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Influence of 2015 flood on the distribution and occurrence of microplastic pellets along the Chennai coast, India

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ABSTRACT

The sources, distribution, surface features, polymer composition and age of microplastic pellets (MPPs) in surface sediments along the Chennai coast during March 2015 (pre-Chennai flood) and November 2015 (post-Chennai flood) were characterised using a Stereoscopic microscope and FTIR-ATR spectroscopy. White MPPs were the most abundant, and specifically polyethylene (PE) and polypropylene (PP) were the dominant polymer types of MPPs found on the coast during both the times. The abundance of MPPs in November 2015 was three-fold higher than those found in March 2015, confirming that huge quantity of fresh MPPs washed through Cooum and Adyar rivers from land during the flood. The winds and surface currents during November were the driving forces for the transportation and deposition of MPPs from the sea to beaches. The results of this study will be useful to formulate beach MPPs litter management policies to effectively create long-term solutions.

1. Introduction

The current global annual production is nearly 40 kg of plastics for each of the 7 billion humans on the planet, approximating the total human biomass. The amount projected by 2050 on current trends, is about 40 billion tons, which is enough to wrap 6 layers of cling film around the planet (Zalasiewicz et al., in press). A recent research study estimated that 4.8–12.7 million metric tons (MMT) of plastic waste enters the world ocean (Jambeck et al., 2015). Of the top 20 countries releasing waste into the oceans, 10 have shores on the Indian Ocean, the third largest ocean in the world. Plastic debris causes physical damage and blockage to marine organisms as a consequence of ingestion and entanglement (Hong et al., 2013). These debris are chemically harmful because plastics contain chemicals added in the manufacturing process or adsorbed from the environment (Engler, 2012).

Microplastic pellets (MPPs) also known as 'nurdles' are primary microplastics (MPs), used as raw material for the manufacturing of plastic materials. MPPs have a cylinder or disk shape with maximum diameter of 5 mm (Ogata et al., 2009). The sources of MPPs in marine systems are both sea and land based sources (Gregory and Andrady, 2003). Sea based sources could be from accidental and/or unintentional spillages from ships during their voyages or handling of raw materials in harbours. MPPs may also enter into the coastal waters through rivers, streams, storm water drains and sewerage systems following spills at inland processors or during transport (Cole et al., 2011). Jambeck et al. (2015) estimated that 80% of plastic in the sea originates from land based sources and is transported by rivers to the oceans. The catastrophic events including tsunami and flood can also transport MPPs into the marine environment. The movement and deposition pattern of MPPs in coastal zones are controlled by climatic and oceanic conditions, especially wind, near-shore currents, wave motion and tidal dynamics (Gregory, 1978; Derraik, 2002; Abu-Hilal and Al-Najjar, 2009; Turner and Holmes, 2011; Acosta-Coley and Olivero-Verbel, 2015), as well as the geomorphology of the shoreline (Holmes, 2013; GESAMP, 2015).

The ingestion of MPs by aquatic organism has been widely studied in both laboratory (Browne et al., 2008; Cole et al., 2013; Khan et al., 2015) and field (Wright et al., 2013; Sanchez et al., 2014). Therefore, the MPs are acting as a potential carrier of toxic contaminants from the environment to the organisms including humans (Thompson et al., 2009; Chua et al., 2014). To develop proper waste management strategies, information about abundance, distribution, sources and their weathering pattern of MPPs is essential. Since generation of MPPs data require more time, labour and technical support unlike surveys of larger plastic debris, sufficient data have not yet been documented.

Chennai is the capital of Tamil Nadu state, and the fourth largest city in India with the population of almost 8.7 million people in the Metropolitan area, and over 4.7 million within the Municipal Corporation (Government of India, 2011). Adyar River (~748 km^2) and Cooum

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River (~1266 km^2) meander through the Chennai city. Annual rainfall is 130 cm, and most of it pours down in a few weeks' time during the Northeast (NE) monsoon (October to December) (CMDA, 2008). The 2015 Chennai flood was resulted from heavy rainfall generated by the annual NE monsoon during 22–24 November 2015 and 1–2 December 2015. More than 500 people were killed and over 1.8 million people were displaced. With estimates of damages and losses ranging from 7 to 15 billion US$, it was the worst natural disasters of the year 2015 (Narasimhan, 2015). Cooum and Adyar river discharges were added to the flood water and inundated the city. The flood water had swept away an estimated 0.1 million tons of debris, including plastic, rubber and thermocol (Janardhanan, 2015). The state government was very particular about beach cleaning activities after the flood; however, only macro-sized debris could be removed (Fig. S1).

In India, only a few research studies have been carried out to assess the macro-sized plastic debris (Dharani et al., 2003; Jayasiri et al., 2013; Ryan, 2013; Arunkumar et al., 2016) as well as microplastics (Nigam, 1982; Reddy et al., 2006; Mugilarasan et al., 2015, in press) in coastal, estuarine and marine environment. The present study aims at assessing the abundance and composition of microplastic pellets (MPPs) along the Chennai coast before and after the 2015 flood event. The objectives of this work are: (i) to study the impact of 2015 flood on distribution of MPPs on the beaches of Chennai, (ii) to characterise the surface oxidation features of MPPs, (iii) to identify the polymer types and age of the

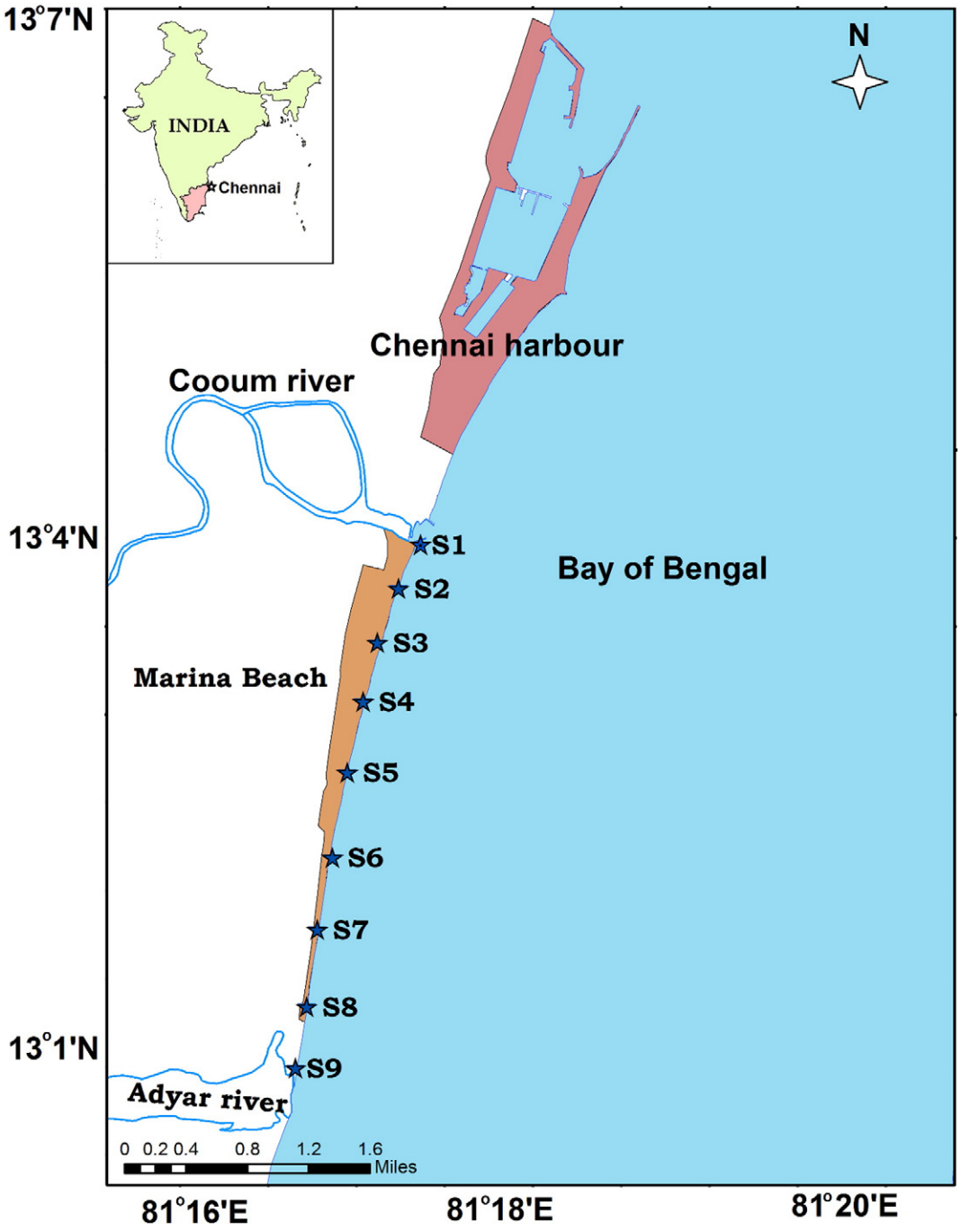

Fig. 1. Study area and sampling locations along the Chennai coast.