

Influence of waste management policy on the characteristics of beach litter in Kaohsiung, Taiwan

Ta-Kang Liu*, Meng-Wei Wang, Ping Chen

Institute of Ocean Technology and Marine Affairs, National Cheng Kung University, 1 University Road, Tainan City 70101, Taiwan

ARTICLE INFO

Keywords:

Transect survey
Economic instrument
Source reduction
Waste management

ABSTRACT

Marine debris is a ubiquitous problem that poses a serious threat to the global oceans; it has motivated public participation in clean-up campaigns, as well as governmental involvement in developing mitigation strategies. While it is known that the problem of marine litter may be affected by waste management practices on land, beach survey results have seldom been compared with them. In this study, marine litter surveys on four beaches of Cijin Island were conducted to explore the effects of waste management and policy implications. Indirect evidence shows that chances for land-based litter, such as plastic bags and bottles, entering the marine environment can be greatly decreased if they can be properly reduced, reused and recycled. We suggest that mitigation measures should focus on source reduction, waste recycling and management, utilizing effective economic instruments, and pursuing a long-term public education campaign to raise the public awareness of this problem.

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1. Introduction

Beaches are important tourist attractions and contribute to improving the quality of life. Clean beach is the main indicator of coastal environmental quality. However, coastal regions are susceptible to litter accumulation, and marine litter has become a global problem. The presence of marine debris can negatively affect the aesthetic appeal of beaches and reduce their recreational value and tourism quality (Pendleton et al., 2001). The anthropogenic marine litter is associated with diverse human activities and comes from a wide variety of sources both onshore and offshore. It reduces the aesthetics of the beaches and also results in many undesired environmental consequences, such as increasing adverse health risks, causing significant ecological changes, threatening marine wildlife, leading to loss of biodiversity and inflicting fishery loss (Chiappone et al., 2002; Derraik, 2002; Tudor and Williams, 2003; Abu-Hilal and Al-Najjar, 2004; Thompson et al., 2004; Cho, 2005; Tudor and Williams, 2008). Nearly 80% of the marine debris comes from land-based sources, so the key to abating the problem largely depends on effective measures of waste management on land, since most trash has the potential to enter the ocean and become marine debris (Balas et al., 2004; US Ocean Commission, 2004; Hetherington et al., 2005). Monitoring marine debris is thus extremely crucial in order to identify the sources of debris and then implement the required effective control measures accordingly

(Earl et al., 2000; Tudor and Williams, 2001; Balas et al., 2001). Marine litter survey results can be used for beach management purposes, and may lead to the establishment of national and international legislation for better waste management on land and at sea. They can also stimulate the sense of responsibility to the environment and encourage public participation in the activities related to the maintenance of environmental quality, such as coastal cleanup activities. It is important to know that raising public awareness of the overall quality of the coastal environment is the only guaranteed way of reducing marine litter (Storrier and McGlashan, 2006).

Many countries have established monitoring programs so the results can be used for beach management and for establishing related regulatory measures. However, most of the survey results were not compared to the land-based waste management policy. The practice of waste management on land should have prevented most of the litter from entering the marine environment, yet its influence has seldom been discussed in the literature. Besides, there has been no litter survey performed by academic researchers in Taiwan, and volunteer-based beach cleanups held by communities and local non-governmental organizations generate relatively few quantitative results. In this study, we performed a transect survey during 2009–2011 to investigate the fluctuation of marine litter on four selected beaches in Cijin, Kaohsiung in order to ascertain the type, material compositions, quantity and source of marine debris. The results were compared with the literature and Taiwan's waste management on land to evaluate if the current practice has any influences on the characteristics of the beach litter found in the survey.

* Corresponding author. Tel.: +886 6 2757575x31146; fax: +886 6 2753364.
E-mail address: tkliu@mail.ncku.edu.tw (T.-K. Liu).

2. Methods

This study was carried out at Cijin Island of Kaohsiung in the southwest coast of Taiwan. Four beaches were surveyed every 2 months during the periods: August 2009–June 2010, and December 2010–October 2011. The locations of the four sites are shown in Fig. 1, where Sites 1 and 2, Cijin coastal park and tourist center, respectively, are popular recreational sites that are typically crowded with tourists. Sites 3 and 4, near a municipal wastewater treatment plant and a ship container distributing center, respectively, are more remote beaches. A transect survey similar to those found in the literature was used (Silva et al., 2008; Oigman-Pszczol and Creed, 2007; Storrier et al., 2007; Sheavly, 2007; Silva-Iniguez and Fisher, 2003; Williams et al., 2003). A 100 m × 5 m transect strip above the high-tide mark parallel to the coastline was chosen at random in each site. The coordinates of each site were recorded via a global positioning system (GPS) to allow the subsequent survey in the same stretch of beach, and for use in possible GIS mapping. To evaluate the composition and abundance of beach litter, all the visible pieces of man-made debris found on each sampling site were identified and recorded in a standardized data card modified from the one used in the National Marine Debris Monitoring Program (NMDMP) of the US Environmental Protection Agency

(USEPA). NMDMP was conducted over a 5-year period between 2001 and 2006 along the coasts of the United States, representing one of the most comprehensive and significant marine debris assessment (Sheavly, 2007). Litter items were recorded precisely, and items not shown on the predetermined data card were also noted. The marine litter was categorized by its type of material and source for litter generation activities. Statistical software packages SPSS and PRIMER v.6 were used for ANOVA and multivariate analysis, respectively. The amount of marine litter and top 10 items were then analyzed. Results of the litter survey were compared with those found in the NMDMP as well as the literature from other countries for detailed comparison. Document analysis was used to review Taiwan's waste management practice on land; its influence on the litter found in the survey was then discussed.

3. Characterization of beach litter in Cijin Island

3.1. Results of Cijin beach litter survey

Fig. 2 shows the total items collected in each transect survey. In the study, we collected 23,264 items of beach litter, for an overall mean litter density of 0.90 items per square meter. All sites in Cijin are likely to be influenced by similar meso-scale oceanographic

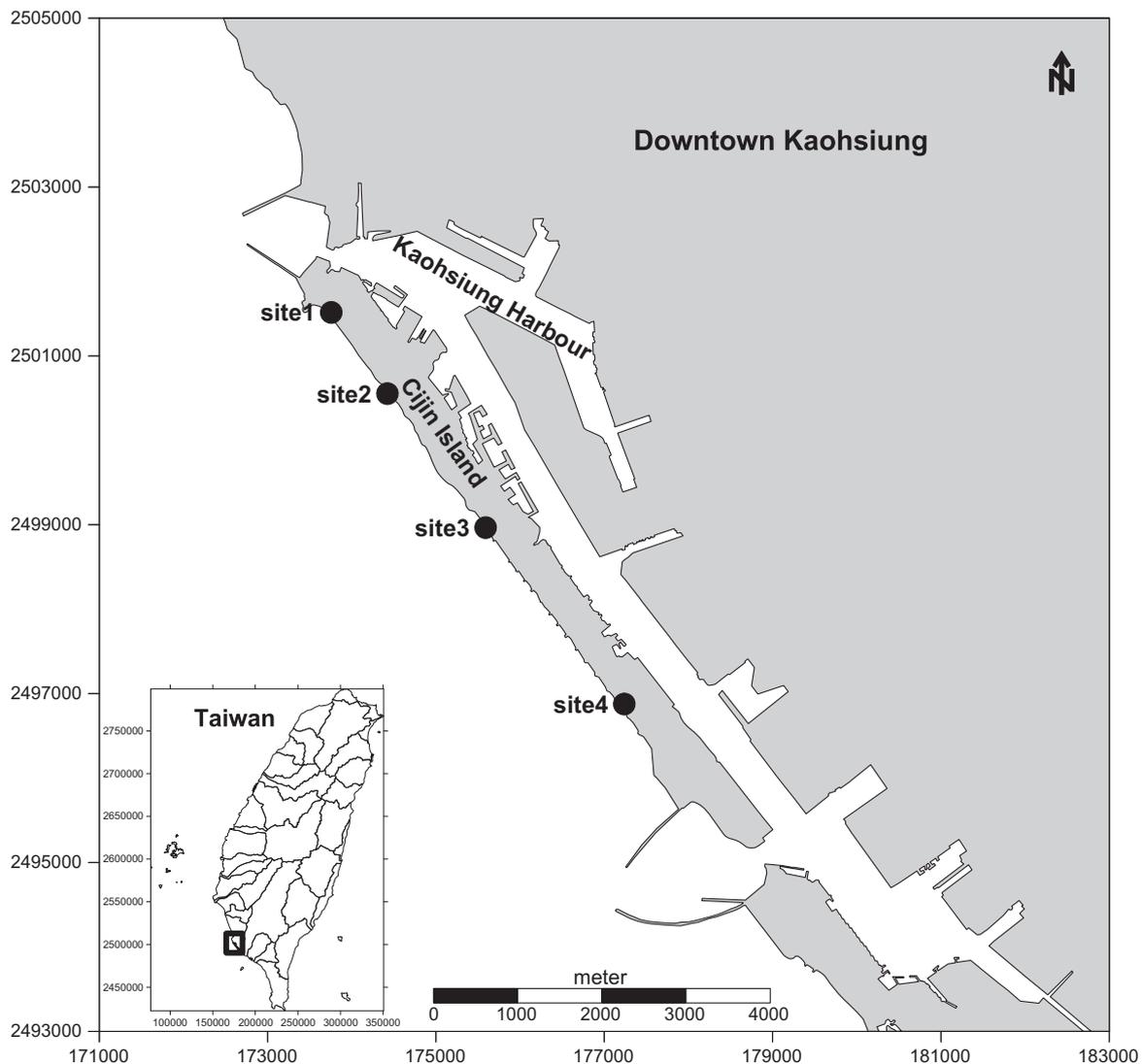


Fig. 1. Location of the survey sites in Cijin Island, Kaohsiung, Taiwan. The coordinates are TWD67 Huzishan 2-degree wide Transverse Mercator projection.

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