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Investigating a probable relationship between microplastics and potentially toxic elements in fish muscles from northeast of Persian Gulf☆

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A B S T R A C T

Although weekly consumption of fish is recommended, the presence of contaminants in seafood has raised many concerns regarding the benefits of fish intake. In the present study microplastics (MPs) and metals' concentration in muscles of both benthic and pelagic fish species from northeast of Persian Gulf were investigated and the risk/benefit of their consumption was assessed. The results demonstrated that MPs and Hg in all species and Se in benthic species increase with size, while relationship between other metals, and fish size is not consistent. Consumption of a meal ration of 300 and < 100 g/week for adults and children, respectively, is recommended since it would provide the required essential elements with no human health risk. On the other hand, the estimated intake of MPs from fish muscles revealed that the mean intake of MPs for *P. indicus, E. coioides, A. djedaba,* and *S. jello* consumption is 555, 240, 233, and 169 items/300 g-week, respectively. Moreover, the relationship between MPs and metals in fish muscles were positive for *A. djedaba,* and negative for *E. coioides.* Considering the chemical toxicity of MPs and metals, and their good linear relationships in some species, consumption of high doses of the studied fish may pose a health threat to the consumers.

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1. Introduction

During the last decades the consumption of seafood products increased considerably due to increasing awareness on their useful effects like reducing the risk of polygenic disease, cardiovascular disease, cancer, and Alzheimer (Kalogeropoulos et al., 2012; Maulvault et al., 2013). Moreover, seafood products are consumed as potent sources of energy, protein, omega-3 polyunsaturated fatty acids (ω3-PUFAs), vitamins and minerals, which are famous for their health benefits (Gu et al., 2015; Maulvault et al., 2013; Olmedo et al., 2013). However, the presence of pollutants (i. e. heavy metals and microplastics) in seafood deduct it's benefits as they could be harmful to organs and induce carcinogenic, mutagenic, and teratogenic effects (Jabeen et al., 2017; Li et al., 2015; Obaidat et al., 2015). Heavy metals are categorized as both essential (i. e. Zn, Cu, Mn, Se, and Fe) and potentially toxic (i. e. Ni, Cd, Pb, and Hg). Obviously, toxic metals are harmful to organisms even at low concentration, however, exposure to high levels of essential elements could also be toxic (Gu et al., 2015; Zhang et al., 2014). Microplastics (MPs) are defined as plastic debris smaller than 5 mm in size and classified as primary (manufactured in a micro-sized scale) and secondary (resulting from large plastics fragmentation), based on their origin (Guven et al., 2017; Jabeen et al., 2017; Vendel et al., 2017). Although the ingestion of plastic litter by marine organisms has been studied by many researchers (Grigorakis et al., 2017; Jabeen et al., 2017; Wesch et al., 2016), the exact toxic effects of plastic debris on marine organisms and eventually to human is yet to be fully understood (Vendel et al., 2017).

Determining pollutants in the marine environment and estimating the potential toxicity of sea foods consumption, especially fish has been growing in recent decades (Guven et al., 2017; Neves et al., 2015; Zaza et al., 2015). Heavy metals and MPs are two groups of pollutants within the aquatic environment due to their persistence and poor biodegradability, bioaccumulation and possible biomagnification in the food chain (Abdolahpur Monikh et al., 2013; Grigorakis et al., 2017; Gu et al., 2015; Vendel et al., 2017). Both MPs and heavy metals can enter the food web through direct and indirect exposure (Hosseini et al., 2015; Vendel et al., 2017).

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Therefore, they pose serious health risks to living organisms from low trophic level to human (Iamiceli et al., 2015; Rummel et al., 2016; Zaza et al., 2015).

Fish are known to be useful bioindicators of contaminants in the aquatic environment (Bellas et al., 2016; Hosseini et al., 2015; Zaza et al., 2015). Bioavailability and concentration of the contaminant in water, physiology of the organism, feeding behavior, environmental factors, and exposure time are the main factors that control the degree of bioaccumulation of pollutants in fish (Koide et al., 2015; Velusamy et al., 2014; Vendel et al., 2017). The accumulation of pollutants in different tissues of fish (muscle, gills, and liver) are not the same. It is well known that the concentration of metals in gills and liver reflect the level of metals in water and accumulated metals in fish, respectively (Hosseini et al., 2015). Since muscle is the most edible part of fish and the potential risks of contaminant in muscles are of great concern to humans, investigating pollutants in fish muscle is momentous despite their lower accumulation potential compared with liver and gill (Abdolahpur Monikh et al., 2013; Mziray and Kimirei, 2016; Neves et al., 2015). However, far fewer studies have been conducted on MPs in fish muscles compared to their liver, gut and gill MPs' content.

Persian Gulf is a major fishing hotspot in Iran hosting a wide variety of benthic and pelagic fish species. Benthic fish feed and live on bottom sediments. While, pelagic fish live in the water column and surface layers (Naccari et al., 2015). Considering the fact that, the Gulf is highly affected by oil-related activities, and untreated urban and industrial discharges (Hosseini et al., 2015), high salinity and evaporation due to heat, and limited circulation (Jaafarzadeh Haghighi Fard et al., 2015), it's aquatic organisms are exposed to high level of all types of anthropogenic pollutants including heavy metals and MPs. Khark Island, located southwest of Iran (northwest of Persian Gulf), is among the main oil terminals in the world. Considering the oil-related activities during the last five decades in the island, the caught fish around Khark Island may represent the pollution situation of the aquatic environment. Thus, this study was carried out to assess the elemental concentration and MPs' content of some commercial fish's muscles from southwest of Iran and therefore the risk and benefit of their consumption to human health.

2. Materials and methods

2.1. Fish collection

The Persian Gulf with 240,000 km^2 area is a shallow closed basin with an average depth of 50 m (Jaafarzadeh Haghighi Fard et al., 2015). In November 2015, a total of 71 whole fish specimens belonging to four popular commercial fish species, were purchased from local fishmongers at the Khark Island. Table 1 shows the characteristics of the studied fish.

2.2. Sample preparation and analysis

The fish were kept in cold boxes with ice and transported to the laboratory. In laboratory, Fish were washed with tap and distilled water and then prepared by eviscerating and beheading. Then, samples were filleted, the muscles were homogenized using a precleaned meat grinder. Half of the homogenized fish was dried at room temperature and ground in a blender. The other half was stored at −18 °C until analysis.

The extraction of MPs from fish muscles was carried out using the method suggested by Karami et al. (2017). So that, 10 g of homogenized fish was immersed in 100 ml of 10% (w/v) KOH at 40 °C for 48 h. After passing through S&S quantitative filter paper, grade 589/3 blue ribbon (pore size <2 μm), the residue was washed with pure distilled water to remove remaining KOH. The filter paper containing the MPs was air-dried before further analysis. Since fish bone remains on filter paper are low, the density separation was not used in this study hoping to preserve all types of MPs with different densities (Table S1).

As visual separation is the most common method used in identifying MPs (Dekiff et al., 2014; Rocha-Santos and Duarte, 2015), the optical analysis and enumeration of extracted MPs were done using a binocular microscope with up to 200× magnification, in this study. The identification of MPs was mostly done using probe/tweezers and physicochemical characteristics of MPs (i. e color, opacity, hardness, specific elasticity and structure). However in some cases the item was tested with a hot probe, for certainty. Generally speaking, fibers should be equally thick along their entire length, with no visible organic or cellular structure and should retain the same color all the way along (Hidalgo-Ruz et al., 2012).

The dried fish samples were sent to the Activation Laboratories Ltd. Ontario, Canada. Trace elements including (As, Cr, Mn, Cu, Fe, Se Ni, Pb, V, and Zn) were measured using inductively coupled plasma mass spectrometry (ICP-MS), and Hg was measured using Hg cold vapor flow injection technique (FIMS). The procedure of sample digestion was as follow: Briefly, 0.5 g of each dried fish sample was microwave digested with 2.5 ml of concentrated H_2SO_4, 4.0 ml of concentrated HNO_3 and 1.5 ml of H_2O_2. The ramp and hold time was 10 (from 30 to 90 °C) and 20 min, respectively. The digested samples were diluted to a final volume of 50 ml with deionized water and analyzed for metals except for Hg. In the case of Hg, Hg in the resulting solution is oxidized to the stable divalent form. Since the concentration of Hg is determined via absorption of light at 253.7 nm by Hg vapor, Hg (II) is reduced to the volatile free atomic state using stannous chloride. Argon is bubbled through the mixture of sample and reductant solutions to liberate and to transport the Hg atoms into an absorption cell. The cell is placed in the light path of an Atomic Absorbed (peak height) directly proportional to the concentration of mercury atoms in the light path.

2.3. Quality assurance (QA) and quality control (QC)

Special care was carried out to minimize the contamination during sample preparation and visual identification. In all steps, Sterile or clean devices were used to collect and keep the samples. Tap water and KOH solution were filtered prior to use. A cotton laboratory coat (100%) was worn during all steps of analysis

Table 1
The name, numbers, size, habitat and feeding mode of the analyzed fish species.

Common name	Binomial nomenclature	Family	Number	Length (cm)		Weight (g)		Habitat	Feeding mode
				range	mean	range	mean		
Shrimp scad	*Alepes djedaba*	Carangidae	20	30–70	41.45	400–4700	1487.05	Pelagic, Reef associated	Carnivorous
Orange-spotted grouper	*Epinephelus coioides*	Serranidae	20	30.5–72	43.92	380–7800	2320.25	Benthic	Carnivorous
Pickhandle barracuda	*Sphyraena jello*	Sphyraenidae	15	49–70	59.20	524–1610	1000.87	Pelagic	Carnivorous
Bartail flathead	*Platycephalus indicus*	Platycephalidae	16	31–41	36.06	200–380	296.87	Benthic	Carnivorous

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