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# Effect of Composting on the Mechanical Properties of Bovine Fibres Filled Waste Low Density Polyethylene Composites

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***ABSTRACT***
*Injection moulding technique was used to prepare composites of waste low density polyethylene (WLDPE) filled with bovine fibres from the hair of Zebu breed of cattle. Composite samples of filler loadings 0, 10, 20, 30, 40 and 50 wt% were prepared. The samples were buried under the ground to investigate the effect of composting on the mechanical properties of the composites. Results obtained showed a general decrease in the mechanical properties tested. Composting had degradation effect on the composites.*

***Key words:*** *Waste plastics, Bovine fibres, Composting, Mechanical properties, Degradation*

## INTRODUCTION

Efforts by scientists to keep the environment green had led to the recycling of non-biodegradable waste plastic materials to produce composites (Liu *et al.*, 2011). The waste plastics are usually employed for the continuous phase of the composites (Henry *et al.,* 2013) Some common commodity plastics such as low-density polyethylene (LDPE), high density polyethylene (HDPE), polypropylene (PP) are used for making every day house hold products such as plastic films for wrapping, food packaging, kitchen utensils (Choudhry and Pandey, 2012). Because these house hold plastics are used almost by every home and are inherently not biodegradable, they constitute a large deposit on refuse dumps in areas where refuse are neatly collected. In areas where there is poor sanitation, there are seen littering the environment. As little as a unit wrapping plastic film could be, a large deposit of it is capable of hampering the efficiency of the drainage system. Blockage of the drainage system have been documented as a major cause of flood (Nkwunonwo *et al.,* 2016). The use of waste plastics for the continuous phase of composite materials have significantly added value to the danger posing commodity plastics.

A composite consists of a discontinuous phase too (Pickering, 2015). Materials scientists have over time added value to waste agricultural products such as rice husk, ground nut shell, cassava peels, cow hair, human hair, goat hair, sheep hair, horse hair and many more by employing them as the discontinuous phase of composites (Isiaka *et al.,* 2015).

However, not much work has been done to investigate what will happen to the composite made after their life span. The thought of whether they will be degradable after recycling or they should be recycled into something else comes to mind. In our earlier works (Muktari *et al.,* 2019a; Muktari *et al.*, 2019b). Composite of WLDPE and bovine fibres were made. This research work is to investigate the degradability effect composting will have on the composite materials.

## MATERIALS AND METHODS

### Materials

Waste LDPE was collected from waste bins of Ahmadu Bello University, Zaria, Nigeria. Bovine Fibres of Zebu breed of cattle was collected from Zaria abattoir, Nigeria.

Twin screw extruder (Prim TSC 16 TC, Thermo Electron Corp), Injection Molding Machine (304 High Performance Structures and Materials V), Instron 1195 universal materials testing machine, Indentec Universal hardness tester-Model no – 8187.5LKV(B).

### Composite Preparation

Melt mixing with a twin screw extruder and injection technique was used to prepare the composites. Two sets of composites were prepared with untreated bovine fibres and bovine fibres treated with $H_2O_2$. The treatment of the bovine fibres is reported in our earlier works (Muktari *et al.,* 2019a; Muktari *et al.*, 2019b). In each set same filler loading of 10, 20, 30, 40, and 50 wt% were used. A sample made of only waste low-density polyethylene was also prepared.

**Composting**

The composite samples were buried in a garden a depth of 10cm for 90 days. The samples were then removed from the soil and cleaned with a dry fabric to remove dust. The samples were oven dried at 70 °C for 24 hr. The mechanical tests were then conducted to determine the effect of composting on the mechanical properties of the composites.

Figures1 to 3 show the tensile properties of LDPE/Hair fibre blends that were buried in the soil and those that were not buried. From the figures, it can be seen that the tensile strength, Young's modulus and elongation at break decreased after 90 days of been buried under the soil. The decrease in the tensile strength, Young's modulus and elongation at break was due to the pit and voids which occurred after the degradation of the reinforcing phase by the action of micro-organisms naturally found under the soil. The pit and voids act as stress concentrator and lead to a decrease in the tensile properties (Hanafi *et al.*, 2011). As the micro-organisms consumed the reinforcing fibres, the blends lost their structural integrity. This process could lead to the deterioration of the tensile properties. The degradation of the blends normally occurs due to the vacation of fibre sites, which are occupied by either microbes or water and thus, leads to extensive degradation of the blends (Rashdi *et al.*, 2010). During the experiment, the water inside the soil diffuses into the polymer sample, causing swelling and enhancing biodegradation. In addition, extra cellular enzymes made by the microbes also attack the resin and may be responsible for the fine cracking and tearing that lower the elongation at break, and can lead to further degradation and lower the tensile properties (Himanshu and Niranjan, 2015). The LDPE/Treated Hair fibre blends buried in the soil showed better tensile properties compared to the LDPE/Untreated Hair fibre blends even though both blends witnessed a decreasing trend. The treated fibres aided better interfacial adhesion with the matrix that could prevent early degradation. Enhanced interfacial adhesion reduced the volumes of voids which created the stress concentration area in the blends. As a result, the mechanism of degradation was reduced.

Figures 4 and 5 show the flexural properties of LDPE/Hair fibre blends that were buried in the soil and those that were not buried. The results revealed a general decrease in the flexural properties of the buried samples compared with their unburied counterparts. The weakening of the protein fibres of the buried samples due to attack by microbes, weather, humidity, and temperature under the soil might be responsible for the reduction in the flexural strength. Hair fibres are naturally produced protein, with keratin been the major constituent, degradability would rest on its wettability (Nagaraja *et al.*, 2013). In compost or healthy moist soil, it goes rather quickly, a matter of weeks or months because these are the location of huge numbers of different bacteria, actinomycetes and fungi (Maria *et al.*, 2009).

## RESULTS AND DISCUSSION

***Tensile Properties***

**KEY:** TBS – Treated Buried Sample; UBS – Untreated Buried Sample; TUBS – Treated Unburied Sample UUBS – Untreated Unburied Sample; UBC -Unburied Control; BC – Buried Control

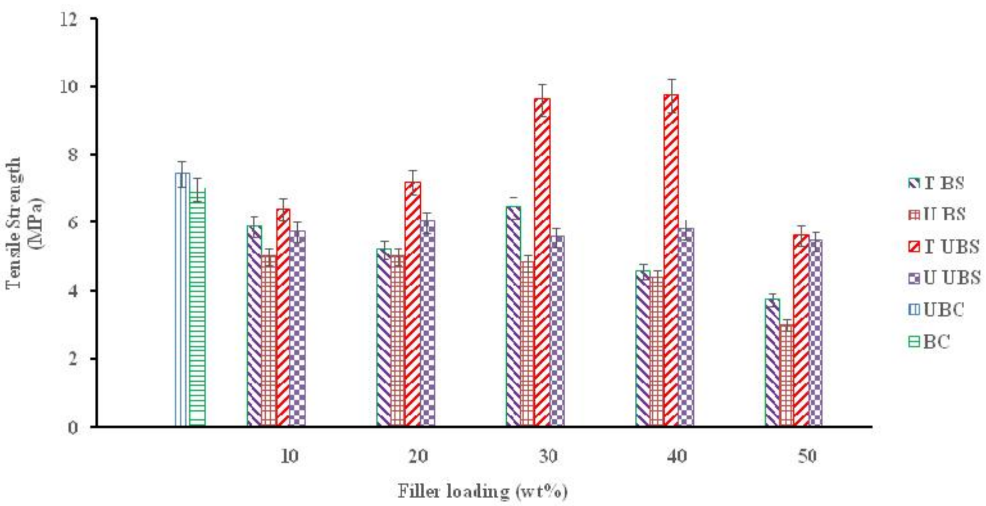


Figure 1: Effect of composting on the tensile strength of WLDPE/Bovine fibre blends

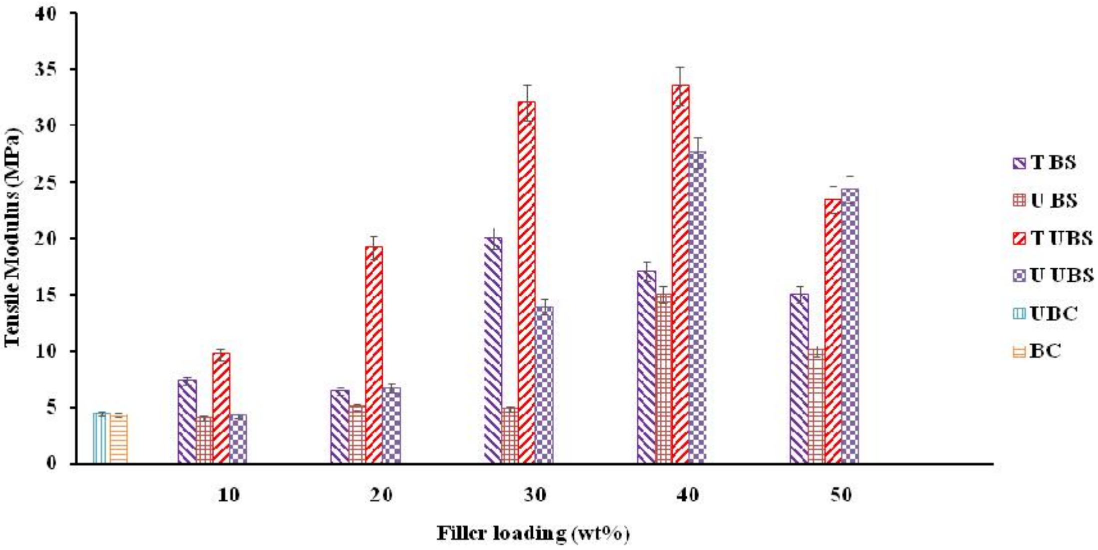


Figure 2: Effect of composting on the tensile modulus of WLDPE/Bovine fibre blends

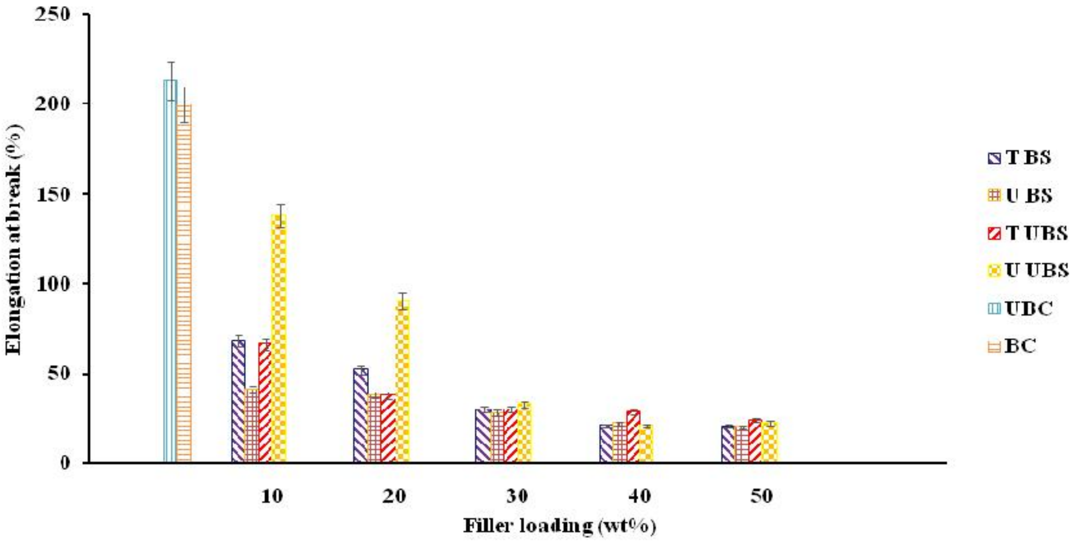


Figure 3: Effect of composting on the elongation at break of WLDPE/Bovine fibre blends

***Flexural Properties***

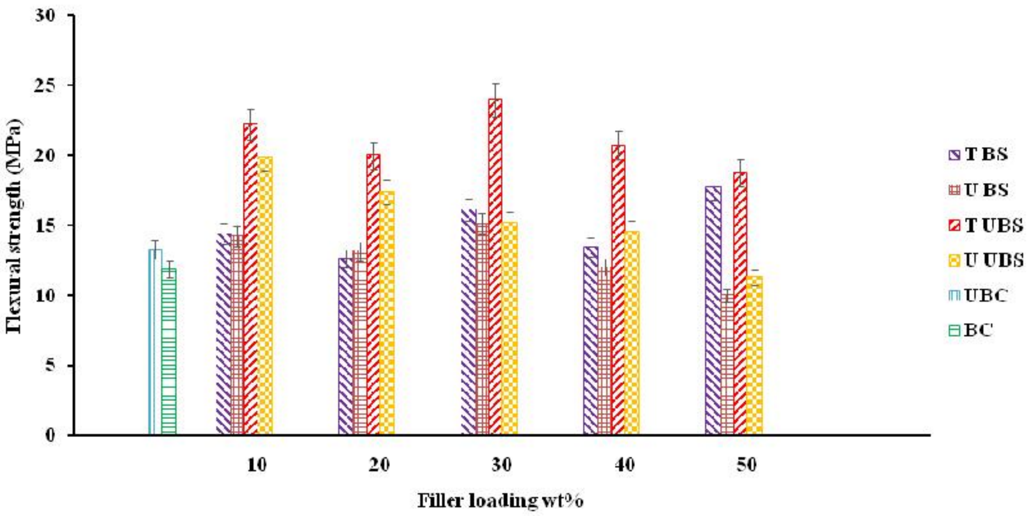


Figure 4: Effect of composting on the flexural strength of WLDPE/Bovine fibre blends

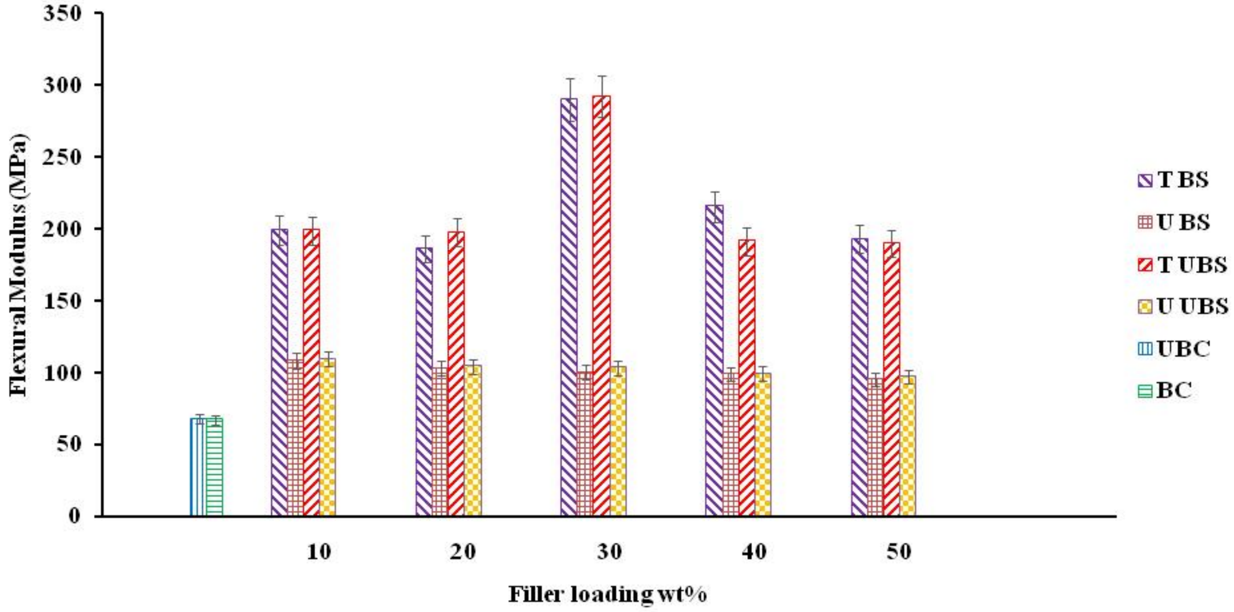


Figure 5: Effect of composting on the flexural modulus of WLDPE/Bovine fibre blends

***Surface Morphology***

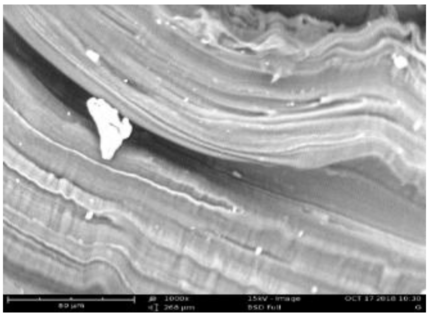

Plate 1: Unburied 0 wt% WLDPE sample

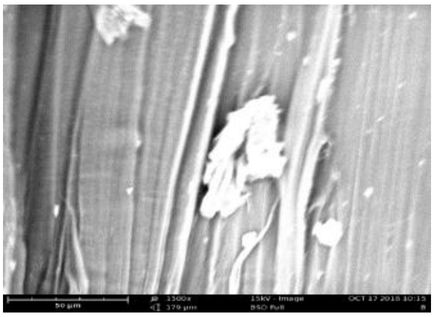

Plate 2: Buried 0 wt% WLDPE sample

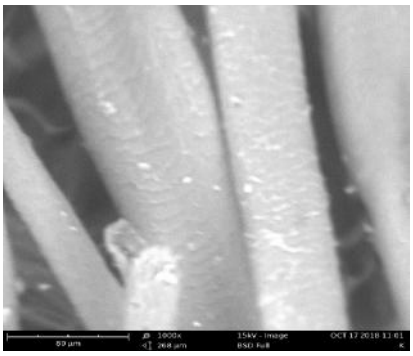

Plate 3: Untreated 30 wt% unburied sample

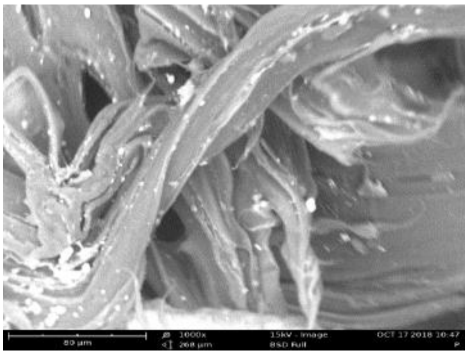

Plate 4: Untreated 30 wt% buried sample

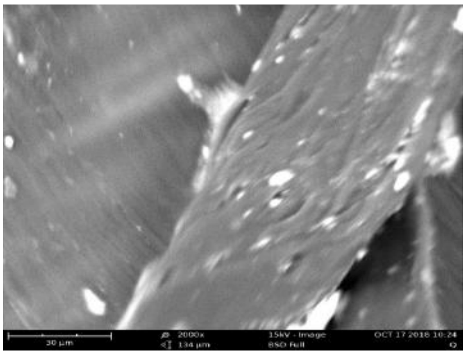

Plate 5: Treated 30 wt% buried sample

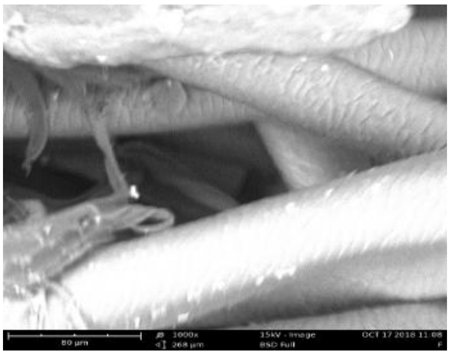

Plate 6: Treated 30 wt% unburied sample

Plates 1-6 show the SEM images of tensile fractured surfaces of some of the buried and unburied composites samples. Plate 1 and 2 show a ductile failure for the unfilled WLDPE sample. This indicates that composting for 90 days had no effect on the degradation of the sample made of only WLDPE. This explains why the tensile and flexural properties of the 0 wt% sample before and after burial had no significant difference. Micrographs of all the soil buried composites show a rougher surface with the presence of voids and holes. The presence of voids and holes are due to the removal of the protein fibres by microorganism in the soil. However, the sample filled with the surface treated protein fibres had less voids and holes after burial. This is due to the strong interfacial adhesion between the matrix and the surface treated fibres. A major feature of hair fibres is the presence of scales on their surface (Yadollah *et al.,* 2013). Surface treatment of the hair fibres further exposed the scales as can clearly be seen in Plate 6. The scales enhance mechanical anchorage with the matrix. The stronger bond between the matrix and the fibres allowed for less water and microbial penetration into the composites causing less degradation effect to the composites. This further proves the higher mechanical properties of the samples filled with treated protein fibres compared to those filled with untreated protein fibres after the composting test.

According to Kim *et al.*, 2006, the presence of holes in bio-composite surfaces may be attributed to the attack by the microorganism under soil environment. It can be identified as a surface degradation of the composites (Sapuan *et al.,* 2013).

## CONCLUSION

Compost test for 90 days revealed that the tensile and flexural properties of waste low density polyethylene filled bovine fibres composites witnessed significant decrease due to attack of the reinforcing phase by degradation causing micro-organisms. Results further revealed that WLDPE alone is not significantly affected by degradation mechanism under the soil when buried for 90 days.

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