Tourism Affecting Amounts of Marine Debris and Microplastic at Samui Island, Southern Thailand

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Abstract

The amount of marine debris in the environment is increasing worldwide, which results in an array of negative effects to biota. This study provides the first account of marine debris and microplastics on the beach and in the sediment (shoreline and infralittoral) in relation to tourism activities on Samui Islands, southern Thailand. The study assessed the quality and quantity of marine debris and the quality, size and quantity of microplastics at three beaches, contrasting those under the influences of tourism and those that were not. Marine debris was counted from ground survey using applied ICC method. Microplastics with a size larger than 1 mm were counted, classified and photographed. Over 90.02% of marine debris was plastic, and microplastics were ubiquitous, which calls for classification of plastics as hazardous materials. A popular tourism beach with frequent cleaning seemed to have an effect on less macrodebris or microplastic quantity detected. Recommendations for future assessments are provided for Samui District Organization Office.

Keywords: Marine debris, plastic, tourism, drone photograph, human impact

Introduction

Marine debris and microplastic (plastic particles < 5 mm) is a global issue that needs to be addressed urgently (Barnes et al., 2009; Kershaw et al., 2011; Depledge et al., 2013) and Thailand ranked number 6th in the world in producing plastic debris to the Oceans(Jamebeck et al., 2015) Ocean currents spread large amounts of debris from industrialized and densely populated areas to even the most remote and unpopulated coastal regions (McDermid and McMullen, 2004; Barnes et al., 2009; Hirai et al., 2011). Marine debris is defined as any persistent, man-made solid waste discarded into the marine environment (Galgani et al., 2010).

Most of it is made of plastic (Barnes et al., 2009) that originates from both land- and ocean-based sources. Plastics foster a myriad of negative effects on marine organisms, such as entanglement, intestinal blockage, suffocating, smothering, and ghost fishing (Gregory, 2009). These further cause negative physiological effects, lower fitness, reproductive failure, changes in community structure, and death (Spear et al., 1995; Barnes, 2002; Derraik, 2002).

Microplastics are minute fragments of plastic debris, which are divided into small (<1 mm in diameter) and large (1–5 mm in diameter) particles (Gregory and Andrady, 2003; Betts, 2008; Moore, 2008; Fendall and Sewell, 2009; Imhof et al., 2012). Microplastics consist of nylon, polyester, acrylic, poly-propylene, polyethylene, poly (ethylene–propylene), polyvinylchloride, polyvinyl alcohol, polystyrene, polyester, polyurethane, polyacrylonitrile, alkyd, alkyd resin, and polyamide fibers. The main component of microplasic is usually synthetic polymers (Barnes et al., 2009; Leslie et al., 2011; Vianello et al., 2013). Microplastic ingestion has been observed in a wide range of marine taxa, including crustaceans, molluscs, fish, birds, and mammals (Thompson et al., 2009a; Fossi et al., 2012; Lusher et al., 2013; Wright et al., 2013; Watts et al., 2014), and can result in a wide range of negative effects, such as blockage of the intestinal tract and abrasion in small organisms (similarly to the effects of macroplastics in large biota) (Wright et al., 2013).

Samui Island is one of the most tourist attraction places in Thailand where marine debris and micro-plastics could be affected by tourism. The objectives of this study are to (1) compare how tourism affecting marine debris and microplastics by comparing high tourist beach, low tourist beach and non-tourist beach, and (2) classify types of marine debris, and microplastics present on Samui Island, Thailand and (3) comparing microplastic quantity between beach zone.

Materials and methods

Study site

This study was conducted at three beaches: Chawang, Lamai and Hua Thanon Beaches at Samui Island, southern Thailand (100.013520° N, 9.509808° E) (Figure 1, Table 1) during 16-19 February, 2020.

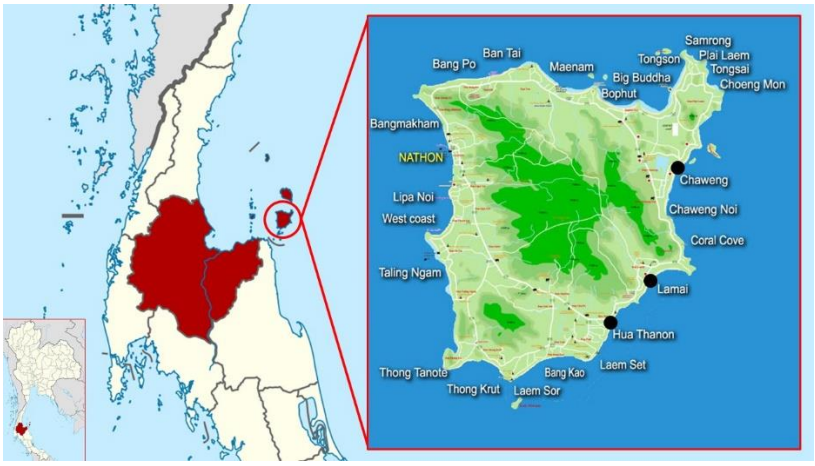

Figure1. Map of Thailand and study site at Samui Island, Surat Thani province, Thailand. (a) Chawang, (b) Lamai and (c) Hua Thanon Beaches at Samui Island, southern Thailand

Table 1. Geographical information of study site.

Sites	Place	Longitude	Latitude
S1	Lamai Beach	100 3’47” E	9 31’46” N
S2	Hua Thanon Beach	100 02’40” E	9 27’ 42” N
S3	Chawang Beach	100 02’ 58” E	9 28’06” N

- High frequent cleaning beach twice a day at a high volume of tourist
- Normal beach which daily clean of large marine debris but we could notice of patches of marine algae
    - Highly tourist activites
- Fishing village where activities and normally non beach cleaning activities are performed normally we can see fishing nets hanging on the adjacent area

Fig. 2 Comparison among three beach conditions: a) Chaweng Beach b) Lamai Beach and c) Hua Thanon Beach

Data Collection

Soil moisture and surface temperature

This study took place during the peak of tourist season in February 2020. One 50-m transect was placed randomly along the beach, parallel to the shoreline. We used GLOBE soil moisture protocol and surface temperature proto col and submitted soil and temperature to the GLOBE website. We collected nine 50-g of wet soil samples at 0, 25 and 50 m line transects with three soil samples per line transect. Then soil samples were oven dried at 60 ºC for 6 hours and weighed soil samples.

Fig. 3 a) Collection of marine debris, b) taking and c) sieving sand samples for further microplastic examination

Marine debris and microplastics

All marine debris was collected in the 50-m transect area ranging from the shoreline to the upper beach limit (determined by the presence of vegetation, dunes, or rocks) within the 50-m transect. Sampling was performed according to the operational guidelines for rapid beach debris assessment described by Cheshire et al. (2009).

Marine debris was classified into three major groups: (1) recycled waste, (2) general waste and (3) hazardous waste. Recycled waste were composed of seven categories: (1) metal cans, (2) UHT milk carton, (3) plastic bottles, (4) beverage bottle (glass), (5) plastic bags, (6) bottle cap (plastic), (7) glass pieces. General waste was composed of six categories: (1) cigarette butts, (2) rope, (3) food wrappers, (4) straw/stirrers, (5) foam pieces, and (6) rubber pieces. Hazardous waste was composed of cigarette lighters.

HSHP Thailand Data Card

Happy Sea Happy People (HSHP), Walailak University, Trash Free Sea® Thailand

Ocean Conservancy

รายละเอียดพื้นที่เก็บข้อมูล (SITE INFORMATION):

พื้นที่เก็บข้อมูลชายฝั่ง (Location of Coastal Cleanup): _____ จำนวนผู้เข้าร่วม (# of participants): _____

ว/ด/ป (Date): _____ ระยะเวลา (Time): _____ นาที (min) น้ำหนักรวม (weight): _____ กก.(kg)

จำนวนถุงขยะ (# of trash bags filled): ____ ระยะทาง/พื้นที่ทำความสะอาด (Distance/Area Cleanup): _____ ม./ตร.ม. (m/m^2)

ขยะรีไซเคิล - Recycle Waste (จำนวนชิ้น) Total (pieces)

กระป๋องเครื่องดื่ม - Beverage Cans _____ = _____
กระป๋องโลหะ อื่นๆ - Other metal cans _____ = _____
กระสอบ - Sacks _____ = _____
ขวดน้ำดื่มพลาสติก - Beverage Bottles (Plastic) _____ = _____
ขวดพลาสติกอื่นๆ - Other Plastic Bottles _____ = _____
ขวดแก้ว - Beverage Bottles (Glass) _____ = _____
ถุงพลาสติก (ถุงหูหิ้ว) - Plastic Bags _____ = _____
ภาชนะบรรจุอาหาร (พลาสติก) - Cups, Plates (Plastic) _____ = _____
ฝาขวด (พลาสติก) - Bottle Caps (Plastic) _____ = _____
ฝาขวด (โลหะ) - Bottle Caps (Metal) _____ = _____
หลอดบรรจุภัณฑ์ - Packaging tube _____ = _____
เศษแก้ว - Glass Pieces _____ = _____
เศษพลาสติก - Plastic Pieces _____ = _____
อื่น ๆ (ระบุ) - Other (specified) _____ = _____
_____ = _____
_____ = _____

ขยะอันตราย - Hazardous waste (จำนวนชิ้น) Total (pieces)

กระป๋องสเปรย์ - Spray cans _____ = _____
ขวดยา/แผงยา - Medicine _____ = _____
เข็มฉีดยา/อุปกรณ์ - Syringes _____ = _____
ไฟแช็ก - Cigarette Lighters _____ = _____
หลอดไฟ/อุปกรณ์ - Light bulbs _____ = _____
ถ่านไฟฉาย/แบตแตอรี่ - Battery _____ = _____
ผ้าอ้อม - Diapers _____ = _____
อื่น ๆ (ระบุ) - Other (specified) _____ = _____
_____ = _____
_____ = _____

ขยะอินทรีย์ - Organic waste (จำนวนชิ้น) Total (pieces)

ไม้เสียบลูกชิ้น – Wooden sticks _____ = _____
อื่น ๆ (ระบุ) - Other specified _____ = _____
_____ = _____
_____ = _____

ขยะทั่วไป - General Waste (จำนวนชิ้น) Total (pieces)

ก้นกรองบุหรี่ - Cigarette Butts _____ = _____
กล่องนม UHT - UHT milk cartons _____ = _____
ของเล่น - Toys _____ = _____
ซองบุหรี่ - Tobacco Packaging/Wraps _____ = _____
ช้อน, ส้อม, มีด (พลาสติก) - Forks, Knives, Spoons (Plastic) = _____
เชือก - Rope _____ = _____
ถุงพลาสติกอื่นๆ - Food Wrappers (candy, chips, etc.) _____ = _____
ทุ่นลอย - Fishing Buoys, Pots & Traps _____ = _____
ภาชนะบรรจุอาหาร (กระดาษ) - Cups, Plates (Paper) _____ = _____
ภาชนะบรรจุอาหาร (โฟม) - Cups, Plates (Foam) _____ = _____
แปรงสีฟัน - Toothbrush _____ = _____
รองเท้า - Shoes _____ = _____
วัสดุก่อสร้าง - Construction Materials _____ = _____
หลอด/ที่คนเครื่องดื่ม - Straws, Stirrers _____ = _____
เศษเชือก - Rope Pieces _____ = _____
เศษโฟม - Foam Pieces _____ = _____
เศษยาง - Rubber Pieces _____ = _____
เสื้อผ้า/เครื่องประดับ/กระเป๋า - Clothings/Accessories/Bags = _____
แห/อวน - Fishing Net & Pieces _____ = _____
อื่น ๆ (ระบุ) - Other (specified) _____ = _____
_____ = _____
_____ = _____

คัดแยกขยะ 4 ประเภท (4 types of marine trash)		
ขยะ 4 ประเภท	น้ำหนักรวม (กก.) Total (kg)	%
ขยะทั่วไป - General waste		
ขยะรีไซเคิล - Recyclable waste		
ขยะอันตราย - Hazardous waste		
ขยะอินทรีย์ - Organic waste *		
น้ำหนักรวม - total weight		

หมายเหตุ - Note:

Fig. 4 HSHP Thailand Data Card for marine debris collection

Marine debris was counted. To analyze the microplastics in the sand, 1-cm deep layers of sand were required to take with a watch glass below the high tide line (Ng and Obbard, 2006). All sands were transferred into prepared bags and sealed properly. Photos were taken by the microscope equipped with a camera. The number of microplastics in sediment was counted by scanning for microplastics. Microplastics were extracted by the use of tweezers for the analysis of the types of microplastics by hand sorting (Fiber, granular, film and fragment) (Nuelle et al., 2014).

Fig. 5 Marine debris sorting and filling data on HSHP Thailand Data Card

a) sorting marine debris into each type , b) Visual presentation of mostly found marine debris items on each survey and c) to collect data in data collection form

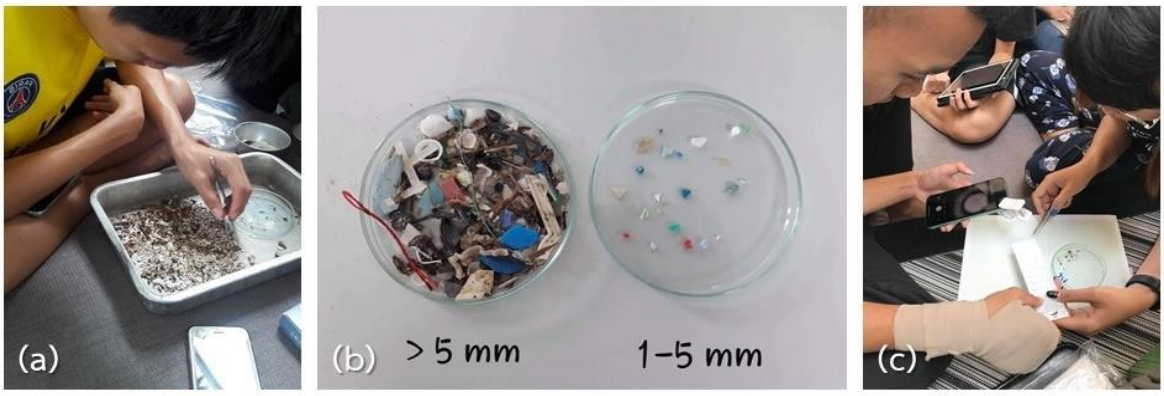

Fig. 6 Sorting of visible microplastic size 1-5 mm

Statistical analyses

Statistical analyses of % soil moisture, surface temperature, marine debris and microplastics data were performed using SPSS software. Marine debris quality and quantity (by count) was compared among beaches within 14 categories in three major groups.

Microplastic quantity was also compared among four categories (i.e. fiber, granular, film and fragment).

Results

General information in the site

- Exclude organic materials (ie. Leaves, shells, .. etc.)
- Which found to be 4 main types (fiber, granular, film and fragment)

Table 2. Soil surface temperature and soil moisture at three sites, Samui Island.

Study Site	Beach transect	Surface Temperature (℃)	Soil moisture (%)
Hua Thanon Beach	Lowest tide	32.10	21.36
	Center line	32.90	14.42
	Highest tide	35.40	4.38
	Mean	33.47	12.95
Lamai Beach	Lowest tide	29.80	9.65
	Center line	30.00	13.64
	Highest tide	28.40	2.67
	Mean	29.40	8.46
Chaweng Beach	Lowest tide	29.80	18.48
	Center line	29.80	15.21
	Highest tide	27.60	7.76
	Mean	29.07	13.64

Marine Debris at the study sites

Table 3. Physical parameters, marine debris and microplastics at three beaches at Samui Island, southern Thailand

Parameters	**Hua Thanon Beach** Mean±SD	**Lamai Beach** Mean±SD	**Chaweng Beach** Mean±SD	**Statistical Test**
Soil Moisture (%)	12.95	8.46	13.64	$F_{2,8} = 0.552$, ns
Surface Temperature (°C)	33.47	29.40	29.07	$F_{2,8} = 10.121$, $P = 0.012$

Parameters	Hua Thanon Beach Mean±SD	Lamai Beach Mean±SD	Chaweng Beach Mean±SD	Statistical Test
Marine Debris				
Recycled waste				$X^2_6 = 41.418$, $P < 0.001$
Metal cans	4	1	0	
UHT milk carton	2	4	0	
Plastic bottles	13	11	0	
Beverage bottle (glass)	8	1	0	
Plastic bags	29	0	0	
Bottle cap (plastic)	44	12	0	
Glass pieces	0	7	0	
General waste				$X^2_5 = 48.25$, $P < 0.001$
Cigarette butts	1	7	7	
Rope	171	12	15	
Food wrappers	0	21	9	
Straw, stirrers	0	3	5	
Foam pieces	30	76	0	
Rubber pieces	0	0	13	
Hazardous waste				-
Cigarette lighters	3	1	0	

- Foam beads (granular); polystyrene which are the most frequent found large microplastic size (1-5 mm) measurement using both ruler and a paper graph ; measurement was conducted on their longest dimension

Parameters	Hua Thanon Beach Mean±SD	Lamai Beach Mean±SD	Chaweng Beach Mean±SD	Statistical Test
Microplastics				
Fiber	0	1	0	
Granular	62	3	1	
Film	1	2	0	
Fragment	19	7	0	
Total	82	13	1	

Table 3. Microplastic types at three beaches with three replicates.

Study site	# Detected	Microplastic types #, (Mean size ± SD)				
		Fiber	Granule	Fragment	Film	Total
Hua Thanon Beach	73	0	55	17	1	73
Lamai Beach	11	1	3	7	0	11
Chaweng Beach	1	0	1	0	0	1

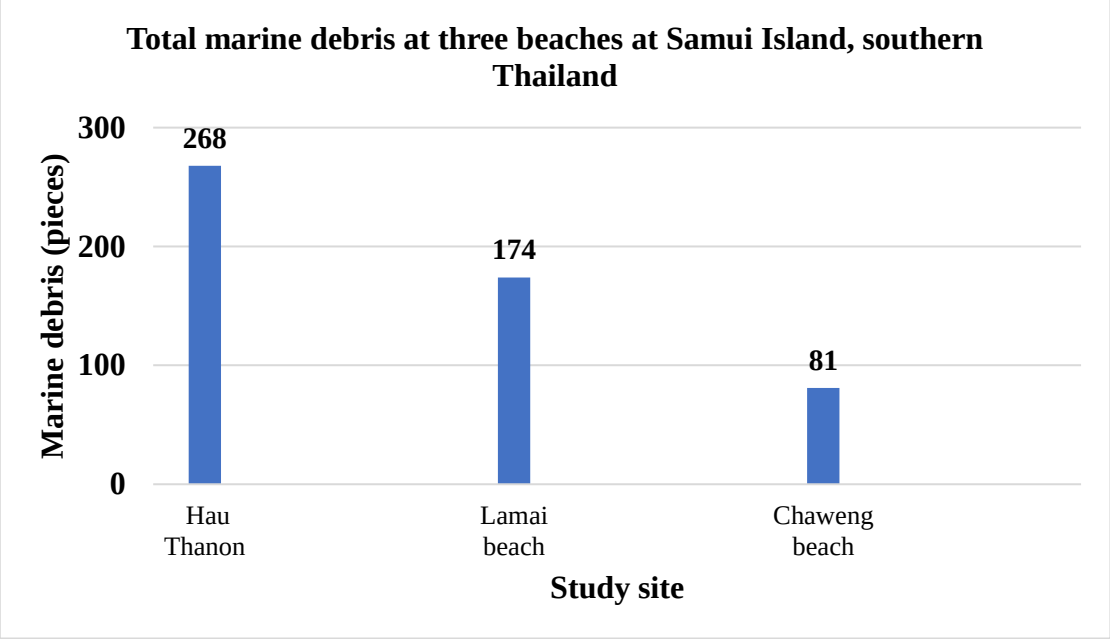

Figure5. Compare total marine debris between three beaches at Samui Island.

Hua Thanon beach is a place where recycled waste have been found the most among other beach. And 44 bottle caps have been discovered at this beach.However, at Chaweng beach contains no marine debris in which consider as one type of recycled waste. At the same time, a short range of rope, general waste has been found for 171 pieces at Hua Thanon beach and 76 small pieces of foam box have been detected at Chaweng beach. 82 pieces of micro-plastic has been discovered at Hua Thanon beach where a slight of it has been saw on Chaweng beach.

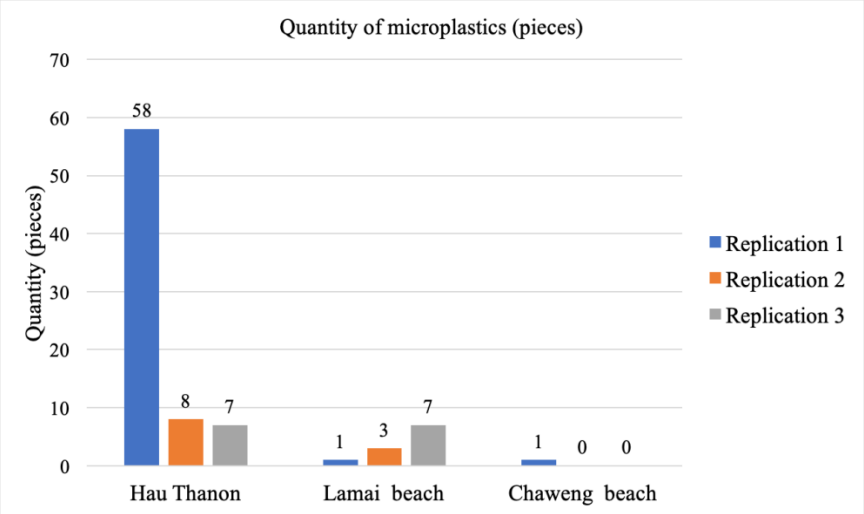

Figure3. Compare quantity of microplastic (pieces) between three beaches at Samui Island.

Surface temperature differed among sites (ONE-way ANOVA: $F_{2,8} = 10.121$, $P = 0.012$). Post-hoc test with Bonferoni adjustment. Hua Thanon Beach had highest surface temperature (Post-hoc test: $P < 0.05$). In addition, soil moisture did not differed among sites (ONE-way ANOVA: $F_{2,8} = 0.552$, ns)

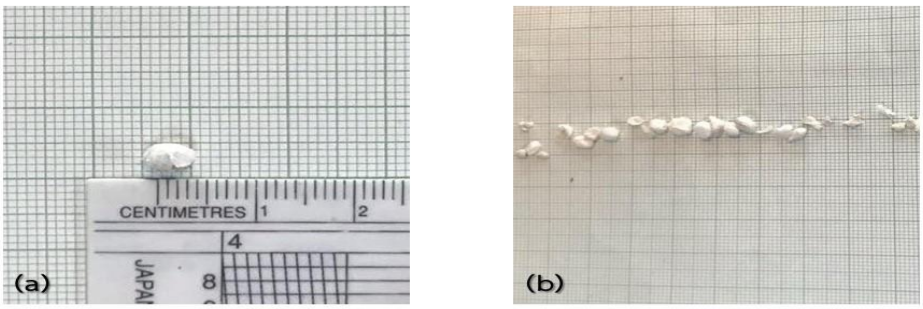

Fig. 6 Characteristics of most frequent found microplastic /… Sorting of visible microplastic size 1-5 mm

Beaches with microplastic contamination tested by Chi-square found differences in numbers of microplastic found among beaches ($P<0.000$)

Discussion

Clearly, marine microplastic size between 1-5 mm have been detected in this study showing the positive impact of the frequent cleaning up of the beach. This activity can help to reduce

both numbers of large marine debris (easily detected) and large size of microplastic (visible to normal eyes). It is, therefore, this can be used for further developing kind of citizen science proptocol which can help to conveniently routine survey and monitoring of the microplastic detection. It is, however, further investigation of microplastic under the size of 1 mm are highly recommended to confirm the existing of microplatic as normally reported using techniques employed by DMCR,Thailand research centre.

Microplastic is largely be a result of a decay process of a much larger size of plastic debris pollution which it is, therefore, worthwhile to remove the large size before the smaller but (much) bigger problems are waiting to be happen!

The results of this study the mean of the moisture in the sand, we may notice that the sand from the Chaweng beach has the most percentage of moisture. This can be analyzed into 2 ways,
1) Chaweng beach is in the lowest land level comparing to the others so the water wave can reach the sand easiest. Especially, in the night there's a sea breeze that makes the water wave become more up higher.
2) Chaweng beach has the lowest mean surface temperature, so the heat can't dry the sand up.
Hua Thanon beach has the most total Marine debris because it's nearby the local fishery village, so it's not a surprised for having the most rope, plastic pieces, plastic bags, bottle caps dropped down. Anyway, the interesting point from this obligation is that plastic fragment is most found in Lamai beach, we can interpret that maybe some breeze bring some foam could be from sea buoy to this beach and the foam split off into smaller pieces and distribute to everywhere on the beach.
The results suggest that, the amount of marine debris is inverse to the amount of tourists because the tourism point like Chaweng beach has the least amount of Marine debris. On the other hands, the local place like Hua Thanon is the one that has the most and the low tourist beach like Lamai beach is the second one. From this study we can guess that the place which has the most amount of tourist, it's sure that this place is going to get the most caring from every sector, but in the place that's local and inaccessible, it's hard to get cure and the right clean up way.

We recommend that a) a standard measures for microplastic assessment dealing with laboratory are needed to investigate smaller than 1 mm microplastic. b) Recommendation for beach marine debris segregation protocol are proposed in to utilize 1) organic waste for producing fresh fertilizer 2) selling recycle plastic items 3) manage harzadous waste in proper manner and, finally, 4) much less amount of general waste to throw away. These good practices can be observed at the Angthong Marine Natinal Parks where these kinds of practices are commonly done (personal communication).

We conclude good practice in tourism such as cleaningl beach regularly can help to reduce quantity of both marine debris and microplastic in beach environment.

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