Marine Pollution Bulletin xxx (xxxx) xxx–xxx

Contents lists available at ScienceDirect

Marine Pollution Bulletin

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

Beach macro-litter monitoring and floating microplastic in a coastal area of Indonesia

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ARTICLE INFO

Keywords:
Marine debris
Polymer degradation
Citizen science
Anthropogenic
Indonesia

ABSTRACT

Qualitative analysis of the structures of the polymers composing floating plastic debris was performed using attenuated total reflectance-Fourier transform infrared spectroscopy (ATR-FTIR), and the aging of the debris was assessed by measuring carbonyl group formation on the particle surfaces. Plastic material made up > 75% of the 2313 items collected during a three-year survey. The size, shape and color of the microplastic were correlated with the polymer structure. The most abundant plastic materials were polypropylene (68%) and low-density polyethylene (11%), and the predominant colors of the plastics were white, blue and green. Cilacap Bay, Indonesia, was contaminated with microplastic at a concentration of 2.5 mg·m^3. The carbonyl index demonstrated that most of the floating microplastic was only slightly degraded. This study highlights the need to raise environmental awareness through citizen science education and adopting good environmental practices.

1. Introduction

The accumulation and potential impacts of plastic debris and particles in the ocean have been recognized worldwide as emerging environmental issues (Morét-Ferguson et al., 2010); Martins and Sobral, 2011; Lee and Sanders, 2015; Suaria et al., 2015). Despite the publication of several relevant studies, quantifying the amounts and sources of plastic and other types of debris in the marine environment is difficult. Barnes et al. (2009) reported that in addition to the recreational use of coastal areas and tourist activities, inadequately managed sanitary landfills, rivers, sewage and storm water, and industrial and manufacturing facilities are potential land-based sources of plastic waste in the marine environment. In Indonesia, Jambeck et al. (2015) estimated that 0.52 kg of waste per person was generated each day and that 83% of that total was mismanaged. Among this huge quantity of waste, plastic accounts for 11%, 10.1% of which is properly managed. With a population of 187.2 million people who live within 50 km of the coastline, Indonesia produces approximately 5.4 million metric tons of plastic waste, 3.22 million of which is mismanaged, resulting in 0.48–1.29 million metric tons ending up as marine waste (Jambeck et al., 2015). Although these substances are not at sufficiently high levels to pose an immediate risk, the management of plastic waste in Indonesia is still inadequate. We acknowledge that we live in a "throwaway culture," in which the packaging of our food and beverages are composed of plastic. The environmental and health concerns associated with plastic pollution are recognized not only in Indonesia but also globally. Thus, addressing this risk and monitoring the extent, fate and impact of plastic debris is an urgent concern in Indonesia. To the best of our knowledge, few studies have been conducted on organic pollution in Indonesia and its neighboring countries (Willoughby, 1986; Evans et al., 1995; Willoughby et al., 1997; Uneputty and Evans, 1997; Ng and Obbard, 2006; Ryan, 2013; Cordova and Wahyudi, 2016). The present study focused on the coast of Cilacap Regency, Indonesia, which is vulnerable to plastic accumulation on beaches from land sources due

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http://dx.doi.org/10.1016/j.marpolbul.2017.06.046
Received 9 May 2017; Received in revised form 15 June 2017; Accepted 16 June 2017

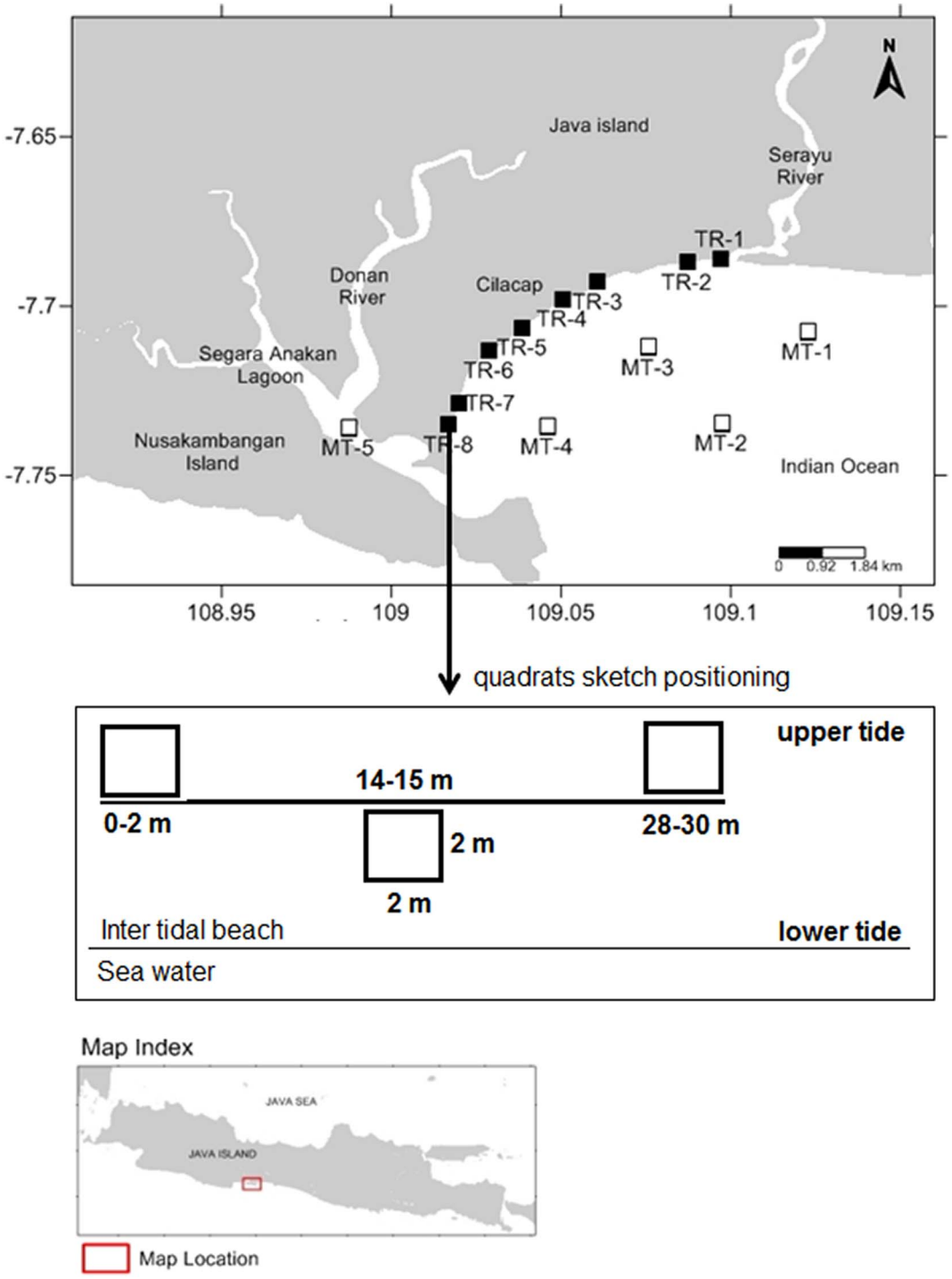

Fig. 1. Location of sampling sites along Cilacap's coast. TR-1 to TR-8 (transects 1–8), with an insert showing the positioning of the quadrats alongside the transects, MT-1 to MT-5 (Mantanet Transect 1–5).

to the river discharge and population concentration along the coast and from marine sources due to fishing, maritime recreation, commercial vessels and cruise ships. The goal of this study was to investigate the composition, distribution and origin of plastic litter along the strand lines of representative islands on the Cilacap coast. Accordingly, the plastic particle composition was analyzed and assigned to the following seven types of polymers: polycarbonate (PC), polystyrene (PS), polyethylene terephthalate (PET), polyvinyl chloride (PVC), low-density polyethylene (LDPE), high-density polyethylene (HDPE) and polypropylene (PP).

2. Materials and methods

2.1. Study area

The Cilacap region is located on the south coast of Java and is surrounded by an area of slough, tributaries, mangrove swamps and intertidal land converted into rice fields (Fig. 1). A population of approximately 1.8 million, which is equivalent to 900 persons/km^2 and includes 33,000 commercial fishermen, lives along the Cilacap coast. The Cilacap coastal water is important for marine traffic, with 4500 boats being listed as operational vessels, mostly for fishing and