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RESEARCH ARTICLE

NON-BIODEGRADATION OF POLYMERIZED POLYETHYLENE RADICALS AT SELECTED DUMPSITES IN KEFFI, NASARAWA STATE NIGERIA

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ABSTRACT

Polythene and plastic bags pollutes the soil because these are non-biodegradable, and so, they cannot be degraded by the action of the microbes. Therefore, they remain in the soil and will pollute the soil. Polyethylene Terephthalate (PET) is therefore belongs to the class of polymers known as polyesters. In the natural environment, PET can be degraded by thermal oxidation, but hydrolytic cleavage and photo-oxidation initiated by UV light are more common under ambient conditions. In general, polyethylene offers excellent chemical and impact resistance, electrical properties and low coefficient of friction. It is considered a dielectric material. In addition, polyethylene are lightweight, easily processed and offer near-zero moisture absorption. In this study, selected dumps were covered in Keffi. The laboratory analysis was conducted. It was found out that there are two categories of Polyethylene with different properties, characteristics and functions. These are the High Density Polyethylene (HDPE) and Low Density Polyethylene (LDPE). The analysis revealed that T4 and T5 Isolate after drying contained more density of 8-9% degradation of high density polyethylene. While in the second tests of Low Density Polyethylene the T2, T7 and T8 have the highest coefficient of degradation. The residual plot of the dry weight polyethylene T9 has the highest weight in the model.

KEYWORDS

Degradation, modelling, waste dumps, HDPE, LDPE

1. INTRODUCTION

Due to the non-biodegradability of polyethylene and the inability of microorganisms to break down plastic bags, they pollute the soil. As a result, they stay in the soil and contaminate it. PET, also known as polyethylene terephthalate, is a member of the category of polymers known as polyesters. PET can oxidize thermally in the natural environment, but hydrolytic cleavage and UV light photo-oxidation are more frequent under ambient conditions. Electrical properties, good chemical and impact resistance, low coefficient of friction, and other characteristics are all common features of polyethylene. It is regarded as a dielectric. Additionally, polyethylene has a low moisture absorption rate, is lightweight, and is simple to process. In this study, a few dumpsites were chosen and covered in keffi.

In addition to having significant negative effects on sustainable lifestyles and people's well-being, polyethylene is a serious environmental pollutant that has a long-term ecological imbalance on soil productivity. The fact that we have not yet treated this matter seriously, however, is extremely concerning (Dhaka et al., 2022). More than ever, polyethylene is a part of our daily lives and is used for a number of purposes, such as grocery shopping and the packaging of food and other goods. Polyethylene pollutes the environment and will always be a problem because it is toxic and non-biodegradable (Ghatge et al., 2020).

To increase efficiency, polyethylene has been combined with numerous other chemicals that are more toxic to both people and animals. It harms plants and animals on Earth when its burned because the toxic fumes it produces mix with the air. Air pollution brought on by it is harmful. The worst victims of this horrifying invention are marine life. Every square kilometre of ocean has between 46,000 and 1,000,000 floating plastic molecules, which eventually disrupt entire ecosystems by killing seagulls, turtles, and whales due to toxic chemicals. The majority of the plastic bags we use on a daily basis are not recyclable. They are carried out to sea and have a terrible impact on marine life. But cautious waste management practices can successfully safeguard marine life from the negative effects of polyethylene and plastics (Huang et al., 2021).

The UN estimates that every year, 100 million tonnes of plastic are dumped into the ocean. In the intestines of whales and other deep-sea creatures, large concentrations of microplastic have been discovered by scientists (Kumar and Agrawal, 2023). The most fundamental component of polyethylene, the ethylene molecule, which consists of two carbon atoms and four hydrogen atoms, is made up of hydrocarbon chains. When ethylene molecules are linked together in straight or branched chains, polyethylene is created. Numerous nations have prohibited or severely restricted the use of plastics, polyethylene, or single-use plastics as a result of these negative effects and poor waste management practices (Maheswaran et al., 2023).

In the presence of a catalyst, several ethylene molecules react to form polyethylene. Numerous catalysts are used in the polymer industry, and new catalysts are created annually (Mierzwa-Hersztek et al., 2019). Even within the same reactor, various catalysts can be used to produce polymers with distinct properties. Natural gas or petroleum are converted into the monomers that make up traditional plastics. According to

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estimates, this process used a lot of energy and produced 400 million tonnes of greenhouse gas emissions in 2012, or about 1% of all emissions worldwide (Snagle et al., 2019). Additionally, 4–8 percent of the world's oil and gas production comes from the fossil fuel feedstock used to make plastics 9, 10, and this percentage may rise further in the future. When break down the hydrocarbon molecules that are initially inert and bound into the structure of plastics, carbon dioxide and other greenhouse gases are released (Maroof et al., 2022).

Plastic pollution is a widespread, enduring problem as a result of the widespread use of plastics and inadequate end-of-life waste management. Only 9% of the approximately 6 300 million tonnes of plastic waste that were produced between 1950 and 2015 were recycled, and 12% were burned, leaving nearly 80% to deteriorate in landfills or the environment (Naaz and Siddiqi, 2022). All of the world's major ocean basins, including remote islands, the poles, and the deep seas, are contaminated by plastic, and an additional 5 to 13 million tonnes are added annually (Ebong et al., 2007).

According to modeling, there was improper management of about 10% (or 30 Mt) of the world's plastic waste production in 2010. Less than 2 percent of this content is thought to come from the G7 countries; the majority comes from ten significant emerging markets. This demonstrates how crucial it is to enhance waste collection services in middle- and low-income countries (Lal, 2001). The alternatives to recycling landfill or incineration are generally less expensive in many countries on top of these factors. The full social cost of these alternatives may not always be reflected in the per-tonne fee assessed for waste disposal. If properly designed, polyethylene pipes can typically last 50 to 100 years (Wróbel et al., 2023).

2. Materials and Methods

The Dumpsites were obtained in Unguwan Nepa and Kofa Kokona in Keffi Town as samples. There was a sizable landfill nearby that was filled with various types of polyethylene plastic bags. The soil samples were taken to the lab for additional analysis after being kept at room temperature for storage. Semi-crystalline polyethylene has a wide range of properties, excellent chemical resistance, and wear resistance. When compared to other plastics, polyethylene is easily distinguished because it is stiff and heat-resistant but also has good corrosion resistance.

2.1 Study Area

Figure 1: The locations of the Dumpsites in the study area (Keffi) with two samples of Dumpsites full of Polythene sheets accumulated in the soil.

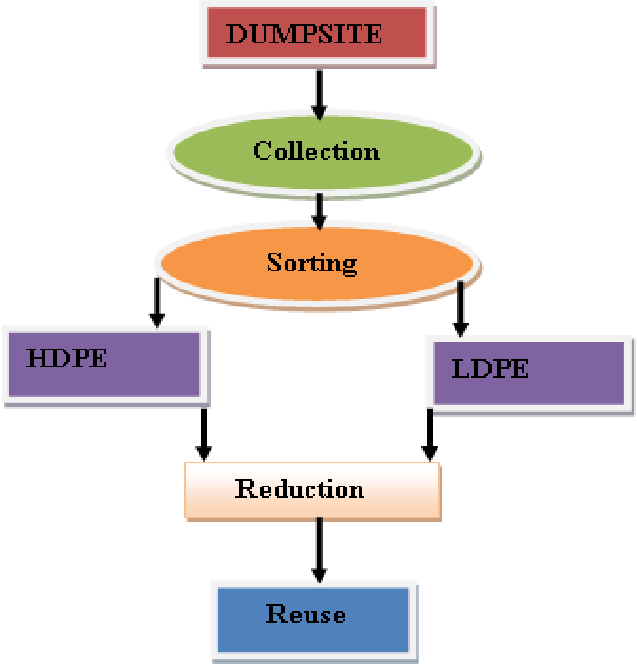

Figure 2: Flow chard of the Study

3. Result and Discussion

The most important advantages of polyethylene are listed below for the benefit of it user as well as the environment. These include the following.

1. Good electrical properties
2. Moisture resistance
3. Impact resistance
4. Low coefficient of friction
5. Chemical resistance
6. Abrasion resistance
7. Durability Easily fabricated

3.1 Characterization of the Polyethylene

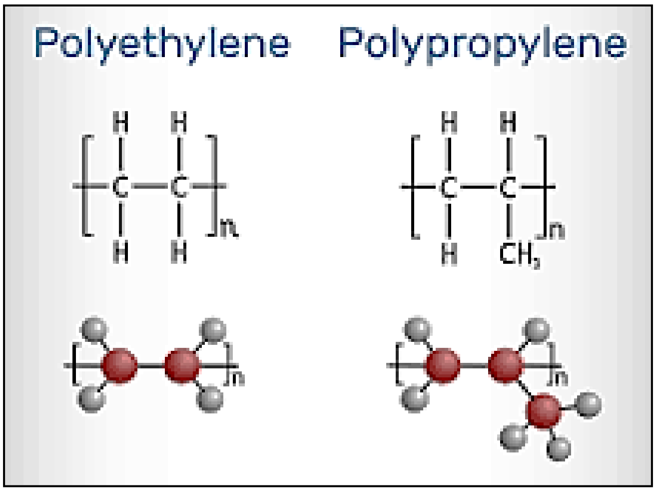

Figure 3: Polymerization of the Polyethylene and polypropylene

In contrast to polypropylene, which has a monomer unit of propylene, polyethylene has an ethylene monomer. The main difference between polyethylene and polypropylene is that, as was previously mentioned, polyethylene is created by polymerizing ethylene monomer units, whereas polypropylene is created by polymerizing propylene monomer units. Chemical Formula: (C2H4), Density: 0.88-0.96 g/cm3, Magnetic susceptibility: 9.67106, Solubility in water: Not soluble (HDPE, SI, 22 °C), Melting point: 115-135 °C (239-275 °F; 388-408 K), log P: 1.02620.

Table 1: Comparison between HDPE and LDPE Categories of Polyethylene

Types of Polyethylene	Physical Properties
HDPE	1. The density is approximately 0.95g/mL
	2. It has high tensile Strength
	3. 70-90% crystallized
	4. High melting point
	5. its durable, robust and Rigid
LDPE	1. Low tensile strength
	2. Density -0.920-0.945
	3. it has high degree long and short chain reaction
	4. Low Crystalline below (48%)
	5. Very low durability
	6. Highly malleable

3.2 Grades of Polyethylene

3.2.1 High Density Polyethylene (HDPE)

HDPE has the ability and offers good application of high-quality tensile strength, light in weight, moderate to low moisture absorption, non-toxicity and non-staining capacity. The Laboratory results have shown that 9 different isolates were presented in Table 1. The T4 with 9% and T5 with 8% and T3 with 5% have the highest degradation ability base on the decomposition of the radicals. Some of the benefit obtained from HDPE includes:

1. High resistance impact
2. Resistance to Abrasion
3. Low friction coefficient
4. Resistance to scratch and marking.
5. Moisture and water resistance
6. Chemical resistance

Other uses and application of High-Density Polyethylene includes are

1. Prosthetic devices
2. Radiation shielding
3. Corrosion resistant covers
4. Self-supporting containers
5. Food cutting boards.
6. Pipe flanges

Table 2: High Density Polyethylene (HDPE)

TESTS	DRY WEIGHT (Gram)		Differences (Gram)	Degradation (%)
Isolate	Before	After		
T1	1	1	0	1
T2	1	0.90	0.01	1
T3	1	0.95	0.05	5
T4	1	0.91	0.09	9
T5	1	0.92	0.08	8
T6	1	0.96	0.04	4
T7	1	0.97	0.03	3
T8	1	0.98	0.02	2
T9	1	0.93	0.07	7

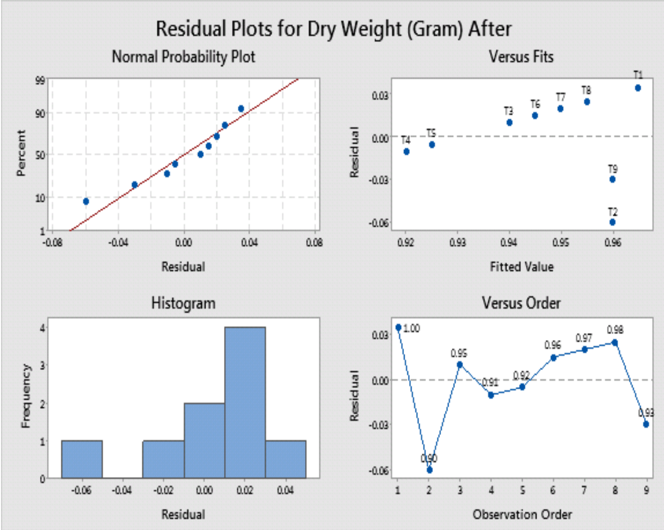

Figure 4: Residual Plot of Dry Weight (After) High Density Polyethylene in Keffi

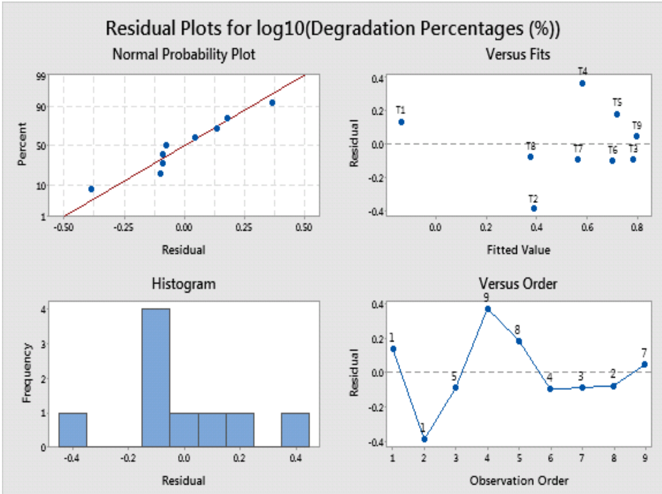

Figure 5: Residual Plot of (Degradation) High Density Polyethylene in Keffi

Figure 6: Model of combined fitted plot of degradation and dry weight contents in the dump site

3.3 Grades of Polyethylene

3.3.1 Low Density Polyethylene (LDPE)

Among the 9-isolate presented in Table 2, the Laboratory tests have shown that T 8 with 10%, T7 with 9% and T2 with 7% are have highest biodegradation in the soil. The material in Low Density Polyethylene offers low permeability and moisture retention, High flexibility, High temperature, little stuffiness, orthopaedic products; it is used for costumer packaging, bags, bottles and liners.

Some of the advantages of the LPDE include.

1. Good electrical properties
2. Light in weight
3. Formable
4. Low impact resistance
5. Easy to fabricate
6. Easier to clean

Other uses of the LDPE are

1. for food preservation containers
2. use as Laboratory equipment
3. Use for Surface corrosion resistance
4. use as moisture barrier
5. use a end cap and tops for Vacuum
6. use as chemical resistance to containers and tanks

Table 3: Lab Low Density Polyethylene (LDPE)

TESTS	DRY WEIGHT (Gram)		Differences (Gram)	Degradation (%)
Isolate	Before	After		
T1	1	0.09	0.91	1
T2	1	0.93	0.07	7
T3	1	0.95	0.05	5
T4	1	0.97	0.03	3
T5	1	0.94	0.06	6
T6	1	0.96	0.04	4
T7	1	0.91	0.09	9
T8	1	0.90	0.1	10
T9	1	0.98	0.02	2

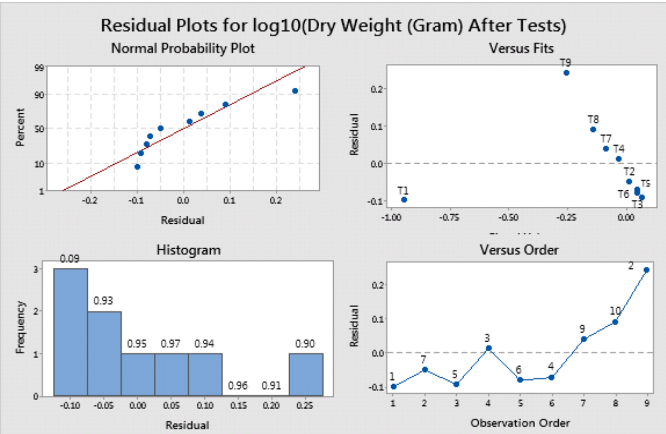

Figure 7: Residual Plot of Dry Weight (After) Low Density Polyethylene in Keffi

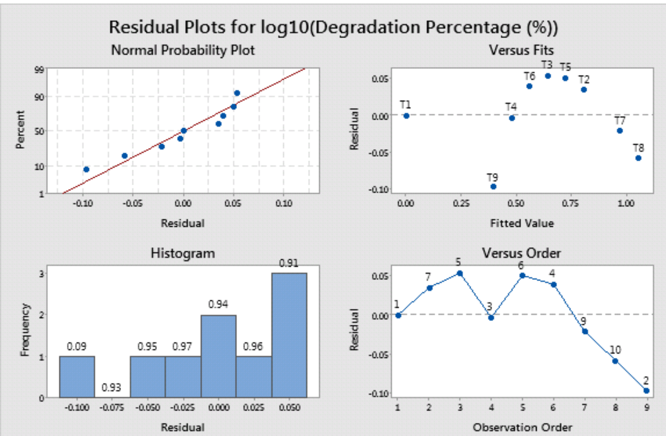

Figure 8: Residual Plot of (Degradation) Low Density Polyethylene in Keffi

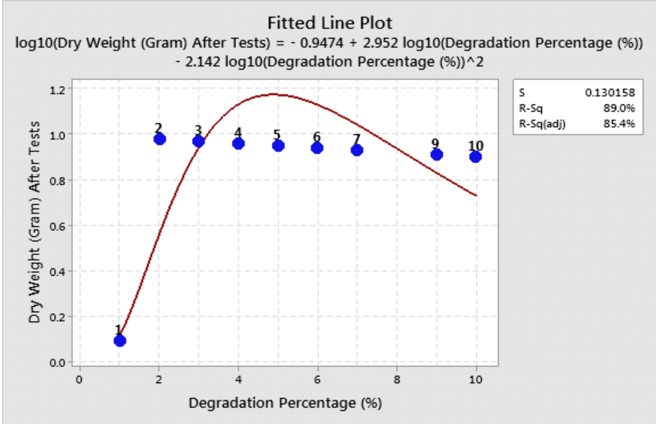

Figure 9: Model of combined fitted plot of degradation and dry weight contents in the dump site

3.4 Toxicity

Chlorinated plastic has the potential to release dangerous chemicals into the soil around it. These chemicals can then seep into nearby water sources, including groundwater, and the ecosystem. The species that drink the water may experience a variety of potentially harmful effects as a result.

4. Conclusion

Polyethylene takes almost 10-50 years before it chemical decompose and free it radicals on the soil. Hard plastic leather and bottles usually take 50-100 years before it will degradation in the soil. Based on the laboratory tests, the High Density Polyethylene (HDPE) with T4 and T5 are the isolate with highest density in dry weight content of the Polyethylene. The Low Density Polyethylene (LDPE) has the highest degradation contents of dry weight polyethylene of T2, T7 and T8.

Recommendations

The following are some ways that the developing countries could handle these issues. such as:

1. Introduction of systems allowing separate collection of multiple streams of data.
2. Creation of rewards for improved product and plastics design (e. g. plan for reuse. and recycling), such as through improved extended producer responsibility. Product stewardship and systems for deposits and refunds;
3. Support for the sustainable and improved plastics management systems. plastics are made in a way that makes them easier to recycle or biodegrade
4. Harmonization of the introduction of more challenging recycling rate targets. New techniques could be used to determine these rates.
5. Stricter landfill and incineration fees to better account for society as a whole for cost of these pursuits.
6. Laws should be enforced on indiscriminate disposal of polythene in water ways to avoid flood.
7. Marine organisms must be protected from the harm course but disposable unwanted materials such polyethylene.

References

Dhaka, V., Singh, S., Ramamurthy, P.C., Samuel, J., Swamy, S.K., Naik, T., Khasnabis, S., Prasad, R., and Singh, J., 2022. Biological degradation of polyethylene terephthalate by rhizobacteria. Environmental Science and Pollution Research, Pp. 1–10.

Ebong, G.A., Etuk, H.S., and Johnson, A.S., 2007. Heavy metals accumulation by Talinum triangulare grown on waste dumpsites in Uyo metropolis, Akwa Ibom State, Nigeria. Journal of Applied Sciences, 7 (10), Pp. 1404–1409.

Ghatge, S., Yang, Y., Ahn, J.H., and Hur, H.G., 2020. Biodegradation of polyethylene: a brief review. Applied Biological Chemistry, 63 (1), Pp. 1–14.

Huang, D., Xu, Y., Lei, F., Yu, X., Ouyang, Z., Chen, Y., Jia, H., and Guo, X., 2021. Degradation of polyethylene plastic in soil and effects on microbial community composition. Journal of Hazardous Materials, 416, Pp. 126173.

Kumar, A., and Aggrawal, P., 2023. A Novel Application of Waste Polythene in Concrete. Iranian Journal of Science and Technology, Transactions of Civil Engineering, Pp. 1–10.

Lal, R., 2001. Soil degradation by erosion. Land Degradation & Development, 12 (6), Pp. 519–539.

Maheswaran, B., Al-Ansari, M., Al-Humaid, L., Raj, J.S., Kim, W., Karmegam, N., and Rafi, K.M., 2023. In vivo degradation of polyethylene terephthalate using microbial isolates from plastic polluted environment. Chemosphere, 310, Pp. 136757.

Maroof, L., Iqbal, M., Farman, S., and Faisal, S., 2022. Biodegradation of Low-Density Polyethylene (LDPE) Bags by Fungi Isolated from Waste Disposal Soil. Applied and Environmental Soil Science.

Mierzwa-Hersztek, M., Gondek, K., and Kopeć, M., 2019. Degradation of polyethylene and biocomponent-derived polymer materials: an overview. Journal of Polymers and the Environment, 27 (3), Pp. 600–611.

Naaz, R., and Siddiqi, W.A., 2022. Screening for Polythene-Degrading Bacteria from Dumped Soil Area and Its in vitro Microbial Polythene Degradation. In Polymeric Biomaterials and Bioengineering, Pp. 87–99. Springer.

Sangale, M.K., Shahnawaz, M., and Ade, A.B., 2019. Potential of fungi isolated from the dumping sites mangrove rhizosphere soil to degrade polythene. Scientific Reports, 9 (1), Pp. 1–11.

Wróbel, M., Szymańska, S., Kowalkowski, T., and Hrynkiewicz, K., 2023. Selection of microorganisms capable of polyethylene (PE) and polypropylene (PP) degradation. Microbiological Research, 267, Pp. 127251.