การจำแนกชนิดของขยะพลาสติกหน้าดินบริเวณปากแม่น้ำระยอง

Characterization of Plastic Benthic Litter in Rayong River Mouth, Rayong Province, THAILAND

นภาพร เลียดประถม[1*], พงศธร ใจรัศมี[1], สุหทัย ไพรสานฑ์กุล[2], ธชณัฐ ภัทรสถาพรกุล[1], พิมพ์ทอง ทองนพคุณ[3]

Napaporn Leadprathom[1], Pongsathon Jairusamee[1], Suhatai Praisankul[2], Tachanat Bhatrasataponkul[1] and Pimthong Thongnopkun[3]

[1]คณะเทคโนโลยีทางทะเล มหาวิทยาลัยบูรพาวิทยาเขตจันทบุรี อ.ท่าใหม่ จ.จันทบุรี 22170

[2]กรมทรัพยากรทางทะเลและชายฝั่ง กรุงเทพ 10210

[3]คณะอัญมณี มหาวิทยาลัยบูรพาวิทยาเขตจันทบุรี อ.ท่าใหม่ จ.จันทบุรี 22170

[1]Faculty of Marine Technology, Burapha University, Chanthaburi Campus Ta-mai Chanthaburi 22170

[2]Department of Marine and Coastal Resources, Bangkok 10210

[3]Faculty of Gems, Burapha University, Chanthaburi Campus Ta-mai Chanthaburi 22170

*corresponding author: napapork@go.buu.ac.th

บทคัดย่อ

ขยะพลาสติกเป็นปัญหาสิ่งแวดล้อมที่สำคัญโดยเฉพาะในพื้นที่ทางทะเลและเอสทูรีที่มีรายงานว่าพลาสติกเป็นชนิดขยะที่พบมากที่สุด ดังนั้นในการศึกษาครั้งนี้จึงได้ทำการสำรวจขยะหน้าดินบริเวณปากแม่น้ำระยองซึ่งเก็บตัวอย่างโดยอวนลากทั้งในฤดูแล้งและฤดูฝน ในปีพ.ศ. 2554 ผลการศึกษาพบว่าในฤดูแล้งพบขยะเฉลี่ย 4.5±0.2 ชิ้นต่อ 100 ตรม. ซึ่ง 80.7% เป็นขยะพลาสติก ในขณะที่ฤดูแล้งพบขยะเฉลี่ย 9.0±4.8 ชิ้นต่อ 100 ตรม. และ 82.4% เป็นขยะพลาสติก โดยการจำแนกขยะพลาสติกตามการใช้งานพบขยะพลาสติกทั้งหมด 14 ชนิด ชนิดที่พบมากที่สุดคือชิ้นส่วนที่แตกหัก รองลงมาคือภาชนะใส่อาหารและถุงพลาสติกตามลำดับ จากการวิเคราะห์ชนิดของพลาสติกตามโครงสร้างทางเคมีพบพลาสติกทั้งหมด 13 ชนิด ชนิดที่พบมากที่สุดคือ โพลีโพรไพลีน 35% รองลงมาคือโพลีเอททีลีน 32% โพลีไวนิลคลอไรด์ 9%และ โพลีเอททีลีนเทเรพลาทาเลต 8% ตามลำดับ

คำสำคัญ: ขยะหน้าดิน; พลาสติก; FTIR; ปากแม่น้ำ; ระยอง; ประเทศไทย

Abstract

Plastic litter is an ongoing problem everywhere and reported as the predominant type of litter in marine and estuary environments in many surveys. Therefore benthic litter samples were collected in 2011 and examined from the Rayong River estuary in dry and rainy seasons by trawling. Average density of benthic litter in the dry season was 4.5±0.2 items/100 m^2 and 80.7% was plastic material. Whereas in the rainy season was 9.0±4.8 items/100 m^2 and 82.4% was plastic as well. Fourteen types of plastic litter was inspected according to usage category. The dominant type was plastic fragments followed by food packages and carry bags. Meanwhile, there were 13 types of plastic according to

chemical structures. The most dominant was Polypropylene (PP) (35%), followed by Polyethylene (PE) (32%), Polyvinylchloride (PVC) (9%), and Polyethylene terephthalate (8%).

Keywords: Benthic Litter; Plastic; FTIR; Estuary; Rayong; Thailand

Introduction

Marine litter is a global widespread pollution problem. Several studies indicated that plastic is the most common type of material in both beach-stranded litter and benthic litter (Guven *et al*., 2013; Koutsodendris *et al*., 2008; Morishige *et al*.; 2007; Santos *et al*.; 2003). Plastic litter generates adverse impacts on environments and ecosystems, such as gastro-intestinal blockage and entanglement of marine mammals and marine birds (Votier *et al*., 2011; Williams, *et al*. 2011). Meanwhile, the accumulation of benthic litter may affect the habitats of benthic biota. One reason that plastics are so harmful to ecosystems is releasing of toxic chemicals. Plastitizers that disrupt the endocrine systems of marine animals is one example. Moreover plastic litter can contaminate marine environments by accumulating other pollutants (e.g., DDT and PCBs) on their surface (Van *et al*., 2012). Different types of plastic present different degrees of pollutant adsorption. Therefore, type of plastic litter must be investigated to assess the risk of plastic waste to marine environment. Unfortunately, surveys of benthic litter in Thailand are very rare. In addition, beach-stranded litter is a definite problem, and plastic bags is the most commonly found litter on beaches (DMRC, 2013). Therefore, this preliminary study is a survey of marine benthic litter in Thailand's coastal areas. The selected site is the Rayong River mouth area, which affected by both urban and industrial waste. Some areas along Rayong River were designated as a pollution control zone in 2009. This study aimed to survey benthic litter in the river mouth in order to keep the aquatic ecosystem clean and healthy.

Materials and methods

Study area and sampling methods

The benthic litter sampling area is located at the mouth of the Rayong River (12°40′32″N and 101°16′42″E), Muang district of Rayong province, in the east of Thailand. Benthic litter was collected twice per season in the dry (April and May) and rainy (July and September) seasons in 2011 by the trawling method. The size of the bottom trawling net was 2x4x20 m and its mesh size was 2 cm. The sampling area covered 300x250 meters in the area. There were three hauls per sampling time.

All litter samples were cleaned and then counted and weighed on an analytical balance. Collected objects were categorized by material type, such as plastic, metal, and glass, and by using

purpose, such as bags, food containers, and fragments. Plastic benthic litter was separated and then further analyzed the infrared spectra by Fourier transform spectroscopy (FTIR).

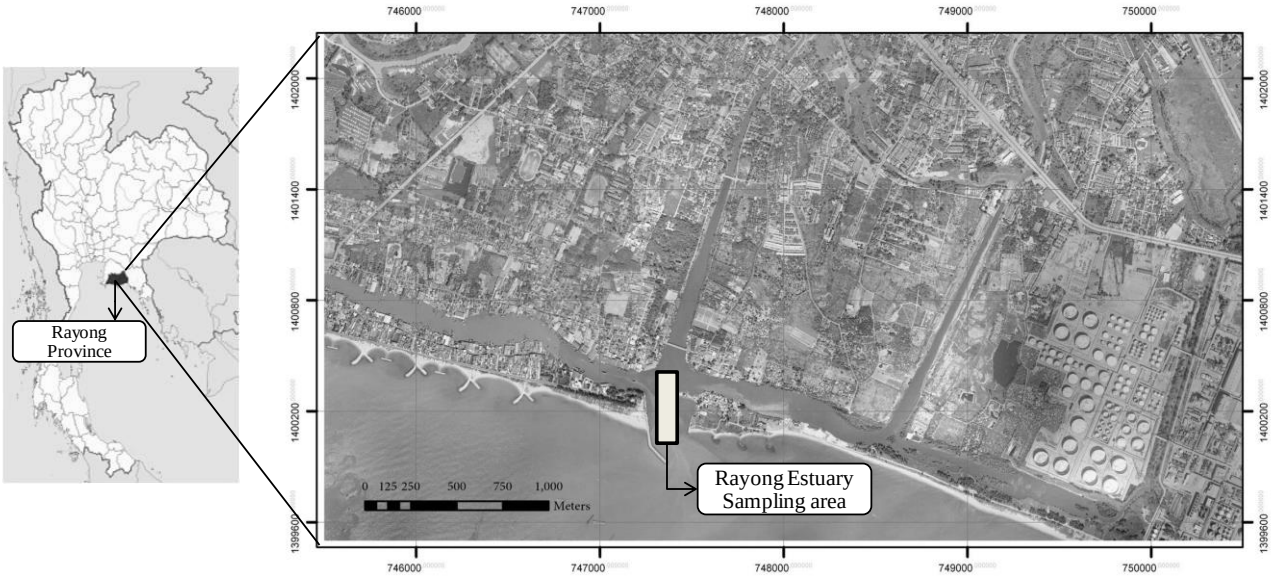

Figure 1 Benthic litter sampling area, Rayong Estuary, Thailand

Plastic characterization by FTIR

Plastic benthic litter samples were cleaned by washing in a sonicator ultrasonic cleaner with de-ionized water for 5 minutes and then air dried at room temperature. The infrared spectra measurements were performed by absorption-reflection technique using a Nicolet iN10 Infrared Microscope. Spectra were recorded in the mid infrared region with 64 scans at a resolution of 4 cm^{-1}.

Results and discussion

General information about benthic litter

A total of 962 items of benthic litter were reported in this study at Rayong Estuary by trawling. There was an average of 7.0±0.5 items/100 $m^2$and density of litter in the dry season (4.5 ±0.2 items/ 100 m^2) was higher than in the rainy season (9.5 ±2.0 items/100 m^2). In Thailand, the monsoon period is from May to October. Therefore, causing high runoff volume in that period and may influence litter loading into the river. (Hydrology and Water Management Center for Eastern Region, 2011).

Materials of litter

Nine types of litter material were categorized from the collected samples. The most common material was plastic litter (83.9%), followed by fabric (4.7%), wood (4.4%), paper (2.2%), metal (1.8%), rubber (0.8%), styrofoam (0.3%), ceramic (0.3%), and other (0.1%). Consistency with the

other studies, the most significant problem in all areas was plastic. The percentage of plastic litter in this study was higher than other studies (Table 1). Even the annual consumption of plastic in Thailand per capita (40 kg) was still lower than in many countries such as France (92 kg) and Japan (82 kg). However, the percentage of plastic litter which recycled was only 14% (PCD, 2011). Therefore there is no doubt that this study shows a high proportion of plastic litter. In addition the depth of area in this study is less than other studies (Table 1) meanwhile the density of litter was the highest. The topographic of the study area may cause the high accumulate of benthic litter at bottom of estuary

Table 1: Comparison of plastic litters in different region

Material / Location	Plastic	Metal	Glass	Paper	Other	Density (Item/km^2)	Depth (m)	Reference
Greece Coast	56	17	11	-	-	165	15-350	Koutsodendris *et al*. (2008)
Antalya Bay Turkey	81.1	2.2	73.9	-	Other 12.8%	115-2,762	200-800	Guven *et al*. (2001)
U.S. west coast	24.1	36.7	13.4	-	-	67	55-1280	Keller *et al* (2011)
Belgium coast	95	3.4	-	0.9	-	1,250-11,527	-	Canwenberg *et al*. (2013)
Northern Mediterranean	48	1	8	28	Other 12%	0-45,000	40-80	Sanchez *et al*. (2013)
Rayong Estuary Thailand	86.27	1.6	0.3	2	-	70,000	4-20	This study

Weight of Benthic Litter

Total weight litter from 12 hauls was 57 kg classifying, 7 kg from the dry season and 50 kg from the wet season. Wood benthic litter was 23 kg, followed by rubber 22.4 kg, plastic 5.8 kg, and metal 4.3 kg (Table 2). Similar to the abundance of litter items, the loading of litter in the wet season was tremendously higher than in the dry season. If focusing only on the plastic weight, was between 0.03-2100 g in range.

Table 2 Weight of Benthic Litter

Type of litter material	Total weight (kg)	Range of Weight (g)
Wood	23.0	0.91-2,700
Rubber	22.4	1.06-14,400
Plastic	5.8	0.03-2,100
Metal	4.3	0.53-4,000
Fabric	1.1	0.02-264
Paper	0.3	0.02-59
Glass and ceramic	0.2	7-147
Styrofoam	0.01	0.12-12
Other	0.2	1.3-86

Types of plastic benthic litter

There were 15 types of plastic litter analyzed by categories of use. The highest frequency litter was plastic fragments, followed by plastic bags and bottles. The sequencing of categories of use was similar in both the dry and wet seasons. The sources of litter were both marine (fishing nets and monofilament line) and land-based (food containers, bottle caps, and lids). However, most of the benthic litter may originated from land-based sources which indicate that the management of solid waste from the area near the river is not effective. This is similar to sources of marine litter from the Mediterranean Sea, where studies show that 80% of litter is from land-based sources (CUG, HELMEPA and MIO-ECSDE, 2007).

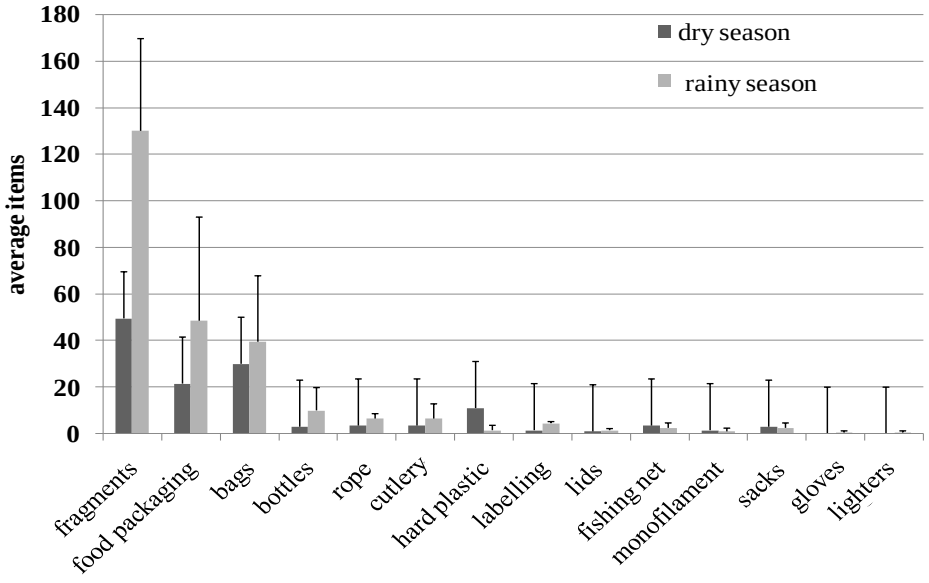

Figure 2 Type of benthic litter by categories of use

Spectra of plastic litter

There were 13 plastics according to spectra of litter. FTIR analysis of 804 plastic samples showed that 280 samples were polypropylene (PP), 269 samples were polyethylene (PE), 71 samples were polyvinyl chloride (PVC), and 66 samples were polyethylene terephthalate (PET). Spectra from polyethylene samples peaked around 2916, 2849, 1471, and 718 cm^{-1}, which are characteristic of this material (Figure 3). Polypropylene samples also produced characteristic peaks between 2723 and 2952 cm^{-1}. However, there were some highly degraded plastic litter samples (28 items) were not able to identify specific type of plastic by FTIR (table3).

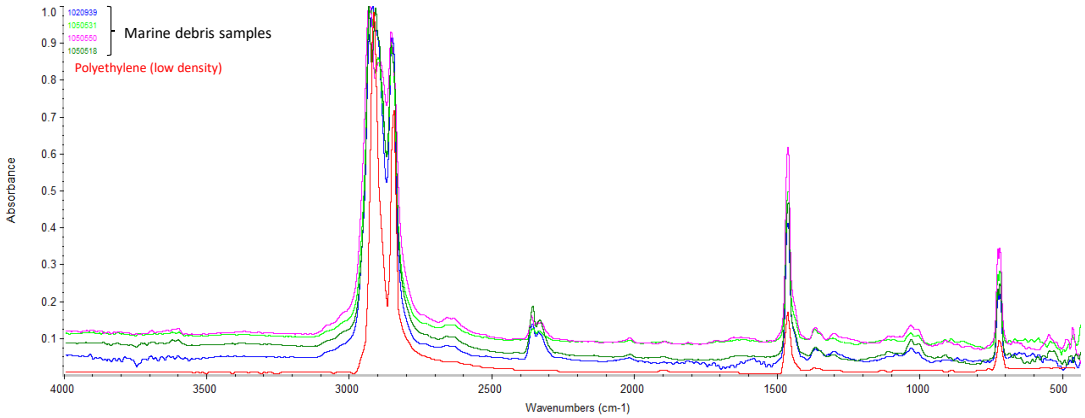

Figure 3: FTIR Spectra of PE benthic litter

Table 3 Classification of type and amount of plastic benthic litter

Type of plastic	Items	Percent
Polypropylene (PP)	280	34.8
Polyethylene (PE)	269	32.2
Polyvinyl chloride	75	9.3
Polyethylene terephthalate	70	8.7
Polystyrene	23	2.9
Poly butyl terephthalate	22	2.7
Ethylene/maleic	8	1.0
Polyvinyl stearate	9	1.1
Nylon	8	1.0
Poly methylphenylsiloxane	7	0.9
Poly acrylonitrile	6	0.7
Poly caprolactone	5	0.6
Poly methyl methacrylate	4	0.5
Unidentified	28	3.5

Based on FTIR analysis for characterize plastic debris type, polypropylene (PP) and polyethylene (PE) were the dominant plastic types (Claessens *et al*.; 2011; Moret Feguson, *et al*.; 2010). Since these two types of plastic are used to make several types of products that are used in daily life. Meanwhile the high polymer consumption in Thailand included PE, PP and PVC (PTIT, 2010) which consistent to the high plastic litter types in this study. Most of the plastics in this study were thermoplastics such as PP, PE, and PET, which can be recycled. Therefore waste minimization management, particularly in terms of recycling technology, including preventing flow of garbage with run off in rainy season, should be a major concern in this area.

Conclusion

This study was preliminary survey of benthic litter in an estuary in Thailand. Not surprisingly, the survey shows that plastic is the dominant litter material. Moreover the percentage of plastic presented higher than in other studies. Runoff is the factor that might account for high loading of litter in the rainy season. We suggest that benthic litter should be continuously monitored in other areas in Thailand. Solid waste management mitigation measures, particularly to address the increasing percentage of recyclable plastic litter, are urgently needed.

Acknowledgements

This research was supported by Department of Marine and Coastal Resources Thailand.

Reference

Claessens, M., Meester, S.D., Landuyt, L.V., Clerck, K.D., Janssen, C.R. 2011.Occurrence and distribution of microplastics in marine sediments along the Belgian coast. Marine Pollution Bulletin, (62) 2199–2204.

Cauwenberghe, L. V., Claessens, M., Vandegehuchte, M.B., Mees, J., Janssen, C.R. 2013. Assessment of marine debris on the Belgian Continental Shelf. Marine Pollution Bulletin, (73)161–169.

CLEAN UP GREECE, HELMEPA and MIO-ECSDE. 2007 Public awareness for the management of marine litter in the Mediterranean. Athens. p 9.

DMRC (Department of Marine and Coastal Resources Thailand). 2013. Database on beach debris in Thailand. [Online] Available from http://61.19.55.253/Thailandcoastalcleanup/datalist.php [2013, October 7] [in Thai]

Güven, O., Gülyavuz1, H., Deval, M.C. 2013. Benthic debris accumulation in Bathyal Grounds in the Antalya Bay, Eastern Mediterranean. Turkish Journal of Fisheries and Aquatic Sciences, (13)43-49.

Hydrology and Water Management Center for Eastern Region, 2011. Monthly runoff at Tubma Canal,Rayong Province. [Online] Available from http://water.rid.go.th/hydro6/mainframe.htm [2011, September 20] [in Thai]

Keller, A.A., Fruh, E.L., Johnson, M.M., Simon, V., McGourty, C. 2010. Distribution and abundance of anthropogenic marine debris along the shelf and slope of the US West Coast. Marine Pollution Bulletin, (60)692–700.

Koutsodendris, A., Papatheodorou, G., Kougiourouki, O., Georgiadis, M. 2008. Benthic marine litter in four Gulfs in Greece, Eastern Mediterranean; abundance, composition and source identification. Estuarine, Coastal and Shelf Science. (77)501-512.

Morét-Ferguson, S., Law, K.L., Proskurowski, G., Murphy, E.K., Peacock, E.E., Reddy, C.M. 2010. The size, mass, and composition of plastic debris in the western North Atlantic Ocean. Marine Pollution Bulletin, (60)1873–1878.

Morishige, C., Donohue, M.J., Flint, E., Swenson, C.; Woolaway, C. 2007. Factors affecting marine debris deposition at French Frigate Shoals, Northwestern Hawaiian Islands Marine National Monument, 1990–2006. Marine Pollution Bulletin. (54)1162–1169.

Petroleum Institute of Thailand. (PTIT). 2011. PTITS Petrochemical Product Classification 2011. [Online] Available from http://www.ptit.org/ptit_medias/arlcat_155db32f924ec30fee98a53e76a306e4.pdf [2012, December 2] [in Thai]

Pollution Control Department. (PCD). 2011. Summary of Pollution Situation in Thailand 2011. Bangkok: BTS Press. [in Thai]

Sanchez, P., Maso, M., Saez, R., Juan, S., Muntasas, A., Demestre, M. 2013. Baseline study of the distribution of marine debris on soft-bottom habitats associated with trawling grounds in the northern Mediterranean. Scientia Marina, (77)247-255.

Santos, I.R., Friedrich, A.C., Barretto, F.P. 2005. Overseas garbage pollution on beaches of northeast Brazil. Marine Pollution Bulletin. (50)778–786.

Votier, S.C., Archibald, K., Morgan, G., Morgan, L. 2011. The use of plastic debris as nesting material by a colonial seabird and associated entanglement mortality. Marine Pollution Bulletin. 62:168–172.

Williams, R., Ashe, E., O'Hara, P.D. 2011. Marine mammals and debris in coastal waters of British Columbia, Canada. Marine Pollution Bulletin. (62)1303–1316.

Van, A., Rochman, C.M., Flores, E.M., Hill, K.L., Vargas, E., Vargas, S.A., Hoh, E. 2012. Persistent organic pollutants in plastic marine debris found on beaches in San Diego, California. Chemosphere. (86)258–263.