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Heavy metal contamination and health risk assessment in three commercial fish species in the Persian Gulf

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ABSTRACT

Five heavy metals/metalloids and related potential health risks were investigated in three commercially important fish species (*Anodontostoma chacunda*, Belangerii, and Cynoglossurs arel) in Musa Estuary and Mahshahr Harbour of the Persian Gulf. A total of 116 fish samples were collected, and their liver and muscle organs were separately analyzed using ICP-MS. Results revealed that studied metals concentrations (with some exceptions) varied among sampling stations, fish species and their organs. Human health risk is evaluated using different indices. The results indicated that arsenic and mercury are the most hazardous elements. Estimated daily intake (EDI) for the metals exceeded the provisional tolerable daily intake (PTDI) for all studied fish species. Also, target risk (TR) of arsenic indicated that consumption over a long period of time may result in a carcinogenic effect. The results are expected to create awareness among the public on the safety of consuming food products grown in particular areas.

1. Introduction

Persian Gulf with an average depth of 40 m, pours into the Indian ocean via the Strait of Hormuz (Mortazavi and Sharifian, 2012; Fard et al., 2015). During the past few decades rapid industrial development and population growth in countries surrounding the Persian Gulf have resulted in a considerable increase in the heavy metal content in its aquatic ecosystems (Pourkerman et al., 2017). Within the Persian Gulf, the Musa Estuary and Mahshahr Harbour are two coastal ecosystems that host a various unique fauna and flora. These ecosystems receive tremendous amounts of contaminants from urban and agricultural effluents, petrochemical plants, and large shipping ports (Malmasi et al., 2010; Fard et al., 2015). A number of past studies have documented heavy metal contamination in the Persian Gulf's aquatic organisms, including different fish and shrimp species (Adel et al., 2016; Dadar et al., 2014; Abdolahpur Monikh et al., 2013; Saei-Dehkordi and Fallah, 2011; Agah et al., 2009; Pourang et al., 2005).

As fish are commonly considered as bio-indicators for heavy metals in aquatic ecosystems, past research has focused on the accumulation of potentially toxic heavy metals in their target organs (Subotić et al., 2013; Yildirim et al., 2009; Chahid et al., 2014; Bosch et al., 2016; Abdolahpur Monikh et al., 2013; Ahmad et al., 2010; Balcıoğlu, 2016). In many regions of the world fish is widely consumed as it represents a source of high-quality protein (Galimberti et al., 2015; Storelli, 2008; Taweel et al., 2013). However, despite the recognized benefits, fish is prone to contamination and may pose serious risks to human health (Qin et al., 2014), especially for highly consumed types of fish when considering biomagnification up the food chain leading to humans. Thus, studying the capacities of different fish species for metals accumulation is necessary as it helps to ensure that fish consumption will not provide a route for heavy metals transfer to human (Gu et al., 2015; Nor Hasyimah et al., 2011). Furthermore, calculation of human health risk indices can provide guidance to decision makers and responsible authorities.

Since a potentially contaminating source (a petrochemical complex) is located close to a main fishery harbour in the study area, and as fish is a very popular and highly consumed food by the locals, the present study was undertaken. The main aims of this study are to investigate selected heavy metals content (arsenic, cadmium, copper, mercury, lead) in some fish organs (muscle and liver) caught in Musa Estuary and

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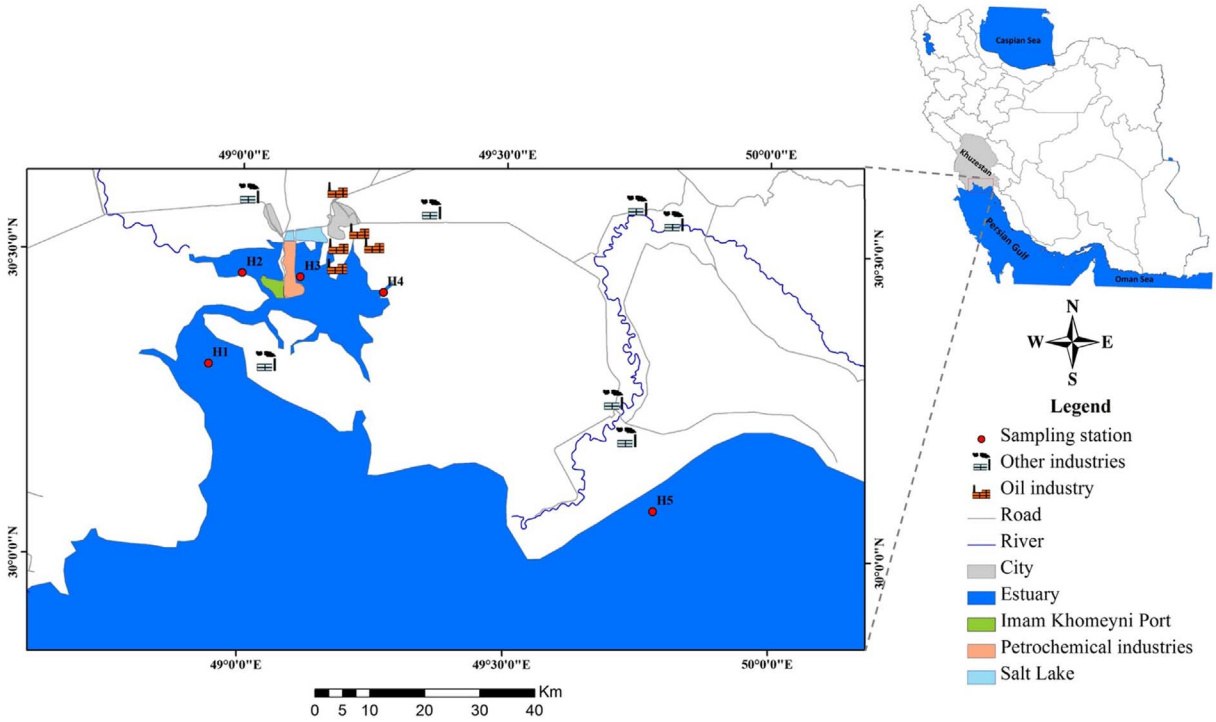

Fig. 1. Map of the study area and location of the sampling sites.

Mahshahr Harbour (industrial zone) and to calculate related health risks for consumers. This work focuses on three commonly consumed fish species (i.e., *Anodontostoma chacunda*, Belangerii, Cynoglossurs arel) representing pelagic, mesopelagic, and benthic classes of organisms, respectively. The studied species are important because they are edible, abundant and representative for different habitats.

2. Material and methods

2.1. Study area

Musa Estuary (30°15′–30°32′, 49°–49°20′), the biggest estuary in Iran, is located northwest of the Persian Gulf in Mahshahr county (Fig. 1). This estuary along with Mahshahr Harbour (30°27′/49°10′), are two coastal ecosystems that host various unique marine fauna and flora (Fard et al., 2015). Some economically important fish and shrimp species migrate to this area and turn it into a commercial region for fisheries (Abdolahpur Monikh et al., 2013). The annual average temperature and annual average precipitation in Mahshahr, are 25.5 °C and 213.4 mm, respectively (Khuzestan Meteorological Organization, 2016). Due to the presence of several petrochemical plants, Imam Khomeyni port, and related metal and oil industries, the area enjoys a strategic position and is an important industrial hub in Iran. Due to tidal stream complexities and bed erosions, bed elevation of the main branches of this estuary present irregular bed elevations. In addition, because of its geographical position, many tankers and ships navigate in the Musa Estuary.

2.2. Sampling and chemical analysis

Sampling of the three abundant fish species was carried out by fishing with a mid-water trawl net along the coast at five sampling sites including Ghabrenakhoda (H1), Khoredoragh (H2), East pond of a petrochemical center (H3), Khoreghzaleh (H4) and Hendijan Harbour (H5) (Fig. 1). The sampling stations were selected based on data received from Mahshahr Environmental Protection Office regarding the main fisheries, contaminating industries, shipping routes, and docks. Collected fish (116 samples) were immediately preserved in an ice box containing dry ice cubes and transferred to the laboratory where they were archived and kept frozen at −20 °C until further analysis. The samples were washed carefully with distilled water and the length (cm) and weight (g) of each collected sample were recorded. The collected species were then divided into three groups according to habitat, including *Anodontostoma chacunda* (pelagic, 30 samples), Belangerii (mesopelagic, 58 samples), and Cynoglossurs arel (benthic, 28 samples) (Table 1).

In order to measure metals concentration, frozen fish were thawed at room temperature and dissected using a stainless steel scalpel. Muscles and the liver were taken out; composite samples each weighting 5 g were used for subsequent analysis. Then the samples were freeze dried for 24 h and 1 g aliquots were taken from each wet sample. For this purpose, a Zirbus freeze drying machine (Hossein Khezri et al., 2014) (Model: VaCo 5) with one stage cooling system (free of CFC) was used (condenser dimensions, volume, condenser temperature, and ice capacity were Ø 270 × 280 mm, 16 l, −50 °C and 5 kg/24 h, respectively). The aliquots were dried and dry samples were sent to Actlab in Ancaster- Canada for ICP-MS analysis. In the laboratory, microwave

Table 1
Biometric data of the sampled fish species and the number of samples.

Species	Favorable diet	Habitat	Number	Average weight (g)	Average length (cm)
Anodontostoma chacunda	Small invertebrates and herbivore (on algae)	Pelagic	30	32	16
Belangerii	Small invertebrates and herbivore (on algae)	Mezopelagic	58	36	14
Cynoglossurs arel	Filter Feeders (benthic invertebrates)	Benthic	28	83	20