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Occurrence, identification and characterization of plastic pollution from an open solid waste dumpsite in Calabar, Southern Nigeria

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A B S T R A C T

Landfills and dumpsites are the final point of solid waste deposition and management in developing countries due to lack of recycling methods. Herein, we have investigated the occurrence, polymer composition and characterization of plastic pollution at the Lemna solid waste dumpsite, Calabar Nigeria. A total of 21 plastics were sampled and categorized into 10 representative plastic types for effective identification and characterization. The plastic categories were PET bottles, LDPE, PP, HDPE, PS tray, PVC fiber and PVC others. PET bottles were the most abundant (28.5%), followed by PP > LDPE > HDPE, while PS trays, PVC fiber and PVC others were the least prevalent plastics at the dumpsite. FT-IR analysis showed that only 5 different plastics polymers (PP, PET, PE, PVC, and PS) were identified and characterized, out of the 10 plastics categories collected. However, PP and PET were the most abundant plastic polymers at the dumpsite consisting of 33.3- and 28.6%, respectively, and reflecting their widespread application in domestic and household packaging products. PS was the least abundant plastic (4.8%) polymer. We used the density gradient separation techniques and recovered only three (3) plastic polymer types from soil at the dumpsite, namely - PET, PS, and PP with sizes >5mm in diameter and indicating macroplastics. Given that plastics are vectors of contaminants of legacy and emerging concern, their continuous deposition at dumpsites represent a significant environmental, human and wildlife health issue of concern.

1. Introduction

The increased application and use of plastics for several industrial and domestic processes including food packaging and construction has resulted in their ubiquitous occurrence and distribution in the environment with human, biota and ecosystem health concerns (Adeogun et al., 2020; Jia et al., 2019; Lebreton and Andrady, 2019; Roosen et al., 2020; Zheng and Suh, 2019). Some reports have indicated a significant and alarming increase in global plastic production from 2 million tons (mt) in 1950 to 380 mt in 2015 with an annual increase rate of 8.4% (Geyer et al., 2017). Interestingly, about 58% of global plastic waste is discarded in dumpsites and landfills, while only 18% is recycled based on the cited 2015 data (Geyer et al., 2017). An estimated 330 and 360 mt of global annual plastic production was reported in 2016 and 2018, respectively, and this is expected to double in the coming years.

Plastics represent a low-cost, hydrophobic, easily formable, high-modulus, bio-inert material that is applied in a wide range of consumer products with huge social and societal benefits accounting for its popularity as a material (Andrady and Neal, 2009). They are indispensable preferred consumer packaging products accounting for 42% of global annual resin production (Geyer et al., 2017). The durability, low cost and lighter weight of plastics has resulted in their replacement of metals and woods in building applications, fabric, carpeting, wool, cotton/silk and medical appliances, accounting for about 20% of global

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production. To address the growing environmental-, biota and human health issues resulting from plastic pollution, several global regulatory bodies has listed plastics as environmental contaminants of legacy and emerging concern (SAPEA, 2019). For example, the European Union (EU) law on plastic pollution stipulates that 50% of plastic packaging should be recycled by 2025 and 55% by 2030. The United Nation Environmental Assembly (UNEA) and G20 has recently listed plastic pollution as a major global environmental problem (UNEP, 2017). Further, the Basel Convention as amended in the 2019 Basel Conference of parties has recently included plastic waste in legal binding frameworks indicating a transparent and better regulated global trade in plastic waste (Lusher et al., 2021). Other global plastic pollution policies and efforts have proposed plastic recycling methods through thermal-mechanical and chemical recycling approaches, including polymer immiscibility utilizing little resources and energy (Garcia and Robertson, 2017; Huysveld et al., 2019; Ragaert et al., 2017).

Single-use plastics are banned in Canada since 2021, while about 170 United Nation member states have pledged to significantly reduce plastic use by 2030 (Tessnow-von Wysocki and Le Billon, 2019). Other developed nations such as Norway have recently initiated and enforced focused and strong environmental actions towards plastic pollution management (Lusher et al., 2021). Some scientific investigations have identified and demonstrated that plastics are substances of legacy and emerging concern due to their ability to act as vectors of major environmental contaminants with hazardous public- and ecosystem health effects (Amelia et al., 2021; Endo and Koelmans, 2016; Koelmans et al., 2016; Takada and Karapanagioti, 2019; Völker et al., 2022). Other reports have demonstrated that plastic (macro- and microplastics) and their associated contaminants produce reproductive, developmental, endocrine, metabolic disruptive, immune system/cellular damage and alterations of energy budget effects (Cole et al., 2015; Kershaw, 2015; Martínez-Gómez et al., 2017; Ogonowski et al., 2016; Pittura et al., 2018; Völker et al., 2022).

While global efforts towards plastic pollution reduction and control are priorities for most legislative/policy agenda in most developed countries, no such efforts are currently available for developing countries in Africa and Asia, including Nigeria, where plastic pollution remains a serious environmental-, biota and human health issue. In addition, the absence of systematic methods for solid waste collection and management, including poor technological advancement and development for recycling plastic waste remains a serious problem. For Nigeria as Africa's most populous nation with an estimated population of >200 million and 0.58 kg of solid waste/person/day (Ibor et al., 2020; Ogwueleka, 2009), unhygienic and inefficient ways of solid waste management such as dumpsites, landfills and open burning are the only available waste management methods (Bassey et al., 2015). Unfortunately, these dumpsites and landfills are below international standards for solid waste managements (Oyeku and Eludoyin, 2010), with potential negative effects on human, biota and environmental health (Ibor et al., 2020; Laniyan et al., 2011; Schrapp and Al-Mutairi, 2010).

The Lemna solid waste dumpsite in Calabar, Southern Nigeria is the final and major waste deposition site in the city of Calabar and has existed for over three decades. It is the only available solid waste management site in the city and increasing human population with associated urban development has positioned the dumpsite neighborhood as one of the fastest growing residential areas within the Calabar metropolis. Plastics are rapidly growing segments of municipal solid waste, constituting a dominant and significant proportion of the total waste deposited in most dumpsites and landfills. There is need to generate important scientific information on plastics occurrence, polymer identification and characterization towards providing a scientific and technical basis for plastic pollution management and recycling in developing countries. Therefore, this study is aimed at evaluating the occurrence, polymer identification and characterization of plastics from the Lemna solid waste dumpsite in Calabar, Nigeria and to provide a scientific basis for mitigation and management procedures.

2. Materials and methods

2.1. Chemicals and reagents

Sodium chloride (NaCl) and hydrogen peroxide (H_2O_2) were purchased from Sigma-Aldrich, Oslo Norway. Other reagents and chemicals used in the study were of the highest commercially available analytical grades.

2.2. Study area

The Lemna solid waste dumpsite is located along the Goodluck Jonathan bypass in Calabar metropolis (with a population of about 372,000) and the capital city of Cross River State, Southern Nigeria (Fig. 1). The dumpsite is situated at latitude 4°57N and longitude 8°20E and has existed for over three decades with a length of about 960m, width of 430m and a depth of 180m (Eni et al., 2014). For the city of Calabar and its environs, the Lemna solid waste dumpsite is the major and only waste deposition site in the region and repositories for several kinds of unsorted industrial and household wastes including plastic products, oils, electrical/electronic gadgets, paints, batteries, tyres, among others with plastics constituting bulk of the waste. Due to lack of technological advancement for solid waste recycling and management including plastics, the dumpsite is the only available solid waste management effort representing a significant source of pollutants of legacy and emerging concern with associated significant environmental, wildlife and public health problem in the region.

2.3. Sample Collection and Preparation

Plastic samples which represent large and greater parts of the solid waste at the dumpsite were strategically collected from fifteen (15) different sampling points across the dumpsite and surface soil samples were also collected at a depth of about 1–10 cm from the same sampling points across the 960m length of the Lemna dumpsite using stainless steel spoon and transferred into glass containers. The fifteen (15) regular grid sampling points were unbiasedly selected to cover the entire 960 m length and 430m width of the dumpsite at about 64m spacing across the Lemna solid waste dumpsite. The grid sampling strategy was used to ensure a configurational sampling which consist of sampling clusters arranged in some standard geometrical pattern. Because plastics constitute bulk of the waste at the dumpsite, we collected about 30 kg of waste at each sampling location, and manually separated/sorted the plastics to about 5 kg for further analysis. Collecting the surface soil was meant for investigating if most of these plastic particles and their polymers could also be recovered from the surface soil even after decomposition. The collected samples were transported to the laboratory for sample preparation and analysis. In the laboratory, plastic samples were washed with running tap water to remove soil debris, avoiding contamination. The washing process was repeated several times until no dirt or debris was visible on the samples and subsequently the samples were allowed to air-dry at room temperature in a fume hood.

2.4. Extraction and detection of plastics in soil samples

For this study, we adopted the density separation/filtration and visual sorting/identification methods for extracting and detecting the plastics in soil samples from the dumpsite, using standard methods with slight modifications (Avio et al., 2015; Bour et al., 2018; Li et al., 2019; Zhang et al., 2017). Briefly, soil samples were dried at 50°C and about 5g of the dried soil samples were emptied into a 500 mL glass beaker and 100 mL of NaCl hypersaline solution (1.2 g/cm^3) prepared with Milli-Q water. The solution was stirred for 10 min and supernatant decanted into another glass beaker (500-mL) and this extraction was repeated until all the dried soil were extracted. The supernatant was filtered

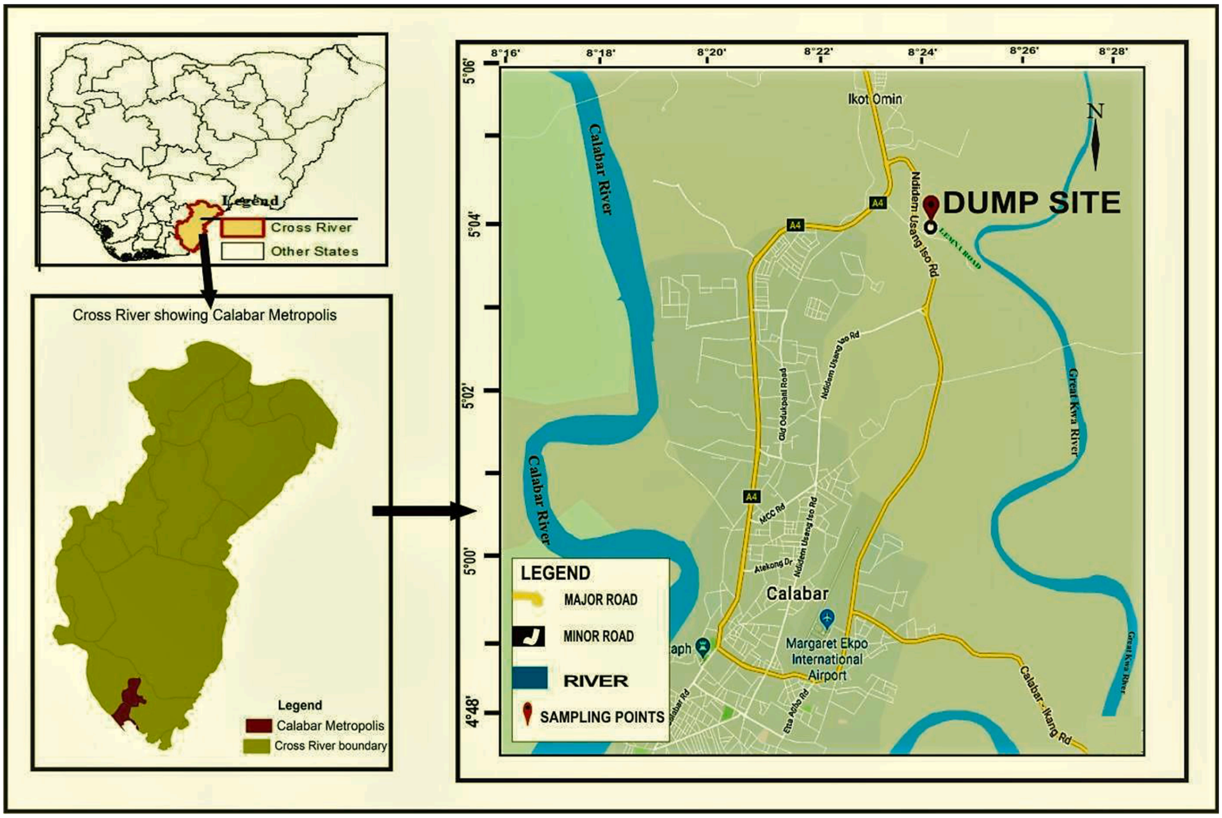

Fig. 1. Map of the study area showing the sampling points.

under vacuum onto a membrane filter paper (0.45 μm filter) and the membrane was transferred into a glass petri dish, digested with 3 mL of 15% H_2O_2 for partial digestion of organic materials and allowed to dry in the oven at 50°C overnight (Capriotti et al., 2021). Thereafter, the membranes were examined for plastics via visual inspection/identification using the fluorescence stereo zoom microscope (Ziess Axio Zoom V16). The plastics were then photo-micrographed and the number of fluorescence plastic particles were counted and recorded. To prevent external contamination of plastics, the hypersaline solution was pre-filtered.

2.5. Visual categorization and sorting of plastics

After washing and drying, the plastic samples were sorted and categorized visually into different plastic types. The sorting and categorizing were aided largely by classifications found on the labels of the plastic samples as well as other information on plastic types. After this categorization, ten (10) representative plastic samples were selected from the total sample size (Fig. 2). A small portion of each sample was cut up, properly labeled, and then transferred to the Laboratory for FT-IR identification, polymer chemical/structural characterization and analysis.

2.6. Fourier-transform infrared spectroscopy (FTIR) analysis

The selected plastic samples were processed using the recently developed procedure based on trituration of dried samples and FT-IR characterization for polymer determination as described by Avio et al. (2015). The polymeric chemical and structural analysis were performed using the SHIMADZU FT-IR-8400S machine to collect spectra from 4000 cm^{-1} to 400 cm^{-1}. The attenuated total reflection (ATR) diamond crystal was cleaned and background scan for each sample was performed. The absorption bands of the sample were recorded and FT-IR results output of the analysis on each sample, the polymeric composition of each sample was determined through comparison with reference database generated by standard material characterization.

2.7. Statistical analysis

Data obtained after collection, visual categorization, and FTIR analysis (absorption spectra bands) was recorded. Identified plastic polymer types based on visual categorization and FTIR analysis were tabulated appropriately into percentages (wet weight) of collected plastics and frequency of occurrence in Lemna solid waste. The percentage abundance of plastics was calculated by dividing the number of plastic polymer type with the total number of plastics, multiplied by a factor of 100. All analysis was performed using Prism GraphPad 9 (GraphPad Software, La Jolla, USA).

3. Results

A total of 21 different plastics were collected and identified from the dumpsite and these plastics were further sorted and classified into ten (10) different plastic categories (Fig. 2). The visual images and corresponding infrared absorption spectra of each plastic sample collected from the dumpsite shows that it is possible to ascertain conclusively the polymeric composition of each plastic sample using the reference spectra (SI Fig. 1A–J). The ten (10) plastic categories identified were polyethylene terephthalate (PET) bottles, polypropylene (PP) bags, polypropylene fiber, polypropylene trays, polypropylene others, polystyrene (PS) trays, low density polyethylene (LDPE), high density polyethylene (HDPE), polyvinyl chloride (PVC) fiber and polyvinyl chloride (SI Fig. 1A–J). The PET bottles were the most abundant plastic, constituting 28.5% of total plastic products collected in this study, followed by PP (others 14.2%; trays 9.5%; fiber and bags 4.8% each) > LDPE > HDPE, while PS trays, PVC fibre and PVC others were the least

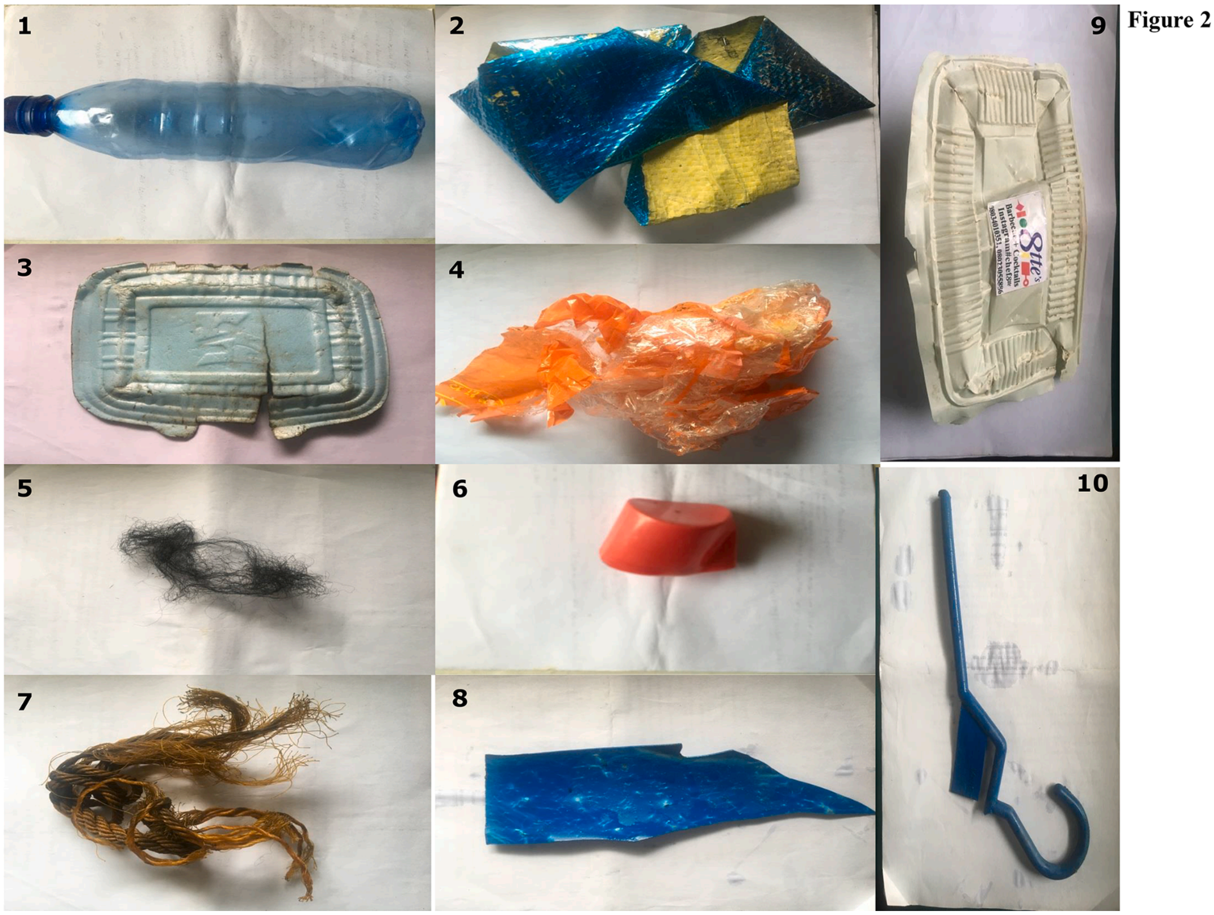

Fig. 2. Visual pictorial images of the plastic categories from the Lemna solid waste dumpsite from Calabar, Nigeria. 1=Polyethylene Terephthalate (PET); 2=Polypropylene; 3=Polystyrene; 4=Low Density Polyethylene (LDPE); 5=Polyvinyl Chloride (PVC); 6=High Density Polyethylene (HDPE); 7=Polypropylene, 8=Polyvinyl Chloride; 9=Polypropylene; 10=Polypropylene.

prevalent plastics at the dumpsite (Fig. 3).

The overall infrared absorption band spectra peaks for all the 10 categorized plastics are presented in SI-Table 1, while representative

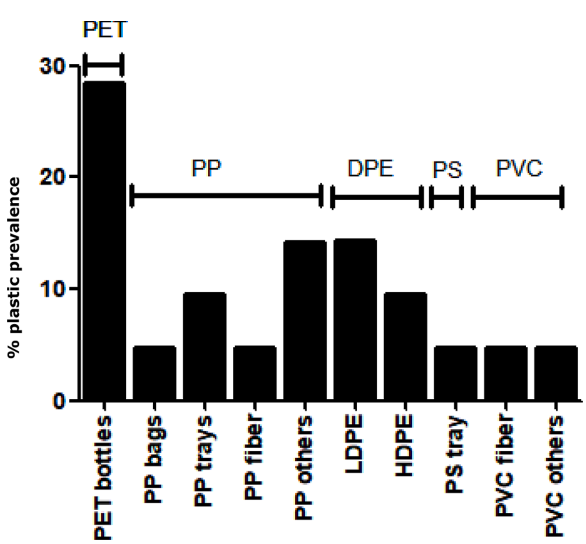

Fig. 3. Percentage prevalence (% wet weight)) of plastics pollutants collected from the Lemna solid waste dumpsite Calabar, Nigeria. Polyethylene Terephthalate (PET); Polypropylene (PP); Low Density Polyethylene (LDPE) and High-Density Polyethylene (HDPE); Polystyrene (PS) and Polyvinyl Chloride (PVC).

polymer composition of plastics from the Lemna solid waste dumpsite is presented in Fig. 4A–D. The infrared (IR) absorption spectra of sample 1 (PET bottles) showed characteristic peaks at 3437, 2966, 2906, 1730, 1240 and 1096 (Fig. 4A). For the PP bags, the infrared absorption peaks at the wave number of 2953 and 2920 followed by 1455, 1378, 1165, 997, 973, 840 and 808 cm^{-1} (Fig. 4B). Similarly, infrared absorption spectra for PS tray showed peaks at the wave number of 3450, 3061, 3026, 2922, 2849, 1602, 1492, 1452, 758 and 698 (Fig. 4C), while the absorption band spectrum of LDPE peaks at of 2920 wave number followed by 2843, 1464, 1375, 1306 and 1168 (Fig. 4D). On a cursory visual examination of the FT-IR spectra and comparative textural feel of some suspected PP bags, PP fibers, and PP others, they were suspected to be of similar chemical content. To resolve this, the respective spectra were superimposed on the same axis (Fig. 5A). Interestingly, the characteristic peaks of the spectra of PP bags, PP fibers and PP others matched well (Fig. 5A). This is an indication that the PP bags, fibers and others were made of polypropylene polymers (PP). The few peaks that are not in consonance with already established characteristic peaks of polypropylene, may likely be emanating from the polymer interaction with environmental chemical processes.

The FT-IR absorption spectra peak analysis showed that only five different plastics polymers were identified and characterized out of the 10 different plastics categories collected from the Lemna solid dumpsite. These include polypropylene, polyethylene terephthalate, polyethylene, polyvinyl chloride, and polystyrene. However, polypropylene (PP) and polyethylene terephthalate (PET) were the dominant and most abundant plastic polymers at the dumpsite consisting of 33.3 and 28.6% of plastics collected, respectively, while polystyrene (4.8%) was the least abundant

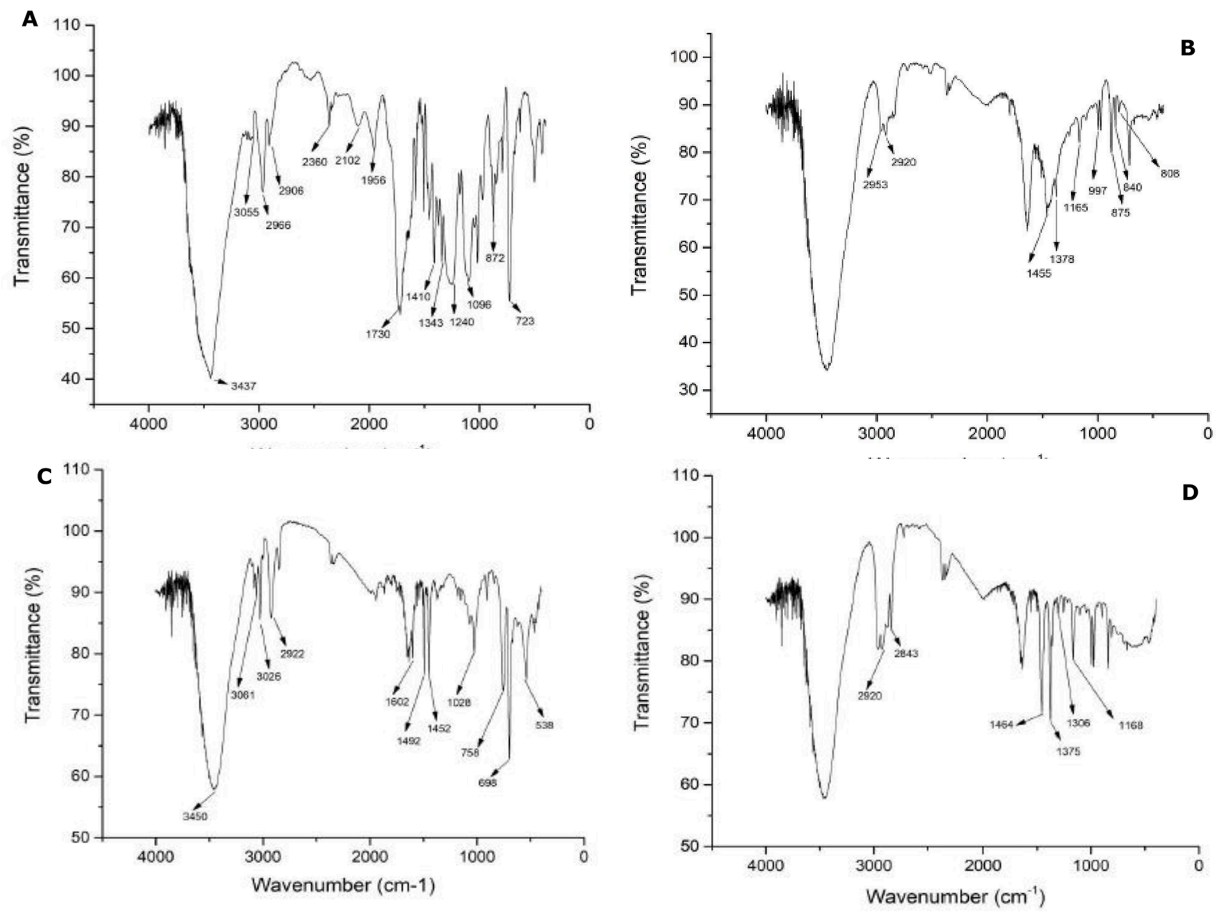

Fig. 4. (A) Fourier-transform infrared spectroscopy (FTIR) absorption bands spectrum of polyethylene terephthalate (PET) bottle (sample 1), (B) polypropylene (PP: sample 2); (C) polystyrene (PS: sample 3), (D) polyethylene (sample 4).

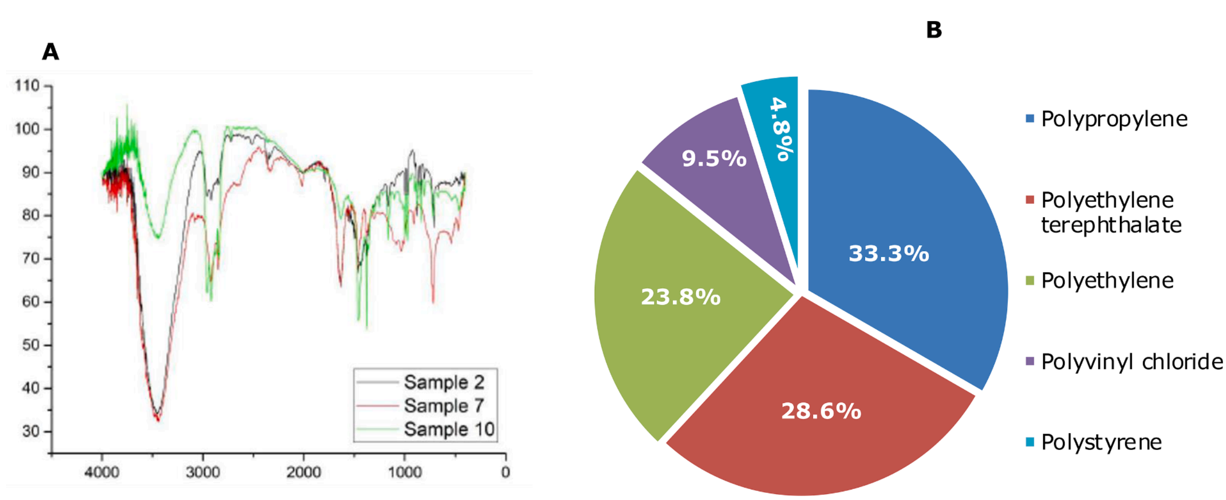

Fig. 5. Overlay of the infrared FT-IR spectra of polypropylene (PP) for sample 2, 7 and 10 indicating a similar absorption peaks and polymer composition and characterization (A) and Percentage plastics polymer abundance and occurrence at Lemna solid waste dumpsite (B).

polymer at the dumpsite (Fig. 5B). Plastics polymers prevalence at the dumpsite were in the order polypropylene > polyethylene terephthalate > polyethylene > polyvinyl chloride > polystyrene (Fig. 5B). For the surface sediments collected between 1 and 10 cm from the dumpsite, we used the density gradient separation techniques and only recovered three (3) plastics polymer types: polyethylene, polystyrene, and polypropylene with polypropylene as the dominant polymer recovered from the sediment with all the recovered plastics > 5 mm in diameter (Fig. 6A–D).

4. Discussion

Currently, plastic (including macro, micro- and nanoplastics) pollutants and associated chemicals with detrimental negative consequences on human, wildlife and ecosystem health has generated societal and scientific attention (Bank et al., 2021; Qin et al., 2020). This is due

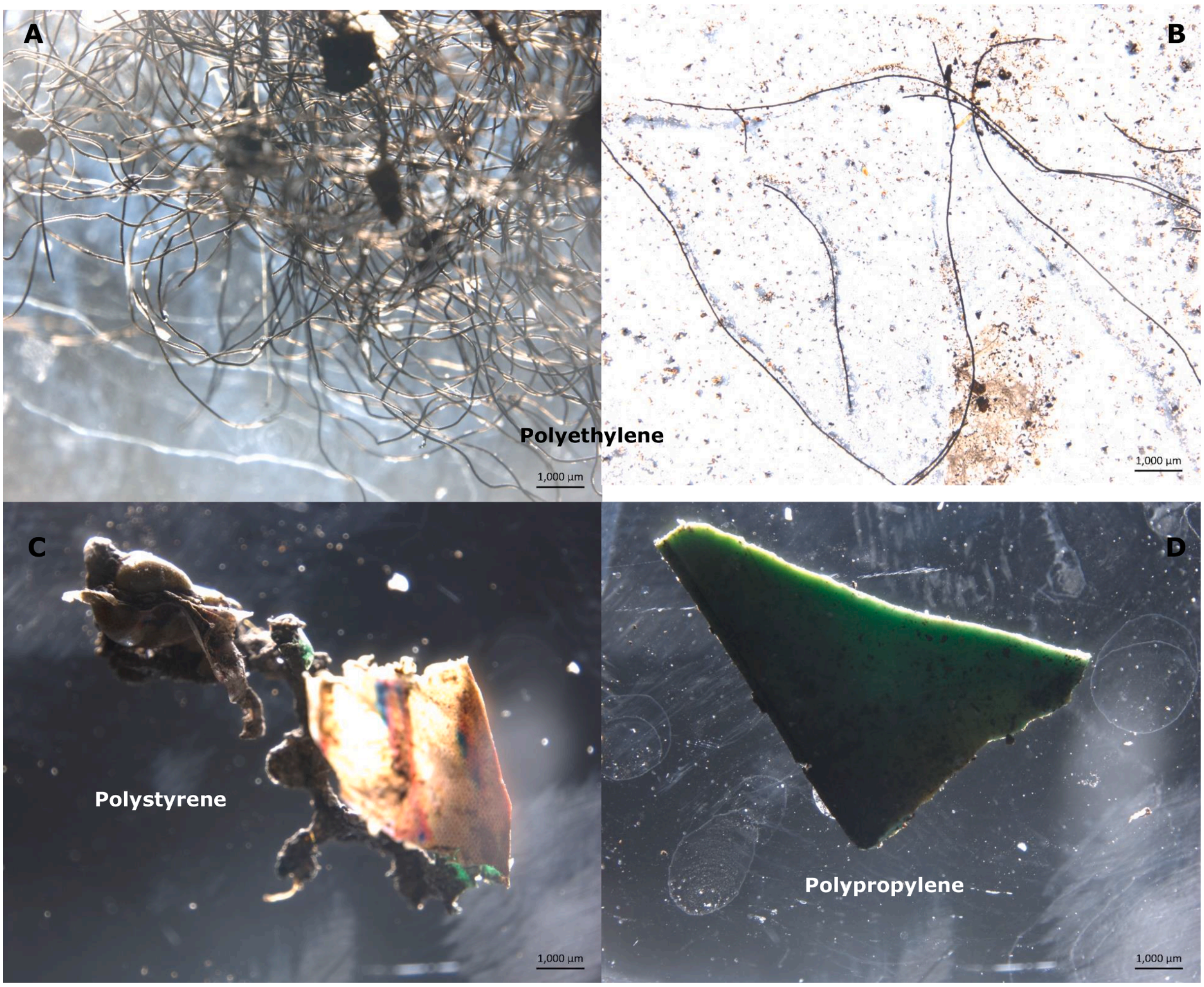

Fig. 6. Photomicrographs of polyethylene (A and B), polystyrene (C), and polypropylene (D) recovered in soil samples from the Lemna solid waste dumpsite Calabar, Nigeria.

to the unique and common characteristics between plastics with legacy and emerging contaminants with low biological degradation, persistence, including their long-term fate and transport range within several environmental matrices (Chakraborty et al., 2022; Qin et al., 2020). While global plastics pollution has been identified as a pervasive environmental problem impacting remote and rural regions, developing countries lack systematic plastic recycling or even management methods (Allen et al., 2019). Herein, we have investigated for the first time, the occurrence and polymer identification and characterization of plastics from a solid waste dumpsite in Calabar, Southern-Nigeria. We showed that out of the ten (10) plastics categories identified, PET bottles and PP (bags, fiber, trays and others) were the most abundant and prevalent, while PS and PVC were the least prevalent plastics at the Lemna solid waste dumpsite. Furthermore, FT-IR absorption spectra peaks analysis showed that only five different plastics polymers (polypropylene, polyethylene terephthalate, polyethylene, polyvinyl chloride and polystyrene) were identified and characterized out of the ten (10) different plastics categories collected from the Lemna solid dumpsite. Polypropylene and polyethylene terephthalate were the dominant and most abundant plastic polymers, while polystyrene was the least abundant polymer at the Lemna dumpsite.

In this study, PET bottles and PP (bags, fiber, trays, and others) were the dominant plastics at the dumpsite reflecting their widespread application and use in domestic (including ceremonies and social gatherings), household packaging products in the Nigerian market with no formal or informal regulations, control, and recycling efforts. In addition, these findings may suggest PET and PP as typical thermoplastic polymers dominating the dumpsite and indeed other dumpsites and landfills elsewhere in the Nigerian environment. Consistent with our findings, PET and PP have been reported as one of the most important and dominant plastic polymers in some countries in Europe (Braunegg et al., 2004; Dahlbo et al., 2018; Eriksen and Astrup, 2019; Foschi et al., 2021; Gala et al., 2020; Patel et al., 2000; Roosen et al., 2020; Zimmermann et al., 2021; Zimmermann et al., 2019); in South Korea (Jang et al., 2020) and in the United States of America (Subramanian, 2000). On a global scale and when the results from the present study are compared with reports from other countries, it is evident that there are unique and glaring similarities of major plastic polymer composition across different countries. We believe that this could be crucial and important scientific information that can be used towards initiating plastic pollution management campaigns in Nigeria and other developing countries where no such research data are either currently non-existent or limited.

Furthermore, we performed a detailed analysis of the polymer composition and characterization of the different plastic types collected at the dumpsite by FT-IR and showed that only five (5) plastic polymers (polypropylene, polyethylene terephthalate, polyethylene, polyvinyl chloride, and polystyrene) were present at the dumpsite. While only three (3) polymers were recovered by density separation method in the soil samples from the dumpsite with diameters > 5mm indicating macroplastics. In this study, we only recovered three (3) plastic polymers from the surface soil and this was not surprising considering that some plastic polymers may lose or gain few peaks that are not in accordance with already established characteristic peaks resulting from the polymer interaction with environmental chemical processes. This could explain why we only recovered only 3 polymers from the surface soil instead of the entire five (5) observed at the dumpsite. Interestingly for both the soil and open dumpsite, polypropylene and polyethylene terephthalate were the dominant and most abundant plastic polymers at the dumpsite. This may suggest that polypropylene and polyethylene terephthalate are the most abundant and dominant polymers in the dumpsite. This is important and could serve as a baseline information for future plastic polymer bio-analytical and toxicological endpoints assays that will inform regulatory policy decisions and management in Nigeria.

Using Fourier Transform Infrared (FT-IR) spectroscopy and the resulting absorption spectra band analysis, data was collected on the polymer composition and characterization of each representative plastic sample obtained from the dumpsite (SI-Table 1). The absorption peaks at the wave number of 3439 cm^{-1} for PET bottles (sample 1) indicates the presence of a hydroxyl (OH) group in the analyzed sample (Edge et al., 1996; Silverstein and Webster, 1998). In addition, the absorption peaks at wave numbers 2966 and 2906 cm^{-1} is assigned to the aromatic CH stretching vibration absorption, 1730 (stretching of the C═O bond of the carboxylic group), 1240 indicates the existence of a terephthalate group ($OOCC_6H_4$-COO), while the peak at 1096 is indicative of the presence of a methylene group and vibrations of the ester C—O bond (Pereira et al., 2017).

These absorption peaks are characteristic of polyethylene terephthalate, thus confirming that sample 1 is polyethylene terephthalate (Edge et al., 1996; Pereira et al., 2017; Silverstein and Webster, 1998). For polypropylene plastic category (PP bags, fiber, trays and others: - sample 2, 7, 9 and 10), the peaks at wave numbers of 2953 and 2920 cm^{-1} indicate asymmetrical stretching of CH_3 and CH_2, respectively, suggesting the presence of methyl and methylene functional groups, 1455 and 1378 cm^{-1} [indicate a symmetrical bending of the methyl group (CH_3)], 1165 cm^{-1} (wagging of the C—H bond and the rocking of CH_3), while 997 cm^{-1} is due to the C—C stretching vibration absorption and the rocking of CH_3 (Fang et al., 2012). These characteristic absorption peaks indicate that sample 2 is polypropylene. Therefore, given the similar absorption peaks for samples 2, 7, 9 and 10, it can thus be inferred that all four plastic categories are polypropylene (PP) polymers. The infrared absorption spectra of sample 3 showed absorption peaks at the wave numbers of 3061 and 3026 (due to aromatic C—H stretching vibration absorption), 1602, 1492, and 1452 cm^{-1} (due to aromatic C═C stretching vibration absorption) and these absorption peaks indicate the existence of benzene rings (Fang et al., 2010). The absorption peaks at wave numbers 758–698 cm^{-1} correspond to C—H out-of-plane bending vibration absorption and indicate that, there is only one substituent in the benzene ring. Furthermore, the absorption peaks at the wave numbers of 2922–2849 cm^{-1} indicate the existence of methylene, while 3450 cm^{-1} signifies stretching vibration of O–H, which indicates the existence of hydroxyl group and these characteristic peaks confirm that sample 3 is actually polystyrene (PS) plastic polymer (Fang et al., 2010). The IR absorption spectra of sample 4 showed absorption peaks at wave numbers of 2920 and 2843 (due to the asymmetric and symmetric stretching of CH_2, respectively, indicating the presence of methylene); 1464 (due to bending deformation vibration absorption) and 1375 (due to the symmetric deformation of CH_3). These absorption peaks are all characteristic of polyethylene (PE) and indicate that sample 4 is polyethylene.

It can be inferred that sample 6 (identified as HDPE) with similar absorption peaks as sample 4 is polyethylene as well (Mendes et al., 2012; Ramos and Mendes, 2014). The IR spectra of sample 8 (PVC fiber) shows peaks at 3450 and 3248 cm^{-1} indicating asymmetric and symmetrical stretching bond of C—H, respectively; 2916 and 2850 cm^{-1} (CH_2 asymmetric stretching vibration), 1425 cm^{-1} (C—H aliphatic bending bond), 1257 cm^{-1} (attributed to the bending bond of C—H near Cl), 1101 cm^{-1} (are due to the C—C stretching bond of the PVC backbone chain) and the peak at the wave number of 615 cm^{-1} indicates the presence of a C—Cl gauche bond. These peaks are characteristic of PVC and strongly suggest that sample 8 is PVC (Pandey et al., 2016).

There is a current global plastics treaty by the UN Environment Assembly towards combating plastic pollution by 2024 (Bundela and Pandey, 2022;), including demand for national/regional plastic pollution data towards initiating policies and regulations for mitigating plastics pollution related emerging environmental and human health problems (Bergmann et al., 2022; Qin et al., 2020; Zhang et al., 2020). Conclusively, the present study represents a novel and integrated effort towards generating important scientific data for viable and effective plastic pollution management in Nigeria, particularly, and Africa, in general. Results presented herein showed that the PET bottles and PP were the dominant plastics at the dumpsite. Polymer composition and characterization by FT-IR analysis showed that only five (5) plastic polymers were present at the dumpsite with polypropylene (PP) and polyethylene terephthalate (PET) as the most abundant and dominant polymers. Our data represents the first report on the occurrence and polymer composition and characterization of plastic pollutants from Nigeria and contributes significantly towards future plastic pollution and toxicological endpoints assessments, and may inform regulatory policy decisions, recycling, and management in Nigeria where such efforts are currently lacking.

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CRediT authorship contribution statement

Oju R. Ibor: Conceptualization, Methodology, Formal analysis, Funding acquisition, Investigation, Writing – original draft. **Nten-Osowo L. Mpama:** Conceptualization, Formal analysis. **Chukwunonso P. Okoli:** Conceptualization, Methodology, Formal analysis, Writing – review & editing. **Dinah M. Ogarekpe:** Conceptualization, Methodology, Formal analysis, Writing – original draft. **Uwem O. Edet:** Conceptualization, Formal analysis. **Raymond O. Ajang:** Conceptualization. **Chinedu E. Onyezobi:** Conceptualization. **Jennifer Anyanti:** Conceptualization. **Omokhudu Idogho:** Conceptualization. **Dennis Aizobu:** Conceptualization. **Augustine Arukwe:** Conceptualization, Methodology, Formal analysis, Funding acquisition, Project administration, Supervision, Writing – review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationship that could have appeared to influence the work reported in this manuscript.

Data availability

No data was used for the research described in the article.

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.envadv.2022.100338.

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