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Determination of Microplastics in Soil and Leachate from the Landfills

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Abstract

Microplastics (MPs) from soil and leachate at the landfill sites located around the gulf of Thailand were determined. The 12 soil samples and 10 leachates from the landfills were collected and were analyzed by using the density separation technique. The average of MPs from soil samples and leachates were 1457.99±489.71 Items/1Kg.dryweight and 20.90±4.96 Items/1Kg.dryweight, respectively. There are 5 specific plastic shapes, including fibers, films, sphere, granules and irregular were determined from the microplastics. Resulting from Fourier Transform Infrared Spectroscopy (FTIR) analysis is indicated that 3 main types of microplastics from the landfill are Polyethylene (PE), Polypropylene (PP), and Polyethylene Terephthalate (PET). This was confirmed by the types of plastic wastes found in the landfills. As a result, microplastics can occur in the landfill whether the age of the landfills is still young. This research could be concluded that the landfills were one of the main sources for releasing microplastics to the environment. The further study, the degradation rate and the other routes of plastics that may cause microplastics contaminated in the environment will be studied.

Keywords : plastic wastes; microplastics; soil and leachate; landfills; water source; FTIR

Introduction

Plastics are the synthetic materials that being used since 1900. From 1950 to 2012, the amount of plastics produced were rapidly increased from 1.7 to 288 million tons. According to the growth trend, the amount of plastics in 2020 will be 540 million tons [1]. As a result of plastics increasing, an environmental impact has widely grown up as well. However, plastics take more than 100 years to be decomposed. Therefore, it is possible that a lot of plastic waste remaining for the disposal [2]. In Thailand, 16.83% of waste is plastic and most of them are single-use plastics. Only 79% of single-use plastics correctly disposed of in the landfills. The remaining was leaked to the environment. Also, the illegal landfills can cause plastic leaking to the environment.

The route of plastic leaking starts from land to a canal or a river and then ends up in the ocean [3]. After long exposure to the sun, plastics in the ocean break into very small pieces. These small pieces are called "Microplastics (MPs)", which the sizes are less than 5 mm [4]. Most MPs can be found in the ocean because the surface is exposed to the sun [5]. According to the reports, MPs were found in both soil and water zones, for example; beach, river, canal, lake, and the sea [6]. Moreover, MPs were also found in water, from Waste Water Treatment Plants (WWTPS) around 1-7 pieces [7]. As reported by the study, one plastic bottle of water can break into 10,000 pieces of MPs [8]. According to the above mentioned, it leads to future problems about the huge amounts of MPs in the environment.

Nowadays, MPs problem affects ecosystems in Thailand. In 2016, there were 355 of sea animals founded dead in the Gulf of Thailand e.g. whale, dolphin, manatee, and sea turtle. The investing report revealed that all of them had pieces of plastics in their digestive system which caused the death. In addition, MPs waste was found on beaches, soil sediments, and mussels at Chao Lao and Kung Wiman Beaches, Chanthaburi province. The discovery of MPs waste in the environment conforms with many studies worldwide [9].

The sustainable solution for reduction of MPs should be controlled at the source. In the previous studies, MPs sources from some sources such as sea water and soil sediments from the Gulf of Thailand were already studied. However, the MPs from the landfill sites has not been determined yet. In this study the landfill sites are focused to determine MPs from the waste problems which may affect the ecosystems and the environments.

Materials and Methods

Sampling Methods

The samples were collected from 12 landfill sites. Leachate and soil samples were collected at 10 locations in each landfill site. For leachate, the samples were collected by taking from a leachate pond. In addition, soil samples were collected by using hand auger with the depth of 10-20 cm. Then, all samples were stored at the 4 Degree Celsius refrigerator.

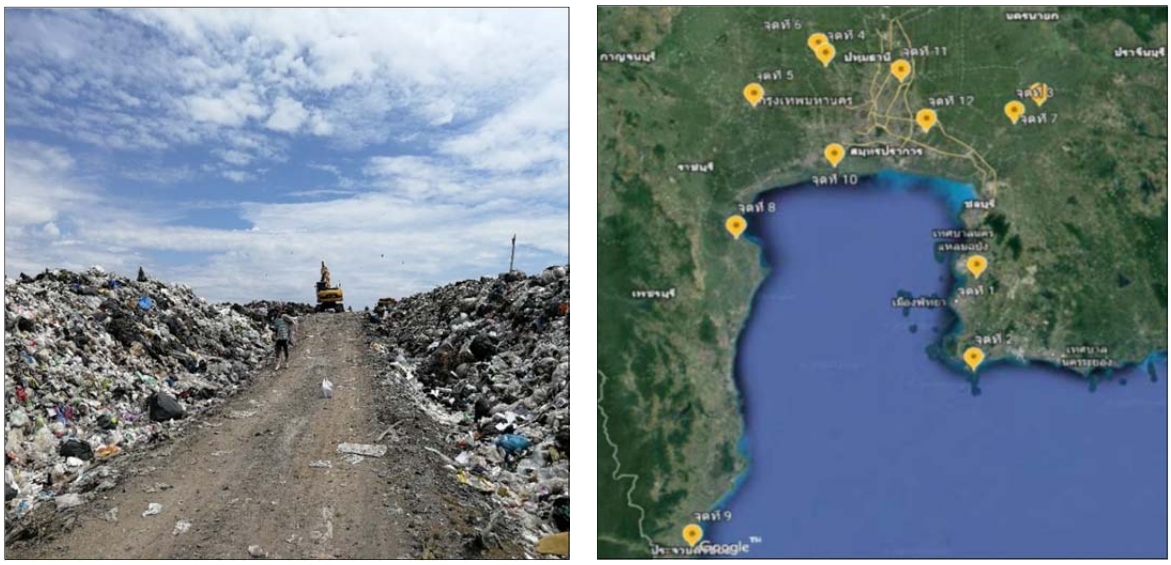

Figure 1 The landfill areas that all samples were collected

Analysis of microplastics from the samples

In this study, MPs were identified by using density separation technique [10], which was adopted from National Oceanic and Atmospheric Administration; NOAA method [11]. The first step, a stainless-steel mesh sieves no.50 (330 μm) was used to separate sample. The second step, the separated sample was added into a beaker and then baked at 90 degree Celsius for 24 hours. For the landfill soil samples, in the first step the samples were mixed with ZnCl, waited for a moment, scooped the top layer for the sample, and then followed the second step. The third step, the organic compounds in sample was removed by the addition of the mixture solution of 0.05M Fe^{2+} and hydrogen peroxide (30%). A chemical reaction was activated by increasing the ambient temperature to 75 degree Celsius for 5 minutes. As the white foam appeared, temperature was reduced until the foam was disappeared. The fourth step, the sample was heated repeatedly at 75 degree Celsius for 30 minutes. The fifth step, NaCl was added with the ratio of 3 grams of NaCl per 20 milliliters of sample. The last step, sample was transferred from a beaker to a glass funnel and left for 24 hours. Then, the MPs were floating on top of the surface.

Figure 2 Determination of microplastics from soil and leachate samples

Data analysis of microplastics

A Fourier Transform Infrared Spectroscopy (FTIR) model Alpha-E (Bruker) is used to identify the types of plastics waste [12]. The MPs images are analyzed by using a stereoscopic microscope. Variances of microplastic abundances are analyzed by one-way ANOVA (p-value < 0.05).

Results and Discussion

For the determination of microplastics from soil and leachate from the landfills, it was found that there are amount of microplastics contamination. The amount of microplastics from landfill soils were around 686.45-2278.44 Items/1Kg.dryweight with the average number of microplastics at 1457.99±489.71 Items/1Kg.dryweight ($p<0.05$. In addition, the amount of microplastics from landfill leachates were around 13.50-27.50 Items/1Kg.dryweight with the average number of microplastics was 20.90±4.96 Items/1Kg.dryweight. Compared to the reports of microplastic contamination in the soil from China such as North Yellow Sea and The Gorges Reservoir, it was found that the average values of microplastic were 37.10±42.70 Items/1Kg.dryweight and 82.00±60.00 Items/1Kg.wetweight, respectively [13-14]. In addition, there were reports from the other continents such as the North Tunisian from Mediterranean Sea showed that an average value of microplastics was 316.03±123.74 Items/1Kg.wetweight [15]. Anyway, it was found that the MPs found in this study is higher than the other studies. This may be indicated that the landfill sites in Thailand might contain the amount of plastic waste than from the other countries. Also, all samples are directly collected from landfills, which plastic waste is remained for such a long time and possible rapidly transformed to MPs. MPs adsorbed into landfill's soil and then solute to leachate pond. From 12 landfills, only 1 landfill is a sanitary-landfills the remaining are open dumping, which can cause plastic waste leaking to the environment. The quantity of microplastics from landfill's leachate and landfill's soil are shown in Table 1.

Table 1 The quantity of microplastics from landfills

Landfills	Leachate (items/1kg-Dry Weight)	Soil (items/1kg-Dry Weight)
Takhian Tia	27.00	1112.25
Samae San	18.00	1076.39
Chachoengsao	26.00	1703.92
Sai Noi	18.50	1495.42
Nakornpathom	22.50	2278.44
Bang Khla	18.50	1180.1
Ban Lam	13.50	686.45
Prachuap Khiri Khan	15.00	898.86
Pan Thai Nor Ra Sing	27.50	1445.8
Nong Prue	22.50	1617.78
Sai Mai	-	1860.87
Nonthaburi	-	2139.65

Characteristics of microplastics were classified into 5 shapes including; films, fibers, spheres, granules and irregular. As a result of this study, we found microplastics shapes from 12 sampling points of landfills' soil which were 396.33±148.26, 262.94±107.35, 16.47±13.72, 464.00±255.52, 318.26±149.35 Items/1Kg.dryweight respectively. In order of most to least, we found; granules 32%, films 27%, irregulars 22%, fibers 18% and spheres 1%. Next result of leachate, we found microplastics shapes from 10 sampling points of landfill's leachate which were 5.85±2.59, 3.55±1.62, 0, 9.80±1.86, 1.70±1.14 Items/1Kg.dryweight respectively. Ranking of microplastics shapes were granules 47%, films 28%, fibers 17%, irregular 8% and spheres 0%. All of microplastics are smaller than 5 mm, from plastic waste break into pieces [16]. Shape of MPs can be traced from plastic goods. For example; films are from plastic bags and others plastic packages. They are thin and transparent so it easily breaks when exposed to the sun. Granules, spheres, and irregulars are from plastic containers e.g. a bottle of water, food storage container and beads. Fibers shapes are from synthetic fibers e.g. fibers from washing clothes and sewage from textile industry [17]. These plastics wastes were small and very light weight, which were easy to disperse into the environment. The sample shape of microplastics is shown in Figure 3.

The researcher sent the microplastics samples to be examined by using FTIR at the Department of Materials Engineering, Kasetsart University. The results showed that the microplastics obtained from landfill's soil and landfill's leachate samples, which have 3 type of plastic component: PE, PP and PET. By specifying the type of plastic will use the graphs obtained from the analysis of microplastics samples. To compare with the standard graphs of 3 types plastics, that are consistent. Makes it possible to specify what kind of plastics are there in the microplastics samples. The sample graph from landfills' soil sample is shown in Figure 4.

Figure 3 The samples of microplastics from experiment

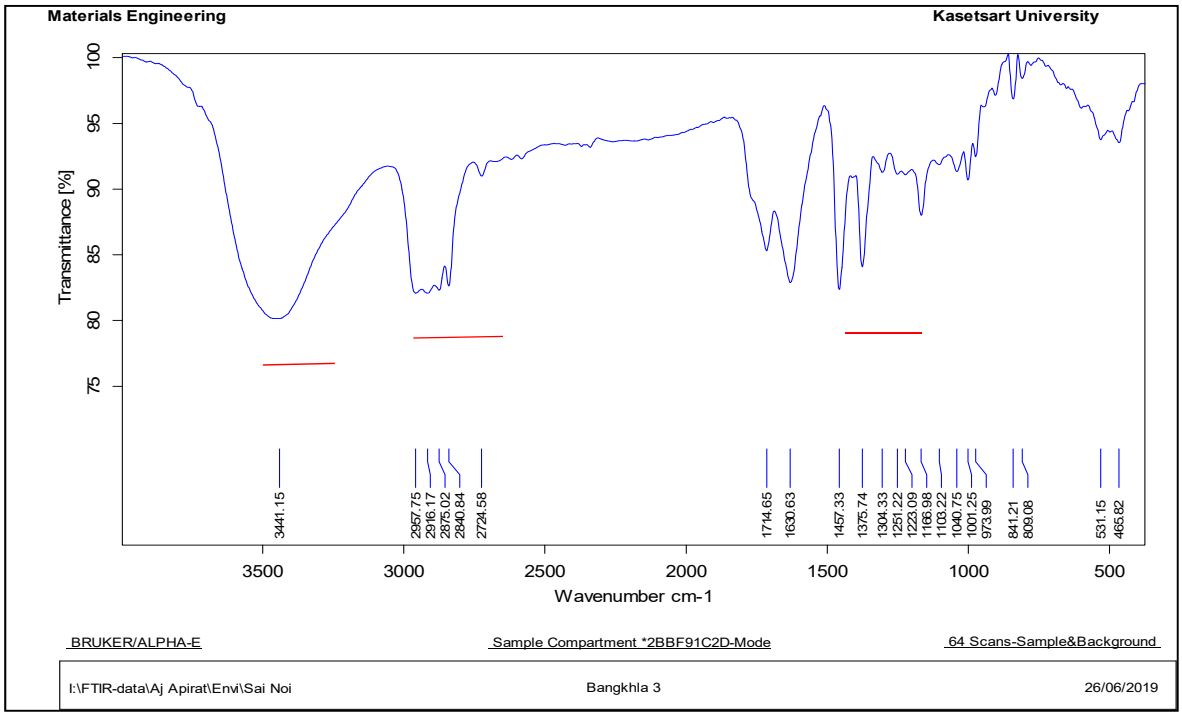

Figure 4 The example of microplastic analysis graphs by using the FTIR

From the sample graph data of landfills' soil analyzed with FTIR, we found 3 peak points with the red line. This data will be used including values between peaks point, to be compared with the standard graphs of all 3 type plastics as described. The result of this sample graph can be identified as PE, PP and PET plastics in the landfill's soil sample. If the values in the graph being analyzed did not correspond to the standard graph Indicating, which may be of the other materials. Since soil and leachate samples were likely to have a variety of materials mixed in as well.

Conclusion

The average MPs amount from soil and leachate samples in the landfills were 1457.99±489.71 Items/1Kg.dryweight and 20.90±4.96 Items/1Kg.dryweight, respectively. This MPs in the landfill soil are very high. The study revealed that 5 shapes of MPs in the landfill are granules, films, irregulars, fibers, and spheres. Percentages of shapes in the samples were as following; landfills' soil, granules 32%, films 27%, irregulars 22%, fibers 18%, and spheres 1%. In leachate, the percentage of the shapes are granules 47%, films 28%, fibers 17%, irregulars 8%, and sphere 0%. Furthermore, 3 plastic components were identified in the samples including PE, PP, and PET which related to the types of plastic wastes found in the landfills. This leads to strong conclusion that microplastics are from the plastic wastes in landfills. On the other hand, landfills are one of the sources for microplastics possibly leaked to the environment. In the future study, an approach solution to control plastics waste from the landfills should be mentioned. The sustainable control of plastic wastes should be cooperated between industrial sectors, where plastics are manufactured, and the consumer in which the plastics waste are produced and ended up into the landfills.

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