Preliminary Examination on isolation of Microplastics (MPs) in Sewage Sludge from the Local Wastewater Treatment Plant

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Abstract*: The outfalls from wastewater treatment plant has become a major receptor for the release of large quantity of microplastics (MPs) in the environment. To investigate such premise, the present work investigates the preliminary study on detecting and isolating the microplastics present in the sewage sludges, which extensively used as a fertilizer. Especially, the sludge-based MPs are greatly found in India and Southeast Asian countries. The average concentration MPs found in the sludge was found to be 31x103 particles per kg of dry sludge. In order to evaluate the performance of the methods used, spike study was tested using Polystyrene, polyethylene terephthalate and polyethylene materials. These outcomes confirmed that sewage sludge disposal is one of the main sources of microplastic pollution in the ecosystem.

Keywords*: Microplastics, Sewage sludges, Isolation, Quantification, Distribution.

I. INTRODUCTION

Globally, the production of plastics is being increased due to its wide range of applications. Currently, the particles which are in micro sizes are increasing its attraction towards researchers because of its adverse effects in the environment [1–3]. Microplastics (MPs) are the plastic debris whose size is less 5mm which it categorized into primary and secondary microplastics. Primary are the one which origin in micro sizes like scrubs, cosmetic products etc, whereas secondary are the debris which is fragmented from the larger particles due to wind, sunlight, water etc [4,5]. When it is ingested directly or indirectly by the living being results to disrupting endocrine systems, intestinal blockages and highly carcinogenic. These particles also attract the toxic elements like metals, Bisphenol A, pesticides and other contaminants. The chemicals which are accumulated on its surface starts to leach in the intestine of living being which impact the health [6,7]. Recently, it was noticed that wastewater treatment plant (WWTPs) was also the main source of microplastics produced in the environment. The microbeads which used in the cosmetics, detergents and other products are transported to the treatment plant. Owing to its smaller size, it might bypass in all treatment process and escape to the environment [8,9]. The vast number of microplastics in the wastewater reminds in sewage sludge. Around 80% of the produced sludge was being used as a fertilizer in the agricultural sectors. In order to avoid it in food chain it is highly essential to separate them before entering into the environment. In this research work, preliminary study was carried out in order to isolate and separate the microplastics from the sewage sludge which was collected from the local sewage treatment plant.

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II. EXPERIMENTAL APPROACH

2.1 Sample collection

The sewage sludge sample was collected from the Wastewater Treatment Plant (WWTP) located at Vellore, Tamilnadu, India. The dried sludge samples before the primary treatment and after the tertiary treatment was collected and stored at room temperature. Sea water was collected from the Marina Beach Chennai. Hydrogen peroxide (H2O2 30%) was purchased from the Nice Chemicals, Pvt. India.

2.2. Extraction of microplastics from sewage sludge

In order to isolate the microplastics from the sludge samples, the sludge samples were pre-treated by placing them in hot air oven at 80°C for one day. 40grams of dried sludge was taken in the 1000mL beaker with 600mL of sea water. The mixture was allowed to stir in the jar apparatus for 30minutes and kept undisturbed to settle down the particles for 2 hours. Later the supernatant was filtered using 41µm pore diameter filter paper. Triplicate set of extraction experiments was carried out to collect all the extracts from the sludge particles. The filter paper was washed for several times to remove the presence of any salt residues. The remaining sludge particles was treated with 80mL of H2O2 solution and 1mL of 0.1N of H2O2 solution. So as to remove the organic particles present in the sludge, the above mixture was heated up at 80℃ until the floc settles down. After cooling down the mixture was again treated with copious amount sea water and filtrated to obtain the microplastics present in the sludges.

2.3. Identification of microplastics in samples

The presence of microplastics in each extract was identified using the trinocular research microscope (OLYMPUS CH20i, India) equipped with Canon EOS 1500D digital camera. All the MPs was carefully removed using microforceps from the filters under the stereomicroscope. The removed particles were cleaned with water to remove the organic matters stick on the surface. The concentration of microplastics present in the samples are given as number of MPs kg-1 of dry sludge samples.

2.4. Spiking and retrieval study

The spike study was performed to evaluate the quality on separation of microplastics. The clean sludge samples are taken as a control samples and tested for this extraction. Polyethylene (PE), Polypropylene (PP), Polyethylene terephthalate (PET) and Polystyrene (PS) particles whose size less than 5mm was used to spike in the clean sludge samples. 80 polymers of each type were spiked for 20min with 40g of clean sludge samples. Aluminium foil sheets were used to cover the set of samples to avoid any other contaminants. Using the above discussed method, the quantity of particles was quantified from the clean sludge and efficiency in separation was identified.

III. RESULTS AND DISSCUSION

Due to wide range of applications, these sludge sample should to treated before leaving into the environment. Currently in India, 81% of samples were used for various application mainly to compost with an average use of 43%. After the pre-treatment process, these samples were allowed to settle down to quantify the number of MPs present in the sample. The average number of MPs in treated sludge samples was found to be 31x103 particles per kg of sludge. This might be due to the MPs which retained in sludges as they are enriched in the wastewaters. Similar research found with the average size of 0.3 to 24x103 particles per kg of sludge sample in Europe and United States [10,11]

It was observed that the MPs present in the dried sludge was found in various colours which include White (53.4%), Black (32%), Green (6.6%), Blue (4.2), Red (2.3), Orange (0.2%) and others (1.3%). In the meantime, fibres were found to be maximum portion of MPs with 53%, followed by flakes (16.5%), films (17%), shafts (10.5%) and spheres (3%). White colour and fibres are found to the predominantly found in the sludge samples as shown in Figure. 1(a & b). Similar results was found by Li et al (2018), where fibres and white colour MPs was found abundantly in sewage sludge samples found in China [12]. In addition, Talvitie et al (2015) also projected the similar results as majority of MPs are found in fibers and white in colour [13].

(a) **(b)**

Figure 1. The average percentage of MPs based on (a) Colours (b) Types of Plastics

The discharge of fibers by washing clothes could be one of main reason for the contamination in the sludges while flakes relates the breakage of plastic debris which usually ends in the sludges. These may be considered as the main source and origin of MPs in the waste sludge. It was also observed that the MPs found in the sewage sludge mainly composed of polystyrene (PS), fibers, polyethylene terephthalate (PET), polyamides (PA), nylons, polypropylene (PP) and other type of materials. The efficiency in removing the low-density materials like PP, PS was found to be higher than the high-density materials (PET) using sea water.

The morphology of retrieved MPs from the sewage sludge samples are shown in Figure 2. It was that the percentage of fibers are more than the other materials. In addition, the surface of the debris was also disturbed due to collision and abrasion effect which happened due to the processes taken place in the wastewater treatment plant.From the spike study, it was observed that that the separation efficiency was found to be high in case of PP and it follows in the order of PP > PS > PE > PET and as shown in Figure 3. Since, the density of sea water (1029kg/m3) is higher than the density of water (997kg/m3) some materials like PE floats which is easy for its removal.

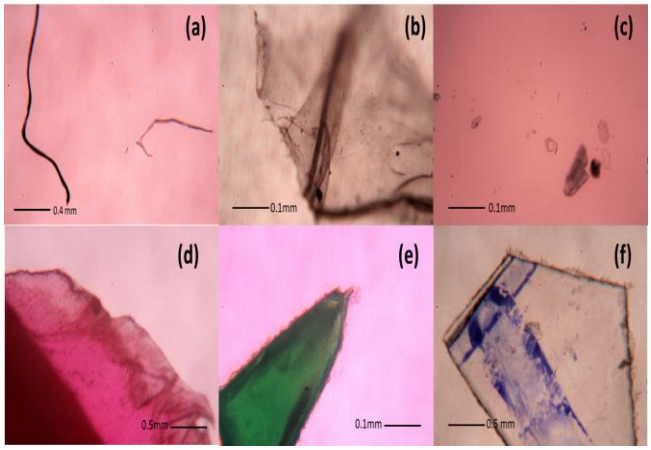

Figure 2. Microscopic Images of MPs extracted from the samples

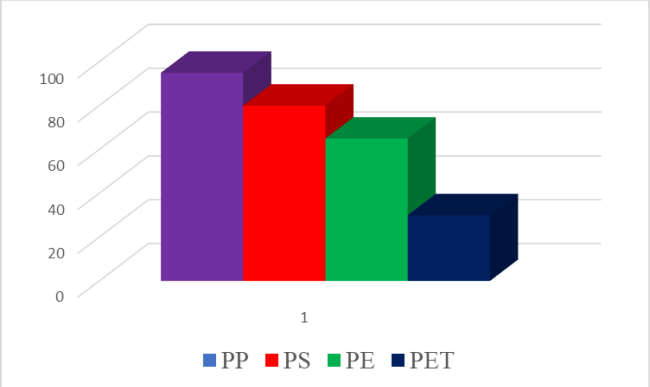

Figure 3. Retrieval percentage of MPs in spike study

IV. CONCLUSION

In this present research work, preliminary work was carried out to isolate and quantify the amount of microplastics released in the wastewater treatment plant. From this study, it was noted that average particles present in the sludge exceed than in the countries like Europe and US. The separation method was entirely carried out using the sea water to mimic the practical applications. Spike study was also performed in order to ensure the efficiency of method adopted in this research work. This work is will be further out using different methods and various environmental conditions. It is highly essential to remove the microplastics from the sludge discharged to prevent the ecosystem and life of living being.

REFERENCES

1. M. Cole, P. Lindeque, C. Halsband, T.S. Galloway, "Microplastics as contaminants in the marine environment: A review", Marine Pollution Bulletin. 62 (2011) 2588–2597. doi:10.1016/j.marpolbul.2011.09.025.
2. J.G.B. Derraik, "The pollution of the marine environment by plastic debris: a review", Marine Pollution Bulletin. 44 (2002) 842–852. doi:10.1016/S0025-326X(02)00220-5.
3. A.L. Andrady, "Microplastics in the marine environment", Marine Pollution Bulletin. 62 (2011) 1596–1605. doi:10.1016/j.marpolbul.2011.05.030.
4. D. Eerkes-Medrano, R.C. Thompson, D.C. Aldridge, "Microplastics in freshwater systems: A review of the emerging threats, identification of knowledge gaps and prioritisation of research needs", Water Research. 75 (2015) 63–82. doi:10.1016/j.watres.2015.02.012.
5. F. Murphy, C. Ewins, F. Carbonnier, B. Quinn, "Wastewater Treatment Works (WwTW) as a Source of Microplastics in the Aquatic Environment", Environ. Sci. Technol. 50 (2016) 5800–5808. doi:10.1021/acs.est.5b05416.
6. S.L. Wright, R.C. Thompson, T.S. Galloway, "The physical impacts of microplastics on marine organisms: A review", Environmental Pollution. 178 (2013) 483–492. doi:10.1016/j.envpol.2013.02.031.
7. S.L. Wright, F.J. Kelly, "Plastic and Human Health: A Micro Issue?", Environ. Sci. Technol. 51 (2017) 6634–6647. doi:10.1021/acs.est.7b00423.
8. S. Ziajahromi, P.A. Neale, F.D.L. Leusch, "Wastewater treatment plant effluent as a source of microplastics: review of the fate, chemical interactions and potential risks to aquatic organisms", Water Sci Technol. 74 (2016) 2253–2269. doi:10.2166/wst.2016.414.
9. S.A. Carr, J. Liu, A.G. Tesoro, "Transport and fate of microplastic particles in wastewater treatment plants", Water Research. 91 (2016) 174–182. doi:10.1016/j.watres.2016.01.002.
10. J.R. Jambeck, R. Geyer, C. Wilcox, T.R. Siegler, M. Perryman, A. Andrady, R. Narayan, K.L. Law, "Plastic waste inputs from land into the ocean", Science. 347 (2015) 768–771. doi:10.1126/science.1260352.
11. L.C.M. Lebreton, J. van der Zwet, J.-W. Damsteeg, B. Slat, A. Andrady, J. Reisser, "River plastic emissions to the world's oceans", Nature Communications. 8 (2017) 15611. doi:10.1038/ncomms15611.
12. X. Li, L. Chen, Q. Mei, B. Dong, X. Dai, G. Ding, E.Y. Zeng, "Microplastics in sewage sludge from the wastewater treatment plants in China, Water Research". 142 (2018) 75–85. doi:10.1016/j.watres.2018.05.034.
13. J. Talvitie, M. Heinonen, J.-P. Pääkkönen, E. Vahtera, A. Mikola, O. Setälä, R. Vahala, "Do wastewater treatment plants act as a potential point source of microplastics? Preliminary study in the coastal Gulf of Finland, Baltic Sea", Water Science and Technology. 72 (2015) 1495–1504. doi:10.2166/wst.2015.360.