The Effects of Rice Husk Ashes Filled Recycled Polyethylene Composites towards Physical, Mechanical Properties and Its Degradation Characteristics

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Abstract. Plastic waste is dominated by 46% Low Density Polyethylene (LDPE) and High Density Polyethylene (HDPE). The plastics waste are persistent pollutants that is not biodegradable waste. Recycled polyethylene (RP) from the plastic waste would potentially be used as polymer composites for pavement or road construction application. In order to improve physical, mechanical and water absorption properties, some fillers need to be added. The agro-industrial waste of rice husk ashes (RHA) containing highly silica SiO\textsubscript{2} may be utilized as filler in this composites. The objective of this research is to observe the effect of RHA addition in to the recycled plastic composites towards its physical, mechanical properties and degradation characteristics. The RHA loading was designed weight/weight of RP as follows 0%; 5%; 10%; 15%; 20%, while degradation duration was 0, 30 and 60 days. The recycled ethylene was smelted and mixed with the RHA at temperature 120 °C; and then pressed using 200 kg.cm\textsuperscript{2} hydraulic press as pavement block (20x10x6 cm dimension). The results showed that the addition of RHA leads to increase the water absorption capacity, whereas it reduces the compressive strength. The RHA filler addition into composites has less significantly effects on thickness and surface-physical appearance (cracking profile). The 60 days degradation at ambient temperature with the sun lighting in a burial soil has a slight effect on the decreasing of compressive strength, thickness, and physical appearance (small crack on the surface) due to the thermal oxidative degradation. In addition, the burial soil exacerbate the bio-degradation mechanism due to the presence of high water absorbed within the RP-RHA composites. To sum up, the RHA may be potentially used as filler to improve water absorption capacity. Anti-oxidant and plasticizer types need to be researched to improve its physical mechanical properties.

Keywords: compressive strength, water absorption, recycled polyethylene, rice husk ashes filler

1. Introduction

In a modern life, plastic waste from household activities, offices, markets, social activities and other sources becomes a serious problem. Generally, plastic waste in only burned and put into the ground as landfill without any treatments. Therefore, reuse and reutilization plastic waste in order to minimize soil and air pollution would become as an alternative [1]. The plastic waste was mostly dominated by HDPE and LDPE Polyethylene about 40-48%, polypropylene and polystyrene approximately 30-35%, polyvinyl chloride (PVC), polyethylene terephthalate (PET), Acrylonitrile-butadiene styrene (ABS) about 7%, 5%, 5% respectively [2].
The HDPE and LDPE is the biggest quantity of plastic waste that becomes main sources of environmental pollution. Polyethylene waste grows at rate 12% and around 140 million tons of synthetic polymers are produced worldwide annually. The burning of those polyethylene cause a serious air pollution due to dioxin and some gas pollutants, while land fill would affect the soil quality due to the micro plastics in burial soil [1, 3].

Indonesia has a large number of paddy field and rice production about 56.54 million tons. Rice husk ash in paddy field waste is about 20% of total rice production. Currently, rice husk ash waste has been utilized for refractory and ceramic industries, fuel, and others [4, 5]. Rice husk ash containing 87-97% amorphous SiO2 and other minerals that is potentially used as filler in cement, concrete or adsorbent in water treatment [6].

The performance of structural concrete with recycled plastic waste as a partial replacement for sand has been studied, the results show that replacing 10% of sand from the volume of recycled plastic is a viable proposition that has the potential to save 820 million tons of sand every year [7]. The addition of about 10% volume sand and cement into polyethylene pavement concrete blends leads to increase compressive strength and hardness [8]. Furthermore, temperature process on blending sand and polyethylene into pavement give significant results, it is stated that the process at 300 o C has higher harness and compressive strength compared to blending at 200 o C. Meanwhile, the bulk density experience decreasing as high sand replacement in polyethylene blending [3, 7].

Research on rice husk ash for cement replacement in concrete have been widely developed. It is found that 10% RHA or more may cause the increasing of optimum moisture content while decreasing maximum dry density [9]. In addition, 20% RHA loading in high performance fine-grained concrete could improve compressive strength, tensile strength, and chloride penetration resistance [10].

In terms of recycling plastic waste for pavement or road construction, physic mechanical properties of recycled polyethylene needs to be improved by adding some fillers. Some fillers like calcium carbonates, kaolin and recycled silicon have been researched [6, 9, 11, 12]. However, the research of using RHA in HDPE and LDPE blending is still limited particularly for pavement or road construction.

Bearing in mind, the necessity of technology for recycling process of HDPE and LDPE using agro-industrial waste such as rice husk ashes filler, this research would contribute technology of blending that composites for pavement and road construction application. The key important parameter is the water absorption of the composites. It indicates the capability of the composites to allow water steep into the ground so the surface run-off could be reduced more effectively. Therefore, this recycled plastic and RHA composites could be applied in road construction as a replacement of concrete or sand pavement. Therefore, this work would investigate the effects of rice husk ashes (RHA) as filler on recycled polyethylene towards physical, mechanical properties and its degradation characteristics. The research result would contribute knowledge and practical information on developing the recycled plastic products for pavements.

2. Experimental method

The materials used are rice husk (paddy field), plastic waste and water. The equipment hydraulic press (capacity 200 kg.cm²), temperature sensors, stopwatch, digital calliper, smelted furnace, reactor, magnifying glass, and water bath.

Rice husk was burnt at 150 °C until it becomes ashes and the ground it into 150 mesh. The plastic waste was separated only for LDPE & HDPE plastic (Recycled Plastic) and then washed and cleaned by soaking the LDPE-waste using water and then dry it. The blending process of RP and RHA is in accordance with previous research that used injection moulding machine with compressive strength about 200-220 kg.cm² [8, 12]. The composite of Recycled Plastic (RP) and rice husk ashes (RHA) as filler was prepared by melting and blending the RP, RHA and Cu (catalyst) in a furnace reactor at temperature 120 °C for about 15 minutes. After that the composites of RP and RHA was pressed by hydraulic press at 200 kg.cm² for about 3-5 minutes using metal moulding 10 x 20 cm thickness 6 cm. Finally, the composites was soaked in water for about 8 minutes before testing. In this research, the
composition of RP and RHA was designed by varying the percentage weight/weight of (PR:RHA) as follows (100:0); (95:5); (90:10); (85:15); and (80:20) %.

The degradation characteristics was observed by burying the composites in a burial soils (media of garbage dump soil), while 1 cm is on the surface that could contact with the air, sunny lighting and ambient temperature. The physical appearance, compressive strength, water absorption and thickness were measured in duration of burial of 0, 30, and 60 days. Physical appearance was observed using magnifying glass on the surface of the composites, while the thickness was measured using digital calliper. Compressive strength was tested in according to ASTM C 936 and the water absorption testing was carried out based on ASTM D570-95. The testing of those properties were conducted in three repetitions in order to obtain high accuracy data.

3. Results and discussion

3.1. Physical Appearance

Table 1 shows the physical appearance of composites RP/RHA in 0, 30 and 60 days degradation. After 30 days degradation, the surface of each composites using RHA as filler was not deteriorated significantly. The surfaces become brittle and rough with a few voids and cracks. The surface of recycled plastic composites without RHA remain stable and does not experience serious attack rather than composites with higher RHA. It could be inferred that the higher RHA loading, the surface attacks become more serious rather than without RHA. This degradation may be explained due to the existence of bacteria/ microorganism and air/ozone attack during degradation process [3, 9]. The oxidation on surface cause cracks on surface and brittle due to the lack of antioxidant agent in the composites [11, 13]. In addition, the process-ability and dispersion of the filler within the low density and high density polyethylene matrix may not very fine, so that the surface attack could not be hindered.

3.2. Thickness

Table 2 shows that the thickness of the composites were not significantly changes due to the longer degradation days. The composites of RP/RHA (85/15) % experience the highest shrinkage after 60 days. The RHA as filler give positive physical properties contribution in the composites and improve its strength. It is predicted that the longer degradation periods would influence the decreasing of thickness of the composites, particularly the higher RHA contained in the PR/RHA composites.
Table 2. Thickness of Composites of RP/RHA in 0, 30 and 60 days degradation

| RP/RHA (w/w) | 0 Day Degradation | 30 Days Degradation | 60 Days Degradation |
|--------------|-------------------|---------------------|---------------------|
| 100/0        | 6 cm              | 6 cm                | 6 cm                |
| 95/5         | 6 cm              | 6 cm                | 6 cm                |
| 90/10        | 6 cm              | 6 cm                | 5.99 cm             |
| 85/15        | 6 cm              | 5.99 cm             | 5.99 cm             |

3.3. Compressive Strength

Figure 1 shows the compressive strength of the RP/RHA composites with RHA variation loadings in 0, 30 and 60 days degradation. Composites without RHA has the highest compressive strength (94.08 MPa), while the higher loading of RHA cause the decreasig of compressive strength slightly. The rice husk ashes containing 87-97 % amorphous SiO₂ that would acts as reinforcing filler in polymer matrix such as natural rubber and styrene rubber [4, 7, 10]. For cement or concrete application, RHA filler contributes positively to not only compressive strength but also for its hardness. Conversely, in this recycled polyethylene composites, the RHA may not finely disperse within the polymer and its process ability is very limited due to the difference polarity, density and size between filler and polyethylene [2, 9, 11, 12]. Those physical and chemical barrier may probably limit the chemical and physical bonding between hydroxyl groups of silica with the ester functional of polyethylene [4, 7, 10]. Therefore, the physical surface appearance and its compressive strength decrease due to the RHA addition.

As shown in Figure 1, the longer degradation under sun lighting in a burial soil do not significantly affect the compressive strength of PR/RHA composites. After 60 days degradation, the compressive strength decrease slightly for about 2-5 MPa. This phenomena may be explained as the effect of thermo-oxidative ageing that exacerbate the degradation both in surface and within the composites. Figure 1 also shows that the longer degradation duration with the higher RHA loading cause the decreasing of compressive strength due to the low filler dispersion and process-ability.

![Figure 1](image_url)

**Figure 1.** Compressive Strength of PR/RHA Composites in 0, 30, 60 days degradation.

3.4. Water absorption

For pavement ground and road construction application, the water absorption capacity is the key important properties to determine its utilization and function. The water absorption test is carried out by immersing the whole test sample in water for about 24 hours, weighing the weight in wet state, drying approximately in ambient temperature °C until weighing at two weighing disputes not more than 0.2% of the previous weighing.

Figure 2 illustrates the water absorption capacity of the RP/RHA composites and degradation profile within 0, 30, and 60 days. It can be seen that the highest water absorption (3.14%) was obtained in 20% RHA loading substituted the recycled polyethylene, while the composites without RHA filler has very low water absorption only 0.52%. This result indicates that RHA loading contributes positively
in order to improve water absorption capacity of the composites. The nature of polyethylene is impermeable to water and does not dissolve in water at ambient temperature, so that polyethylene without filler is not inevitable for road or pavement construction. However, polyethylene has high crystallinity and strong intermolecular attraction so that its mechanical strength is excellent [7, 9, 11, 14].

![Figure 2. Water Absorption of RP/RHA Composites in 0, 30 and 60 days.](image)

The presence of RHA improves the hydrophilicity of the RP composite and allows more water absorption due to ease of hydrogen bonding between silica and hydroxyl of rice husk ashes and water molecules. Figure 2 shows that the longer degradation increase the water absorption of the composites. It could be seen that the RHA addition also increase the water absorption capacity during 30 and 60 days degradation. It could be explained that high RHA contain would absorb more water into the composites and enable microbial attack during degradation in a burial soil. Biodegradation on RP/RHA may happen due to the existence of microbial from burial soil and water activity within the composites [3, 10, 13, 15]. Thermo-oxidative ageing and biodegradation along with the surface attack by sun lighting allows more water absorbed and leads to some cracks, weight loss and possibly breakdown the polyethylene within the matrix [3, 15].

4. Conclusion
Composite of recycled plastic that consist of LDPE and HDPE using rice husk ash as filler has been successfully synthesized. The RHA loading causes the surface of the composites become more brittle and rough with a few voids. It is indicated that the higher RHA concentration would affect the physical appearance of the composites. The compressive strength of the composites tend to decrease due to the higher loading of RHA. This phenomena could be explained that the process-ability and dispersion of RHA filler within the polyethylene matrix may need to be improved. Conversely, the water absorption capacity of the RP/RHA composites increase slightly due to the RHA addition. It is suspected that silica and hydroxyl groups from RHA may allow water absorption through hydrogen bonding. Further research would be study anti-oxidant and plasticizer types to enhance the dispersion of RHA filler and recycled polyethylene in order to improve its mechanical, thermal ageing and bio degradation properties.

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