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NARRATIVE REVIEW: MICROPLASTIC SAMPLING TECHNIQUE IN LEACHATE TREATMENT PLANT BASED ON APPROACH OF WWTP MICROPLASTIC SAMPLING TECHNIQUE

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ABSTRACT

Landfill solid waste composition 21-42% is plastic waste potentially as a microplastic source because of the extreme environments. The abundance of microplastics from waste degradation can be discovered inside leachate in a Leachate Treatment Plant (LTP). The compatibility of the sampling technique supports knowing the effects of LTP into representatively microplastic concentration. The article review aims to understand the similarity characteristic between a LTP and a Wastewater Treatment Plant (WWTP) and to know the microplastic sampling technique in a LTP with an approach of microplastic sampling technique in a WWTP. The characteristic comparison between both showing three similarities is that the waste being treated is a type of wastewater, parameters of treated liquid waste to meet the quality standard, and both of them include secondary treatment and advanced treatment. Therefore, the microplastic sampling technique in LTP can be approached by WWTP's microplastic sampling technique. Microplastic sampling technique in LTP tent to several factors, such as sample type and volume which is determined by sampling point, sampling method looks from the homogeneity of sampling point, sampling tool adjusted kind of sample in the LTP, sampling point based on the purpose of sampling, and two times minimum of sampling time and sampling replication.

KEY WORD : LTP, Microplastic, Refuse, Sampling Technique, WWTP

INTRODUCTION

The appearance of the microplastic contamination problem just realized in the environment in 1960 with the discovery of tiny plastic fragments in the plankton net. Microplastic is plastic with a size range of 1 nm - < 5 mm. Microplastic contamination has spread into water, soil, and living creatures (GESAMP, 2015). One of the ways to resolve the problem is to avoid microplastics entering into an environment from their sources for holding down the abundance of them. A landfill is one of the microplastic sources which is recently known where the system is the most popular solid waste management in the world. The extremes environment in a landfill forms microplastics, which are flowed by leachate into the leachate treatment plant before releasing them to the environment (He, *et al*., 2019; Nizzetto, *et al*., 2016).

Research of microplastic in a leachate treatment plant is still limited because microplastic is a discovery pollutant and more focused on the abundance of microplastic in a landfill. Those make the formulation of a microplastic sampling technique in a leachate treatment plant is yet well regulated because representatively and suitable sampling is a crisis and fundamental. The sample must represent the right result, so the conclusion from data is true (Abadi, 2006; NSW EPA, 2016). Comprehensive microplastic sampling technique in a leachate treatment plant for knowing it's abundance and reduction in the right step need to

do (Praagh *et al*., 2018; Su*et al*., 2019).

One of the ways to depict the microplastic sampling technique in a leachate treatment plant is by using WWTP microplastic sampling technique approaches as other sources of microplastic (Murphy*et al*., 2016). This article reviews aims to know the leachate treatment plant and WWTP similar characteristics and to represent the microplastic sampling technique in a leachate treatment plant. Hereafter, this article can be used as a reference for the determination of the leachate treatment plant microplastic sampling technique.

METHOD

Reviewing had been done using a qualitative approach through a meta-ethnography technique by reinterpretation using iterative cross-thematic analysis with identification of the repeating pattern for formulating the result, so the aims of the article are fulfilled. Twenty-five international articles have been reviewed. Further, the results were reinterpreted based on the similarity characters between a leachate treatment plant and WWTP to present an appropriate microplastic sampling technique in a leachate treatment plant for getting representative microplastic concentration.

RESULTS AND DISCUSSION

Similarity of a leachate treatment plant and WWTP

The microplastic sampling technique in a leachate treatment plant is based on WWTP microplastic sampling technique. Similarization between both of them as a base to reinterpretation sampling technique. There are three similarities between a leachate treatment plant and WWTP. First is both of them treating wastewater to meet a regulated quality standard. WWTP treats the wastewater as general likes domestics and industries while a leachate treatment plant treats leachate as specific industry wastewater with a high level of organic and inorganic pollutants (Bhagawan *et al*., 2017; Jotin *et al*., 2012). The second similarity is wastewater parameters being treated to meet quality standards. Similar parameters from leachate in Leachate Treatment Plant and wastewater in a Wastewater Treatment Plant are BOD, COD, pH, and heavy metals, like Pb, Cu, and Fe (Menteri Lingkungan Hidup and Kehutanan, 2016; Sulistia and Septisya, 2019; Sari and Afdal, 2017; Drozdova *et al*., 2018). Those similar supporting treatment with a single treatment scheme. This choice was used to decrease the money spent when two kinds of wastes balance. The effectiveness of treatment needs to recalculated when the ratio of two wastewater is different because of phosphorus content in wastewater and nitrogen content in the leachate (Aziz*et al*., 2014).

Third and the last similarity is a leachate treatment plant and WWTP, including biology and advanced treatment plant as a part of the treatment system. Generally, WWTP includes pre-treatment, primary treatment, secondary treatment, and advanced treatment while a leachate treatment plant composed of aerobic and anaerobic biology treatment, advanced treatment, and physical chemistry treatment (Zhao, 2019; Sperling, 2007). The scope of a treatment unit in a leachate treatment plant can be said less than WWTP, or most of them are part of the WWTP treatment unit (Raghab *et al*., 2013). Those show a leachate treatment plant and WWTP have similarities as wastewater treatment unit with the particular treatment units adjusted to waste characteristic.

Overview of Microplastic Sampling Techniquesin a Leachate Treatment Plant

Type and sample volume

The type and sample volume of microplastic on some previous research can be seen in Table 1.

In Table 1, the sample volume for microplastic analysis is very diverse from under 1 l until more than 1000 l. Many variations of sample volume can be affected by filter clogging because of too many volumes filtered (Murphy *et al*., 2016; Talviti *et al*., 2017), availability of waste, time, and effort are possible to do (Praagh *et al*., 2018; Covernton *et al*., 2019), differentiation of methods and tools are used (Talvitie *et al*., 2017; Park *et al*., 2020), and different sampling point causing increases of sample volume, likes 1 l on the influent system and 30 l on primary and secondary treatment unit(Lee & Kim, 2018; Gies *et al*., 2018). Based on Table 1, the graphic has been made by classification on some volume range which can be seen in Figure 1.

Based on those data yet known specific amount of water samples should be picked to identify microplastic, but according to the largest percentage of used volume is 10-100 l of 41,94% and the smallest percentage is >1000 L of 9,69%. In Table 1, the amount of sample volume can't be determined representative of the sample, likes Xu *et al* (2020) that

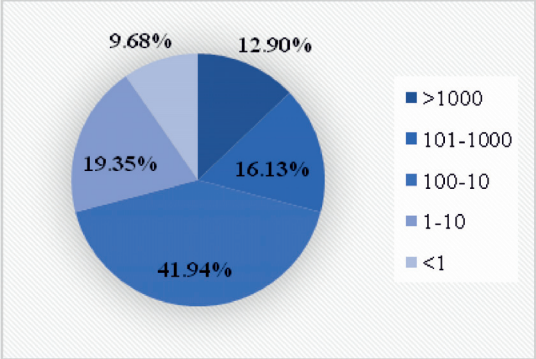

Fig. 1. Sample volume of wastewater from previous research

microplastic concentration in 1 l sample has 8.5 times bigger than the sample volume 10 l. The larger volume will be representative if the desired size of microplastic is large because there is a correlation between availability level microplastic based on size with needed sample volume. It's become a negative correlation if the sample volume increases so microplastic concentration decreases (Bannick *et al.*, 2018; Lusher *et al.*, 2014). The Number of solid samples from some previous research can be seen in Table 2.

In Table 2 to quantify the number of solid samples, there is a unit of volume and unit of weight. Recommendation volume picked from the sampling point is ≥ 1 l as a minimum in each sampling (Murphy *et al.*, 2016; Gies *et al.*, 2018) while in the unit of weight the minimum weight is ≥ 1 kg with 5-g dry subsample and 400-g wet subsample (Lee and Kim, 2018; Hongprasith *et al.*, 2020; Gies *et*

Table 1. Type and sample volume of microplastic on some previous research

No	Sample Volume	Microplastic concentration (particle/L)	Amount of microplastic type	Amount of microplastic polymer	Authors
1	24 l	0.42-24,58	5	17	He *et al.*, 2019
2	30 l; 50 l	3,4-15,7; 0.25	5	5; 8	Murphy *et al.*, 2016
3	454-5450 l	0,3406; 2,42	5	n/a	Dyachenko *et al.*, 2016
4	5 l	1,15-1,68	3	7	Gundogdu *et al.*, 2018
5	3 l	4,2-9,8	3	8	Su *et al.*, 2019
6	1440-25920 l	0.004-0,195	5	n/a	Mason *et al.*,2016
7	1 l; 30 l	31,1; 0,5-2,6	6	5	Gies *et al.*, 2018
8	30 l	0,4-2,5	3	20	Magni *et al.*, 2019
9	3,6 l; 7,5-11,5 l; 30 l	15,8-152,5; 155; 4	2	n/a	Conley *et al.*, 2019
10	2,5 l; 7,5 l; 100 l	21,9-102,3; 4,0-10,3; 0, 10-1,22	3	n/a	Wang *et al.*, 2020
11	2-1000 l	0,005-6,9	5	13	Telvitie *et al.*, 2017
12	0.4 – 25.5 l	<0,04-3,2	5	13	Telvitie *et al.*, 2017
13	2 l	33-31,400	4	n/a	Hidayaturrahman and Lee, 2019
14	30 l	0,59-12,03	2	18	Yang *et al.*, 2019
15	5 l – 305 l	0,03-4,51	n/a	8	Praagh *et al.*, 2018
16	250 ml	157,2	5	5	Xu *et al.*, 2020
17	300 ml	600-725	5	n/a	Xu *et al.*, 2020
18	250 ml	291	5	6	Xu *et al.*, 2020
19	10 l	0,6-3,1	4	5	Akarsu *et al.*, 2020
20	10 l; 100 l;	2,95-23,75; 0,05-0,330	2	n/a	Lee and Kim, 2018
21	1 l	10-470	2	8	Park *et al.*, 2020
22	1000 l	0,004-0,51	2	3	Park *et al.*, 2020
23	660 l	0,45-1,97	3	3	Magnusson and Noren, 2014
24	2 l; 1000 l	15,1; 8,25	3	3	Magnusson and Noren, 2014
25	0.43-13 l	1,23-12,43	4	17	Bayo *et al.*, 2020
26	1.89-2.29 x 10^5	0-50	4	n/a	Carr *et al.*, 2016
27	100 ml; 4.23x10^5 l	0,00088	4	n/a	Carr *et al.*, 2016
28	10 l; 20 l	11,8 ; 2,76-7,91	7	3; 15	Raju *et al.*, 2020
29	5-10 l	2,0-138,2	5	14	Hongprasith *et al.*, 2020

Table 2. Amount of solid samples from some previous research

No	Number samples	Microplastic concentration (particle/kg)	Number of microplastic types	Number of microplastic polymers	Author	Sample type
1.	n/a	2.5-20.0	n/a	10	Murphy *et al*., 2016	Sediment
2.	30 g	4.196-15.385	5	3	Mahon *et al*., 2016	Sediment
3.	4-10 kg	115-223	5	12	Su *et al*., 2019	Soil
4.	n/a	1.60-56.4	5	6	Li *et al*., 2018	Sludge
5.	250 mL	4.4-14.9	4	n/a	Gies *et al*., 2018	Sludge
6.	50 mL	113	3	13	Magni *et al*., 2019	Sludge
7.	5 L	n/a	3	n/a	Wang *et al*., 2020	Sediment
8.	n/a	1620-13.275	2	n/a	Lee dan Kim, 2018	Sludge
9.	25 g	16.7-720	3	3	Magnusson and Noren, 2014	Sludge
10	2,1-5 g	476.19-4000	n/a	n/a	Carr *et al*., 2016	Sludge
11	1 kg	103.4	4	11	Hongprasith *et al*., 2020	Sludge

al., 2018). The subsample is picked to increase the effectiveness of analysis time (Jaworski *et al*., 2019).

Microplastic sampling divided into the sampling method and the sampling tool which are the data can be seen in Figure 2

In Figure 2 (A), the highest percentage of sampling method is grab sampling which represents microplastic concentration just in sampling time and sampling point with homogenous analyte distribution (Hadi, 2015; Hongprasith *et al*., 2020). Composite sampling is the second-highest sampling method that combines many samples at different times and places with non-homogenous analyte distribution at the sampling point and represents the average of microplastic concentration in a certain period of time or places (Hadi, 2015; Su *et al*., 2019; Dyachenko *et al*., 2016; Gündoìdu *et al*., 2018). Integrated sampling being the last method is commonly used in surface water or river microplastic sampling and not yet implemented for horizontal or vertical sampling in WWTP or leachate treatment plant. This method picks several places in time (Xu *et al*., 2020; Magnusson and Norén, 2014).

In Figure 2 (B), the most often sampling tools to take microplastic is a container. It's because the container can take a wastewater sample and solid sample, easy to use, and inexpensive, but the volume of a container in sampling is limited, so it needs to take more than one time (Sun *et al*., 2019). The second-highest percentage is pump and filtration which can take until a thousand liter in one time and can be modified, but an increase of sample volume can make the filter clogged (Sun *et al*., 2019). The least percentage is autosampler and plankton net. Autosampler can be sampling constantly and easy to operate, but autosampler is limited sampling volume and expensive, while a plankton net can filter high volume and inexpensive. In another way, a plankton net needs others helping tools to use that like ship and the accuracy of sampling volume is not precise because to calculate sampling volume is by measure wastewater flow rate multiplied with the mouth area of the open net (Sun *et al*., 2019; Abeynayaka *et al*., 2020; Lenz and Labrenz, 2018).

Deciding sampling place

The deciding sampling point must be to answer the goals of the research (Badan Standarisasi Nasional, 2008). There are several research goals from microplastic sampling in previous research that's make the sampling place is different. If the research goal is to know microplastic concentration in one

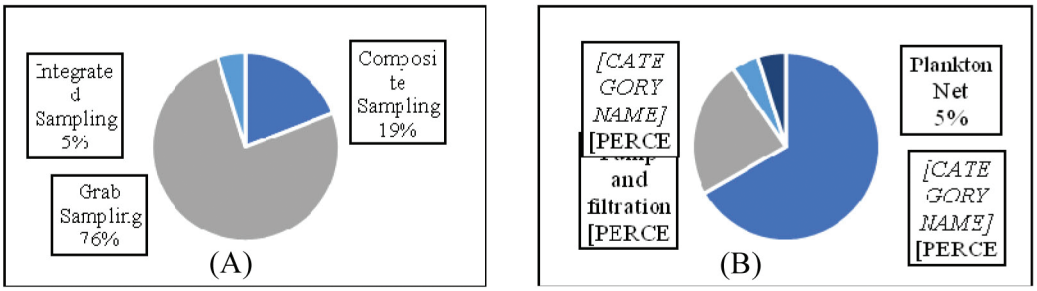

Fig. 2. (A) Percentage of sampling method (B) Percentage of the sampling tool

treatment unit then sampling can be done in the influent (He *et al*., 2019; Mahon *et al*., 2016). When the research goal is to know the effectiveness of one treatment unit or the treatment plant, it needs to take sampling in influent and effluent of them. Meanwhile, if the research goal wants to know the mass balance of the microplastic in the treatment system, so the microplastic sample must be taken in all treatment units of the leachate treatment plant (Magnusson and Norén, 2014; Hidayaturrahman and Lee, 2019; Talvitie *et al*., 2017; Hongprasith *et al*., 2020; Carr *et al*., 2016; Murphy *et al*., 2016). Another factor to decide how many sampling points in the sampling place is homogenous of the sampling place because it takes effect into sampling method which is to be used (Hadi, 2015).

Time and replication sampling

Considerable time and replication sampling in microplastic research can be determined by the data from previous research in Fig. 3.

From Figure 3, it can be identified it's has a

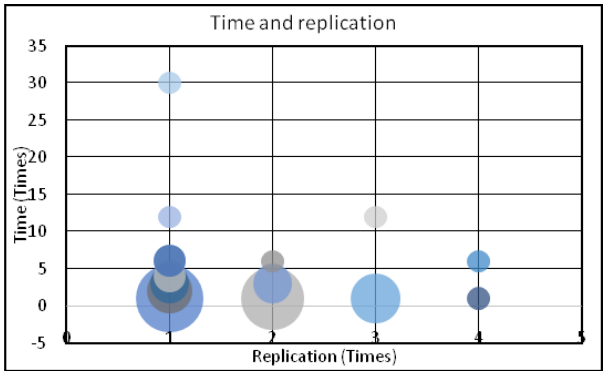

Fig. 3. Data of time and replication from previous microplastic research

pattern that when the replication of sampling increases the repetition of sampling time decreases. The pattern is understandable because of the consideration of the cost being spent, but it is important to make more than one-time sampling and replication to make sure the higher precision and accuration of the data by comparing them (Hadi, 2015; Underwood *et al*., 2017; Kreyling, 2018). Plenty of time for microplastic sampling, ideally, should be done at least twice in every microplastic research by considering the time when the WWTP or leachate treatment plant operates normally and the weather conditions (Lusher *et al*., 2014; Xia *et al*., 2020). The minimum sample replication that needs to be done is 2-3 times at each point. Increased time and sample replication are preferable if possible (Brander *et al*., 2020).

CONCLUSION

Three similar characteristics between a leachate treatment plant and WWTP for interpretation microplastic sampling technique WWTP into types of waste that are processed are wastewater, parameters of liquid waste that are processed to meet quality standards, and liquid waste processing units in the form of secondary and tertiary processing.. Based on those similarities, the microplastic sampling technique in leachate treatment according to type and sample volume should adjust by the sampling point; the sampling method is determined on sampling point homogeneity, the sampling tool accustom with sample type, sampling point is reviewed from research goal, and replication and time of sampling are at least twice for comparing the result.

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