The presence of microplastics in the Indonesian environment and its effects on health

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Abstract

Introduction. Microplastics are plastic particles with a microscopic size of <5 mm in diameter. Microplastics are new contamination of the environment and can be bad for health.

Objective. This paper aims to examine the presence of microplastics in the Indonesian environment based on the results of research in 2022 and its effects on health.

Materials and Methods. Systematic review based on the results of research journals published in 2022. Journal obtained from a search on Google Scholar with keywords "microplastics", "microplastics in Indonesia", and "effect microplastic to health".

Results. The results of a review showed that the research location was dominated in East Jawa. The presence of microplastics in the environment in Indonesia is most widely studied, namely in river and sea sediments. The forms of microplastics identified are fiber, fragment, film, pellets, granule, foam, filament, and bead. In microplastic research on the environment in Indonesia in 2022, as much as 16% analyzed plastic polymer types. The study that identified the number, shape, and color of microplastics using visual methods with a microscope was 84%. Research on the effects of microplastics on health is still little done.

Conclusions. Microplastics are widely studied in sediments, water, food, and air. Microplastics in the environment in Indonesia have been identified in number, shape, color, and polymer type. There have not been many studies that have conducted an analysis of the type of polymer. The environment in Indonesia has been polluted by microplastics that can have an impact on health.

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Introduction

Plastic began to be used about 50 years ago. About 500 million to 1 billion plastic bags are used by the world's population in one year. Use of plastic results in an increase in the amount of plastic waste. The increase in plastic waste is due to population growth, plastic consumption and the habit of disposing of waste. Plastics are synthetic and semi-synthetic polymeric materials derived from fossils, coal, natural gas, crude oil and organic products formed at a certain temperature and pressure.[1] Plastics are divided into 3 categories, namely thermoplastics, thermosets, and elastomers.[2] Types of plastics that are widely used include *polyethylene* (PE), *polypropylene* (PP), *polyvinyl chloride* (PVC), *polyethylene terephthalate* (PET), *polyurethane* (PUR) dan *polystyrene* (PS).[3]

PET is mostly used for synthetic fiber materials (60%) and as the basic material for packaging bottles (30%). PVS contains DEHA which can react with food or beverages packed with this plastic. Such reactions can be harmful to the kidneys, liver, and weight loss. PS is an aromatic polymer that can secrete styrene materials. This material should be avoided, because in addition to being harmful to brain health, it interferes with the hormone estrogen in women which results in reproductive, growth and nervous system problems, it is also difficult to recycle. PE plastic cannot be degraded by microorganisms, causing problems in the environment. PP has the characteristics of clear, strong, light weight, low vapor penetrating power, resistant to fat and stable to high temperatures.[2] Plastic can change to a smaller size in the presence of degradation, namely fragmentation and biodegradation. Factors that affect plastic fragmentation are biological, chemical, and mechanical physical factors.[4] Influential biological factors include bacteria, fungi, predators, and higher organisms. Influential chemical factors include hydrolysis and oxidation. Influential physical or mechanical factors such as washing, UV rays, climate, and mechanical pressure.[4] The degradation of plastics into small sizes is called microplastics. Microplastics are plastic particles measuring 1µm–5mm. The presence of microplastics is found in the environment, namely air, soil, fresh water, and seawater. [5] Microplastics are categorized into

primary and secondary microplastics. Microplastics resulting from fragmentation are called secondary microplastics, while primary microplastics are microplastics created for specific applications.[3] Primary microplastics are generally spherical, pelletized, granulated, and foamed. Primary microplastics are used either as resin pellets to produce larger items or directly in cosmetic form such as facial scrubs and toothpaste. Secondary microplastics take the form of larger plastic debris because they form from plastic fragmentation.[6] Microplastics are hazardous and toxic materials (B3). Once released into the environment, microplastics will enter the human body. Humans can be exposed to microplastics through inhalation, ingesti, and adherence. Health problems that can be caused by microplastic exposure include respiratory disorders, cardiovascular, lung cancer, and reproductive disorders. The presence of microplastics in the environment also results in an imbalance in the ecosystem.[6] Microplastic research has been conducted in many countries. The study was conducted with various objectives, including describing the presence and characterization of microplastics in the air.[7–10], analyze the effects of microplastics at the cellular and molecular level.[11–13] The purpose of this study is to describe the presence of microplastics in the environment in Indonesia. In addition, it also describes the results of microplastic identification in the environment in Indonesia and its risks to health.

Materials and Methods

A literature search was conducted to support the discussion of the presence of microplastics in the Indonesian environment, and their impact on health. Literature searches are obtained from various databases of research publications, namely Google Scholar and Science Direct. The keywords used in journal searches are "microplastics", "microplastics in Indonesia", and "effect microplastics to health". The journal source used for review is a journal of research results published in 2022. There are 46 studies that can be reviewed. Journal sources are then reviewed and analyzed descriptively into several components of the review, including research locations, research samples, microplastic forms, types of microplastic polymers, and microplastic analysis methods. The classification of each component of the review can be seen in Table 1. Research is classified based on location, sample, microplastic forms, types of polymer, microplastics analysis method, and effect of microplastic. Then analyzed and calculated the percentage. Presentation of data in the form of graphs and narratives.

Results

Location of microplastic identification in the environment in Indonesia in 2022

The results of a review research journals in Indonesia published in 2022 show research on microplastics in Indonesia has not been conducted in all provinces. The distribution of microplastic study sites is shown in Figure 1. Microplastic research in Indonesia in 2022 was conducted in 15 provinces. Microplastic research in Indonesia in 2022 was the most conducted in East Java province with 10 studies.[14–21] In addition to East Java province, microplastic research on the environment in Indonesia is also carried out in other provinces. Microplastic identification locations in Indonesia in 2022 are sequential from the highest number of studies to the least, namely East Jawa, Central Jawa[22–28], DKI Jakarta[29–32], West Jawa[33,34], Lampung[35–37], South Sulawesi[38,39], Yogyakarta[40,41], East Kalimantan[42], North Sulawesi[43], South Sumatera[44], Banten[45], Central Sulawesi[46], Maluku[47], East Maluku[47,48], and West Papua.[49]

Microplastic in the Indonesian environment

The results of a review of microplastic research journals in Indonesia published in 2022 showed the presence of microplastics in various environmental media. The distribution of the presence of microplastics in the Indonesian environment can be seen in Figure 2.

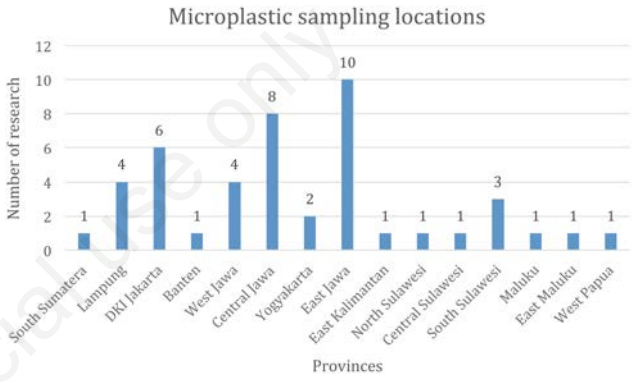

Figure 1. Location of microplastic identification in the environment in Indonesia in 2022.

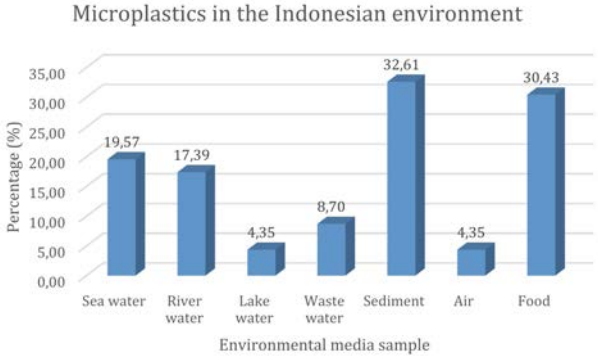

Figure 2. Microplastic in the Indonesian environment in 2022.

Table 1. Journal review classification component.

No.	Component	Classification
1	Research location	Provinces in Indonesia
2	Sample of research	Seawater, river water, lake water, wastewater, sediment, air, and food
3	Microplastic forms	Fiber, fragment, film, pellets, granule, foam, filament, and bead
4	Types of polymer	All types of plastic polymers identified in the sample
5	Microplastics analysis method	Visual and Fourier Transform Infrared (FTIR)
6	Effect of Microplastic	The health effect of microplastics

Sediment was the largest sample used to identify the presence of microplastics in the environment, at 32,61%. The sediments used as samples are taken from the seas[50], rivers, and coastlines. Food is also a widely studied sample of 30,43%. The presence of microplastics in food includes snack, fish[45,51], shellfish[18], and crabs. Seawater samples of 19,57% and river water of 17,39% were also identified for the presence of microplastics. The presence of microplastics in lake water is still slightly studied, namely 4,36%. The wastewater used as a sample is water from the decomposition of waste called leachate water.[41] In addition, domestic waste and industrial waste water are also used as research samples.[52] The number of studies that identified the presence of microplastics in wastewater was 8,70%. The identification of the presence of microplastics in lake water and air is still little studied. The number of studies identifying the presence of microplastics in lake water was 4.35% as well as the number of studies identifying microplastics in the air. The identification of microplastics in the air has not been widely studied by researchers in Indonesia. There are 2 studies that identify the presence of microplastics in the air during 2022.[53,54]

Identification of microplastic form in the Indonesian environment

The results of a review journals that identified microplastics forms in the environment in Indonesia in 2022 are presented in Figure 3.

The forms of microplastics identified in seawater samples include fibers, fragments, films, pellets, granulles, and foams. The shape of microplastics in seawater is dominated by fibers, fragments, films. The forms of microplastics identified in river water samples include fibers, fragments, films, pellets, foams, and filamen. The shape of microplastics in river water is dominated by fragments, fibers, and films. The forms of microplastics identified in lake water samples include fibers, fragments, films, foams, and

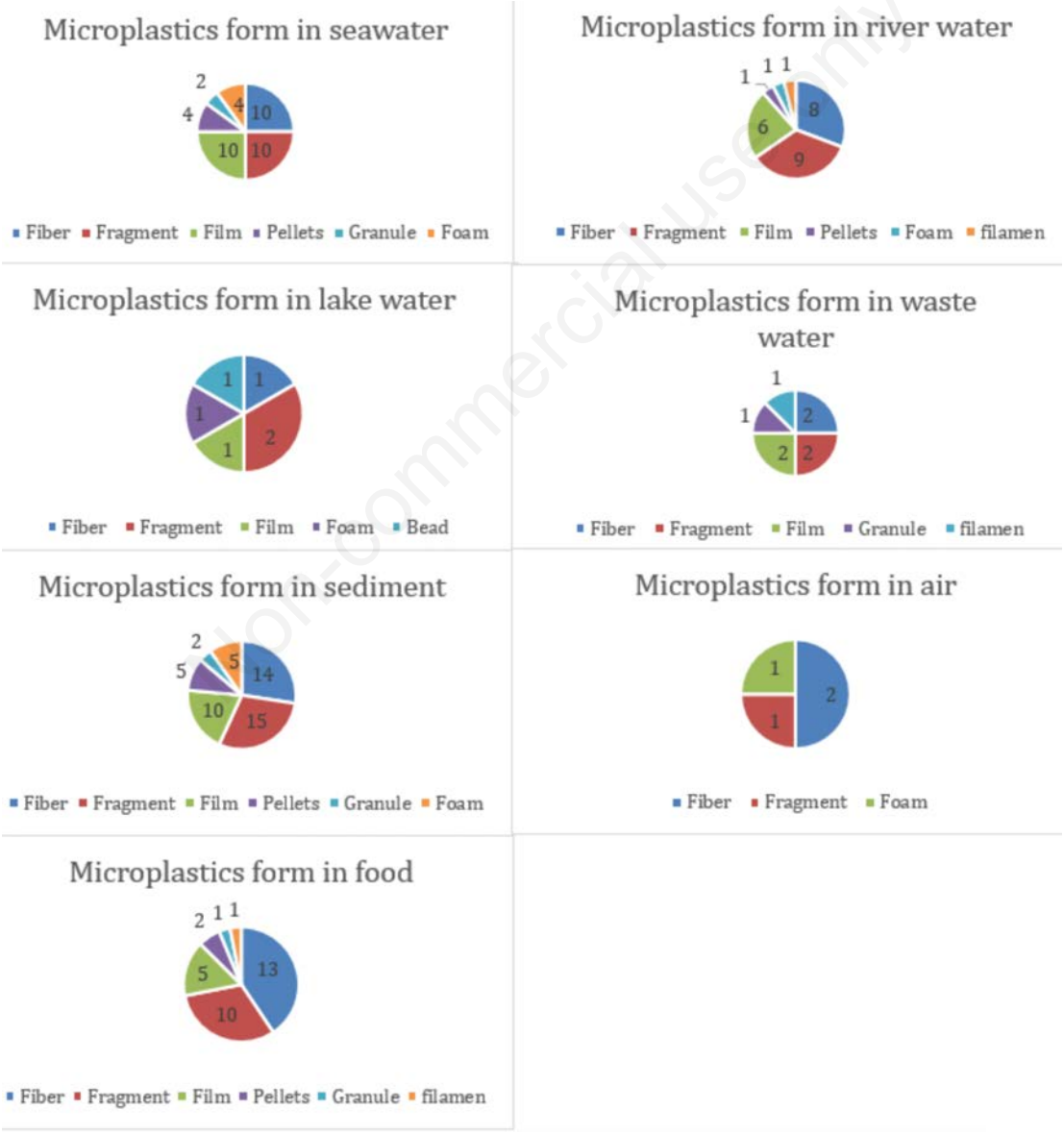

Figure 3. Microplastic form in Indonesian environment.

bead. The shape of microplastics in lake water is dominated by fragments. The forms of microplastics identified in wastewater samples include fibers, fragments, films, granule, and filamen. The shape of microplastics in waste water is dominated by fragments, fibers, and films. The forms of microplastics identified in sediment samples include fibers, fragments, films, pellets, granule, and foam. The shape of microplastics in sediment is dominated by fragments, fibers, and films. The forms of microplastics identified in air samples include fibers, fragments, and foam. The shape of microplastics in air is dominated by fibers. The forms of microplastics identified in food samples include fibers, fragments, film, pellets, granule and filamen. The shape of microplastics in food is dominated by fibers, fragments, and films.

Identification of types of plastic polymers

Based on the results of a review of microplastic research journals in Indonesia in 2022, not all studies conduct polymer type analysis. The study with the aim of analyzing the type of plastic polymer in 2022 as much as 16%, while the remaining 84% only identified the number, shape, and color of microplastics. The types of plastic polymers identified in the sample are Polyethylene (PE), Low Density Polyethylene (LDPE), High Density Polyethylene (HDPE), Polyethylene terephtalate (PET), Polyethersulfone (PES), Polyethylene Terephthalate (PETE), Polystyrene (PS), Polypropylene (PP), Polyvinyl Chloride (PVC), PA, PC, Politetrafluoroetilena (PTFE), Polyvinyl alcohol (PVA), PVDF, PPS, Nylon, Nitrile, Polybutad, Cellophane, Bakelite. The most common polymers found in research samples are PE, PET, PP, PVC, PS, LDPE, and HDPE.

Microplastic identification method

There are 2 microplastic identification methods used by researchers to analyze samples, namely visual and irradiation methods with fourier transform infrared. The methods used to identify microplastics can be seen in Figure 4. As many as 84% of the studies used visual methods to identify the number, shape, and color of microplastics using a microscope. Only a small percentage of studies identified plastic polymer types using fourier transform infrared (FTIR), which was 16%.

Effect microplastics on health

Three studies analyze the effects of microplastics on living things at the molecular and cellular levels. The analysis of microplastic effects performed on test animals. The test results showed that oral exposure to microplastics affects leukocytes in the blood of the test animal.[14,55] Analysis of the effects of microplastics on the human gut microbiome.[56]

Discussion

Sediment, seawater and river water is the most widely used sample in microplastic research. Water biota present in water bodies are at high risk of exposure to microplastics, especially plankton predatory aquatic biota. Microplastics can be consumed by aquatic biota due to their microscopic size.[2] This logic underlies the examination of microplastics in water biota samples. Consumption of microplastics by aquatic biota can result in the entry of microplastic contaminants into the human food chain. Air is the least researched environmental medium for analysis of the presence and characteristics of microplastics. This may be due to the lack of standardized air sampling techniques for microplastic examination. Air sampling also tends to be difficult because it requires a special pump that can suck in air.[5] Compared with research conducted abroad, the presence of microplastics in the air has been identified in several places such as offices, houses, apartments and outdoor air. Microplastics found in indoor and outdoor air in Paris.[8] Microplastics are also found in the air of houses in the city of Sydney, Australia.[9] Identification of microplastics found in outdoor air in the city of Shanghai, China.[57] The presence of microplastics in indoor air is affected by airflow and ventilation.[10]

The presence of microplastics in the terrestrial environment has received less attention than the presence of microplastics in the aquatic environment. This is evidenced by the greater number of microplastic studies in the aquatic environment compared to the terrestrial environment. The distribution of microplastics in the oceans is caused by many factors, including wind, coastline geography, ocean currents, and human factors.[58] The main source of microplastics in the air comes from urban dust and erosion of vehicle tire rubber and synthetic fabric fibers. Other sources of airborne microplastics include building materials, industrial emissions, plastic fragmentation of furniture, particulate resuspension, landfills, traffic particles, waste incineration, dryer exhaust, synthetic particles used in horticultural soils, and sewage sludge used as fertilizer.[8] Microplastics can enter the soil through weathering and disintegration of plastic films on agricultural land, fragmentation of plastic waste and plastic goods in landfills, atmospheric precipitation and wastewater irrigation.[58] Microplastics can enter the body through food. Several studies have identified microplastic contamination in seafood, including drinking water, salt, honey, sugar and beer.[58]

Microplastic forms identified in the sample include fibers, fragments, films, pellets, foams, granules, filaments, and bead. The forms of microplastics found are primary microplastics with characteristics of spherical, pelletized, granulated, and foamed shapes. Primary microplastics originate from human activities that deliberately use microplastics for their applications. According to[2] fragments are microplastic particles that have irregular elongations, crystals, bristles, powders, granules, cuts, and flakes. Fiber is microplastic particles in the form of fibers, filaments, microfibers, strands, and threads. The shape of the microplastics can be seen in Figure 5.

The shape of microplastics can be identified using the method of visual examination with a microscope. The visual method can also be used to calculate the amount of microplastics in the sample. Visual identification is strongly influenced by human bias,

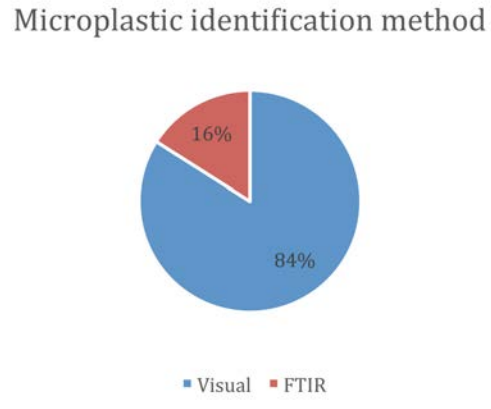

Figure 4. Microplastic identification method.

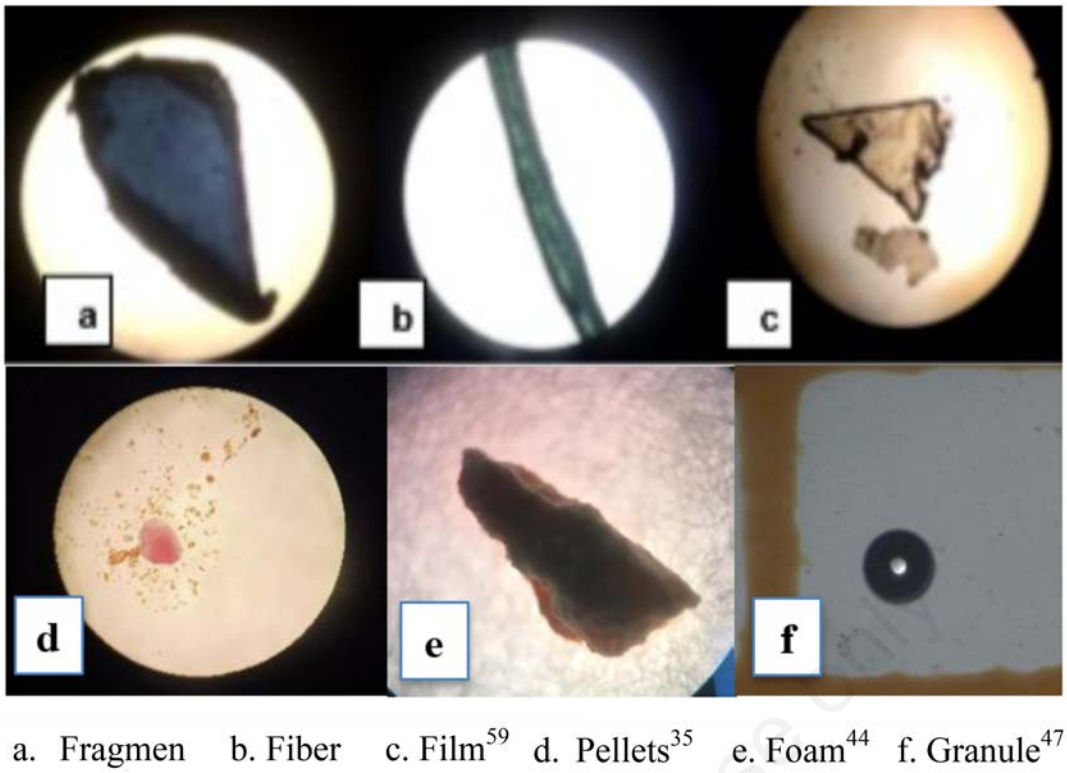

Figure 5. Microplastics form.

microscope quality, sample matrix, and particle size.[5] Microplastic particles measuring >500 µm can be visually identified. The examination visually identifies microplastics by shape and color using a stereo microscope, then confirmed using chemical analytical methods. Guidelines for visually identifying microplastics include:

Plastics do not have a cellular or organic biogenic structure[60]

Removing biofilms, organic matter, inorganics for clear and accurate identification[61]

The shape of the fragments and film is expected to be relatively homogeneous in color level and clear transparent[61]

Long-standing plastic surface are more fragile and weathered with irregular edge shapes[62]

The color of the plastic is identified as transparent, white, orange, bureau, green, purple, and black. Fibers with green, red, and transparent colors need to be checked with higher magnification[60]

The H_2O_2 reaction in sample preparations results in less visible colored plastic particles making it difficult to distinguish from residual biogenic materials[5]

Plastic is a synthetic polymer material, divided into 3 categories, namely thermoplastics, thermosets, and elastomers.[2] Thermoplastic is a type of plastic that can be recycled and reprinted by heating, for example PE, PP, PA, PVC, and PS. A thermoset is a type of plastic that cannot be recycled or reprinted by heating, e.g. PU and polyester resin, bakalite. Elastomers are elastic polymers that can return to their initial shape after being pulled, e.g. rubber and neoprene. Today there are 6 polymers that are widely used, namely polyethylene, polypropylene, polyvinyl chloride, polyethylene terephthalate, polystyrene, and polycarbonate. Each of these polymers has different degradation, heat, light and chemical properties. Polymer identification can be performed by examination using Fourier Tranform Infrared (FTIR). FTIR is widely used to examine characteristics and calculate particles as well as size distribution. Microplastic particles can be checked with FTIR if their size is at least 50 µm. FTIR checks the characteristics of samples with an IR wavelength of 400-4000 cm^{-1} The use of FTIR has several advantages including higher output compared to hot needle analysis and visual analysis, the ability to analyze smaller particle sizes of <500 µm, automatically analyze and determine sample characteristics.[5] In addition to visual and FTIR methods, microplastic identification can also use the raman spectroscopy method. Although raman and FTIR are considered scopy vibration spectro, raman is different from FTIR. Raman uses a higher frequency of 532 nm to stimulate the surface of the material until it emits photons. Photons are usually emitted at a right angle known as raman scattering. The raman method is relatively recently used for the identification of microplastics.[5]

Polymers can be classified into two, namely natural and synthetic polymers. Plastic polymers are synthetic polymers, for example PE, PVC, PC, PS, nylon, silicone rubber, and so on. Each type of polymer has a different density. Density is the time of the type of object that can affect the buoyancy force of the object. If the lifetime of the polymer type is smaller than the time of the liquid or gaseous type of object, then the polymer will float on the surface and vice versa. The type of microplastic polymer with the lowest density is Polypropylene with a density of 0.9 – 0.91 g/cm^3. The type of microplastic polymer with enlarged density is Polyoximetylene with a density of 1.41 – 1.61 g / cm^3.[2] PVC, nylon and PET are more likely to sink in water. Whereas PP, PE, and PS polymer types tend to float or be suspended in the water

environment.[63] Plastics consist of monomers, additives, dyes and other materials of a toxic nature, monomers and harmful chemicals have an effect on health. The use of plastic for food containers can cause contamination of such food dyes. Plastic dyes can decompose when exposed to heat, and degrade into radical forms. The radical form has one unpaired electron, so it becomes reactive and unstable so that it can be harmful to health. PC, PS, PVC type plastics are proven to release toxic monomers that cause effects on the reproductive organs, mutagenesis, and cancer.[64] Many studies have shown that microplastics are able to absorb and accumulate pollutants, such as heavy metals, polychlorinated bisphenyl (PCB) and polycyclic aromatic hydrocarbons (PAHS). This causes concern because the chemicals are mutagens and casinogens. Exposure to microplastics can be an external source of causes of increased free radicals in the body. Free radicals react with surrounding cell molecules to obtain electron pairs so that they become more stable, while the molecules of the body cells that are taken electrons will turn into free radicals. This reaction will continue and if not stopped will cause oxidative stress which causes inflammation, DNA damage, and cell damage resulting in various diseases.[65] Microplastic exposure also affects the increase of leukocyte cells in the blood.[55]

Research on the effects of microplastics on health has not been widely carried out in Indonesia. Experimental research using test animals was conducted to determine the effects of microplastics on health through oral exposure. Higher doses of microplastics with oral exposure lead to increased levels of leukocytes and basophils in the blood of the test animal.[14] The presence of microplastics in the blood results in increased expression of metabolites malondialdehyde and 8-hydroxy-2-deoxyguanosin in hippocampal neurons.[55] In Indonesia, there have been no studies on the effects of microplastic inhalation exposure on health. Research on the effects of microplastic inhalation exposure on lung tissue began to be widely carried out abroad. The presence of microplastics is found in human lung tissue.[66] This suggests that microplastics that humans inhale through the respiration process can accumulate in the lung tissue. Exposure to microplastic inhalation results in an increase in pro-inflammatory cytokines TNF-α and TGF-β in the lung tissue of test animals.[11] The presence of microplastics in the lung tissue can result in acute and chronic inflammation.[63]

Conclusions

The results of a review journals show that research on microplastics has not been evenly distributed throughout Indonesia. Microplastics have been identified for their presence in the environment, including seawater, river water, lake water, wastewater, sediment, air, and food. The identification of microplastics in air media is still little studied, so that it can be the potential for further research. Microplastic forms identified in the sample include fibers, fragments, films, pellets, foams, granules, filaments, and bead. A total of 16% have identified the type of polymer in the sample. The effects of microplastics with oral exposure on health began to be studied using test animals. However, the effect of microplastics on health through inhalation exposure has not been studied in Indonesia. Research on the effects of microplastics is still small so it is necessary to do to determine the acute and chronic effects of microplastic exposure.

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