Application of Industrial Cement in the Durability of Degradable Bioplastic Pot

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Received: *30 March 2016*
Revised: *29 April 2016*
Accepted: *31 April 2016*
In press: *15 May 2016*
Online: *30 June 2016*

Keywords:
Degradable bioplastic; additive cement industry; water absorption; soil burial test

Abstract

This paper presented the result of an experimental study investigating the durability of degradable bioplastic pot with additive cement industry. The ratios of degradable bioplastic were varied from B10%:N90%, B30%:N70%, B50%:N50%, B70%:N30 and B10%:N90% and mixed with 6%, 9% and 12% of industrial cement. Pots were prepared, tested for 90 days for Soil Burial Test in order to determine the biodegradability rate of pot and tested in the laboratory for Water Absorption Test in order to determine the presence of industrial cement as an additive decrease the moisture absorption capacity of the degradable bioplastic. The result of weight loss percentage shows that the lowest percentage of weight loss of soil burial test above ground was 31.80% for B10%:N90% mixed with 12% industrial cement. The highest weight loss percentage 100% was B90%:N10% mixed with 6% below ground after 90 days of soil burial test. The highest 75% of water absorption percentage of degradable bioplastic was B90%:N10% mixed with 6% industrial cement and the lowest 12% of water absorption percentage was B10%:N90% mixed with 12% industrial cement.

Introduction

Bioplastics are plastics that consist all carbon that was obtained from renewable feedstocks and biomass resources, for example the oils and fat of vegetables, or starch. Not all the resources can be biodegradable. Based on the American Society for Testing and Materials (ASTM) (1999), the definition of biobased material is an organic material in which carbon is derived from a renewable resource via biological processes. Biobased materials include all plant and animal mass derived from CO_2 recently fixed via photosynthesis, per definition of a renewable resource.

Usually products on the market are made from a variety of renewable resource including corn, potatoes, rice, tapioca, palm fiber, wood cellulose, wheat fiber and bagasse and are available for a wide range of applications such as cups, bottles, cutlery, plates, bags, bedding, furnishings, carpets, film, textiles and packaging materials. A biodegradable material is where under the right conditions the microbes in the environment can break down the material. Its property usually depends very much on the circumstances of the biological environment. Some biobased products are degradable in municipal or commercial composting facilities, home composting, and aquatic and roadside environments, others will degrade in very specific environments and some will not biodegrade at all. Kerry and Butler (2008) stated that the process of biodegradation depends on the surrounding environmental conditions such as the location or temperature of the process, depends on the material and on the application. Bioplastic pot is a material that can be used as another alternative to reduce the reliance on plastic based for seedlings plantation in the forest industry.

Industrial cement is known as a binder, which can be described as a substance that sets and hardens and can bind other materials together. The industrial cement used to describe masonry resembling modern concrete that was made from crushed rock with burnt lime as binder. The volcanic ash and pulverized brick supplements that were added to the burnt lime, to obtain a hydraulic binder, were later referred to the term as cementum, cimentum and cement (Black *et al.*, 2010). Based on the characteristics of industrial cement, these materials applied in this study as an additive to improve the durability of bioplastic pot and conducting Water Absorption Test to investigate the capability of bioplastic pot mixed with industrial cement to absorb water. Based on Liew & Khor (2015), bioplastic pots degraded within 60 days tested both below and above ground. This study was using industrial cement as an additive to the previous study to prolong the degradation of bioplastic pot to more than 60 days because most of tree seedlings need more than 60 days potting before planting to another medium.

Materials and Methods

Raw materials and chemicals

Raw materials for production of bioplastic pot were tapioca starch, vinegar, water, glycerol, newspaper pulp and industrial cement as an additive. One of the variables in this study is the ratio of bioplastic and different percentage of cement industry. Ratio of bioplastic, newspaper pulp and mixed with industrial cement as follow:

Table 1. Ratio of bioplastic, newspaper pulp and the percentage of industrial cement as an additive.

Ratio of Bioplastic (B) and Newspaper Pulp (N)	Industrial Cement (%)
B90%:N10%	6
	9
	12
B70%:N30%	6
	9
	12
B50%:N50%	6
	9
	12
B30%:N70%	6
	9
	12
B10%:N90%	6
	9
	12

Production of bioplastic pot and mixed with industrial cement

Different ratio and percentage of bioplastic, newspaper pulp and industrial cement mixed in temperature 80°C hot plate until the mixture turned into sticky form. The mixture used to form bioplastic pot manually. Formation of bioplastic pots for 2mm thickness. Formed bioplastic pot dried in oven for 24 hours.

Soil Burial Test

Biodegradability of bioplastic pot tested by using Soil Burial Method. Bioplastic pots planted with plant below ground and above ground at University Malaysia Sabah Nursery. Bioplastic pot from each ratio planted above soil and below soil for 90 days and weight loss percentage of bioplastic pot calculated in order to determine the biodegradability rate of pot.

Weight Loss Percentage (above and below ground)

The initial weight of bioplastic pots was taken. A total of 30 bioplastic pots from each variable were tested below soil in order to test the degradability of the pot with soil contact, and another 30 bioplastic pots from each variable were tested above ground in order to test the degradability of bioplastic pot above ground. Next, cleaned bioplastic pots were dried at 50°C for 24 h in oven. Dried bioplastic pots were left for 24 hours (Singh & Sharma, 2008). Thus, in this study, the Weight Loss Percentage was calculated as expressed in Equation (1).

$$\text{Weight Loss} = \frac{\text{Initial weigh of Pot (g)} - \text{Final weight of Pot} \times 100\%}{\text{Initial weight of Pot (g)}} \qquad (1)$$

Water Absorption Test

Water absorption test was performed using a modified procedure based on ASTM D570. The specimens was dried in an oven for a specified time and temperature and then placed in a desiccator to cool. Immediately upon cooling the specimens were weighed. The specimen was then emerged in water in temperature 23°C for 24 hours or until equilibrium. Specimens was removed, patted dry with a lint free cloth, and weighed. Percentage of Water Absorption can be generally calculated as in Equation (2).

$$\text{Percentage of Water Absorption} = (\text{Wet weight} - \text{Dry weight}) / \text{Dry weight} \times 100 \qquad (2)$$

Results and discussions

Soil Burial Test

The weight loss percentage of degradable bioplastic pot during Soil Burial Test above and below ground after 90 days is shown in Figure 1 and 2. The lowest degradation of bioplastic pot was B10%:N90% mixed with 12% industrial cement with 31.8% of weight loss percentage that placed above ground. The highest degradation was B90%:N10% mixed with 6% industrial cement with 100% weight loss percentage that planted below ground. Bioplastic pot planted below ground has the highest percentage of degradation because of affected by environmental factors such as biological activity and moisture. For these reasons, it can be observed that the biodegradation rate is faster below ground than in above ground. Microorganisms such as bacteria and fungi were involved in the degradation of both natural and synthetic plastics material (Gu *et al.*, 2011). Polymers, especially bioplastics, are potential substrates for heterotrophic microorganisms (Glass & Swift, 1989). So it was clear that the biodegradation rate is very fast in the case of below ground placement for bioplastic pot. Above ground has the lowest degradation rate because less of environmental activity and the factors that contribute to the degradation of bioplastic pot were moisture content and temperature.

Based on the results obtained from Figure 1 and 2, the degradation rate both above and below ground indicating the presence of industrial cement in different percentage has shown the different rate of degradation. The highest percentage of industrial cement has shown the lowest degradation of bioplastic pot based on the weight loss percentage. For example (Figure 1), B10%:N90% mixed with 12% industrial cement placed above ground after 90 days shows the less degradation (31.8%) compare to B10%:N90% mixed with 6% industrial cement (40%).

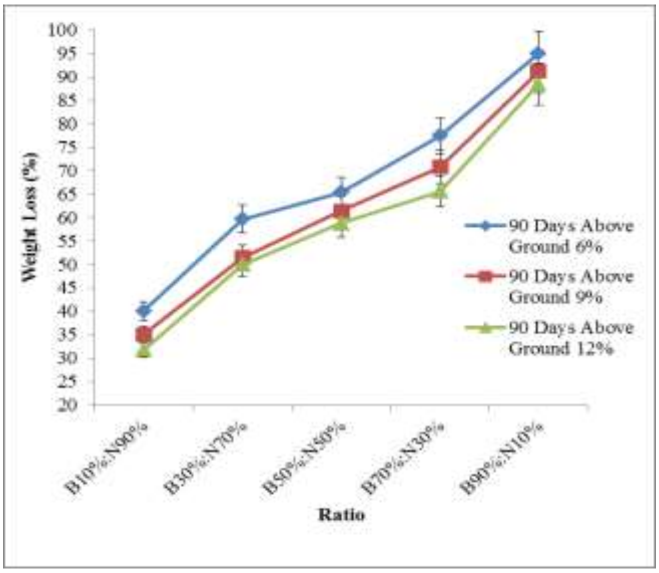

Figure 1. Weight loss percentage of degradable bioplastic pot with different ratios of bioplastic and different percentage of industrial cement that were tested above ground for 90 days.

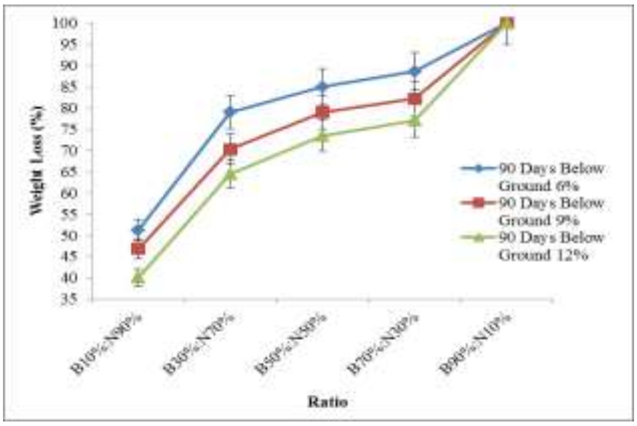

Figure 2. Weight loss percentage of degradable bioplastic pot with different ratios of bioplastic and different percentage of industrial cement that were tested below ground for 90 days.

Water Absorption Test

The results presented in Figure 3 shows the percentage of water absorption of bioplastic sample with different percentage of industrial cement. The lowest water absorption was B10%:N90% mixed with 12% of industrial cement (12%) and the highest percentage of water absorption was B90%:N10% mixed with 6% of industrial cement (75%). Obtained results shows the bioplastic with addition of industrial cement has been improve the water absorption resistance. The bioplastic pot mixed with industrial cement did not significantly influence their durability properties, but also decreased their water absorption.

One of the factor affected the degradation of degradable bioplastic pot was the moisture content from environment. Due to the hydrophilic property of tapioca, that causing the percentage of water absorption to increase (Tsou *et al.*, 2014). Munthoub *et al.* (2011), also stated that water absorption value of the degradable bioplastic increased with higher content of glycerol due to the properties of glycerol itself whereby glycerol is soluble in water and naturally hygroscopic. Moisture was absorbed by starch through the starch particles. The increase of moisture uptake with increase in starch content has been reported earlier (Otey & Doane, 1987).

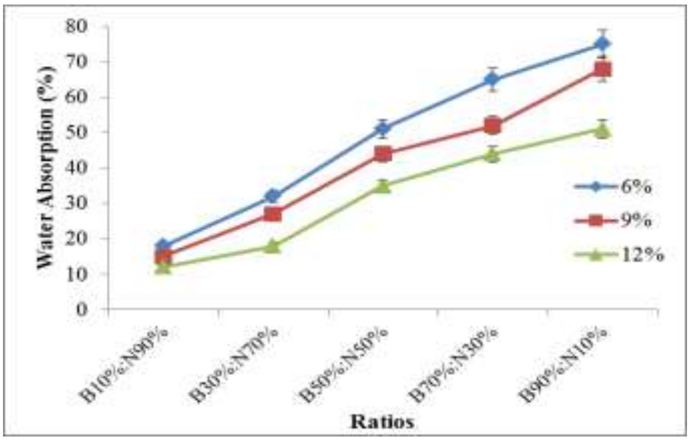

Figure 3. Percentage of water absorption of degradable bioplastic with 6%, 9% and 12% industrial cement.

Conclusion

In general, it can be concluded that the degradation of degradable bioplastic pots under this study was faster in below ground than above ground placement. The obtained results can be summarised as follows: the percentage of industrial cement mixed with the ratio of bioplastic influencing the degradation of bioplastic pot. The different percentage of cement industry as additive to degradable bioplastic pot improves the durability of sample to the environment and to humidity. The ratio of starch in the bioplastic also increases the degradation rate of the sample. The degradation process increases as the starch content increases. The water absorption also shows that the increases percentage of water absorption as the starch ratio increases.

Acknowledgements

The authors would like to acknowledge with thanks the support from Faculty of Science and Natural Resources and University of Malaysia Sabah (UMS), Sabah.

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