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Assessment of Physicochemical Properties of Municipal Solid Waste Leachate from Dumpsites in Ovia North-East Local Government Area, Nigeria

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Abstract

Municipal solid waste collection is the gathering of solid waste (SW) from the point of production (residential, industrial, commercial, and institutional) to the point of treatment or disposal. Waste collection is the main component of waste management that links waste generators to the waste management system. Leachates arise as a result of the infiltration of precipitation to the interior of dumpsites and landfills, but at the same time water present in the wastes and released in different processes taking place in a dumpsite also contributes to the generation of leachates. In this research work, the physicochemical assessment of leachate in three open dumpsites in Ovia North East Local Government Area, Edo State was carried out in this study using standard methods for the examination of water and wastewater by APHA, 2005. The findings from the research work shown that the pH of leachate sample from the three samples were ultra-acidic (5.1 m - 5.9 m) with electrical conductivity of in the range of 4750 µS/cm to 8700 µS/cm. The physicochemical analysis indicated the hazards of open waste dumping, as leachate in these dumping sites contains ammonia, calcium carbonate, nitrate, sulphate and other heavy metals which can percolate and contaminate surface water and ground water thereby, causing public health issues and environmental pollution.

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1. Introduction

One of the most important environmental issues is the existence of municipal waste dump sites where different materials with changing physical and chemical properties are irregularly deposited as wastes (Figure 1). Therefore, the selection of a waste storage site is a crucial problem, and particularly the geological properties of the selected site have a highly important role to create or avoid environmental problems. In Ovia North-East Local government Area, Edo State, Nigeria, solid wastes are mostly deposited in un-engineered landfills.

These wastes may contain toxic substances and as they decompose or are biodegraded, infiltrating water, mixed with organic liquid effluents, produce leachate. This could lead to the transport of specific contaminants, such as semi-volatile organic compounds, pesticides, heavy metals, radioactive wastes, chemicals, etc., into groundwater and soil-to-plant transfer processes which results in the accumulation of heavy chemicals in plants and animals especially humans may be exposed to high doses of these chemicals. Sadly, modern engineering sanitary landfilling is not a common practice in Nigeria, thus, it is necessary to carry out assessment of physicochemical properties of municipal solid waste leachate from open dump sites in the study area.

i. Oloku, Ovia North-East Local Government Area, Edo State, Nigeria

ii. Solid Waste Leachate discharge in stream, Okada, Ovia North-East, Local Government Area, Edo State, Nigeria

Figure 1. Open dumpsite in the study area

Sadly, the progression in civilization, urbanization, industrialization and demographic growth has subsequently increased the rate of municipal solid waste generation (MSWG) [1]. Figure 2 shows the projected waste generation, by region (millions of tonnes/years). With Nigeria's growing population, more solid waste is expected to be generated. In Okada town, a town located in Ovia North-East Local Government Area, Nigeria, piles of generated solid waste lie everywhere, and the trend might remain the same as a results of poor waste management policy [2-8].

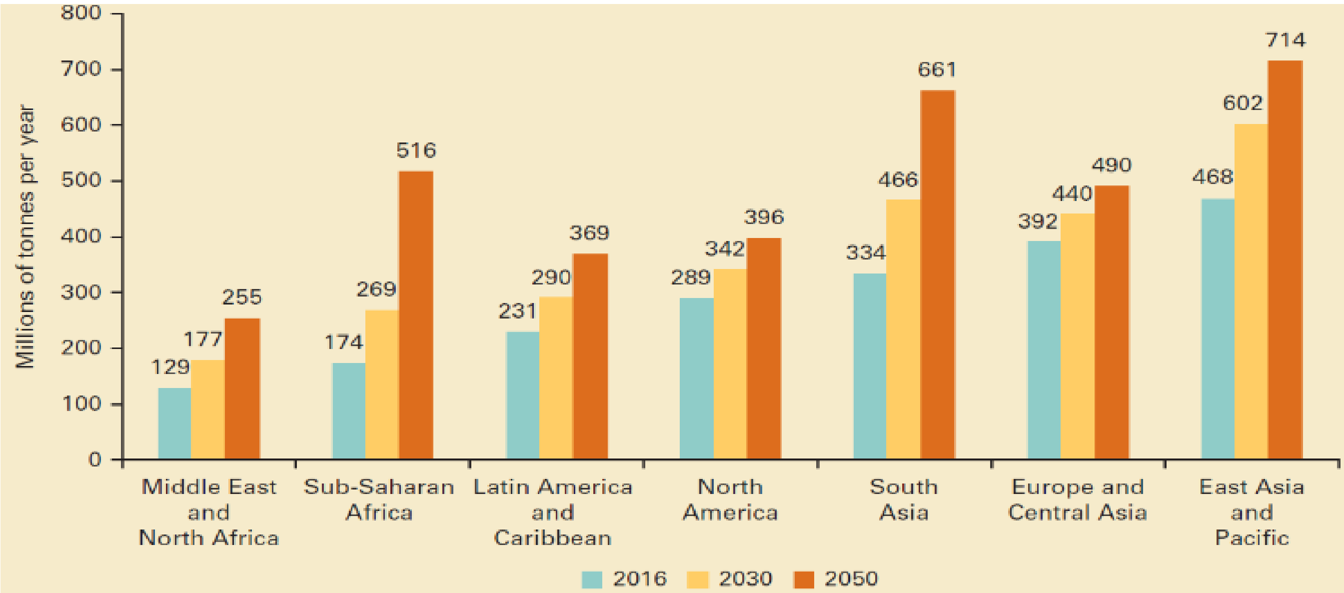

Figure 2. Projected waste generation, by region [21].

According to the United States of Environmental Protection Agency [9], municipal solid waste (MSW) can be defined as wastes generated on daily activities, which includes items like packaging box, grass and garden trimmings, damaged furniture, rags, bottles and cans, food residues, papers, electronics and electrical appliances. Also, municipal wastes are regarded those wastes that arise in households, as well as wastes that do not contain hazardous materials originating from other producers, whose nature or composition resembles wastes arising in households [10]. Furthermore, municipal solid waste management (MSWM) is concerned with the act of storing, collecting, movement, handling, conversion, and disposal of MSW in such a way that good health and stable economy can be guaranteed.

The U.S. Agency for International Development defines MSWM as the systematic way of managing the activities involved in planning, funding, collecting, transporting and processing of municipal solid waste. The processes include: storage, collection, separation, transportation, treatment, energy recovery from waste, recycling, composting and landfill of municipal solid waste [8]. Open dumpsites continue to be the main and most common method of disposal of municipal solid wastes (MSW) in Nigeria. The unwillingness of most municipal authorities to make provision for functional waste collection and disposal services has been the cause of poor MSWM in Nigeria [11]. The effect is that improper management and disposal of MSW would result to environmental challenges such as: pollution, infection transmission, flooding, surface water contamination, environmental degradation, emission of greenhouse gases and ozone depletion [6].

Besides, past research work has shown that the release of hazardous substances related to the pollution of ground and surface waters is closely tied to leachates generated during the exploitation of MSW open dumpsites [13-14]. The scale of this threat depends on the quantity and composition of the leachates and the distance of the dumpsites from waters [15]. Leachate waters are formed as a result of the penetration of rainfall inside a dump site and the subsequent leaching of soluble organic and mineral compounds [12]. Leachate contain many organic compounds that readily succumb to biodegradation, giving rise to refractory compounds that accumulate with the exploitation of dumpsites and are resistant to biochemical degradation [16]. In the case of leachates characterized by high values of Biochemical Oxygen Demands (BOD), Chemical Oxygen Demand (COD), Total Organic Carbon (TOC) and considerable concentrations of ammonium nitrogen, with pH values in the range of 6.7-8.7, high toxicity for crustaceans, fishes and algae was observed [17].

The reason for the harmfulness of these leachates for bioindicators used was the high content of ammonium nitrogen, which under the conditions that lean towards alkaline values give rise to non-ionized toxic ammonia [15]. MSW dumpsites leachates can be considered as highly concentrated complex effluents which may contain mineral and organic compounds (humic substances, fatty acids, aromatic compounds), heavy metals and many other hazardous chemicals [18-19]. Therefore, knowledge of the quantity and composition of leachates is necessary when designing treatment facilities and is important in determining raw leachate pollution effect on the environment.

2. Materials and Methods

2.1 Materials
The following materials and equipment were used in this study; nose mask, hand groves, bucket, shovel, atomic absorption spectrophometer model, ice block, polythene bags, and weighing balance.

2.2 Methods
The following methods were adopted in this study.

2.2.1 Description of Study Area
Ovia North-East Local Government Area is located in Edo State, Nigeria. It lies between latitudes 5°40’ and 7°40’ North and longitudes 5°00’ and 6°30’ East. It covers an estimated area of about 350 square kilometres and falls within the tropical equatorial climate. Geologically, the area is essentially sand witched between the Niger-Delta basin and Anambra basin and lies within the aquiferous Benin formation of the Niger-Delta and aquiferous Ogwashi-Asaba formation of the Anambra basin. The Benin formation consists of thick continental sands. It extends from the west across the whole of Niger- Delta area and southward beyond the present coastline.

2.2.2 Feasibility Study
A feasibility study will be carried out to identify different dumpsites in Ovia North-East Local Government Area. Three dumpsites were identified in the study area and classified as;

Sample A: Oluku dumpsite one (1) leachate collection
Sample B: Okada-Lagos expressway dumpsite leachate collection
Sample C: Oluku dumpsite site two (2) leachate collection

Sample A Sample B Sample C

Figure 3. Leachate accumulating in dumpsites for leachate collection. (Sample A) Oluku dumpsite one (1) (Sample B) Okada-Lagos expressway dumpsite (Sample C) Oluku dumpsite site two (2)

2.2.3 Collection of Municipal Solid Waste Leachate

Municipal solid waste leachate was collected from the identified open dumpsite in the study area (sample A-sample C).

2.2.4 Sorting of different Municipal Solid Waste

Different components of municipal solid waste were collected from each waste batch brought in by waste management trucks to the various dumpsites visited. This was followed by sorting and characterization according to their classification before measurement.

2.2.5 Storage of Collected Municipal Solid Waste Leachate

The collected samples were stored in a cooler containing ice block to maintain a temperature below 5 ^oC after which it was transported to the laboratory for analysis. Total iron, nitrate and phosphate was be determined by molecular absorption spectrometry method. Also, the pH and electrical conductivity of the leachate samples were recorded on site using digital pH meter and digital electrical conductivity meter. The concentration of heavy metals will be estimated by direct air acetylene flame method using the Atomic Absorption Spectrophometer Model (SL168 Elico, India).

3. Results and Discussion

Table 1 shows the composition of leachate from the mid-section of the three majorly used dumpsites in Ovia North East Local Government Area of Edo State, Benin City, Nigeria.

Table 1 Composition of leachate from mid-section of three different dumpsites in the study area

S/N	Parameters	Sample A	Sample B	Sample C	FEPA Standard
1	pH (m)	5.9	5.4	5.1	6.8-7.2
2	Electrical conductivity (µS/cm)	4750 µS/cm	8400 µS/cm	8700 µS/cm	-
3	Temperature (^oC)	32.6	32.8	32.5	-
4	Phosphate (mg/l)	1.48	1.32	1.28	< 500
5	Zinc (mg/l)	0.53	0.61	0.59	< 1
6	Nickel (mg/l)	0.033	0.021	0.014	< 1
7	Cadmium (mg/l)	0.25	0.02	0.01	-
8	Mecury (mg/l)	1.5	0.01	0.01	
9	Manganese (mg/l)	0.45	0.03	0.04	< 0.5
10	Iron (mg/l)	7.65	12.76	13.05	< 20.0

11	Copper (mg/l)	0.43	0.02	0.03	-
12	Calcium (mg/l)	33	38	35	-
13	Lead (mg/l)	0.86	0.34	0.43	< 1
14	Chloride (mg/l)	523	465	385	< 600
15	Nitrate (mg/l)	18.24	17.14	16.55	< 20
16	Sulphate (mg/l)	16.98	13.45	15.06	

Due to the poor waste management system in the study area and Nigeria at large, waste segregation (sorting) before disposal [2, 6] is not practiced, hence, organic waste at open dumpsites interacts with other forms of hazardous waste such as battery waste, chemicals and other toxic materials forming leachate with various heavy metals that percolates and contaminate surface water and ground water. The pH of leachate across samples of dumpsites is 5.9 m for sample A dumpsites, 5.4 m for sample B dumpsites, and 5.1 for sample C dumpsites (Figure 4).

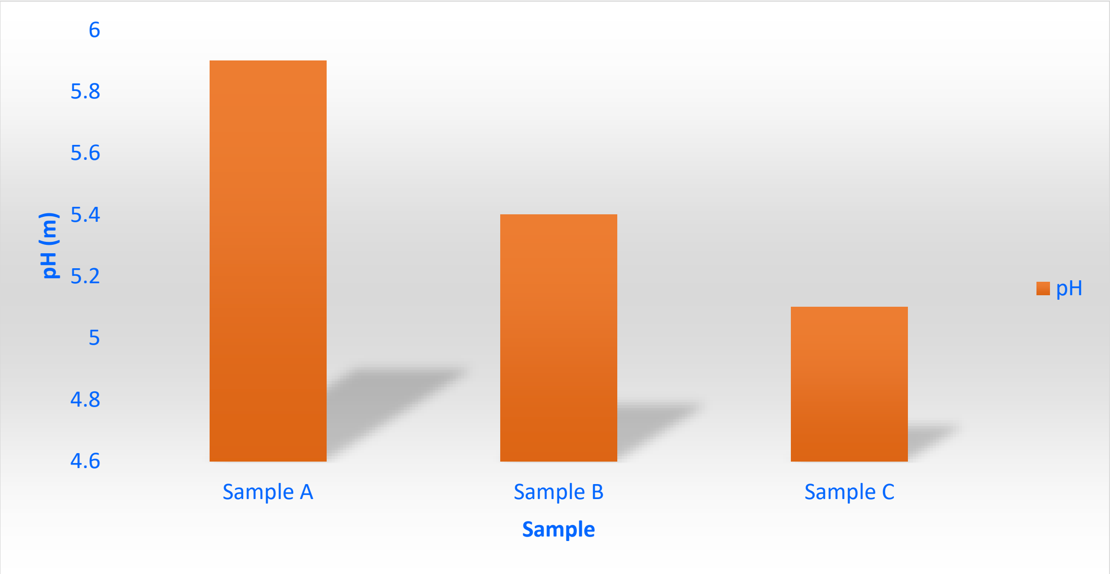

Figure 4. Comparative analysis of pH present in 3 different samples of collected leachates

These values are below the recommended values for a safe environment. According to [20], pure water has a pH of 7 which is neutral while pH below 6.8 and above 7.2 is unsafe for drinking. Besides, leachate with pH values between 1 and 6 indicates the decomposition of organic matter within a body of water, releasing carbon dioxide, which interacts with water to form carbonic acid. Also, the presence of some heavy metals such as aluminium, copper, zinc, lead, calcium, mercury, nickel as well as toxic waste effluent in dumpsites such as calcium oxide and sodium carbonates (Figure 5), produces low pH of leachate as water passes the waste matter. Photoelectric reactions result in the formation of acidic oxides such as SO_2 and NOx, which easily dissolve in water making it acidic. Chemical pollution as a result of waste decomposition in dumpsites can equally reduce water pH. Low pH affects aquatic animals negatively as seen in the formation of mucus on fish gills, retarded growth, and problem with ion regulation as well as reproductive failure [20]. If leachate percolates groundwater, raising the pH to 8.5 and above, it is an indication that the water is hard. Although hard water does not pose any health risk, it causes the formation of scales on dishes, cooking utensils, and laundry basins, inability of soaps and detergents to lather, and the formation of insoluble precipitates on clothing.

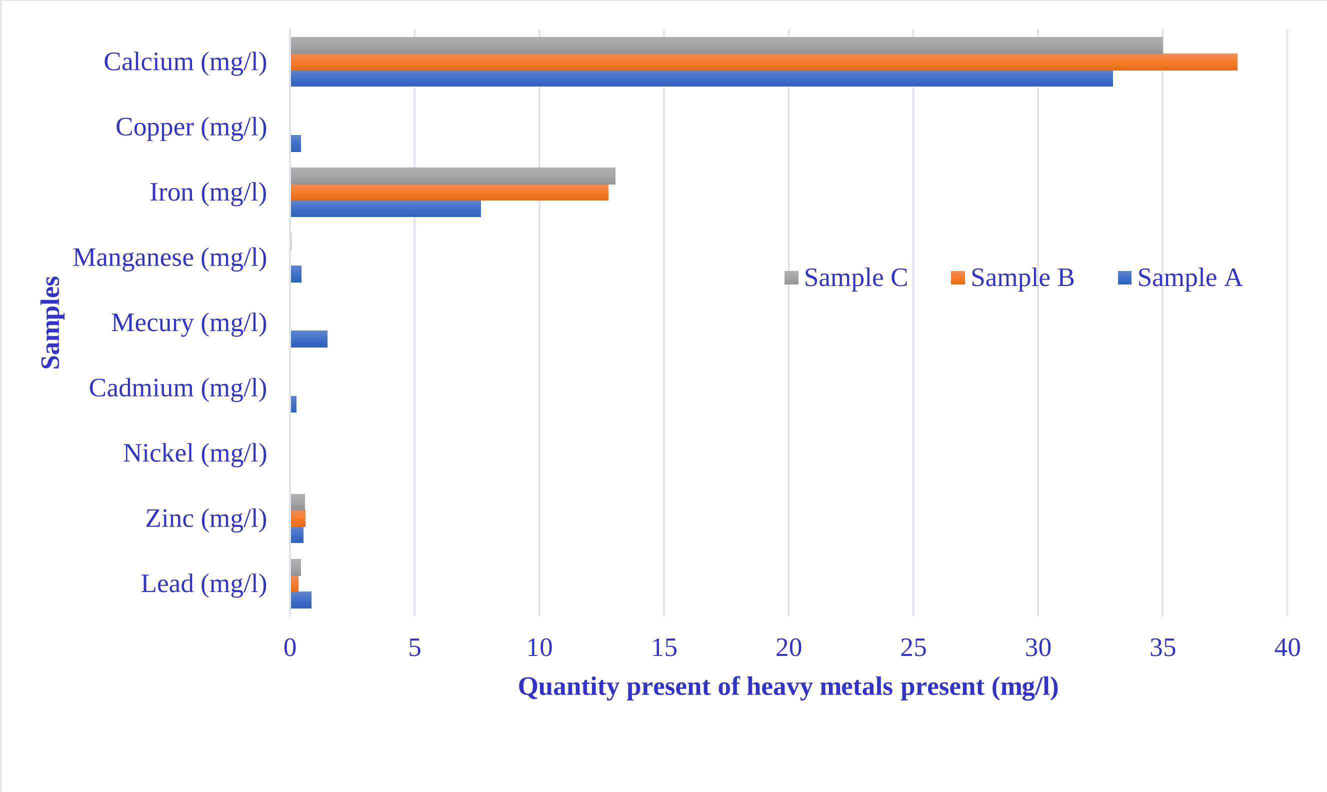

Figure 5 Comparative analysis of heavy metals present in 3 different samples of collected leachates

The analyzed results indicated high concentration of chloride, nitrate, sulphate as shown in Figure 6 and other heavy metals in higher and lower concentrations. This is in agreement with related investigations conducted by [3, 5]. Nitrate which is a form of oxidized nitrogen compound was observed in the range of 16.55-18.24 mg/l in leachate samples indicating the presence of pollutants in all the leachate samples. High level of nitrate concentrations beyond permissible limit may result to the development of cyanosis in infant.

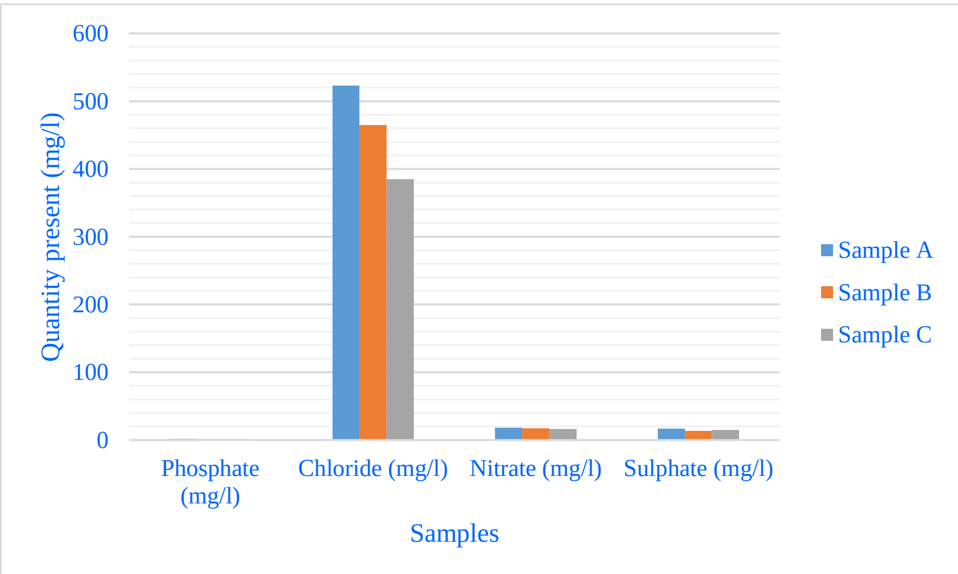

Figure 6. Comparative analysis of concentration of chloride, nitrate, sulphate, and phosphate present in leachates

The results of solid composition/characterization are showed in Table 4.2.

Table 2. Waste characterization in three major dumpsites sites in Ovia North East Local Government Area

Solid Waste Composition	Sample A	Sample B	Sample C
Organic waste	73.25	65.76	74.70
Plastics	11.08	17.25	10.28
Papers	4.04	4.01	4.03
Metals	2.55	3.61	2.14
Glass	5.67	5.55	5.53
Textile	3.41	3.82	3.32

The outcome of the results as shown in Figure 7 revealed sample A, sample B, and sample C dumpsites have 73.25%, 65.76%%, and 74.70 of organic waste matter respectively implying that more organic waste matter is generated.

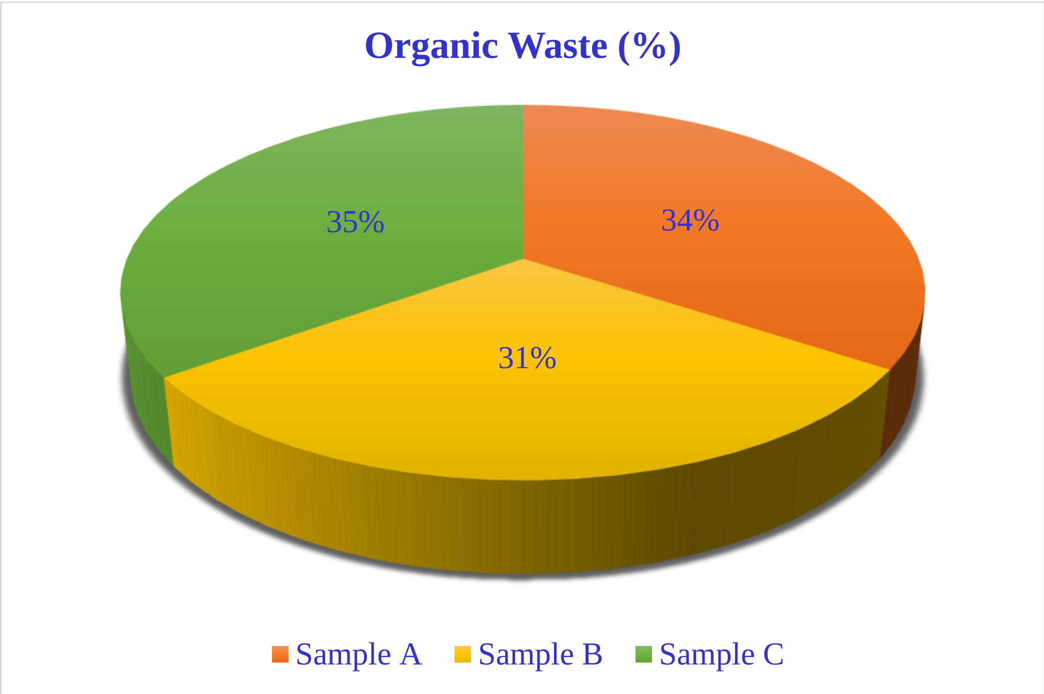

Figure 7. Comparative analysis of organic waste stream

The waste characterization also shown that 11.08%, 17.25%, and 10.28% of plastic wastes are generated in sample A dumpsites, sample dumpsites, c dumpsites respectively. Furthermore, more of glass wastes and paper wastes are generated across all dumpsites used in this study as compared to metal wastes. The reduced in metal wastes recorded could have been as a results of metal wastes collector across the study area. A lot of youth in the study area move from house to house in search of metal wastes which they sell.

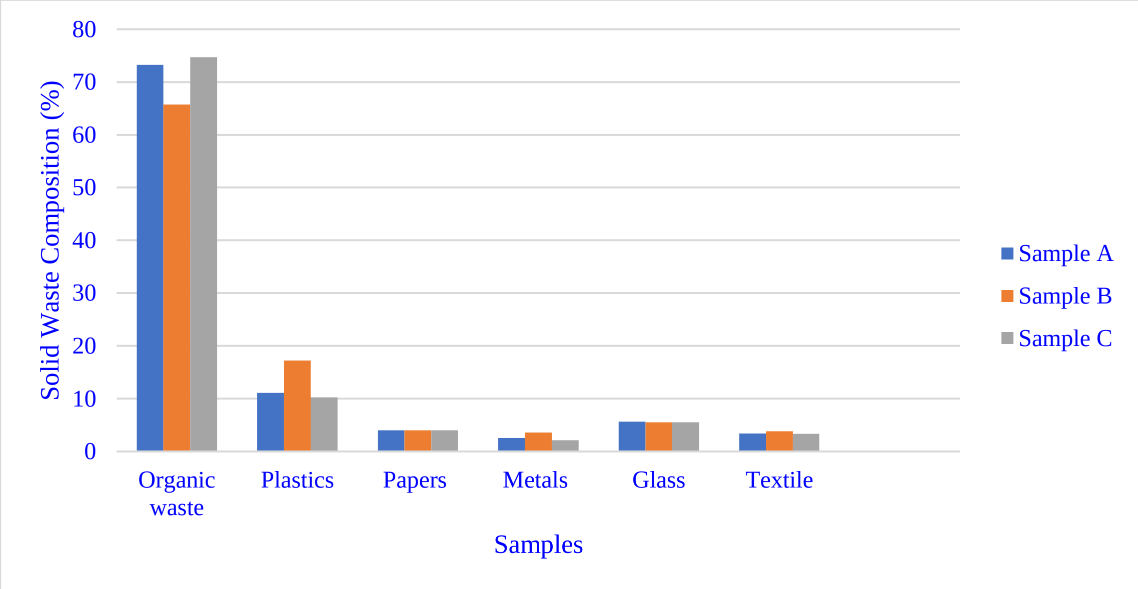

Figure 8. Comparative analysis of municipal solid waste composition

4. Conclusion

This research work has shown that uncontrolled and untreated solid waste can result in environmental pollution and severe health risk. Also, the high toxicity level of organic compounds and heavy metals present in leachate samples tested in this study has a huge potential of surface and ground water contamination as well as compromising plant growth. Therefore, it is important for waste management agencies to create public awareness of the dangers associated with open dumping of MSW as well as enacting stringent laws and policies, in order to proffer sustainable environmental solutions for the wellbeing of Nigerian residents.

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