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Microplastics Found In Rice Consumed By Humans

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Abstract

Terrestrial ecosystems are considered as one of the main sources of microplastic pollution, especially in agroecosystems. Based on the source of microplastic pollution, agroecosystems tend to be the most plastic-contaminated terrestrial systems outside of landfills and urban spaces. As one of the third major ecosystems on earth, wetlands contribute nearly 40% of ecosystem functions and services (i.e., groundwater recharge, nutrient cycling and biogenic habitats). However, wetlands can represent large reservoirs of microplastics from sewage disposal, surface runoff, and plastic waste. Several studies have looked at plastic pollution in groundwater and warned about the dangers of plastic particles in aquatic and terrestrial ecosystems. Various studies have proven the presence of microplastics in several types of food and beverages consumed by humans. Rice is the staple food for most of the global population and is the highest food yield among cereals. Recently a recent study in Australia found that microplastics are present in rice. Rice samples were dissolved using 10% KOH solution with a volume of 50 ml and allowed to stand for 5 days. Next, the sample was observed under a stereo microscope with a magnification of 45 times. The samples that have been identified are then subjected to an FT-IR test to determine the type of polymer contained in the rice. The results of the identification of microplastics found in rice consumed by humans in daily life, namely microplastics in the form of white fragments and red lines. The FT-IR characterization of rice identified the types of polymers Polyvinyl Chloride (PVC) and Polyethylene (PE). This study identified the presence of microplastics in rice consumed by humans. The results of this study can be used as a reference or basis for the development of microplastic research, especially microplastics found in rice.

Keywords: Microplastic, Rice, agroecosystem, Polyvinyl Chloride, Polyethylene.

Introduction

Persistent plastic has a long enough life to survive in the ocean. However, within a certain time plastic will degrade slowly so that it breaks down into small particles with a micrometer size called microplastics [1]. The process of degradation of large plastics into microplastic particles occurs through physical, chemical, and biological processes [2].

Plastic waste that mostly comes from human activities spreads from land and ends up in aquatic systems, both in the sea and in fresh water [3]. According to Auta, Emenike, & Fauziah plastic waste that has been degraded into microplastic particles has even reached oceans, lakes, reservoirs, estuaries, and even polar regions. Not only that, microplastics have also entered the terrestrial ecosystem area.

Terrestrial ecosystems are considered as one of the main sources of microplastic pollution, especially in agroecosystems [4]. Microplastics in agroecosystems can be produced directly through the breakdown of plastic film mulch and greenhouse materials, or indirectly through the use of treated wastewater and biosolids [5]. In addition, Weithmann from their research found that organic fertilizers also have the potential to be a pathway for microplastics to enter the environment. Based on the source of microplastic pollution, agroecosystems tend to be the most plastic-contaminated terrestrial systems outside of landfills and urban spaces [6].

As one of the third major ecosystems on earth, wetlands contribute nearly 40% of ecosystem functions and services (i.e., groundwater recharge, nutrient cycling and biogenic habitats) [7]. However, wetlands can represent large reservoirs of microplastics from sewage disposal, surface runoff, and plastic waste [8]. Several studies have looked at plastic pollution in groundwater and warned about the dangers of plastic particles in aquatic and terrestrial ecosystems [9]. Microplastics can be easily ingested and accumulate in living organisms (such as shrimp, fish, zooplankton and mammals), potentially affecting their fitness and survival.

In addition, microplastics in groundwater are also able to inhibit the growth of microalgae scenedesmus obliquus. A study conducted by [10] showed that five types of suspensions of polystyrene particles with different sizes and surface charges resulted that the 50% growth inhibition rate of S. obliquus showed no significant difference between the five types. microplastic, but the toxic mechanism varies with particle size. Larger microplastics cause adverse effects by blocking light transport and affecting photosynthesis, while smaller microplastics destroy cell walls by adsorption to the algal surface. The accumulation of ingested polystyrene microplastics in the digestive organs (catching and digesting prey) causes a significant delay in the growth rate of aquatic plants [11].

According to [12] microplastics can also cause physical damage to plants, because they can accumulate in seed pores, limiting germination, growth and reproduction. In addition, microplastics have strong effects on plant growth, rhizosphere microbial community composition and structure, soil enzyme activity and soil properties in agroecosystems [13]. Microplastics can alter the structure and metabolic status of microbial communities and thus have a significant impact on the C cycle in agroecosystems. The presence of microplastics in soil is not benign so every step should be taken to minimize their entry into the soil ecosystem and their potential to move up the food chain [14]. Plastic particles can interfere with nitrogen removal in artificial wetlands by inhibiting nitrogen uptake [15].

To date, microplastic contamination has been found in various foods and beverages. A study conducted by Oliveri et al found that there are microplastics in vegetables and fruits that are commonly consumed in everyday life. Microplastics can enter carrots through the plant roots and up to the leaves [16]. Another study conducted by Kosuth et al. (2018) also found microplastics in tap water, seawater, and beer. Microplastics are also found in sugar and honey [17] even on milk [18] and table salt [19].

The various studies above have proven the presence of microplastics in several types of food and beverages consumed by humans. Recent research in Australia has found that microplastics are present in rice [20]. This study is the first study to find plastic contamination in rice or rice plants.

Rice is the staple food for most of the global population and is the highest food yield among cereals providing >20% of human dietary energy worldwide especially in Asia, parts of Latin America and the Caribbean, and Africa [21]. Indonesia as an agricultural country has the characteristics of a population, most of which work in agriculture. This makes Indonesia a major producer of agricultural products [22].

Currently, most of the rice available to consumers is packaged in plastic packaging using either plastic packaging (plastic bags) or plastic-based sacks. Plastic contamination in rice, one of which comes from packaging made of plastic. Micro and nano-sized plastics are considered as contaminants that cause concern for environmental and human health because of their small size and are ubiquitous. Microplastics are plastic particles that are less than 5 mm in size [23]. The impact caused by microplastics can cause environmental contaminants that threaten food safety. The presence of microplastics in various types of food poses a threat to the food chain that leads to human health problems.

Methods

Sampling Strategy

Rice was taken from two different places in April 2022 at the homes of two respondents who were willing to provide samples of the rice consumed daily. The two samples are rice that has been cooked into rice using a rice cooker. Before the rice is cooked, the rice is rinsed first using PDAM water 3 times. It aims to clean rice from dirt or harmful substances contained in rice. After the third rinse is removed, the rice is then added with water and put into the rice cooker. After the rice has been cooked into rice, then it is put into a glass sample bottle. Before the bottle is used, it must be rinsed with aquabidest to clean and remove the particles contained in the bottle. Each rice that has been in a glass bottle has a different weight, namely bottle 1 contains 3gr and bottle 2 contains 5gr. The sample is then taken to the laboratory for analysis.

Reagents and Materials

KOH solution with a concentration of 10% was added to each sample bottle of 50 ml. After that, it was closed and allowed to stand in the sample bottle at room temperature for 5 days. Before the identification process is carried out, each tool to be used is rinsed using aquabidest. Aquabidest is pure water produced from a multilevel distillation process (twice the distillation process) used to clean the particles attached to the equipment to be used. The tools to be used include: sample bottles, spoons, petri dishes, tweezers, and pins.

Quality Control

Particular care was taken during the experiment to minimize contamination of microplastics by particles from the laboratory environment. All materials to be used are covered with aluminum foil until used. Likewise, samples that are not processed or have been processed will be covered with aluminum foil.

Researchers made blanks as a form of control that the environment in the laboratory is maintained and free from microplastic. The blank used a petri dish containing distilled water and was placed in the laboratory during the analysis process. Blanks are placed next to the sample, during sample processing to measure possible contamination from the environment around the sample to be analyzed.

Sample Treatment

Rice that has been cooked using a rice cooker is put into a sample bottle. Samples were divided into two types, namely samples weighing 3gr and samples weighing 5gr. This aims to see if there is a difference between the volume of rice and the process of dissolving the rice after being given a 10% KOH solution. To isolate microplastics, samples need to be processed by removing natural organic matter. Recently, 10% KOH has been shown to be suitable for this purpose as it degrades natural organic matter without degrading most of the polymers with the exception of some changes in cellulose acetate (CA) and polyamide (Foekema et al, 2013; Dehaut, et al., 2016). After being put into the sample bottle, it was immediately closed and taken to the laboratory. The rice sample was given additional 10% KOH solution until it melted into a thick liquid for further analysis.

Figure 1.
Sample rice that has been dissolved

Figure 2.
Blanks (Control Variables)

Analysis

The rice sample that had been prepared in the bottle was added with a solution of 10% KOH with a volume of 50 ml. The sample was then allowed to stand at room temperature for 5 days [24]. After 5 days, the sample was poured into a petri dish and observed with a stereo microscope (45x magnification). The microplastics found were then taken from the sample and their shape characteristics were determined based on GESAMP, 2019. Each microplastic found was photographed and the length was calculated using the measure feature in the Image J software.

Meanwhile, to control microplastics originating from the laboratory room, the researchers prepared blanks (control variables) which were stored in the laboratory during the data identification process. The process of identifying microplastics in rice in the ecotoxic laboratory took 10 days. The rice sample which was left for 5 days was then opened and slowly poured into a petri dish to be identified under a microscope with a magnification of 45 times. During the process, the blanks that have been prepared in the petri dish are opened until the identification process is complete. After all samples have been analyzed, then proceed with the blank analysis process.

Table 1. Microplastic Characteristics Data on Rice Samples

Sample Code	Characteristics of MPs		Number of MPs	Magnification (10*)	FT-IR
	Shape	Color			
T3	Fragment	White	1	4,5	Polyvinyl Chloride (PVC)
T5	Line	Red	1	4,5	Polyethylene (PE)
Blanks	None	None	0	4,5	None

Results and Discussion

The results of the identification of microplastics found in rice consumed by humans in daily life are shown in table 1. Both rice samples were detected with microplastics in the form of white fragments and red lines. The FT-IR characterization of rice identified the types of polymers Polyvinyl Chloride (PVC) and Polyethylene (PE).

Figure 3.
Transparent Fragments

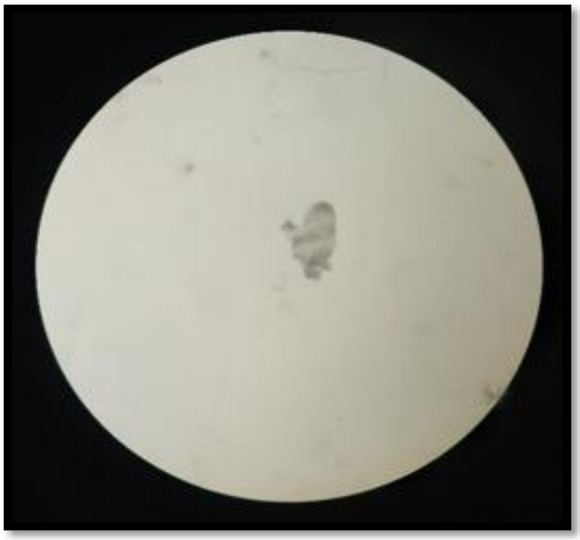

Figure 4.
Red Line

Polyethylene is one of the polymers found in the rice samples analyzed in this study which is also the most common plastic found in the environment. This type of polymer has quite a wide application, especially as packaging containers, such as food packaging containers, plastic bags, baby bottles, facial cleansing gel bottles, packaging foams, plastic bowls, Ziploc bags, packaging films, grocery bags, mulch. Agriculture [25].

Meanwhile, PVC is the third type of polymer in the world in terms of the number of uses. This type of polymer has a very wide application, including being used as a material for household exhaust pipes, leather-like clothing materials (making jackets, coats, and bags), electrical wires that must use plasticizers to make them more elastic (UNEP, 2016), pipes, ducts, house walls, window frames [25]. Based on this statement, it is suspected that the PVC polymer found in human feces originates from clothing fibers that are accidentally ingested. Apart from that, it can also come from drinking water which is treated with a piping system.

The microplastic identification process was not only carried out on the two samples, but also identified the blanks containing the aquabidest and resulted that there were no microplastics in the blanks. This indicates that there are no microplastics in the rice sample analysis area. Thus, it can be concluded that the microplastics found in the rice samples were not affected by the area or location of the sample analysis. The blank identification process was carried out after all rice samples had been identified with a microscope.

Sources of Microplastics

This research is in line with previous research conducted by Dessi regarding Plastics contamination of store-bought rice. Not only that, various other studies have also found microplastics in food and beverages consumed by humans. Plastic polymers can be measured in 100% of the rice samples analyzed. However, due to the limitations of the researchers, this study did not test other sources of microplastics, such as rice sacks and water used to cook rice.

Sources of microplastic pollution can come from wastewater treatment plants, large plastic fragmentation, solid waste management, aquaculture, runoff, agriculture, fisheries, or industrial plants. Microplastics spread from the remains of human activities on land and end up in the oceans [26].

Marine pollution from natural sources, such as floating vegetation or volcanic ash deposits (tuff), is common in the oceans. However, there is pollution originating from human activities which has increased substantially, especially in the last hundred years. Garbage pollution, from non-natural sources is usually defined as persistent solid material, which is created or disposed of or left in the marine and coastal environment [1]. This includes goods manufactured or used by people and intentionally disposed of or lost accidentally directly into the sea, or on the coast, and materials transported into the marine environment from land by rivers, drainage or sewage systems or through the wind. These objects can consist of metal, glass, paper, cloth or plastic. Of these various objects, plastic is considered the most abundant and the most problematic (GESAMP, 2015).

The issue of ocean pollution by microplastic particles has opened many people's eyes to the potential dangers that target marine life and humans due to indiscriminate dumping of plastic waste into the sea. Without realizing it, the use of plastic packaging and other materials containing plastic has triggered the accumulation of plastic waste in the oceans due to the absence of good waste management. Plastic pollution in the environment today has become a serious problem. Although plastic is persistent, it can degrade over time into smaller particles. Plastic waste is found floating in the sea, can be degraded by ultraviolet light, heat, microbes, and physical abrasion into plastic flakes [27].

Impact of Microplastics on Agroecosystems

Microplastics have spread throughout ecosystems, both in the sea and on land. The impact of microplastics on the oceans has greatly affected environmental conditions and the survival of marine biota. Not only that, nowadays microplastics have had a lot of negative impacts on the terrestrial environment. Recently, [5] reviewed the source and fate of microplastics in the terrestrial environment, and found that primary and secondary microplastics tend to be ubiquitous, in all compartments of terrestrial and freshwater environments due to their proximity to most point sources and sources. spread. It is a fact that more than 80% of plastic pollution that arrives in the oceans is produced, used, and often dumped on land [28].

Primary and secondary microplastics that enter the environment will survive and continue to be fragmented into smaller particles. These smaller fragments tend to pose a greater risk to the health of the organism due to the possibility of increased absorption, increased surface area for interaction with chemicals and a larger number of particles per unit mass mass. The absorption starts from the soil as a planting medium or a place to live for the plant. Land is the center of production and food security. The role of soil in determining the composition of food for living things on earth is very important, especially agricultural soil which has been considered a major absorber of microplastics (Boots et al. 2019).

Various sources of microplastics entering agricultural soils, plastic films and compost applications are thought to be significant sources of the dominance of heterogeneous fragments and films in terrestrial environments [29]. A study conducted by [5] showed that plastic pollution in the terrestrial environment is about 23 times greater than that in the ocean. This means that plastics have spread widely on agricultural land and pollute agroecosystems.

Microplastic contamination in terrestrial ecosystems may be 4–23 times greater than in oceans [5]. According to [6] Soils can store even more microplastic debris than ocean basins. Microplastics can enter the soil environment in a number of ways. The accumulation comes from adding organic waste to the soil (e.g., compost, biosolids) which has the potential to be contaminated with plastics and the use of plastic mulch covers is the most common input to soil [30].

Microplastics that enter agroecosystems are produced (e.g. in aqueous paints, medical applications, electronics, coatings, adhesives), or indirectly as secondary microplastics and nanoplastics produced by the breakdown of larger plastic debris [31]. Recently shown degradation photos of recovered marine microplastic debris [32].

The direct sources of microplastics in agriculture are plastic mulch films and greenhouse materials and soil conditioners (eg polyurethane foam and polystyrene flakes). Plastic films have been widely used as shed greenhouse or mulch films. Over the past few decades, plastic mulch film is a technology driven to promote resource efficiency and food security [33]. Research conducted by von Moos et al. (2012) estimated that in 2016, there were 4 million tonnes of agricultural plastic film on the global market, its value is expected to increase at an annual rate of 5.6% by 2030. However, due to its thin characteristics (8-50 m thick) and lack of plastic recycling facilities, residual plastic fragments will form sustainable macro, micro and nano plastics in the soil through tillage, UV irradiation, and biodegradation [35].

Meanwhile, indirect sources include general waste disposal and the use of treated wastewater and biosolids [5]. According to [6] Microplastic and nanoplastic emissions per capita vary widely between regions because they are influenced by population size, prosperity, existence, and the efficacy of waste management practices.

A laboratory study has shown the adverse effects of plastic particles mainly caused by mechanical and chemical damage; for example, polystyrene microplastics can block light transport and affect photosynthesis in microalgae [10]. The accumulation of ingested polystyrene microplastics in the digestive organs (catching and digesting prey) results in significantly reduced growth rates in aquatic plants [33]. The presence of microplastics in the terrestrial environment is also able to inhibit root growth, photosynthetic activity, and cell viability in freshwater floating plants (Lemna minor and Spirodela polyrhiza) [34].

Not only that, in terms of physical damage, microplastics can accumulate in the pores of the seeds, limiting germination, growth and reproduction [12]. Microplastics also have a strong influence on plant growth, rhizosphere microbial community composition and structure, soil enzyme activity and soil properties in agroecosystems [13]. Microplastic particles can alter the structure and metabolic status of microbial communities and thus have a significant impact on the C cycle in agroecosystems [33]. Another impact that can be caused by microplastics is to interfere with nitrogen removal in artificial wetlands by inhibiting nitrogen absorption [15].

Microplastics provide many benefits for agricultural soils. However, these benefits are estimated to outweigh the potential disadvantages as microplastics can pose a threat to individuals, populations, communities and ecosystem functions [35].

Impact of Microplastics on Human Health

The presence of microplastics that are getting closer to the environment and human life makes special concerns about the survival of ecosystems in the future. Microplastics that are now being found everywhere not only have a bad effect on the environment. Various bad impacts caused by microplastics in damaging the environment, in fact are now affecting the survival of marine biota, plants, and even humans [36].

One of the entrances for microplastics into the human body is through the consumption of foods containing microplastics. A recent study conducted by Cox, et al (2019) found that there are 1.44 MPs/g in seafood, 0.44 MPs/g in sugar, 0.11 MPs/g in salt, 0.03 MPs/g in sugar. found in alcohol, and 0.09 MPs/g was found in bottled water. Humans can also assume an estimated intake of 80 g of microplastics per day through plants (fruits and vegetables) which accumulate microplastics through absorption from polluted soil [37]. The basic human diet includes fruits and vegetables, meat, fish, cereals and legumes, and water as the main source of hydration for microplastic contamination [38].

The very small size of microplastics and their abundance in the oceans make them ubiquitous and bioavailable to higher aquatic organisms. As a result, microplastics can be eaten by marine biota [39]. This concern is caused by the very small size of microplastics, so that it is possible for microplastics to enter the body of marine biota such as fish and bivalves, as a result these pollutants can enter the aquatic food chain system. Thus, the presence of these plastic pollutants in seafood consumed by humans can pose a food safety risk [40].

Rice is one of the most important staple crops because it is a source of food for almost half of the world's population. This plant is widely cultivated throughout the world and especially in Asia [41]. This study has shown the presence of microplastics in rice that is consumed by humans, so that the entry path for microplastics is increasingly wide open.

Increasing evidence suggests that microplastics are being integrated into widely consumed foods through animals ingesting microplastics in the environment [42], contamination during production [43] and/or contamination by plastic packaging [44]. Microplastic particles (MPs) less than 130 m in diameter have the potential to translocate into human tissue, trigger local immune responses, and release constituent monomers, toxic chemicals added during plastics production, and pollutants absorbed from the environment, including heavy metals and pollutants. persistent organics such as polychlorinated biphenyls (PCBs) and Dichlorodiphenyltrichloroethane (DDT).

Microplastics can harm humans both physically and chemically. According to EFSA (2016) the human body's excretory system is capable of removing microplastics, by removing >90% of ingested micro and nanoplastics through feces. Factors affecting retention and clearance rates are size, shape, type of polymer, and chemical additives of microplastics ingested by humans [45].

Meanwhile, the severity of side effects resulting from exposure depends on the nature of the toxic chemical, exposure characteristics, individual susceptibility, and hazard control. The physical effects of microplastic accumulation are subject to further review than the distribution and storage of toxins in the human body, but preliminary research has shown several potential effects, including increased inflammatory response, toxicity related to plastic particle size, chemical transfer of adsorbed chemical pollutants, and disruption of the gut microbiome.

Plastic particles that enter the human body can be in the form of micro or nano. The oral exposure pathway of nano plastics is transported by M cells, mucosa-specific epithelial cells, from the gut into the blood carried through the lymphatic system and to the liver and gallbladder. Their size and hydrophobicity allow them to cross the placenta and the blood-brain barrier and enter the gastrointestinal tract and lungs, potential sites for damage [46]. Its large surface area to volume ratio makes it potentially very chemically reactive, more so than some microplastics. Research studies have demonstrated in vitro toxicity to lung, liver, and brain cells (GESAMP, 2016). The systemic distribution of oral exposure to nanoparticles has been shown to have multiple effects: cardiopulmonary response, alteration of endogenous metabolites, genotoxicity, inflammatory response, oxidative stress, effects on nutrient absorption, gut microflora, and reproduction [17].

Conclusion

This study identified the presence of microplastics in rice consumed by humans. The results of this study can be used as a reference or basis for the development of research on microplastics, especially microplastics found in rice as the staple food for most people in the world. As we know that food is one of the entrances for microplastics to the human body. Several studies show some of the risks that can arise in the future. For this reason, researchers hope that we can all change lifestyles that are more environmentally friendly so that there is a balance of ecosystems properly.

Indication for Further Research

This research is a qualitative research which is limited to the description of one variable. The results of this study became the basis for finding a method for identifying microplastics in rice. Furthermore, the variables studied can be developed and the control variables can be further expanded to minimize biased results in a study

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