Geo-Informatics evaluation of characteristics and amounts of microplastics contaminated in water surface level: Case of Songkhla Lake, THAILAND

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ABSTRACT

Plastic waste causing significant problems to the aquatic ecosystems, especially plastic scraps smaller than 5 millimeters that are formed by breaking or decomposing of large plastic waste, which called microplastics, which affect more toxic to aquatic organisms. Microplastics might come from different waste sources such as agriculture, aquaculture, domestic wastewater etc. Songkhla Lake Basin has been diversely utilized, either land use types or diverse ecosystems, which stand for cause and effect of microplastics contaminated in Songkhla lake. This study aimed to identify the characteristics and amounts of microplastics at water surface level in Songkhla lake and use Geo-Informatics techniques to evaluation. Water samples were collected from 17 stations located around Songkhla lake at the surface level once in June 2020. The average amount of microplastics at the water surface level in Songkhla lake was 6.0±3.6 pcs/L. Thale Noi area was higher contaminated level with 15.0±11.5 pcs/L, and lower contaminated level at the middle lake of Thale Luang area with 0.6±1.0 pcs/L. The major area of Songkla lake (506,029 Km^2) was contaminated with microplastics about 4.7-6.8 pcs/L. Whereas the highest contamination level (12.9-15.0 pcs/L) was covered only about 5,591 Km^2 in Thale Noi area. Fiber shape and black color particle were the most common characteristic of microplastic found in Songkhla lake.

Keywords: Microplastics, Songkhla lake, Water surface level, Geo-Informatics techniques.

1. INTRODUCTION

Plastic waste causing significant problems to the aquatic ecosystems, especially plastic scraps smaller than 5 millimeters that are formed by breaking or decomposing of large plastic waste (Browne *et al.*, 2007; Thompson *et al.*, 2004), which called microplastics, makes it easier for intake and toxic to aquatic organisms (Hall *et al.*, 2015; Teuten *et al.*, 2007). Microplastics may come from different waste sources such as agriculture, aquaculture, domestic wastewater etc. Songkhla Lake Basin is the only watershed in Thailand that has a lagoon system (Office of Natural Resources and Environmental Policy and Planning, 2014) which is diverse ecosystems consisting of freshwater lake (Thale Noi) at the upper north area, brackish water lake (Thale Luang) at the middle area and saltwater lake (Thale Sab Songkhla) at the lower south area. Therefore, majority land use in this area is diversified i.e., paddy field and moderate communities in the upper north area, paddy field and few communities in the middle area, paddy field and dense communities in the lower south area. This diversity of activities might cause microplastics contamination affecting the characteristics and amount of microplastics contaminated in Songkhla lake. To be able to effectively manage the problem of microplastic contamination in the Songkhla Lake, this study was therefore conducted to identify the characteristics and amounts of microplastics at water surface level in Songkhla lake.

2. METHODOLOGY

Water samples were collected from 17 stations located around Songkhla lake (Figure 1 and Table 1) at the surface level once in June 2020. Collected water samples were digested by Wet Peroxide Oxidation method (NOAA Marine Debris Program, 2015) then filled through GFC filter paper and oven dried at 30-60°C, after that microplastics remained were classified and counted under stereo microscope. The contamination level of microplastics were then evaluated through Inverse Distance Weighted (IDW) interpolation techniques (Burrough, 1986).

3. RESULTS

The average amount of microplastics at the water surface level in Songkhla lake was 6.0±3.6 pcs/L. Data was indicated in Table 1 showing that Thale Noi was the most contaminated area (11.6±4.7 pcs/L), which the highest contaminated level of 15.0±11.5 pcs/L was found at Khlong Yuan Station (SK8). Thale Luang was lower contaminated area (4.7±2.8 to 5.0±2.7 pcs/L), where Khlong Ruea station (SK15) in the middle lake area was lowest contaminated level of 0.6±1.0 pcs/L.

Table 1. Microplastics contaminated in water surface level of Songkhla Lake.

Lake Area	Sampling Station	Code	GPS Coordinates*	Amount of Microplastic (pcs/L)**
Thale Noi	Khlong Yuan	SK8	47N 0624920-858806	15.0±11.5
	Khlong Kwai Klang	SK9	47N 0623800-861619	8.3±5.6
			Average Amounts	11.6±4.7
Thale Luang:				
Upper Lake	Khlong Hone	SK5	47N 0645062-839823	4.3±0.5
	Khlong Rong	SK6	47N 0645451-850382	9.3±7.0
	Khlong Chiang Phong	SK7	47N 0643968-857088	5.7±1.9
	Klong Pak Pra	SK10	47N 0626445-854135	3.0±3.0
	Khlong Lampam	SK11	47N 0627412-842570	2.7±2.8
			Average Amounts	5.0±2.7
Middle Lake	Khlong Sanamchai	SK4	47N 0654218-834772	3.3±0.8
	Khlong Tha Maduea	SK12	47N 0632622-828961	6.3±5.5
	Khlong Mha Khobdang	SK13	47N 0635203-825559	7.9±0.8
	Pak Payoon	SK14	47N 0645922-814644	5.1±4.6
	Khlong Ruea	SK15	47N 0648097-824737	0.6±1.0
			Average Amounts	4.7±2.8
Thale Sab Songkhla	Koh Yor	SK1	47N 0668935-790331	3.1±2.0
	Khlong Sathing Mor	SK2	47N 0668222-798774	10.2±6.4
	Khlong Pak Ror	SK3	47N 0658994-801858	9.8±8.8
	Khlong Phumi	SK16	47N 0656522-794402	2.7±1.0
	Khlong U-Tapao	SK17	47N 0661819-790412	5.0±0.6
			Average Amounts	6.2±3.6
Average Amounts of Songkhla Lake				6.0±3.6

* UTM-a

** Mean±SD

The result from Inverse Distance Weighted (IDW) interpolation was showed in Figure 1. The major water surface area of Songkhla lake (506,029 Km^2) was contaminated with microplastics about 4.7-6.8 pcs/L followed by contamination levels of 2.7-4.7, 6.8-8.8, 0.6-2.7, 8.8-10.9 and 10.9-12.9 pcs/L which covered about 264,183, 155,235, 41,152, 31,552 and 5,109 Km^2 respectively. The highest contamination level (12.9-15.0 pcs/L) covered only 5,591 Km^2 in Thale Noi area.

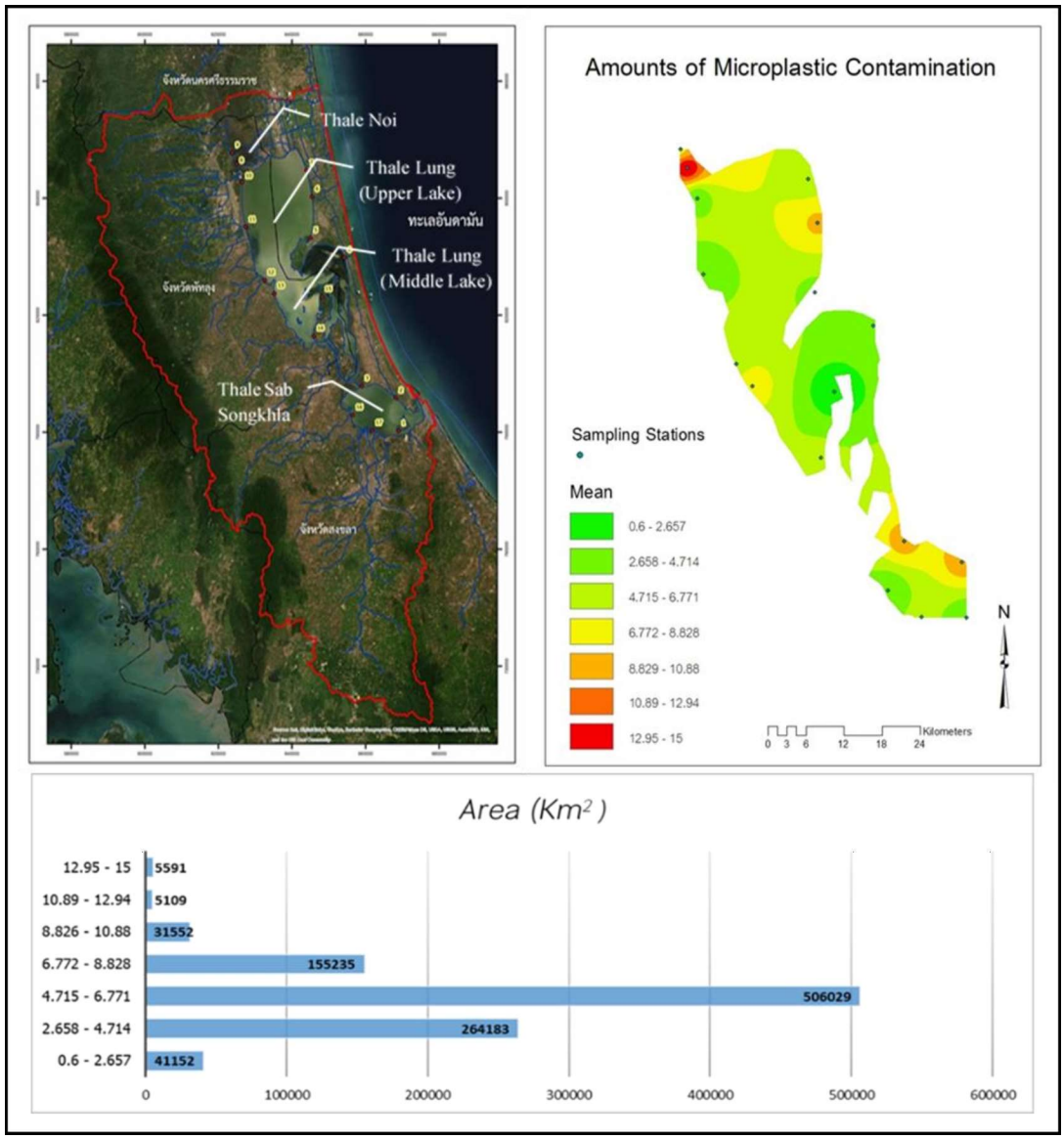
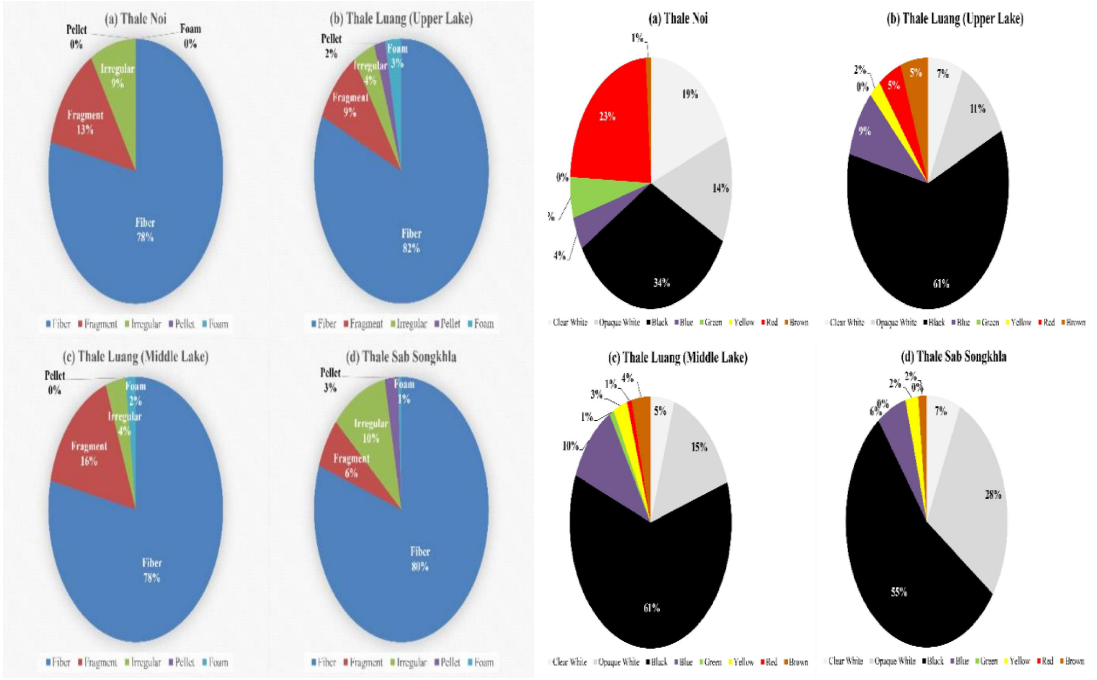


Figure 1. Contamination levels of microplastics in water surface level of Songkhla Lake.

As showed in Figure 2 (1), fiber shape was the most common characteristics of microplastic found in Songkhla lake (78%-82%). The highest amount of the fiber shape microplastic was found in upper lake of Thale Luang area, followed by fragment (6%-16%), irregular (4%-10%), foam (0%-3%) and pellet (0%-3%) respectively. Whereas the color of microplastics contaminated was showed in Figure 2 (2), Black color was the most common characteristic of microplastic found in Songkhla lake (34%-61%), which highest in upper and

middle lake of Thale Luang area, followed by opaque white (11%-28%), red (0%-23%), clear white (5%-19%), blue (4%-10%), brown (1%-5%), green (0%-5%) and yellow (0%-3%) respectively.



(1) Shape of microplastics contaminated (2) Color of microplastics contaminated

Figure 2. Characteristics of microplastics contaminated in water surface level.

4. DISCUSSION AND CONCLUSION

The average amounts of microplastics found at the water surface level in Songkhla lake was similar to the other water reservoirs located in urban area. The major source of contamination along and surrounding lake area was human activities as indicated in Lake Geneva, Switzerland (Faure *et al.*, 2012) and Three Gorges Reservoir, China (Di and Wang, 2018). The microplastic materials found in this study consisted of polystyrene, polypropylene, and polyethylene. However, where the main contaminated sources in Thale Sab Songkhla were municipal wastewater, industrial plant, farming, and ranch indicating high contamination level since these point sources contained dense of both primary and secondary microplastics (Su *et al.*, 2016). In addition, various watershed development projects, especially the closure of the route linking the Gulf of Thailand to prevent saltwater invading to Songkhla Lake (Office of Natural Resources and Environmental Policy and Planning, 2014).

As compared to the other lake area, Thale Noi which the smallest water reservoir in Songkhla lake, was the highest contaminated area. These might cause by the morphology of the reservoir since Thale Noi had shallow water depth and dense of aquatic plants distributing along the shoreline. Moreover, most of domestic wastewater without any treatment processes was directly discharged into Thale Noi with only two small outlet canals connect to Thale Lung area would make this reservoir as the basin of microplastics. The contamination level would rapidly increase as occurred in the Dutch river delta and Amsterdam canals which contained more than 40 pcs/L (Leslie *et al.*, 2017), makes it more toxic to aquatic organisms (Hall *et al.*, 2015; Teuten *et al.*, 2007) in case of no actions to prevent and reduce growth of aquatic plant,

and remove the organic rich sediment. The evidence from previous study in running and deep water showed lower microplastic contamination level (Lechner *et al.*, 2014). This indicated that water dept and flow could lower the contaminated load of microplastics.

In freshwater studies to date, microplastic particle counts ranged from around 0 to 1000 particles/L. Thus, contamination levels in water surface level of Songkha lake were in the average ranged. Most of Songkla lake water surface area of 998,151 Km^2 contained less than 10.0 pcs/L microplastic particle. The rest of 10,700 Km^2 water surface area contained more than 10.0 pcs/L microplastic particle. The contaminated level reported in this study could not directly compare to the other studies i.e., Laurentian Great Lakes, USA (Eriksen *et al.*, 2013), Hovsgol Lake, Mongolia (Free *et al.*, 2014), urban surface waters of Wuhan, China (Wang *et al.*, 2017), and Lake Winnipeg, Canada (Anderson *et al.*, 2017). However, this might be the prospective point of view for Local Administrative office which located along and surrounding Songkhla lake area to create microplastics management plans to avoid the same problems occurred in other water reservoir. In particular, the toxic of chemical adhesive on microplastics such as heavy metals such as iron (Fe), manganese (Mn), aluminium (Al), lead (Pb), copper (Cu), silver (Ag), zinc (Zn) and hydrophobic organic contaminants (HOCs) such as polyaromatic hydrocarbons (PAHs), organochlorine pesticides (OCPs) and polychlorinated biphenyls (PCBs) could be bioaccumulated through trophic levels (Verla *et al.*, 2019).

The shape of microplastics found tended to similar in each area of Songkhla lake, with fiber type being the most common microplastics shape. The types of fibers found might came from human activities included clothing scraps, fishing gears and aquaculture facilities mainly made up of fibers or ropes such as gill nets, cast nets, traps, cages, ropes, etc. Whereas the fragment and irregular shape might cause by large plastic dumping waste such as plastic bottles, plastic bags, bottle caps waste, etc. that breaks into a small plastic then floats along the canals finally sink into the lake (Mason *et al.*, 2016; Talvitie *et al.*, 2015). The most common colors of microplastics found in the Songkhla Lake area were black, blue, and opaque white respectively. These related to the colors of plastic waste from human activities i.e., clothing scraps, fishing gears, and aquaculture facilities. Particularly, the black-blue-colored waste from plastics commonly used to made ropes, such as nylon or fiber.

It could be concluded that Thale Noi area has the highest amount of microplastics contaminated in water surface level (11.6±4.7 pcs/L) because it received wastewater from many sources, mainly domestic wastewater, farming, and ranch. The most common characteristics of microplastics found were fiber shape, especially in upper lake of Thale Luang area (82%). The found fibers were probably from pieces of clothing scraps, fishing gears, and aquaculture facilities, whereas black was the most common microplastic color found, particularly in Thale Luang area (61%).

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