Marine Pollution Bulletin 102 (2016) 243–249

Contents lists available at ScienceDirect

Marine Pollution Bulletin

journal homepage: www.elsevier.com/locate/marpolbul

Microplastics in the Solent estuarine complex, UK: An initial assessment

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ARTICLE INFO

Available online 20 April 2015

Keywords:
Microplastics
Plankton trawls
Fourier Transform Infrared Spectroscopy (FT-IR)
Estuarine complex

ABSTRACT

Microplastics are known to be an increasing component found within both marine sediments and the water column. This study carried out an initial assessment of the levels of microplastics present within the Solent estuarine complex, focusing specifically on the water column. A plankton net trawl survey was carried out, with samples analysed using visual observation and Fourier Transform Infrared Spectroscopy (FT-IR). The study identified significant quantities of plastics, ranging in shape, with hot spots found at confluence points within the estuary. Though the FT-IR analysis was inconclusive, the nature of the samples indicates the effect of oceanographic conditions on the prevalent types of microplastics found, which in turn identifies key local sources such as wastewater treatment plants and the plastics industry as being the dominant inputs.

1. Introduction

Since their initial development in the mid-20th Century, plastics have shown themselves to be incredibly versatile materials, being inexpensive, lightweight, strong, durable, resistant to corrosion, and with high thermal and electrical insulation properties. As a result, an increasing number of synthetic polymers have offered a broadening range of technical solutions to practical problems. Global production has consequently increased dramatically from approximately 5 million tonnes in the 1950s to around 260 million tonnes now, which in itself constitutes approximately 8% of global oil production (Graham and Thompson, 2009). This ever increasing consumption of plastics has also lead inexorably to ever increasing levels of waste, much of which enters the marine environment via industrial discharge, littering and terrestrial run-off (Ng and Obbard, 2006). The degree to which plastics pollute the oceans is reasonably well documented with estimates showing that 75–80 tonnes of packaging end up in the oceans globally each year (Andrady, 2011). A recent study by Eriksen et al. (2014) estimated that there is 5.25 trillion plastic pieces floating in the world oceans weighing over 250,000 tonnes.

Microplastics however are less well documented despite being first reported in the marine environment in the 1970s. They are defined as pieces of plastic less than 5 mm in size, which can normally pass through a 500 μm sieve (Thompson et al., 2004b). Recent studies have shown that these are common within marine sediment and the water column throughout the world (Browne et al., 2011; Thompson et al., 2004a,b; Ng and Obbard, 2006); however, few studies have focused on estuaries (Ivar do Sul and Costa, 2013).

The studies to date have only covered small sample areas and have used a variety of methods. As such there is a need for further studies to help determine the extent and spatial distribution of microplastics in the marine environment as well as contributing towards the identification of suitable methods to quantify and analyse such pollution. The GESAMP Working Group 40, who are tasked with presenting a final global assessment report on microplastics in the ocean, are also tasked with developing the methodologies involved. This report is due in 2015.

Much of the available research to date has been on beach and estuarine sediments with correspondingly less on the water column of estuaries. This study therefore addresses this gap by focussing on the levels of microplastics found within the water column of the Solent estuarine complex in Hampshire, UK; a complex that comprises the estuarine Rivers Hamble, Itchen, and Test as tributaries to Southampton Water, as shown in Fig. 1. The catchment areas of these three rivers vary considerably with the Test having the largest catchment of 1269 square kilometres, the Itchen 400 square kilometres and the Hamble 160 square kilometres. Southampton Water therefore has a catchment of around 1800 square kilometres (Environment Agency, 2009).

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http://dx.doi.org/10.1016/j.marpolbul.2015.04.002
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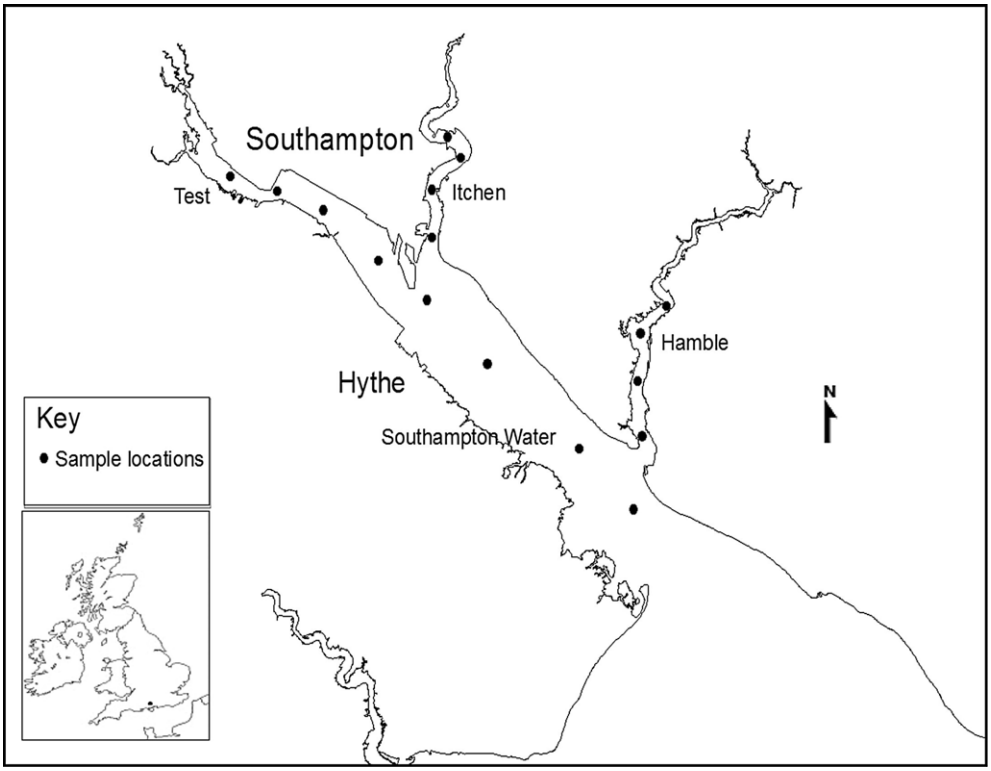

Fig. 1. Plankton trawl locations in the Solent estuarine complex.

2. Microplastics

The presence of microplastics in the marine environment can result from either the degradation of in situ larger plastic objects through photo chemical action or physical breakdown; or from the direct input by industrial processes and domestic uses. These are typically either particulates or fibrous in form, with the latter resultant from such sources as facial cleaners, cigarette butts and the fibres from clothes. Of the particulates, a significant proportion are known as microbeads, or round pellets that are typically around 4.5 mm in diameter, and are either used as components in products such as toothpastes or represent the output of raw material plastic production. As such, these virgin pellets are melted down to form other plastic products and packaging, and are prominent in the marine environment, with large numbers found in rivers and in varying numbers on the majority of beaches (Browne et al., 2011; Andrady, 2011).

Both particulates and fibres are of course small enough to pass through wastewater treatment plants allowing for large quantities to enter water courses, but it is the fibres that are most often cited as being the more significant component (Andrady, 2011; Fendall and Sewell, 2009). For example, one of the first studies into microplastics by Thompson et al. (2004a) found that on the beaches sampled around Plymouth, UK the majority of microplastics were fibrous, whilst other studies found similar results (Thompson et al., 2004b; Claessens et al., 2011; Frias et al., 2010; Ng and Obbard, 2006). By way of explanation, an experiment by Browne et al. (2011) showed that a single piece of clothing could shed 1900 pieces of polymer fibre per wash and that these fibres tend to be present in higher numbers during the winter months as more washes are done during this period (*ibid.*).

Given the propensity for a significant proportion of microplastics in the marine environment to be associated with wastewater it is perhaps not surprising that studies have also shown there to be higher levels of plastics in more populated areas, due to the greater concentration of industrial and domestic sources (Browne et al., 2011). However, since high volume production polymers (e.g. polyethylene) are buoyant, and even heavier polymers float just below the surface layers (Leslie et al., 2011), oceanographic conditions are clearly very important in determining spatial distribution. Investigations in the Caribbean and Sargasso Sea, for example have indicated that large numbers of microplastics are circulated by oceanic currents, as levels were higher at convergent zones with the rest of the Caribbean having relatively low levels in comparison. The Bahamas had higher levels due to more human and fishing activity in the region (Gordon, 2000).

2.1. The environmental impact of microplastics

Microplastics can impact on the marine environment through various pathways. One possible route is through the release of Persistent Organic Pollutants (POPs), such as polyaromatic hydrocarbons (PAH) and polychlorinated biphenyls (PCB) (Norén and Naustvoll, 2010). These organic compounds are resistant to environmental degradation, and known to bioaccumulate through marine food chains. However, there is still some debate as to the actual involvement of microplastics in this way, with Zarfl et al. (2011) stating that their release is likely to have an adverse impact on marine life whilst Gouin et al. (2011) states that microplastics are unlikely to act as the source of POPs.

Another key route by which microplastics can directly affect marine creatures is through ingestion. This can block intestines; lower steroid hormone levels; effect reproduction; prevent growth; and, reduce organism's utilisation of nutrients (Murray and Cowie, 2011; Wright et al., 2013). Filter feeders and detritus feeding organisms are all particularly susceptible to exposure in this way (Wright et al., 2013). Lusher et al. (2012) studied the levels of microplastics within 10 fish species in the English Channel, out of the 504 fish sampled 184 contained on average two pieces of plastic. Synthetic materials were the most common