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Microplastics contamination in molluscs from the northern part of the Persian Gulf☆

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ABSTRACT

Microplastics (MPs) are well-known emerging contaminants in the marine environment. A key route by which MPs can directly affect marine life is through ingestion. The objective of the present study was to evaluate the occurrence of MPs in marine life and seafood for human consumption in the Persian Gulf. We conducted a whole body analysis of MP (between 10 and 5000 μm in diameter) abundance in five species of molluscs with different feeding strategies, including both gastropods and bivalves from the littoral zone of the Iranian coast of the Persian Gulf. The mean number of total encountered MPs in all species ranged from 0.2 to 21.0 particles per g of soft tissue (wet weight) and from 3.7 to 17.7 particles per individual. Overall, microfibres followed by fragments were the most common type of MP isolated in each species (respectively > 50% and ≈26%). Film (≈14%) and pellets (≈2%) were less commonly observed. The observed MPs were classified into three size groups (ca. 10–25 μm, 25–250 μm and 250–5000 μm), and 37–58% of MPs fell into the smallest size group. Fourier transform infrared (FT-IR) analysis confirmed the presence of polyethylene (PE), polyethylene terephthalate (PET), and nylon (PA). Our results indicated that molluscan shellfish from the Persian Gulf contain MPs, with higher concentrations in a predatory species, suggesting trophic transfer of MPs in the food web. The consumption of edible species may be a source of human microplastic intake. We compared our results with those previously reported for other regions of the world and identified the need for further studies in the Persian Gulf.

1. Introduction

Plastic, including micro-sized particles and fibres of 5 mm or less (microplastics; MPs), is one of the most common types of litter in the marine environment. Rough estimates show that about 80% of plastic debris in the sea comes from inland sources through rivers (Jambeck et al., 2015). Another study suggested that there could be about 5.35 trillion particles floating on sea and ocean surfaces, corresponding to 250,000 tons (Eriksen et al., 2014). This figure does not consider debris throughout the water column, the beaches and the bottom of the seas and oceans (Bergmann et al., 2015).

More than 220 different marine species have been found to consume MP debris in nature (Lusher et al., 2013). The primary environmental risk associated with microplastics is their bioavailability to marine organisms (Wright et al., 2013; Li et al., 2015, 2016). MPs have been shown to be ingested by a large variety of farmed and wild species, including fish (Lusher et al., 2013; Rochman et al., 2015; Miranda and de Carvalho-Souza, 2016) and various invertebrate groups, such as zooplankton (Cole et al., 2013), crabs (Watts et al., 2014), bivalves (Farrell and Nelson, 2013; Mathalon and Hill, 2014; Van Cauwenberghe and Janssen, 2014; Rochman et al., 2015; Li et al., 2016; Santana et al., 2016), shrimps (Devriese et al., 2015), and scleractinian corals (Hall et al., 2015).

There is a growing global concern about MPs as they have been shown to enter marine food webs (Lusher, 2015; EFSA, 2016). Moreover, ingestions of MPs by marine animals can cause adverse health effects, including increased immune response, decreased food consumption, weight loss, decreased growth rate and energy depletion, and could potentially endanger marine populations and living resources (Rochman et al., 2015; GESAMP, 2016; Lusher et al.,

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The objective of this study was to evaluate the occurrence of MPs in various shellfish species from the coastal water of the Persian Gulf for the first time to gain insight into the bioavailability of MPs to marine life and the potential relevance of this emerging contaminant for consumers of seafood. In previous studies, we reported on the occurrence of plastic debris and microplastics in littoral sediments from the Persian Gulf (Naji et al., 2017a,b). In the present study, we collected 5 intertidal mollusc species, including both gastropod and bivalve species, in the same region of the Persian Gulf (the Strait of Hormuz). The species included the facultative deposit/suspension feeding clams *Amiantis umbonella* and *Amiantis purpuratus* (Bivalvia: Veneridae), the suspension feeding pearl oyster *Pinctada radiata* (Bivalvia: Pterioida), the deposit feeding mud snail *Cerithidea cingulata* (Gastropoda: Potamididae) and the carnivorous snail *Thais mutabilis* (Gastropoda: Muricidae). The two clam and two snail species are commonly found on muddy flats; the pearl oyster is attached to littoral rock and other hard substrata (Table 1). The clams and oyster are popular for human consumption in the area. Molluscan shellfish are of particular interest because they have a broad geographical distribution, and they are easy to sample and easy to maintain under laboratory conditions for effect assessment (Browne et al., 2008; Li et al., 2016). Furthermore, extensive filter and deposit-feeding activity expose them directly to MPs present in the environment.

2. Materials and methods

2.1. Study area and sampling

The Persian Gulf is a semi-enclosed water body located in the Middle East. Aquatic organisms there dwell in one of the harshest marine environments known due to high levels of salinity, temperature, and low pH in the Persian Gulf (Uddin et al., 2012). In addition to these naturally harsh physical conditions, the Persian Gulf belongs to the most anthropogenically impacted regions in the world (Halpern et al., 2008). It is estimated that roughly 40% of the coasts of the Persian Gulf have been developed (Hamza and Munawar, 2009). Sewage discharges (Sheppard et al., 2010), industrial effluents (Sale et al., 2011), oil exploration, production, and transport (MEMAC, 2003) have been major contributors to pollution in the Persian Gulf. The study area is well-known as Hara (mangrove) Protected Area (HPA) in the south of Iran. It is a valuable reserve, officially recognized by UNESCO due to its uniqueness, richness, and diversity. Molluscs were sampled from 3 coastal sites at HPA in the northern part of the Persian Gulf (Hormozgan province), with approximately 102 km from the most easterly site at Qeshm Island to the most westerly at Bandar Lengeh (Fig. 1). The sampling sites are situated in close vicinity to multiple urbanized and densely populated places with more than 1 million inhabitants, including Qeshm Island and the major city Bandar Abbas (see also Naji et al., 2017a,b). Also, all of the sampling sites are closely situated to the Strait of Hormuz, which is a busy international shipping lane. The Khor-e-Khoran (comprising S1 and S2) in the east contains extensive mangrove forests and has the status of HPA with commercial use restricted to fishing, tourist boat trips, and limited mangrove cutting for animal feed. Furthermore, most of the industrial growth in Hormozgan Province in the south of Iran has developed along the coastline. The most important potential sources of plastic debris input into the Persian Gulf are manufacturing industries, agriculture and tourism. There is also a great deal of pollution from urban activities such as road runoff, domestic sewage as well as atmospheric fallout (Naji et al., 2017a; Sarafraz et al., 2016).

A total of 123 individual molluscs representing 5 species were collected in the intertidal zone during low tide. The sampling was carried out during October and November 2016. Sampling of *Cerithidea cingulata* (n = 24) and *Thais mutabilis* (n = 6) was performed at Angur (S1), sampling of *Amiantis umbonella* (n = 30) and *Amiantis purpuratus* (n = 30) was performed at Gelkan (S 2) and sampling of *Pinctada radiata* (n = 33) was conducted at Bandar-Lengeh (S3) (Fig. 1; Table 1). Directly after sampling, the molluscs were preserved in aluminium foil and kept in an icebox and transported to the laboratory at the University of Hormozgan. There they were rinsed four times with distilled water for removal of most of the sediment grains, biofilm and debris. The samples were then placed in aluminium foil and stored at −20 °C for future analysis.

2.2. Sample preparation and extraction

The shell length and wet weight (ww) of each animal were recorded (Table 1). Following the methods of Li et al. (2015), the soft tissues (whole body except the shell) of 3–11 individuals of each species were placed into a 1-L glass bottle, and 2–5 replicates for each site were prepared (Table 2). Then the digestion method using 30% H_2O_2 to remove soft tissue was applied followed by filtration of the solution through 25 μm pore filter paper with 12.5 cm in diameter (Whatman PLC 122 United Kingdom) using a vacuum system (for details see Li et al., 2015), followed by final filtration over a 0.45 μm nitrocellulose filter with 47–50 mm in diameter (Sartorius Stedim Biotech, Göttingen, Germany) (for details see Naji et al., 2017a). MPs were rinsed in distilled water to remove salts. The filter was placed in a clean glass petri dish for further analysis.

2.3. Identification of MPs

Initial visual inspection was made by eye and under a dissection microscope for particles resembling plastics. After that, optical

Table 1
Characteristics of the sampling sites and mollusc species used to study microplastic contamination along the coastal water of the Persian Gulf. Biometric values expressed as Mean ± Standard Error.

Site	Geographic position	Species	Habitat	Number	Shell length (cm)	Shell weight (g/individual)	Soft tissue weight (g/individual)
Angur (S1)	26°58′55.97″ N 55°43′40.11′E	*Cerithidea cingulata*	Mangrove-vegetated mudflats	24	1.9 ± 0.22	0.55 ± 0.13	0.17 ± 0.09
Angur (S1)	26°58′55.97″ N 55°43′40.11′E	*Thais mutabilis*	Mangrove-vegetated mudflats	6	3.7 ± 0.77	12.5 ± 9.6	1.8 ± 1.57
Gelkan (S2)	26°58′51.11″ N 55°42′28.20′E	*Amiantis umbonella*	Mangrove-vegetated mudflats	30	4.4 ± 0.24	22.0 ± 3.3	2.8 ± 0.71
Gelkan (S2)	26°58′51.11″ N 55°42′28.20′E	*Amiantis purpuratus*	Mangrove-vegetated mudflats	30	4.4 ± 0.24	21.9 ± 3.2	2.7 ± 0.51
Bandar Lengeh (S3)	26°32′29.71″ N 54°53′25.26′E	*Pinctada radiata*	Rock and other hard substrata	33	6.9 ± 0.65	65.7 ± 15.9	25.8 ± 10.15