Wastewater treatment plants as a pathway for the release of microplastics into the environment: Investigation of sludge and treated effluent of Sari wastewater treatment plant

Somayye Sadat Alavian Petroody[1], Seyed Hossein Hashemi[2*]

[1] Ph.D. candidate, Department of Environmental Technologies, Environmental Sciences Research Institute, Shahid Beheshti University, Iran

[2] Associate professor, Department of Environmental Technologies, Environmental Sciences Research Institute, Shahid Beheshti University, Iran.

Abstract

Problems caused by the widespread presence of microplastics in the environment have attracted the attention of many researchers. Urban wastewater treatment plants are considered as one of the main releasing sources. In this study, Sari municipal wastewater treatment plant was investigated as one of the potential sources of contaminating aquatic ecosystems (Tajan River and the Caspian Sea) and terrestrial. The samples from effluent and sludge were taken with 3 replications, in April and June 2018. The effluent samples were passed through 500, 300 and 37 µm steel sieve. Organic materials in the sludge and effluent samples were digested using hydrogen peroxide. Then, microplastics were extracted based on the density separation technique by sodium iodide salt and analyzed using a stereomicroscope and micro-Raman. The average number of microplastics in the effluent was 423.4 per cubic meters, of which more than 77% were fiber and the dominant size of microplastics was 37-300 µm. Also, sewage sludge had an average of 128.8 microplastic per gram (dry weight), mostly in fiber form (87.5%). Examination of the microplastics structure showed that fibers were mainly polyester (effluent 40% and sludge 59%), whereas the majority of particles were polyethylene (effluent 73% and sludge 68%), which are mainly due to the wastewater of washing clothes and microbeads used in cosmetics. Therefore, considering the amount of microplastics present in the effluent and sludge, Sari wastewater treatment plant can be considered as one of the most important sources for the release of microplastics in the aquatic and terrestrial ecosystem in the north of the country.

KEYWORDS

Microplastic, Effluent, Sludge, Wastewater treatment plant, Mazandaran.

* Corresponding Author: Email: h_hashemi@sbu.ac.ir

1. Introduction

"Microplastics" (MPs) is defined as small pieces of plastic with dimensions less than 5 mm [1]. These emerging contaminants have been identified in various aquatic environments, sediments, soil, and organisms. Due to physical and chemical damages of MPs to the organisms and possible transfer of organic contaminants and heavy metals to their bodies, MPs considered as an environmental concern [2]. Although research has been conducted in recent years to detect MPs in the environments around the world, identifying the sources of their emission into the environment is a challenging subject [3]. Wastewater treatment plants by releasing large amounts of fibers and plastic particles into the environment through effluent and sludge is one of the most important sources of MPs' pollution [4]. As far as authors concern, there is no study conducted regarding MPs emission from sludge and effluent of Iran's municipal wastewater treatment plants. Therefore, in this paper, MPs in sludge and effluent from Sari wastewater treatment plant have been studied as one of the sources of MPs diffusion sources to the Tajan River, Caspian Sea and agricultural lands.

2. Material and method

Sampling was carried out in April and June 2018 of effluent and sludge. Composite 270-liter/24-hour samples of clarifier output (final effluent) in 3 replicates were taken on three consecutive days. Samples were passed through a series of sieves (500, 300, and 37µm) and the residues on the sieves were washed with 1,000 ml of pure water and transferred into clean bottles [2]. The sludge samples were taken after the mechanical dewatering stage with a shovel, in three replicates and placed in glass containers that had previously been washed and dried, and their lids covered with clean aluminum foil. All effluent and sludge samples were stored in the dark at 4°C to transfer to the laboratory for further processing [5]. To extract MPs, first, the organic matter was digested by hydrogen peroxide and then sodium iodide solution (1.75 g/cm^3) was used for separating MPs from inorganic materials [2-6]. Also, Bengal Rose solution was added to samples for staining natural materials to avoid the overestimation of MPs [2]. Finally, the MPs extracted from the purification phase were examined using a stereomicroscope (KERN, OZL-45) and micro-Raman spectrometer (Confocal Raman microscope, LabRAM HR Evolution–HORIBA) to study morphology and determine their structures.

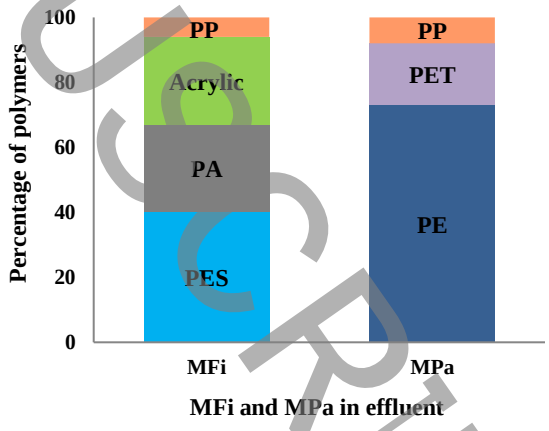
3. Result and discussion

On average, 423.4±44.9 MPs were found per cubic meter of effluent (9316047± 988313.2 MPs/day) that mostly consists of microfibers (77.5%). The dominant size of MPs was 37-300 µm (63%), and microfibers ≤300 µm accounted for 45% of all MPs in the effluent. The high number of small MPs may be attributed to the low ability of the processes in the treatment plant to remove them [2]. Examination of sludge samples also showed that there were 128.8±16.7 MPs per gram (dry weight) (276353200.9±35859319.8 MPs/day) and fibers were the most common type (87.5%) of MPs in the sludge (Table 1).

Table 1- The mean number of microplastics (MPs), microfibers (MFi) and microparticles (MPa) (SE, n = 3) in the dewatered sludge and effluent in wastewater treatment plant of Sari

	MPs $\bar{N} \pm SE$	MFi $\bar{N} \pm SE$	MPa $\bar{N} \pm SE$
Effluent (N/m^3)	423.4±44.9	328.4±33.4	95.1±12.2
Sludge (N/g (d.w))	128.8±16.7	112.7±15.3	16.1±1.9

Examination of fiber structure using the micro-Raman spectrometer showed a high amount of polyester (PES) fibers and other synthetic fibers such as nylon (PA) and acrylic in sludge and effluent and small amounts of polypropylene (PP) in the effluent of this treatment plant. The presence of these fibers in samples may be due to sewage from washing clothes and carpets [7]. Morphological study of micro-particles extracted of effluent and sludge showed that most of them were spherical or irregular blue particles and often in the range of 37-300 µm, which had a polyethylene structure and were similar to the microbeads used in cosmetic products [2]. In addition to polyethylene, which was the most common type of polymer for particles, polypropylene, polyethylene terephthalate (PET), and polycarbonate (PC) were other types of particles found in effluent and sludge that may have originated from the degradation or erosion of plastic goods (Figure 1).



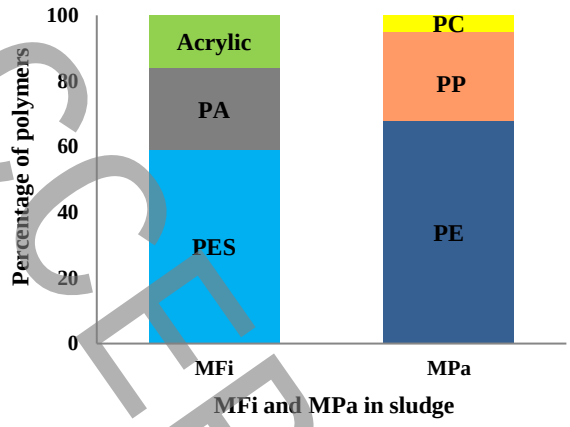


Figure 1: Percentage of polymers forming the microfibers (MFi) and the microparticles (MPa) in the effluent and sludge of Sari wastewater treatment plant

4. Conclusion

The results of this study show that a high number of MPs are introduced into the aquatic environment and agricultural lands by effluent and sludge every day that most of them are microfibers with a size of ≤300 µm. Due to their high surface-to-volume ratio, they can play an important role in the absorption and transport of pollutants, especially persistent organic pollutants and heavy metals, as a result, increase environmental concerns. Therefore, more research is needed on the sources of MPs emissions into the environment and their contribution, especially to wastewater treatment plants, and their relationship to the values observed in aquatic environments, sediments, and organisms.

5. Reference

[1] S.S. Alavian Petroody, S.H. Hashemi, Occurrence and Characterization of Microplastics in Urban Wastewater, A Case Study: Sari Wastewater Treatment Plant, Modares Civil Engineering journal, 19(6) (2020) 145-154. (In Persian)

[2] S. Ziajahromi, P.A. Neale, L. Rintoul, F.D. Leusch, Wastewater treatment plants as a pathway for microplastics: development of a new approach to sample wastewater-based microplastics, Water research, 112 (2017) 93-99.

[3] J. Hammer, M.H. Kraak, J.R. Parsons, Plastics in the marine environment: the dark side of a modern gift, in: Reviews of environmental contamination and toxicology, Springer, 2012, pp. 1-44.

[4] S. Magni, A. Binelli, L. Pittura, C.G. Avio, C. Della Torre, C.C. Parenti, S. Gorbi, F. Regoli, The fate of microplastics in an Italian wastewater treatment plant, Science of the Total Environment, 652 (2019) 602-610.

[5] J. Talvitie, A. Mikola, O. Setälä, M. Heinonen, A. Koistinen, How well is microlitter purified from wastewater?–A detailed study on the stepwise removal of microlitter in a tertiary level wastewater treatment plant, Water research, 109 (2017) 164-172.

[6] S. Sujathan, A.-K. Kniggendorf, A. Kumar, B. Roth, K.-H. Rosenwinkel, R. Nogueira, Heat and bleach: a cost-efficient method for extracting microplastics from return activated sludge, Archives of environmental contamination and toxicology, 73(4) (2017) 641-648.

[7] B.M.C. Almroth, L. Åström, S. Roslund, H. Petersson, M. Johansson, N.-K. Persson, Quantifying shedding of synthetic fibers from textiles; a source of microplastics released into the environment, Environmental Science and Pollution Research, 25(2) (2018) 1191-1199.