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Oxoplastics, Bioplastics, and their Potential of Microplastics Generation (Case Study: Indonesia)

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Abstract: Plastics are still becoming a popular topic in public news. This was initiated by some sea-animals that was trapped by plastic straws, plastic fishing net, and other plastic packaging. These plastics problems are starting to become a global issue and escalate the awareness of people to reduce the use of the plastics. Some campaigns for reducing plastic use are varied, such as starting a zero-waste lifestyle, banning plastic bags, and the other solution is using degradable plastics. Degradable plastic that commonly being used is oxoplastic. Oxoplastic is plastic with some additives that increase its degradability. However, with the increasing issue of microplastics, these degradable plastics were still skeptical from some academic perspectives. The other solution is using biodegradable plastics or bioplastics. This bioplastic is said to be a better option because it is made from a natural substrate that easily degrades, is edible, and is claimed to be safer for the environment. But this claim still needs further research and also standardization of biodegradability definition. This review will provide the definition of biodegradable plastics, the differences between oxoplastics and bioplastics; the implementation of bioplastic or oxoplastic products in Indonesia, and issues related to microplastic generation.
Keywords: biodegradable, bioplastics, microplastics, oxoplastics, waste management

1. Introduction

Plastic production in the world are increasing since 1950 until now. Unfortunately, most of the plastic waste only ended up in landfill, and only a small percentage of plastic that recycled and incinerated [1]. In addition, Indonesia is the second highest contributor of plastic waste to the environment [2]. The report from National Plastic Action Partnership (NPAP) in 2020 showed that the recycling rate of plastic in Indonesia was about 10% of the total 6.8 million tonnes of plastic waste generation [3].

Plastics are one of materials that cannot be separated from our life. Most plastics are designed with complex stabilizers that can slow the degradation process. However, this stability more or less becomes a challenge in the environment. Some types of plastics such as polystyrene (PS), polyethylene (PE), polypropylene (PP), and polyethylene terephthalate (PET) are persistent in the environment and hardly degradable [4].

Some researchers are trying to solve this problem by producing some plastics that are easier to degrade. These plastics are known as degradable plastics. The degradable plastics can come from fossil fuel that has been added some additives. The other types of plastics are natural-based polymers which are known as bioplastics that design can be ingested by microorganisms easier.

However, both of degradable plastics and ordinary plastics can have very slow fragmentation into small particles through physical, chemical, and biological degradation processes. This small fragment nowadays was known as microplastic that could have potential damage to the organism [4].

This review will provide the rapid introduction of degradable plastics comparing oxoplastics and bioplastics, and their development of implementation and challenges in Indonesia. This review will also highlight the potential of microplastic generation on both the plastics type.

2. Methods

The methods are literature review from journal articles, proceeding, books, websites, and a thesis regarding bioplastic, oxoplastic, and biodegradable plastic in recent years. The keyword, “bioplastic”, “biodegradable plastic”, and “oxo plastic” are used to search in the literature. From the literature found, the pros and cons will be discussed.

The review will discuss bioplastic as biodegradable plastic, followed by a comparison with oxoplastic. After that, the microplastic generation issue will be explored from a waste management perspective in the Indonesia case study (Figure 1).

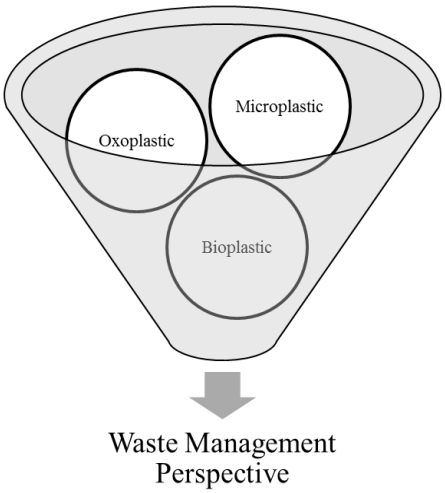

Figure 1. Schematic diagram of the Review Process

3. Results and Discussion

3.1 Bioplastic as Biodegradable Plastics

Bioplastic is a bio-based plastic that was synthesized from biomass. Example of bioplastics that are commo used is Poly (lactic acid) (PLA), Polyhydroxyalkanoate (PHA), and Starch based plastics. Bioplastics are considered to be more environmentally friendly materials than the other types of plastics because the biodegradation process from bioplastic can utilize CO_2 and H_2O [5].

However, there are some weaknesses of bioplastics. Bioplastics still have poor mechanical properties and high production costs. Some solutions for these issues is using waste as a source of renewable resources, such as agricultural waste, so it can reduce the cost [5].

Many types of bioplastics has been researched in Indonesia [6]. Bioplastics were made by a government research institutes, universities, and also from the private company [6]. For example, biodegradable plastic that was made from different types of raw material, such as kapok banana weevil [7], high sweet potato starch [8], durian seed [9], cassava [10][11], palm empty fruit bunch [12]. and even from bamboo [13].

Mostly the research on bioplastics in Indonesia is using a different types of starch source biomass [14], with different compositions of additives such as chitosan, glycerol, or sorbitol. Those additives can influence in the characteristics of bioplastics [15].

However, the implementation of bioplastics into the industry is not so massive in Indonesia. Companies that their main business in bioplastic is not much in Indonesia. For example, Telobag [16], Ecoplas [17], Avani Eco [18], and Envi Plast [19], that using cassava as their raw material (It can be seen in Table 1 and Figure 2). The weakness of these industries compared to the conventional plastic companies is the competitive price. The price of bioplastic is much higher compared to conventional plastics [20].

Table 1. Price comparison of some bioplastic products

No	Company name	Est. time	Product Based	Price range (IDR)
1	Telobag	2016	Cassava	22000
2	Ecoplas	2019	Cassava	Not mentioned
3	Avani Eco	2014	Cassava / Corn Starch	73000-85000
4	Envi Plast	2011	Cassava / Corn Starch	Not mentioned

For future development in Indonesia, other researchers said that we need a consortium which consists of researchers, governments, NGOs, and industry to define the roadmap of bioplastic implementation together [20].

3.2 Oxoplastic as Degradable Plastics

Oxo-degradable plastics are made of petroleum-based polymers and contain additives that catalyse the degradation process. The oxoplastic will become brittle and fragment into smaller pieces [21]. Example of additives is transition metal salts of carboxylic acids and dithiocarbamates. Oxoplastic can be found for agricultural use, or packaging [4].

However, some of the oxoplastic research found that the process of degrading the oxoplastic needs some special condition [19]. Even in compost, anaerobic digestion, and soil burial environments did not give any significant decrease in biodegradation [21]. The example of oxoplastic with texposure to heat, light, and oxygen, disintegrates only into small fragments not completely into CO_2 and H_2O [22][23][24]. In other studies, oxoplastics found can be degraded in the environment if only has a small molecular weight [25].

The faster degradability process of oxoplastics becomes an interesting point for the industry to make them like “green industry” because they will reduce the use of conventional plastics. But on the contrary, the oxoplastics themselves were found not degraded entirely in the environment [22]. These pros and cons of oxoplastic are still becoming a concern in the world, even some country ban using oxoplastic such as European Union [26], but other country keeps using the oxoplastics like Saudi Arabia [25].

Figure 2. Telobag [16], Ecoplas [17], Avani Eco [18], and Envi Plast product [19]

In Indonesia, some companies produce oxoplastic, such as Oxium [27] (Figure 3). Oxium has been used in many other manufacturers such as for plastic bags in the minimarket, or other industries.

Figure 3. Product of Oxium

3.3 Microplastic Issue in Bioplastics and Oxo Degradable Plastic

Microplastic is a plastic polymer with a diameter of less than 5 mm [28]. This common definition has been used worldwide even though there are some common justifications. Such as, microplastic is only for synthetic chemicals not natural polymer, and the definition of minimum length of microplastic range from 1 µm – 5 mm, because lower than that, we define it as nanoplastic [29][30].

Based on that definition, microplastic can be potentially released from large plastic if the degradation process is just make the plastic to become smaller fragment. Even from plastic that made from biological process, such as Bio-PS, Bio-HDPE, they also can generate microplastic [31].

Microplastic has been widely researched and found will potentially have several impacts, such as reducing food intake, delaying growth, causing oxidative damage, etc [32]. Microplastic was already found everywhere from the river [33], air [34], drinking water [35], and even in the human placenta [36] and lungs [37].

In Indonesia, there were also much research about microplastics, especially on Java island, most about the occurrence of microplastic in freshwater, marine water, and organism [38]. This occurrence of microplastics is also found in human stools collected from a fisherman community in the coastal area of Surabaya, Indonesia [39]. This indicates that microplastic has been widely spread in the environment and even in the human body.

In this case, oxoplastic, which we define as degradable plastics can potentially release microplastics. This can happen from the degradation process which is caused by physical or chemical interaction. There is research that mentions that oxodegradable release fragment [26]. Some paper discuss that the particle releases from oxoplastic was not microplastic but only microparticle. However, with the definition of microplastic itself, and the source of oxoplastic that come from synthetic polymers, like the other conventional plastic [38], the

particles are more likely to be defined as microplastic.

However, the definition of microplastic is only limited to synthetic material/polymer. Bioplastic or biobased plastic can also be defined as a synthetic polymer. Therefore, the fragment that releases from the degradation of bioplastic can also be mentioned as microplastics. For example, PLA and PBS bioplastic were found to release many microplastics [39] (Figure 4).

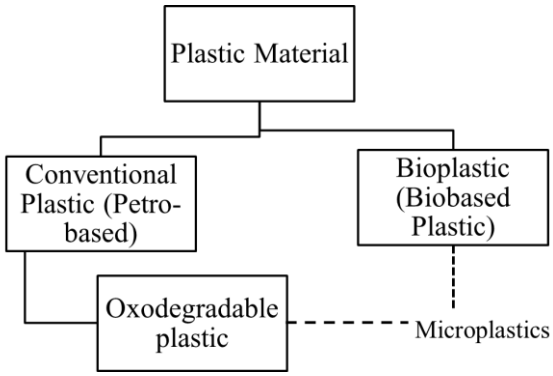

Figure 4. The Potential release of microplastic from both oxoplastic or bioplastic

This can happen because bioplastic will degrade to biomass, CO_2, and H_2O, but before the steps, there is biodeterioration steps that the growth of microorganism inside or on the surface of polymers, and then continued with the biofragmentation process [40] (Figure 5). If the biofragmentation did not occur entirely, the microplastics will be released [40]. However, there is a need to identify if the microplastics from bioplastic will have same impact as petrochemical microplastics or not [5].

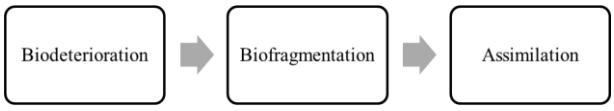

Figure 5. Biodegradation process [41]

3.4 Waste Management Perspective

Improper waste management especially municipal waste management is related to the usage of bioplastic or oxoplastic as the alternative solution. Because one of the causes of the increasing of plastic waste in the environment is improper solid waste management.

Especially in Indonesia, although there are regulations in Law No. 18 of 2008 about Solid Waste Management, Presidential Regulation on National Policy and Management Strategy of Household Waste and Household-like Waste, and Presidential Regulation on Marine Debris Management that mentions the target to reduce 70% of plastic pollution by 2025, the actual daily practice of solid waste management hierarchy is mainly still traditional with collect, transport, and disposal to landfill [42] (Figure 6). All the solid waste is mixed without any proper classification. The solid waste is only brought into landfill, and probably the plastic waste which in this case, bioplastic or oxoplastic will also end up in the landfill.

Figure 6. Traditional Waste Management Hierarchy in Indonesia

The degradable plastics that ended up in landfill will not degrade easily, this is because the degradation of oxoplastic or bioplastic in the environment is needed special conditions. Some of the research in Mexico tried to measure the degradability of several types of plastics in landfill, and it is mentioned that oxo-degradable and compostable plastics will not biodegrade readily in landfills [43]. In a different study, also mentioned that the pro-oxidant PE only made holes on the surface of the plastics [44]. Thus, the microplastics from the degradable plastics will potentially release in the environment [45].

Both oxoplastics and bioplastics will not become the solution if the after-use and recycling facility for degradable plastics are not developed. This degradable plastics solution still needs to be further researched followed by the improvement of solid waste management in Indonesia.

Some of the improvement is implementing the regulation itself, the Law No 18 of 2008. The regulation of Solid Waste Management and Plastic management is needed to be implemented, not just the regulation without the power. The aspect of solid waste regulators, community participation, and financial support is needed to focus on. After that, any kind of solid waste facility and technology will be useful, including the biodegradable plastics innovation. Then finally, if the solid waste management condition is improved, then maybe the circular economy or green circular economy will occur [46].

4. Conclusion

From the discussion, it can be seen that bioplastic and oxoplastic implementation in Indonesia is just starting. Oxoplastics is fuel-based, but bioplastics are natural-based. From the quality and the price of the product, bioplastics need to be improved. But bioplastic is said to be better for the environment because it will biodegrade into CO_2, H_2O, and biomass. However, both degradable plastics have the potential to release microplastic from the degradation process. The effect of microplastic on bioplastic is still needed to be further researched whether will have the same effect as petrochemical microplastics or not. However, if we want this degradable plastic to become

the solution for plastic waste pollution, the improvement of solid waste management to collect the degradable plastics and recycle them properly is needed to be taken into account so the microplastic released will be prevented.

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