

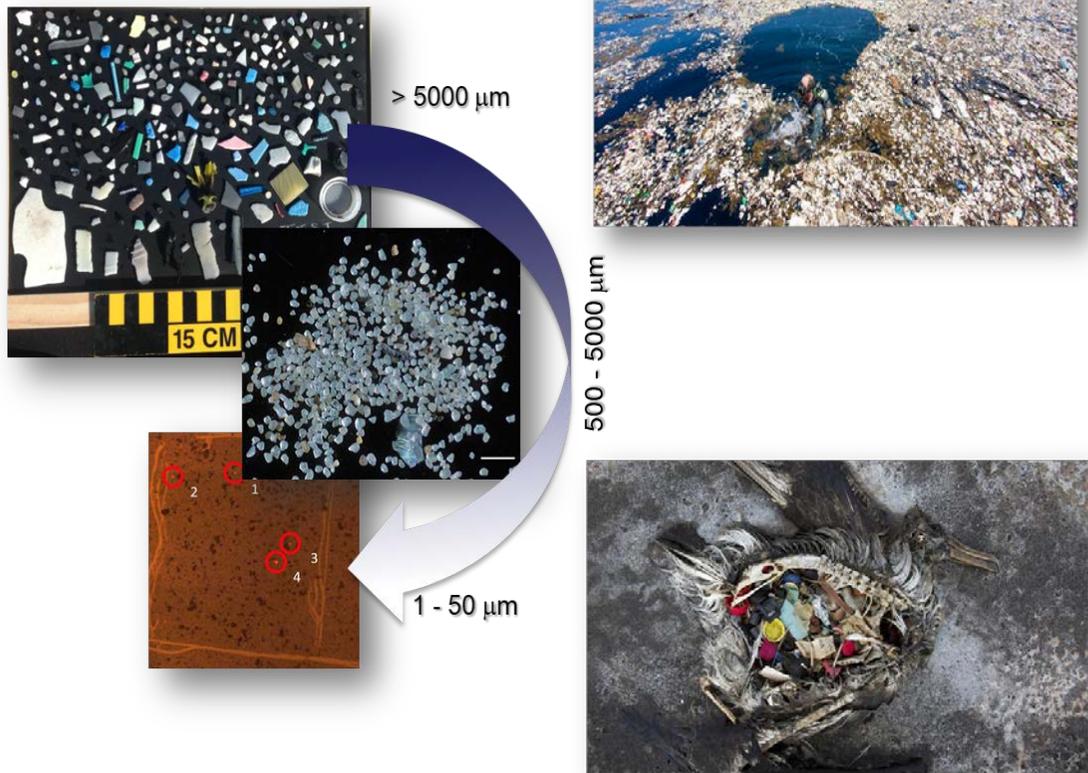
Water Perspectives in Emerging Countries

Focus Issue

Microplastics in the Water Environment

S. Babel, A. Haarstrick, M. S. Babel, A. Sharp (Eds.)

August 19 - 21, 2019 - Island of Koh Samui, Thailand



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Today, plastic materials are present in nearly all spheres of modern life, starting from simple packaging, clothes containing synthetic fibers, containers, drinking bottles and tires to various life-supporting medical equipment. Their manufacture, use and discharge have significantly increased the amount of plastic waste, including plastic marine litter in oceans, which is detrimental to the ecosystems and human health. Marine litter and microplastics are having a great impact on global environment and human health. How to improve reuse and recycling, to minimize plastic waste and to promote plastic alternatives, have received much attention recently for the purpose of controlling plastic litter in the freshwater and marine ecosystems.

Research related to microplastics is at its infant stage and thus is facing a number of unknowns and incompletely answered questions. Most of known literature studies are concentrated in the Northern hemisphere (Europe, North America, etc.), but very few studies are known in the Southern hemisphere, for example Asia or Africa. In addition, most of the investigations were carried out in marine ecosystems; however, the main source of microplastics pollution actually originates from terrestrial and freshwater ecosystems. Until today, no reliable inventory of microplastics pollution of rivers, estuaries, and sediments has been carried out in order to assess the current state and subsequent health risks to human and other living organism.

The objectives of this book is to provide readers with state-of-the-art knowledge of MP pollution and its related implications, and to identify and to deliberate upon the research needs and concepts against the background of increasing threats to ecosystems, wildlife and human health.

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CONTENT

Preface	1
Current status of microplastics contamination in marine and freshwater environments (<i>A.T. Ta, S. Babel</i>)	2
Recent advances in microplastic research in Japan (<i>A. Isobe</i>)	14
Presence and distribution of microplastics from upstream to downstream of Citarum River, West Java, Indonesia (<i>E. Sembiring, F.C. Alam, V. Suendo, M. Reza</i>).....	24
Prospects of microplastics in the sedimentary deposits on Patos Lagoon Coast (<i>E.S. Vogelmann, V.R. Alegrini, G.O. Awe, J. Prevedello</i>)	34
Sampling strategy to conduct studies on spatial and temporal contamination of microplastics in estuarine ecosystems (<i>M. Barletta</i>)	43
Detection and identification of microplastic materials waste in water systems (<i>S. El Hajjaj, J. Mabrouki, C. Bakkouche, A. Dahchour</i>)	54
Influence of typical ions and natural organic matter on the aggregation of microplastic particles in aqueous phase (<i>R. Liu, H. Wang</i>)	63
Microplastics in human consumption: table salt contaminated with microplastics (<i>E.V. Ramasamy, S.N. Sruthi, A.K. Harit, N. Babu</i>)	74
Microplastics removal from municipal wastewater by an electrocoagulation system (<i>G.H. Bracher, C. Graepin, D. Elkhatib, V. Oyanedel-Craver, E. Carissimi</i>)	81
Potential of plastic-degrading microbe in preventing plastic pollution and its circular sustainability program (<i>D.K.T. Sukmadewi, A.B. Mustafa</i>)	92
Microplastics challenges and international governance mechanisms (<i>M. Mumtaz, J.A. Puppim de Oliveira, I. Ahmed</i>)	102
An evaluation of downstream policies to reduce marine plastic litter in Thailand (<i>S.K.M. Huno, G. Borongan, N. Tsukamoto</i>)	115

PREFACE

Today, plastic has become virtually indispensable in our daily lives. The wide plastic family is composed of a variety of materials designed to meet different needs of thousands of end products. The global plastic production has almost reached 350 million tons in 2017. Based on the current trends, a future scenario predicts that 40 billion tons of plastics will be produced by 2050. At the end, it leads to an ever-increasing quantity of plastic waste, much of which ends up in marine and freshwater environments. The long-term persistence of plastics in the water environment results in microplastics (particles below 5 mm), which are recognized globally as an emerging contaminant. Microplastic contamination in marine and freshwater bodies causes a lot of undesirable impacts, collectively on the global environment and humans. Not only the ecological hazards, but chemical and biological hazards are also associated with microplastics. A large number of additives incorporated in the polymer blend are leached out from microplastics, potentially causing toxic effects on both humans and aquatic organisms, if ingested. On the other hand, microplastics are efficient vectors that transfer heavy metals and micro-organisms bound to them over long distances.

Most of the microplastics studies have been conducted in Europe and United States, and very few investigations in Asian and African regions. Still many gaps exist in microplastics research, e.g., sources of origin, their fate inside human and organism bodies, and subsequent health implications. Researchers have largely focused on marine microplastics as the major portion of the plastic debris ends up in oceans. But freshwater ecosystems are exposed to microplastics often due to the greater proximity to densely populated areas and receiving discharges from wastewater treatment plant. Now, microplastics are reported to be found in drinking water, salt, beer, honey, etc. So, we will soon encounter its dangers. Therefore, it is an hourly need to discuss and investigate on this topic.

The Expert workshop on “*Microplastics in the Water Environment*” was held at the Island of Koh Samui, Thailand, August 18 – 22, 2019. The main objectives of the workshop were to provide the participants with state-of-the-art knowledge of microplastic pollution and its related implications, and secondly, identifying the research needs and concepts on the increasing threats to ecosystems, wildlife and human health. Selected papers from this workshop are presented in this book. This book will provide readers with an improved understanding of microplastics genesis and its threat, bear a holistic view on the microplastics problem and its inherent risk potential.

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CURRENT STATUS OF MICROPLASTICS CONTAMINATION IN MARINE AND FRESHWATER ENVIRONMENTS

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Keywords: Microplastics, sources, freshwater pollution, marine debris, plastic waste

Abstract

Microplastics (MPs) are ubiquitously found all over the world, from densely populated areas to remote ones. The presence of MPs poses a great threat to the entire ecosystem. The pollutants mainly come from daily use products such as cosmetics, paints, etc. (primary MPs); or the breakdown of larger macroplastic debris under environmental conditions (secondary MPs). MPs enter aquatic environments through terrestrial and land-based activities. Since the last few decades, about 93-236 thousand metric tonnes of MP particles have accumulated in the marine environment due to improper disposal of waste plastics. With this situation, this paper reviews sources of MPs and the existing state of MPs in the marine and freshwater environments. In marine environment, MPs are found in their highest concentrations along coastlines and within mid-ocean gyres. Fiber and fragment are the majority morphologies of MPs found in oceans. While a large number of studies on MPs have focused on the marine environment, few are reported in the freshwater environment.

RECENT ADVANCES IN MICROPLASTIC RESEARCH IN JAPAN

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Keywords: Pelagic microplastics, standardization/harmonization, field surveys and prediction

Abstract

Recent advances of microplastic (MP) studies in Japan are reviewed. To standardize and to harmonize the oceanic MP measurement, the Ministry of Environment, Japan recently opened a guideline publicly on their website. In line with the protocols in the guideline, the situation was uncovered that the East Asian seas are located in a hotspot of marine plastic pollution, and the situation will continue in the future unless the mismanaged plastic waste is drastically reduced around these regions.

PRESENCE AND DISTRIBUTION OF MICROPLASTICS FROM UPSTREAM TO DOWNSTREAM OF CITARUM RIVER, WEST JAVA, INDONESIA

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Keywords: *Citarum* River, microplastics, occurrence, sediment, upstream downstream, water

Abstract

Occurrence of microplastics (MPs) along *Citarum* River, Indonesia, one of the most polluted rivers in the world, has not been established yet. A grab sampling was conducted to find the occurrence and abundance of MPs in water and sediments of *Citarum* River from upstream (pristine area) to downstream (bay area). The average concentration (\pm standard deviation) of MPs was 9.5 ± 3.03 particles/L in surface water, and the average concentration of MPs in sediment samples was 3.68 ± 1.5 particles/100 g of dried sediment. Those MPs concentration in surface water of *Citarum* River is significantly higher at the bay than at the upper sites. The most prevailing type of MPs is polyethylene terephthalate (PET), which is known as polyester.

PROSPECTS OF MICROPLASTICS IN THE SEDIMENTARY DEPOSITS ON PATOS LAGOON COAST

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Keywords: Water quality, water pollution, environmental pollution, micoplastics

Abstract

Despite the increasing number of studies addressing environmental problems arising from microplastics (MP) in Brazil, the research about this subject is recent and there are currently no studies evaluating the presence of MP as well as their distribution in the southern country region. The objective of this study was to identify and to quantify MP in the sedimentary deposits at different points of the coastal area of São Lourenço do Sul, southern Brazil. For this, sediment samples were collected in seven points at the border of Patos Lagoon in São Lourenço do Sul. At each sampling point, two sediment samples were collected at depths of 0-2 and 10-12 cm. In the laboratory, the sediment samples were disposed in a saline solution (300 g/L NaCl) to separate the supernatant; hydrogen peroxide was added to the fractions after drying to destroy organic material. After this, the fractions were immersed in ethanol solution, adding successive volumes of a saline solution by varying the solution density and adjusting the resultant mixture density to 0.8, 1.0 and 1.2 g/L. The new supernatant was separated and the fragments number was counted using a stereomicroscope. In most part of city coast, MP are incorporated in the superficial (0-2 cm) or subsurface (10-12 cm) sediment. However, in the region near the mouth of São Lourenço stream had the largest MP amount incorporated into the sediment. The predominance of MP with a density between 0.8 and 1.0 g/cm³ was observed.

SAMPLING STRATEGY TO CONDUCT STUDIES ON SPATIAL AND TEMPORAL CONTAMINATION OF MICROPLASTICS IN ESTUARINE ECOSYSTEMS

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Keywords: Fish ontogenetic phase, Feeding Ecology, Microplastics Contamination, Estuary

Abstract

Microplastics (MPs) are present in high densities in estuaries, where they become easily available to the biota. The aim of this study was to describe a methodology developed to study the relationship among the spatio-temporal patterns of habitat utilization, feeding ecology and MPs contamination across the different ontogenetic phases of fishes belonging to different trophic levels and living along the riverine-estuarine-coastal food chain (ecocline) of a tropical environment case study (Goiana Estuary). The water column of Goiana Estuary was examined for the seasonal and spatial variation of MPs (< 5 mm) and their quantification relative to zooplankton and demersal fish species contamination following the same sampling design. The fish species were assigned to different size classes (juvenile, sub-adult and adult). A total mean of $13.7 \times 10^3 / m^3$ (Zooplankton: 99%, Ichthyoplankton: 0.6%, microplastics: 0.2%) were captured in the seston. The highest amounts of MPs were observed during the late rainy season. The density of MPs in the water column determines their bioavailability to plankton feeders, and then to larger predators. This process possibly promotes the transfer of MPs between trophic levels. Polyamide (Nylon) and polyethylene blue fibres were the most frequent types of MPs found in the estuary. Their presence could possibly be linked to nets and cables used in fisheries and other maritime operations. Juveniles of socio-economically important species (*Cynoscion acoupa* – Acoupa weakfish and *Centropomus undecimalis* - Snooks) occur in the upper estuary, an important nursery ground during the early rainy season. Sub-adults also inhabit the upper estuary, a rich feeding ground, where marine predators are absent and competition is reduced. When river runoff increases, Acoupa weakfish and Snooks move to adjacent coastal areas. During this time of the year, species of these genera spawn close to the entrance of the estuarine ecosystem. During the end of the dry season, the juveniles of *C. acoupa* and *C. undecimalis* use the upper and middle estuary as nursery. Studies on MPs distribution in relation to spatial and temporal variation of the fauna and environmental factors, which influence the movements of the marine biota, are increasing in quantity and quality. If these sampling strategies are replicated in other estuaries, comparisons could be made. Standard protocols for sampling, extraction, enumeration and classification of MPs ingested by fishes have been developed and are presented here in order to enable worldwide comparisons. Standardized sample designs and laboratory procedures are an important strategy in order to establish comparisons among different sites. Also, it facilitates comparisons along time periods when studying the same environment, which is important when assessing the effectiveness of managerial measures taken to abate pollution.

DETECTION AND IDENTIFICATION OF MICROPLASTIC MATERIALS WASTE IN WATER SYSTEMS

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Keywords: Microplastics, freshwater systems, detection, identification, waste

Abstract

Microplastics (MPs) are particles smaller than 5 mm, object of an increasing number of investigations that demonstrates being this issue concern of all compartments and lattices of the earth and featuring developing doubts about their poisonous quality. In this specific circumstance, examination of the procedures utilized for the identification (ID) and measurement of MPs in water is very relevant. Plastic particles were outwardly recognized, extricated, checked and gauged, at that point the concoction structure of one piece of them distinguished by infrared spectroscopy (FT-IR ATR). Plastic particles were found in all samples, the mass being from the discontinuity of bigger plastic articles and particularly plastic sacks or bundling. The greater part of the dissected particles comprised of PET, PE and PVC. This exploratory research requires a developing of such diagnostic strategies on tests, on a bigger scale or on smaller size portions.

INFLUENCE OF TYPICAL IONS AND NATURAL ORGANIC MATTER ON THE AGGREGATION OF MICROPLASTIC PARTICLES IN AQUEOUS PHASE

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Keywords: Aggregation, Inorganic Ions, Microplastics, Nano-plastics, NOM

Abstract

Micro-plastic contamination has become a global issue, and contamination of smaller-sized nano-plastics in water system has brought many concerns. Understanding the aggregation process of nano-plastics is a key step to analyze their fate and transport in aqueous phase. This article explores the effects of typical inorganic cations, anions, natural organic matter and pH on the aggregation of polystyrene nanoparticles (PS NPs) in aqueous phase. The result shows that PS NPs remained substantially stable in low ionic strength (NaCl: 1-200 mM or CaCl₂: 0.1-5 mM), whereas significant aggregation occurred in high ionic strength (NaCl: 400 mM or CaCl₂: 10 mM). In addition, under the same ionic strength conditions, the particles remained more stable in Na₂SO₄ solution rather than in NaCl. The addition of natural organic matter had no significant effect on the aggregation of PS NPs at 150 mM NaCl, 0.1-1 mM CaCl₂, or 1/3 - 50/3 mM Na₂SO₄. The aggregation of PS NPs was boosted at 5 mM CaCl₂, while it was inhibited at 200 mM NaCl or 200/3 - 400/3 mM Na₂SO₄. When pH was close to the isoelectric point of PS, the condensation effect was significantly enhanced and the aggregation of PS NPs promoted. Based on the influence of several different factors, the aggregation behavior of PS NPs can be fitted and predicted by using DLVO theory.

MICROPLASTICS IN HUMAN CONSUMPTION: TABLE SALT CONTAMINATED WITH MICROPLASTICS

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Keywords: Table salt, human consumption, microplastics, Raman spectroscopy, polymers

Abstract

Plastic debris of less than 5 mm size, known as Microplastics (MPs), have been found in aquatic and terrestrial environment, and it has become a global concern. In India, reports on MPs are scarce and very limited as far as their presence in items being consumed by human are concerned. There exists only a single report on the presence of MPs in table salt from India, and no report exists particularly on the national and local brands of salts available in the southern part of India. Present study aimed to investigate six brands of table salts available in Indian market for the presence of MPs. Stereomicroscopy, fluorescent microscopy and Raman spectroscopy were used in the process of identification of MPs and to study the polymer content of the same. The findings indicate the presence of MPs in all brands of salts examined in this study. To the best of our knowledge, the current study is the first report on the presence of MPs in table salt samples from Kerala – the state located in the southernmost tip of the country.

MICROPLASTICS REMOVAL FROM MUNICIPAL WASTEWATER BY AN ELECTROCOAGULATION SYSTEM

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Keywords: Electrocoagulation, aluminum electrodes, microplastics, wastewater treatment

Abstract

The presence of microplastics (MP) in water resources has been widely reported worldwide and the negative effects to aquatic organisms, ecosystems and human health are a growing concern. Municipal wastewater is an important route for the transport of MP to the water, thus the development of techniques for MP removal in the municipal wastewater treatment is essential. In this context, the objective in this study was to evaluate an innovative semi-continuous electrocoagulation system for the MP removal from municipal wastewater. To achieve this goal, the best treatment conditions of an electrocoagulation system were evaluated using a rotatable central composite experimental design 2², considering the operational parameters of electrical current and electrolysis time. The electrocoagulation system was composed of a peristaltic pump, a direct-current power supply and an electrocoagulation reactor with a serpentine flow configuration, a work volume of 0.7 L and five electrodes pairs of aluminum (1.4 x 5 cm). The system was operated with a workflow of 0.9 L/min and hydraulic retention time of 22.5 min (with recirculation). The performance of the system was evaluated considering the effect on the response variables such as MP removal, electrodes mass consumption and energy consumption. The electrocoagulation system showed a removal efficiency of 96% with an electrodes mass consumption of 1.4 g/g MP and an energy consumption of 0.016 kWh/g MP. Results showed that the use of lower electrical current and higher electrolysis time (lower current density) promoted a higher energetic efficiency in the electrocoagulation system and lower electrodes mass consumption in comparison with the evaluated in the opposite conditions. So, it was possible to conclude that the electrocoagulation system presented potential to be applied for the MP removal in a municipal wastewater facility.

POTENTIAL OF PLASTIC-DEGRADING MICROBES IN PREVENTING PLASTIC POLLUTION AND ITS CIRCULAR SUSTAINABILITY PROGRAM

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Keywords: Plastic degrading microbes, pollution prevention potential, circular sustainability program, polyethylene

Abstract

Biotechnology offers a potentially powerful approach to the management of plastic wastes. Plastic waste could be degraded through biodegradation processes. An environmental factor that influences the biodegradation process is a microbe. This paper aims to study potential plastic degrading microbes in preventing plastic pollution and its circular sustainability program. This paper is based on literature review studies related to plastic degradation based on weight loss measurements (determination of residual polymer). To confirm the degradation process, some literature conducted further tests using Scanning Electron Microscopy (SEM) and Fourier Transform Infrared Spectroscopy (FTIR). Biodegradation process might be accelerated and efficient with the application of microbes of degradation activity. According to given data, microbes can degrade plastic, especially polyethylene (PE) with the ability to range from 8-46.7% in a period that varies from one month to six months in different media. Microbes that can degrade plastic waste were *Bacillus cereus*, *Pseudomonas* sp., *Aspergillus oryzae*, *Arthrobacter*, *Streptomyces* sp, *Aspergillus flavus*, *Rhodococcus ruber*, and *Penicillium simplicissimum*, *Brevibacillus borstelensis*. Solid polymer degradation by microbes, e.g., of PE, requires the formation of a biofilm on the surface of the polymer to enable the microorganism to efficiently utilize the non-soluble substrate. These microbes are using oxidation and hydrolysis processes by produced enzymes that leads to segregation of high polymer chain to be a small monomer by some metabolism process. The implementation of this concept can be applied by creating a bioreactor in each landfill. The circularity aspect would be stemmed from bioreactor processes, in which the microbes degrading plastics and their enzymatic products are attainable. Afterward, this material could be used as a substrate resources for microbial growths. The integration of mechanical, chemical, thermochemical and biotechnological recycling techniques with microbial ones may perhaps be the key to attaining the goal of a circular program in this sector.

MICROPLASTICS CHALLENGES AND INTERNATIONAL GOVERNANCE MECHANISMS

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Keywords: Adaptive governance, local governments, microplastics, transboundary issues

Abstract

This study contributes to understand plastic governance and analyzes governance initiatives to address plastic pollution. Plastic pollution has become a challenge for the world especially for marine life and steps are being taken from global to the local scale to address this issue. However, there are multiple challenges and policy implementation gaps to effectively address the issue of plastic pollution. This study is conducted to understand the governance problems and to uncover the implementation challenges. The study also identifies the drivers behind the existing challenges for plastic governance. The study is conducted by employing literature review as research methodology. The study finds that transboundary and multi-level governance approaches are in place to manage the issue. The study finds that the focus of governance initiatives remained mainly at regional or national scale during the first decade of this century. However, on the heels of Paris Agreement 2015, the role of local governments and civil society are recognized to deal with the issue of climate change including plastic pollution. This shift of governance to the local scale gave birth to adaptive form of governance. This governance strategy is equipped to involve all the relevant local stakeholders including media and civil society organizations and to mobilize youth to tackle the issue of plastic pollution. Despite these positive governance initiatives, certain challenges for the existing governance mechanisms are identified. Lack of cooperation among transboundary communities, different political interests, weak institutional capacity and scarcity of financial resources especially in developing world are some of the major challenges of plastic governance. The main drivers behind these challenges are identified as: regional conflicts, absence of regulatory measures, weak institutional capabilities, lack of intergovernmental cooperation, and absence of engaging local actors in decision making. It is imperative to take variety of actions, legislative measures and cooperative approaches will ultimately help to resolve this tragedy of plastic pollution.

AN EVALUATION OF DOWNSTREAM POLICIES TO REDUCE MARINE PLASTIC LITTER IN THAILAND

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Keywords: Evaluation, marine plastic litter, plastic waste management policy

Abstract

Marine plastic pollution damages ecosystems and threatens the existence of biodiversity. Thailand ranks among the ten most marine plastic polluted regions in the world. Existing waste management strategies focus on implementation of 3R strategies to manage land-based plastic pollutions that leaks into marine environments. To formulate effective policies to tackle this problem, policies on marine litter must be beneficial to environment and all stakeholders, socially responsible, politically and economically viable, and adaptive enough to remain relevant to the changing waste and technological regimes. Until 2017, Thailand has promoted Municipal Solid Waste Management policies mainly through voluntary policy instruments. However, the launch of the “Plastic Debris Management Plan 2017–2021” introduces a mix of policy measures including direct regulatory and market instruments to drive policy implementation. An evaluation framework was applied to analyze and to understand the political, economic, social, legal and technological dimensions of the existing downstream marine plastic management policies.