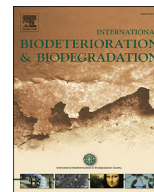




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Phthalate ester distributions and its potential-biodegradation microbes in the sediments of Kaohsiung Ocean Dredged Material Disposal Site, Taiwan

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ABSTRACT

The aim of this study was to examine the effect of dumping harbor dredged sediments into the ocean on the phthalate esters distribution in the sediments of Kaohsiung Ocean Dredged Material Disposal Site (KODMDS). Compared with the sediments outside the disposal site (Area R), the particle size distribution of sediment in disposal site has no significant difference, because the pattern of particle size distribution in the dredged sediments is similar to that in the sediments of KODMDS. Results indicated that the mean phthalate ester content in the centres of the four disposal areas (Area I) were significantly ($p < 0.05$) higher than those in Area R, whereas those in the vertex angles of disposed area (Area II) were no significantly higher than those in Area R. This result implied that the dredged sediments were mainly deposited inside the disposal area, and the surface sediments in KODMDS may be impacted by the disposal of dredged sediments. The percentage of sediment samples for phthalate esters content exceeding Maximum Permissible Concentrations (MPC) and/or Ecotoxicological Serious Risk Concentrations (SRC_{eco}) in Areas I and II was higher than that in Area R, indicated that the disposal of dredged sediments may increase the potentially ecological risks for benthic organisms that lived in the surface sediments of KODMDS. However, the present study has found the bacteria have the ability to degrade PAEs in KODMDS, indicating PAEs in KODMDS could be biodegraded eventually.

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1. Introduction

Kaohsiung Ocean Dredged Material Disposal Site (KODMDS) was established by the Taiwan Environmental Protection Agency (TWEPA) in 2003. The disposal site is located 12–15 nm from the shore. It is centered at E120°03.59', N22°27.57', and covers an area of 36 km² with a side length of 6 km and a water depth between 500 and 700 m (Fig. 1). KODMDS is an exclusive dredged sediment disposal site for Kaohsiung Harbor. It receives 500 thousand m³ of

dredged sediments from Kaohsiung Harbor every year, and has accumulated 4.69 million m³ of dredged sediments by 2013. The disposal site is divided into four disposed areas which receive ocean dumping in turn; a maximum of 15 thousand m³ of dredged sediments are allowed to be dumped into each disposed area in turn for ocean dumping (TIPC, 2013).

Previous studies (Chen et al., 2016) have shown that the total concentration of phthalate esters (Σ PAEs) varied from 4425 to 51,261 ng/g dw, with the mean concentration of 13,196 ng/g dw for dredged sediments in Kaohsiung Harbor. Bis(2-ethylhexyl) phthalate (DEHP), diisononyl phthalate (DiNP), and diisodecyl phthalate (DiDP) were the major species of PAEs. However, some of PAEs (including dimethyl phthalate (DMP), diethyl phthalate (DEP), butylbenzyl phthalate (BBP), dibutyl phthalate (DnBP), and DEHP) have been indicated that they have the bioaccumulation, toxicity,

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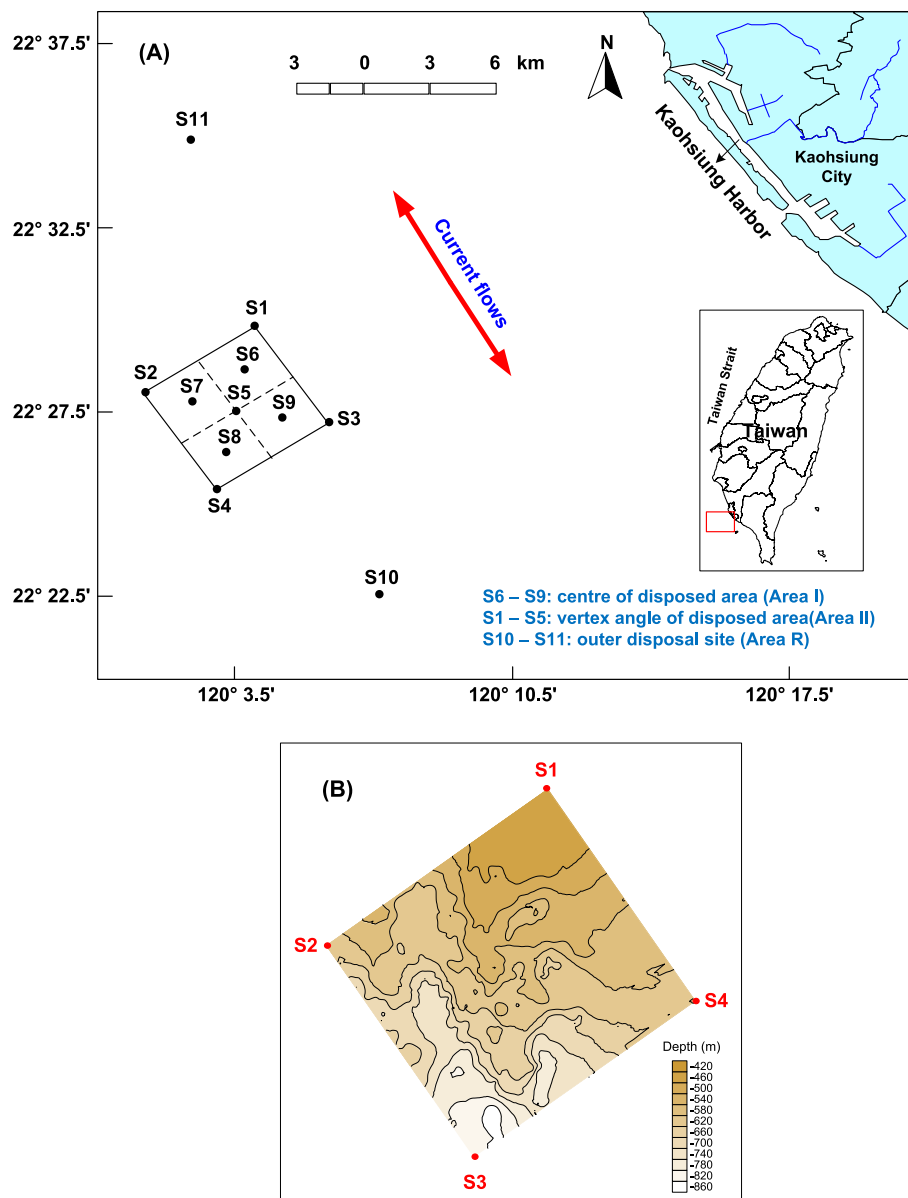


Fig. 1. Map of the study area and sampling locations (A) and bathymetric chart (B) of KODMDS.

and estrogenic effects to aquatic organisms, leading to affect their reproduction, development and to induce genetic aberrations (Ye et al., 2014, 2016; Kambia et al., 2001; Chen et al., 2014; Oehlmann et al., 2009). Therefore, it is necessary to monitor the PAEs concentrations in the sediments of KODMDS, as well as their potential impact on the organisms after the ocean dumping. Although the negative effect of dredged sediments on the aquatic environment can be reduced by the dilution and diffusion effect of the ocean, the long-term ocean dumping of dredged sediments, may lead to the changes of sediment quality in the disposal site (Zimmerman et al., 2003; Kim et al., 2009; Chen et al., 2017), especially for those chemicals harmful to organisms, such as PAEs.

This study was conducted through periodical on-site sampling and monitoring, surveyed the 10 PAEs distribution of the sediments inside and outside KODMDS to examine the PAEs in the sediments of disposal site, and then assessed the changes of the PAEs content after the ocean dumping, in addition to their potential ecological impact. In addition to the above, the bacterial communities in

sediments at centre point of KODMDS were analyzed using the high-throughput sequencing technology of Illumina MiSeq 2 platform to understand the abundance and species of microbes that have the potential ability of degrading PAEs in sediments.

2. Materials and methods

2.1. Survey site and sampling

Surface sediment (0–15 cm) samples were collected at 11 sampling sites (S1–S11) located in the KODMDS in March, May, August and October, 2014 (Fig. 1). A total of 44 samples were analyzed in this study. Details of the sampling point settings, locations, and sampling procedures have been reported in Chen et al. (2017). The collected sediments were placed immediately in amber glass bottles pre-washed with *n*-hexane and sealed with Teflon-lined cap and stored in a refrigerator at $-4\text{ }^{\circ}\text{C}$ until they were sent to the lab. Surface sediment were freeze-dried for 72 h,

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