Quantification and Seasonal Characterization of Solid Waste: A Case Study of Koh Sukorn, Andaman Sea, Southern of Thailand

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Abstract

This study aimed to investigate quantification and seasonal characterization of solid waste at beaches of Koh Sukorn, Trang Province. The solid waste sampling area was defined as a block 10 meters wide and 10 meters long, with every piece of waste collected in an area of 100 square meters. The solid waste was divided into three types according to its physical composition: general waste, recyclable waste, and hazardous waste. The study period was divided in 2 i.e., rainy (May 25, 2022) and dry season (November 29, 2022). Data analysis used Student's t-test to examine seasonal change and quantity of solid wastes. The average solid wastes during rainy and dry seasons were

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0.43 kg/m2 and 0.22 kg/m2, respectively. The amount of solid waste during the rainy season (Mean = 0.43, SD = 0.33) was significantly higher than the amount of solid waste during the dry season (Mean = 0.22, SD = 0.16) at the level. 0.02. The highest quantity of solid wastes was found on Haad Lo Yai follow by Haad Sai Yao, which is a beach on the Andaman Sea coast bordering Phuket Province and neighboring countries include Malaysia, Indonesia, and Burma. Recyclable wastes comprised a significant portion of the marine wastes found on the beaches of Koh Sukorn. Most waste physical characteristic were plastic products: fishing nets and ropes, fishery floating foam, plastic bottles, dangerous packaging containers and plastic bag. During monsoon season, solid waste leaked into the sea would be washed back to the Sukron beaches, especially Andaman Coastal Region. Findings from Sukron beaches indicated that plastic waste leaking into the marine environment remains a significant problem in Thailand. Recommendations needs to better enforce the laws to address the dumping of fishing gear and highlight this issue at an international level.

Keywords: Quantification, Seasonal, Characterization, Solid waste, Marine waste

ปริมาณและองค์ประกอบทางกายภาพของขยะมูลฝอยตามฤดูกาล: กรณีศึกษาเกาะสุกรทะเลอันดามัน ภาคใต้ของประเทศไทย

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บทคัดย่อ

การศึกษานี้มีวัตถุประสงค์เพื่อศึกษาปริมาณและองค์ประกอบของขยะมูลฝอยตามฤดูกาลของชายหาดของเกาะสุกร จังหวัดตรัง พื้นที่ในเก็บตัวอย่างขยะมูลฝอยกำหนดเป็นบล็อกกว้าง 10 เมตร และยาว 10 เมตร โดยเก็บรวบรวมขยะมูลฝอยทุกชิ้นในพื้นที่ 100 ตารางเมตร ขยะมูลฝอยแบ่งออกออกเป็น 3 ประเภทตามองค์ประกอบทางกายภาพ ได้แก่ ขยะทั่วไป ขยะรีไซเคิล และขยะอันตราย ช่วงระยะเวลาการศึกษาแบ่งเป็น 2 ช่วงตามอิทธิพลของมรสุม ได้แก่ ฤดูฝน (25 พฤษภาคม 2565) และฤดูแล้ง (29 พฤศจิกายน 2565) การเปรียบปริมาณขยะมูลฝอยเฉลี่ยระหว่างฤดูกาลมรสุมกับช่วงไม่ใช่ฤดูมรสุมด้วยการทดสอบค่าที ผลการศึกษาพบว่าปริมาณขยะมูลฝอยเฉลี่ยในช่วงฤดูฝนและฤดูแล้งเท่ากับ 0.43 กก./ตร.ม. และ 0.22 กก./ตร.ม. ตามลำดับ ปริมาณขยะมูลฝอยในช่วงฤดูฝน (ค่าเฉลี่ย = 0.43, ส่วนเบี่ยงเบนมาตรฐาน = 0.33) สูงกว่าปริมาณขยะมูลฝอยในช่วงฤดูแล้ง (ค่าเฉลี่ย = 0.22, ส่วนเบี่ยงเบนมาตรฐาน = 0.16) อย่างมีนัยสำคัญทางสถิติที่ระดับ 0.02 ปริมาณขยะมูลฝอยมากที่สุดบนหาดโล๊ะใหญ่ รองลงมาคือหาดทรายยาวซึ่งเป็นชายหาดชายฝั่งทะเลอันดามันติดต่อกับจังหวัดภูเก็ต ประเทศเพื่อนบ้าน

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ได้แก่ มาเลเซีย อินโดนีเซีย และพม่า ขยะรีไซเคิลเป็นองค์ประกอบทางกายภาพของขยะมูลฝอยที่พบมากที่สุดบนชายหาดของเกาะสุกร นอกจากนี้ องค์ประกอบของขยะมูลฝอยส่วนใหญ่คือขยะพลาสติก ได้แก่ อวนและเชือก โฟมลอยน้ำในการประมง ขวดพลาสติก ภาชนะบรรจุภัณฑ์อันตราย และถุงพลาสติก ช่วงฤดูมรสุม ขยะมูลฝอยที่รั่วไหลลงสู่ทะเลจะถูกพัดพากลับไปยังชายหาดของเกาะสุกรโดยเฉพาะบริเวณชายฝั่งอันดามัน จากข้อค้นพบจากการศึกษาของชายหาดของเกาะสุกรระบุว่าขยะพลาสติกที่รั่วไหลออกสู่สิ่งแวดล้อมทางทะเลยังคงเป็นปัญหาสำคัญในประเทศไทย ข้อเสนอแนะจำเป็นต้องบังคับใช้กฎหมายให้ดีขึ้นเพื่อจัดการกับการทิ้งเครื่องมือประมงและเน้นประเด็นนี้ในระดับสากล

คำสำคัญ: ปริมาณ ฤดูกาล องค์ประกอบ ขยะมูลฝอย ขยะทะเล

Introduction

Island beaches are an important place for various tourism activities such as hotels, restaurants, water sports and fishing. These activities can directly or indirectly impact marine and coastal environments. The most visible environmental problems on coastal island are solid waste. Only in 2019, Thailand's 23 coastal provinces alone produced an estimated 11.47 million tons of solid waste and approximately 12% was plastic (World Bank, 2022). Solid waste accumulating on the beach and ocean at a high proportion compared with the quantity of solid waste contributed from the whole country (Bureau of Information Office of the Permanent Secretary of MOPH, 2019). According to a nature sustainability report in 2021, the ten most commonly found items of marine litter included plastic bags (14.1%), plastic bottles (11.9%), food containers and cutlery (9.4%), wrappers (9.1%), synthetic rope (7.9%), fishing items (7.6%), plastic caps/lids (6.1%), industrial packaging (3.4%), glass bottles (3.4%) and drinks cans (3.2%) (Ritchie & Roser, 2022). According to Department of Marine and Coastal Resources of Thailand database, more than one million tons of garbage was dumped in the oceans every year or 45,931 pieces led by plastic debris (12%), styrofoam boxes (10%), food wrappers (8%), plastic bags (8%), glass bottles (7%), plastic bottles (7%) and straws and stirrers (5%) (Thailand Development Research Institute, 2021). Jambeck et al. (2015) studied available data on solid waste to estimate the amount of land-based plastic waste entering the ocean. Plastic waste makes up 60 to 80% of all marine waste and around 90 to 95% of all marine waste in some areas. Similar to other studies, the results showed that between 61 and 87% of coastal and marine litters comprised of plastics (Barboza et al., 2019; Tekman et al., 2019)

Numerous problems and threats are caused directly or indirectly by solid waste, including environmental, economic, health and global impacts. The environmental impacts, especially fishing and plastic items, can deteriorate coral reefs, injure bottom-dwelling species and entangle or drown ocean wildlife such as fish, seabirds, sea turtles and marine mammals (Lincoln et al., 2022). Solid wastes significantly impact the tourism potential of landscapes, beaches and waterways. Solid wastes also produce potential economic implications to maritime activities, such as fishing, aquaculture and recreation. In addition,

the economic impacts of solid wastes include the cost of cleaning up beaches and other areas (UN Environment. Marine Litter Socio Economic Study, United Nations Environment Programme, 2019). For health impacts, once solid waste enters the ocean, it breaks down into debris, in the case of plastics called "microplastic". The marine debris and microplastic can be circulated within the ocean by currents as hazardous waste because they adsorb toxic pollutants while they traverse through the environment (Wang, He & Sen, 2019; Casabianca et al., 2021). The marine debris or microplastic can transfer to humans through the food chain resulting in threats of chronic biological effects and potential health hazards for humans including gastrointestinal disorders, impaired immunity, respiratory problem, cancer, infertility and altered chromosomes (Mamun et al., 2023). The solid waste can cause global impacts. The solid waste produced from one country can be transported across the seas and oceans over long distances before being deposited or accumulated in other countries as coastal or marine debris. These problems lead to geographic disputes as well as greenhouse gas emissions.

Koh Sukorn (Koh means island), also known as "Koh Muu" meaning "Pig Island", is an island in the Andaman Sea in Palian District, Trang Province, southwest Thailand (Koh Sukorn Subdistrict Administrative Organization, 2022). The Lower Central Andaman Coastal Region stretches from Koh Sukorn in the south all the way north to Koh Ngai-a distance of about 60 km (37 miles) (Figure 1). No bridge connects Koh Sukorn and the mainland. The island sits roughly 3 km off the coast of the mainland; therefore, only boats connect to the mainland and other islands. On the island, 3000 villagers reside in four villages. Most villagers are Muslims involved in fishing, rubber, watermelon and rice occupations. Koh Sukorn is about 14 square kilometers and most of the area is flat landscape and hilly terrain. Sukorn's hilly northwestern terrain is blanketed in rubber trees while rice fields, coconut groves and watermelon patches extend from southeast flat landscape to the west coast. The beaches on Koh Sukorn reveal shallow water and considerable rocks a long way offshore. A narrow, 17-kilometre cement road encircles almost the entire island, cutting northwest from Baan Saimai to a cliff-top pavilion. Only Haad Lo Yai is suitable for swimming and a few resorts. Thus, the tourist destination of Koh Sukorn is only for local cultural life, rural and agricultural tourism. The rainy season runs

roughly from May to October, during which time the resorts on the island are closed. The dry (and high) season runs roughly November to April, with January and February in particular being busy, but the crowds are mostly found on other islands (WorldAtlas, 2023). Moreover, Koh Sukorn faces coastal and marine debris especially during rainy season.

This study aimed to investigate the quantity and physical composition of solid waste at the beaches of Koh Sukorn, Andaman Sea, Southern of Thailand, with intention of determining the effects of seasonal characterization. Koh Sukorn is promoted as one of a new community-based tourism and "Clean Island" in Trang Province of Thailand. This strategy promotes economic growth bringing more income to the island because tourism is an important economic activity that plays a vital role in Thailand's socio-economic development. The results of this study would provide data for government, non-governmental organization or educational institution to continuous handle with solid waste on the island, especially plastic wastes.

Figure 1: Map of the study areas of Koh Sukorn (Koh Sukorn Subdistrict Administrative Organization, 2022; World Atlas, 2023; Koh Sukron, 2023)

Material and Methods

The quantitative and physical composition of solid waste was studied per area (Kilogram per square meter) covering the whole area of the beach. Methods used in this quantitative and physical composition of solid waste on the beaches of Koh Sukron were based on Guidance on Monitoring of Marine Litter in European Seas (European Commission Joint Research Centre, 2013); the OSPAR "Guideline for Monitoring Marine Litter on the Beaches in the OSPAR Maritime Area" (OSPAR Commission, 2010); the NOOA "Marine Debris Monitoring and Assessment: Recommendations for Monitoring Debris Trends in the Marine Environment (Lippiatt, Opfer & Arthur, 2013); "UNEP/MAP MEDPOL Monitoring Guidance Document on Ecological Objective 10: Marine Litter" (UNEP/MAP MEDPOL, 2023). The sampling procedure should follow these criteria as closely as possible. However, the judgment of sampling procedure is related to the coastal area and marine litter situation in each country (Vlachogianni, 2017).

Equipment of Study

1) Trash sacks (size 30 x 45-inch) were used to hold solid waste that was sorted into categories based on physical composition and weighed.
2) Thick rubber gloves were protective equipment for researchers and research assistants in sorting waste according to its physical composition.
3) Sanitary Masks were a protective device to protect against the dangers of breathing in dust and chemicals for the researchers and research assistants while sorting waste according to its physical composition.
4) Rubber Worker Boots were protective equipment for researchers and research assistants from walking on the beach to protect them from accidents, stepping on sharp objects and poisonous animals.
5) Weight Machine size 60 kilogram was used to weigh each type of solid waste.
6) Measuring Tapes of 50 meters was used to measure the distance to determine the area for collecting solid waste in the study.
7) Rope was used to mark the boundaries of the solid waste sorting area on Koh Sukorn's beach.

Study Area

The inclusions criteria for the selected beaches should meet the guidance criteria (European Commission Joint Research Centre, 2013; OSPAR Commission, 2010; Lippiatt, Opfer S & Arthur, 2013; UNEP/MAP MEDPOL, 2023) including: (1) to have a minimum length of 100-meters, (2) to have a low to moderate slope (~1.5-4.5°), and (3) to have clear access to the sea. The exclusions criteria were very shallow tidal mudflat areas, blocked by breakwaters or jetties, and no cleaning activities before 2 weeks (Vlachogianni, 2017). The selected beaches comprised Sai Thong Beach (Haad) (5 points of solid waste sorting), Tang Mo Beach (Watermelon) (6 points of solid waste sorting), Tha Lay Beach (2 points of solid waste sorting), Lo Yai Beach (3 points of solid waste sorting), and Sai Yao Beach (3 points of solid waste sorting) referred to as Figure 1.

Sampling procedure

The sampling procedures followed as the guidance for monitoring marine litter on the beaches are described below (OSPAR Commission, 2010; Lippiatt, Opfer S & Arthur, 2013; UNEP/MAP MEDPOL, 2023; Vlachogianni, 2017).

1) The first sampling unit was at the beginning of the beach. The guidance of sampling unit should be a 100-metre stretch of beach along the strandline and reaching to the back of the beach (European Commission Joint Research Centre, 2013; OSPAR Commission, 2010; Lippiatt, Opfer S & Arthur, 2013; UNEP/MAP MEDPOL, 2023). However, the sampling unit of this study was 10-metre stretch because the beach was quite narrow. The block of sampling unit was marked by rope with 10 meters in width and 10 meters in length (100 square meters) (Figure 2). The back of the beach was defined as the presence of vegetation, dunes, cliff base, road, fence, piled boulders, and concrete structures (Vlachogianni, 2017).

2) The sorting sampling unit was in 100 square meters, collected all pieces of solid waste, divide the solid waste into 3 categories, i.e., 1) general waste: cigarette ends, food containers and cutlery, wrappers, lunch boxes made of foam and plastic, plastic straws, plastic cups, utensils, plastic food bags containing rope, fishing items, clothes, shoes, etc., 2) recyclable waste: plastic bottles, glass bottles, drink cans, metal etc. and 3) hazardous waste: pesticides and cleaning bottles, fluorescent lamps, fluorescent tubes,

batteries, lighters, syringes, medical tools, sanitary masks etc (Pasquini, G., et al.; Pasternak et al., 2017; Rattanapan, Phokaew & Ninlaao, 2009; International Maritime Organization, 2016) with the exception of organic wastes: wood, leaves, seaweed etc. as this type of waste can decompose naturally.

3) Solid wastes were weighted based on physical composition (3 categories: general waste, recyclable waste and hazardous waste)

4) The next sampling unit was 100 meters from the first sampling unit European Commission Joint Research Centre, 2013; OSPAR Commission. Guideline for monitoring marine litter on the beaches in the OSPAR maritime area, Edition 1.0, 2010; Lippiatt, Opfer S & Arthur, 2013; UNEP/MAP MEDPOL, 2023). The number of sampling unit depended on the distance of the beach.

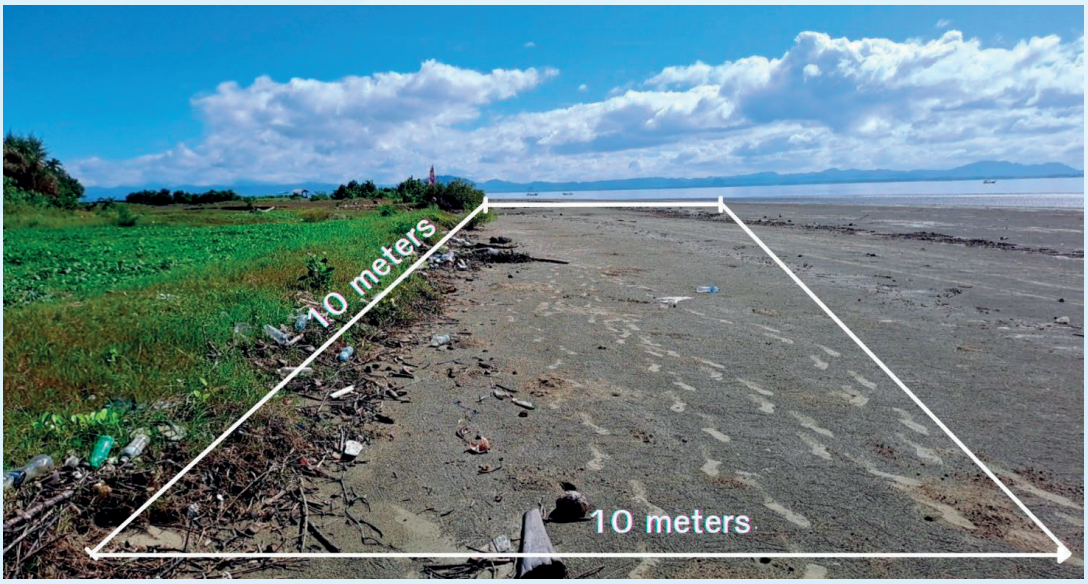

Figure 2: Sampling area

Study Period

The study period to investigate quantitative and physical composition of solid wastes on Koh Sukorn beaches was divided in two periods including rainy and dry seasons. The study during rainy season was May 25, 2022, and the study during dry season was November 29, 2022 (Koh Sukorn Subdistrict Administrative Organization, 2022). The limitation of this study was to study only 1 time for each seasonal period due to

the limitations of the Covid-19 epidemic and the monsoon, which limits visits to the island. The solid waste quantity and physical characteristic might change over the time. The better study design should increase solid waste sorting in several months covering rainy and dry season.

Analysis

The average amount of solid wastes was calculated in 1 square meter area (Rattanapan, Phokaew &Ninlaao, 2009). Percentage composition of each solid waste was calculated using Eq. 1 (Alabdrab & AL-Qaraghully, 2013)

$$\text{Percentage composition waste fraction} = \frac{\text{weight of separated waste} \times 100}{\text{the total mixed weight sample}} \quad \text{Eq.1}$$

Student's t-test (Mishra, et al., 2019) was used to examine seasonal change and quantity and physical composition of solid wastes.

Results and Discussions

Quantification and seasonal characterization of solid wastes

Regarding the quantity of solid wastes in rainy season (May 2022), the results showed Haad Tang Mo (Watermelon), Haad Tha Lay, Haad Lo Yai, Haad Sai Yao, and Haad Sai Thong had solid wastes of 1.78, 1.08, 2.67, 2.13 and 0.57 kg/m2, respectively. The average solid wastes on the beaches of Koh Sukorn during rainy season totaled 0.43 kg/m2. The highest quantity of solid wastes was found on Haad Lo Yai followed by Haad Sai Yao referred to as Table 1. Concerning quantity of solid wastes in dry season (November 29, 2022), the results showed Haad Tang Mo (Watermelon), Haad Tha Lay, Haad Lo Yai, Haad Sai Yao and Haad Sai Thong had solid wastes of 1.01, 0.61, 1.26, 1.02 and 0.30 kg/m2, respectively. The average solid wastes on the beaches of Koh Sukorn during dry season totaled 0.22 kg/m2 referred to as Table 2. The highest quantity of solid wastes during rainy and dry seasons was found on Haad Lo Yai followed by Haad Sai Yao referred to as Table 1-2. The sources of beach litters may be either land- or marine-based (Veiga et al., 2016). In this case, most litter was ocean-based because the beaches on Koh Sukorn reveal shallow water and considerable rocks a long way offshore. The beaches on Koh Sukorn subject to be not suitable for recreational activities (Koh Sukorn Subdistrict

Administrative Organization, 2022). A number of authors indicated that marine-based sources are largely those from shipping (recreational, public transport, and commercial) and fisheries (Galgani, Hanke & Maes, 2015; Sloan, Wallner & Mounsey, 1998; Whiting, 1998; Roeger, 2002; Kiessling & Hamilton, 2001). As the current results, the most sources of beach litters and marine debris on Koh Sukron were local and neighboring fisheries where they were subjected to wind and river-driven transport, ultimately reaching the coast. Haad Lo Yai and Haad Sai Yao are located in the Andaman Coastal Region constituting a union territory of Phuket Province and neighboring countries: India, Malaysia, Indonesia, and Myanmar as shown in Figure 1. The most marine waste productions on the beaches of Koh Sukorn may come from coastal provinces and neighboring countries. Moreover, the origins of marine waste production can be identified from label of product labels such as fishing nets, plastic or glass beverage bottles. Van Franeker categorized labels and bar-codes of marine wastes found on Texel beach in the Netherlands. The results revealed that the majority of marine wastes originated from the Netherlands or neighboring regions (Van Franeker, 2005). According to this result, the marine debris found on the beaches of Koh Sukorn had product labels both from Thailand and neighboring countries (Malaysia, Indonesia and Myanmar). Marine waste from one country can travel to the beach in another country; therefore, marine waste management requires multi-stakeholder cooperation, knowledge sharing, technology transfer, increasing public awareness and innovation dissemination to combat marine debris both national and international level. The need for strengthened knowledge and identify strategies for intervention should be transferred to individual level to prevent litters are being lost or disposed of into the marine environment. On the international level, the global declarations on combat marine debris in ASEAN such as Bangkok declaration on combating marine debris should really take action (Bangkok declaration on combating marine debris in ASEAN, 2020).

Table 1: Quantity of solid wastes during rainy season (May 25, 2022)

Sampling point	Quantity of solid wastes (Kg/m^2)					
	Tang Mo Beach	Tha Lay Beach	Lo Yai Beach	Sai Yao Beach	Sai Thong Beach	
1	0.40	0.41	1.24	0.50	0.14	
2	0.37	0.67	0.63	0.65	0.17	
3	0.30		0.80	0.98	0.09	
4	0.32				0.04	
5	0.26				0.13	
6	0.13					
Total	**1.78**	**1.08**	**2.67**	**2.13**	**0.57**	**8.23**
Average	**0.59**	**0.54**	**1.34**	**0.71**	**0.11**	**0.43**

Table 2: Quantity of solid wastes during dry season (November 29, 2022)

Sampling point	Quantity of solid wastes (Kg/m^2)					
	Tang Mo Beach	Tha Lay Beach	Lo Yai Beach	Sai Yao Beach	Sai Thong Beach	
1	0.15	0.24	0.6	0.25	0.10	
2	0.19	0.37	0.27	0.28	0.07	
3	0.25		0.39	0.49	0.05	
4	0.16				0.02	
5	0.07				0.06	
6	0.19					
Total	**1.01**	**0.61**	**1.26**	**1.02**	**0.30**	**4.20**
Average	**0.17**	**0.43**	**0.42**	**0.34**	**0.06**	**0.22**

When comparing the quantity of solid wastes between rainy and dry seasons, solid waste volume (kg/m2) during rainy season accounted for approximately twice the solid waste volume during dry season referred to as Figure 3. Further, Table 3 confirmed the effect of seasonal characterization on solid waste volume at the beaches of Koh Sukorn

with statistical analysis. Table 3 reported that solid waste volume during rainy season (M = 0.43, SD = 0.33) was statistical significance higher than solid waste volume during dry season (M = 0.22, SD = 0.16, p-value = 0.02). Similarly, several areas tended to exhibit an increase in accumulated rates of debris on beaches after wet season storms (Galgani, Hanke & Maes, 2015; Sloan,Wallner & Mounsey, 1998; Whiting, 1998; Roeger, 2002; Kiessling & Hamilton, 2003). The rainy season runs roughly from May to October, when the resorts on the Koh Sukorn are closed. The dry (and high) season runs roughly November to April, with January and February in particular being busy, but not many crowds are found on other islands (Koh Sukorn Subdistrict Administrative Organization, 2022). Based on our results and analysis, we posit that ocean-based sources should be a high priority for waste managers as a point of intervention at Koh Sukron.

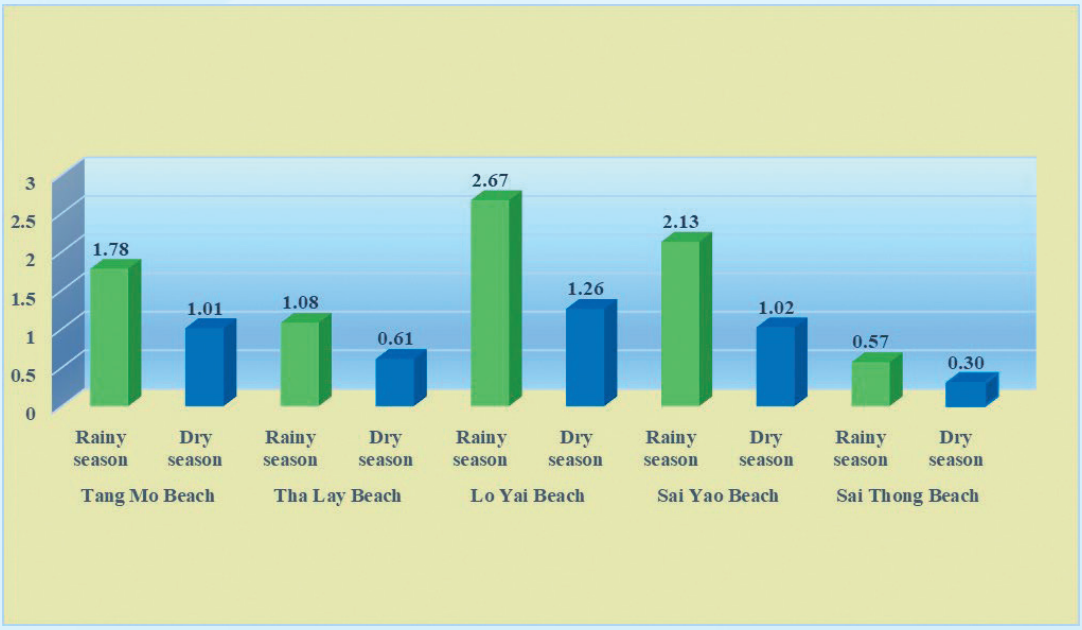

Figure 3: Seasonal characterization and quantification of solid waste on Koh Sukron (kg/m2)

Table 3: Seasonal characterization and quantification of solid waste with Student t-test analysis

Sseasonal	Mean	Std.dev	t	*p*-value
Rainy season	0.43	0.33	2.56	0.02
Dry season	0.22	0.16		

Seasonal characterization and physical composition of solid wastes

Analysis of the results of physical composition of solid wastes collected on the beaches of Koh Sukron during rainy season revealed that the recyclable wastes had the highest volume accounting for 68.73% by weight followed by general waste accounting 30.49%, and hazardous wastes accounting for 0.78%. Similarly, during dry season, the recyclable wastes, general waste, and hazardous wastes were 70.38%, 28.14% and 1.48%, respectively. According to the results of the analysis performed on five different beaches on Koh Sukorn Island, the recyclable waste amount was the highest during both rainy and dry seasons referred to as Table 4. Similar outcomes of this study were found in Koh Mook Village, Trang Province (Rattanapan, Phokaew, & Ninlaao, 2009) and four different points located on both Asian and European sides of Istanbul (Bilgili, Adar & Sezer, 2019). Moreover, the results of this study differed from those in the study on Phetphoom Beach, Phuket Province that among all types of marine debris found, general waste was the highest amount (Sangkhanan, Kumlom & Klongrue, 2022).

Table 4: The percentage of physical composition of solid wastes

Solid waste type	Rainy season		Dry season		Total	Percentage by weight
	Weight (Kg.)	Percentage by weight	Weight (Kg.)	Percentage by weight		
General waste	259.10	30.49	106.60	28.14	365.70	29.76
Recycle waste	584	68.73	266.60	70.38	850.60	69.24
Hazardous waste	6.60	0.78	5.60	1.48	12.20	0.99
Total	**849.70**	**100%**	**378.80**	**100%**	**1,228.50**	**100%**

The most common types of general waste were fishing nets and rope (40.77% by weight of general waste), followed by fishery floating foam (30.67% by weight of general waste) referred to as Figure 3. Analysis results of recyclable waste types, it was found that glass bottles had the highest accounted as 55.04% by weight of recyclable wastes followed by plastic bottles accounting for 27.32% referred to as Figure 4. Analysis results of hazardous waste types revealed that dangerous packaging containers comprised the highest amount accounting for 50.16% by weight followed by fluorescent light bulbs accounting for 29.18% referred to as Figure 5. The results from this study showed that fishing nets, rope and fishery floating foam were ranked the first and second general waste types. Coastal surveys of the north-west coast of Australia also found that a great number of fishing nets were washed ashore. In addition, Asian manufactured goods were likely to comprise the greatest proportion (around 80%) of all nets washed ashore. Taiwanese manufactured nets accounted for 26 to 39% of all nets identified, while Indonesian and Japanese manufactured nets accounted for 17% and up to 11% of identified nets, respectively (Van Franeker, 2005). However, this study did not identify net manufactures. Another important result of this study identified the most common solid wastes on the beaches of Sukron Island could be identified as plastic polluters including fishing nets and rope, plastic bottles, dangerous packaging containers and plastic bags. Similarly, to several studies in several areas of the globe, plastics are the dominant marine waste (Hengstmann et al., 2017; Pasternak et al., 2017; Munari et al., 2016; Pasquini et al., 2016; Bouwman et al., 2016; Kordella et al., 2013) The high percentage of plastics can be explained because plastic waste is incapability of biodegradation compared with paper, cardboard, wood and food waste in the marine environment and sunken metal and glass (Pasternak et al, 2017). Several studies have documented that fishing and plastic items can cause deterioration to coral reefs, injure bottom- dwelling species and entangle or drown ocean wildlife such as fish, seabirds, sea turtles and marine mammals (Hengstmann et al., 2017; Pasternak et al., 2017; Munari et al., 2016; Pasquini et al., 2016; Bouwman et al., 2016; Kordella et al., 2013; Rees & Pond, 1996). Additionally, tiny fragments of degraded plastics called microplastics may be consumed by sea animals inhibiting their ability to feed (Faris & Hart, 1994; Ananthaswamy, 2001). Research has also demonstrated a strong potential for biological uptake of heavy metals and/or other toxic

substances through ingestion of suspended microplastics (Mato et al., 2001; Moore et al., 2001; Slavin, Grage & Campbell, 2012; Poeta, Battisti & Acosta, 2012). Today, plastic waste requires immediate attention from waste managers and waste planners because it is a growing problem worldwide, with myriad consequences for both environmental and public health.

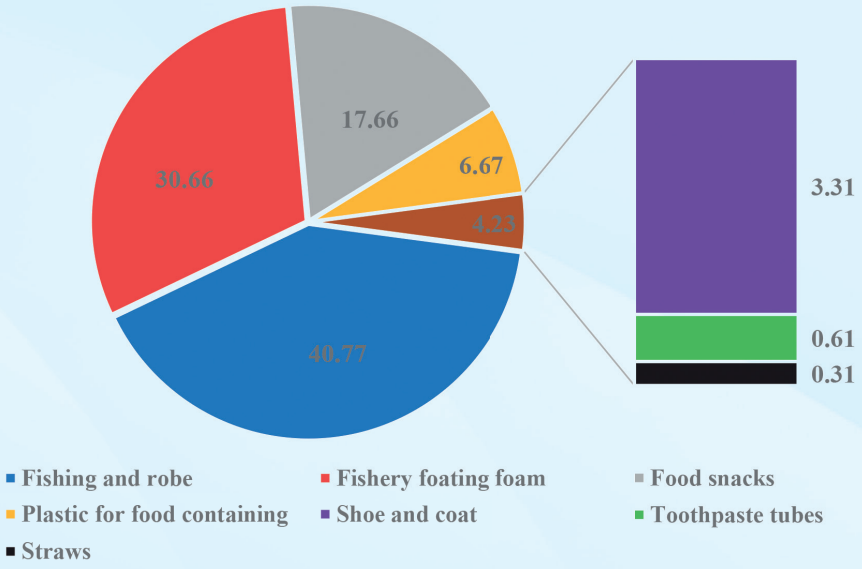

Figure 3: The percentage of general waste type by weight

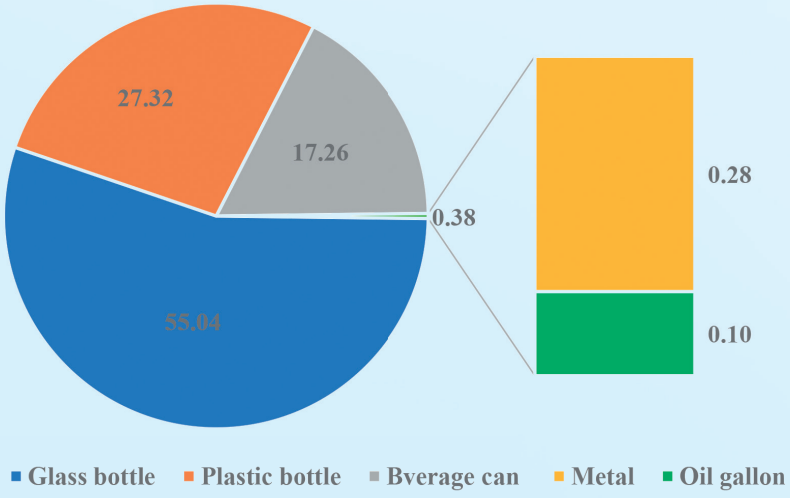

Figure 4: The percentage of recycle waste type by weight

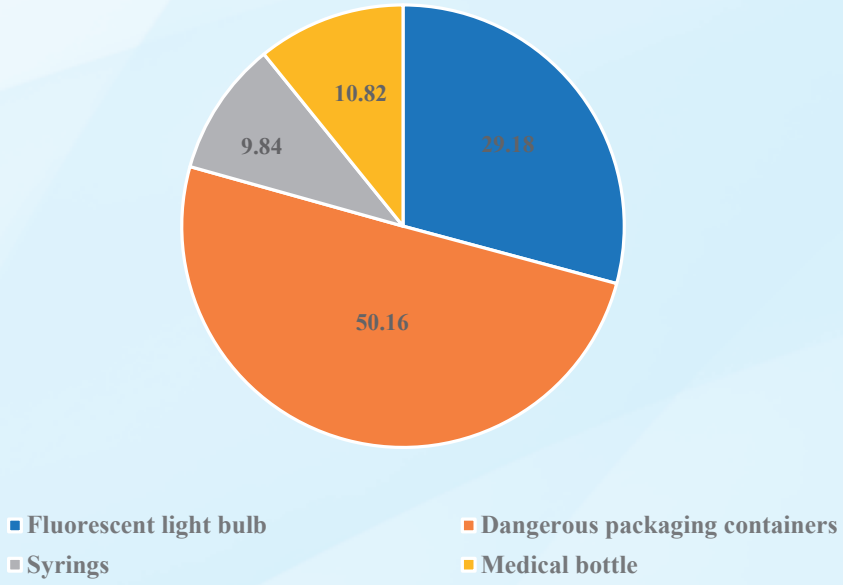

Figure 5: The percentage of hazardous waste type by weight

Conclusions

According to the results, it could be concluded that the greatest marine waste found on the beach of Koh Sukorn especially Haad Lo Yai and Haad Sai Yao came from coastal provinces and other countries. One reason can explain that Haad Lo Yai and Haad Sai Yao is in the Andaman Coastal Region which constitutes a union territory of Phuket Province and several countries: India, Malaysia and Myanmar. In addition, the marine debris found on the beaches of Koh Sukorn had product labels from Thailand and other countries. Other reasons support the conclusion that an increase in accumulation rates of debris on the beaches of Koh Sukorn is always found during rainy season when tourists are scarce. Marine waste from one country can travel to the beach in another country; therefore, marine waste management requires multi-stakeholder cooperation, knowledge sharing, technology transfer, increasing public awareness and innovation dissemination to combat marine debris both national and international level.

Recyclable wastes comprised a significant portion of the marine wastes found on the beaches of Koh Sukorn. Most marine wastes on Koh Sukorn were plastic products including general, recyclable and dangerous wastes, for example, fishing nets and rope, fishery floating foam, plastic bottles, dangerous packaging containers and plastic bags. Several studies have confirmed substantial evidence that plastics-associated chemicals, such as methyl mercury, plasticizers and flame retardants, can enter the body and are linked to health concerns. Less than 10% of plastics have been recycled while millions of tons of plastic waste are lost in the environment, or sometimes shipped thousands of kilometers to destinations where they are mostly burned or dumped. Recommendations should take the clean seas pledge and adopt new habits to limit plastic footprint issues.

Implications

1. During monsoon season, solid waste leaked into the sea would be washed back to the Sukron beaches, especially Andaman Coastal Region. Subdistrict Administrative Organization must plan to manage marine waste during monsoon season. Marine waste left on the beach, especially plastic waste will be buried on the beach sand. When sea water rises, these plastic waste particles can be carried back into the marine environment or accumulate in the food chain of marine animals and plants.

2. Recyclable wastes comprised a significant portion of the marine wastes found on the beaches of Koh Sukorn. Most waste physical characteristic were plastic products: fishing nets and ropes, fishery floating foam, plastic bottles, dangerous packaging containers and plastic bag. Findings from Sukron beaches indicated that plastic waste leaking from fish boat into the marine environment remains a significant problem in Thailand. Recommendations needs to better enforce the laws to address the dumping of fishing gear and highlight this issue at an international level.

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