SENIOR PROJECT

Contamination and Characteristics of Microplastics in Recreation Beach Sediment of the Western Part of the Inner Gulf of Thailand

By

Miss Pawonwan Sanguanpan

A Senior Project Submitted in Partial Fulfillment of the Requirements for
the Bachelor's Degree of Science Program in Environmental Science
Department of Environmental Science
Faculty of Science, Chulalongkorn University
Academic Year 2020

Title	**Contamination and characteristics of microplastics in recreation beach sediment of the western part of the inner Gulf of Thailand**

Name	Miss Pawonwan Sanguanpan	Student ID	6033326823
Project adviser	Assistant Professor Sarawut Srithongouthai, Ph.D.		
Department	Environmental Science		
Academic year	2020		

Accepted by Department of Environmental Science, Faculty of Science, Chulalongkorn University in Partial Fulfillment of the Requirements for the Degree of Bachelor of Science.

…………………………………… Head of Department of Environmental Science

(Assistant Professor Pasicha Chaikaew, Ph.D.)

PROJECT COMMITTEE

……………………………………………………………… Chairman

(Associate Professor Nuta Supakata, Ph.D.)

……………………………………………………………….. Committee

(Assistant Professor Vorapot Kanokkantapong, Ph.D.)

………………………………………………………………… Project Advisor

(Assistant Professor Sarawut Srithongouthai, Ph.D.)

หัวข้อ	**การปนเปื้อนและลักษณะสมบัติของไมโครพลาสติกในตะกอนดินชายหาดท่องเที่ยวของอ่าวไทยตอนในฝั่งตะวันตก**

โดย นางสาวปวรวรรน สงวนพันธุ์ รหัสประจำตัวนิสิต 6033326823

อาจารย์ที่ปรึกษา ผศ.ดร.สราวุธ ศรีทองอุทัย

ภาควิชา วิทยาศาสตร์สิ่งแวดล้อม

ปีการศึกษา 2563

บทคัดย่อ

การปนเปื้อนไมโครพลาสติกตามแนวชายฝั่งเป็นปัญหาสิ่งแวดล้อมของโลกที่ส่งผลกระทบทางด้านลบเนื่องจากการจัดการขยะมูลฝอยที่ไม่มีประสิทธิภาพ และมีการปล่อยของเสียจากแหล่งต่าง ๆ ลงสู่แหล่งน้ำธรรมชาติเพิ่มมากขึ้น การศึกษาครั้งนี้เพื่อวิเคราะห์การปนเปื้อนไมโครพลาสติกในตะกอนดินในพื้นที่ชายหาดท่องเที่ยวสำคัญ 3 แห่ง ของอ่าวไทยตอนในทางฝั่งตะวันตก โดยจะเก็บตัวอย่างตะกอนดินชายหาดที่ระดับความลึก 0–5 เซนติเมตร จาก 9 สถานีซึ่งอยู่ในเขตเหนือบริเวณที่น้ำทะเลขึ้นสูงสุด และเขตที่อยู่ระหว่างน้ำทะเลขึ้นสูงสุดและลงต่ำสุด เพื่อระบุลักษณะสมบัติและชนิดโพลิเมอร์ของไมโครพลาสติกที่มีการปนเปื้อน จากผลการศึกษาพบว่าไมโครพลาสติกมีการปนเปื้อนในตะกอนดินชายหาดในปริมาณที่แตกต่างกันตั้งแต่ 17–210 ชิ้นต่อกิโลกรัม ในเขตเหนือน้ำทะเลขึ้นสูงสุด และพบ 16–70 ชิ้นต่อกิโลกรัมในเขตที่อยู่ระหว่างน้ำทะเลขึ้นลงสูงสุดและต่ำสุด จากการปนเปื้อนของไมโครพลาสติกทั้งหมดรูปร่างที่พบมากที่สุด คือ ชิ้นส่วนร้อยละ 53 ตามด้วยเส้นใยร้อยละ 28 และโฟมร้อยละ 12 สำหรับสีที่พบมากที่สุด คือ สีน้ำเงินร้อยละ 25 โปร่งใสร้อยละ 23 และสีขาวร้อยละ 21 ในขณะที่ไมโครพลาสติกขนาด 16–1000 ไมโครเมตร มีมากที่สุดในทุกจุดเก็บตัวอย่างและทุกเขตชายหาดที่ศึกษา เมื่อทำการวิเคราะห์ชนิดโพลิเมอร์ของไมโครพลาสติกด้วย micro-FTIR พบว่า โพลีเตตระฟลูออโรเอทิลีน โพลีโพรพีลีน โพลีเอทิลีน และโพลีเอไมด์ เป็นโพลิเมอร์ประเภทหลักที่พบในไมโครพลาสติกที่มีอยู่ในชายหาดท่องเที่ยวที่สำคัญของอ่าวไทยตอนในทางฝั่งตะวันตก

คำสำคัญ: ไมโครพลาสติก
ตะกอนดินชายหาด
ชายหาดท่องเที่ยว
อ่าวไทยตอนใน

Project Title **Contamination and characteristics of microplastics in recreation beach sediment of the western part of the inner Gulf of Thailand**

Name Miss Pawonwan Sanguanpan Student ID 6033326823
Project adviser Assistant Professor Sarawut Srithongouthai, Ph.D.
Department Environmental Science
Academic year 2020

Abstract

Contamination of microplastics along the coast is an environmental issue of the world problem that has negative impacts, due to inefficient waste management and increased input of sewage from various sources to natural water resource. The present study, microplastic contamination in beach sediments were carried out at 3 recreation beaches of western part of the inner Gulf of Thailand. Sediment samples at depth of 0-5 cm were collected from 9 stations, where located in the supratidal and intertidal zones in order to identify the characteristics and polymer-types of microplastic contaminations. The results showed that abundance of microplastics in sediment beach varied from 17–210 items/kg in supratidal zone and 16–70 in intertidal zone items/kg. According to total microplastic contamination, major shape of the microplastics was fragment (53%), followed by fiber (28%) and foam (12%). In addition, blue (25%), transparent (23%) and white (21%) were the most common colors. While microplastics sized 16–1000 μm were most abundant at all the sampling sites and beach zonation. The polymer types of microplastics were identified through micro-FTIR analysis, which was revealed that polytetrafluoroethylene, polypropylene, polyethylene and polyamide were the main types of microplastics present in the important recreation beach of the western part of the inner Gulf of Thailand.

Keywords: Microplastics
Beach sediment
Recreation beach
The inner Gulf of Thailand

ACKNOWLEDGEMENTS

This project would not have been possible without the support and help of all people around me and organizations. I would like to express my sincere thanks to all of them.

First, I am thankful to Chulalongkorn University CU_GR_63_04_23_02 and the Ratchadapisek Sompoch Endowment Fund (2020) for their financial support and providing guidance concerning project implementation for their supports in completing this project.

I would like to express my sincere gratitude to my project advisor, Assistant Professor Sarawut Srithongouthai, Ph.D., for giving me the opportunity to do this research and providing invaluable knowledge, guidance and suggestion all along the project process. Thank you for helping me in every step.

I would like to thanks to committee, Associate Professor Nuta Supakata, Ph.D. and Assistant Professor Vorapot Kanokkantapong, Ph.D. for their suggestions and assistance of my research.

I am also grateful to Mr.Pathompong Vibhatabandhu for assistance to sampling in the field, teaching me to prepare the samples for quantitative analysis, assistance to use laboratory instrument and solved the problem about the equipment in every time. In addition, Ms. Ketsaraporn Kaenkaew and Ms. Pansuree Jariyavijit, the laboratory assistant who advise me about laboratory works.

Furthermore, I would like to thank Department of Environmental Science, Faculty of Science, Chulalongkorn University and also people in this organization for giving me such attention and time.

The product of this research paper would not be possible without all of them.

Pawonwan Sanguanpan

CONTENTS

Page

CONTENTS (continue)

LIST OF TABLES

Page

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

1.1 Significance of the Research

At present, Thailand has developed in many ways from the past both economic, social and industrial by these developments, the country has made great progress. But what is clearly seen is industrial development in Thailand. Over the years the industrial sector of country is growing rapidly. Due to the increasing population and the increasing demand resulting in the production of various goods necessary for consumption as well. But the things followed after that was enormous amount of waste and one of them is plastic waste. But the waste management system in Thailand is still not good. Therefore, causing the problem of accumulated waste and contamination into the environment. When plastic waste disintegrates to a size smaller than 5 mm, it is called microplastic and if these things are discharge, it will contaminate the microplastics in sea and beach.

When microplastics are contaminated into marine ecosystem, it's will result in various marine organisms having the chance to receive those microplastics into the body through eating without knowing (Cole et al., 2011). When that happens, microplastics will enter the food chain and will affect humans who is definitely at the top of the food chain. In which microplastic contains a substance called Bisphenol A, this substance will interfere with the release of estrogen in the body (Huo et al., 2015).

However, microplastic levels in beach sediment generally increase with proximity to regions of high population density. While microplastic contamination is well documented for the more populous in Europe, but there is currently only limited data on the prevalence of microplastics in Asia (Bridson et al., 2020), especially the beach area in the western part of the inner Gulf of Thailand consists of the Chao-Samran, Cha-Am and Hua-Hin beaches, where there are high tourisms, communities and various activities along the beaches. Moreover, the beach sediments can be a potential sink and source of microplastics in the inner Gulf of Thailand. Therefore, there is a risk of microplastic contamination in these beaches. Due to the inner Gulf of Thailand is an important area because of natural resource, biodiversity, and economic zone. Therefore, it is necessary to find the quantity of microplastic in sediment entire the beaches, in order to clarify the status of microplastics contamination in recreation beaches. Finally, the database on microplastics and their characterizations can be used as information for waste management and legislation to reduce the effects of microplastic.

1.2 Research Objectives

1) To quantify abundance, sizes, shapes and colors of microplastic in surface sediments of recreation beaches in the western part of the Inner Gulf of Thailand.
2) To qualify chemical compositions of microplastic in order to identify polymer types of microplastic contaminations.

1.3 Scope of the Research

1) **Study areas:** recreation beaches in the western part of the inner Gulf of Thailand including the Chao-Samran, Cha-Am and Hua-Hin beaches are chosen to study microplastic contaminations and their characterizations.
2) **Sampling points:** sampling points of this study are established along beaches in area of the northern beach, middle beach and southern beach. In addition, two sampling sites are established in supratidal and intertidal zones.
3) **Sampling:** sediment samples at depth of 0-5 cm were collected at each sampling points in southwest monsoon.
4) **Quantitative analysis:** samples are analyzed total concentration, size, shape and color of microplastics.
5) **Qualitative analysis:** a polymer type of contaminated microplastics were identified using the FTIR microscopy.
6) **Study period:** this research was carried out both field base and laboratory analysis during August 2020 to April 2021.

1.4 Research Outcomes

1) Abundance, sizes, shapes, color and polymer type of microplastic contamination along recreation beaches are improved in the western part of the inner Gulf of Thailand.
2) Finding data will used to develop plastic waste management and environmental policies in Thailand.

CHAPTER 2

THEORY AND LITERATURE REVIEWS

Plastics are versatile, ubiquitous and cheap to produce. They allow us to make technological advances unimaginable even a century ago. But they are almost everlasting, and therein lies a major environmental problem of the future. Moreover, microplastics are new environmental issue of the world problems. Therefore, the knowledges, theories and literature reviews are required in order to understand the whole of plastics and microplastics as follow:

2.1 Plastics

2.1.1 Definition of plastic

Plastics is the term commonly used to describe a wide range of synthetic or semi-synthetic materials that are used in a huge and growing range of applications (PlasticsEurope, n.d.). Plastics are typically organic polymers of high molecular mass and often contain other substances. They are usually synthetic, most commonly derived from petrochemicals. However, array of variants is made from renewable materials such as polylactic acid from corn or cellulosic from cotton linters.

2.1.2 Plastic productions

Global plastics manufacturing has initiated to increase rapidly since 2009 (Nuelle et al., 2014). Average plastic materials production rate around the world has increased by 9% in each year (Crawford & Quinn, 2017a). Indeed, by 2014 the rate of global production had reached 311 million tonnes per year, and the top three global producers of plastics were China, Europe and North America at 26%, 20% and 19% respectively. Five countries accounted for 63.9% of the total European demand for plastics: Germany (24.9%), Italy (14.3%), France (9.6%), the United Kingdom (7.7%) and Spain (7.4%) (PlasticsEurope, 2015). The plastics in most demand worldwide were polyethylene and polypropylene. By 2015 the worldwide consumption of plastic materials was almost 300 million tons (Muenmee et al., 2015).

2.1.3 Types and uses of plastic

Nowadays, there are many products made from plastics, which are used in daily life. The most commonly used plastic materials can be classified into 7 types as appropriate and structural properties of plastic to be use as products as follow:

Table 2.1

Difference types of plastic.

Plastic Types	Properties	Common Uses
Polyethylene (PE)	High heat resistance Clarity and Toughness	Mineral water bottles, medicine jars High heat resistance food trays Fibers for clothing
High-Density Polyethylene (HDPE)	Excellent moisture and chemicals resistance Rigid and strong Soft waxy surface	Milk and non-carbonated drink bottles Construction pipe, furniture Household fences
Polyvinyl Chloride (PVC)	Excellent transparency Good resistance to chemicals, grease and oil Hard and rigid	Window and door frames Pipes and fittings, wire and cable sheathing, guttering Synthetic leather products
Low-Density Polyethylene (LDPE)	Flexibility Floats in water Low melting point	Packaging films, bubble wrap, shopping bags, frozen food bags Wire and cable applications Highly-resistant sacks
Polypropylene (PP)	Excellent resistance to heat, chemicals, grease and oil Strong and tough, Versatility High melting point	Refrigerated containers Bottle tops, biscuit wrappers, ketchup and syrup bottles Drinking straws
Polystyrene (PS)	Versatility and clarity Easily formed Glassy surface	Egg boxes, food boxes, fast food trays, disposable cups Video cases, packaging foam Coat hangers
Other	There are other polymers that have a wide range of uses, particularly in engineering sectors	Polyamide or Nylon used for fiber textiles Polycarbonate used for cups, bottles

2.1.4 Plastic wastes

In 2018, Thailand has generated 27.4 million tons of solid waste by approximately 12% or 2.7 million tons is plastic waste, average 7,000 tons per day. It’s divided into plastic bags 80% or 5,300 tons per day, and the rest is foam waste that take up to 450 years to decompose (Pollution Control Department, 2019). However, 50% of plastic waste are being disposed of improperly. If using a landfill, it was used space more than solid waste about 3 times or burned, it will significantly damage the environment. In addition, it also causes the environment residue due to plastic bags are made from petroleum product.

2.1.5 Marine debris and their impacts

Marine debris is defined as any persistent, manufactured or processed solid material discarded, disposed of or abandoned in the marine and coastal environment (UN Environment Program, 2009). It has affected a wide range of environment as follows; Marine debris are degrading the beauty of the coastal environment and may cause economic loss if an area is a popular tourist destination, It can damage important marine habitat which is the basis of marine ecosystems, wildlife entanglement and debris ingestion lead to intestinal blockage and even death (NOAA, 2021).

2.2 Microplastics

2.2.1 Definition of microplastic

Microplastics are smaller plastic pieces less than 5 mm in size with a lower limit of 1 μm (Arthur, 2009) as illustrated in Figure 1.1, that occur in the environment as a consequence of plastic pollution. There are present in a variety of products such as cosmetics, synthetic clothing, plastic bags and bottles. Many of these products readily enter the environment in wastes. Microplastics consist of carbon and hydrogen atoms bound together in polymer chains. Other chemicals such as phthalates, polybrominated diphenyl ethers (PBDEs) and bisphenol A (BPA) are typically also present in microplastics (Jiménez-Skrzypek et al., 2021), and many of these chemical additives leach out of the plastics after entering the environment.

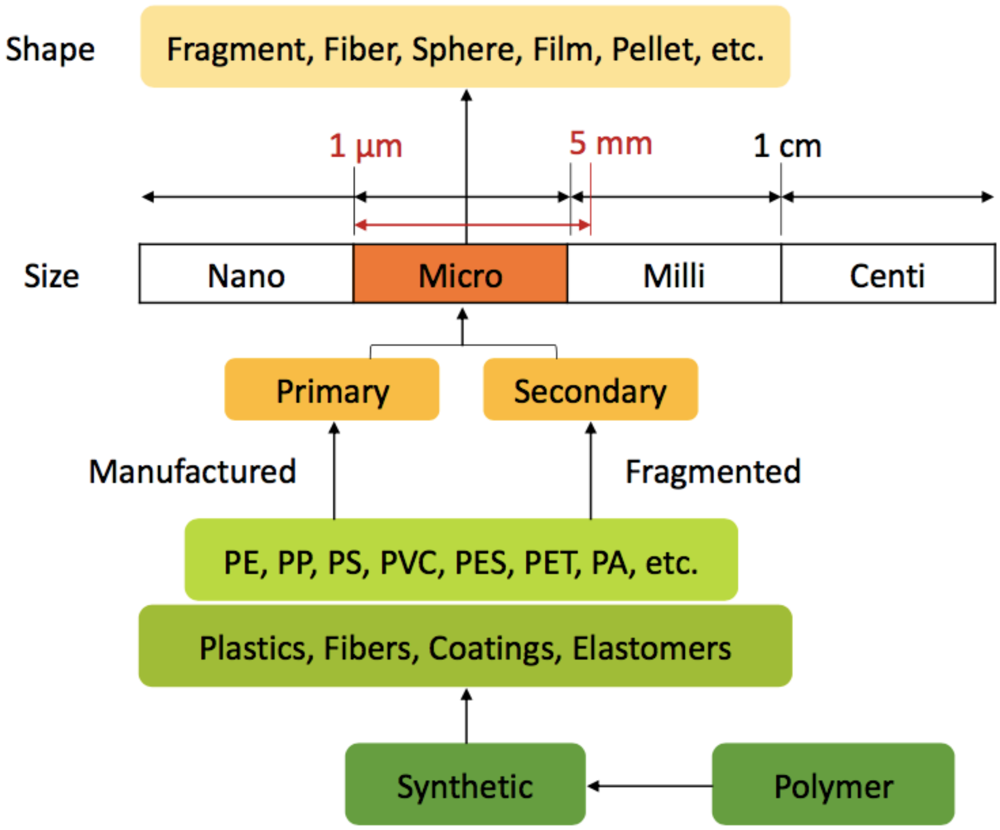


Figure 2.1 Schematic diagram of microplastic definitions and classifications

2.2.2 Types of microplastic

Microplastics are commonly categorized primary and secondary based on their origin. Examples of primary microplastics include microbeads found in personal care products, plastic pellets used in industrial manufacturing, and plastic fibres used in synthetic textiles (Cole et al., 2011). Primary microplastics enter the environment directly through any of various way for example personal care products being washed into wastewater systems from households, unintentional loss from spills during manufacturing. Secondary microplastics from the breakdown of larger plastic particles; this typically happens when larger plastics undergo weathering and degrading from wave action, photo-oxidative from sunlight, thermal and chemical degradations (Andrady, 2011).

2.2.3 Fate and transportation of microplastic

Microplastics may be manufactured for particular applications or result from fragmentation of larger items. They can be released as a result of many different human activities (Wang et al., 2021), but there are no reliable estimates of the quantities entering the marine environment, at a regional or global scale. The surface of any solid object rapidly becomes coated with inorganic and organic compounds and biofilms when immersed in seawater. This may cause floating plastic particles to sink. Microplastics will tend to absorb and concentrate hydrophobic contaminants from the surrounding seawater (Jiménez-Skrzypek et al., 2021). In addition, additive chemicals incorporated during manufacture may represent a significant proportion of the particle composition. After entry into the ocean microplastics can become globally distributed and have been found on beaches, surface waters, beach sediments and variety of biota. They become concentrated in some locations such as ocean gyres, following long-distance transport, but also close to population centers, shipping routes and other major sources. Organic matter will become adsorbed to the surface of microplastic particles, it has increased density of the microplastic and resulting in it eventually sinks under the sea (Figure 2.2).

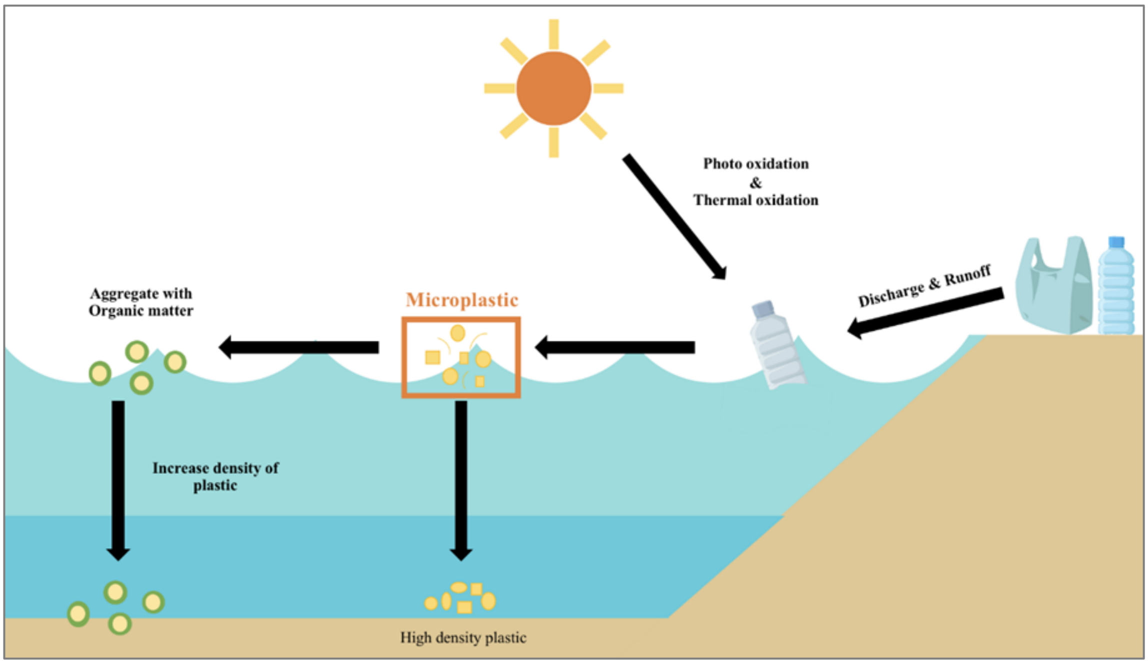


Figure 2.2 Sources, fate and transportation of microplastics in the marine environments

2.2.4 Impacts of microplastic

Microplastics are ingested by a wide range of marine organisms including invertebrates, fish and some organisms the incidence of ingestion is widespread across populations. The risk of associated effects following exposure to microplastics will depend on the number of particles, size, shape, surface properties, polymer composition and adsorption of contaminants with respect to the plastic and the organism. Marine organisms are exposed to microplastic from eating, filtration or transport across the gills. Microplastics can be transferred from prey to predator (Dolan, 2018), but the process will be species-specific. Currently, there is no evidence to support or refute potential bio-magnification of particles or associated chemicals. The ingestion of microplastics may have an effect on the feeding, movement, growth and breeding success of the host organism (Crawford & Quinn, 2017b).

2.3 The inner Gulf of Thailand

The Gulf of Thailand is the northernmost part of the Western Pacific Ocean. It's a semi-enclosed bay surrounded by the coastline of Malay Peninsula and land of Southeast Asia. Landform of the Gulf of Thailand is structured as a sedimentary basin, which is caused by the formation of north-south fault (Department of Mineral Resources, 2012). It has an average depth of about 44 meters.

The Inner Gulf of Thailand has scope from Hua-Hin District, Prachuap Khiri Khan to Samaesarn cape, Sattahip District, Chonburi. This bay is a large estuary that receives fresh water from 4 rivers: the Mae Klong, Tha Chin, Chao Phraya and Bangpakong rivers. The water mass of the Inner Gulf of Thailand is in a variable salinity in the range of 30.5-32.5 psu and it has a high concentration of nutrients especially during the rainy season. Characteristics of the coast at the top of this bay is mudflat beach in the tidal current zone covered with mangroves. On the Western side is a long sandy beach along the way. In addition, the coast is also a habitats, food and shelter for marine animal (Erftemeijer et al., 2012).

2.4 Literature Reviews

2.4.1 International microplastic contaminations

The occurrence of microplastics on beaches was first reported in the 1970s. Industrial resin pellets (2-5 mm) were one of the major concerns in many early studies because of their high abundances on beaches. The major point sources were identified as large ports and local plastic industries. Over the last 30 years, plastic resin pellets have been recovered from several Pacific beaches in both Japan and Russia. However, numerous beaches all over the world are still contaminated by microplastics, as illustrated in Table 2.2

Table 2.2 Occurrence of microplastics found in beach sediment

Problems/Goals	Solutions					References
	Abundance (Items/kg)	Characteristics				
		Size	Color	Shape	Type	
Why: To identify, quantify and characterize microplastics in the coastlines of New Zealand's largest city, Auckland. **How:** Use a FTIR to identified microplastics as polyethylene.	459	0.5-1 mm	Colorless White Black	Fiber Film Fragment	PE PP PET PVC PA PVA PU	Bridson et al. (2020)
Why: To determine the levels of microplastics in beach sediments along the coast of Dubai, and characterize the identified microplastics according to shape, color and polymer type. **How:** Use a FTIR to identified microplastics as polymer type of fibers, strings and polystyrene spheres.	59.17	-	Blue Green Red Yellow Black White Grey Orange Pink Transparent	Fiber String Fragment Sphere	PE PP	Aslam et al. (2020)
Why: To quantify microplastic contamination of European beach sediment, allowing examination of microplastic distributions, and secondly to characterize microplastics in terms of the physical properties and polymer type. **How:** Use Raman spectrometry to identified particles as polyester, polyethylene, and polypropylene.	147	0.3-5 mm	Blue Red Black Green Orange Purple Grey White	Fiber Film Sphere Angular Irregular	PE PP Nylon PEST	Lots et al. (2017)
Why: To evaluate accumulation patterns for microplastic particles of the four beaches are mainly characterized by different expositions, grain size compositions. **How:** Use a glass elutriation column to separate density of microplastics as PET and PVC.	88.10	0.06-1 mm	-	Fiber Fragment	PET PVC	Hengstmann et al. (2018)
Why: To quantify and characterize microplastics, to investigate the spatial and seasonal distribution of microplastics, and to assess the association between tourism activity and microplastic abundance in the sand of beaches along the coast of the Hengchun Peninsula, Taiwan. **How:**	480	0.3-5 mm	White Blue Black Transparent	Fiber Film Fragment Pallet Foam	PE PP	Chen&Chen (2020)

Use a FTIR to identified microplastics as polyethylene and polypropylene.						
Why: To assess the estuarine and barrier island sediments of coastal Virginia and North Carolina for microplastic particles, to determine the concentration of microplastic particles in the sediment at each study site, to identify main morphologies, to analyze the chemical compositions of the microplastic particles. **How:** Use Raman microspectroscopy chemically to identify a subset of microplastic particles.	596	0.3-5 mm	-	Fiber Fragment	PE PP PS PVC	Dodson et al. (2020)
Why: To assess the occurrence of MPs in the beach sediment, to identify the types of polymer, to estimate the degree of weathering, to confirm the findings by FTIR-ATR. **How:** Use a FTIR spectrophotometer with ATR to identified polymer.	439	0.5-3 mm	White Green Red Blue Black	Fiber Fragment Foam	PE PP Nylon PES PS	Sathish et al. (2019)
Why: To determine the level of contamination of plastic resin pellet, to determine the levels of trace metal accumulated on plastic pellets. **How:** Use plastic tweezers to remove plastic particles from sieve tray and collected the pellets by rinsed with MQ water to remove the impurities and sediment particles.	92	-	White Yellow Brown	Pellet	-	Maršić-Lučić et al. (2018)
Why: To evaluate the current state of microplastic pollution in four popular sandy beaches from the coast of Lima, to determine the characteristics and distribution of microplastics along the coast. **How:** Use a FTIR spectrophotometer to identified microplastics as polystyrene.	489.7	1-4.75 mm	White	Fiber Fragment Pellet Foam	PS	De-la-Torre et al. (2020)
Why: To study the prevalence of microplastics in the biota of this region and the impacts it may have on them. **How:** Use Raman spectroscopy to identified microplastics	720	0.3-1 mm	White Green Yellow Brown Red Blue Black	Fibre Fragment Film Pellet Foam	PP PS PU HDPE LDPE	Dowarah& Devipriya (2019)

2.4.2 Microplastic contaminations in Thailand

From microplastics pollution problems that occur all over the world. As a result, Thailand has been affected as well as by inefficient waste management issues in the country and from the drift of garbage patch from other countries. In the present, Thailand has more study on Microplastics in recent time that can be observed from many research that is published continuously such as Contamination of microplastic in bivalve at Chaolao and Kungwiman beach Chanthaburi province (Tharamon et al., n.d.), The contamination of microplastics in sediment beach area at Lower Gulf of Thailand (Y. Wang et al., 2020), Preliminary study of distribution and quantity of plastic-debris on beaches along the coast at Phuket (Akkajit et al., 2019) and Microplastics on beaches along the eastern Gulf of Thailand (Bissen & Chawchai, 2020) etc. In addition, microplastics can also get into the food chain, and effected to human health from toxic chemicals such as heavy metals adsorbed on microplastics surface. When we get these into the body, it can lead to illness (Figure 2.3).

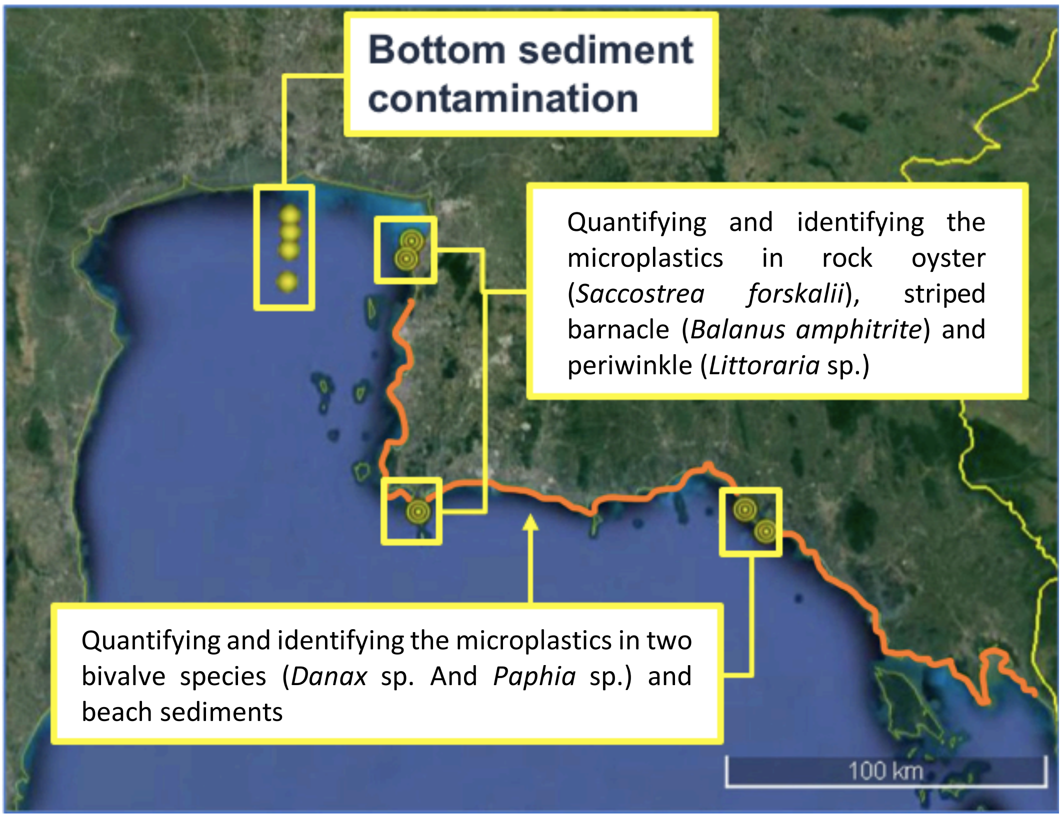


Figure 2.3 Microplastics contamination in beach sediment and marine life in coastal of Thailand

CHAPTER 3

MATERIALS AND METHODS

3.1 Study Areas and Sampling Points

The Inner Gulf of Thailand is an important resource for the developments in the part of economy, society, and environment. It's also an area that supports water from major rivers of the country and also has a beach that is an important tourist destination for the economy of the country too. Beach is an ecosystem that is a high chance of microplastic contamination because area around recreation beach has many activities that cause plastic waste from tourists and many tourist attraction places. So, this research is focus on the accumulation of microplastic pollution in important recreation beaches of the western part of the inner Gulf of Thailand including the Chao-Samran (CS), Cha-Am (CA)and Hua-Hin (HH) beaches (Figure 3.1).

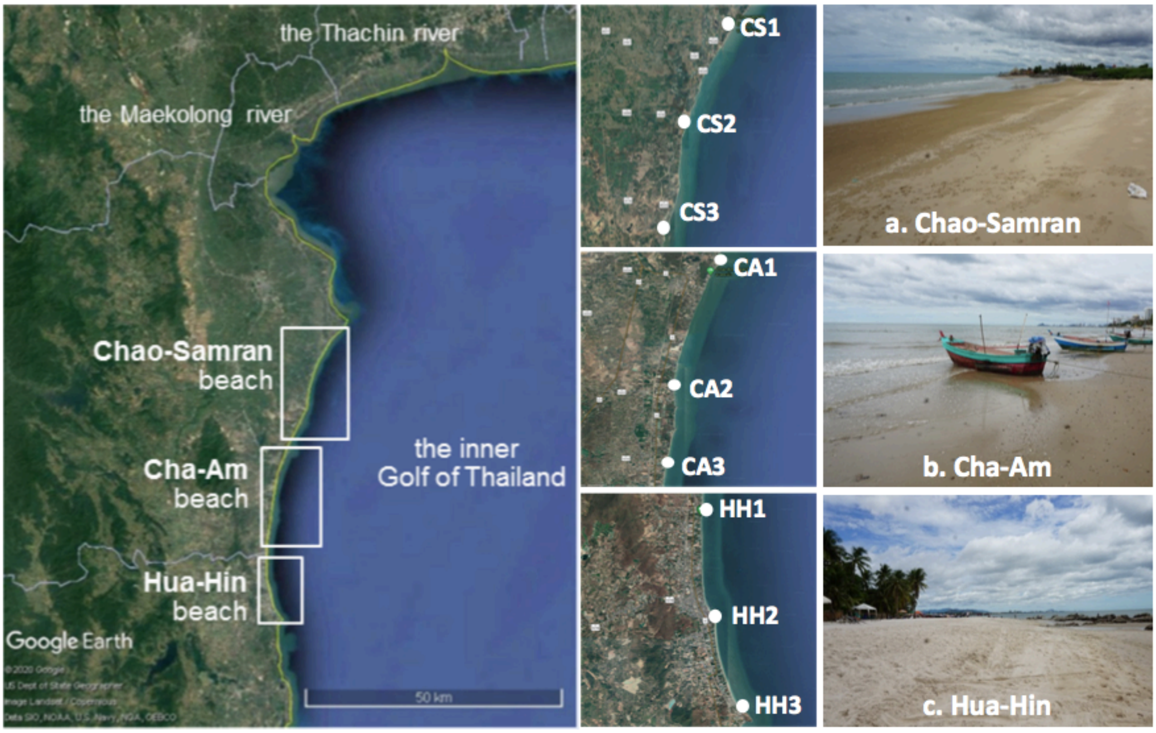


Figure 3.1 Study areas and sampling points showing in the Chao-Samran, Cha-Am and Hua-Hin beaches

Study area 1: the Chao-Samran beach is locate in Chao-Samran Sub-district, Muang District, Phetchaburi Province. Characteristics of this beach is a beautiful recreation beach and it have length about 20 km. The beaches are coastal erosion in the northeast monsoon season and the offshore bar to prevent the shoreline erosion from the waves that effect to the beach aesthetic. Station CS1, CS2 and CS3 are established in northern, middle and southern parts of the beach for sediment sampling (Figure 3.1).

Study area 2: the Cha-Am beach is locate in Cha-Am Sub-district, Muang District, Phetchaburi Province. The Cha-Am beach has approximately 5 km long and it have a canal and a jetty at the northern of the beach. However, problem of this beach is a lot of tourist and recreational activities, the offshore bar contributes to the coastal pollution. Station CA1, CA2 and CA3 are established in northern, middle and southern parts of the beach for sediment sampling (Figure 3.1).

Study area 3: the Hua-Hin beach is locate in Hua-Hin Sub-district, Hua-Hin District, Prachuap Khiri Khan Province, which have length about 2 km long beach. The beaches are dominated by fishing activities from northern part and tourism from southern part. Station HH1, HH2 and HH3 are established in northern, middle and southern parts of the beach for sediment sampling (Figure 3.1).

In each station, two sub-sampling points are established in supratidal and intertidal zones along the coast beach (Figure 3.2). Supratidal zone is the area above the highest sea level (high tide), where not directly influenced by seawater. Therefore, the potential for microplastic contamination in this zone are land-based source. Intertidal zone is any interface between the land and sea which is exposed during low tide and submerged at high tide. The intertidal zone can encompass sandy beaches, rocky shores, bays and estuaries. This zone is directly influenced by seawater, which causes microplastic contamination is also sea-base source.

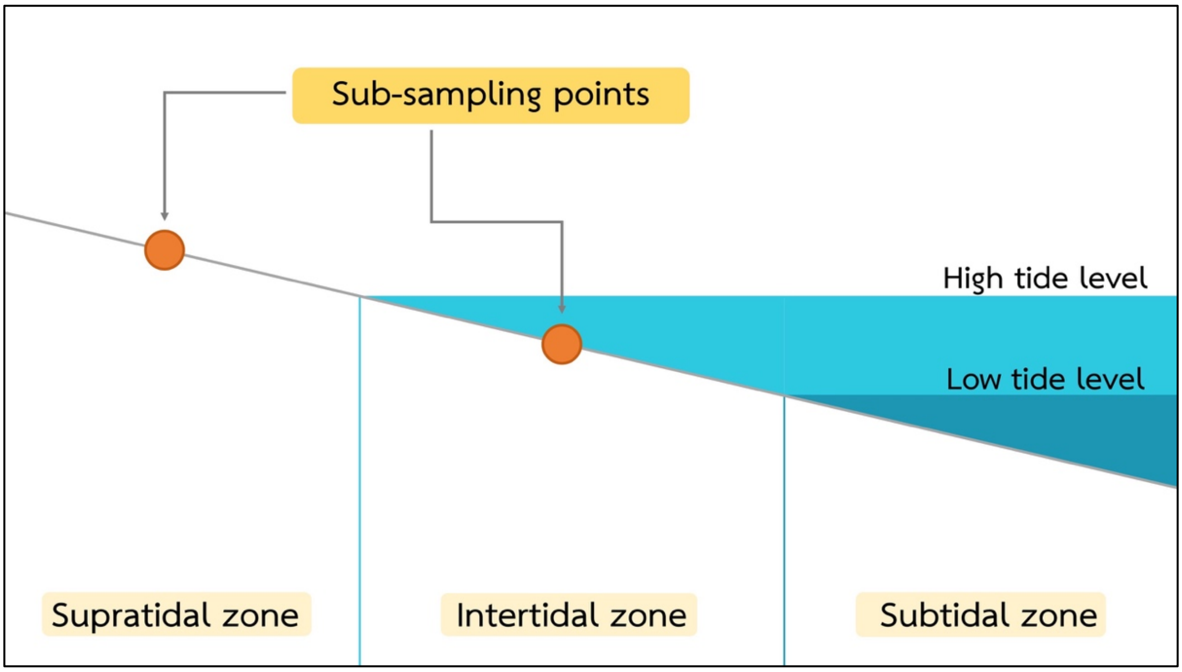


Figure 3.2 Schematic drawing of sub-sampling point in supratidal and intertidal zones of beach ecosystem

3.2 Research Materials

3.2.1 Field equipment

1) Wooden grid frame
2) Aluminum tray
3) Stainless tray
4) Aluminum bucket
5) Stainless bucket
6) Wooden ladle
7) Aluminum foil

3.2.2 Laboratory instruments

1) Digital balance four digits (Mettler Toledo, MS204S, Switzerland)
2) Digital balance 2 digits (Mettler Toledo, ML1602/01, Switzerland)
3) Drying oven (Memmert, 600, Germany)
4) Stereo microscope 30X magnification (Shodensha, Trinocular Stereomicroscope NSZ405J3, Japan)
5) Fourier-Transform infrared micro-spectrometer (Lumos 1, Bruker, German)

3.2.3 Laboratory equipment

1) Filter paper (Whatman, No.42, UK)
2) Glass beakers
3) ASTM test sieves
4) Standard Metal Forceps
5) Distilled water bottle
6) Metal spatula
7) Watch glass
8) Laboratory hot plate
9) Separation unit
10) Retort stand
11) Spring clamp
12) Aluminum foil
13) 4-mL glass vials
14) Dropping funnel
15) Nuclepore Track-Etched Membranes

3.2.4 Chemical substances

1) Iron (II) sulfate
2) Sulfuric acid
3) 30% Hydrogen peroxide
4) Sodium chloride

3.3 Sampling Methods and Sample Preparation

Sampling at all stations were carried out during low tide period on August 8-9, 2020, which is in southwest monsoon season. Sediment at the depth of 0-5 cm (surface sediment) of both supratidal and intertidal zones was collected by using wooden grid frame in area of 15x15 cm. All samples were kept in stainless tray or aluminum bucket and covered with aluminum foil in order to avoid plasticle contaminations.

3.4 Laboratory Analysis

3.4.1 Quantitative analysis

Beach sediments were weighed about 300 g and then added into aluminum can. All sediment samples are dried at 60 °C using hot air oven (Memmert, 600, Germany) until sample dryness. Subsequently, dried samples were sieved with 5 mm and 1 mm pore size of the ASTM test sieves in order to separate meso- and macro-plastics (size > 5 mm) from the samples.

Microplastics of sediment sample were separated using saturated NaCl (1.2 g/cm^3). Add aqueous NaCl solution to the dried beach sediments in the 500-mL beaker and then stirred the sand-aqueous mixture in the beaker for several minutes with a glass rod to float out the microplastics. Transfer all floating solids in the beaker to Dip net 16 microns pore size and rinsed the dip net with distilled water 3 times to transfer all solid particles to glass bottle. All microplastics are kept in glass bottle for later analysis in laboratory.

Organic matters were removed from separated microplastics using wet peroxide oxidation (WPO). First, add 20 mL of aqueous Iron(II) sulfate and 20 mL of 30% hydrogen peroxide to the beaker were containing of solid particles. Added a stir bar to the beaker and covered with a watchglass, mixture on a hot plate at room temperature for ten minutes. After that, turned on heat to 75 °C. As soon as gas bubbles are observed, removed the beaker from the hot plate and slow the reaction by using distilled water. Added 6 g of NaCl per 20 mL of sample to increase density of the aqueous solution and heat mixture until NaCl dissolves.

Transfer the WPO solution to the dropping funnel, rinsed the WPO beaker with distilled water to transfer all remaining solids and settle overnight. Drain settled solids from the funnel and filtered floating solids (microplastic samples) on pre-weight Nuclepore Track-Etched Membranes. Rinse the dropping funnel several times with distilled water to transfer all solids to the filter.

Total number and various shapes (fiber, film, foam, fragment, and pellet) of microplastics were counted under stereomicroscope (Shodensha, NSZ-405J3). Additionally, colors of microplastics were categorized to be red, blue, green, brown, black, white, transparent, and other.

3.4.2 Qualitative analysis

Microplastics in each shape were picked-up under stereomicroscope in order to analyze polymer types of plastics using the Fourier-Transform infrared micro-spectrometer (Lumos 1, Bruker, German).

3.5 Data Analysis

Comparative analysis of contamination on recreation beach, both quantitative and qualitative based on the physical characteristics of the beach ecosystem (supratidal and intertidal zones) to assess the accumulation of microplastic pollutants which is evaluated using one-way ANOVA and Duncan multiple range test (DMRT).

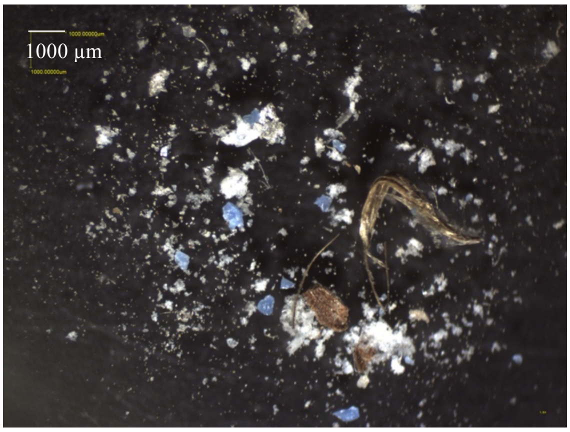
CHAPTER 4

RESULTS AND DISCUSSION

Microplastics in the surface sediment of Chao-Samran, Cha-Am and Hua-Hin beaches were sampled at supratidal and intertidal zones during southwest monsoon season. Beach sediment was analyzed in triplicate samples in all sampling points, therefore mean and standard deviation are reported in total MPs of the present study. Additionally, sizes, shapes, color and polymer types of MPs were descripted. Results of the present study showed that MPs were contaminated in various abundance and characteristics at all the sampling points (Table 4.1 and Figure 4.1). All finding results were reported as follow:

Table 4.1
Overall detection of microplastics analysis in the western beaches of the inner Gulf of Thailand

Abundance/ Characteristics	Categories	Western beaches of the inner Gulf of Thailand					
		Chao-Samran		Cha-Am		Hua-Hin	
		STZ	ITZ	STZ	ITZ	STZ	ITZ
Total concentration	mg/kg SDW	×	×	×	×	×	×
	pieces/kg SDW	✓	✓	✓	✓	✓	✓
Size composition	5000-1000 µm	×	×	✓	×	✓	✓
	1000-16 µm	✓	✓	✓	✓	✓	✓
Shape composition	Pellet	✓	✓	✓	×	✓	✓
	Fragment	✓	✓	✓	✓	✓	✓
	Fiber	✓	✓	✓	✓	✓	✓
	Film	✓	✓	✓	✓	✓	✓
	Foam	✓	✓	✓	✓	✓	✓
Color composition	Red	✓	×	×	×	✓	✓
	Blue	✓	✓	✓	✓	✓	✓
	Green	✓	×	✓	×	✓	×
	Brown	×	×	×	×	×	✓
	Black	×	✓	✓	✓	×	×
	White	✓	×	✓	×	✓	✓
	Transparent	✓	✓	✓	✓	✓	✓
	Others	✓	✓	✓	×	✓	✓



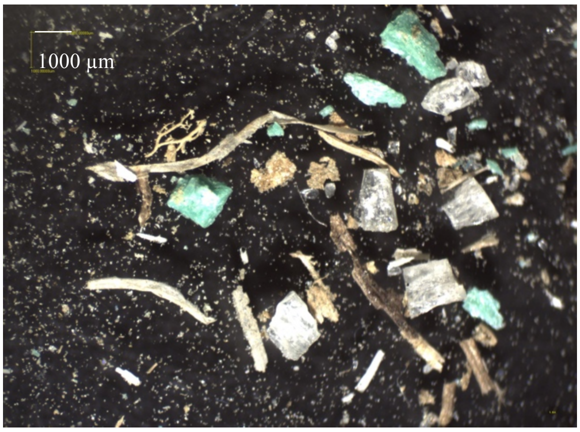


Figure 4.1 Photo of various MPs contamination in the western beaches of the inner Gulf of Thailand

4.1 Abundance of MPs Contamination

Microplastics were contaminated variously at all the sampling points. The abundance of MPs varied from 17 to 210 items/kg in supratidal zone and 16 to 70 items/kg in intertidal zone. The number of MPs that found in each sampling points and mean abundance of MPs were obtained in each beach are shown in Figure 4.2. In Chao-Samran beach, the highest abundance of MPs was observed in supratidal zone is station CS1. There is the highest MPs of all beaches were sampled in this study with 210 items/kg and the lowest accumulation of MPs in this beach was observed at CS3 with 17 items/kg. In contrast, the highest and lowest of MPs were found in any station of Chao-Samran beach in the intertidal zone is CS2 (70 items/kg) and CS3 (16 items/kg) respectively. In Cha-Am beach, the highest MPs were found in supratidal zone is 80 items/kg at station CA1 and the lowest is 17 items/kg at CA3. The intertidal zone of this beach was found the highest number of MPs at CA2 is 52 items/kg and the lowest number is 33 items/kg at station CA3. In the last recreation beach, Hua-Hin, MPs were found the most at HH3 in supratidal zone was 92 items/kg and the lowest accumulation of MPs in HH1 was 31 items/kg. In the intertidal zone of Hua-Hin beach, HH1 is a station that found the highest number of MPs were 29 items/kg and the lowest number of MPs were found in this zone is HH3 were found 23 items/kg.

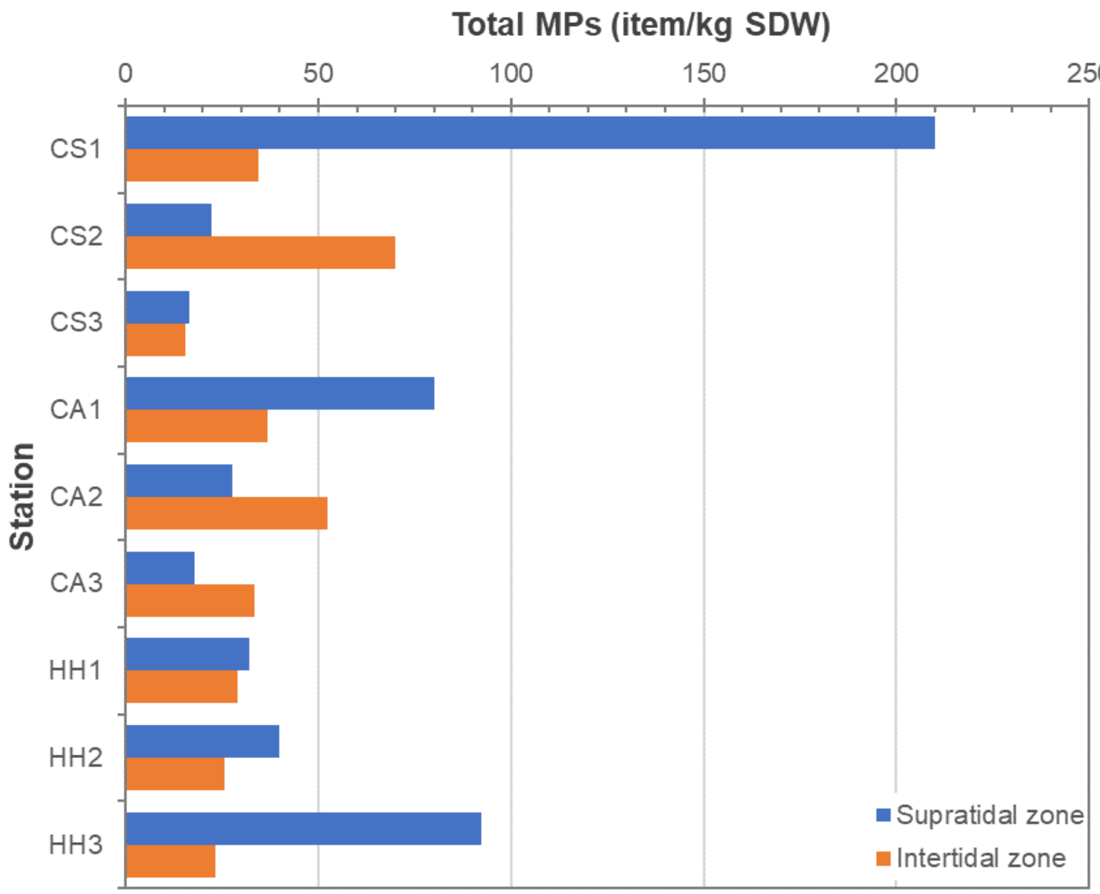
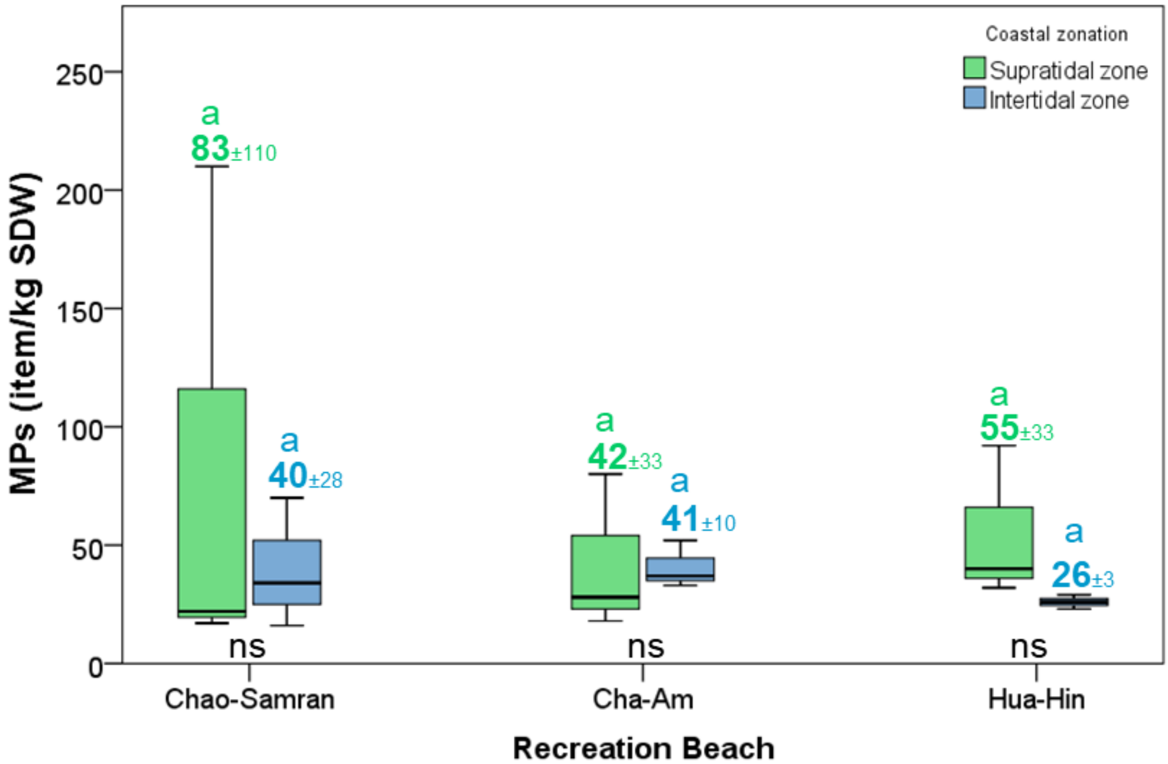


Figure 4.2 Comparison of MPs abundance between Chao-Samran, Cha-Am and Hua-Hin beaches, and supratidal and intertidal zones

From abundance of MPs result in all sampling points in each recreation beach of western part of the inner Gulf of Thailand, when compared with surrounding environment in each sampling point. The highest MPs of all study beaches had different level of activities that affected to amount of MPs. CS1 of supratidal zone in Chao-Samran beach has the highest MP items compare with other sampling points because the characteristics of this point is one of the major recreation beaches in Phetchaburi. There are both shops located on the beach side and a lot of tourists as well. All of these factors and events lead to waste generation, which is the origin of microplastics. And the position of the event occurring it can be assumed that the microplastics found at this point are influenced by land. The same goes for CA1 of supratidal zone. For HH3 in supratidal zone area, most of them are accommodation for tourists. But the different things from other sampling point is there are many fishing boats in this area. In contrast, sampling point with the least number of MPs were CS3 in supratidal and intertidal zone, and CA3 in supratidal zone because the areas were not any restaurant, tourists and recreational activities. As a result, no waste on the coastal which is the origin of MPs. It was assumed that the MPs were found may not be influenced by current onshore activities. Probably caused by marine debris being swept by a wave or other reasons such as the environment of the beach area in the past may not be the same as today. The study found that the number of MPs could be different in each region is influenced by a number of residents. Activities that occurred and the degree of urbanization (Sathish et al., 2019).

When analyzing the relationship between abundance of microplastics in each beach showed no significant difference between the three recreation beaches ($F = 0.414$, $p > 0.05$). In term analysis of variance between the number of microplastics along the supratidal zone and intertidal zone in the overall of the western part of recreation beaches showed no significant difference in two zone due to their values ($p > 0.05$, $df = 9.107$). When comparing the mean differences between the zones of each beach, it was found that there was no significant difference between supratidal and intertidal zones for each beach studied ($p > 0.05$)



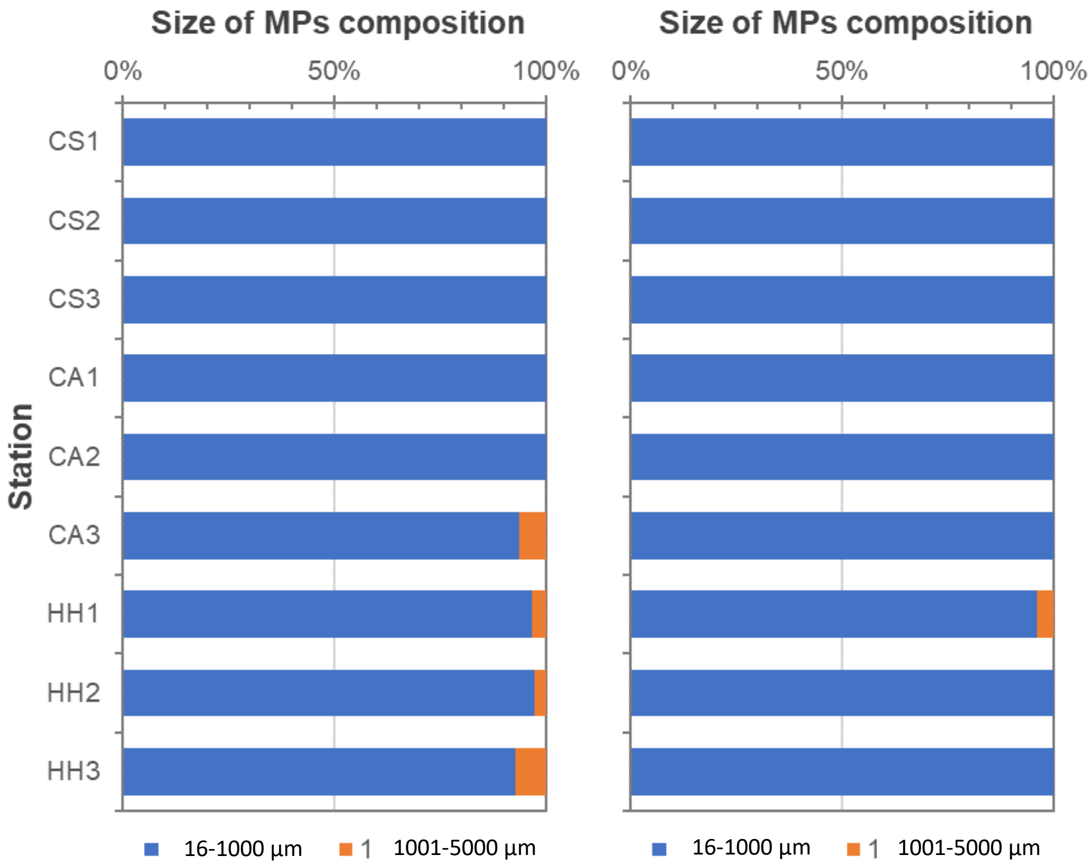
Remark: a descripted statistic significant difference between supratidal and intertidal zones
ns is non-significant difference between beach

Figure 4.3 Boxplots of the microplastics concentration in beach sediments of Chao-Samran, Cha-Am and Hua-Hin beaches, in supratidal and intertidal zones

4.2 Size of MPs Contamination

In present study, the observed size of MPs varied from 16 to 5000 µm. The MPs samples were classified in 2 size categories: 16-1000 µm and 1001-5000 µm. 98.7% of all measured microplastics were 16-1000 µm while size 1001-5000 µm of MPs were found only 1.3%. When analyze by divide into zonation of all recreation beaches, the most of size 1001-5000 µm were found in supratidal zone at station CA3 HH1 HH2 HH3 and found in the intertidal zone at only HH1 (Figure 4.4). The average number of MPs size 1001-5000 µm in supratidal zone was 10 items/kg or 1.9% while along the intertidal zone was only 1 items/kg or 0.3%.

The study of the size divided into zonation of all recreation beaches. The microplastics size 1001-5000 µm were found at the supratidal zone more than with the intertidal zone due to the larger pieces of plastic will have originated from the land because plastic waste is a major source of MPs coming from land.



a) Supratidal zone b) Intertidal zone

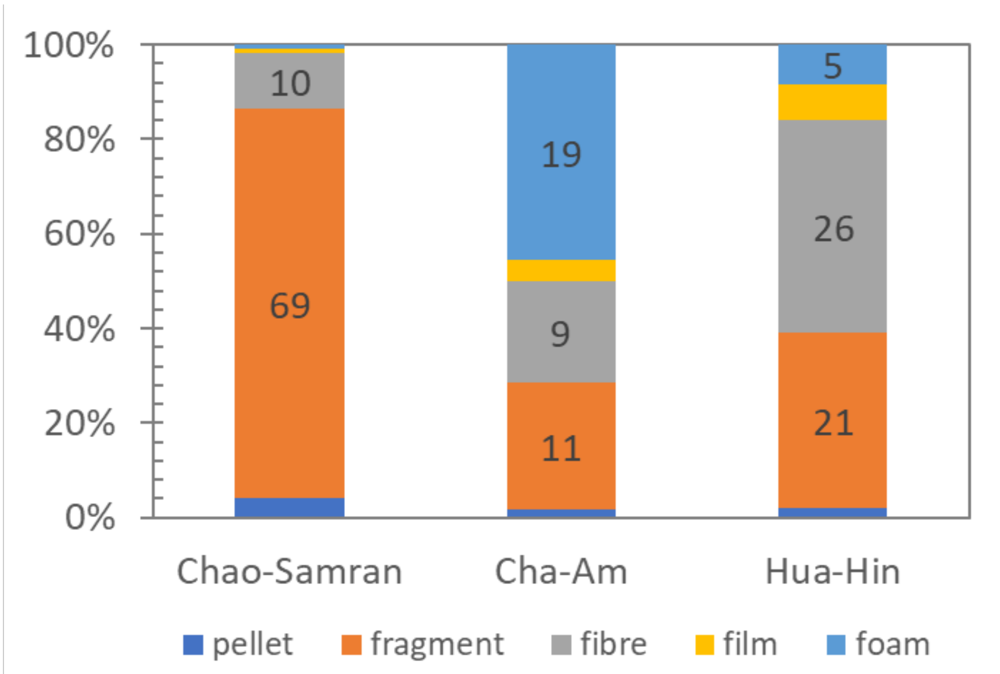
Figure 4.4 Size fractionations of the microplastic contamination in a) supratidal and b) intertidal zone

4.3 Shape of MPs Contamination

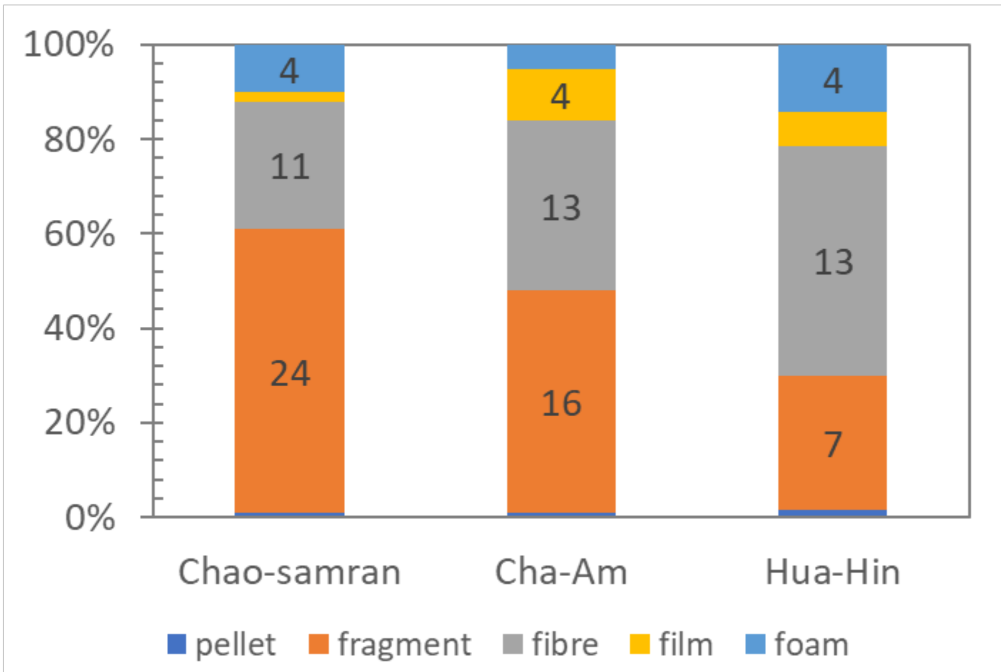
Of all the microplastic shapes are found in both sampling zone of each recreation beaches had different microplastics shape. In supratidal zone of Chao-Samran beach, fragment is the most common shape were found 69 items, followed by fibers 10 items respectively. Cha-Am beach, foam is the highest number were found in this beach (19 items), followed by fragment 11 items and fibers 9 items. The last beach, Hua-Hin, the majority of microplastics identified in this beach of supratidal zone were fiber (26 items) and other shapes of MPs found were fragment (21 items), foam (5 items) and film (4 items). In contrast, the intertidal zone of Chao-Samran beach, the most common is fragment were 24 items, followed by fibers 11 items and foam 4 items. Cha-Am beach, fragment contributed to the major portion of MPs in this beach (16 items), followed by fiber 13 items and film 4 items. The last recreation beach from western part of the inner Gulf of Thailand, Hua-Hin, were found fiber is the most shape (13 items), fragment 7 items and foam 4 items.

Microplastics were found from the beach sediment in the study area come in a multitude of different shape, size and color. The types of MPs observed in the present study are pellet, fragment, fiber, film and foam. The shape of the MPs found in each area has different. The most common shape of the Chao-Samran beach in both zones is the fragment which is found in supratidal (79.2%) and intertidal zone (63.6%), followed by fibers were found in supratidal (10.9%) and intertidal zone (31.8%) and pellets respectively. Film and foam were not found in the sample from intertidal zone as shown in Figure 4.5 and Table 4.4. Cha-Am beach in the supratidal zone were showed foam is the most common shape (73.4%), while the intertidal zone showed fragment is the highest (57.1%), but film wasn't found in both zones. Hua-Hin beach, another important recreation beach of country. Fiber is the most common in both zones were 63.3% of supratidal and 34.5% of intertidal zone followed by fragment and foam respectively. Pellet was not found in intertidal zone as well as Cha-Am beach.

From the shape of MPs found at each sampling point of each beach. Fragments contributed to the major portion of microplastics in the Chao-Samran beach because it is a tourist attraction with a lot of tourists followed by occurrence a lot of solid waste, whether it is waste generated by restaurants along the beach such as plastic food containers or plastic cutlery and fragments of waste that come from tourists such as water bottles, plastic bags, sachets and items that have been discarded. Over time, structure of these waste will degradation resulting in smaller fragment. Hua-Hin beach area is the most commonly found fibers, as there is a lot of trawling fishing in this area, noticeable as there are many fishing boats docked on the beach. This kind of fishing is the main source of fiber and may be cause of the coastal environment everywhere with fishing vessels increasing the number of fibers. As secondary microplastics as it can be observed that the formed MPs shape is due to fracture from the original object.



a) Supratidal zone



b) Intertidal zone

Figure 4.5 Shape compositions of microplastic contamination along a) supratidal zone and b) intertidal zone area in various beaches

Table 4.2

Shapes of microplastics in all site samples from supratidal zone and intertidal zone

Sampling point	Supratidal Shape in %					Intertidal Shape in %				
	Pellet	Fragment	Fibre	Film	Foam	Pellet	Fragment	Fibre	Film	Foam
CS1	4.2	94.2	1.6	-	-	-	32.3	32.3	-	35.5
CS2	-	20	75	5	-	-	82.5	17.5	-	-
CS3	6.7	20	53.3	6.7	13.3	7.1	21.4	57.1	14.3	-
CA1	-	18.1	11.1	5.6	65.3	-	69.7	24.2	3	3
CA2	4	56	32	-	8	-	38.3	38.3	14.9	8.5
CA3	6.7	26.7	60	-	6.7	-	43.3	56.7	-	-
HH1	-	17.9	60.7	7.1	14.3	-	24	44	-	32
HH2	2.9	17.1	71.4	5.7	2.9	4.3	43.5	47.8	-	4.3
HH3	2.6	58.4	33.8	-	5.2	-	14.3	57.1	23.8	4.8

Table 4.3

Shapes of microplastics in all beaches from supratidal zone and intertidal zone

Beach	Supratidal Shape in %					Intertidal Shape in %				
	Pellet	Fragment	Fibre	Film	Foam	Pellet	Fragment	Fibre	Film	Foam
Chao-Samran	7.9	79.2	10.9	1.0	1.0	4.5	63.6	31.8	-	-
Cha-Am	1.6	3.1	21.9	-	73.4	-	57.1	38.1	-	4.8
Hua-Hin	4.1	20.4	63.3	2.0	10.2	-	31.0	34.5	3.4	31.0

4.4 Color of MPs Contamination

Microplastics occurred in a variety of colors including red, blue, brown, green, black, white, transparent and others. In supratidal zone, blue was the most common color in Chao-Samran beach (87 items), followed by yellow (73 items), pink (63 items) and green (60 items). Cha-Am beach, white is the most color that were found (147 items) followed by transparent (37 items). And the most color were found in Hua-Hin beach is transparent (100 items), green (27 items) and blue (17 items). In intertidal zone, all of the beach was found blue is the most color of MPs as follows; 53 items in Chao-Samran beach, 37 items in Cha-Am beach and 27 items in Hua-Hin beach. Other colors that were identified were white (27 items in Hua-Hin), transparent (10 items in Chao-Samran, 20 items in Cha-Am and Hua-Hin) and black (7 items in Chao-Samran and 13 items in Cha-Am).

Multicolored particles were observed in all beach stations during this study such as red, blue, brown, green, black, white, transparent, yellow and pink. In each zone there were observed a different color in the descending order in supratidal zone is blue (26%) > yellow (22%) > pink (19%) > green (18%) > transparent (9%) > white (5%) > red (1%) in Chao-Samran; white (68.8%) > transparent (17.2%) > blue (6.3%) > black = pink (3.1%) > green (1.6%) in Cha-Am; and transparent (61.2%) > green (16.3%) > blue (10.2%) > yellow (6.1%) > white (4.1) > Red (2%) in Hua-Hin. In the intertidal zone of each beach there are blue (72.7%) > transparent (13.6%) > black (9.1%) > pink (4.5%) in Chao-Samran; blue (52.4%) > transparent (28.6%) > black (19%) in Cha-Am; and blue = white (27.6%) > transparent (20.7%) > brown (13.8%) > red (6.9%) > yellow (3.4%) in Hua-Hin. (Figure 4.6)

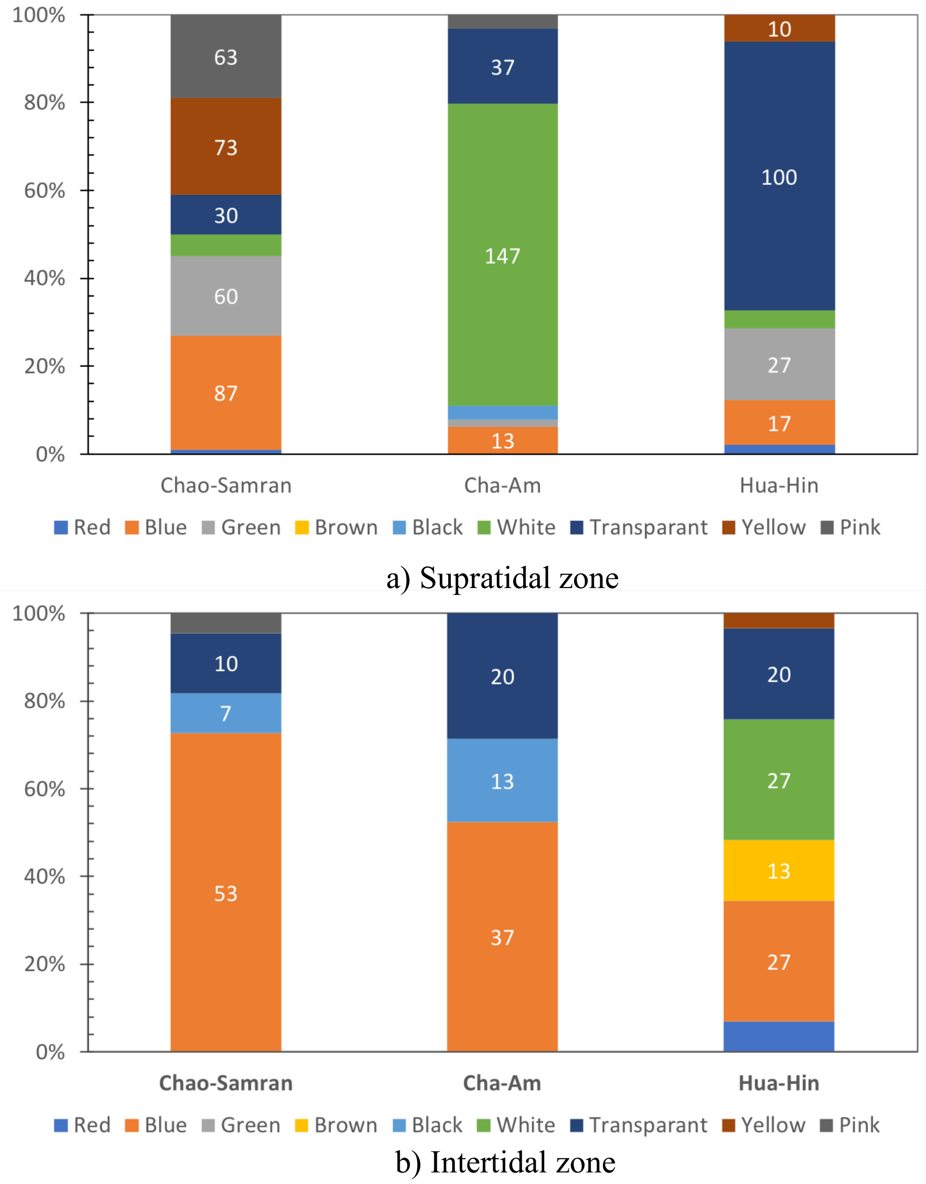


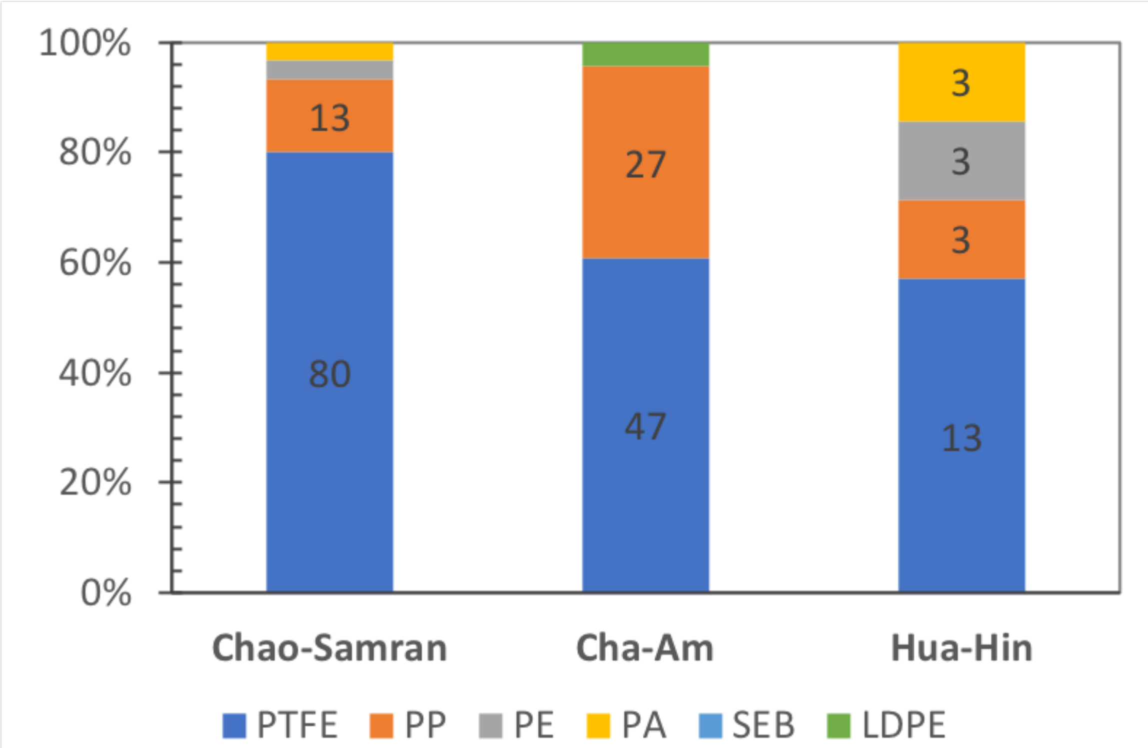
Figure 4.6 Color variations of microplastic contamination in a) supratidal zone and b) intertidal zone at different beaches

In the study areas were found microplastics with many different colors depending on the color of the source material, which some part of microplastics that are found may have discoloration. Due to the structural of plastic has changes, pigment deterioration of the material, temperature in the environment is elevated or photo-oxidation reaction. When the MPs remain in environment for a long time, thus resulting in the color of microplastics can fade away.

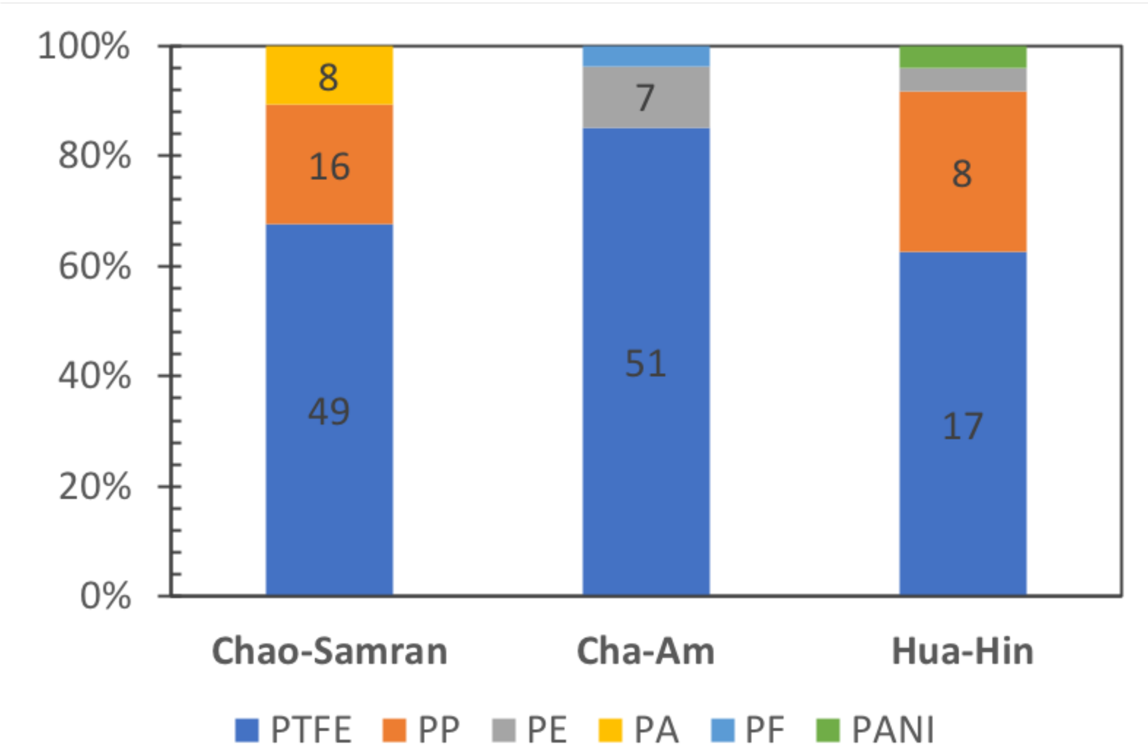
4.5 Polymer Compositions of MPs Contamination

Analysis the chemical composition of microplastics were found in beach sediment samples of the three recreation beaches of the western part of the inner Gulf of Thailand by using Fourier Transform Infrared Microspectrometer (Micro-FTIR). To identify the polymer types of MPs that could be analyzed from this study which consist of polytetrafluoroethylene (PTFE), polypropylene (PP), polyethylene (PE), polyamide (PA), low density polyethylene (LDPE), styrene-ethylene-butylene-styrene (SEBS) and phenol-formaldehyde (PF). Analysis of samples shows that PTFE has a dominant polymer type presence in all samples of beach sediment both in the supratidal and intertidal zone as follows; In supratidal zone, PTFE were identified 80 items in Chao-Samran, 47 items in Cha-Am and 13 items in Hua-Hin beach. Other polymer compositions were found followed by PP (13 items in Chao-Samran, 27 items in Cha-Am and 3 items in Hua-Hin beach), PE and PA respectively. In intertidal zone, all of the beach was found PTFE is the most polymer type of MPs as follows; 49 items in Chao-Samran beach, 51 items in Cha-Am beach and 17 items in Hua-Hin beach. Other polymers that were identified were PP, PE and PA according to Table 4.6 and Figure 4.7.

The characteristics of the polymer are found in each beach is different in each area may result from activities that cause pollution such as PTFE which is the most common polymer in this study. Polytetrafluoroethylene (PTFE) is a very useful material and is widely used in both domestic and commercial applications such as bottle caps, coating a non-stick cookware or providing stain resistance in carpets and fabrics, furthermore, may also find it in nail polish, wiper blades and hair styling tools are degradation and contaminate to marine environment. Apart from PTFE is the majority polymer types were found in this study. PP, PE and PA were also found respectively. PP is a polymer that found in all recreation beach in this study area. It was originated from plastic waste found along the beach such as plastic bags, food packaging and straws. As a result, they found this polymer because every point has tourists there is always solid waste on the beach. In areas, where found PE and PA there are potential areas where coastal activities occur including tourism activity, fisheries, and fishing which are all contributing to MPs pollution to the sea.



a) Supratidal zone



b) Intertidal zone

Figure 4.7 Percentage composition of analyzed samples collected from Chao-Samran, Cha-Am and Hua-Hin beaches at a) supratidal zone and b) intertidal zone.

Table 4.4

Polymer types of microplastics in all sites from supratidal zone and intertidal zone

	Supratidal	Intertidal
Sampling point	Polymer	Polymer
CS1	PTFE (97%), PP (2.5%)	PTFE (100%)
CS2	PTFE (84.6%), PP (3.8%), PE (7.7%), PA (3.8%)	PTFE (67.5%), PP (32.5%)
CS3	PTFE (43.5%), PP (39.1%), PE (4.3%), PA (8.7%), SEB (4.3%)	PTFE (20%), PP (10%), PA (70%)
CA1	PTFE (88.2%), LDPE (11.8%)	PTFE (90.9%), PE (9.1%)
CA2	PTFE (38.1%), PP (61.9%)	PTFE (57.1%), PE (42.9%)
CA3	PTFE (63.3%), PP (33.3%), PA (3.3%)	PTFE (85.7%), PF (14.3%)
HH1	PTFE (69.2%), PP (15.4%), PA (15.4%)	PTFE (83.3%), PP (5.6%)
HH2	PP (50%), PE (50%)	PP (100%)
HH3	PTFE (50%), PP (25%), PE (25%)	PP (66.7%), PE (16.7%), PANI (16.7%)

Table 4.5

Polymer types of microplastics in all beaches from supratidal zone and intertidal zone

Beach	Zone	Polymer
Chao-Samran	supratidal	PTFE (79.8%), PP (12.4%), PE (3.4%), PA (3.4%), SEB (1.1%)
	intertidal	PTFE (67.7%), PP (21.5%), PA (10.8%)
Cha-Am	supratidal	PTFE (61.8%), PP (33.8%), PA (1.5%), LDPE (2.9%)
	intertidal	PTFE (85.2%), PE (11.1%), PF (3.7%)
Hua-Hin	supratidal	PTFE (57.9%), PP (21.1%), PE (10.5%), PA (10.5%)
	intertidal	PTFE (62.5%), PP (29.2%), PE (4.2%), PANI (4.2%)

4.6 Comparison of microplastic concentrations to worldwide beach sediments

Measuring the concentration of microplastics in each research study around the world, each work has a different method. From the selection of the sampling location (e.g. supratidal and intertidal zone, high tide and low tide line), various laboratory procedures. Whether it is a sample extraction method or a polymer composition analysis method. And determining the size range of microplastics to be studied Which of these factors It indicates the different microplastics found in each area.

Microplastics found in beaches around the world differ in quantities, as shown in Table 4.4. The average number of microplastics found in the recreation beaches of the western part of the inner Gulf of Thailand was 47.1 ± 19.5 items/kg. When compared with the current number of microplastics were found in worldwide, the area that found the least microplastics is 8.1 ± 2.9 items/kg Cox's Bazar, Bangladesh. While the area was found the highest microplastics is Da Nang, Vietnam was 9238 ± 2097 items/kg which compared to the value of Thailand, it was found that the number of microplastics were found in this study was less than that of other countries because the beaches of Thailand in this study point that is not connected to any estuary. As a result, these beaches are not influenced by microplastics that come from domestic wastewater that run-off to the sea through the estuary. The reason why Da Nang, Vietnam found a lot of microplastics in the study area, because it might be attributed to the discharge of domestics wastewaters to the beach (Horton et al., 2017) and the wastewater treatment plant in Da Nang are applying basic treatment, that cannot remove all the microplastics from wastewater, as in Thailand. Virginia and North Carolina, the microplastics were found are expected to be influenced by high amount of wastewater and run-off into the Atlantic Ocean and the large metropolitan areas in Virginia (Dodson et al., 2020a). Cox's Bazar, Bangladesh is the place that microplastics are found the least compared to other areas, may be introduced to the beach sediment from fishing and tourist activities (Hossain et al., 2021) etc.

Table 4.6

Number of microplastics in the beach samples reported from other regions and the western part of the inner Gulf of Thailand.

Location	MPs size range (µm)	Beach zone	MP concentration /kg	References
Da Nang, Vietnam	300 - 5000	Shoreline	9238 ± 2097	(Tran Nguyen et al., 2020)
Odisha Coast, India	100 - 1000	Beach	258.7 ± 90.0	(Patchaiyappan et al., 2021)
Cox's Bazar, Bangladesh	300 - 5000	High tide line	8.1 ± 2.9	(Hossain et al., 2021)
Virginia and North Carolina, USA	500 - 5000	Intertidal zone	1410 ± 810	(Dodson et al., 2020b)
Southern Baltic Sea, Poland	100 - 2000	Intertidal zone	160 ± 86	(Urban-Malinga et al., 2020)
Western beaches of the inner Gulf of Thailand	**16 - 5000**	**Supratidal zone** **Intertidal zone**	**59.9 ± 21** **35.6 ± 8.3**	**This study**

CHAPTER 5

RESEARCH CONCLUSIONS

5.1 Conclusions

The present study was focused on the contamination and characteristics of microplastics in supratidal zone and intertidal zone along 60 km of recreation beach of the western part of the inner Gulf of Thailand. The chemical compositions of microplastic were analyzed using the Fourier-Transform infrared micro-spectrometer. All results are concluded for this study as follow:

5.1.1 Abundance of microplastics contamination

The average concentration of microplastics from the three recreation beaches was found in the order of Chao-Samran (83 items/kg) > Hua-Hin (55 items/kg) > Cha-Am (42 items/kg) in supratidal zone. While, the average concentration of microplastics in intertidal zone was found in order of Cha-Am (41 items/kg) > Chao-Samran (40 items/kg) > Hua-Hin (26 items/kg) respectively. Additionally, microplastics were contaminated 60±62 and 36±16 items/kg in supratidal and intertidal zones. However, abundance of microplastic contamination was not significant difference both between beaches and coastal zonation.

5.1.2 Characteristics of microplastic contamination

1) Size of microplastics

The results of all beach sediment samples were found microplastics size 16-1000 µm greater than 1001-5000 µm both in supratidal and intertidal zones of all beaches as follows; in supratidal and intertidal zone, the major of MPs size in this study were 16-1000 µm was 98.1% and 99.7%, respectively.

2) Shape of microplastics

The most common shape was found in this study is fragment from both supratidal and intertidal zone were 56% and 47% respectively. Other shapes of MPs that were identified were fiber (24% and 36%), foam (13% and 10%), film (4% and 6%) and pellet.

3) Colors of microplastic

In each study area was found different colors of microplastic. The abundance of MPs in terms of colors in supratidal zone is in the order of white (24%), transparant (23%), blue (16%), green (13%), yellow (12%), pink (10%) and others (2%). In contrast, the abundance of MPs in terms of colors in intertidal zone is in the order of blue (49%), transparant (21%), white (11%), black (8%) and others (11%).

5.1.3 Polymer-types of microplastic

Polymer-types of microplastics in beach sediment of recreation beach of the inner Gulf of Thailand in supratidal and intertidal zones were found in the order as follows polytetrafluoroethylene are found 67% in supratidal zone and 72% in intertidal zone, followed by polypropylene are found 22% in supratidal zone and 17% in intertidal zone, polyethylene are found 5% in both zone and others.

5.2 Research Suggestions

Forecasting and characterization of microplastic contaminant in coastal environment:

1) Environmental suggestion

Relevant agencies should arrange for regular collection of plastic waste which causes microplastics around the beach and should be developed the waste management system in that area to be more efficient.

2) Research suggestion

Therefore, increasing the amount of sampling time that should covers in 2 seasons for a year (dry season and wet season). In addition, to cover the problems arising from microplastic contamination in the environment, further studies of heavy metals contaminated from microplastics should be carried out.

REFERENCES

Akkajit, P., Thongnonghin, S., Sriraksa, S.,&Pumsri, S.(2019). Preliminary Study of Distribution and Quantity of Plastic-debris on Beaches Along the Coast at Phuket Province. In *App. Envi. Res* (Vol. 41, Issue 2).

Andrady, A.L.(2011). Microplastics in the marine environment. In Marine Pollution Bulletin (Vol.62, Issue8, pp.1596-1605)

Arthur, C. (2009). Proceedings of the International Research Workshop on the Occurrence, Effects, and Fate of Microplastic Marine Debris. www.MarineDebris.noaa.gov

Aslam, H., Ali, T., Mortula, M. M., & Attaelmanan, A.G.(2020). Evaluation of microplastics in beach sediments along the coast of Dubai, UAE. Marine Pollution Bulletin, 150, 110739.

Bissen, R.,&Chawchai,S.(2020). Microplastics on beaches along the eastern Gulf of Thailand – A preliminary study. Marine Pollution Bulletin, 157(June), 111345.

Bridson, J.H., Patel, M., Lewis, A., Gaw, S., & Parker, K.(2020). Microplastic contamination in Auckland (New Zealand) beach sediments. Marine Pollution Bulletin, 151, 110867.

Chen, M.-C., & Chen, T.-H. (2020). Spatial and seasonal distribution of microplastics on sandy beaches along the coast of the Hengchun Peninsula, Taiwan. Marine Pollution Bulletin, 151, 110861.

Cole, M., Lindeque, P., Halsband, C.,&Galloway, T.S.(2011). Microplastics as contaminants in the marine environment: A review. In Marine Pollution Bulletin (Vol. 62, Issue 12, pp. 2588–2597).

Crawford, C.B., &Quinn,B.(2017a). Physiochemical properties and degradation.In Microplastic Pollutants (pp. 57–100). Elsevier.

Crawford, C. B., & Quinn, B. (2017b). The biological impacts and effects of contaminated microplastics. In Microplastic Pollutants (pp.159–178). Elsevier.

De-la-Torre, G.E., Dioses-Salinas, D.C., Castro, J.M., Antay, R., Fernández, N.Y., Espinoza-Morriberón, D., & Saldaña-Serrano, M. (2020). Abundance and distribution of microplastics on sandy beaches of Lima, Peru. Marine Pollution Bulletin, 151, 110877.

Department of Mineral Resources. (2012). Physical geology of the upper Gulf of Thailand Marine geology section Bureau of Geotechnology, August 2555.

Dodson, G. Z., Shotorban, A. K., Hatcher, P. G., Waggoner, D. C., Ghosal, S., & Noffke, N. (2020a). Microplastic fragment and fiber contamination of beach sediments from selected sites in Virginia and North Carolina, USA. Marine Pollution Bulletin, 151(October).

Dodson, G. Z., Shotorban, A. K., Hatcher, P. G., Waggoner, D. C., Ghosal, S., & Noffke, N. (2020b). Microplastic fragment and fiber contamination of beach sediments from selected sites in Virginia and North Carolina, USA. Marine Pollution Bulletin, 151, 110869.

Dolan, J. R. (2018). The Villefranche Strombidium sulcatum: A review. In European Journal of Protistology (Vol. 66, pp. 68–76). Elsevier GmbH.

Dowarah, K., &Devipriya,S.P.(2019).Microplastic prevalence in the beaches of Puducherry, India and its correlation with fishing and tourism/recreational activities. Marine Pollution Bulletin, 148, 123–133.

Erftemeijer, P.L.A., Riegl, B., Hoeksema, B.W., &Todd, P.A.(2012). Environmental impacts of dredging and other sediment disturbances on corals: A review. Marine Pollution Bulletin, 64(9), 1737–1765.

Hengstmann, E., Tamminga, M., vom Bruch, C., & Fischer, E. K. (2018). Microplastic in beach sediments of the Isle of Rügen (Baltic Sea) - Implementing a novel glass elutriation column. Marine Pollution Bulletin, 126, 263–274.

Horton, A. A., Walton, A., Spurgeon, D. J., Lahive, E., & Svendsen, C. (2017). Microplastics in freshwater and terrestrial environments: Evaluating the current understanding to identify the knowledge gaps and future research priorities. Science of the Total Environment, 586, 127–141.

Hossain, M.B., Banik, P., Nur, A.A.U., & Rahman, T. (2021). Abundance and characteristics of microplastics in sediments from the world's longest natural beach, Cox's Bazar, Bangladesh. Marine Pollution Bulletin, 163(December 2020).

Huo, X., Chen, D., He, Y., Zhu, W., Zhou, W., & Zhang, J. (2015). Bisphenol-a and female infertility: A possible role of gene-environment interactions. In International Journal of Environmental Research and Public Health (Vol. 12, Issue 9, pp. 11101–11116). MDPI AG.

Jiménez-Skrzypek, G., Hernández-Sánchez, C., Ortega-Zamora, C., González-Sálamo, J., González-Curbelo, M. Á., & Hernández-Borges, J. (2021). Microplastic-adsorbed organic contaminants: Analytical methods and occurrence. In TrAC - Trends in Analytical Chemistry (Vol. 136). Elsevier B.V.

Lots, F. A. E., Behrens, P., Vijver, M. G., Horton, A. A., & Bosker, T. (2017). A large-scale investigation of microplastic contamination: Abundance and characteristics of microplastics in European beach sediment. Marine Pollution Bulletin, 123(1–2), 219–226.

Maršić-Lučić, J., Lušić, J., Tutman, P., Bojanić Varezić, D., Šiljić, J., & Pribudić, J. (2018). Levels of trace metals on microplastic particles in beach sediments of the island of Vis, Adriatic Sea, Croatia. Marine Pollution Bulletin, 137, 231–236.

Muenmee, S., Chiemchaisri, W., & Chiemchaisri, C. (2015). Microbial consortium involving biological methane oxidation in relation to the biodegradation of waste plastics in a solid waste disposal open dump site. International Biodeterioration and Biodegradation, 102, 172–181.

Nuelle, M. T., Dekiff, J. H., Remy, D., & Fries, E. (2014). A new analytical approach for monitoring microplastics in marine sediments. Environmental Pollution, 184, 161–169.

Patchaiyappan, A., ZakiAhmed, S., Dowarah, K., Khadanga, S. S., Singh, T., Jayakumar, S., Thirunavukkarasu, C., & Devipriya, S. P. (2021). Prevalence of microplastics in the sediments of Odisha beaches, southeastern coast of India. Marine Pollution Bulletin, 167(March).

PlasticsEurope. (2015). An analysis of European plastics production, demand and waste data.

Pollution Control Department. (2019). Reduction guidelines And sorting solid waste in government agencies, Guidelines for the reduction and separation of solid waste in government agencies.

Sathish, N., Jeyasanta, K. I., & Patterson, J. (2019). Abundance, characteristics and surface degradation features of microplastics in beach sediments of five coastal areas in Tamil Nadu, India. Marine Pollution Bulletin, 142, 112–118.

Tharamon, P., Praisanklul, S., & Leadprathom, N. (n.d.). Microplastic contamination in bivalves around Chao Lao beach And Kung Wiman Beach Chanthaburi.

Tran Nguyen, Q. A., Nguyen, H. N. Y., Strady, E., Nguyen, Q. T., Trinh-Dang, M., & Vo, V. M. (2020). Characteristics of microplastics in shoreline sediments from a tropical and urbanized beach (Da Nang, Vietnam). Marine Pollution Bulletin, 161(October).

Urban-Malinga, B., Zalewski, M., Jakubowska, A., Wodzinowski, T., Malinga, M., Pałys, B., & Dąbrowska, A. (2020). Microplastics on sandy beaches of the southern Baltic Sea. Marine Pollution Bulletin, 155(April).

Wang, C., Zhao, J., & Xing, B. (2021). Environmental source, fate, and toxicity of microplastics. In Journal of Hazardous Materials (Vol. 407). Elsevier B.V.

Wang, Y., Zou, X., Peng, C., Qiao, S., Wang, T., Yu, W., Khokiattiwong, S., & Kornkanitnan, N. (2020). Occurrence and distribution of microplastics in surface sediments from the Gulf of Thailand. Marine Pollution Bulletin, 152(January), 110916.

RESEARCHER PROFILE

Miss Pawonwan Sanguanpan
Birth of date: October 5, 1998

Student in the
Bachelor's Degree of Science
Major in Environmental Science

from

Department of Environmental Science
Faculty of Science,
Chulalongkorn University,
Bangkok 10330, THAILAND
E-mail: nupor_m@hotmail.co.th

Academic experience

June – July 2020	Interned as Environmental Officer in Bangkok Aviation Fuel Services Public Company Limited (BAFS)

Computer skills

1. Microsoft office	☐ excellent	☑ good	☐ fair
2. SPSS	☐ excellent	☐ good	☑ fair

Language skills

1. English (Reading)	☑ excellent	☐ good	☐ fair
2. English (Writing)	☐ excellent	☐ good	☑ fair
3. English (Listening)	☑ excellent	☐ good	☐ fair
4. Communications	☐ excellent	☐ good	☑ fair