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Assessment of Microplastics Physical and Chemical Characteristic in Top Soil Surface of Uyo Metropolis Akwa Ibom State, Nigeria

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Abstract— *A study was carried out at different locations in Uyo metropolis where waste plastics are indiscriminately disposed. Five soil sampling stations with GPS coordinate were taken, analyzed in the laboratory and compared with control site to assess the level of microplastics in the soil and it impacts. Soil samples were collected, sieve to get the microplastic particles present and analyzed using standard procedures of Associations of Official Analytical Chemist and American Public Health Association. The stations comparisons and location of significant differences were carried out using ANOVA and Duncan multiple range tests, while correlation analysis was done to check the differences in parameter relationship. The mean value of the physical and chemical parameter (proximate and ultimate analysis) had a ranges value of pH (6.32-6.00), HHV (34870.00-21050.00KJ/g), Moisture content (15.32-9.67%), carbon (37.25-18.89%), Oxygen (45.87-22.03%), Nitrogen (0.57-0.21%), Hydrogen (13.21-4.12 %), Sulphur (0.64-0.027%). Fixed carbon, Ash content, volatile matter, residual content from all the location were higher than the control and were also significantly different (with 95% confidence limits) from each other and were higher that the control site and it showed a strong positive correlation with each other. Similarly, heavy metals and ranges as follow; Pb (61.75-16.78 ppm), Cd(9.65-2.28 ppm), Hg(0.87-0.10 ppm), Cr(71.25-33.85 ppm), As (2.38-0.16 ppm), Cl (2165.31-498.76 ppm), and Br (567.14-89.88 ppm). The parameters in the location where high and from the contamination degree (10.651-7.993 ppm) and pollution load index (544.40-81.62 ppm), Anions contamination level was above moderate level but could pose danger to the food chain as some of these beads are picked by birds and lower organisms. Pollution index was also high in the soil samples collected. This shows that toxic substances are in large amount and is stored for long time as this waste plactic and other organic matter are deposited every day. If proper check and regulation is not taken the soil around that region could be completely damaged and useless. The study concludes that, there is high level of plastic disposal in the soil of Uyo metropolis which result to high amount of microplastic in the soil. This trend needs to be reversedso as to safeguard the soil biota and food chain. It is therefore recommended that government and legislatures should take proactive step to regulate reduce and recycle single used plastic.*

Keywords— *Anions Concentration, Heavy metal, Microplastic particles, Ultimate and Proximate Characteristic.*

I. INTRODUCTION

Humans being depend greatly on their surrounding environment for natural and manmade resources they need for their existence [1]. Large population growth, which is seen in many African countries, has been as a result of a strong expansion and uncontrolled urbanization, agricultural practices, industrial, land use, which resulted in a tremendous increase in pollutant discharge into the environment [1]. Nigeria as a country lacks adequate technological and sufficient manpower with required technical, managerial training skills to properly handle wastes component in an environmentally friendly, safe and sound manner. Badly, the usual methods and approaches of waste disposal in the country are; land filling, dumpsites, land spreads, water disposal, and incineration. This waste gets into the environment and stays for a long period of time before degrading. Physical forces and conditions that cause plastics disintegration in the environment are winds, waves and ultraviolet radiation (from sunlight). According to [2], microplastics materials or products are made from a wide range of polymers of high molecular mass and varying density. These materials have broad and wider applications temporally and spatially due to their durability, ease of production, less cost and relatively less weight. Decades ago they have been a tremendous increase in microplastic used in a wide range of products manufactured. Globally the production of this product increased from 1.5 million tons (Mt) per year in 1950 to 245 Mt in 2008 as reported by [3]. Microplastic produced from plastics products originate from petroleum product just like a refined gasoline. According to Environmental Protection Agency, production of plastic products and it particle account for an estimated 8% of global oil production [4]. In Nigeria, the increasing production, usage of single use plastics and the uncontrolled disposal of plastics debris into the environment (land and marine habitat) facilitate widespread plastics pollution and subsequence microplastics generation [5]. This microplastic particles is transportation as recorded in Early research evidence where plastic particles are used to monitor particle movement as tracers through porous media from a soil physical perspective [6]. However, apart from being the producers of bio-pores, soil biota contribute actively to the

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movement of this microplastic particles in the environment. Moreover, micro-arthropods (collembola) in recent study as recorded by [7] have been proven to be able to move microplastic beads in a laboratory arena. This kind of active, incidentally, relatively small-scale movement could enhance wide spread of microplastic particles horizontally. It may also facilitate their subsequent entrance into the soil surface. According to [8], fungal hyphae also serve as preferential paths for the movement of microplastic bead in cm-range, this has been demonstrated for movement of bacterial cells. Other studies on particle transportation in the soil by bioturbation process also suggests that, plant processes (e.g., root growth, uprooting) and various animals (earthworms, various larvae, vertebrates) can contribute to microplastic particle movement as reported by according to [9]. Furthermore, [19] noted in speculation that, secondary microplastic fibre emanating from washing machines could end up in soil biota as a result of water treatment plants failure to completely and carefully filtration of all microplastic fibers out of it before disposal. Therefore, Soil fauna, such as earthworms, mites, and collembolan could contribute to the high amount of secondary microplastic fibre present in soil by converting consumed plastic products into microplastic in the process of digestion [19]. The study seek to investigate the concentration of microplastics physical and chemical characteristics, heavy metal and anion content in studied soil samples of Uyo metropolis.

II. Materials and Methods

Study Area

The study was at Uyo, the metropolis within the capital city of Akwa Ibom State. According to [34], Uyo lies between longitudes $7^0 51'$ E and $7^0 59'$ E, and between latitudes $5^0 40'$ N and $5^0 59'$ N. Uyo is the Capital City and it covers approximately land mass area of 188.024 km2 and an estimated population of 305,961. Moreover, Uyo metropolis comprises the entire Uyo, parts of Itu, Uruan, Nsit Ibom and Ibesikpo Asutan Local Government Areas in Akwa Ibom State as reported by [35]. Urbanization and economic growth has tremendously leads to the infrastructural development which thereby extends it to the nearby local government areas of Itu, Uruan and Ibesikpo Asutan.

According to [37], the temperature of Uyo metrolis correspond with that of the tropical humid climate and it ranges between 26.2^0C and 35^0C with mean annual temperature of 28.4^0C. [37] also noted that the annual precipitation of the city ranges between 2000-3000mm per annum. According to [36], this rainfall regime received in most parts of the state encourages farming throughout the year; therefore, the occupations of the inhabitants reflect the economic activity of the area. The settlement pattern and structure in Uyo metropolis can be described as nucleated. These inhabitants engage in farming and other commercial and business ventures within and around as a means of augmenting and supplementing family income and food supplies [36]. Uyo is characterized by a gentle undulating terrain. According to [38] sandstone hills and ravine are attributed to most parts of Uruan and Uyo Local Government Areas while other sections of the study area are filled with low lying undulating plain sandy terrain as reported by [34].

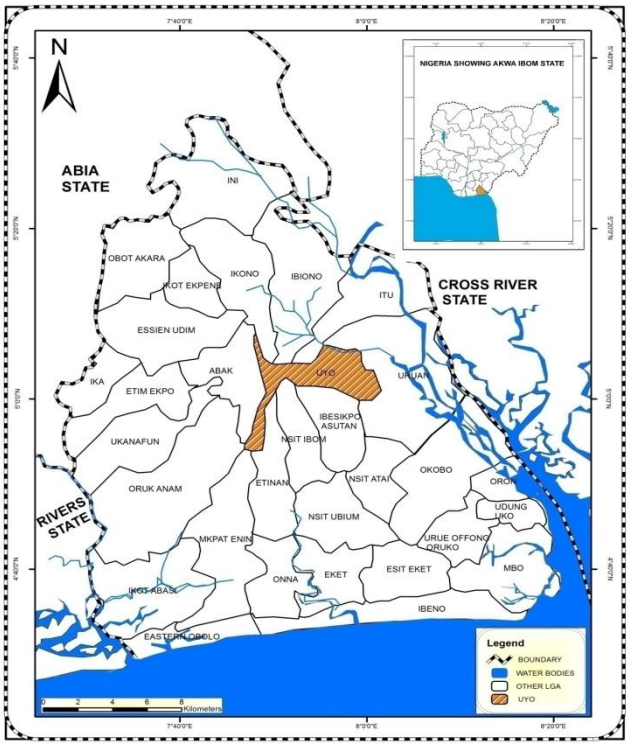

Fig. 1. Map of Akwa Ibom State Showing the Uyo LGA.

Samples Location and Collection

In order to obtain composite samples, 10 composite soil samples were randomly collected from selected five locations where microplastics particles and plastic waste were generated and disposed. They were from; Plastics bottle/nylon production factories, Waste dump site, Cosmetics factory waste disposal site, Laundry waste disposal site and a control sample (500 m away from the metropolis). The soil samples were collected at a depth of 0-30cm using soil auger into a stainless steel core and mixed thoroughly according to [17]. The mixed soil was labeled properly using masking tape and biro pen and transported to scientific laboratory in Ibadan, Oyo State. The samples were stored in a refrigerator at 4°C prior to analysis according to [17].

At each sampling location, GPS coordinates was taken to show the positioning of the site in the area (Table 1).

TABLE 1. GPS Coordinates of the Sampling Point:

Soil locations	Latitude/ Elevation	Longitude/ Elevation
Uyo village road site	N5º2'51.888''/5.04775	E7º56'12.642''/7.93684
Akpan-adem market site	N5º1'2.802''/5.61744	E7º 5'28.266''/7.92456
Uniuyo site	N5º2'11.814''/5.03662	E7º 58'50.916''/7.9801
Oron road	N4º59'20.868''/4.98913	E7º 58'13.566''/7.9703
Control site	N5º4'51.174''/5.08088	E7º55'50.46.638/7.92958

Soil Sample Preparation and Laboratory Analysis.

The laboratory analysis of soil samples was in multi-step process. This include: sample preparation (such as sample homogenization); extraction of microplastics; removal of

additional non-microplastic materials, detection of microplastics particles and analysis [10].

The soil samples were pulverized with mortar and pestle and passed through a sieve as the first step in the isolation of microplastics (under 5 mm) from the soil [11][12]. High density solution of zinc chloride (density <1.4 g/mL) was prepared and used to separate the plastics bead (density < 1.4 g/mL) in the sample from the rest of the soil sample using a density separation step as described by [13][18]. The samples were allowed to settle overnight. During the phase of the experiment, the liquid portions of the sample containing suspended plastics were vacuum filtered and the collected solid were exposed to the Fenton reagent to digest the organic soil matrix and natural fibers as described by [25].

For the Fenton's reagent reaction, ferrous iron reacted with hydrogen peroxide and the liquid sediment of the samples that has been pH adjusted to 2−3; the reaction mixture was subjected to mild heat with stirring until froth formation ceases. The froth formation is a result of carbon dioxide gas escaping following secondary oxidation reactions, and it indicates the end of the reactions that digest the organic soil matrix as described by [21].

During the phase of the experiment, the solutions were vacuum filtered again in order to isolate the remaining debris on the nylon filter. The filtrate on the filter was visualized under the stereomicroscope, and microplastic are identified and classified.

Spectroscopy was used to confirm and identify microplastic in the soil, and their synthetic polymer for particles <1 mm in size as described by [10].

The concentrations of microplastic physical and chemical properties were identified in the four soil samples and compared to the control to ascertain the status in the soil. Heavy metals and anions concentrations in the microplastic/polymers were compared with control and WHO standard limit.

Determination of Physical and Chemical Characteristics of Microplastic Identified Using Proximate and Ultimate Analysis Method.

After identification of microplastic particles from soil samples, they were grinded for size reduction and analyzed further for their physical and chemical characteristics. The parameters and method used are as follows:

Physical Characteristic of Microplastics

Heating value: The heating value of plastics particles was calculated using Dulong equation as Stated.

$$HV = 33801(C) + 144158[(H) - 0.125(O)] + 9413(S) \quad (1)$$

Where:

HV (kJ/kg) is a Heating Value whereas C, H, O and S are carbon, hydrogen, oxygen and sulfur content respectively in the dry basis. Higher heating value (HHV) is important properties which define the quantitative energy content and determine the clean effective and efficient utilization of the plastic products according to [19].

pH value: the pH value of polymer identified and grinded samples were determined using Digital pH meter as described in recent study by [19].

Moisture content: the percent moisture content of microplastic was determined by weighing the wet microplastic particles and drying the samples in oven at 105^{o}C for 1 hour using desiccators to a constant weight according (ASTMD 3173) method. The percent moisture content was calculated as a percentage loss in weight before and after drying using Equation (2 and 3) as described by[19].

% Moisture content =

[(Wet Weight – Dry Weight)/ Wet weight] x 100 (2)

Or

The percentage of moisture content (MC) was calculated as a fraction loss in weight of sample before and after drying.

M1=mass of empty crucible (g)

M2=mass of empty crucible + sample (g)

M3=mass of empty crucible + sample after heating (g)

Moisture content = M2 – M3

% moisture content = M2 - M3/ M2 - M1 x 100 (3)

Chemical Characteristics of Microplastic

Proximate analysis: The parameters analyzed include Residual Content (R), volatile matter (VM), Fixed Carbon (FC) and Ash Content (Ash). The method used was based on the ASTM Standard D 3172 as suggested by [29]. The weights of dry samples were measured according to [19].

Ultimate analysis: The parameter analyzed includes Carbon, Hydrogen, Sulphur and Oxygen Content. In this study, the equipment used is Elemental Analyzer (CHNS Analysis) model EA 1106 prepared by Thermo Quest Italian S.p.A. In this study, the equipment used was Elemental Analyzer (CHNS Analysis) model EA. The weights of dry samples were measured according to [19].

Neutron activation analysis: The parameter analyzed includes total chlorine and total bromine content using Trig Mk II Reactor, Rotary Rack, Pneumatic Transfer System and detector. For Total Chlorine determination, short irradiation process was used and for total bromine, long irradiation process was used. The weight of dry samples was measured according to [19].

Heavy metals Analysis: Heavy metals parameters include Cd, Cr, Hg, Pb and As were determined from the identified microplastic particles in the soil samples. They were determined after extraction by Flame Atomic Absorption Spectrometry in accordant with American Society for Testing and Material [28] standard test method.

Determination of Ultimate analysis (Elemental Composition)

The combustible percentage is shared among nitrogen, carbon, oxygen and hydrogen in standard ultimate analysis [27]. Nitrogen, Hydrogen, Sulfur and Carbon (NHSC) are the elemental composition of the solid waste which was carried out at the laboratory in accordance with the procedures of the Association of Official Analytical Chemists [33]. The composition of waste was determined using wet oxidation. 1.0-g of the particle sample was weighed into the digestion tube and 5W of digestion mixture was added to it. The mixture

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was left overnight in the fume cupboard. Using a testator, the mixture was digested for 2 hours at 170° C and allowed to cool. Moreover, to digest the mixture vigorously, 30-ml of distilled water was added to the solution and mixed. 50-ml of distilled water was added to the solution to increase the volume of digested mixture to 80-ml. Atomic Absorption spectrometer was used to identify the elements under analysis.

Volatile Matter Determination: The volatile matter percentage was carried out by heating the sample at a temperature of 50°C for 7 minutes using a muffle furnace. The crucible was cooled in the desiccator after it was removed from the furnace and weighed. The percentage loss of mass of the sample excluding the percentage moisture is the percentage of volatile matter according to [27]. This was calculated using this formula;

% Volatile matter =M2 - M3/M2 - M1 x 100 – MC (4)

Where;

M1=mass of empty crucible (g)

M2=mass of empty crucible + sample before heating (g)

M3=mass of empty crucible + sample after heating (g)

MC=percentage of moisture content

Ash Content Determination: Ash content is the non-combustible residue of the sample gotten after combustion which contains Sulfur and oxides. The process was carried out by burning of the sample at temperature of 750°C for an hour in a muffle furnace without a lid. The sample was cooled in desiccators and weighed and the process was repeated constantly until a constant weight was attained according to [27]. This was calculated using this formula;

% of ash content = M3 - M1/M2 - M1 x 100 (5)

Where;

M1=mass of empty crucible (g)

M2=mass of empty crucible + sample before heating (g)

M3=mass of empty crucible + residue (g)

Ash content= M3 – M1

Fixed Carbon Determination: Mass of fixed carbon is determined by deducting the percentage of ash content, moisture content and volatile content from the total percentage according to [27].

% FC=100 – % ASH – % MC - % VM (6)

Contamination Factor and Pollution Index Determination

Contamination factor (Cf,): The assessment of soil contamination can also be carried out using Cf. This index enables the assessment of soil contamination, taking into account the content of heavy metal from the surface of the soil and values of pre-industrial reference levels given by [30].

Cf was calculated by the following formula:

$C_f = C_m/C_{p\_i}$. (7)

Where Cm—mean content of at least five samples of individual element (like heavy metal)

Cp-i—preindustrial reference value for the substances

Contamination factor/level determination

$C^i < 1$= low contamination

$1 \leq C^i < 3$ = moderate contamination

$3 \leq C^i < 6$ = considerate contamination

$C^i \geq 6$ = very high contamination

Single Pollution Index (PI)

An index that can be used to determine which heavy metal represents the highest threat for a soil environment is the Single Pollution Index (PI). This is also necessary for the calculations of some of complex indices called Pollution Load Index (PLI)

Pollution load index was calculated using this formula described below according to [32];

PI = Cn/GB (8)

Where

Cn—the content of heavy metal in soil and

GB—values of the geochemical background.

PLI = $\sqrt[n]{}$ (CF1xCF2xCF3x…xCFn) (9)

Where, CF = contamination factor,

n = number of metals

C metal = metal concentration in polluted sediments

C Background value = background value of that metal.

The Pollution Load Index (PLI) value of >1 is polluted, whereas <1 indicates no pollution according to [31].

Statistical analysis: Data collected from the laboratory analysis were subjected to descriptive statistical analysis using SPSS version 20. Results were presented in tables (mean, and standard deviation,) and charts. ANOVA and correlation analysis was used to establish it relationship and mean separation was done using Duncan multiple range test.

III. Results and Discussion

Physical characteristic of microplastic particles in the soil of Uyo metropolis Akwa Ibom State.

The physical properties of the microplastics from the soil analyzed showed that the pH ion of the was highest in Uniuyo water waste site soil 6.32 %, followed by Uyo village road waste site 6.13 %, Akpan-andem market soil recorded 6.21 **%**, Oron road soil 6.15 % and control recorded the least 6.00 % as shown in figure 2. High Heat value of the plastics polymer recorded highest in Uniuyo water waste dumpsite soil 34870.00 Kj/g, followed by Uyo village road waste dumpsite soil 33690.00 Kj/g, Oron road soil 29820.00 KJ/g, Akpan-andem market soil 21050.00 KJ/g while the least was recorded in the control.

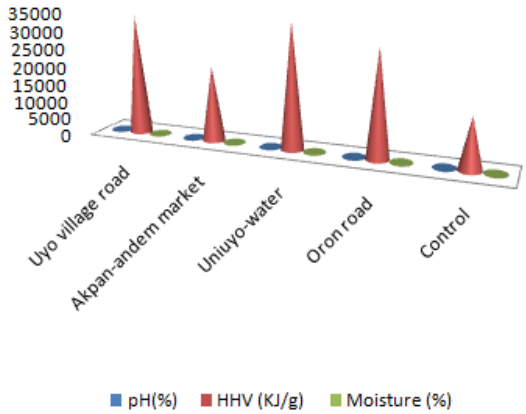

Fig. 2. Shows mean result of physical characteristic of microplastic particles in soil of Uyo metropolis.

This finding implies that plastic waste disposed within the area has high heating energy and may be attributed to the type of plastics used. Moisture content of the polymer recorded highest in Oron road soil 15.32 %, followed by Akpan-andem market 14.26 %, Uniuyo water waste soil recorded 13.77 % and Uyo village road recorded 11.39 % while the least was recorded in the control 9.67 %.

Correlation analysis result of microplastics physical characteristics parameters in soil samples.

Correlation analysis of physical Characteristics of microplastic polymer assessed in soil samples collected in Uyo metropolis of Akwa Ibom state showed that all parameters exhibited strong correlation with each other. However, the relationships were not significant ($P \leq 0.05$). According to the results reported in table, the correlation coefficient (R2) between concentrations levels of the microplastic polymer were quite high and shows strong positive correlation. This means that their source may be the same as expected but they are not dependent on each other (Table 2).

TABLE 2. Correlation analysis of physical Characteristics of microplastic polymer

Correlation	HHV (KJ/g)	%Moisture Content	pH
HHV (KJ/g)	1		
%Moisture Content	0.820	1	
pH	0.908	0.996	1

*Correlation is significant at 0.05 percent

Chemical characteristic of microplastic particles in the soil of Uyo metropolis, Akwa Ibom State.

Ultimate assay of soil whole microplastic polymer:

Ultimate assay of soil whole microplastic particles as represented in figure 3 showed that 37.25 % Carbon was in Uyo village road dumpsite which was the highest of all the sampling stations followed by Uniuyo water waste site 27.45 %, Oron road site 25.87 %, Akpan-andem market recorded 21.88 % while the least was recorded in the Control site 18.89 %. This shows that the metropolis has high concentration of carbon in the soil microplastic. Oxygen in the soil recorded highest in Uyo village road dumpsite soil 51.28 %, followed by Uniuyo water waste soil 45.87 %, Akpan-andem market soil recorded 39.76 %, Oron road waste site recorded 35.32 % while the least 22.03 % was recorded in control site. Nitrogen content recorded highest 0.57 % in Uyo village road waste site followed by Uniuyo water waste site 0.47 %, Oron road site recorded 0.35 %, Akpan-andem market soil recorded 0.32% while the least 0.21 % was recorded in the control site Hydrogen content in the soil recorded highest in Uyo village road waste site 13.21 %, followed by Uniuyo water waste dump site 11.23 %,Oron road waste site 10.92 %, and Akpan-andem market soil recorded 9.63 % while the least 4.12 % was recorded in control site. Sulphur content recorded highest in 0.64 % in Uyo village road soil, followed by Oron road waste site 0.59 %, Uniuyo water waste site recorded 0. 47 %. Akpan-andem recorded 0.27 % while the least 0.22 % was recorded in the Control site.

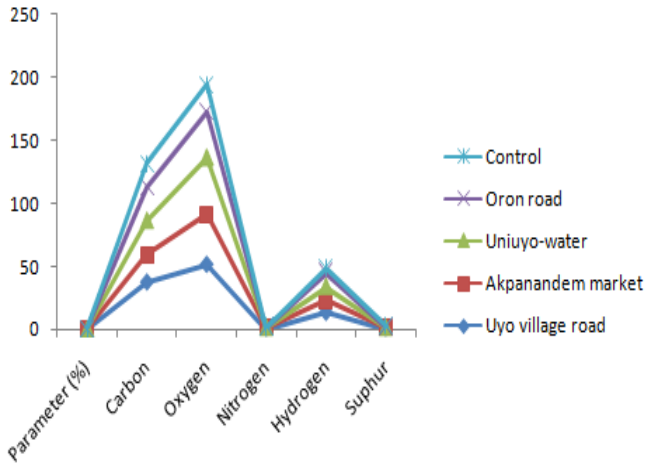

Fig. 3. Shows mean ultimate analysis of soil samples microplastic in Uyo metropolis.

Correlation analysis was employed to measure the extent of the relationship between the concentration of ultimate assay of whole microplastics in soil samples collected from Uyo metropolis in Akwa Ibom State and the result of the analysis is presented in table 3 showed that all parameters exhibited strong positive correlation with each other. However, the relationships were significant ($P \leq 0.05$) for some like Carbon-Nitrogen (0.923 %), Oxygen-Nitrogen (0.977 %), Oxygen-Hydrogen (0.936 %) and Nitrogen-Hydrogen (0.956 %) but not significant for other. The significant level implied that as one element increases, they other increases too and vice versa. According to the results in tables, the correlation coefficient (R2) between concentrations levels of the microplastic polymer were quite high and close to 1, showing strong positive correlation.

TABLE 3. Correlation analysis of the Microplastic Ultimate assay of whole microplastic in soil samples.

Correlation	% C	% O	% N	% H	% S
% C	1				
% O	0.851	1			
% N	0.923*	0.977**	1		
% H	0.846	0.936*	0.956*	1	
% S	0.865	0.681	0..812	0.843	1

*Correlation is significant at 0.05 percent

Proximate analysis of whole microplastic in soil samples of Uyo metropolis:

Proximate analysis of whole microplastic in soil samples showed that 29.22 % of fixed carbon was in Oron road soil axis and it was the highest of all as shown in figure 4. This was followed by Uyo village road dump site (26.12 %), Uniuyo water waste site (25.45 %) and Akpan-andem market recorded (22.43 %) compared to the least in Control sample. Ash content of the soil microplastic recorded highest (2.54 %) in Uniuyo water waste site, followed by Akpan-andem market (2.15 %), Oron road soil recorded (2.11 %), Uyo village road recorded (1.56 %) and the least was recorded in the control sample. Volatile matter was higher in Uyo village road (72.38 %), followed by Akpan andem market soil (70.89 %), Oron road soil (69.71 %). Uniuyo-water waste site recorded (60.23

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%) and the least recorded in (30.23 %). Residual content recorded highest inUyo village road waste site soil (1.28 %), followed by Oron road waste soil (1.21 %), Akpan andem market soil (0.93 %), Control site recorded (0.89 %) while the least (0.85 %) was recorded in Uniuyo water waste site.

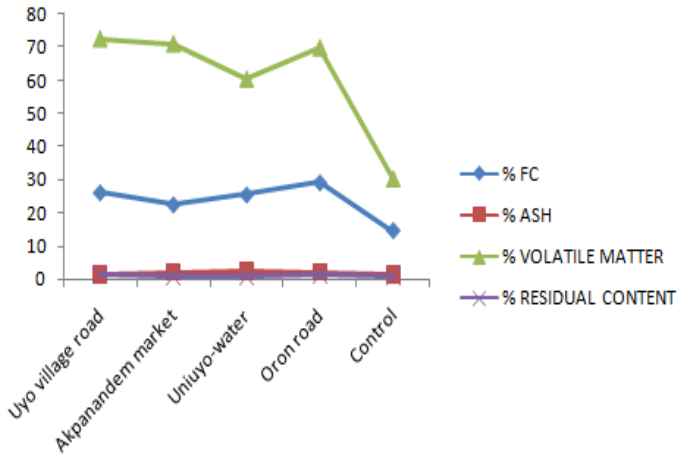

Fig. 4. Shows mean proximate analysis of soil samples microplastics in Uyo metropolis

This finding showed that the present of microplastic in soil of the metropolis was higher than the control. It therefore means that civilization and urbanization leads to increase pollution of the soil with plastics material by inhabitants. Correlation analysis showed the extent and relationship between the concentrations of proximate assay of microplastics in soil and is presented in Table 4.

TABLE 4. Correlation analysis of the proximate assays in the soil samples.

Correlation	% FC	% Ash	% Volatile matter	% Residual content
% FC	1			
% Ash	0.593	1		
%Volatile Matter	0.871	0.515	1	
%Residual content	0.608	-0.274	0.562	1

*Correlation is significant at 0.05 percent

Correlation analysis showed the relationship between the concentrations of proximate assay of micoplastic assessed in soil samples collected. All parameters exhibited strong positive correlation with each other except in the case of Ash-Residual (-0.274) content relationship which shows negative correlation. However, the relationship between fixed carbons, ash, Volatile Matter, Residual content was not significant ($P \leq 0.05$). This indicate that the occurrence of the concentration may be from through same source but not dependent on each other.

Soil Microplastic Heavy metal and Anion concerntration

The heavy metal and anion content of the soil microplastic polymers in Table 5. showed that 61.75±0.03 %) of Lead concentration in whole microplastic was in Uyo village road soil and was significantly (p>0.05) different from other locations like Akpan-andem market soil (37.89±0.03 %), Uniuyo-water waste disposal soil (34.77±0.01 %), Oron road dumpsite (28.45±0.01 %) and Control site (16.78±0.01 %) which was 500 meters away. Similarly, Cadmium concerntration in Uyo village road soil (9.65±0.04 %) was significantly (p>0.05) different from Akpan-andem market soil (5.31±0.02 %), Uniuyo-water waste disposal soil (4.78±0.02 %), Oron road dumpsite (3.98±0.01 %) and Control site (2.28±0.01 %).

Mercury concentration in Uyo village road soil (0.87±0.04 %) followed the same trend and was significantly (p>0.05) different from other locations like Akpan-andem market soil (0.52±0.03 %), Oron road dumpsite (0.48±0.02 %) Uniuyo-water waste disposal soil (0.32±0.02 %) and Control site (0.10±0.01 %). Chromium concerntration obtained in Uyo village road soil (71.25±0.02 %) was not an exception, the same observation was seen. It was significantly different (p>0.05) from sampling location like Uniuyo water waste disposal site (49.89±0.01 %), Oron road dumpsite (38.29±0.02 %), Akpan-andem market soil (33.85±0.03 %) and Control site (12.12±0.03 %). Arsenic concentration obtained from Uyo village road soil (2.38±0.02 %) was significantly (p>0.05) different from Akpan-andem market soil (1.05±0.04 %), Uniuyo water waste site (1.03±0.01 %), Oron road dumpsite (0.95±0.01 %) and Control site (0.16±0.01 %).

In terms of anion concentration, Chlorine value in Uyo village road soil (2165.31±0.03 %) was observed to be significantly (p>0.05) different from other locations like Akpan-andem market soil (1928.44±0.03 %), Uniuyo-water waste disposal soil (1867.21±0.08 %), Oron road dumpsite (1822.78±1.38 %) and Control site (498.76±0.79 %). Moreover, Bromine found in the whole microplastics in Uyo village road soil (567.14±0.03 %) was significantly (p>0.05) different from Oron road dumpsite (389.87±4.10 %), Akpan-andem market soil (296.44±0.02 %), Uniuyo water waste dump site (256.23±0.01 %), and Control site (89.88±0.90 %).

Correlation analysis was employed to measure the extent of the relationship between the concentration of heavy metals in microplastics particles in soil samples collected from Uyo metropolis in Akwa Ibom State and the result of the analysis is presented in Table 5.

The result of the correlation analysis showing the relationship between the concentrations of heavy metals in whole microplastics in soil samples collected from Uyo metropolis of Akwa Ibom state indicates that most of the heavy metal elements exhibited a strong correlation with each other. However, some of these relationships were significant ($P \leq 0.05$) while other were not significant ($P \geq 0.05$). According to the results reported in Tables 6, the correlation coefficients (R^2) between heavy metal concentration levels in the whole microplastics are quite very high.This is a clear indication that all pollutants have the same origin, as expected. The relationships that were significant are Pb-Cd (0.997), Pb-Hg (0.939), Pb-Cr (0.926), Pb-As (0.987), Cd-Hg (0.939), Cd-Cr (0.915), Cd-As (0.988), and Hg-As (0.958). This indicates that as one increase, the other increases too and vise versa. How ever they was a relationship check between heavy metal and anions in the analysis and it shows that there was a

significant (P > 0.05) relationship between Lead Pb-Bromine Br (0.885),

Cd-Br (0.889), Hg-Br (0.969), Cr-Br (0.887), Cr-Br (0.887) and As-Br (0.940). These indicate that there is a dependent and strong positive relationship between them. This relationship also shows that their source of origin is the same.

TABLE 5. Shows the Soil Microplastic Heavy metal and Anion concentration

Parameter	Soil Sample location				
	Uyo village road	Akpan-andem market	Uniuyo-water waste site	Oron-road dumpsite	Control
Pb (ppm)	61.75±0.03[a]	37.89±0.03[b]	34.77±0.01[c]	28.45±0.01[d]	16.78±0.01[e]
Cd (ppm)	9.65±0.04[a]	5.31±0.02[b]	4.78±0.02[c]	3.98±0.01[d]	2.28±0.01[e]
Hg (ppm)	0.87±0.04[a]	0.52±0.03[b]	0.32±0.02[c]	0.48±0.02[b]	0.10±0.01[d]
Cr (ppm)	71.25±0.02[a]	33.85±0.03[d]	49.89±0.01[b]	38.29±0.02[c]	12.12±0.03[e]
As (ppm)	2.38±0.02[a]	1.05±0.04[b]	1.03±0.01[b]	0.95±0.01[c]	0.16±0.01[d]
ANIONS CONC.					
Cl (ppm)	2165.31±0.03[a]	1928.44±0.03[b]	1867.21±0.08[c]	1822.78±1.38[d]	498.76±0.79[e]
Br (ppm)	567.14±0.03[a]	296.44±0.02[c]	256.23±0.01[d]	389.87±4.10[b]	89.88±0.90[e]

TABLE 6. Shows the Correlation Analysis the Microplastics Heavy Metals and Anions Relationships in the Soil Samples of Uyo Metropolis, Akwa Ibom State.

Correlation	Pb	Cd	Hg	Cr	As	Cl	Br
Pb	1						
Cd	0.997**	1					
Hg	0.939*	0.939*	1				
Cr	0.926*	0.915*	0.856	1			
As	0.987*	0.988**	0.958*	0.951	1		
Cl	0.786	0.744	0.822	0.842	0.799	1	
Br	0.885*	0.889*	0.969**	0.887*	0.940*	0.827	1

*Correlation is significant at 0.05 percent

TABLE 7. Shows Contamination factor/degree and Pollution load index (PLI) of Heavy metal and Anion in the soil of Uyo Metropolis.

Parameter	Soil Sample location			
	Uyo-village road dumpsite soil	Akpan-andem market soil	Uniuyo-water-dump site soil	Oron road dump site soil
Pb (ppm)	3.68	2.36	2.07	1.69
Cd (ppm)	4.23	2.33	2.10	1.75
Hg (ppm)	8.7	5.20	3.20	4.8
Cr (ppm)	5.88	2.80	4.12	3.16
As (ppm)	14.88	6.56	6.44	5.94
Contamination degree	37.366	19.243	7.922	17.337
PLI	544.40	114.59	96.06	81.62
ANIONS				
Cl (ppm)SS	4.341	3.866	3.744	3.655
Br (ppm)	6.310	3.298	2.851	4.338
Contamination degree	10.651	7.164	6.598	7.993
PLI	10.467	7.141	6.534	7.964

Contamination factor/degree and Pollution load index (PLI) of Heavy metal and Anion in the soil of Uyo Metropolis.

Contamination factor/degree and Pollution load index (PLI) of Heavy metal and Anion in the soil of Uyo Metropolis in Table7. show that Lead Pb recorded highest in Uyo village road site (3.68), followed by), Akpan andem market soil (2.36 ppm), Uniuyo water waste dump site(2.07ppm) and the least was recorded in Oron road site (1.69ppm). Similarly, Uyo village road dump site soil recorded highest (4.23ppm) contamination rate of Cadmium Cd in the soil, followed by Akpan andem market (2.33 ppm), Uniuyo water waste site contamination factor (2.10 ppm), and the least was in Oron road waste site (1.75 ppm). Mercury Hg contamination factor was higher in Uyo village road waste soil site (8.7 ppm), followed by Akpan andem market soil waste soil site (5.20 ppm), Oron road waste site (4.8 ppm), Uniuyo water waste site recorded the least (3.20 ppm). Moreover, Chromium- Cr recorded highest contamination factor in Uyo village road dump site soil (5.88 ppm), followed by Uniuyo water waste dump site recorded (4.12 ppm), Oron road waste dump site soil (3.16ppm) while the least (2.80ppm) was recorded in Akpan andem market soil. Arsenic-As contamination in the soil was highest (14.88 ppm) in Uyo village road site, followed by Akpan andem market soil (6.56 ppm), Uniuyo water waste dump site recorded (6.44 ppm) while the least (5.94 ppm) was recorded in Oron road waste dump site soil. Contamination degree and pollution load index was higher in the soil of Uyo village road dump site (37.366 ppm and 544.40 ppm respectively) compared to other locations (Table 7). Anions pollution shows that Chloride-Cl contamination was highest (4.341 ppm) in Uyo village road soil, followed by Akpan andem market soil (3.866 ppm), Uniuyo water waste dump site recorded (3.744 ppm) while the least level of contamination (3.655 ppm) was recorded in oron road waste dump site soil. Bromine contamination rate in the soil recorded highest (6.310 ppm) in Uyo village road soil,

followed by Oron road soil (4.338 ppm), Akpan andem market soil recorded (3.298 ppm) while the least (2.851 ppm) was observed in Uniuyo water waste soil. However, contamination degree (10.651 ppm) and pollution load index (10.467 ppm) was significantly higher in Uyo village road soil compared to other locations as shown in table.

Discussion

This study reveals the present and concentration of microplastic particles and their heavy metals in the soil of some selected locations in Uyo metropolis of Akwa Ibom State. From the research study, there are high concentrations of microplastics particles in the soil as a result of indiscriminate waste disposal which has become a problem to the society. From the analysis of the proximate and ultimate components of the plastic representing the physical and chemical component of the particles found in the soil, it showed that the pH level were slightly acidic in all locations ranging from 6.32 % (highest) to 6.00 % the lowest which is the control site, the calorific energy (High heating value) of the plastic were very high in all the locations recording the highest 34872.00 KJ/g concentration and low moisture content was 14230 KJ/g which was in the control site. Moisture content in the microplastic was higher than the control. This shows that some particles which were thermoset must have absorbed moisture in the process of disintegration since it was deposited in the soil. Also like the ultimate parameters analyzed, the microplastic particles Carbon, Oxygen, Nitrogen, Hydrogen, and Sulfur were higher than the control site showing that there is much deposition of plastic waste in those study locations. From the correlation analysis, it showed that all parameters exhibited strong positive correlation with each other. However, the relationships were significant ($P \leq 0.05$) for some like Carbon-Nitrogen (0.923), Oxygen-Nitrogen (0.977), Oxygen-Hydrogen (0.936) and Nitrogen-Hydrogen (0.956) but not significant for other. The significance difference implies that as one element increases, they other increases too and vice versa and that the microplastic particles are from the same source. High heating values recorded agrees with the report of [19] that due to the existing of carbon and hydrogen content which led plastic to have higher energy content of the plastic particle, the particles from waste dump site is a potential fuel to recover energy. In general, the product of combustion is carbon dioxide, water and a good deal of energy. Hence, alternative options such as recycling and thermal treatment need to be incorporated into the waste management concept in order to address the solid waste disposal [24]. A study found that the greater the percentage of plastic in the refuse burned in a garbage incineration, the more efficiency the burning, the greater the quantity of energy released and the lower the emission of air bone pollutant (Othman *et. al*., 2008). Proximate analysis also showed that the fixed carbon concentration were 29.22, 26.12,25.45, 22.43 %, and 14.45 % for Oron road, Uyo village road site, Uniuyo water site, Akpan-andem market site and control respectively. This shows the high present of indiscriminate disposal which may affect the soil if not control. Ash content, Volatile organic matter and residual content were in high amount compared to the control site. The increase concentration and amount of one parameter led to the increase in another. This agrees with this report that ash content represents the part of the microplastic that wills not combust [26] and can be influenced by the high heating capability of the microplastic recorded in the result. High heating values of the microplastic can yield high ash content when there is low moisture content and volatile matter.

Heavy metals recorded from the particles analysis shows highest concentration of 61.75ppm, 9.65ppm 0.87ppm 71.25ppm 2.38ppm all from Uyo village road dumpsite. These concentrations were higher than the controls showing that the particles with high amount of moisture content and residual matter contain high level of heavy metals. These concentrations are hazardous to microorganism and food chain. The same observation was recorded in the anions content which was high in Uyo village road site and other locations compared to low amount recorded in control site. This finding may be attributed to the report from [20] that some metals and anions are additive in the production process but due to environmental factor like pH and temperature of the environment, additional quantity of the metals and anions are added to the microplastic surface area. [15] Also added that these heavy metals get absorbed in the plastic surface area and find their way into the environment.

This study finding agrees with [16] who reported that additive chemicals substances are commonly added to plastics and are therefore likely to be present in microplastics in the environment, representing a potential harm. Examples of these substances include polybrominated diphenyl ethers (PBDEs) and other brominated flame retardants as well as Bisphenol A (BPA). Several EU risk assessments for phthalates show that plastics accumulated in the natural environment are one of the main sources of phthalates releases to the environment. Ingested microplastic laden with polybrominated diphenyls (PBDEs) may transfer to birds and to lugworms [23]. The contamination levels from this study could be due to the large amount and types of waste materials deposited over the years which may contains heavy/trace metals substances. Anions contamination level was above moderate level but could pose danger to the food chain as some of these beads are picked by birds and lower organisms.

Pollution index was also high in the soil samples collected but shows that toxic substances are in large amount and is stored for long time as this waste plastic and other organic matter are deposited every day. If proper check and regulation is not taken the soil around that region could be completely damaged and useless.

IV. CONCLUSION

Indiscriminate waste disposal is a major problem in Nigeria and there is need to address the trend especially the way plastic waste is disposed to our environment. The study finding concludes that greater percentage of waste disposed to our environmental media are plastic in nature and this waste has slow breakdown process which may allow it to remain in the soil for decades before its breakdown. From all the locations of the study, microplastic particles in the sampled

soils were higher than the control site soil. The analyzed microplastic has high calorific energy which can be converted to useable energy. Therefore, proper thermal treatment operation is important to control emissions of these compounds so as to reduce the quantity of plastics disposed. Carefully monitored and controlled thermal treatment can lead to large reduction in plastic waste, generate much needed energy and have little negative impact on environment. Recycling opsyen and thermal treatment offer benefit of material recovery and energy recovery so as solving the waste disposal problem.

Recommendation

From the study findings, the researcher recommends thermal treatment technology such as refuse derived fuel (RDF) power plant or thermal depolymerization as the best practicable environmental option (BPEO) for plastic waste when carried out to the latest standards with energy recovery followed by land filling of the solid residues.

The researcher also recommends for legislative body to formulate policies and regulations to control plastic usages in the country and encourage recycling reuse and reduce plastic product in our society.

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