Preliminary Investigation of Microplastics in Roadside Soils of Port Harcourt and Elele in Rivers State, Nigeria

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Abstract

This study evaluated the occurrence of microplastics in roadside soils in Port Harcourt and Elele, Rivers State, Nigeria. Topsoil samples were collected from three major road networks in Rivers State (Port Harcourt city internal roads, Port Harcourt to Elele Road, and Elele to Owerri road). Microplastics were extracted from the samples using density separation and quantified via microscopy. Microplastic abundances in the samples ranged from 3 particles/50 gram - 20 particles/50 gram. The highest number of microplastic particles were found on roads with the highest traffic density. Secondary microplastics were most abundant in the samples as fragments constituted 69% of the total plastics and made up 67%, 73% and 70% of Port Harcourt internal roads, Port Harcourt to Elele road and Elele to Owerri road, respectively. This study presents baseline data on microplastics in roadside soils in an urban Nigerian city and highlights the contribution of road traffic and vehicles to both terrestrial and aquatic microplastics as well as the need for routine monitoring in order to mitigate plastic pollution.

Keywords: Plastic Pollution, Road traffic density, Terrestrial microplastics, Microplastic fragments; Urban runoff

Introduction

Plastic use in Nigeria has grown over the years to become an essential part of everyday life due to its favourable properties such as affordability, durability and wide application in various sectors such as health, food and beverage packaging, textile and agriculture.[1-3] Annual plastic use in Nigeria has grown from 1 million in 2015 to 1.5 million tons in 2020.[4] Furthermore, more than 5 million sachet water packages are disposed of per day in Nigeria without any plan for recycling or proper management. Increasing plastic use has led to increased plastic disposal, and due to poor waste management system and recycling infrastructure in Nigeria, plastic wastes accumulate, pollute the environment and inevitably end up in the marine and freshwater ecosystems.[5-7] Plastic waste management has remained one of Nigeria's greatest environmental challenges.[8] Recently, the Lagos state government banned the use of single-use plastics (SUPs) in the state because they block the stormwater channels, causing flooding in the country's commercial and most populous state.[9] Plastics, when littered in the environment fragment into microplastics because of diverse environmental and biological factors.

Microplastics are plastic particles that are less than 5 mm in any one dimension. They are either primary microplastics when they are intentionally produced to be 5 mm, or secondary microplastics when they break out from larger plastic materials in diverse shapes such as fragments, fibers, and films.[10] Microplastics are persistent in the environment and can be transported from one ecosystem to another causing harm to biodiversity when ingested by organisms or via entanglement. Toxic plastic constituents may also leach from microplastics, contaminating the environment. In some cases, microplastics transport pollutants from highly polluted area to less polluted or pristine environment.[11-13] One of the major sources of pollutants to the aquatic ecosystems is road soils and dusts. Transportation of legacy pollutants such as polychlorinated biphenyls, petroleum hydrocarbons and heavy metals from road soils to aquatic ecosystems have been reported in literature.[14-17] Also, microplastics have been

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reported to be transported from roadside soils and dusts into aquatic ecosystems.[18-20] Furthermore, vehicle parts and tires are significant sources of microplastics due to wear and tear as well as friction between tires and road surfaces leading to release of tire particles on the road.[21] Thus, roadside soils may be huge reservoir of microplastics. As emerging pollutants, adverse effects of microplastics on biodiversity include reduced fertility, oxidative stress, poor feeding and growth, change in soil properties and reduced crop yield.[22-26]

Currently, there is no data on plastic pollution in road soils in Nigeria except for Okigwe road in Imo state.[27] Effects such as microplastics contamination of garri (cassava flakes) spread on roadside for drying have also been reported by Enyoh *et al*.[28] Therefore, this study aimed to evaluate the occurrence of microplastics in roadside soils in Port Harcourt and Elele in Rivers State, Nigeria. The result of this study is expected to provide baseline data on microplastic pollution of roadside soil.

Materials and Methods

Study Area

Rivers state is located in the Niger Delta region of southern Nigeria (Figure 1). It is a commercial and industrialised state considered to be the commercial centre of the Nigerian crude oil industry. The roads usually witness high traffic density in major urban areas and city outskirts especially the roads leading to other state capitals like the Port Harcourt-Elele-Owerri road which was the centre of this study.

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Figure 1. Map of Nigeria showing Rivers State (in red)

Sample Collection

Topsoil samples (0-5 cm depth) were collected from roadside soils besides (≈ 2m) high traffic and low traffic density roads in Port Harcourt and outskirts (Elele-Owerri road) in Rivers State with metallic spoon, transferred into aluminium foils and taken to the laboratory for further analysis. Samples were collected at multiple points at each sampling location and later mixed in the laboratory to make a composite sample. Sampling locations and geographical coordinates are presented in Table 1.

Table 1. Sampling locations and geographical coordinates

Sampling location	Latitude	Longitude
Benjack Junction	4.8352 °N	7.0143 °E
Tontex Garden Centre	4.8352 °N	7.0233 °E
Madonna University Gate	5.9314 °N	6.8376 °E
Rivers Joy, Rumudumaya	4.9040 °N	7.0003 °E
Madonna University Church Gate	5.1344 °N	6.8270 °E
Port Harcourt Airport Road	5.0157 °N	6.9541 °E
Salvation Ministry Igwuruta	4.9421 °N	7.0117 °E
The Promise, Elele	5.0083 °N	6.9114 °E
Market Junction	5.1029 °N	6.8121 °E
St. Aquinas Secondary School, Elele	49936 °N	6.9142 °E
Elekahia Housing Estate	4.8134 °N	7.0237 °E
HCUE Restaurant	4.7844 °N	7.0384 °E
Rumumasi Market	4.8331 °N	7.0292 °E
Asaga Junction	5.1018 °N	6.8190 °E
Greater Evangelism Headquarter	4.9293 °N	6.9971 °E
Betylino Int'd Limited	5.1138 °N	6.8243 °E
SPDC Pipeline	4.8944 °N	7.0055 °E
TNC Hotel	4.8934 °N	7.0072 °E
Rumuheinwo Housing Estate	4.8934 °N	7.0024 °E
Regeneration School	4.8939 °N	7.0065 °E

Density Separation and Microplastic Quantification

Saturated solution of sodium chloride (300 g/L) was added to 50 g of soil samples in a volumetric flask. Samples were stirred for ten minutes and kept for 24 hours to settle while covered with aluminium foil.[29] The mixture was decanted through a vacuum separation system.

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The residue on the filter paper was dried in an oven (40 °C), stored in glass petri dishes, and used for microplastic quantification. The filter paper was viewed under Olympus Compound Light Microscope (x40) and microplastic in soil samples (50 g) were identified, counted, shapes recorded, and their photographs taken.

Quality Control

Only glass wares were used for this study to avoid contamination from plastic products. Double distilled water used for the study were also pre-filtered to avoid contamination. Samples were covered with aluminium foils when not in use and all processes were done in fume cupboard to prevent air-borne contamination. Blank samples were also analysed to ensure removal of any contamination during the sample preparation and analysis.

Results and Discussion

Microplastic Abundance

The number of microplastics in the roadside soils ranged from 3 to 20 particles/50g. The highest concentration of microplastics was found in Benjack roadside soils (20 particles/ 50g) while the least concentration of microplastics was found in Rumuomasi roadside soils. Benjack junction is a major road intersection that services one of the major commercial areas in Port Harcourt with occasional stops due to traffic controls and a high traffic burden. This may be the reason for the high microplastic concentration in the roadside soils from the road. Microplastics were present in all samples except the soil samples from around TNC Hotel (Figure 2). Microplastics abundances were highest in Port Harcourt roads (69 particles) and Port Harcourt-Elele Road (69 particles) followed by Elele-Owerri road (37 particles). Soils from roadsides with high traffic density constitute 69% of all microplastics found in the study while soils from low traffic density roads made up 31% (Figure 3). This confirms that vehicles/vehicular traffic contributes microplastics to roadside soils as also seen in Benjack

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roadside soils.[30, 31] There are a few studies on microplastics in roadside soils to compare to the result of this study. However, the microplastics in roadside soils from Port Harcourt roads were higher than the microplastics in roadside soils and dusts in rural and urban roads in Victoria, Australia and in soils on roadside soils of Qinghai, Tibet Plateau. [32, 33] Pellet was the highest occurring microplastics in Qinghai roads while fibers occurred most frequently in the Victoria study in Australia. This is in contrast with the Port Harcourt roads which were dominated by fragments.

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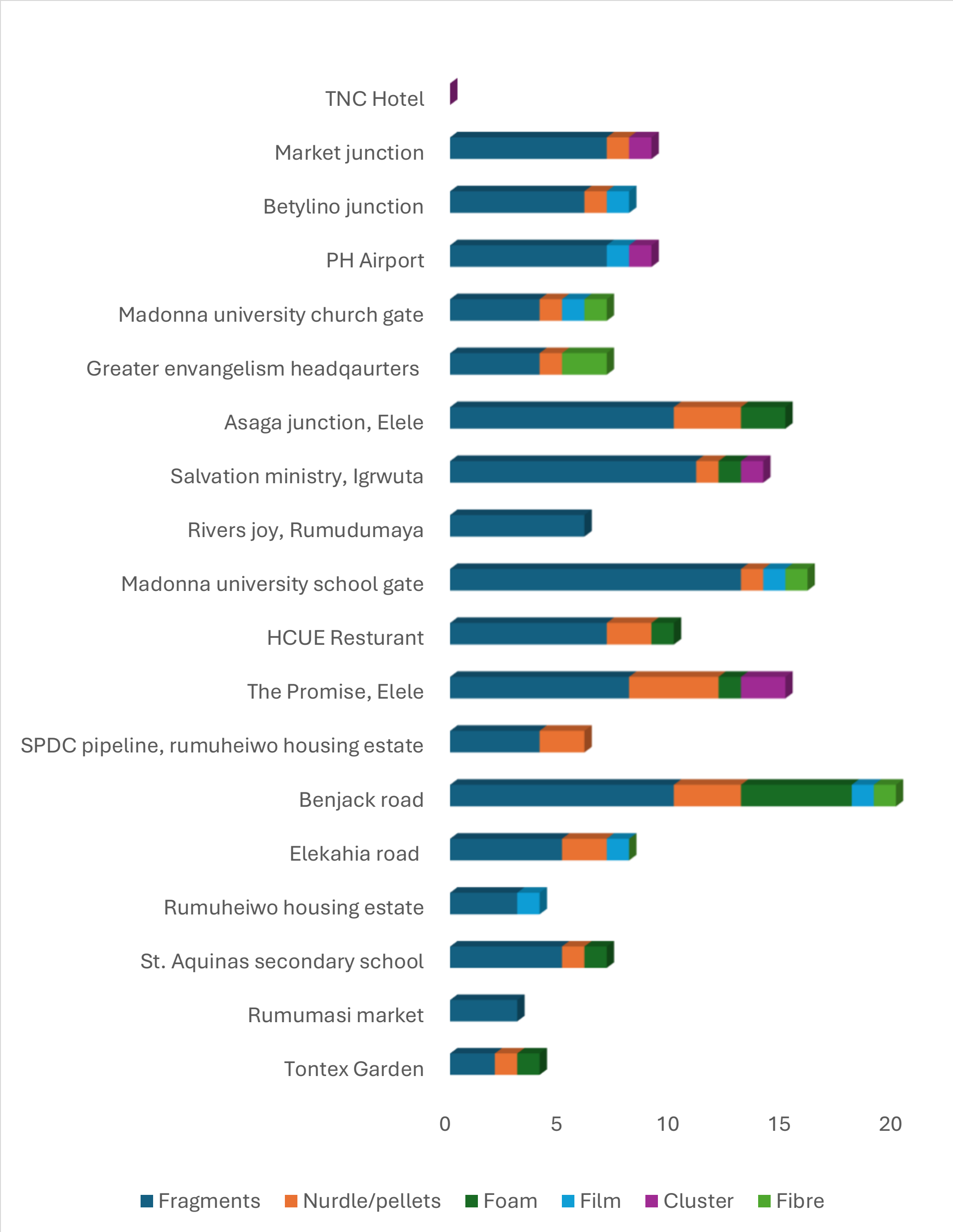
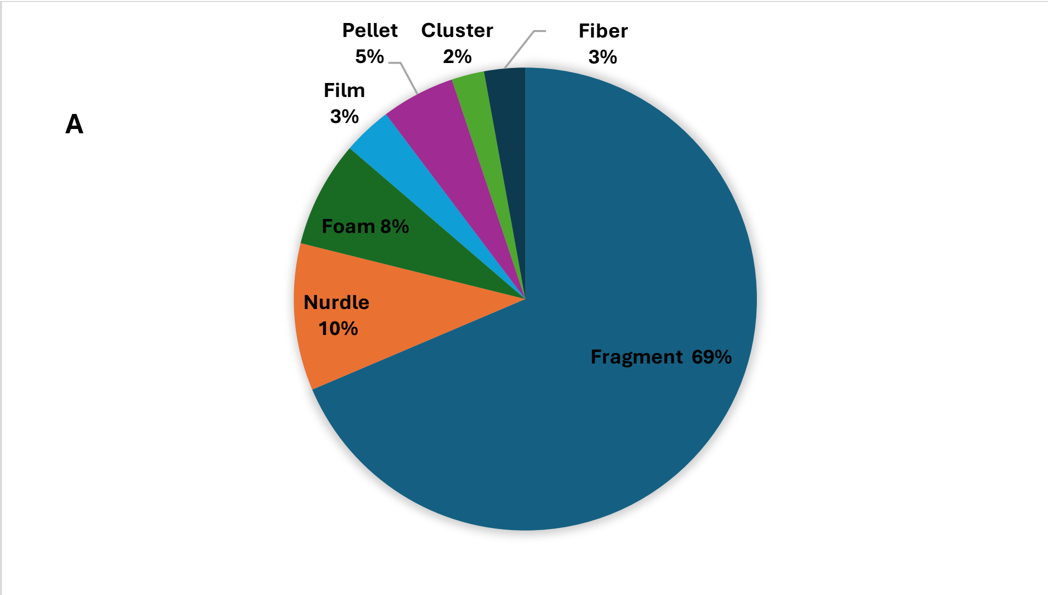
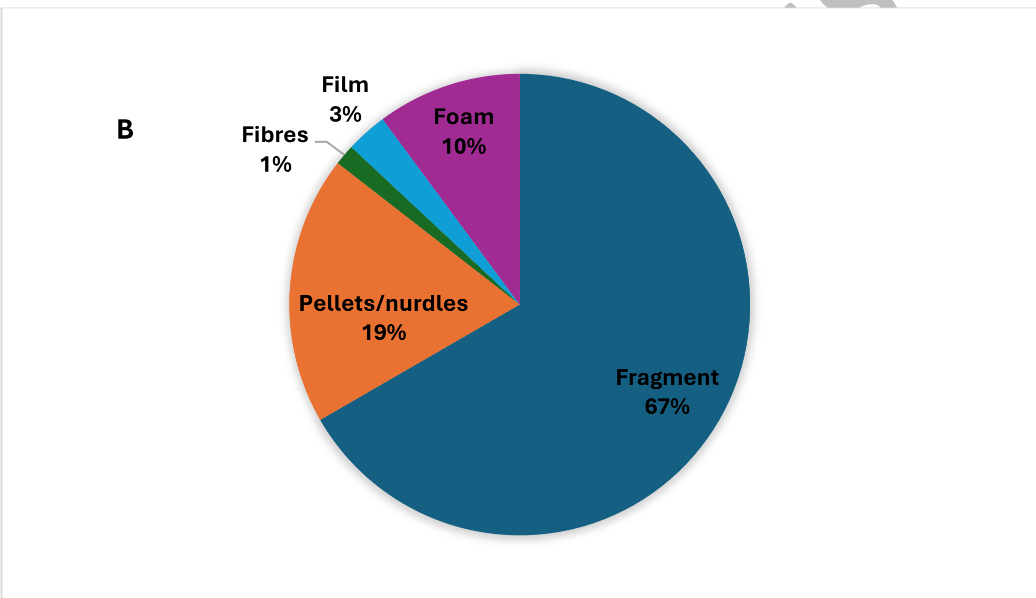


Figure 2. Microplastic abundance in Rivers State roadside soils (particles/50g)





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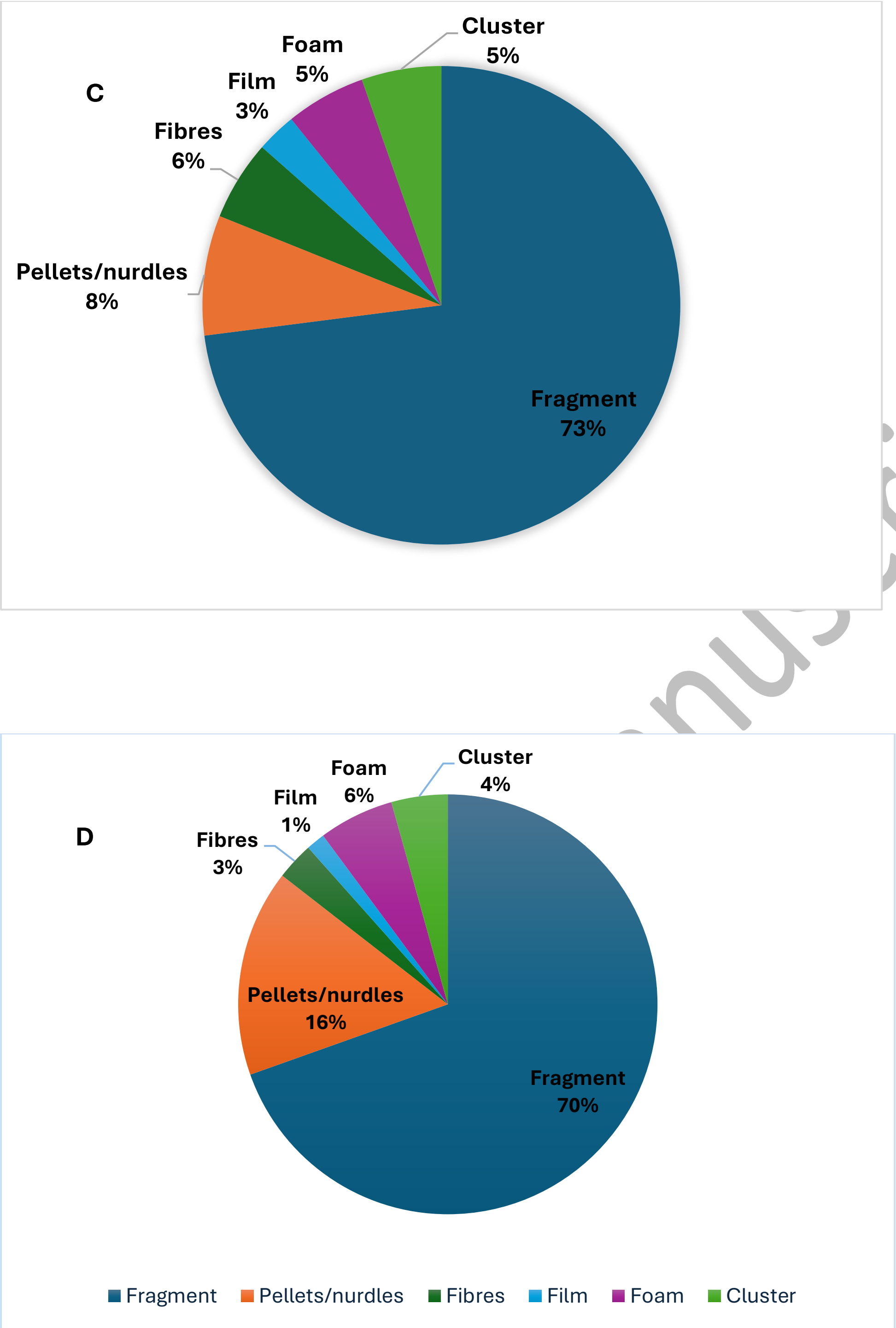

Figure 3. Percentage composition of microplastic shapes in A): total road soils B): Port Harcourt internal roads C): Port Harcourt to Elele Road D): Elele to Owerri road

The correlation between traffic density and the microplastic concentration in the studied roadside soils shows a weak positive correlation with a correlation coefficient of 0.27 (Figure 3 and Table 2). This shows that there may be other factors contributing to microplastic abundance in roadside soils besides vehicles. These other sources may include atmospheric deposition, rainfall, storm water flow and improper waste disposal.[34] Microplastic particles deposited on roadside soils may also be transported farther away from the roads by storm water from precipitations.

Table 2: Traffic density of sampling locations (vehicle/minute)

Sampling location	**Traffic Density (Vehicle/min)**	**Microplastic Abundance (Particles/50g)**
Benjack Junction	41.10	20.00
Tontex Garden Centre	17.80	4.00
Madonna University Gate	4.40	16.00
Rivers Joy, Rumudumaya	22.20	8.00
Madonna University Church Gate	4.40	7.00
Port Harcourt Airport Road	15.56	9.00
Salvation Ministry Igwuruta	17.80	14.00
The Promise, Elele	20.00	15.00
Market Junction	11.10	9.00
St. Aquinas Secondary School, Elele	17.80	7.00
Elekahia Housing Estate	17.80	8.00
HCUE Restaurant	17.80	10.00
Rumumasi Market	44.40	3.00
Asaga Junction	11.10	15.00
Greater Evangelism Headquarter	17.80	7.00
Betylino Int'd Limited	11.10	8.00
SPDC Pipeline	0.30	6.00
TNC Hotel	1.11	0.00
Rumuheinwo Housing Estate	8.90	4.00
Regeneration School	0.30	6.00

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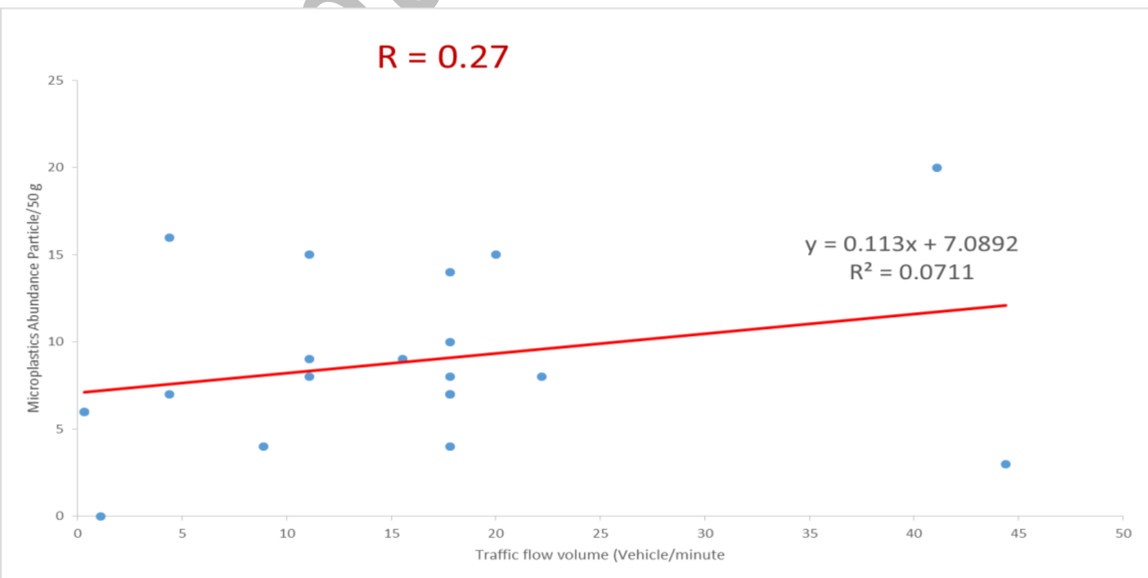

Figure 4. Correlation between traffic density and microplastic abundance

Microplastic Shapes

The percentage of the constituent shapes of the microplastics in each sampling location is described in Figure 3. Fragments were the most frequently occurring microplastics in all samples followed by pellets (Figure 5). Soil microplastic studies usually report fragments and pellets as the most abundant microplastic shapes.[30, 35, 36] These fragments may have been from vehicular parts or transported by rainwater runoff.[37] The fragments also show the microplastics are secondary microplastics from larger plastic materials unlike pellets/nurdles which are primary microplastics. The presence of fibers which also indicate secondary microplastic sources from vehicular tire wear, road markings, clothing and ropes during runoff.[18, 38-40] Other microplastic shapes identified in the samples are also secondary microplastics. Individually, fragments made up 67% of microplastics in Port Harcourt roads and 73% of microplastics in Port Harcourt-Elele Road and 70% in Elele-Owerri roads (Figure 4).

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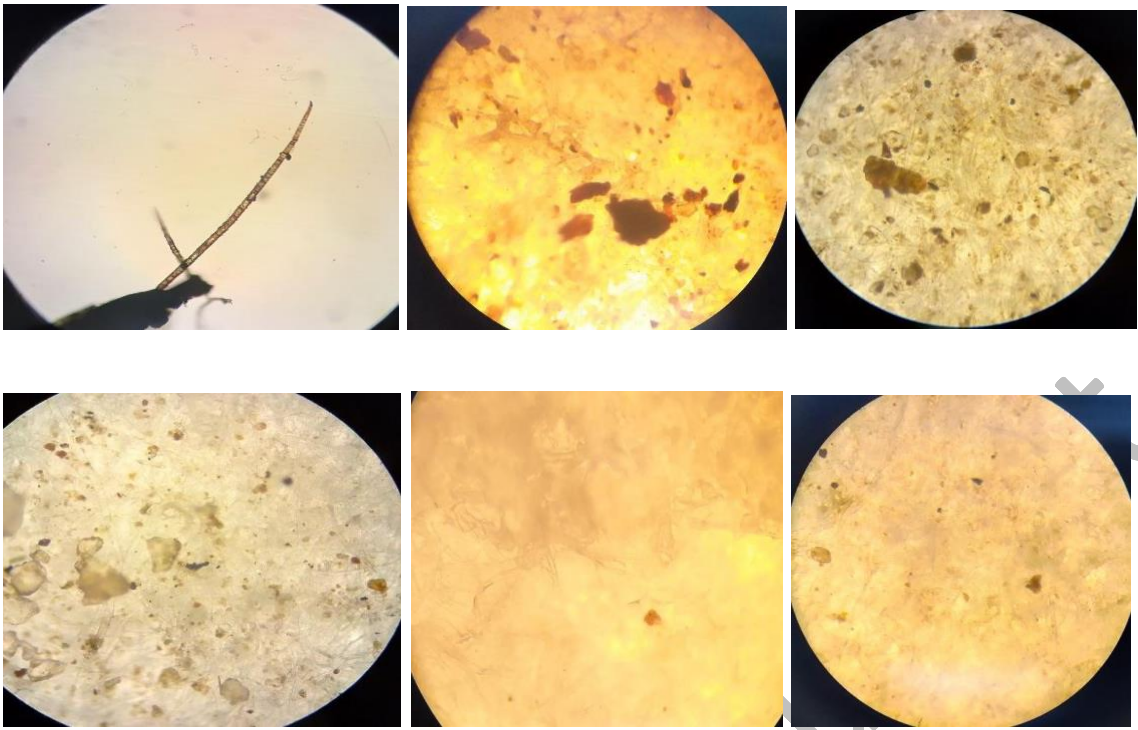

Figure 5. Microscopic fibers and fragments from roadside soils in Port Harcourt

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Conclusions

This preliminary study intends to draw attention to the occurrence of microplastics on roadside soils, particularly in Africa roads which are currently understudied. It shows that microplastics in Port Harcourt internal roads, Port Harcourt to Owerri road and Port Harcourt to Elele road soils were chiefly fragments, indicating the dominance of microplastics. The microplastic abundance correlated weakly with the traffic density, an indication that vehicle traffic may not be the only source of microplastics on roadside soils. Other microplastic shapes found in the road soil samples were film, foam, fibre and pellets. There is need for more monitoring studies on Nigerian roads to evaluate the contribution of road traffic density to microplastic pollution and how road runoffs and tire particle toxicity affect the freshwater ecosystem.

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