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ANALYSIS OF MICROPLASTICS ABUNDANCE IN SELOREJO RESERVOIR SEDIMENT AT MALANG REGENCY

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ABSTRACT

Plastic waste is a problem that has the potential to pollute the environment and can be asource of problems for waters. Microplastics that enter the waters will enter the water body and will eventually settle in the sediment. This study aims to determine the abundance based on the type, size, color and number of microplastics, to determine the comparison of the abundance of microplastics in sediments at each station and to determine the abundance of microplastics based on the pollutant source, to make a distribution map of the presence of microplastics in the Selorejo Reservoir and to analyze the abundance of microplastics based on pollutant sources in the area. Selorejo Reservoir. The results of the study revealed that in the Selorejo Reservoir sediment the most dominant type of microplastic was fragment (42%), based on color it was black (46%), and based on size was microplastic with a size of 125-250 m (48%). Overall the abundance of microplastics in the Selorejo Reservoir is 56637.5 particles/kg sediment where the abundance is high on grid 8 where the grid is the outlet of the Selorejo Reservoir. The results of the Fourier Transform Infrared (FTIR) analysis on sediment samples showed several polymers, namely polyethylene (PE), polystyrene (PS), polyprophylene (PP), and polyamide (PA) ornylon.

KEY WORDS: FTIR, Microplastic, Sediment

INTRODUCTION

The increasing use of plastic nowadays is a phenomenon that we find very often. The use of plastic materials is increasingly widespread because of their strong nature and are not easily damaged by weathering. The development of plastic products in Indonesia is very rapid it is almost in all types of human needs the use of plastic containers, styrofoam, and plastic bags which are identical to food packaging. Unfortunately, apart from being needed by the people, those plastic products also have a bad impact on the environment. Plastic waste is a problem that potentially pollutes the environment. Besides, plastic waste can be the source of problems since most of them are thrown directly into the river without any prior processing. Plastic waste can be the source of problems for the water since it can contaminate the water. According to Verschoor (2015), plastic waste that is generally only used once has been a global environmental problem. Plastic waste itself is a type of solid waste that comes from the waste of the surrounding society. The plastic waste will be accumulated in the aquatic ecosystem and will cause the degradation of the water environment both in production and in environmental health. The plastic waste can be degraded into smaller pieces of plastic which are called microplastics. According to Caruso (2015), microplastic contamination of the aquatic environment originating from wastewater, industrial raw materials, and factories becomes a priority for future research since it has been recognized as an emerging global threat with various implications towards the environment and social condition. In addition, the small size of microplastics which has a diameter less than 5mm, potentially threat more severe than large plastic materials. The problem of microplastics and water pollution does not only have an impact on human health, predominantly, but this phenomenon can also damage the food chain and the entire biota in the water. Moreover, the small size of microplastics can be ingested by the aquatic organisms.

Microplastics that enter the waters will enter the water body and eventually settle in the sediment. According to D.K.A Barnes, *et al.* (2009), plastic waste has resilience and persistent properties, production continues to increase, and the recoveryrate is low. This causes an accumulation of plastic debris along coastlines, on surface waters, at various water depths, and in sediments. The danger posed by the content of microplastics in the sediment is the disruption of aquatic ecology. Microplastics are estimated to be able to absorb more contaminants at a location where there is a higher concentration of contamination, and longer stay duration of particles, as well as the potential storage in the sediment. Besides, microplastics can adsorb a toxic hydrophobic compound from the environment (Cole *et al*., 2011). Microplastics are carcinogenic and can disrupt the endocrine system in biota. The presence of microplastics in aquatic sediments is concerned to be dangerous because plastics are persistent and often contain chemicals that, when consumed by organisms, are potentially toxic and carcinogenic. Furthermore, this microplastic waste can enter the food chain and ultimately impact both human and environmental health.

The dam has different characteristics from other water bodies. It receives water supply continuously from the river that flows through it or it can be said that the accumulation of river water. The river water contains microplastics where the weight of microplastics found is affected by the amount and shape of microplastics. The possible source of microplastics is because the waters of the dam are one of the areas with various potentials. The potential can be in the form of cultivation as well as tourism. The potential of microplastics in the tourism sector may cause ecosystem disruption. The disruptions upon the aquatic ecosystem due to the tourism sector are generally caused by human activities, either directly such as fishing or indirectly such as throwing waste in the river to bedammed.

The role of the Selorejo Reservoir for the society is quite crucial, that is as flood prevention, generating electricity, supplying water for agricultural irrigation, inland fishing, and tourism activities. Selorejo Reservoir is a dam that stems from the Kwayangan, Konto, and Pinjal rivers. The number of activities conducted in Selorejo Reservoir and the accumulation of several rivers can increase the quantum of plastics waste.

MATERIALS AND METHODS

Tools and Materials

In this study, the tools used are a grab sampler, a plastic bag of 1kg in size, cool box, Olympus CX33 microscope, label paper, camera, GPS, aluminumfoil, analytical balance, beaker glass, oven, magnetic stirrer, hotplate stirrer, petridish, Erlenmeyer 100 ml, FTIR.

The materials used are sediment samples, saturated NaCl, 0,05 M Fe (II) solution, 30% H_2O_2 solution, and aquadest.

Work Procedure

Determination of Sampling Location

The determination of sampling location point used the purposive sampling method. This method is selected because it can determine the sampling point based on the researcher's needs. The determination of the station is according to the location or area that has activity as the source of plastic waste in Selorejo Reservoir. There are nine points of sampling which are portrayed in the grid by dividing 1 km^2 reservoir area in each grid. The determination of this point sampling is carried out by using google maps and with the help of a GPS device. Sampling points were planned earlier before the sample was taken.

Sampling

Sediment sample at each sample point was taken 1 kg to be analyzed for the microplastics content. Sediment sampling used a metal grab sampler to avoid contamination with plastic. There are nine points of sediment sampling. The samples that have been taken, then put into plastic that has be enpreviously labeled and put in a cool box for further analysis in the laboratory.

Laboratory Analysis

The stages of laboratory analysis are sample preparation, sample separation or flotation based on the density, destruction of organic matter using hydrogen peroxide, filtration, and identification of microplastics.

Sample Preparation

Sediment samples that have been stored in the plastic are taken from its middle part to avoid contamination from plastic and then homogenized manually. A total of 150 grams of wet sediment samples were put into a beaker glass, and the wet weight is calculated using ananalytical balance. Then, those samples are dried using the oven at 90 °C overnight. It is aimed to ensure that water contained in the sediment is completely lost. Finally, the weight of dry samples is obtained (based on sediment condition), and then the dry sediment was mashed using the mortar.

Sample Reduction

The dried sediment sample will be filtered on a sieve and mashed using a mortar. The strainer or sieve used has a pore size of 4 mesh with a sieve diameter of 20 cm. This sifting or filtrating is conducted to reduce the sediment volume, and also to sort out macro sediment and identify ≤ 5 mm of microsediment.

Density Separation /Floatation

Sediment samples of 100 g were then given a saturated NaCl solution (300 g of NaCl/1 liter of distilled water) as much as 300 ml and homogenized using a magnetic stirrer. The sample was covered using aluminum foil to avoid contamination from outside and allowed to stand for 24 hours to obtain a perfect supernatant. The supernatant was filtered using a 0.1 mm sieve and the filter product was transferred to a glass beaker in order to destruct its organic matter.

Organic Matter Destruction with Hydrogen Peroxide

Samples were added by Fe (II) 0.05 M solution and 30% H_2O_2 solution where each volume is 20 ml. Samples were heated and homogenized at 75 °C on a hot plate stirrer for about ±30 minutes. If samples still contain organic material, then another 20 ml of 30% H_2O_2 solution was added until the organic material was completely destructed.

Microplastic Identification

Samples and the sieve were placed in a petri dish which was being visually identified and further identified using an Olympus CX33 microscope with ten times magnification.

Microplastics Abundance Calculation

Microplastic abundance was obtained from the number of plastic particles found in the sediment sample divided by the weight of the dry sediment. According to Dewi *et al*. (2015), the formula for calculating the abundance of microplastics in sediment samples can be calculated using the following formula:

Fourier Transform Infrared Spectrophotometry (FTIR) Test

Samples of the microplastic type found in the sediment were examined for the type of polymer and its abundance, which was then tested using *Fourier Transform Infrared* or FTIR.

Data Analysis and The Making of Microplastic Distribution Map

The result of microplastics abundance calculation at each sampling point will be made amicro plastic distribution map in the sediment of Selorejo Reservoir. The method used in making a distribution map is Geographic Information System (GIS) by applying the spatial interpolation method. The spatial analysis used in this study is an interpolation. Interpolation is a method to find or determine a value located among other known values. Generally, those values are symbolized in point. Interpolation can be used to estimate a function, which is the function is not defined by a formula, but using tabulated data, such as data from rainfall measurements at a point of measurement station, or latitude data at apoint location. Interpolation can also be applied to digital image processing, creating elevation maps, and rainfall. In mapping, interpolation is a process of estimating values at a location that are not measured, so that map or distribution ofvalues made over the entire area (Gamma Design Software, 2005). The method of spatial interpolation consists of IDW, Spline, and Kriging methods. In this study, the researcher use IDW (Inverse Distance Weight) interpolation method or inverse weighted distance in interpolation which is implemented using ArcGIS software.

The Inverse Distance Weighted (IDW) method is a simple deterministic method by considering the surrounding points. The assumption of this method is the interpolation value will be more similar at closer sample data than further sample data. The weight will be changed linearly based on its distance from sample data. This weight will not be affected by the location of the sample data. IDW method was selected in this study because according to Pramono's (2008) research, the IDW method provides more accurate results than the Kriging method.

RESULTS AND DISCUSSION

Types of Microplastics in The Sediment

The result of microplastic analysis in the sediment sample in the Selorejo Reservoir at Malang Regency, East Java, indicated the presence of microplastic types namely *fiber, film*, *fragment* and *pellet* as shown in Figure 1.

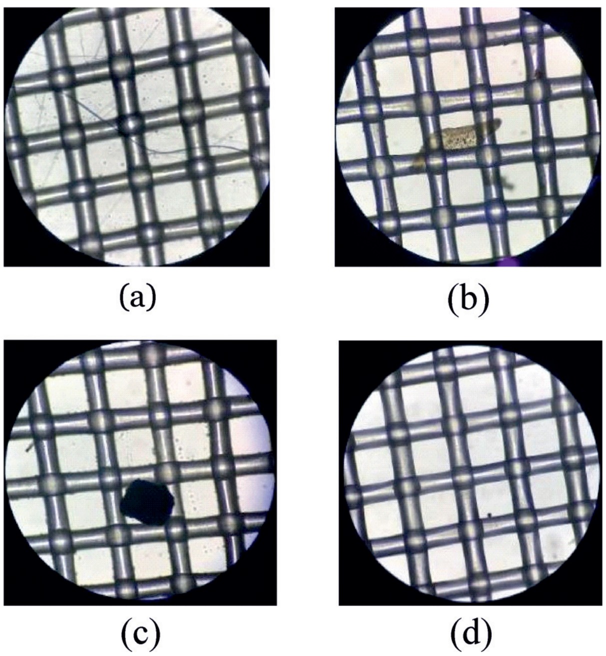

Fig. 1. Microplastic Type in the Sediment Sample with ten times Magnification (a) *Fiber*, (b) *Film*, (c) *Fragment*, and (d) *Pellet*

According to the data that has been obtained, it is known that the total abundance of fiber type microplastic is 4483 particles, film type is 3180 particles, fragment type 5736 particles, and pellet type is 194 particles. Therefore, it can be understood that the most common types of microplastics found from eighteen (18) sample points for sediment sampling in Selorejo Reservoir in sequence were 42% fragments, 33% fiber, 23% film, and 2% pellets.

Microplastics Color in the Sediment

There were found seven colors of microplastics in Selorejo Reservoir, that is black, chocolate, red, transparent, blue, green, and purple. It shows that microplastics have various colors. The color of microplastics at each point has a different amount. The total number of microplastics in black is 6220 particles, brown is 2361 particles, red is 145 particles, transparent is 4665 particles, blue is 169 particles, greenis 21 particles, and purple is 12 particles. Sequentially, known that the color of microplastics found from eighteen (18) sediment sample points in Selorejo Reservoir from the highest is black by 46%, transparentby 34%, brown by 18%, blue by 1%, red by 1%, green by of 0.15%, and purple of 0.08% can be seen in Figure 2.

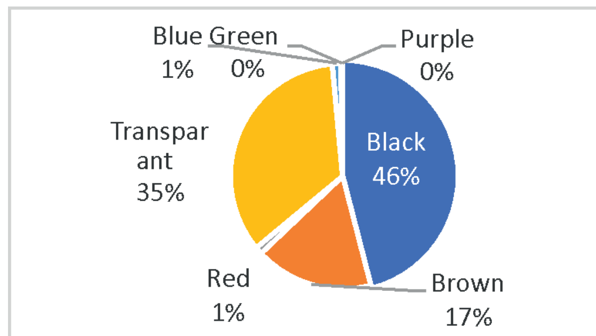

Fig. 2. Percentage of Microplastics Based on Color in Sediment

Number of Microplastics Based on Size in The Sediment

Microplastics are generally classified according to morphological characters, namely size, shape, color. Microplastics are generally classified according to morphological characters, namely size, form, color. The form becomes a significant factor since related to the scope of effects affected on the organisms. Microplastics at the bottom of the sediment are affected by gravity and the density of plastic is higher than the density of water. This condition causes the plastic to sink and accumulate in the sediment (Woodall *et al.*, 2015). Microplastic is divided into two categories, that is the large size (1-5 mm) and the small size (< 5 mm). In this study, microplastics that were found in Selorejo Reservoir have 125-250 μm, 250-600 μm, and >600 μm in size. The use of sieve in those sizes to obtain microplastic with a sizeof <5mm. Microplastics that were discovered in Selorejo Reservoir have 125-250 μm, 250-600 μm, and >600 μm in size. It can be seen in the microplastics percentage as shown in Figure 3.

Microplastic in size>600 μmis 23%, the size of microplastic in 250-600 μmis 29%, and the size of microplastic in 125-250 μmis 48%. Sediment

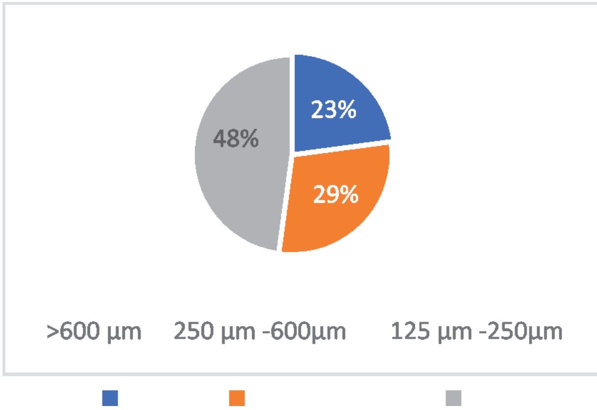

Fig. 3. Percentage of Microplastics by Size Basedon Figure 3, it can be seen that the smaller the filter size, the higher the abundance of microplastic in each type and color.

collecting in Selorejo Reservoir is carried out in the depth of 25 m–35 m. The same particle size of microplastics and sediments also allows the accumulation of microplastics along with the accumulation of sediments so that the accumulation of microplastics in the deeper layers is more than the top layers. The movement of microplastic particles to deeper layers is caused by bioturbation or water flow, for example storms or floods and transportation by animals (Lestari, 2019).

Microplastics Abundance in Sediment Sample

The microplastic abundance found ranged between 615,5 -1089,5 particle/kg. The average abundance of microplastics in each grid of sampling sediment in Selorejo Reservoir can be seen in Table1.

The total microplastics abundance in the Selorejo Reservoir sediment is 56637,5 particle/kg. The microplastics abundance in each grid of sampling sediment, included grid 1 is 8%, grid 2 is 12%, grid 3 is 12%, grid 4 is 13%, grid 5 is 12%, grid 6 is 9%, grid 7 is 9%, grid 8 is 16%, and grid 9 is 9%. Overall, the highest microplastics abundance is in grid 9. The high microplastic abundance in the sediment of Selorejo Reservoir is due to its characteristics which are muddy, soft, and can absorb the waste. Another factor that can affect the high microplastics abundance in this study is the high rainfall during sediment sampling.

The high rain fall can increase the accumulation of plastic waste because rain can carry the plastic waste from land to water. According to Watters *et al.*, (2010), the soft sediment can adsorb the debris compared to the rocky and gravel area. In that area, the abundance of microplastics from medium to high explains that human activities (tourism) have an impact on the high input of microplastic. The distribution of abundance microplastics map in the sediment sample in Selorejo Reservoir can be seen in Figure 4.

Tabel 1. Total of Microplastics Abundance in The Sediment

Grid	The average microplastic abundance (Partcle/Kg)
Grid 1	4870,83
Grid 2	6704,16
Grid 3	6662,5
Grid 4	7412,5
Grid 5	6900
Grid 6	4966,66
Grid 7	5129,16
Grid 8	9079,16
Grid 9	4912,5
Total Abundance of the Entire Selorejo Reservoir Area	56637,5

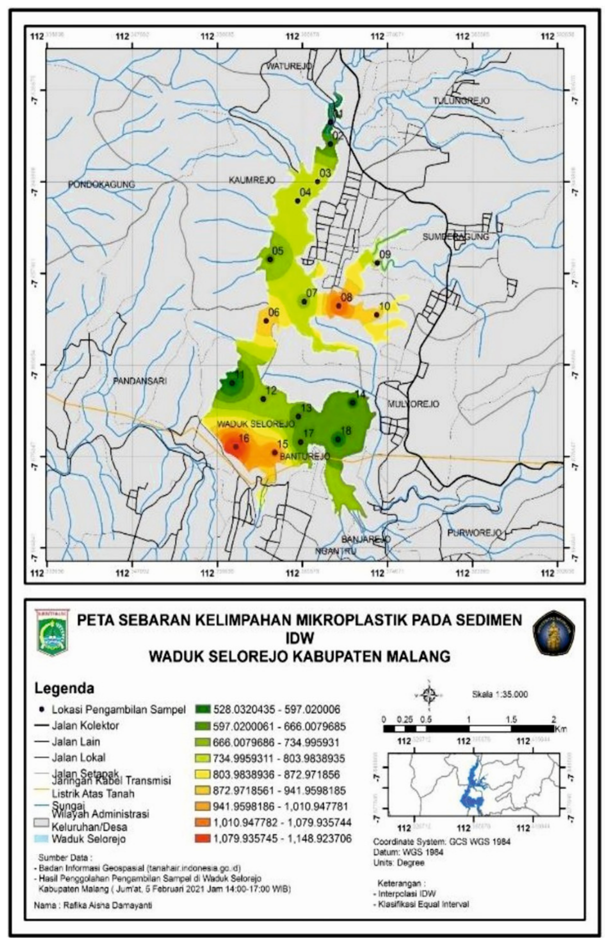

Fig. 4. Microplastic Distribution Map in the sediment of Selorejo Reservoir

The dark green area shows the lowest microplastics abundance compared to other areas, while the red area indicates the highest microplastics abundance than the other areas. According to Triyatno (2014), the sediment distribution is influenced by the wave, tidal, wind, and flow. The sediment transport in the river mouth is caused by the tidal and freshwater river currents. This wave flow distinguishes the sediment transport mechanism on the coast from that of the river. The abundance of microplastic is strongly influenced by their activity and pollutant sources. Waste is a solid matter produced by humans, whether directly or indirectly, thrown or left in the environment. The plastic contamination in the ocean is started from the mainland, then the influence of ocean flow brings the waste (plastics/microplastics) to the remote area (Pawar *et al*., 2016).

Data Analysis of Differences in Sediment Sample Abundance

The number of particles found at each sampling point showed different values so that the microplastics abundance at each point was also different. Data analysis in quantitative research uses statistical data analysis toassist in processing, analyzing, and presenting the data, as well as conclude the research results. The data analysis is conducted to determine the effect of area on the total values of microplastics abundance found at each sampling point. The test of *Analysis of Variance* (ANOVA) is applied in analyzing the effect of area on the total value of microplastic abundance found at each sampling point.

According to the one-way ANOVA test, the significance value of the F Count is 4,310412. Therefore, the value of F count > F Table. Thus it can be concluded that grid (area) significantly affects the total values of microplastics abundance. On the other hand, the result of testing the effect of area on the abundance of microplastics based on the type, namely *fiber*, *film*, *fragment*, and *pellet* found in each sampling point, reveal that grid (area) does not influence significantly affect the abundance of microplastic types of fiber, fragment and pellets but had a significant effect on the abundance of film type microplastics.

FTIR Analysis of Microplastics Sediment Sample

Fourier Transform Infrared (FTIR) is a method that used infrared equipped with Fourier transformation for detection and analysis of the sample spectrum result. In infrared spectroscopy, infrared radiation is passed through the sample, so that some of the infrared are absorbed by the sample and another part is passed or transmitted. The test result by FTIR is in the form of graphs with certain wavelength values. The value of *Fourier Transform Infrared (FTIR)* intends to identify microplastics functional groups detected within the sample. The type of microplastics is identified based on the value of wave peak that shows the functional group of a compound. To discover the compound, the first thing that should be known is to understand how to read the graphic of FTIR. The result of the FTIR test of microplastic sediment samples at Selorejo Reservoir can be seen in Figure 5.

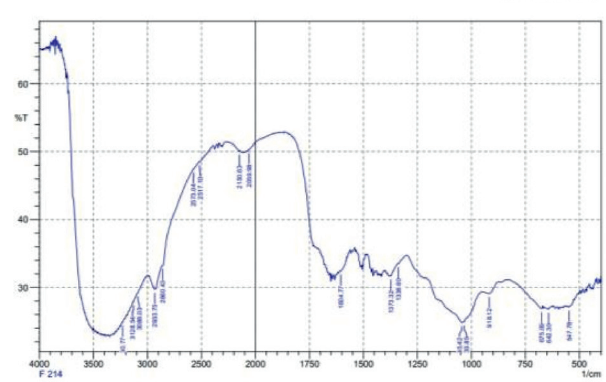

Fig. 5. FTIR Test Results of Selorejo Reservoir Microplastic Sediment Samples

Based on the wave data, there are many chemical bonds in the Selorejo Reservoir sediment. There are chemical bonds that are not expected to be present due to the lack of addition of H_2O_2. A plenty amount of chemical bonds whose detected during the FTIR test is because the sample still contains organic or others materials. The result of FTIR analysis on the sediment sample of Selorejo Reservoir shows several polymers, namely *polyethylene* (PE), *polystyrene* (PS), *polypropylene* (PP), and nylon (PA). According to GESAMP (2019), four types of microplastics that are mostly found in the sediment and ocean are 79% polyethylene (PE), 64% polypropylene (PP), 40% polystyrene (PS), and 17% nylon (PA). As stated by Hiwari *et al*. (2019), the most common types of polymers found in sediment are polypropylene, polyethylene, and polystyrene.

CONCLUSION

The types of microplastics found in the sediment at

Selorejo Reservoir were 42% fragment, 33% fiber, 23% film, and 2% pellet. There are seven colors of microplastic found in Selorjeo Reservoir, namely black, chocolate, red, transparent, blue, green, and purple. Consecutively, the microplastic color in the sedimentat Selorejo Reservoir from the highest is 46% black, 35% transparent, 17% chocolate, 1% blue, 1% red, 0,15% green, and 0,8% purple. The smaller size of the sieve, then the higher the microplastics abundance in eacht ype and color. Microplastic in >600 µm size is 23%, in 250-600 µm size is 29%, and in125-250 µm is 48%.

The abundance of microplastic in each sediment sampling grid, that is grid 1 at 8%, grid 2 at 12%, grid 3 at 12%, grid 4 at 13%, grid 5 at 12%, grid 6 at 9%, grid 7 at 9%, grid 8 st 16% and grid 9 at 9%.

The smaller size of the sieve, then the higher the microplastics abundance in each type and color. Microplastic in >600 µm size is 23%, in 250-600 µm size is 29%, and in 125-250
µm is 48%.

Grid/area has a significant effect on the total number of microplastics at each pointand affects the total value of microplastics and the abundance of film and grid types (area) does not significantly affect the abundance of fiber, fragment and pellet microplastics.

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