Environmental Pollution 236 (2018) 619–625

Contents lists available at ScienceDirect

Environmental Pollution

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

Microplastics in oysters *Saccostrea cucullata* along the Pearl River Estuary, China☆

Heng-Xiang Li [a], Li-Sha Ma [b], Lang Lin [a, c], Zhi-Xin Ni [d], Xiang-Rong Xu [a, *], Hua-Hong Shi [e], Yan Yan [a], Guang-Ming Zheng [b], Daniel Rittschof [f]

[a] CAS Key Laboratory of Tropical Marine Bio-resources and Ecology, Guangdong Provincial Key Laboratory of Applied Marine Biology, South China Sea Institute of Oceanology, Chinese Academy of Sciences, Guangzhou 510301, China
[b] Pearl River Fisheries Research Institute, Chinese Academy of Fishery Sciences, Guangzhou 510380, China
[c] University of Chinese Academy of Sciences, Beijing 100049, China
[d] South China Sea Environmental Monitoring Center, South China Sea Branch of the State Oceanic Administration, Guangzhou 510300, China
[e] State Key Laboratory of Estuarine and Coastal Research, East China Normal University, Shanghai 200062, China
[f] Marine Laboratory, Nicholas School of the Environment, Duke University, Beaufort, NC 28516, USA

A R T I C L E I N F O

Article history:
Received 11 November 2017
Received in revised form
24 January 2018
Accepted 24 January 2018

Keywords:
Microplastics
Oyster
Estuary
Biomonitor
Fiber

A B S T R A C T

As a transitional zone between riverine and marine environments, an estuary plays an important role for the sources, accumulation and transport of microplastics. Although estuarine environments are hotspots of microplastic pollution, the correlation between microplastic pollution and aquatic organisms is less known. Here we investigated microplastic pollution in wild oysters *Saccostrea cucullata* from 11 sampling sites along the Pearl River Estuary in South China. The microplastic abundances in oysters ranged from 1.4 to 7.0 items per individual or from 1.5 to 7.2 items per gram tissue wet weight, which were positively related to those in surrounding waters. The oysters near urban areas contained significantly more microplastics than those near rural areas. Fibers accounted for 69.4% of the total microplastics in oysters. Microplastic sizes varied from 20 to 5000 μm and 83.9% of which were less than 100 μm. Light color microplastics were significantly more common than dark color ones. Based on the results, oysters are recommended as a biomonitor for the microplastic pollution in estuaries.

1. Introduction

In recent years there is a growing concern over microplastic pollution, which is a global environmental problem in the oceans (Andrady, 2011). It was estimated more than 5 trillion plastic pieces and over 250,000 tons of plastics floating in the world's oceans (Eriksen et al., 2014). Plastic litter from land-based sources has being continually discharged into the oceans and their accumulation has resulted in widespread presences of microplastics (Andrady, 2011). These microplastics have been frequently detected in seawater, sediments, biota, and even in polar ice (Auta et al., 2017), with densities of 1.72 million pieces km^{-2} in the surface seawater around Japan (Isobe et al., 2015). The small and ubiquitous plastic particles, microplastics, could be ingested by a wide range of marine organisms from invertebrates to fish (Wright et al., 2013). Once ingested, microplastics could transfer pollutants and plastic additives into the bodies of biota and cause adversely biological effects (Browne et al., 2013; Avio et al., 2015). As a result, microplastics are regarded as an emerging threat to marine ecosystems and biodiversity worldwide (Galloway and Lewis, 2016; Wright et al., 2013).

As a transitional zone between riverine and marine environments, estuarine environments play an important role for microplastic accumulation and transport (Eerkes-Medrano et al., 2015). Microplastics enter the riverine and estuarine environment through runoff, sewage discharge, effluents from plants, and atmospheric deposition from surrounding areas (Browne et al., 2011; Wagner et al., 2014). Accumulation of microplastics in estuarine environment was documented significantly higher than that in surrounding coastal areas (Peng et al., 2017; Zhao et al., 2014). The estuaries are the most important path for microplastic delivery to the oceans. It was estimated that 1.15–2.41 million tonnes of plastic litter, including microplastics, has been discharged into marine

☆ This paper has been recommended for acceptance by Eddy Y. Zeng.
* Corresponding author.
E-mail address: xuxr@scsio.ac.cn (X.-R. Xu).

https://doi.org/10.1016/j.envpol.2018.01.083
0269-7491/

environment every year from rivers worldwide (Lebreton et al., 2017). Therefore, microplastic monitoring in estuaries is very important for tracing its sources and understanding its role in contribution of microplastic pollution to the oceans.

The Pearl River Delta is one of the most urbanized and industrialized areas in China, with more than 60 million people living there. The intensively anthropogenic activities have resulted in severe pollution in the Pearl River Estuary (PRE). Fok and Cheung (2015) stated that wastewater from populated areas discharged large amounts of contaminants, including microplastics into South China Sea via the PRE. Additionally, there were 10.05 million tons of plastic productions manufactured in Guangdong province in 2016, most of which were from the Pearl River Delta. Thus microplastics might be discharged from plastic industries and enter the PRE. To date, the coastline along the PRE has been documented as hotspots of microplastic pollution (Cheung and Fok, 2016; Fok and Cheung, 2015; Fok et al., 2017), however, microplastic pollution in the water and aquatic organisms is still unknown.

Microplastic pollution in the estuary may pose potential threats to aquatic organisms, especially those bivalves that filter large volume of water for food, including microplastics in water. Oysters are common benthic organisms widely distributed in estuaries due to their high tolerance to salinity and pollution (Wang et al., 2014). These filter-feeding mollusks settle gregariously and expose directly to contaminants in water, thus they were reported as biomonitoring agents to reflect environmental pollution status, such as metal contamination (Wang et al., 2014). However, few reports have been known about the microplastic pollution in oysters (Li et al., 2015; Rochman et al., 2015; Van Cauwenberghe and Janssen, 2014). Two oyster species, *Crassostrea gigas* (Rochman et al., 2015; Van Cauwenberghe and Janssen, 2014) and *Alectryonella plicatula* (Li et al., 2015), were reported to contain microplastics in their bodies. Since oysters are commercial seafood in many countries such as China, the United States, the United Kingdom, and European Union, microplastics in oysters may transfer in the food chain and become a source of microplastics that human intake, but their potential risks to human health have been still unknown. Considering the commercial and environmental importance of oysters, we conducted an investigation of microplastic pollution in oysters along the PRE of China. Our aims were to understand 1) the abundance and spatial distribution of microplastics in oysters, 2) the correlation between microplastic abundances in oysters and surrounding waters, 3) the size, color, and composition of microplastics in oysters.

2. Materials and methods

2.1. Sample collection

A species of oysters *Saccostrea cucullata* was chosen and collected from 11 sites along the PRE of South China in July 2016 (Fig. 1). These sites are located at different areas with different anthropogenic activities and pollution levels (Suppl. Table 1). At least 30 wild individuals of oysters were collected in the intertidal zones at each site. Oysters were put into a tin-foil bag after collection and transferred to the laboratory on ice and then stored at −20 °C for subsequent analysis. In addition, 30 L of bulk surface water at the top 20 cm was collected three times at each site by a

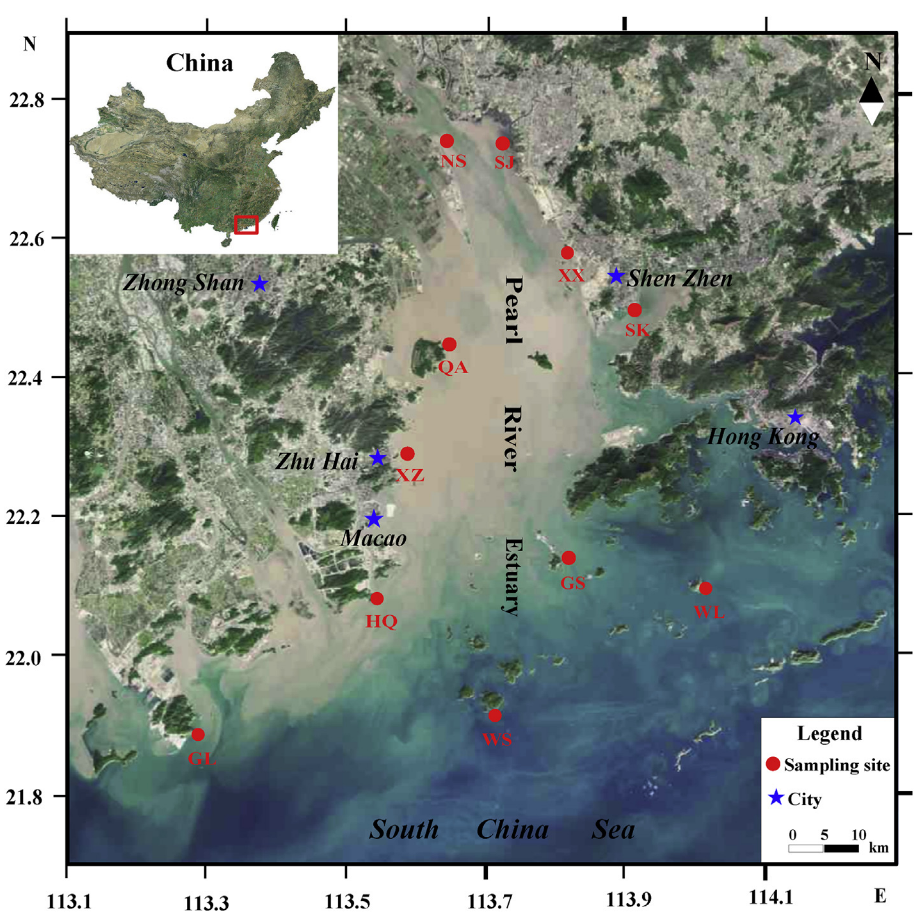

Fig. 1. Geographic location of sampling sites along the Pearl River Estuary.