetland using measurement of heavy metals in fish species: Case study from two Iranian international wetland (Gomishan and Zarivar)

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ABSTRACT

Wetlands are highly sensitive to pollution effects as they are usually low lands in comparison to the surroundings. Consequently, pollution with heavy metals in the wetlands ecosystems may have changed the ecosystem's biogeochemistry. Gomishan and Zarivar wetlands are regarded as two of the most important wetland regions in south eastern corner of Caspian Sea and in Western Iran respectively. We report the results from a detailed research based on two metals (Pb and Cd) measured in muscle of two fish species (*Cyprinus carpio* and *Liza saliens*) from Gomishan and Zarivar wetlands. Twenty three leaping mullet (*Liza saliens*) fish samples (from the 9 stations) and twenty common carp (*Cyprinus carpio*) were collected in year 2013 from Gomishan international wetland and Zarivar wetland respectively. Using a hot-block digester, the muscle samples were digested with a combination of perchloric acid (HCLO4) and nitric acid (HNO3) and then examined by atomic absorption spectrophotometry. The ranges of the concentrations of metals in the edible muscle tissues were: Pb 0.14–0.57 μg/g; Cd 0.34–0.49 μg/g; in common carp and Pb 0.00075–0.03 μg/g; Cd; 0.08–0.025 μg/g in leaping mullet. Pb and Cd concentrations between both fish species were statistically significant (insert the p value). There was no statistically significant correlation between the metal concentration of the muscles and the fish weight for both species. The concentrations of heavy metals in muscle of examined both fish species were below the permissible levels and should not pose health problems for human consumption. Periodic monitoring of these metals in both fishes and water to ensure safety is recommended.

1. Introduction

Wetlands are generally defined as lands transitional between terrestrial and aquatic ecosystems (Sridevi Karpagavalli et al., 2012). Based on presented definition by the Ramsar Convention (1971), wetland are areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres (Ramsar Convention, 1971). Wetlands ecosystems are among the most productive life support systems in the world and provide a range of valuable ecosystem services to human society. However, they are also very much ecologically sensitive and fragile ecosystem (Bassi et al., 2014). Wetlands eco-systems might be more easily contaminated by toxic heavy metals due to wastewater discharges from municipal, industrial, and agricultural sources, agricultural runoff, surface mine drainage, irrigation return flows, urban stormwater discharges, leachates, and other sources of pollution (Sin et al., 2001). Therefore, it is important to evaluate and obtain data on the ecosystem health of wetlands. Heavy metal pollution in wetlands and aquatic ecosystems is becoming a potential global concern. Heavy metal contamination in wetlands not only deteriorates the water quality, but also has destructive effects on the ecological balance and decrease the biodiversity in wetlands. Organisms that live in wetlands ecosystems, can bio-accumulate pollutants over time, and are at the risk of both lethal and sublethal effects from pollutants such as heavy metals (Zhang and Ma, 2011).

Among animal species, fishes are the inhabitants that cannot escape from the harmful effects of these pollutants. Also due to their position in top of the food chains in wetland ecosystems, they are suitable to degree of metal pollution in aquatic ecosystems. Thus fish are widely applied for evaluation of the health of aquatic ecosystems because pollutants build up in the food chain and are responsible for adverse effects and death in the aquatic systems (Squadrone et al., 2013; Al-Sayegh Petkovˇsek et al., 2012; Salem et al., 2014). Fish are more

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sensitive to many toxicants than most other freshwater animals, and are a convenient test subject for indication of the ecological health of a wetland (Authman et al., 2015). Thus, heavy metal pollution of aquatic ecosystems by fish species has recently been investigated to understand their environmental distribution and effectively manage these ecosystems (Salamat et al., 2015; Authman et al., 2015; Tabatabaie et al., 2011; Birungi et al., 2007).

Monitoring heavy metals is necessary in understanding their contamination status, emission sources, and environmental behavior. Due to wetlands' importance in maintaining the stability of the environment and essential ecological services, especially for protecting biodiversity richness, we have selected the two important wetland ecosystems in north (Gomishan international wetland) and west (Zarivar wetland) of Iran. Gomishan and Zarivar wetlands are considered as two of the most internationally important wetland in southern coast of Caspian Sea and west of Iran respectively, which is registered in the Ramsar Convention. These aquatic ecosystems receive effluents discharges from the heavily industrialized and densely populated areas. These wetlands receive effluent discharges from domestic, agricultural, and petrochemical and chemical industry, wood and paper manufacturing, energy production and shipping (Tabatabaie et al., 2011) contain different pollutants including heavy metals. The primary objectives of this research are to investigate the heavy metals (Pb and Cd) in wetlands ecosystems by their measurement in muscle tissue of two fish species. Another goal of this investigation was to compare the levels of these heavy metals in the marine and lacustrine systems. Gomishan is a brackish water wetland while the Zarivar is a freshwater wetland. Also, the findings obtained from this research were compared with certified human consumption safety guidelines recommended by the international organizations.

2. Material and methods

2.1. Study areas

Two wetlands have been selected as case studies for this research: coastal-marine wetland Gomishan (MWG) in Golestan province and the Zarivar lacustrine wetlands (ZLW) in Kurdistan province of Iran.

Gomishan international wetland that met the criteria of Ramsar Convention on wetlands is one of the most important ecosystems of south eastern corner of Caspian Sea and stretching in north-south direction. Gomishan wetland (37°11′ N, 53°57′ E) with a surface area of 20,000 ha is limited to Gorgan River (Iran) from south and to northern branch of Atrak River (Turkmenistan) in north. In west a narrow ribbon like sand bar is separating Gomishan lagoon from Caspian Sea. Connection between wetland and Sea is through a number of inlets. Still there is the change in the eastern border of this wetland due to fluctuations in Caspian Sea water level. Gomishan international wetland is comprised of lowland with fine silty to highly adhesive carbonated clay sand sediments. The water depth is variable and depends on oscillations in Caspian Sea water level, the average water depth of 1 m, maximum depth being 2.5 m (Gandomi et al., 2011). The altitude of the wetland is 23 m below sea level and it is a shallow with brackish water that its level changes seasonally-flood (Mansoori, 2009).

Zarivar wetland in the North of Kurdistan province (Iran) is a unique natural heritage with specific aesthetic and biodiversity values. Zarivar wetland (ZW) is fresh water ecosystem with a surface area of about 750 ha and average water depth of 4–5 m in the west of Iran. This wetland is located between 35°30′ to 35°35′ northern latitude and 46°06′ to 46°09′ eastern longitudes with altitude of 1285 m from sea level (Fig. 1) (Jafari and Sobhanardakani, 2014). ZW have an average area and water depth of 720 ha and 4–5 m respectively, it is a main source of water supply for Marivan City and other agricultural areas (Mansouri et al., 2016). ZW is the only natural aquatic ecosystem in Kurdistan province that wetland has formed due to intensive erosion of geological formations of the region. This important ecological zone is located in the 2 km far from northwest of Marivan city in Kurdistan province and situated in the north of Zagros fold belt. Based on the classification system for wetland habitats authorized by Ramsar convention, ZW is in the sweet water section of the permanent reservoirs of permanent sweet water wetlands (more than 8 ha). Marivan region is tectonically active region and its fold belongs to the middle of the third geological period (Reyahi-khoram and Hoshmand, 2012)

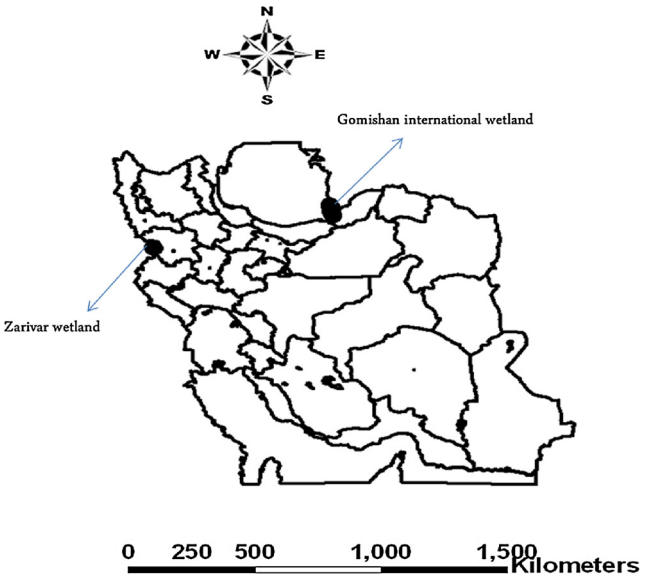

Fig. 1. Locations of the study wetlands in the map of Iran.

2.2. Field sampling and sample analysis

In this study, 23 leaping mullet (*Liza saliens*) fish samples (from the 9 stations) and 20 common carp (*Cyprinus carpio*) were collected from Gomishan international wetland and Zarivar wetland respectively. All fish samples caught were placed in iceboxes for transportation to the laboratory. The sex and body weight of each specimen were recorded as Table 1. Then fish samples were frozen at −20 °C until further analysis. Before the analysis, samples of fish were allowed to defrost. The fish were rinsed with deionized water to remove surface contaminants and muscles were dissected using stainless steel scalpels. After dissection, all the muscle samples were dried by oven at 105 °C for 24 h and cooled to room temperature. Samples were then homogenized and hand-ground with mortar and pestle.

1 g of each powdered sample was digested in a mixture of 12 cc concentrated perchloric acid (60% Merck) and Nitric acid (65% Merck) in the 1:4 ratio by using heating block digester first at 40 °C for 1 h and then in 140 °C for 3 h. After digestion, the solutions were cooled to room temperature and then filtered with Whatman No. 42 filter paper. Finally solutions diluted to a 25 ml by adding distilled water (Yap et al., 2002). After filtration, the prepared samples were analyzed for Cd and Pb using graphite furnace atomic absorption spectrophotometer (GF-AAS). The obtained detections of metals in fish muscle tissues are presented in μg/g (ppm) dry weight.

Three replicates are performed for each solution obtained by acid digestion. Reagent blanks were prepared in the same way as the samples and were run in each analysis batch. The precision of analytical, in terms of relative standard deviation (RSD), was lower than 7%. LOD values of Cd and Pb Zn were observed to be 1.7, and 12.16 μg/l, respectively. The recovery of spiked samples ranged from 4% to 98%.

2.3. Health risk assessment

The estimated daily intake (EDI) of each heavy metal was calculated as follows: