Water Quality, Marine Debris and Microplastic Detection in Krabi Province, Southern Thailand

School: Samsenwittayalai School

Student: Amornkarn Srimugda, Pawichaya Prakobkij, Kanyarak Junsri, Peelada Chabumnet, Kamolnant Muangpradit, Pichamon Tinsiripattanakij, Nutthawat Zhang, Suvijak Khacheesawatdikarn, Theerawee Rujivipat, Nattakorn Jundee, Phattarasak Lerttripinyo, Koen Plodpradista, Chanawit Krobbang, Yossavit Samneangngam, Jaruphat Kaewyoo, Chaiwut Thongkoen, Praphatsorn Sooksabai, Natnicha Inthong, Naliya Phuensaen, Thunyaporn Buasri

Teacher: Mrs. Kornkamon Kumnerdkarn, Ms. Nattaya Chuichai

Scientists: Assoc. Prof. Dr. Krisanadej Jaorensutasinee, Assoc. Prof. Dr. Mullica Jaroensutasinee, Miss Khatthariya Saeli, and Miss Thunwarut Sutthipun, Center of Excellence for Ecoinformatics, School of Science, Walailak University

Email: rat.kornkamon@gmail.com, nattaya@samsenwit.ac.th

Abstract

We investigated types, amounts, and sources of marine debris and microplastics and compared how tourism, utilizing different levels of beach cleanup, affected them. We collected marine debris and microplastics at four beaches based on frequencies of beach cleanup: high (Nopharat Thara Beach, Poda Island) and no beach cleaning (Thara Park, Chao Fah Park). The Clean Coast Index (CCI) counted marine debris from a ground survey to assess beach cleanliness. Over 95% of the marine debris was plastic, and microplastics were ubiquitous, which calls for classifying plastics as hazardous materials. Chao Fah Park had the highest (CCI = 89.87), next was Thara Park (CCI = 65.6) and Poda Island (CCI = 7.47), and the lowest CCI was Nopharat Thara Beach (CCI = 6.4). Since Nopharat Thara Beach is a famous tourist beach, it has the highest frequency of beach cleaning. This rapid survey could be developed and applied for a citizen-science project on surveying marine debris and microplastics and monitoring our beaches' condition.

Keywords: Marine debris, microplastic, tourism, human impacts, Clean Coast Index (CCI).

1. Introduction

The coastal tourism and recreation sector is vital to Thailand's economic bloodstream. This sector counts heavily on the healthy coastline and marine resources and the aesthetic quality of the environments, attracting both local and foreign tourists for long-term benefits. Marine debris and microplastics could be the undisputable issues that devalue our precious natural resources (UNEP, 2016). Marine debris and microplastic (plastic particles < 5 mm) is a global issue that needs to be addressed urgently (Barnes et al., 2009; Depledge et al., 2013).

Thailand ranked 6th worldwide in producing ocean plastic debris (Jambeck et al., 2015). Marine debris is any persistent, artificial solid waste discarded into the aquatic environment (Galgani et al., 2015). Most marine debris made of plastic originated from land- and ocean-based sources, well documented for 80% of land-based sources relating to human activities (Barnes et al., 2009). Ocean currents spread large amounts of debris from industrialized and densely populated areas to even the most remote and unpopulated coastal regions (McDermid and McMullen, 2004; Barnes et al., 2009; Hirai et al., 2011). Microplastics are minute fragments of plastic debris, which are divided into small (< 1 mm in diameter) and large (1-5 mm in diameter) particles (Horton et al., 2017). Microplastics consist of nylon, polyester, acrylic, polypropylene, polyethylene, poly (ethylene–propylene), polyvinyl chloride, polyvinyl alcohol, polystyrene, polyester, polyurethane, polyacrylonitrile, alkyd, alkyd resin, and polyamide fibers. The main component of microplastic is usually synthetic polymers (Barnes et al., 2009; Vianello et al., 2013).

Krabi province is one of Thailand's most popular tourist attractions, where marine debris and microplastic debris could be affected by tourism. In this study, we conducted a simple field examination to survey the type, amount, and source of marine debris and to compare how tourism, utilizing different levels of beach cleanup, affects the numbers and density of (visible) microplastic debris among the study locations as well as to find a correlation between marine plastic debris (on the surface) and the residues of visible microplastic debris (found in sand sediment). We predicted that beaches with high beach cleanup frequency would have lower amounts of marine debris, microplastics, and CCI. We tested our prediction on three beaches based on beach cleaning frequencies: high (Nopharat Thara Beach and Ko Poda), intermediate (Chao Fah Park), and no beach cleaning (Thara Park).

Objectives

1. To survey the type, quantity, and source of marine debris on four beaches based on beach cleaning frequencies: high (Nopharat Thara Beach, Ko Poda) and no beach cleaning (Thara Park, Chao Fah Park) in Krabi province, Southern Thailand.
2. To compare how cleaning in different beaches affects the amount and density of microplastic waste.

Hypotheses

- What is the amount of microplastics found, and how does beach cleaning affect the amount?

2. Materials and Methods

2.1 Study sites

This study was conducted at four sites: (1) Poda Island, (2) Nopparat Tha National Park, (3) Chao Fah Public Park, and (4) Thara Public Park in Krabi Province, Southern Thailand (Figure 1). Poda Island (7.974982°N, 98.811579°E) was a frequently clean beach and a high tourist area (Figure 1a). Nopparat Thara National Park (8.046064°N, 98.799021°E) was cleaned occasionally and is a high tourist area (Figure 1b). Chao Fa Park (8.062808°N, 98.919556°E) is close to Chao Fa Pier, where tourists take boats to the islands, and is crowded with many restaurants (Figure 1c). Thara Park was located at 8.053300°N, 98.920141°E (Figure 1d).

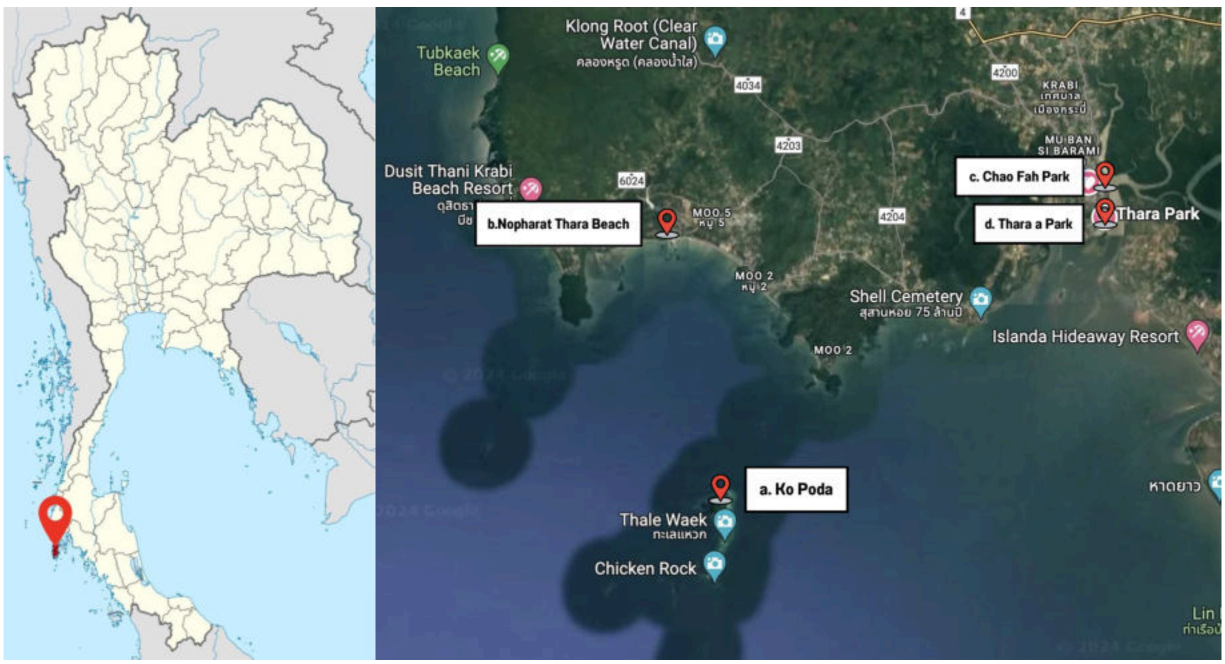


Figure 1. Map and coordination of study sites in Krabi province, Thailand. (a) Poda Island, (b) Nopharat Thara National Park, (c) Chao Fah Park, and (d) Thara Park in Krabi province, Southern Thailand.

2.2 Data collection

We conducted field surveys during the peak tourist season in February - March 2024. We collected marine debris (size larger than 5 mm) in the 15 m transect area ranging from the shoreline to the upper beach limit (determined by the presence of vegetation line). We sampled marine debris according to the operational guidelines for rapid beach debris assessment described by the NOAA guidebook (Cheshire et al., 2009). We determined the types, amounts, and sources of marine debris from a ground survey using the International Coastal Cleanup

(ICC) method to assess the beach's cleanliness (Alkalay et al., 2007). We studied marine debris in the area of 150 m^2 (n = 1) with the calculation of the CCI equal to the marine plastic debris concentration (B) multiplied by a constant number of 20 (Portman & Brennan, 2017, see Table 1). The CCI values from 0-2 indicated spotless beaches, 2-5 clean, 5-10 moderately clean, 10-20 dirty, and > 20 extremely dirty (Portman & Brennan, 2017). For a possible and quick field survey of microplastic existence, the visible microplastic debris size of 1-5 mm

We used two methods to collect microplastic samples. The first method involves taking three random sand samples from a size of 15 × 10 × 1 m^3. Sand samples were filtered through a sieve and collected microplastics. The second method is to randomly collect water samples three times in a 600 ml volume and then filter them for microplastics using an ultrasonic mist sprayer. We sprayed seawater, and ultrasonic frequencies produced mist. After 2 hours, seawater on the plate was completely evaporated, and microplastics remained as residues on the plate. We classified microplastics into four types: fibers, foams, films, and fragments. We used a clip-on camera on the cellphone to get 60x magnitude.

2.3 Water Quality Parameters

GLOBE hydrosphere protocols were employed to measure water parameters at three distinct stations. We sampled water three times per study area and measured water pH, temperature, and salinity.

2.4 GLOBE Observer App

The GLOBE Observer: Cloud App was employed to gather data on cloud types and the percentage of cloud cover at the five study sites. This application, part of the GLOBE Program, facilitates environmental observations that supplement NASA satellite data, supporting scientists studying Earth and the global environment (Figure 3).

Figure 2 GLOBE Observer: Cloud App

2.5 Data analysis

One-way ANOVA tests were used to test the amount of microplastics, water pH, temperature, and salinity among three sites. Simple linear regressions were used to find some association between the microplastic amount, water pH, temperature, and salinity among the three sites.

3. Results and discussion

3.1 Marine debris and marine plastic debris

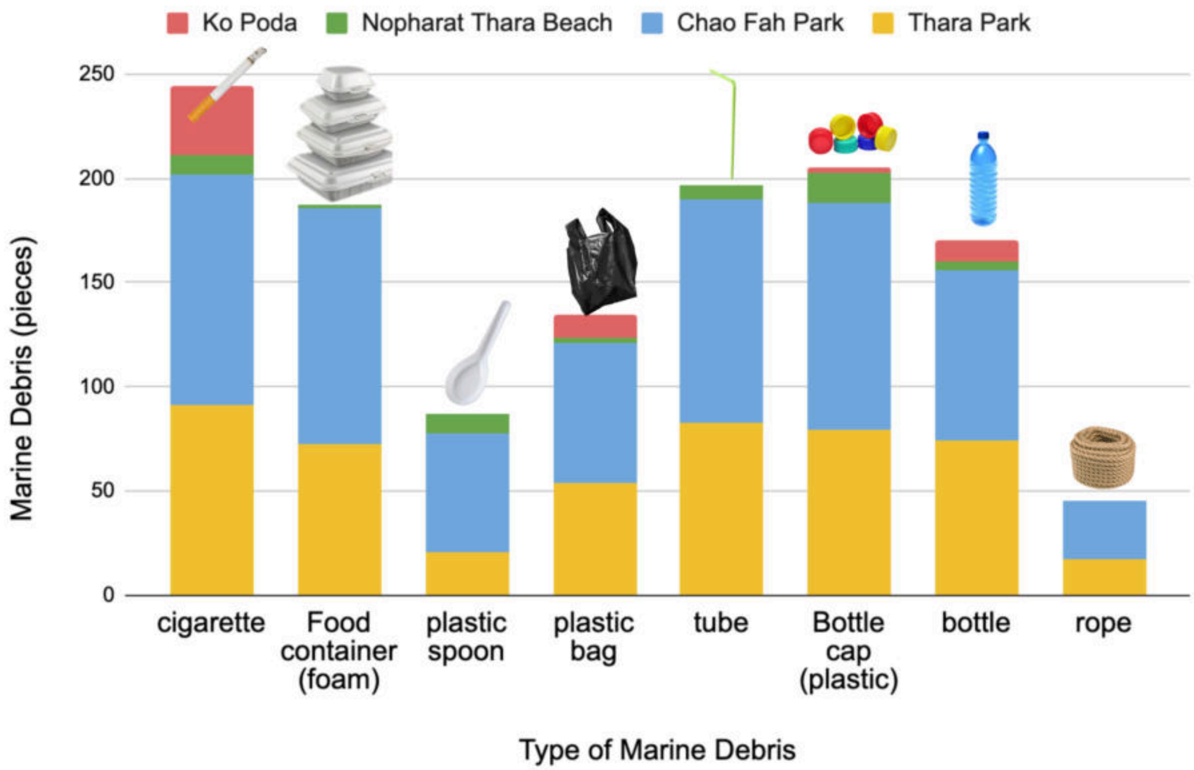
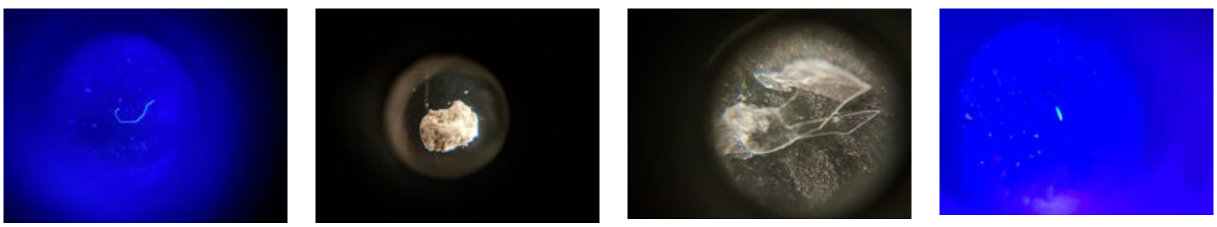


Figure 3 Types and amounts of marine debris at three Krabi province, Southern Thailand beaches.

Table 1. Amounts and concentrations of marine, plastic, and microplastic debris at study locations.

Beach areas	Date of collection	Marine debris (items/m^2)	Marine plastic debris (items/m^2)	Clean Coast Index (CCI)	Microplastic debris				
					(items/m^2)	Fiber	Foam	Fragment	Film
Thara Park	February	531(3.540)	492(3.280)	65.60	268(1.787)	189	67	12	0
Chao Fah Park	February	771(5.140)	674(4.493)	89.87	320(2.133)	142	174	0	4
Nopharat Thara Beach	February	59(0.393)	48(0.320)	6.40	53(0.353)	36	0	12	5
Ko Poda	March	89(0.593)	56(0.373)	7.47	74(0.49)	35	19	20	0



fiber foam film fragments

Figure 4 Types of Microplastics.

According to the beach litter, Chao Fah Park had the highest CCI (CCI = 89.87), which indicated that the beach was dirty and needed to be cleaned. Thara Park is the second with (CCI = 65.6). On the other hand, Poda Island has a low CCI (CCI = 7.47), indicating that the beach is messy and needs to be cleaned. A moderately clean beach that is cleaned once a week and has the lowest CCI was Nopharat Thara Beach (CCI = 6.4). It revealed that the beach, with intensive fishing activities and without cleanup, contained high marine debris and microplastic in sand sediment. Our results support Barnes et al. (2009) finding that the greater loads of marine plastic debris and fragments largely came from fishing-related activities.

The most fiber is found at Thara. Park because there is fishing and there is a pier for tourists. The most Foam was found at Chao Fah Park because it is an area where there is fishing and foam boxes are used to freeze food. The most fragments were found at Ko. Poda, because it is a tourist island, food is brought in boxes for tourists to eat. There are no trash cans on the island, so there may be a lot of trash left behind. Film was found the most at Nopharat Thara Beach because shops use plastic bags to put it in food.

3.2 Marine debris and microplastics

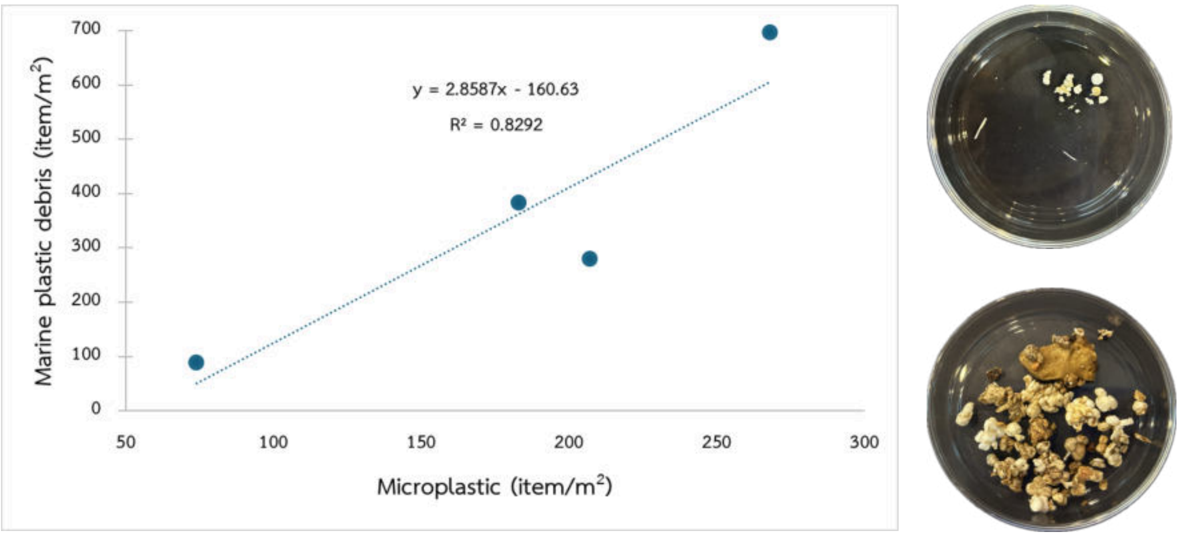


Figure 5 (a) Correlation between marine plastic debris and microplastic debris concentrations on the beaches and (b) a size comparison between visible microplastic debris (1-5 mm) and larger marine plastic debris (>5 mm).

An average of 1270 marine plastic debris and 744 microplastic debris from the sandy beaches were observed in this study. The number of marine plastic debris was positively associated with the number of microplastic debris (Linear regression: y = 2.8587x, $R^2 = 0.8292$) (Fig. 5a). It clearly shows that the concentration of plastic particles is significantly high in beaches without cleaning activities. In contrast, the beach with the most cleanup frequency has the most minor microplastic debris in the area. Proper and complete removal of larger plastic debris can help to reduce the microplastic load in the seashore sediments.

2.3 Water Quality Parameters

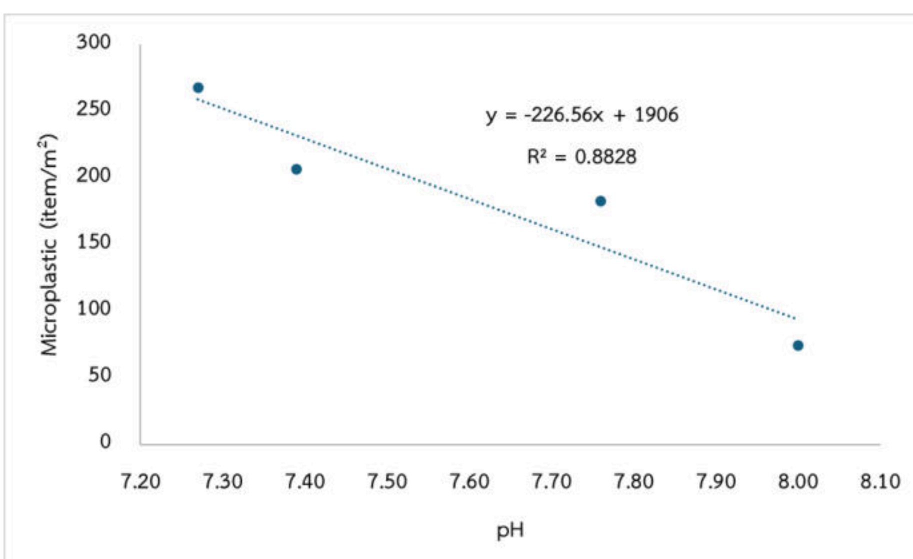


Figure 6 Correlation between pH and microplastic debris concentrations on the beaches.

The amount of microplastic is related to the pH of the seawater. If there is a lot of waste in the sea, more carbon dioxide will make chemical reactions with seawater into hydrogen ions. This results in the seawater becoming an acid solution. Thara Park, which has the most microplastic, has a pH of about 7.27, and the least microplastic, which has been found on Poda Island, has a pH of about 8.00.

4. Conclusions

The field research and observation of microplastics in the areas of Krabi Province beaches (Thara Park, Chao Fah Park, Nopharat Thara Beach, and Ko Poda) show the differences in each region according to time difference, frequency, and quality of cleaning. The data indicate that Chao Fah Park has the highest CCI because this beach has no cleaning routine and is close to a fishing village. It is a public port, a public park, and a place for trade. Tourists make a CCI of about 89.87, meaning this beach is extremely dirty, resulting in being the dirtiest beach. Next is Thara Park, with CCI = 65.6. It is a public pier and a public park and has trade. Tourists are making a CCI of approximately 89.87, meaning this beach is extremely dirty. Next is Ko Poda, with a CCI = 7.47. It is a tourist island, but it has cleaning once a week. Due to the lack of trash cans, some trash remains on the island, but this beach is still moderately clean. Finally, Nopharat Thara Beach has a CCI = 6.4. It is a high tourism beach with a park near the beach area. There are also staff looking after the beach, meaning this beach is moderately clean.

Through research, we not only know the CCI of each beach, but it also lets us know that the number of microplastics is in the same order as the CCI. The number of microplastics found in Chao Fah Park was 206, with the majority foam. At Thara Park, we found 92 microplastics, and the majority were foam. At Poda Island, six microplastics were found, all foam. Lastly, at Nopharat Thara Beach, the number of microplastics we saw on this beach was 9, most of which were film. The data also shows what type of cloud the researchers found the most visible: Cumulus and a small number of Cirrus clouds. After some research from another document, the season change is around early February to late February. The unstable and rising temperatures will cause convection to form cumulus clouds. They cause speedy wind waves and cause litter to wash up on the shore, eventually causing the litter waste to break down into smaller particles, also known as microplastics.

Acknowledgments

We thank Assoc. Prof. Dr. Krisanadej Jaroensutasinee, Assoc. and Prof. Dr. Mullica Jaroensutasinee, Miss Thunwarut Sutthipun, and Miss Khatthariya Saeli for helping with experimental design, fieldwork, data analysis, and manuscript preparation. Samsenwittayalai School, the Center of Excellence for Ecoinformatics, and Walailak University partly supported this work.

I would like to claim IVSS badges

1. **I make an impact**

    The report clearly describes how a local issue led to the research questions or makes connections between local and global impacts. The students must clearly explain or show how the research positively impacted their community by making recommendations or taking action based on findings. This study will help you know what Microplastics are in your local area. It makes us aware of changes in the ecosystem or the impacts, such as global warming and various natural disasters.

2. **I am a STEM professional.**

    The report clearly describes the collaboration with a STEM professional that enhanced the research methods, contributed to improved precision, and supported more sophisticated analyses and interpretations of results. This study uses software to measure diversity. This allowed us to do research with many more samples.

3. **I am a data scientist.**

    The report includes an in-depth analysis of students' data and other data sources. Students discuss the limitations of this data, make inferences about past, present, or future events, or use data to answer questions or solve problems in the represented system. Consider data from other schools or data available from different databases. In this study, we compare results to and adopt methods from other studies. We found that our results are consistent with other studies.

References

Andrady, A.L. (2011). Microplastics in the marine environment. Mar. Pollut. Bull. 62, 1596-1605.

Alkalay, R., Pasternak, G., & Zask, A. (2007). A clean-coast index-a new approach for beach cleanliness assessment. Ocean Coast Manage, 50, 352-362.

Boucher, J. & Friot, D. (2017). Primary microplastics in the Oceans: A global evaluation of sources. Gland, Switzerland: IUCN. 43pp.

Barnes, D.K., Galgani, F., Thompson, R.C., & Barlaz, M. (2009). Accumulation and fragmentation of plastic debris in global environments. Philos. Trans. Roy. Soc. B: Biol. Sci. 364 (1526), 1985- 1998.

Cheshire, A.C., Adler, E., Barbiere, J., Cohen, Y., Evans, S., Jarayabhand, S., Jeftic, L., Jung, R.T., Kinsey, S., Kusui, E.T., Lavine, I., Manyara, P., Oosterbaan, L., Pereira, M.A., Sheavly, S., Tkalin, A., Varadarajan, S., Wenneker, B., & Westphalen, G. (2009). UNEP/IOC guidelines on survey and monitoring of marine litter. UNEP regional seas reports and studies No. 186, IOC Technical Series. (No. 83, 120 p).

Dawarah, K., & Devipriya, S.P. (2019). Microplastic prevalence in the beaches of Puducherry, India, and its correlation with fishing and tourism/recreational activities. Mar. Pollut. Bull. 148, 123- 133.

Davis, W., & Murphy, A.G. (2015). Plastic is in surface waters of the inside passage and beaches of the Salish Sea in Washington state. Mar. Pollut. Bull. 97 (1-2), 169-177.

Depledge, M.H., Galgani, F., Panti, C., Caliani, I., Casini, S., & Fossi, M.C. (2013). Plastic litter in the sea. Mar. Environ. Res. 92, 279-281.

Galgani, F., Hanke, G., & Maes, T. (2015). Global distribution, composition, and abundance of marine litter. In: Bergmann, M., Gutow, L., Klages, M. (Eds.), Marine Anthropogenic Litter. Springer, Berlin, pp. 29-56.

Hirai, H., Takada, H., Ogata, Y., Yamashita, R., Mizukawa, K., Saha, M., & Ward, M.W. (2011). Organic micropollutants in marine plastics debris from the open ocean and remote and urban beaches. Mar. Pollut. Bull. 62 (8), 1683-1692.

Horton, A.A., Svendsen C., Williams, R.J., Spurgeon, D.J., & Lahive, E. (2017). Large microplastic particles in sediments of tributaries of the River Thames, UK– Abundance, sources and methods for effective quantification. Mar. Pollut. Bull. 114, 218–226.

Jambeck, J.R., Geyer, R., Wilcox, C., Siegler, T.R., Perryman, M., Andrady, A., Narayan, R., & Law, K.L. (2015). Plastic waste inputs from land into the ocean. Science 347, 768-771.

McDermid, K.J., & McMullen, T.L. (2004). Quantitative analysis of small-plastic debris on beaches in the Hawaiian archipelago. Mar. Pollut. Bull. 48 (7), 790-794.

Portman, M.E., & Brennan, R.E. (2017). Marine litter from beach-based sources: case study of an Eastern Mediterranean coastal town. Waste Manag. 69, 535-544.

UNEP (2016). Marine plastic debris and microplastics – Global lessons and research to inspire action and guide policy change. United Nations Environment Programme, Nairobi. Web site: http://hdl.handle.net/20.500.11822/7720

Vianello, A., Boldrin, A., Guerriero, P., Moschino, V., Rella, R., Sturaro, A., & Da Ros, L. (2013). Microplastic particles in sediments of Lagoon of Venice, Italy: first observations on occurrence, spatial patterns and identification. Estuar. Coast. Shelf Sci. 130, 54-61.