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Prevalence of microplastics in the marine waters of Qatar

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ABSTRACT

Microplastics are firmly recognized as a ubiquitous and growing threat to marine biota and their associated marine habitats worldwide. The evidence of the prevalence of microplastics was documented for the first time in the marine waters of Qatar's Exclusive Economic Zone (EEZ). An optimized and validated protocol was developed for the extraction of microplastics from plankton-rich seawater samples without loss of microplastic debris present and characterized using Attenuated Total Reflectance-Fourier Transform Infrared spectroscopy. In total 30 microplastic polymers have been identified with an average concentration of 0.71 particles m^{-3} (range 0–3 particles m^{-3}). Polypropylene, low density polyethylene, polyethylene, polystyrene, polyamide, polymethyl methacrylate, cellophane, and acrylonitrile butadiene styrene polymers were characterized with majority of the microplastics either granular shape, sizes ranging from 125 μm to 1.82 mm or fibrous with sizes from 150 μm to 15.98 mm. The microplastics are evident in areas where nearby anthropogenic activities, including oil-rig installations and shipping operations are present.

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1. Introduction

Worldwide plastic production is currently about 300 million tons per annum, with global plastic consumption increasing by about 4% per year (Plastics Europe, 2014/2015). Plastic is considered as the primary material for the 21st century due to its widespread application in industrial and consumer products. However, when discarded inappropriately, it becomes litter with persistent and multi-faceted environmental impacts.

The issue of plastic pollution in the marine environment is of increasing global concern. About 62% of plastic waste generated (out of a 25.2 Mtonne annually, average estimate from 2006 to 2012) disposed of annually, is recovered for recycling and energy recovery processes, but the remainder is improperly disposed of into the environment (PlasticsEurope, 2014/2015). Plastic debris reaches the ocean from inland urban areas via surface drainage systems, as well as directly from anthropogenic activities such as: fishing; discharge from shipping; and the intentional and accidental release of domestic, agricultural, and industrial sewage and wastewater effluent (Horsman, 1982; Galgani et al., 2000; Ng and Obbard, 2006; Andrady, 2011). Wind patterns, ocean hydrodynamics, and sea floor morphology are all important vectors that influence the dispersion of plastic debris in the marine environment (Wright et al., 2013; Isobe et al., 2014; Ioakeimidis et al., 2014; Tubau et al., 2015).

The environmental transport of plastic debris is greatly affected by particle size, shape, density and polymer type (Wright et al., 2013; Isobe et al., 2014). Discarded plastic is now prevalent in the ocean as: floating litter on the ocean surface (Barnes and Milner, 2005; Barnes et al., 2009); stranded litter on coastal shorelines (Barnes and Milner, 2005; Thiel et al., 2013); and as sunken litter on sea floor bottom sediments (Galgani et al., 2000; Schulz et al., 2015). Plastic polymers that are positively buoyant in seawater (sp. gr. of seawater is ~1.025) are retained at the sea surface, then become dispersed on the water surface (pelagic) before entrapment in areas of low circulation, and then finally sink after further entanglement and biofouling (benthic) (Galgani et al., 2000; Morét-Ferguson et al., 2010; Ioakeimidis et al., 2014). Denser polymers such as nylon (sp. gr. ~1.29), polyethylene terephthalate (sp. gr. ~1.37), and polyvinyl chloride (sp. gr. ~1.38) tend to submerge in the water column, and can reach the marine sediment (Andrady, 2011; Claessens et al., 2013). As plastics typically have an intrinsic durability, water insolubility and slow degradation rates, debris has now become both ubiquitous and persistent in the marine environment. Over time, larger plastic pieces disintegrate into smaller fragments via: photolytic UV radiation; oxidation; hydrolysis; mechanical forces; as well as thermal and biological degradation processes that ultimately result in the generation of microplastics (Browne et al., 2007; Barnes et al., 2009; Andrady, 2011). Several studies have reported a variety of microplastic particle sizes ranging from <10 mm (Graham and Thompson, 2009), 2–6 mm (Derraik, 2002), <2 mm (Browne et al., 2011) and <1 mm (Claessens et al., 2011), <500 μm (Browne et al., 2010), <2 μm (Frias et al., 2010; Browne et al., 2010). Microplastics, as defined by the National Oceanic and Atmospheric Administration (NOAA), comprise of plastic particles that are <5 mm in size.

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Microplastics pose a more serious threat to marine biota than larger plastic debris as they are often in the same size-range as natural food items, thus leading to their ingestion when mistaken as food (Boerger et al., 2010; Lusher et al., 2013; Bond et al., 2013). As a result, marine organisms are particularly susceptible to microplastic ingestion with indirect consequent effects on organisms at higher trophic levels via bioaccumulation. Furthermore, due to their hydrophobic nature, microplastics have been found to concentrate a wide-range of organic contaminants such as: PCBs, PBDEs, PAHs, DDT, and BPA (Hirai et al., 2011; Bakir et al., 2014), trace metals (Aston et al., 2010; Holmes et al., 2012); as well as additive-derived chemicals (e.g. phthalates, nonylphenol) (Teuten et al., 2007; Mathalon and Hill, 2014). Due to ingestion, microplastics therefore serve as a vector for the transfer of contaminants into marine biota. This has been reported to result in disruption of the endocrine system, toxicological hazards, and the bioaccumulation of organic pollutants in the marine food chain (Teuten et al., 2007; Hirai et al., 2011; Gassel et al., 2013).

Microplastic abundance in the marine environment has been shown to have a positive correlation with human population density in the adjacent coastal catchment. Increased human population in coastal areas generally leads to an increase in plastic litter generation, and consequent prevalence of microplastics in coastal waters (Depledge et al., 2013).

In the Middle East there is very limited reported data on microplastic pollution, although the region accounts for about 7.3% of global plastic materials production (PlasticsEurope, 2014/2015). Increased population levels, coupled with strong economic development, is expected to coincide with increased litter generation, including plastic. Qatar is a low-lying peninsula nation situated midway along the western coast of the semi-enclosed Arabian Gulf. Its marine environment is particularly susceptible to marine debris due to the county's increased modernization and economic development. Qatar's marine Exclusive Economic zone (EEZ) extends to approximately 32,000 km^2 (15% of the Gulf), and includes a 563 km long coastline (Jones et al., 2002; UNCSD, 1997). Although the country's marine ecosystem is a valuable resource for fisheries, tourism and recreation it co-exists with a growing human population and an expansion of coastal petrochemical industries including oil and gas-rig operations, harbors, port facilities, and land reclamation. Environmental impacts from these anthropogenic activities include: discharge from coastal dredging operations; effluents from power and desalination plants, petroleum industries, and domestic sewage; increased shipping activity, as well as indiscriminate onshore and offshore litter disposal. Moreover, Qatar's marine hydrologic cycle is influenced by extreme high temperatures during the summer season, when atmospheric temperature increases to an average daily maximum of 46 °C, and sea temperatures reach up to 35 °C. In contrast, during the winter season, the average daily maximum lowers to 10 °C and sea temperature reduces to 15 °C. High evaporation rates occur during the summer causing water salinity to rise to 39–41 ppt, while the prevailing northwesterly Shamal winds during the winter months cause sea turbulence which affects sea currents, generating waves of up to 5 m (Jones et al., 2002; UNCSD, 1997). These hydrodynamic conditions are likely to affect the quantity and size distribution of plastic debris.

Knowledge of the extent and impact of microplastic pollution in Qatar's marine environment is still largely speculative, where no baseline data currently exists for Qatar's EEZ. This report is the first documented evidence for the presence of microplastics in the marine waters of Qatar's EEZ. The study also led to the development of an optimized protocol for the extraction of microplastics from plankton-rich seawater.

2. Materials and methods

2.1. Field sampling

To investigate the presence and distribution of microplastics, marine sampling was conducted using the research vessel of Qatar University, the RV Janan. Surface water samples were collected from 12 marine stations within the northeastern section of Qatar's EEZ in May 2015 (see Fig. 1). All samples were collected using a plankton tow-net (Ivar do Sul et al., 2013; Hidalgo-Ruz et al., 2012) attached to the research vessel.

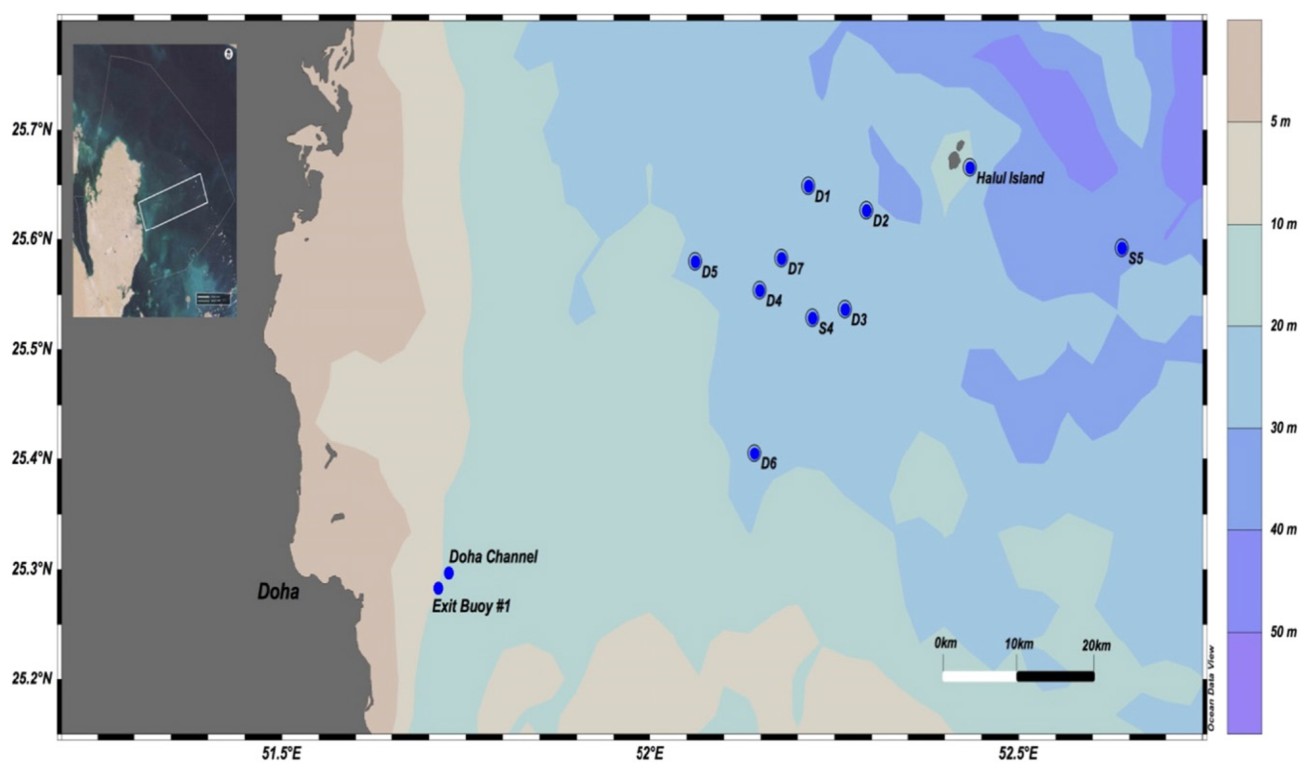

Fig. 1. Geographical location of sampling stations.

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