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PALM BIOMASS-BASED BIOPLASTICS AS A SUBSTITUTE FOR PETROPLASTICS

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RESUME

The production and consumption of petroplastics worldwide have led to an accumulation of plastic waste that threatens the sustainability of the global ecosystem. The world community must take a major step to end the era of petroplastics and transform towards the era of bioplastics as soon as possible. The Palm Oil Research Grant (*Grant Riset Sawit/*GRS) program managed by BPDP(KS) has produced innovative research to develop bioplastics based on palm biomass, which are relatively more renewable, biodegradable, and sustainable, making them a viable alternative for this transformation. To accelerate the transformation from the petroplastic era to the palm biomass-based bioplastic era in Indonesia, the integration of two national policies is needed: a mandatory palm bioplastic policy and a petroplastic import levy policy.

INTRODUCTION

The production of petroplastics (fossil-based plastics) on Earth has increased exponentially. Global petroplastic production was about 2 million tons in 1950 and rose to approximately 475 million tons in 2022. The top-5 petroplastic producing countries are China, the United States, India, the European Union, and Japan. Although not among the top 5 petroplastic producers, Indonesia is one of the petroplastic consumers with increasing petroplastic imports from year to year.

Petroplastics are non-renewable as they are derived from fossil fuels. Their production process also generates a significant amount of carbon dioxide emissions (Spierling *et al*., 2018; Zheng and Suh, 2019). Besides being a source of emissions, petroplastics are also difficult to decompose naturally (non-biodegradable) as it takes more than 450 years for them to degrade (WWF-Australia, 2021). This leads to the accumulation of petroplastic waste from year to year, polluting waters, oceans, and land worldwide. Approximately 50-70 trillion pieces of petroplastic waste pollute the world's waters and oceans and this is estimated to triple by 2040 (Stanton, 2022).

Recycling petroplastics cannot be relied upon as a solution to overcome the accumulation of petroplastic waste, considering that around 85 percent of the world's petroplastic consumption each year is discarded as plastic waste (Hariz *et al*., 2023). Meanwhile, the demand for plastic increases yearly, so plastic waste also accumulates annually.

The challenge is how to produce plastics that are easily biodegradable and renewable, so they do not result in the accumulation of plastic waste in the ecosystem. The answer to this challenge is to accelerate the production of bioplastics that are renewable, biodegradable, and low emission as a substitute for petroplastics.

This paper will discuss the potential of palm biomass-based bioplastics as a substitute for petroplastics. It will also discuss the policy support needed to facilitate the accelerated production of this bioplastics and the substitution of petroplastics.

PALM BIOMASS-BASED BIOPLASTICS AS A SUBSTITUTE FOR PETROPLASTICS

Palm biomass is one of the raw materials that can be used to produce bioplastics. Palm biomass, which includes empty fruit bunches, oil palm kernel shells, oil palm mesocarp fibers, oil palm trunks, and oil palm fronds, can produce about 80.1 - 95.9 tons of dry biomass per hectare per year (Ng *et al*., 2011; Hariz *et al*., 2023). With a global oil palm plantation area of about 27.4 million hectares in 2024 (USDA, 2025), there is a potential for 2.16 - 2.6 billion tons of dry palm biomass each year.

Palm biomass contains cellulose, hemicellulose, and lignin, making it a suitable and potential raw material for bioplastic production. One of the chemical compounds that can be produced from the cellulose in empty fruit bunches is lactic acid, which is the main raw material for making the biodegradable polymer, *Polylactic Acid* (PLA). This polymer can serve as an alternative to conventional polymers like *Polyethylene* (PE), *Polypropylen*e (PP), *Polyethylene Terephthalate* (PET), and *Polystyrene* (PS).

Various innovative research projects under the Palm Oil Research Grant (*Grant Riset Sawit/*GRS) program managed by the Palm Oil Fund Management Agency (*Badan Pengelola Dana Perkebunan*-BPDP or *Badan Pengelola Dana Perkebunan Kelapa Sawit*-BPDPKS, formerly) have also proven that processing palm biomass can produce bioplastics such as *Polybutylene Succinate* (PBS), *Polylactic Acid* (PLA), *Polyhydroxyalkanoates* (PHA), and *Polyhydroxybutyrate* (PHB) (Sitompul *et al*., 2015; Isroi *et al*., 2018, 2019; Setyaningsih *et al*., 2020; Makertihartha *et al*., 2021; Masruchin *et al*., 2022; Hariz *et al*., 2023; Dina *et al*., 2024). These bioplastic products can substitute for petroplastics such as *Polyethylene* (PE), *Polypropylen*e (PP), and *Polystyrene* (PS).

Palm biomass-based bioplastics have several advantages: they are a joint product of palm oil, available year-round and concentrated in relatively large quantities, and low-cost, and they have zero or low carbon emissions and a non-food-fuel trade-off (PASPI Monitor, 2025). The raw material for bioplastics, which comes from biomass, is a result of a biological process, a green feedstock, and a renewable resource (Jabean *et al*., 2015; Lackner, 2015).

Bioplastics are a "green product" and can decompose naturally (biodegradable). While petroplastics take about 500 years to degrade, bioplastics only require a few days to decompose naturally. Various studies (Costa *et al*., 2023; Ashok *et al*., 2018, and Shafqat *et al*., 2022) have compiled research results on how long bioplastics take to degrade, depending on the type of bioplastic. For example, bioplastics in the Thermoplastic Starch (TPS) group require a degradation time of around 72-726 days. The *Polyhydroxyalkanoates* (PHA, PHB, and PHV) group of bioplastics require a degradation time of about 15-280 days. The *Polylactid* (PLA) group of bioplastics require a degradation time of about 28-98 days. The Cellulose-Based Polymers group requires a degradation time of about 14-154 days. The bioplastic group with the fastest degradation time is the Protein-Based Polymers group, which only takes about 36-50 days.

Bioplastics have a lower carbon footprint than petroplastics. The use of bioplastics can save about 30-70 percent of carbon emissions compared to petroplastic emissions (Lackner, 2015). If 65.8 percent of petroplastic consumption is replaced with bioplastics, it would reduce global GHG emissions by about 241-316 thousand tons of CO_2 eq (Spierling *et al*., 2018).

POLICY SUPPORT

Plastic waste is one of the major problems facing the global community. Approximately 360 million tons of plastic waste are added each year, and only about 9 percent can be recycled. This plastic waste not only damages ecosystems but also threatens the safety and health of living things, including humans. Therefore, the effort to stop the production of petroplastics and replace them with bioplastics should be a major agenda and a policy focus for the global community.

The Indonesia National Plastic Action Partnership (NPAP) targets zero petroplastic pollution in Indonesia by 2040. This target can be considered ambitious, considering that Indonesia currently produces about 6.8 million tons of petroplastic waste annually, which pollutes its waters and land.

This target will be difficult to achieve if Indonesia's dependence on petroplastics is not reduced or even eliminated.

Based on ITC Trademap (2025) data, the volume of Indonesian imports of various petroplastic raw materials and products shows an increasing trend from year to year (Figure 1). During the period of 2010-2024, the volume of petroplastics imported by Indonesia increased from about 1.8 million tons to 4.85 million tons. Similarly, the import value also increased from USD 3.41 billion to USD 6.86 billion during the same period.

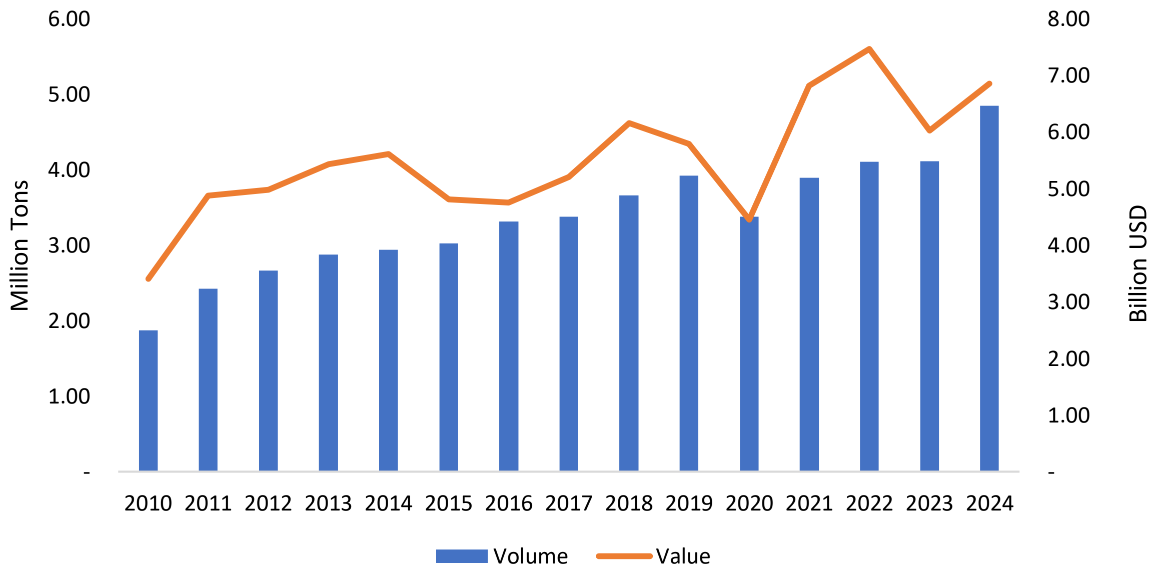

Figure 1. Volume and Value of Indonesia's Petroplastic Imports (Source: ITC Trademap, 2025)

This yearly increase in Indonesia's petroplastic import volume indicates that Indonesia is also becoming more dependent on petroplastics. This also means that a larger accumulation of plastic waste is polluting the environment from year to year. It is ironic that this toxic plastic waste is financed with an increasing amount of import foreign exchange each year. It is time for Indonesia to stop this detrimental trend.

Indonesia needs a national policy to replace petroplastics with bioplastics, such as palm biomass-based bioplastics. In terms of biomass-based bioplastic research and innovation, BPDP(KS), through the GRS program, has produced various innovations needed to create bioplastics from palm biomass over the last 10 years.

In addition to research and innovation support, strategic policy support is needed to accelerate the transformation from petroplastic imports to domestically produced palm bioplastics. The strategic policies referred to are a mandatory domestic bioplastic policy and a petroplastic import levy policy. Regarding the petroplastic import levy policy, there is a different tariff scheme for imported raw materials and finished products based on petroplastics, where the tariff is higher for imported finished products than for petroplastic feedstock.

The mandatory domestic palm bioplastic policy is carried out by requiring domestic plastic producers to mix petroplastics with palm bioplastics at a blending rate that increases from year to year. This mandatory palm bioplastic policy needs to be supported by a petroplastic import levy policy to reduce petroplastic imports while creating incentives for the growth of the domestic palm bioplastic industry. The funds obtained from the petroplastic import levy will be used to finance domestic palm bioplastic research and innovation as well as investment incentives for the domestic palm bioplastic industry (mandatory domestic bioplastics).

Indonesia's experience in implementing the mandatory biodiesel policy (substituting fossil diesel with palm biodiesel), which is considered very successful, can be applied to mandatory palm bioplastics. Integrating a progressive mandatory bioplastic policy and a petroplastic import levy will enable Indonesia to end the unsustainable era of petroplastics and enter a new era of bioplastics that are renewable, biodegradable, and sustainable.

CONCLUSION

The production and consumption of petroplastics worldwide have led to an accumulation of plastic waste that threatens the sustainability of the global ecosystem. The world community must take a major step to end the petroplastic era and move to the bioplastic era as soon as possible.

Palm biomass contains cellulose, hemicellulose, and lignin, making it a potential and suitable raw material for bioplastic production. Palm biomass-based bioplastics have the advantage of being relatively more renewable, biodegradable, and sustainable, making them one of the important alternatives for the future transformation to the bioplastic era.

To accelerate the transformation from the petroplastic era to the palm bioplastic era in Indonesia, the integration of two national policies is needed: a mandatory palm bioplastic policy and a petroplastic import levy policy. The funds obtained from the petroplastic import levy will be used to finance domestic palm bioplastic research and innovation as well as investment incentives for the domestic palm bioplastic industry (mandatory domestic bioplastics).

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