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Microplastics in tourist beaches of Huatulco Bay, Pacific coast of southern Mexico

I. Retama^a, M.P. Jonathan^{a,*}, V.C. Shruti^a, S. Velumani^b, S.K. Sarkar^c,
Priyadarsi D. Roy^d, P.F. Rodríguez-Espinosa^a^a Centro Interdisciplinario de Investigaciones y Estudios sobre Medio Ambiente y Desarrollo (CIEMAD), Instituto Politécnico Nacional (IPN), Calle 30 de Junio de 1520, Barrio la Laguna Ticomán, Del. Gustavo A. Madero, C.P. 07340 México DF, Mexico^b Departamento de Ingeniería Eléctrica-SEES, CINVESTAV-IPN, Av IPN 2508, Col. Zacatenco, C.P. 07360 México DF, Mexico^c Department of Marine Science, University of Calcutta, 35, Ballygunge Circular Road, Kolkata 700 019, India^d Instituto de Geología, Universidad Nacional Autónoma de México (UNAM), Ciudad Universitaria, C.P. 04510, Coyoacán, México DF, Mexico

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ABSTRACT

The presence and impacts of plastic marine debris (PMD) have been documented in the oceans worldwide, and they deserve special attention. This study is the first to report the presence of microplastics in tourist beaches located in Huatulco Bay, southern Mexico. A total of 70 beach sediment samples (for 2 distinct seasons) were collected from Huatulco Bay in April 2013 and December 2014. The samples were subsequently extracted by scanning electron microscopy (SEM) to identify the fibrous microplastics (diameter < 5 mm). The maximum number of fibrous materials was found in April 2013 and December 2014 in the Rincón Sabroso beach (48/30 g sediment) and the Cuatunco beach (69/30 g sediment), respectively. Overall, a high amount of microplastics is present in the Conejos, Tangolunda, Santa Cruz, and San Agustín beaches. The microplastics are mainly derived from tourism-based activities and effluents discharged from the hotels and restaurants located along the beaches.

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In the Anthropocene age, the use of plastic has been considered to provide more advantages than the traditional materials as it provides numerous societal benefits. Plastics are lightweight, durable, strong, economic, and hence useful for a wide range of manufacturing processes. High resistance to aging and non-biodegradable properties of plastics attribute to their hazardous nature (Derraik, 2002). Since the 1950s, the annual plastic production has increased dramatically from 1.5 million tons to approximately 280 million tons in 2011 (Plastics Europe, 2012), and there has been a synchronous global increase in plastic production and plastic litter. Approximately 60–80% of marine debris and about 90% of floating debris worldwide are plastics (Gordon, 2006).

Smaller plastic debris known as “microplastics” (diameter < 5 mm), which are often not visible to the naked eye, pose a great threat and are scientifically one of the major environmental consequences of increased plastic use. Microplastics are sourced by their direct release from scrubs and abrasives used in household activities, personal care products, and synthetic textiles, and by the fragmentation of larger plastics with or without the presence of ultraviolet light radiation (UNEP, 2013). Primary sources of microplastics are microscale products. Secondary sources result from the fragmentation of macroplastics by photodegradation, oxidation, and mechanical abrasion (Andrady,

2003, 2005; Browne et al., 2007; Cole et al., 2011; Wright et al., 2013). Because of the persistence and ubiquitous nature of microplastics, they act as potential vectors for the transfer and exposure of persistent organic pollutants to marine organisms (Hidalgo-Ruz and Theil, 2013). These plastic debris attract the encrusting organisms and can be easily ingested or entangled by various marine organisms (Bockstiegel, 2010; Martins and Sobral, 2011a, 2011b; Von Moos et al., 2012).

Plastics found in beach environments are chemically weathered, and they have mechanically eroded surface textures. Beaches act as an excellent depositional site for plastic debris (Corcoran et al., 2009). The presence of plastic fragments alters permeability of beach sediments and affects heat transfer between sediment grains (Carson et al., 2011). Similarly, the presence of large amounts of white microplastics in the beach sands stimulates various invertebrates for their settling and colonization, resulting in their ingestion, as they resemble a prey (Katsanevakis et al., 2007). The pivotal status of microplastics in the global environmental dimension is considered deleterious, especially for marine environments, because of their high resistance to aging and slower rate of biodegradation.

The extensive beaches along Huatulco Bay of the Pacific coast of Mexico are prominent tourist destinations, gaining approximately 65% of main income from tourism-based activities by fetching >300,000 tourists every year (Huerta and Sánchez, 2011). In the beaches of Huatulco, the huge amounts of microplastics are attributed to the high influences of the sewage disposed by the stationed cruise vessels, hotels,

* Corresponding author.

E-mail address: mpjonathan7@yahoo.com (M.P. Jonathan).

and tourist activities fringing the bays of Huatulco. To date, there are no reports on the presence of microplastics in the sediments of this Mexican coastline. Hence, this is the first study to document the presence of microplastics in the sediments of tourist beaches located along Huatulco Bay of southern Mexico.

The rugged terrain of Huatulco Bay divides the approximately 35-km coastline into nearly nine small bays and 36 beaches. In this study, beaches were chosen according to their accessibility and presence of tourist activities. Samples were collected considering two distinct seasons. The first one was in April 2013 immediately after the Easter week and the second sampling was carried out in December 2014 (Christmas week) to observe the impact of tourism on plastic debris accumulation. A total of 70 sediment samples (35 in each season) were collected from: (1) Bahía Conejos [S. Nos. 1–6]; (2) Bahía Tangolunda [S. Nos. 7–11]; (3) Bahía Chahue [S. Nos. 12–16]; (4) Bahía Santa Cruz [S. Nos. 17–20]; (5) Bahía Órgano [S. Nos. 21]; (6) Bahía Maguey [S. Nos. 22]; (7) Bahía Cacaluta [S. Nos. 23]; (8) Bahía Chahacual [S. Nos. 24–27]; and (9) Bahía San Agustín [S. Nos. 28–31], El Arenal [S. Nos. 32–33], Boca Vieja [S. Nos. 34], and Cuatnalco [S. Nos. 35] (Fig. 1).

Sediment samples were collected along the high tide line where the flotsam accumulates, and these samples were air-dried in laboratory (at room temperature) for further analyses.

The analytical procedure includes density separation method modified by Thompson et al. (2004). It was followed by filtration and visual inspection. The first step of analysis involved treatment of 30-g sediment sample with 30% H_2O_2 overnight to remove natural organic debris, and this pretreatment did not affect any plastic particles. The floating technique was used to extract microplastics from the beach sediments. Because most of the plastics have specific gravity >1 , a zinc chloride solution (density, 1.58 g/cm^3) was introduced into the sample, which made the microplastics to float (Liebezeit and Dubaish, 2012; Imhof et al., 2013; Nuelle et al., 2014). The floating microplastics were filtered using a $1.2\text{-}\mu\text{m}$ nitrocellulose filter paper, subsequently air-dried in the laboratory, and then observed under stereomicroscope to estimate their surface structure, diameter, and size. Later, the selected microplastics were observed under a scanning electron microscope (HRSEM – Auriga) and confirmed as plastic materials (60–72% of C) by inbuilt EDAX.

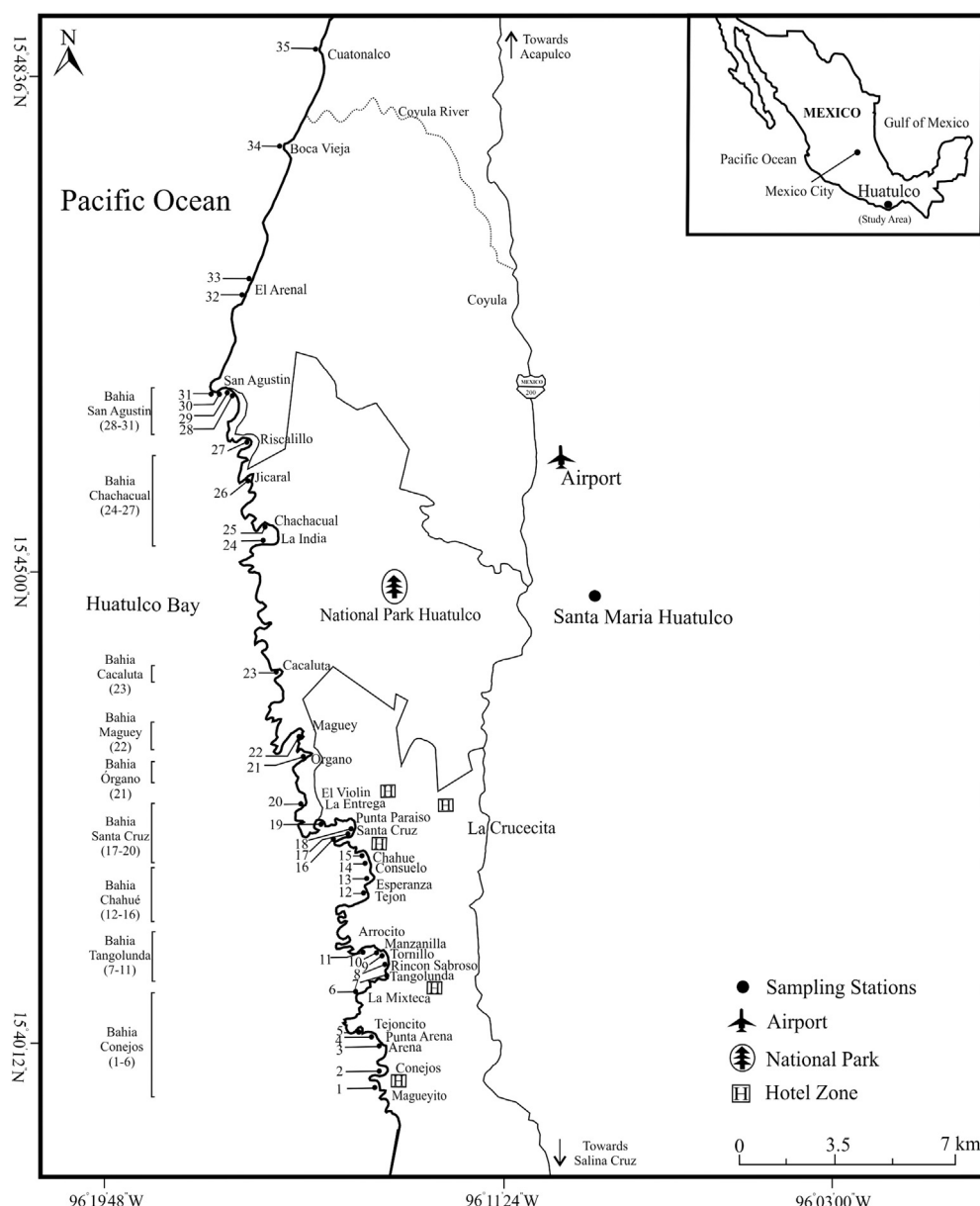


Fig. 1. Map illustrating the sampling locations of tourist beaches and bays in Huatulco Bay, Mexico.

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