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CLIMATE CHANGE PARTNERSHIP ACTIONS FOR SUSTAINABLE FUTURE AND RESTORING LIFE ON EARTH

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PREFACE

There is a growing concern on the adverse impacts of climate on biodiversity. This phenomenon is greatly manifested in form of shifting weather patterns threatening global food security, health and species existence. Humanity is at the receiving end of the consequences of climate change hence there is a need to step up actions on all fronts- overtime, everywhere all at once.

This calls for collaboration, partnership and networking to strengthening synergy among relevant stakeholders in a bid to tackling climate change menace. This forms the basis for the theme of this year world Environmental conservation conference: **CLIMATE CHANGE PARTNERSHIP ACTIONS FOR SUSTAINABLE FUTURE AND RESTORING LIFE ON EARTH.** The theme is conceived with a view to create an interface for information sharing and offer opportunities for participants to refine their commitments and pledges in the quest to achieving Sustainability in the face of climate change.

This year World Environmental Conservation Conference is memorable in the sense that it received overwhelming funding from the host - West African Science Service on Climate Change and Adapted Land use). WASCAL is posed to provide information and knowledge at the local, national and regional level to cope with the adverse impacts of climate change. Thus, this conference will offer opportunities for participants to learn from good practices demonstrated and showcase by WASCAL during the course of the conference. It will also strengthen staff-student exchange and provide prospect for Doctorate Research Doctoral Research in West Africa Climate System Programme (DRP WACS) – WASCAL among others.

Special appreciation goes to the management of The Federal University of Technology, Akure the host institution, National Park Service and African Regional Center for Space Science and Technology Education-English (ARCSSTE-E) that co-host this conference. We equally acknowledge other private, individual and corporate organizations that have contributed towards the success recorded in this event.

All the submitted articles were subjected to strict double blind peer-review process by the reviewers that are experts in the area of the particular submitted manuscript. The accepted manuscripts are published in WECC 2023 proceedings and also available for download on the organization website (www.necorng.org).

The accepted manuscripts fall within the underlisted subthemes:

- Climate change adaptation strategies in Agriculture, Forestry and Other Land Use (AFOLU)
- Climate smart city and architectural landscape design
- Retrofitting and decarbonization in tourism and hospitality industry
- Indigenous knowledge and local innovation in climate change adaptation
- Climate risk management, health, safety and hygiene
- Carbon credit-offset marketing/circular economy
- ICT development in environmental conservation (image processing and acquisition, computer vision, graphics, speed, interface technology, HMD devices, GIS: Body Tracking, AI and IOT, VRT, IVE).

We commend our keynote speaker Prof. Douda Kone Director Capacity Building Department, WASCAL Headquarter, Ghana and other guest speakers Prof. Babatunde Rabiu, Director General, Chief Executive Office, African Regional Centre for Space Science and Technology Education-English (ARCSSTE-E) and Dr. Goni I. M., Conservator General National Park Service.

It is hoped that researchers, students and policy makers will find the papers in this book very useful. Even though all the papers were reviewed and edited, the content and option expressed remain essentially that of the authors and not necessarily that of Netlink Environmental Conservation Organization.

Dr. Oladeji S. O.

President Netlink Environmental Conservation Organization

Convener World Environmental Conservation Conference

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BIODEGRADATIONTRAITS OF BIOPLASTICS BLENDS, LOW-DENSITY POLYETHYLENE, AND CELLULOSE IN TROPICAL SOIL UNDERCONTROLLED HOME COMPOSTING CONDITIONS

[1]Dada, O. E. and [2]Akintoye, P. O.

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ABSTRACT

The biodegradationstraits of bioplastic blends, cellulose, and low density polyethylene (LDPE) in tropical soil in home composting conditions were evaluated. The experimental design of 4x3 was laid in triplicates with five hundred milligrams each of bioplastics, polyethylene, cellulose and blank (control) were sandwiched in compost soil placed in respirometric jars; and arranged in a randomized design under incubation at 25^{0}C according to the procedures of American Standard Testing and Materials (ASTM). The biodegradation propensities of bioplastic blends, cellulose and polyethylene were assayed every three days consecutively for four months. The extents of bio-fragmentation of the three polymers were assessed using scanning electron microscopy (SEM). The bioplastic and LDPE samples were monitored by observing the biodegradations processes before and after soil burial using scanning electron microscopy (SEM). Data obtained were subjected to descriptive and inferential statistical analyses. The scanning electron microscopy (SEM) analyses revealed that at four months, complete biodegradations of the bioplastic and cellulose samples were observed while the PE was recalcitrant. This showed that bioplastics (PBS) and cellulose- based polymers can beeasily managed usinghome composting method.

Keywords: *Bioplastic blends, Cellulose, Home composting, Polyethylene, Soil environment*

INTRODUCTION

Real bioplastics are nature-based polymeric materials with ability to biodegrade easily in the environment. They present an ecological advantage that can help reduce the pollution of natural ecosystems and shrink our energy and carbon footprint because of its propensity to biodegrade completely in the environment (Rhodes, 2018). Thus, there are significant economic and industrial interests in seeking a clean method of reducing plastic wastes pollution on the land. Thereby, fostering a more circular economy in addition with seeking environmentally-friendly alternatives such as bioplastics to traditional petroleum-based plastic products (Urbaneket al., 2018; Quecholac-Piña et., 2020).The production and the use of plastics with a high degree of biodegradability such as bioplastics have been suggested as a feasible alternative to the non-biodegradable plastics because they can biodegrade in natural environment such as soils without leaving toxic moieties.

Thus, it is imperative to constantly work on improving the biodegradation potentials of bioplastics for efficient management of plastic pollution in the environment.

According to ASTM (2012), carbon dioxide is an end product of ultimate biodegradation of polymers. The extent of aerobic biodegradation in soil using a measurement of evolved carbon dioxide was the factor to determine the biodegradability of the polymeric substances. This test requires that the carbon dioxide output from the reference material should be more than 60% and for blank this should be 20% at the end of the test as biodegradation depends on both polymer structure and environmental factors (Dada, 2020).

Globally, Standardized testing procedures have been defined by international organizations. These organizations are the International Organization for Standardization (ISO), Organization for Economic Co-operation and Development (OECD) and ASTM. The experimental procedures and designs from these organizations will ensure a global uniformity in determining the biodegradability of bioplastics. (Dada et al., 2020). In this study, three polymeric substances which are bioplastic blends of two thermoplastic starches, cellulose and polyethylene species were assessed for their ability to biodegrade in home compost soils.

MATERIALS AND METHODS

Sample collection

Compost material used for the degradation test was sampled from the biological garden behind the power house at Elizade University. Three samples were used for the test: Bioplastic, Cellulose and Polyethylene. The bioplasticwas PBS 1020 (commercially named Bionolle 1020), obtained from Toyo Plastics Co., Ltd. (Japan), and manufactured by Showa High Polymer Co., Ltd. In Japan whilethe polyethylene was sourced from the local stores in Ondo State.

Preparation of Samples and Reagents

The compost was sieved to ensure the removal of debris. Plastic samples as well as bioplastic samples were cut into smaller pieces of 2 cm by 2 cm. This was to ensure that the surface area is not too large for microbial action.

Physicochemical Analysis

The pH of the compost was determined by immersing the pH electrode in 1:5, soil to water mixture. The total dry solids and volatile solids test was determined using standard method while heavy metal analysis were carried out using the atomic absorption spectrophotometrymethod.

Experimental Design

The biodegradation test was performed in controlled compost at 25ºC for four months. The compost soil used for the test was air-dried and sieved to a diameter of less than 0.8cm using 1 mm and 600 µm sieves after sampling. This was done to remove all debris in the soil. The mason jars and 40 ml glass beakers, which were used in the degradation setup, were sterilized in the oven at 75ºC for 3 hours. 10 g of perlite was used to line the bottom of each respirometric glass jar before putting in 300 g of sieved compost. This was wet with 5 ml of distilled water to ensure the soil was moist.

The plastic polymer of 0.5 g was put on top of the wet soil after being cut into 2 cm by 2 cm sizes. Two hundred grammesof compost were poured gently over the bioplastic pieces and levelled out with 5 ml of distilled water introduced again to the environment. Tengrammes of perlite were gently poured over the top of the second layer of soil and levelled. One Normal KOH (potassium hydroxide) of 40 mls were poured into a sterilized 40ml glass beaker and this was placed on top of the second layer of perlite in the jar. The perlite was added to preserve the moisture content of the compost material. The jars were closed and put in the incubator at 27ºc for four months. Each beaker containing 40 mls of potassium hydroxide was placed in the mason jars or respirometric jars to absorb the carbon dioxide (CO_2) produced during the biodegradation process. Then, each beaker containing 40 mls of potassium hydroxide was removed every three days; and then back titrated against 1 Normal hydrochloric acid (HCl).

Analytical Characterization

Scanning Electron Microscopy (SEM)

The morphologies of the polymers was characterized using a Scanning Electron Microscope (SEM). The samples were cleaned using distilled water, air dried and put into paper envelopes before the analysis. Standard procedure for sample preparation and analysis was followed to ensure the maximum results.

Calculations for Degree of Biodegradation

To determine the % degree of degradation and the concentration of CO_2evolved calculations were made using the formular below:

Normality of KOH: volume of HCL / 10 x NKOH

The theoretical amount of carbon dioxide (ThCO2 in g per vessel) which can be produced by a total oxidation (or obtained elemental results % C) of the added test or reference material was calculated by $ThCO_2 = M_t \times C_t \times 44/12$

where M_t, is the total weight of the test samples which was 500 milligrams and 0.5g after conversion, C_t is the % carbon of the test samples which is a constant, 44 is the molar mass of carbon dioxide and 12 is the atomic mass carbon.

From the accumulated amounts of biologically produced carbon dioxide, measured in the test vessels (CO_2) test and in the blank control (CO_2) b, the % degree of biodegradation (Dt in % of $ThCO_2$) of the test material was calculated by

Degree of degradation, $D_t = (CO_{2(t)}) - (CO_{2(b)}) / ThCO_2 \times 100$

Where $CO_{2(t)}$, is the amount of carbon dioxide measured in the test vessels, $CO_{2(b)}$ is the amount of carbon dioxide measured in the blank control and $ThCO_2$ is the theoretical amount of carbon dioxide produced by the test materials.

To calculate the concentration of CO_2 evolved, the formula below was used:

$CO_{2(g)} = (NKOH \times ml\ KOH – ml\ HCl \times 1N\ HCl) \times 44 / 2$.

RESULTS

Physicochemical qualities of compost

Table 1 showed the results of the physicochemical properties of the compost material taken before the test. The value recorded for the pH showed that the soil was slightly alkaline in nature. The pH increased by 0.1 after the test. This is important as it fulfils the validity criteria of the test. The values of the other variables; the total dry solids, volatile solids and organic carbon content recorded before and after the test had slight differences between them. The concentration of cadmium and lead exceed World Health Organization (WHO) standards but the values were appropriate for the experiment.

Table 1: Physicochemical properties of the compost

Total dry solids, % [a]	55g
Volatile solids, % [b]	53g
pH of compost material	7.5
Total organic carbon amount, %	12.6g
Cadmium (Cd)	0.021
Lead	0.159

Table 2 shows the observed qualities of the polymers after degradation for four months. For cellulose (CE), being a natural material, there was complete degradation after four months. For bioplastic which is made of bio-based and biodegradable plastics, two out of three test jars degraded completely after four months. However, there was a difference in the third with weight changes while for polyethylene (PE), there was no observed changes in weight or even degradation.

Table 2: Observed Physical Properties of Polymers After Degradation

Polymer	Number of jars used for test	Physical evidence of degradation	Weight before and after test(g)
Cellulose (CE)	3	Complete degradation after four months	0.5 and 0.0
Bioplastic(PBS 1020)	3	Complete degradation in two jars, partial in one observed after four months	0.5 and 0.2
Polyethylene (PE)	3	No microbial degradation observed after four months	0.5 and 0.5

Scanning Electron Microscope (SEM)

SEM imaging showing the changes in surface morphology due to microbial activity on the plastic films (bioplastics and polyethylene) used in the degradation test are shown below. The SEM imaging was done on the samples before and after (four months) the degradation test. Plate 1 showed the difference in the morphology of polyethylene (PE) sample before microbial attack and after microbial activity on the sample while Plate 2 showed that of the bioplastic material (PBS 1020).

Polyethylene (PE)

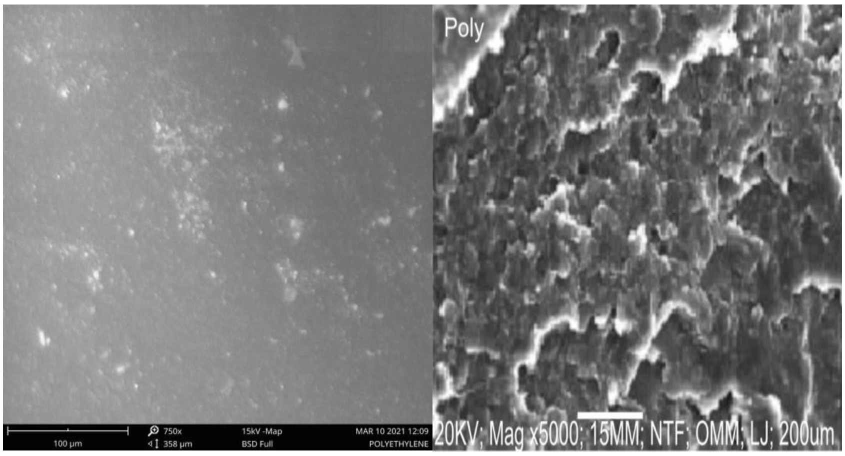

Plate 1: SEM imaging for polyethylene(PE) before test and 4 months after.

Bioplastic (PBS 1020)

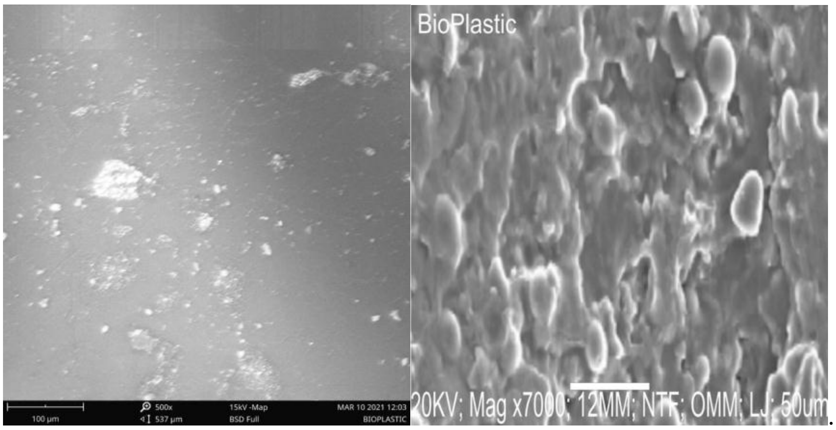

Plate 2: SEM imaging for bioplastic (PBS) before test and 4 months after.

Degree of Biodegradation and Amount of Carbon (di) Oxide evolved.

Figure 1 revealed the degree of bio-deterioration of the three polymers. The bioplastics had 412 % degradation while the cellulose degraded by up to two folds of the degree of degradation of bioplastics while the polyethylene had the least (6%) degradation level.

In Figure 2, the amount of CO_2evolved after the cellulose degradation is twice the amount evolved by the bioplastic while the least value were recorded for the polyethylene after biodegradation.

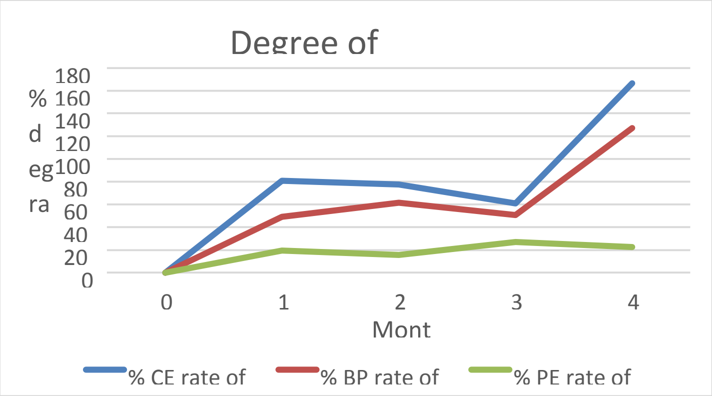

Figure 1: Degree of Degradation

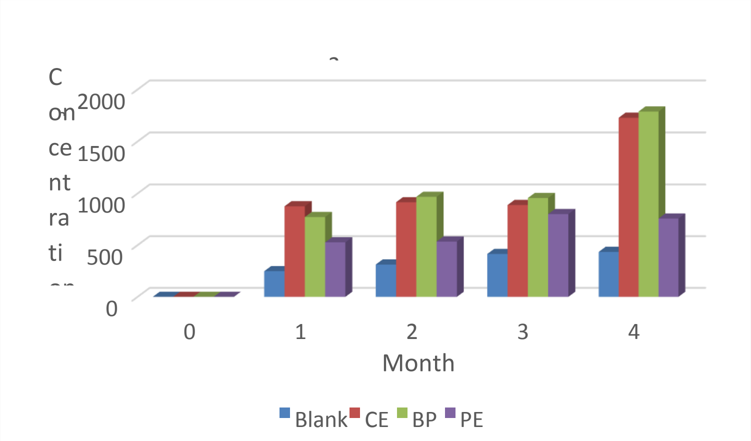

Figure 2: Amount of Carbon (iv) Oxides Evolved

DISCUSSION

Replacing plastics with bioplastics has been identified as a safe method of resolving plastic pollution problems in the environment (Emadian et al. 2018). In this study, bioplastic (PBS 1020), polyethylene (PE) and cellulose (CE) were subjected to microbial degradation in compost soil and it was found that cellulose being a natural plastic degraded faster than bioplastic. Polyethylene was found to be recalcitrant as there was no change in the weight of the plastic after subjection to microbial activity for four months. This shows that the degradability of the polymer is dependent on the nature of the polymer. This supports the findings of Adamcová et al., (2017) both of whom concluded that that the biodegradation of bioplastics materials depends on the environment and the nature of the material. Carbon dioxide and water were released as end products of the aerobic degradation of the polymer materials. Folino et al., (2020) discussed on how the thickness of the material can lengthen the biodegradability of the material. The factors that affect the process of biodegradation include: humidity, temperature, oxygen content, pH, nutrient availability, and the presence of microorganisms (Folino et al., 2020).

The results of the physicochemical properties of the composts showed the material was alkaline in nature which is necessary for optimum growth of the microorganisms responsible for the degradation as well as increased microbial activity(*SOP for Biodegradation Expt*, n.d.). The concentration of lead and cadmium in the compost exceed WHO standard limit however they were within the limit for the United States Environmental Protection Agency (USEPA). This may be due to the composition of the material. High concentrations of heavy metals in soil can affect and alter the physiological and biochemical properties as well as the composition and activity of the microorganism communities in the soil(Ahmedet al., 2018). This can affect the rate of biodegradation of plastic materials in soil. Most composts examined have always exceeded the WHO standard limits except where the content of the compost is entirely of green plant origin (Alshehrei,, 2017). The observed difference in the morphology of the test materials through SEM imaging show that due to microbial activity, the chemical composition of the material, external morphology as well as the surface area were affected.

The biodegradability of plastics is a complex process and is influenced by the nature of each plastic. The results obtained in this study demonstrates that the biomanagement of bioplastics in terrestrial environment using indigenous microbes is an environmentallyfriendly approach to managing and resolving the problem of plastic pollution in our environment today. This study shows that both Cellulose and PBS plastics can be degraded in less than six (6) months in a compost environment if the bacteria isolated and used in this research are present. The validity of the tests was confirmed in positive control (cellulose powder) 100 % biodegradable. From this test, it can be concluded that biodegradable bioplastic Polybutylene succinate(PBS) showed a high level of biodegradation during the 4-month composting test. However, Polyethylene (PE), a petroleum based plastic material showed slower degradation rate. Thus, it can be concluded that the biodegradation of bioplastic materials strongly depends on both, the environment they are placed and the chemical nature of the material. In addition, changes in surface morphology of the plastic films captured by SEM imaging showed avid proof or evidence of the action of the bacteria on the test materials.

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