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ECOTOXICOLOGICAL IMPACT OF PLASTIC ON SELECTED AQUATIC AND TERRESTRIAL HABITATS OF MALETE MORO LOCAL GOVERNMENT AREA OF KWARA NORTH CENTRAL, NIGERIA

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ABSTRACT

Plastic pollution is now a major environmental issue that has a significant impact on ecosystems all around the world. The aim of this research was to examine the ecotoxicological effects of plastic pollution on the aquatic water bodies and terrestrial habitats, in urban centers and waste disposal sites of Malete Community, Kwara State, Nigeria. Plastic samples were collected from three sampling points with the following coordinates, (Latitude 8° 71' 8" and longitude 4° 46' 8"), (Latitude 80 70' 8" Longitude 40 46' 8"), and (Latitude 8° 70' 8" and longitude 4° 46' 8") and they were tagged samples 1, 2 and 3 respectively, this was done as a representative of aquatic and terrestrial ecosystems. Gas Chromatography-Mass Spectrometry (GC-MS) analysis as well as chemical characterization of the plastic samples were carried out using standard procedures and methodologies. Interestingly, sample 1 has high levels of the following compounds, benzene (8.3%) ethylbenzene (22.6, %) and styrene (45.2%), known to have harmful impacts on aquatic life. The presence of 1-Octene (18.9%) and 1-Nonene (22.6%) in Sample 2 indicated the possibility of biomagnification through food chain. The presence of ethyl terephthalate (25.9%), and ethylene glycol (19.3%), which are compounds associated with aquatic toxicity, was evident in Sample 3. This study highlights the widespread ecotoxicological impact of plastic pollution in the aquatic and terrestrial ecosystems of Malete Community, Kwara State. The presence of hazardous compounds in the plastic samples suggests significant risks to environmental health.

Keywords: Plastic pollution, Malete, Characterization, Ecotoxicology

INTRODUCTION

The adaptability, durability, and low cost of manufacture of plastics, which are produced in excess of 360 million metric tons annually worldwide, have transformed modern society (Geyer et al., 2017; Martin et al., 2021). However, due to its extensive usage and inappropriate disposal, plastic pollution has become a serious environmental problem (Akanbi-Gada et al., 2024; Nwafor et al., 2024). Plastics decompose into microplastics that enter soil, water, and the atmosphere and remain in ecosystems for decades (Sajjad, et al., 2022; Suktar et al., 2023).

These microplastics contaminate food chains, injure wildlife, and change microbial communities, disrupting ecosystems along with leached hazardous chemicals like phthalates and bisphenols (Okeke et al., 2022). The widespread occurrence of plastic pollution underscores the pressing necessity for sustainable management approaches to lessen its long-term effects on the environment and human health (Chaudhary and Garg, 2023).

Geographically situated in the Guinea savanna zone, which is distinguished by a mixture of grassland and sporadic trees, Malete is a semi-urban town with a tropical climate that supports a variety of ecosystems. It is situated in the Moro Local Government Area of Kwara State, North Central Nigeria (Salako et al., 2017). Malete is a crucial region for researching environmental effects because it is home to both terrestrial and aquatic environments, such as tiny streams, farmlands, and native vegetation. Socioeconomically, the town's main source of income is agriculture, which includes small-scale fishing in nearby waterways and the production of crops including yams, cassava, and maize. Biodiversity and healthy soils are examples of natural resources that support the community. These important resources are under peril, though, from growing environmental stresses like plastic waste.

Nigerian plastic waste management is severely hampered by a lack of infrastructure and lax enforcement of regulations (Ekanem et al., 2024). Studies on plastic pollution in Nigeria and other comparable areas have shown that it has serious negative effects on the ecosystem and it posses critical toxicity to the aquatic systems when not put under control (Yawaji et al., 2022; Yakubu et al., 2024).

Investigations into various environments have revealed that inadequate waste management, urban runoff, and industrial operations have significantly contaminated water bodies, such as rivers, streams, and coastal areas, with macro- and microplastics (Qasier et al., 2023; Bhardwaj et al 2024). The bioaccumulation of harmful compounds, damage to aquatic organisms by ingestion and entanglement, and disturbance of food webs have all been connected to plastic trash in these environments (Tuuri and Leterme, 2023; Ofuegbu et al., 2024). The uptake of microplastics by freshwater fish in Nigeria, for instance, was reported by Auta et al. (2017), highlighting possible threats to food safety and biodiversity. Notwithstanding, there are significant knowledge gaps, especially with regard to terrestrial ecosystems. Although some research has examined the effects of plastic pollution on microbial activity and soil quality (Udochukwu et al., 2021; Sa·adu and Farsang et al., 2023).

Microplastics can penetrate different soil levels and alter microbial activity and soil structure especially with the addition of low-density polyethylene pieces, for example this can dramatically change the quantity and composition of soil microarthropod and nematode communities (Lin et al., 2020).

The researchers are of the opinion that, microbial activity increased while soil fauna suffered, indicating intricate connections within the soil ecosystem.

Although there is a lack of direct research on the long-term effects of microplastics on crop productivity, the detrimental effects on soil fauna and changes in microbial activity point to possible hazards. For example, at certain concentrations, typical plastic glitter was found to inhibit the reproduction of springtails, which are important soil organisms (Wang et al., 2022). Plant development and thus impacted crop output by this decline in beneficial soil fauna, which could also harm soil health.

There is a lack of information on the bioavailability of microplastics in soils, their interactions with terrestrial fauna, and their long-term effects on crop productivity. Furthermore, studies frequently ignore the combined impacts of chemicals linked to plastic, like phthalates and bisphenols, on aquatic and terrestrial environments.

There has not been any local research done in Malete, Moro LGA to measure plastic pollution or evaluate its ecotoxicological effects. The result from this research will serve as a baseline information on the effects of microplastic on both aquatic and terrestrial ecosystems in Malete. Closing this gap is essential to creating focused mitigation plans and environmentally sound activities. Hence, the main goal of this study is to assess the ecotoxicological impacts of plastic pollution on selected aquatic and terrestrial habitats in Malete.

MATERIALS AND METHODS

Study Design and site selection

To achieve a representative assessment of plastic pollution in the selected sampling points, the procedure outlined by Hidalgo Ruz (2012), a multi-scaled study design was adopted. This study concentrated on a few sampling points close to urban centers and waste disposal facilities because of high human activity and proximity to potential sources of plastic debris. Samples were collected at three sampling points from Kwara State University, Malete with the following coordinates (Latitude 8° 71' 8" and longitude 4° 46' 8"), (Latitude 80 70' 8" Longitude 40 46' 8"), and (Latitude 8° 70' 8" and longitude 4° 46' 8") .

Method of plastic sample collection and Laboratory Analysis of Plastic Samples

Plastic samples were collected using a trawling nets for aquatic environments. For terrestrial habitats, samples were obtained using grab samplers. Special attention was given to different types of plastic debris, such as single-use plastics, microplastics, and macroplastics. Each plastic sample was carefully collected to minimize contamination and was stored in individual airtight containers labeled with location, date, and habitat type. Back in the laboratory, samples were sorted, and foreign materials were removed to ensure the purity of plastic samples.

Chemical Characterization of Plastic

Analytical techniques of Gas Chromatography-Mass Spectrometry (GC-MS) was utilized to identify and quantify chemical additives and contaminants present in the plastic samples. This analysis provided valuable information on potential toxic substances associated with plastic pollution.

RESULTS AND DISCUSSION

Figure 1 shows the Map of the study area.

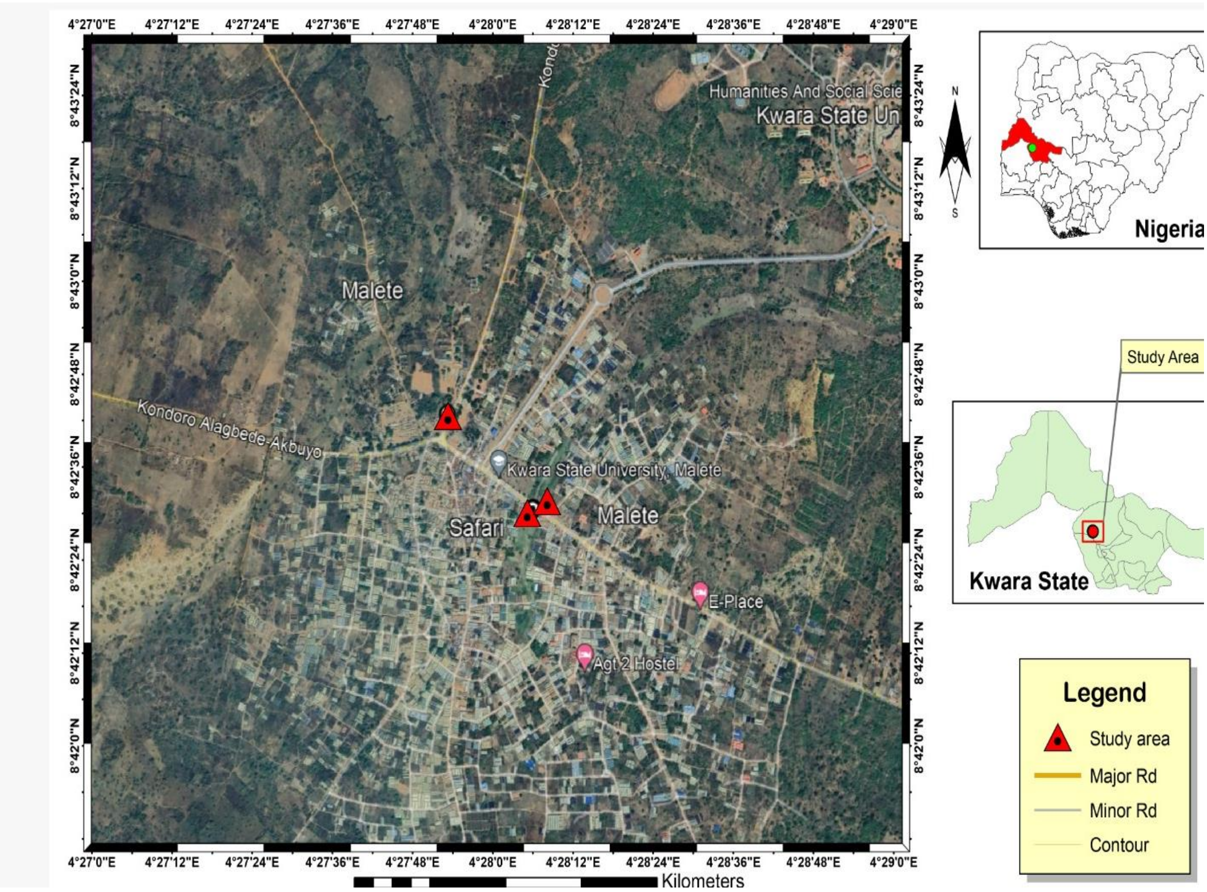

Figure 1: Map of the study area

Results of Chemical Characterization of Plastic Samples
Table 1 shows the results obtained from the GC-MS analysis for the chemical characterization of plastic samples. This table provides the list of the chemical compounds identified in different plastic samples, along with their respective quantities using GC-MS analysis. The retention time corresponds to the time at which each compound eluted from the chromatographic column, and the peak area indicates the proportion of that compound relative to the total area under the chromatogram. These results offer insights into the types and quantities of chemical additives, contaminants, and breakdown products associated with each plastic type.

Table 1: GC-MS analysis of Plastic Samples

Plastic Sample ID	Chemical Compound	Retention Time (min)	Peak Area (%)
Sample 1 (S-1)	Styrene	6.42	45.2
	Ethylbenzene	7.98	22.6
	Benzene	10.34	8.3
	Toluene	12.05	12.1
	Diethyl Phthalate	15.79	11.8
Sample 2 (S-2)	Propylene	8.21	35.7
	1-Octene	9.85	18.9
	Ethylene	11.02	10.2
	2,4-Dimethylpentane	13.47	12.6
	1-Nonene	16.2	22.6
Sample 3 (S-3)	Terephthalic Acid	9.14	31.9
	Ethylene Glycol	11.78	19.3
	Isophthalic Acid	13.65	14.8
	Dimethyl Phthalate	15.92	8.1
	Ethyl Terephthalate	18.03	25.9

The chemical characterization of plastic samples using Gas Chromatography-Mass Spectrometry (GC-MS) has revealed valuable insights into the potential ecotoxicological impact of plastics on ecosystems. The identified chemical compounds and their quantities shed light on the types and concentrations of additives, contaminants, and breakdown products associated with different plastic types. These findings have implications for understanding the potential risks posed by these compounds to aquatic and terrestrial organisms, as well as the overall ecosystem health.

In the plastic sample S-1, the predominant compounds identified were styrene, ethylbenzene, benzene, toluene, and diethyl phthalate. Styrene, a monomer commonly used in the production of polystyrene, was found in significant quantities (45.2% peak area), which is concerning due to its recognized toxicity to aquatic organisms (Guazzoti et al., 2023; Lee and Jeong, 2023). Ethylbenzene, benzene, and toluene are volatile organic compounds (VOCs) associated with plastic manufacturing and have been linked to adverse effects on aquatic life (Nabi et al., 2019; Mo et al., 2020). Diethyl phthalate, a plasticizer commonly used in plastics to increase its flexibility. Phthalates are serious hazards to the environment and human health because they are endocrine disruptors (Wang and Qian, 2021; Wowkonowicz, 2023).

The presence of these compounds (styrene, ethylbenzene, benzene, toluene anddietyhl pthalate) in substantial amounts raises concerns about their potential to bioaccumulate and cause ecotoxicological harm to aquatic ecosystems and hence posing health risks to human beings (e.g neurotoxicity) (Abtahi et al., 2019; Anigala et al., 2024).

In the case of the sample S-2, compounds such as propylene, 1-octene, and 1-nonene were prominent. Propylene, a common plastic material, was present in notable quantities (35.7% peak area). Numerous researchers portends that propylene itself may not exhibit high toxicity, but that its degradation products could potentially contribute to environmental contamination (Dimassi et al., 2022; Yao et al., 2022). 1-Octene and 1-nonene, both aliphatic hydrocarbons, are associated with the breakdown of plastic polymers and can accumulate in aquatic organisms (Faussone and Cecci, 2022; Calero et al., 2023). These compounds may pose risks to aquatic organisms and potentially disrupt food webs (Ali et al., 2023).

The S-3 plastic sample exhibited compounds like terephthalic acid, ethylene glycol, and isophthalic acid. Terephthalic acid, a key component of this plastic, was identified in considerable amounts (31.9% peak area). Since Terephthalic acid is relatively stable, its breakdown products and associated compounds can have ecological implications (Dhaka et al., 2022; Panigrahy et al., 2022). Ethylene glycol, commonly used in the production of this plastic sample, has been shown to have toxicity to aquatic organisms (Balola et al., 2024). Isophthalic acid, another component of this plastic, has been associated with endocrine-disrupting effects (Andersen *et al.*, 2008). The presence of these compounds highlights the potential for ecotoxicological effects associated with S-3 plastics.

It is important to note that the quantities of the identified compounds can vary across different plastic types and samples, potentially influencing their ecotoxicological impact. Additionally, these compounds can undergo transformations in the environment, leading to the formation of potentially more harmful derivatives. The ecotoxicological impact of these compounds can be complex, involving various routes of exposure and interactions with different organisms in the ecosystem.

CONCLUSION

This study highlights the widespread ecotoxicological impact of plastic pollution in the aquatic and terrestrial ecosystems of Malete Community, Kwara State. The presence of hazardous compounds in the examined plastics such as benzene, styrene, ethylbenzene, phthalates, and ethylene glycol in the collected plastic samples suggests significant risks to environmental health. These compounds, originating from plastic degradation and additives, can leach into water bodies and soil, leading to toxic effects on aquatic organisms and potential biomagnification through the food chain.

The findings underscore the urgent need for proper waste management strategies, regulatory policies on plastic use, and further ecotoxicological assessments to mitigate the long-term environmental consequences. Additionally, raising awareness about the hazards of plastic pollution and promoting sustainable alternatives will be crucial in protecting both aquatic and terrestrial ecosystems.

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