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Investigation of Spatiotemporal Variability of Microplastics in Qatar's Coastal Environment

Radhouane Ben-Hamadou[1], Oyebamiji Abayomi[2], Pedro Range[2], Mohammad Salim Alghouti[2], Jeff Philip Obbard[2], Saeed Hashim Almeer[2]

[1]Dept. Biological and Environmental Sciences, College of Arts and Sciences Qatar University, QA
[2]Qatar University, QA

Email: benhamadou@qu.edu.qa

There has been a tremendous proliferation in plastic production in the last five decades due to its low cost and versatile applications. Plastic debris dominates the marine litter globally and has been found in the most pristine environment including the abysmal region of the world ocean. Studies show that over 8 million tons of plastics are dumped in the ocean annually (Gregory, 2009). Plastics are persistent in the environment and take several decades to degrade especially in the ocean. Large plastic debris can heavily damage the coral reefs and may cause entanglement, choking, blockage of digestive tracts when ingested by turtles, whales, sharks etc, causing several thousand deaths annually among these organisms. Microplastics are tiny plastic particles that seldom originate from fragmentation of large plastic debris or are produced to serve some specific purposes. Microplastics pose greater threats as they can be mistaken for food by filter-feeders and planktivorous fish, and can also adsorb large quantities of recalcitrant organic pollutants (OPs). Impacts on marine biota may include endocrine disruption, carcinogenesis, and sexual disruption, etc. These impacts may not always be obvious but OPs surely affect marine biota once they enter the food web even at low concentrations (Mato et al., 2001) which biomagnify up the marine food web, hence, explains the need for their investigation.

In this study, the spatial and temporal distribution of microplastics was investigated for the first time in Qatar; both in sediments and seawater. Eight beaches across Qatar and four sea surface stations were surveyed between the months of December 2014 and March 2015. The objectives of this study were:

1. To analyze the spatial and temporal variability of microplastics in seawater and sediments, in sea surface and intertidal sandy beach environments, respectively.

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2. To characterize the isolated microplastics based on size, shape, colour, and type of polymer.
3. To describe macroplastics collected from beaches based on polymer type and quantify the concentration of OPs adsorbed on their surfaces.
4. To investigate the rate of adsorption of OPs on virgin plastic pellets in a field experiment.

A general overview of the followed methodologies is given in Appendix 1. In the first phase of this study, the spatial and temporal distribution of microplastics was investigated in seawater and sediments respectively. Four sea surface stations (Appendix 2) and eight beaches (Appendix 3) across Qatar were surveyed between the months of December 2014 and March 2015.

Seawater was sampled respectively with a surface neuston net (300 μm mesh size) towed off the side of the speedboat in undisturbed water for 5 minutes at 1.5 knots (Doyle et al., 2011). Next, collected materials in the cod were transferred into labeled, acid-treated insulated glass containers to prevent contamination. Concentrations of microplastics were given in square meters as sampling was done in two-dimensional air-sea interface. Physicochemical parameters (temperature, salinity, pH and dissolved oxygen) were measured in-situ and recorded at each sampling site.

Additionally, eight coastal stations (Al Dhakhira, Ras-Laffan, The Pearl, Doha Bay, Al Ruwais, Dukhan, Umm Bab, and Mesaieed) were chosen on the basis of their accessibility and being evenly distributed along Qatar coastline.

For each sampling, sediments from the top 2 cm were collected at the most recent high tidal mark on shore from a square area (0.5×0.5 m) along the shore line. Three replicate quadrats (5 meters apart) were sampled in each beach. The samples were homogenized and transferred into acid-treated glass containers to prevent contamination and transported to the laboratory for analyses.

Microplastics (Appendix 4) were discovered in all samples and their abundance varied both in intertidal sandy beaches and sea surface. Two-factor ANOVA revealed that the spatial variability of microplastics in sea surface stations was statistically significant however, there was no observable temporal variability (Appendix 5). The average concentration of microplastics in all 8 beaches was not significantly different (Appendix 6). Chemical analysis revealed the occurrence of OPs with endocrine effects on all obtained macroplastics, and concentration of pollutants was consistent in all sites. Large piece-to-piece variations of contamination up to two orders of magnitude were discovered within sites (2 to 1,005 ng/g), although there was no significant difference in contaminant concentration among all sites for PCBs and PAHs respectively.

Since plastic debris are hydrophobic and easily adsorb organic pollutants the second phase of this study was targeted at investigating the concentration of PCBs and PAHs adsorbed on macroplastics in situ. Field adsorption/desorption experiment was performed to investigate how pellets of different polymers and contaminated with POPs behave when placed in ambient seawater. Pellets were deployed and later retrieved at 48h, 96 h, 192 h, and 312 h respectively. The pellets were analyzed for PCBs and PAHs and undeployed pellets were also analyzed at time 0. Adsorbed PCBs and PAHs concentration showed a steady decrease with time, suggesting that contaminated pellets ending in the marine environment release their adsorbed contaminants in less contaminated seawaters revealing a complex OPs dynamic between plastics an seawater as a function of differential concentrations of pollutants and environmental conditions.

This study is the first of its kind in Qatar and seemingly in the entire Arabian Gulf region. Marine pollution is a growing concern in Qatar coastal and offshore environment. Marine debris is of major concern due to the fact that plastic can take several decades to be fully degraded. Results from this study indicate that microplastics are ubiquitous in Qatar coastal environment and the fact that they are easily mistaken for food and ingested by zooplankton and smaller fishes makes them a serious threat to the marine food web. Hence, regular monitoring of the occurrence of microplastics and studying how they may affect the foodweb and potential contaminations of exploited (seafood) species are needed to give policy makers an insight of the sources of the debris and proffer suggestions on how to tackle the menace using a holistic approach.

References

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