Marine Pollution Bulletin xxx (xxxx) xxx–xxx

Contents lists available at ScienceDirect

Marine Pollution Bulletin

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

Effects of microplastics on sessile invertebrates in the eastern coast of Thailand: An approach to coastal zone conservation

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ARTICLE INFO

Keywords:
Microplastic accumulation
Sessile invertebrate
Filter feeder
Coastal ecosystem
Intertidal zone
Coastal pollution
Indicator organism

ABSTRACT

This study assessed the microplastic contamination of 3 most abundant sessile and intertidal invertebrates (Rock Oyster: *Saccostrea forskalii,* Striped Barnacle: *Balanus amphitrite*, Periwinkle: *Littoraria* sp.) in 3 beaches of the eastern coasts of Thailand. The results showed a significant accumulation of microplastics in the invertebrates at rates of 0.2–0.6 counts/g indicating higher pollution levels along the coastline. Filter feeding organisms showed comparatively higher accumulation rates of microplastics. Thus, contaminated bivalves pose potential health risks for seafood consumers. The plastic pollutant prevalence in sessile and intertidal communities was corresponded with pollution characteristics of contaminated beach habitats where they live. Thus, bivalves, gastropods and barnacles can be used as indicators for contamination of microplastics in the areas. This study also demonstrated the need for controlling plastic pollution in Thai coastal areas.

1. Introduction

The coastal zone is defined as the geomorphological region on either side of the seashore where the biotic and abiotic components of the marine and terrestrial environments interact to form complex ecological and economic resources systems, in which the human population, both resident and tourist, performs their social, recreational and commercial activities (Protocol on Integrated Coastal Zone Management in the Mediterranean, 2012). The zone is an ideal place for human activities such as for housing developments, commercial industries and human recreation (Nordstrom, 2000) and consequently is affected by various perturbations such as pollutions (Brown and McLachlan, 2002).

Among the existing pollutants, plastic is a global concern recently because of its negative effects on the coastal and marine environment. The plastic production has doubled worldwide over the past 15 years due to its durability, low cost, attractive appearance, and light weight (Thompson et al., 2004; Plastics Europe, 2010; Jambeck et al., 2015). As a result, approximately 89% of coastal and marine debris is plastic, and > 45,000 pieces of plastic per square mile have been estimated worldwide annually (Central database system and data standard for marine and coastal resources, 2013). The presence of plastic debris in the coastal environment is caused by the tourism, agriculture, aquaculture, fisheries and industrial sectors (Nagelkerken et al., 2001; Fujieda and Sasaki, 2005; Oigman-Pszczol and Creed, 2007).

When plastic reaches the ocean, a fraction of the dense plastic debris is submerged into the deep sea floor, whereas the other fraction remains as floating debris with close proximity to the sea surface and gradually accumulates along the coastal belt (Webb et al., 2013; Thevenon et al., 2014). When mega- and macro- sizes of plastics debris are exposed to atmospheric chemical reactions, ultraviolet rays, sea water, and other physical forces, such as wave actions, these debris gradually break down into micro-sized plastic particles (< 5 mm) (Webb et al., 2013; Barnes et al., 2009; Arthur et al., 2009). Microplastic particles have a similar size range with that of food and other suspended type particles (Wright et al., 2013). Consequently, different invertebrates in the coastal ecosystems are more likely to ingest these micro-sized plastic particles. Sessile organisms or species with low motility in their native habitats are directly affected by these environmental changes (Oehlmann et al., 2009; Thompson et al., 2004; Ward and Shumway, 2004). The impact of microplastic ingestion on different invertebrate groups with diverse feeding mechanisms has been studied in different parts of the world (Thompson et al., 2004; Leslie et al., 2013; De Witte et al., 2014). These previous studies also showed that the eco-toxicological conditions of particular species were related to the

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http://dx.doi.org/10.1016/j.marpolbul.2017.06.010
Received 10 February 2017; Received in revised form 4 June 2017; Accepted 5 June 2017

environmental stress levels in their habitats (Nayar et al., 2004). However, no study was done in Thailand.

From previous studies, significant quantity of plastic accumulates into the oceanic environment and coastal ecosystems are mainly from Asian countries including Thailand which have comparatively high economic growth rates (Jambeck et al., 2015; Ocean Conservancy Report, 2015). Plastic has also been identified as one of key component in Municipal Solid Waste (MSW) composition of Thailand (Chiemchaisri et al., 2006; Kaosol, 2009). Thus, land based plastic can be the main source of plastic pollution in coastal waters (Jambeck et al., 2015; Ocean Conservancy Report, 2015).

Chonburi Province, located in the upper Gulf of Thailand, is one of the most rapid industrialized development areas and urban settlement during the past two decades (Thongra-ar and Parkpian, 2002). Intense tourism and large-scale commercial fishery activities cause plastic contamination along this coastline (Thushari et al., 2017). Consequently, these rapid expansions of man-made activities pose a potential risk to the survival, growth, and ecological relationship of floral and faunal communities and humans. Sessile and intertidal invertebrates, including barnacle, bivalve and gastropod populations, are potentially affected by coastal pollutants, such as plastic debris in this coastline (Thushari et al., 2017). However, several intertidal bivalves have high commercial values because they are popular seafood sources among local residents and tourists in this area. Thus, the eco-toxicity investigation of invertebrates can be useful for identifying whether these seafood sources are within the range of accepted health standards. Currently detailed eco-toxicological indicator data are not available for predicting the effects of plastic pollution along this coastline in Chonburi province, Thailand. This study focused on the assessment of accumulation rate of micorplastic debris in sessile and intertidal invertebrates: rock oyster (*Saccostrea forskalii*), striped barnacle (*Balanus amphitrite*), and periwinkle (*Littoraria* sp.) that represent the bivalve, crustacean and gastropod taxonomic groups respectively.

2. Materials and methods

2.1. Study sites

Three study sites (Angsila, Bangsaen, Samaesarn) were selected at Chonburi Province, the upper Gulf of Thailand (Fig. 1) to represent three different coasts with different anthropogenic activities. Bangsean is a local tourist destination. Angsila is a coastal fishery village with commercial fishing and shellfish culture practices. Angsila is also a popular destination for fresh seafood. Samaesarn beach is in the Royal Thai Naval base. However, the area is currently affected by nearby fishing village and tourism activities.

2.2. Analysis of accumulation rates of microplastic contaminants in natural inhabitants

2.2.1. Sampling of invertebrates

Three invertebrate species (namely, the striped barnacles *Balanus amphitrite*, the periwinkle *Littoraria* sp., and the rock oyster *Saccostrea forskalii*) were selected for microplastic level screening. These organisms are the dominant natural inhabitants in the study sites. The selected species were randomly collected from the intertidal zone on the surveyed beaches from March to May 2015 during low tides. Sessile organisms that are attached to natural hard substrates (rocks) and synthetic debris items (polystyrene, nylon, and hard plastic substrates) were considered during the sampling of invertebrates and pooled prior to the analysis. A total of 50 specimens of periwinkles (> 0.8 cm shell length), 50 specimens of striped barnacles (> 1 cm shell length), and 15 specimens of rock oysters (4–6 cm shell length) were collected in each site, and separately placed inside the specimen glass bottles to prevent cross-contamination. In the laboratory, sampled organisms were thoroughly rinsed by filtered distilled water. All encrusted organisms, impurities, and sediments attached to the invertebrate shells were removed. Microplastic analysis was performed without subjecting to the depuration process because the value prior to depuration reflects the original quantity of microplastics in the specimens, which are linked to the current environmental condition during samplings (Cauwenberghe and Janssen, 2014).

2.2.2. Laboratory tests to analyze microplastic levels of biota

After thoroughly rinsing the samples, each specimen sample was dissected. The samples, including the digestive tracts, were kept in separate, rinsed glass bottles to prevent contamination. The prepared samples were frozen, until further used. In addition, each prepared

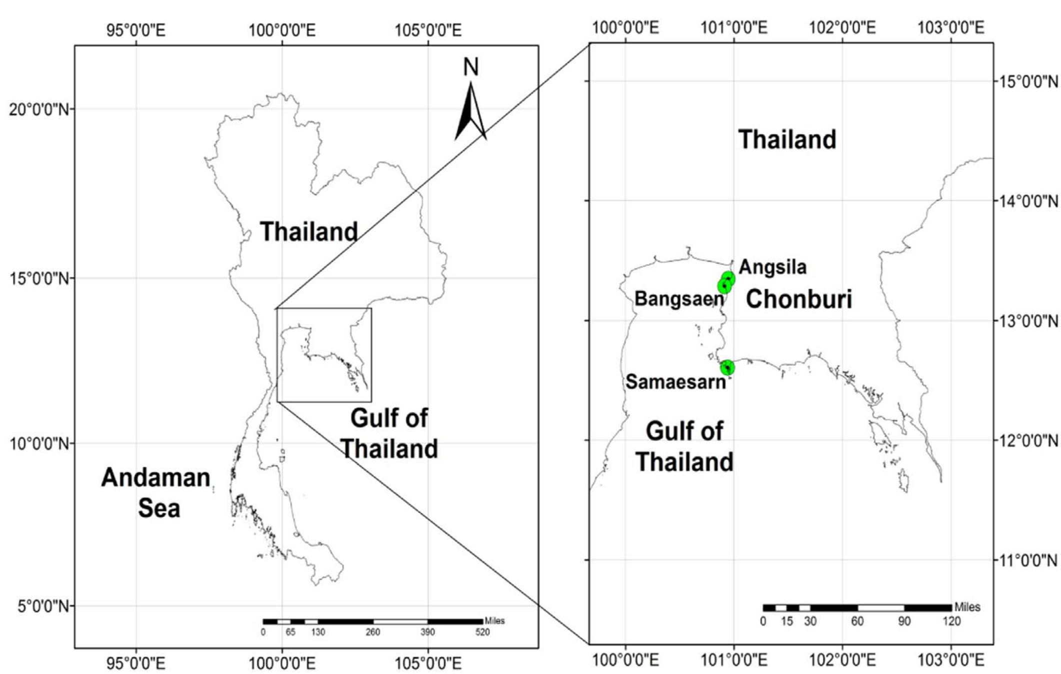

Fig. 1. Map of the study sites in Chonburi Province, the upper Gulf of Thailand.