



## Distribution and quantity of microplastic on sandy beaches along the northern coast of Taiwan



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### ABSTRACT

Plastic pollution is now ubiquitous in the world's oceans, and studies have shown macroplastic and microplastic pollution of beaches in several East Asian countries. However, to our knowledge, no study of microplastic pollution has been conducted in Taiwan yet. Therefore, we collected sand samples from four beaches along the northern coast of Taiwan in 2015 and extracted microplastic particles using a saturated NaCl solution. Microplastic particles were identified using synchrotron-based FTIR spectroscopy. We recovered 4 to 532 particles from eight 0.0125 m<sup>3</sup> samples, with a total of 1097 particles weighing 0.771 g. A negative trend between the size of the particles and their numbers was documented. We thus established that microplastic pollution was ubiquitous along Taiwan's northern coast. Future research should more comprehensively sample beaches around the entirety of Taiwan's coast, and special emphasis should be placed on identifying different sources and movements of microplastic.

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### 1. Introduction

Plastic pollution is a growing global problem in terrestrial habitats (vom Saal et al., 2008; Thompson et al., 2009) but even more so in oceanic habitats (Barboza and Gimenez, 2015; Gross, 2015; Wilcox et al., 2015). Plastic pollution is now ubiquitous throughout the world's oceans and is estimated at a minimum of 5.25 trillion pieces of various sizes weighing approximately 270,000 tons (Eriksen et al., 2014). The negative impacts of this pollution include the death of marine animals through entanglement with and ingestion of plastic debris, transport of invasive species, leaching of toxic chemicals and their introduction into the food chain, and, finally, the pollution of coastal environments (Engler, 2012; Wilcox et al., 2015).

Plastic pollution has been divided into two size classes: macroplastic and microplastic pollution. Currently there is no standard size defined for the upper and lower limits of microplastic. Some studies refer to particles which are smaller than 5 mm as microplastic, whereas other studies use 1 mm as the upper limit. Likewise, due to methodological differences in sample preparation or analytical technique, the lower size limit of reported data from field samples also varies greatly, as it can range from 1 mm down to a few μm (Hidalgo-Ruz et al., 2012; Van Cauwenbergh et al., 2015).

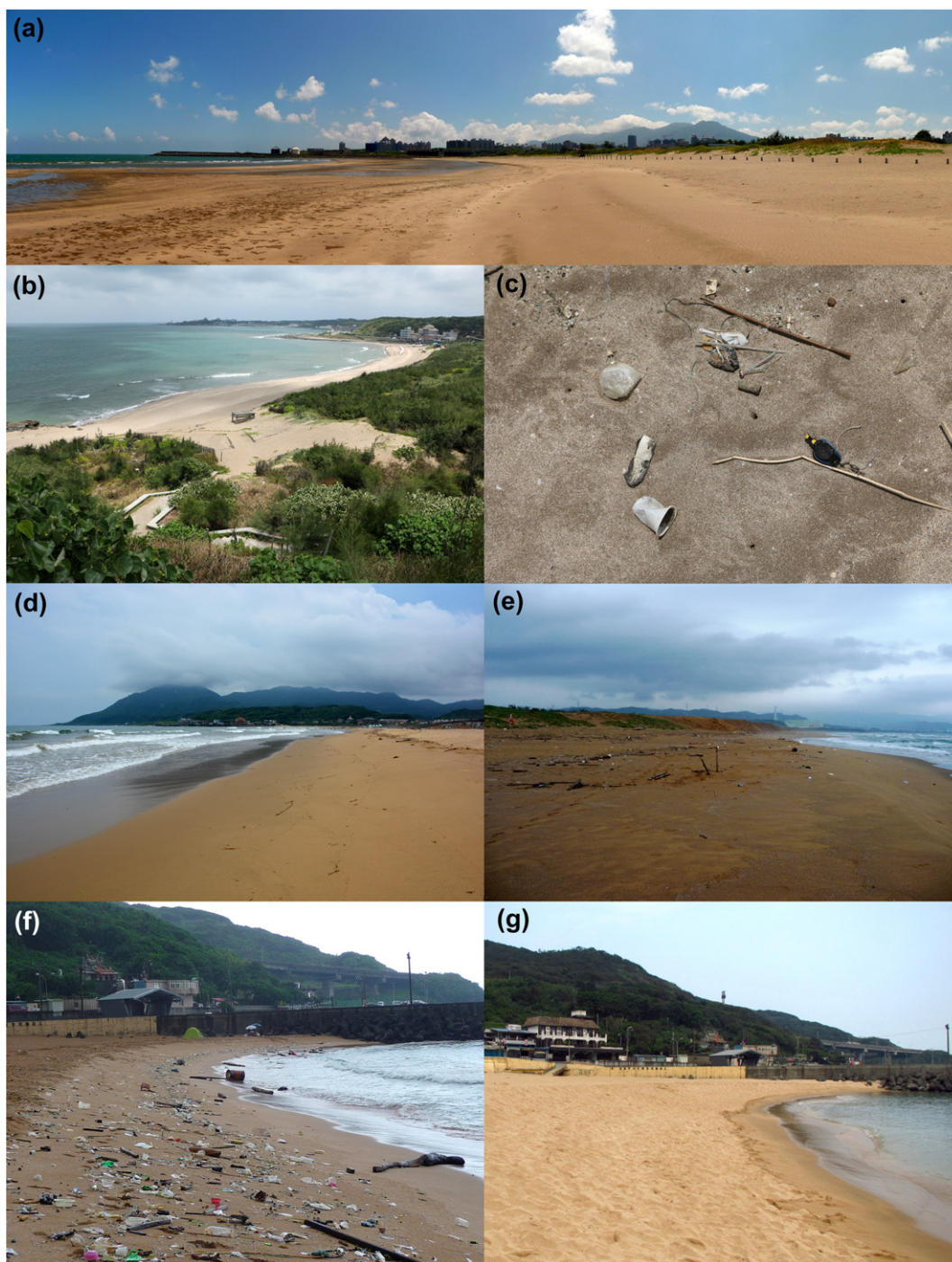
Both types of pollution influence coastal environments, including sandy beaches (Laglbauer et al., 2014; Turra et al., 2014; Kim et al., 2015). Macroplastic may affect animals through entanglement, and another impact is visual pollution which negatively impacts the tourism industry and the resulting costs of continuous cleaning operations (Gregory, 1999; Jang et al., 2014; Kuo and Huang, 2014). While microplastics deposited within the sediments of sandy beaches have no visual impact, they may have significant environmental influence via the introduction of toxic chemicals into the food chain and thus ultimately humans (Thompson et al., 2009; Frias et al., 2010; Engler, 2012; Browne et al., 2013; Fisner et al., 2013; Gross, 2015). Microplastic pollution in sediments may also serve as a spatio-temporal indicator of oceanic pollution.

These concerns about both types of plastic pollution should be especially pertinent to the Taiwanese public because (1) macroplastic pollution has reached pervasive and catastrophic proportions along Taiwan's coastline, (2) macroplastic pollution has already negatively impacted the tourism industry which is forced to regularly clean beaches used by tourists, and (3) a relatively high proportion of people's diet comes from seafood which may cause people to ingest microplastics (e.g., Rochman et al., 2015) or chemicals which enter the food chain via microplastic ingestion (e.g., Engler, 2012). To illustrate the visible macroplastic pollution, we took representative photos (Fig. 1) at the four beaches which we also sampled for microplastics in their sediments (this study).

It is thus surprising that only a few studies have investigated macroplastic pollution along Taiwan's shores (Liu et al., 2013; Kuo and Huang, 2014; Society of Wilderness, 2014), and, to our knowledge, no

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**Fig. 1.** Photos of the studied beaches. (a) Shalun Beach near the Tamsui river mouth at the north-western coast (August 2015). (b) Baishawan Beach at the northern coast (August 2015). (c) Example for macro plastic pollution at Baishawan Beach. (d) Fulong Beach at the north-eastern coast. View from sampling position towards south (June 2015). (e) Fulong Beach after typhoon Soudelor hit Taiwan. View from sampling position towards north. Macro plastic and other debris accumulated above the high tide line (August 2015). (f) Waimushan Beach with heavy pollution of macro plastic and other debris after typhoon Soudelor hit Taiwan (August 2015). (g) Waimushan Beach in March 2014, illustrating that some beaches in Taiwan are regularly cleaned.

study has yet examined in detail microplastics along Taiwan's shores, especially within sandy beach sediments. Within East Asia, a few studies have already investigated macroplastic and microplastics pollution of sandy beaches, e.g., in Hong Kong (Zurcher, 2009), Japan (Kusui and Noda, 2003), South Korea (Heo et al., 2013; Lee et al., 2013; Kim et al., 2015) and Singapore (Ng and Obbard, 2006).

Therefore, we conducted a pilot study to investigate the microplastic pollution along Taiwan's northern coastline (1) to develop and test methods for sampling microplastic pollution within sandy beach sediments, and (2) to quantify the microplastic

pollution in terms of the polymer type, quantity and size of microplastic particles.

## 2. Materials and methods

### 2.1. Study area

We took samples from four different sandy beaches along the northern coast of Taiwan. The northern coast of Taiwan is mostly made up of rocky shores, and sandy beaches occur only in several relatively small

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