CHAPTER ONE

INTRODUCTION

1.1 Background of Study

Waste is any substance which is discarded after primary use, or is worthless, defective and of no use. Waste generation has been an issue for communities since the beginning of civilization. Waste is generated due to goods and service production and the utilization of natural resources. There are many barriers to the proper management of waste. In Nigeria, irregular increases in population, industrialization and changes in consumption patterns have complicated solid waste management (Uzoigwe and Agwa, 2012). The impact of poor waste management on soil properties and human well-being cannot be overemphasized. Individuals living around the dumpsites are at high risk due to the potential of waste to pollute the water, food, soil, vegetation and air around them (Uzoigwe and Agwa, 2012; Essien and Hanson, 2013).

Municipal solid wastes (MSW) are undesirable materials mainly consisting of household wastes and are also called household garbage (Essien and Hanson 2013). They also include similar waste to MSW such as wastes from industrial companies, crafts, trades, hotels, schools, public services, hospitals and municipal services such as; road wastes, parks and gardens' maintenance, and from other recreational facilities (Abur *et al.*, 2014). Majority of the wastes generated from these sources ends up in the dumpsites. Across many cities in Nigeria, wastes are usually burnt outdoors and ashes are poorly disposed (Adamu *et al.,* 2014). This act destroys the organic components of the environment and invariably affect the various properties of the soil (Njoroge, 2007). The incidence of poor waste handling that has infringed on vital environmental components includes but not limited to soil, water and air quality (Adamu *et al.,* 2014). Also, the magnitude of commercialization, industrialization and population expansion of most cities (including Uyo) has also had its added adverse effects on the volume of waste released to the environment (Essien and Hanson, 2013). The problems posed by improper and ineffective management of Municipal Solid wastes (MSW) has become an issue of global concern over the past decades (Adamu *et al.,* 2014; Angaye *et al.,* 2015). The magnitude of waste stream has acquired some abrupt dimensions, with corresponding ineffective and inadequate management strategies, including; insufficient funding on the part of Government (Doan, 1998; Schwarz-Herion, 2008; Amuda *et al.,* 2014, Hossain *et al.,* 2014; Angaye *et al.,* 2015). In most developing countries, anthropogenic activities associated with the precarious disposal of municipal waste poses more grave consequences to the ecosystem (including; the soil physio-chemical properties) and threat to public health (Adamu *et al.,* 2014). The movement of contaminants from dump sites where wastes are disposed to surrounding ecosystems is complex and involves physio-chemical processes (Adeyi *et al.*, 2014). Open dumpsites could be a source of microbial and toxic chemical pollution of the soils of the dumpsites (Abur *et al.,* 2014). This can also pollute hand dug wells, posing serious health risks and leading to the destruction of biodiversity in the environment (Mpofu *et al.,* 2013). The composition of the wastes influences the concentration of the leachates constituents which may be adsorbed in to the soil during this diffusion thereby altering the initial properties of the soil and it outcome is hazardous to both plant and animals (0gbeibu *et al.,* 2013). This process facilitates soil and water pollution, offensive odors, which increases with an increase in ambient temperature levels (Shaikh *et al.,* 2012). Toxic or contaminable leachates from dumpsites could be transformed physically or chemically and transported via the air, or through runoffs which can contaminate either the soil surface or/and groundwater (Kola-Olusanya, 2012). Also, toxic fumes and greenhouse gases are also being produced by uncontrolled in-situ burning, which could have acute or chronic environmental health and consequences (Adekunle *et al.,* 2011; Ayuba *et al.,* 2013; Okeke, 2014). The management strategies of municipal solid wastes varies per country but not limited to landfill system, incineration and recycling. Underdeveloped nations like Nigeria, Ghana and India uses the landfill system, while developed nations like; the United States, Japan and Australia mostly uses the recycling method (Onwughara *et al.*, 2010). Although in Nigeria waste recycling has been encouraged by all stakeholders, unfortunately it is yet to attain full recognition due to slow implementation of policies regarding the environment and insufficient funding by the government (Momodu *et al.*, 2011). As such the commonest method of disposal in Nigeria still remains open dump landfill system and in-situ incineration, which are very prone to environmental pollution affecting the soil physico-chemical properties as observed around Uyo Village Road dumpsite.

1.2 Problem Statement and Justification

Solid waste pose a threat in Uyo municipality and are attributed to the hazards faced by the households living near the dumpsite. There is no sewage existing in Uyo Village Road. Safe and acceptable solid waste management practices are of serious concern from the environmental point of view. The concern comes from both poor policies and solutions proposed by all associated authorities of the government for the management of solid waste and a perception that many solid waste management facilities use poor operating procedures. Lack of support from the authorities such as the Local Government Authority, Uyo Capital City Development Authority, Akwa lbom State Ministry of Environment and Mineral Resources and other stakeholders in the environmental sector has led to negative impacts on the environment. There is paucity of information on the effect of solid waste dumping on the soil physical and chemical properties of the Uyo Village Road, which is prone to affect both surface and sub-surface soil and underground water of the surrounding; hence this is the purpose of this study.

1.3 Objectives of the Study

i. To determine the effect of solid waste dumping on the chemical properties of the soil around Uyo village road dumpsite.

ii. To determine the effect of solid waste dumping on the physical properties of the soil around Uyo village road dumpsite.

CHAPTER TWO

LITERATURE REVIEW

2.1 Municipal Waste

Municipal solid waste normally termed as ‘‘garbage’’ or ‘‘trash’’ is an inevitable by-product of human activity. Solid waste are majorly waste that are on solid form and disposed in the dumpsite after it initial or primary use and these ranges from bottles, glass ware, plastic, agricultural waste and so on. Population growth and economic development lead to enormous amounts of solid waste generation by the dwellers especially in the urban areas (Karishnamurti and Naidu, 2003). Thousands tons of solid waste are generated daily in African countries (Asuma, 2013). In Nigeria, less than half of the solid waste produced is collected and 95 percent of that amount is either indiscriminately thrown away at various dumping sites on the periphery of urban centers or at a number of so-called temporary sites or typically scattered throughout the city highways (Abiye and Haile, 2012). Present day waste disposal is far more advanced than the indiscriminate dumping that occurred in the past, employing modern techniques to better manage a wide range of anthropogenic wastes (Asuma, 2013). Open and unscientific dumping of municipal solid waste is one of the most common methods adopted since years in almost all the cities. One of the main objectives in the design of a landfill site should be the proper management of polluted water and leachate migration, therefore mitigating the risk of health and environmental damage (Taylor and Allen, 2006). Dumpsites are considered a major threat to groundwater resources, either through waste materials coming into contact with groundwater underflow, or through infiltration from precipitation (Taylor and Allen, 2006). The dumpsites solid waste often releases interstitial water and by-products that contaminate the water moving through the deposit, as well as liquids containing several different organic and inorganic compounds that sit at the bottom of the deposit and seep into the soil, affecting its physical and chemical properties (Al-Yaqout and Hamoda, 2003).

2.2 Anthropogenic Sources of Solid Wastes

Anthropogenic source of wastes implies the man-made origination of waste in the environment (Asuma, 2013). The sources of waste in the environment is inexhaustible but not limited to domestic and industrial sources. These include such wastes from; industrial companies, crafts, trades, hotels, schools, public services, hospitals and municipal services such as; road wastes, parks and gardens' maintenance, and from other recreational centers (Adekunle *et al.,* 2011; Ayuba *et al.,* 2013; Abur *et al.,* 2014). In Nigeria, municipal waste density ranges from 280 - 370 kg/m, while the rate of daily waste generation is about 0.44 - 0.66 kg/capital/day with an annual generation of 25 million tons

(Ogwueleka, 2009). Urban municipal solid waste is usually generated from human settlements, small industries and commercial activities (Singh *et al.,* 2011). These solid waste ranges from bottles, glassware, plastics and other wastes in solid form which are discarded after it primary use (Abur *et al.,* 2014).

2.3 General Impact of Waste on the Environment

The environment is the immediate surrounding around us (Adekunle *et al.,* 2011). Indiscriminate and inappropriate management of waste have adverse impact in the environment and the inhabitant of the area (Ayuba *et al.,* 2013). Excluding the alteration of soil physical (texture, porosity) and chemical (pH, cation exchange capacity, organic carbon content) properties; solid wastes also have some detrimental impact in the environment from economical to health impact (Ogwueleka, 2009; Njoroge, 2007). Economically, waste impede the efficient utilization of land for production activities (Edem, 2007). Wastes equally alter the aesthetic of an environment, making such an environment less attractive for investment purpose (Essien and Hanson, 2013). Wastes also causes health threat by polluting water bodies both surface and underground water which can invariably upset severe illness to the inhabitant of the environment (Sharma and Shah, 2005). The available scientific evidence on the waste-related health effects is not conclusive, but suggests the possible occurrence of serious adverse effects, including; mortality, cancer, reproductive health, and milder effects affecting well-being (Sharma and Shah, 2005). Some solid waste (especially from agricultural sources) will eventually rot, but not all, and in the process it may smell, or generate methane gas, which is explosive and contributes to the greenhouse effect (Karak *et al.*, 2012). Leachate produced as waste decomposes may cause pollution. Burning medical waste releases many hazardous gases and compounds, including; hydrochloric acid, dioxins and furans, as well as the toxic metals lead, cadmium, and mercury (Karak *et al.*, 2012). It also releases large amounts of carbon dioxide, worsening climate change and global warming in the environment (Hazra and Goel, 2009; Essien and Hanson, 2013).

2.4 Soil Chemical Properties

Soil is a complex mixture of organic and mineral components (Hazra and Goel, 2009; Balasubramanian, 2017). Soil chemical properties indicate biogeochemical processes in soils and their influence on the bioavailability, mobility, distribution, and chemical forms of both plant essential elements and contaminants in the terrestrial environment (Balasubramanian, 2017). Soil chemical properties include; soil pH, electrical conductivity, total organic carbon, cation exchange capacity and heavy metals concentration.

2.4.1 Soil pH

Soil pH measures the concentration of hydrogen ion (H^+) in the soil and it measures the degree of soil acidity and alkalinity which affects the performance of crops and activities of micro-organisms (Francis and Benjamin, 2020; Essien and Hanson, 2013). A high amount of H^+ corresponds to a low pH value (acidity) and a low amount of H^+ indicate a high pH (alkalinity). The pH scale ranges from 0 to 14; with 7 being neutral, below 7 acidic, and above 7 alkaline (basic). Some elements such as; calcium, nitrogen and other liming materials can increase soil pH (Francis and Benjamin, 2020; Essien and Hanson, 2013). High soil pH level can also be attributed to salt accumulation in the soil (Essien and Hanson, 2013). Furthermore, the slight acidity in soil pH may be due to the presence of basic cations caused by erosion and leaching. This is because basic cations increase as pH and CEC increase, and vice versa.

2.4.2 Electrical conductivity

Electrical conductivity is the potential of the soil to conduct electricity. This chemical property is anchored in a lot of determinant (Essien and Hanson, 2013). A high electricity conductivity in a soil may be attributed to the salinity content accumulated in the soil and it can also due to the present of ions (Suresh, 2008, Essien and Hanson, 2013; Agunwam, 2010)

2.4.3 Cation Exchange Capacity and Effective Cation Exchange Capacity

Cation exchange capacity is the sum total of the acidic and basic cation present in the soil solution. The number of exchangeable cations per unit mass of dry soil which perform a major function in soil fertility is known as cation exchange capacity (Ruth *et al.*, 2011). Effective cation exchange capacity (ECEC) is the total amount of exchangeable cations in non-acidic soils and bases plus aluminum in acidic soils (Karak *et al.*, 2012). It means the total number of exchangeable basic cations, such as: Calcium (Ca), Sodium (Na), Magnesium (Mg) and Potassium (K) ions; they rely on the competence of absorption of heavy metals (Ruth *et al.*, 2011; Ogala *et al.*, 2019). It depends on the summation of properties of soil and a particular properties of soil elements like pH, clay and organic matter contents of soil (Ogala *et al.*, 2019).

2.4.4 Total Organic Carbon and Organic Matter

Organic carbon reflects organic matter (the decomposed carbon in a material. Generally, most of the agricultural waste disposed is usually organic in nature, therefore high Total carbon content of the soil is usually expected in disposed areas than in other areas (Edem, 2007).

2.5 Soil Physical Properties

Soil physical properties include; soil color, texture, structure, porosity and density, consistence. Colors of soils vary widely and indicate such important properties as organic matter, water and redox conditions. Soil texture, structure, porosity, density and consistence are related with types of soil particles and their arrangement (Isirimah, 2000; Edem, 2007). There are two types of soil particle: primary and secondary soil particles (Edem, 2007). Soil comprised of minerals, soil organic matter, water, and air. The composition and proportion of these components greatly influence soil physical properties, including; texture, structure, and porosity, the fraction of pore space in a soil (Isirimah, 2000; Edem, 2007). In turn, these properties affect air and water movement in the soil, and thus the soil's ability to function (Edem, 2007).

2.5.1 Soil Texture

Soil texture can have a profound effect on many other properties and is considered among the most important physical properties (Tripathi and Misra, 2010). Texture is the proportion of three mineral particles; sand, silt and clay, in a soil (Agunwam, 2010). These particles are distinguished by size, and make up the fine mineral fraction. Particles over 2 mm in diameter (the 'coarse mineral fraction') are not considered in texture, though in certain cases they may affect water retention and other properties. The relative amount of various particle sizes in a soil defines its texture, i.e., whether it is a clay, loam, sandy loam or other textural category (Isirimah, 2000).

2.5.2 Soil Structure

Soil structure is the arrangement and binding together of soil particles into larger clusters, called aggregates or ‘peds’ (Isirimah, 2000). Aggregation is important for increasing stability against erosion, for maintaining porosity and soil water movement, and for improving fertility and carbon sequestration in the soil (Nichols *et al.*, 2004). ‘Granular’ structure consists of loosely packed spheroidal peds that are glued together mostly by organic substances (Isirimah, 2000).

Soil texture and structure influence porosity by determining the size, number and interconnection of pores (Agunwam, 2010). Coarse-textured soils have many large (macro) pores because of the loose arrangement of larger particles with one another. Fine-textured soils are more tightly arranged and have more small (micro) pores. Unlike texture, porosity and structure are not constant and can be altered by management, water and chemical processes (Edem, 2007).

CHAPTER THREE

MATERIALS AND METHODS

3.1 Study Area

This study was conducted in Uyo Village road dumpsite located in Uyo Capital City, Akwa Ibom State which lies between latitudes 4°58'N and 5°04'N and longitudes 7°51'E and 8°01'E. It is bounded in the north by Ikono, Itu and Ibiono Ibom Local Government Area (Figure 1). In the East, it shares boundary with Uruan Local Government Area in the west we have Abak LGA while in the south it is bounded by Ibesikpo Asutan and Nsit Ibom Local Government Areas as shown in figure 1. The city covers an area of about 214.31 square kilometers. It can be accessed by road via Abak road, Nwaniba road, Uyo-Itu/Calabar road and Aka-Nung Udoe road, Ikot Ekpene road and Oron road.

The vegetation is rain forest and it is within the humid tropical region with a mean annual rainfall ranging from 2500-3000 mm. temperature of 24^{o}c and a relative humidity ranging from 75%-79%. Soils in this region are acidic (Udoh, 2008).

The municipal dumpsite is located at the Uyo village road. It is an open dump sited in an upland area, with the waste transect located low land of the dumpsite. Its topography is basically plane except a few sloppy terrain which ends in a ravine. The area lacks functional drainage system and it is always flooded each time it rains heavily. Due to poor disposal of municipal wastes, the area is faced with the problem of indiscriminate dumping of wastes on streets and roads causing serious environmental pollution and invariably affecting the soil chemical and physical properties.

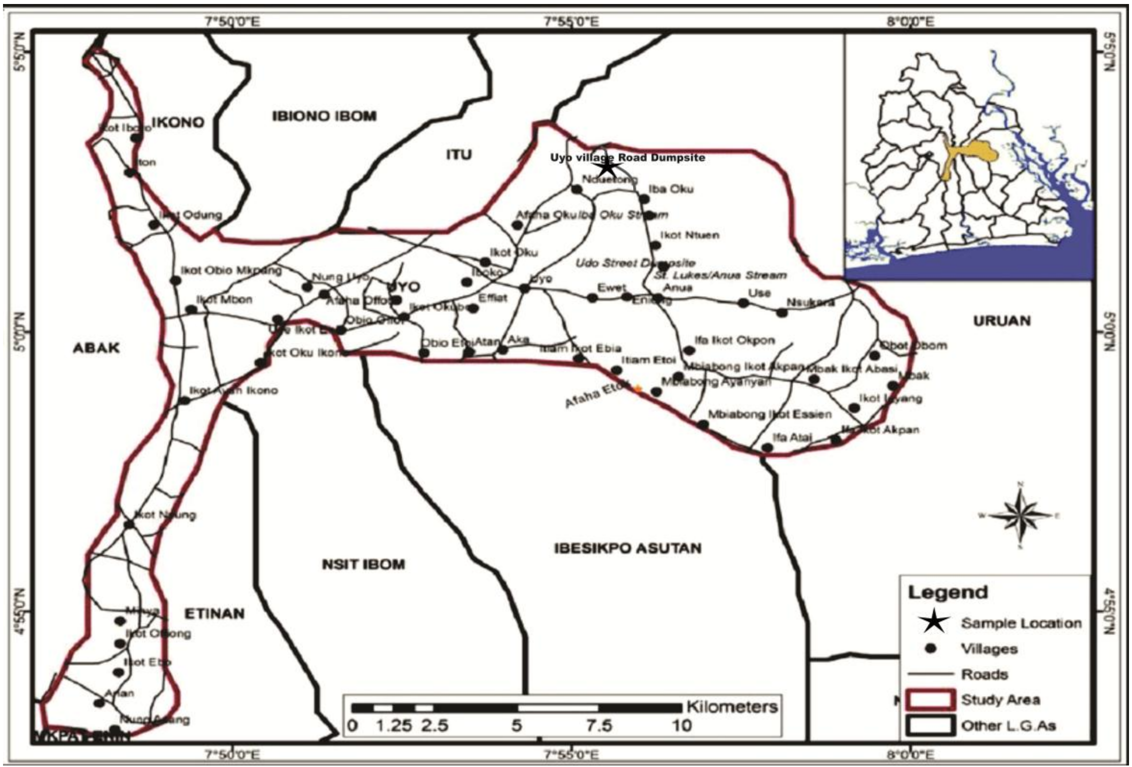

Figure 1; Geology of the Study Area

3.2 Sampling and Samples treatment

The soil samples were randomly collected from the Uyo village road dumpsite at a depth of 0-10, 10-20, 20-30cm. The collected dumpsite samples were stored in 500ml polyethylene bag which was used for soil chemical and physical properties analysis. Other samples were collected from the surrounding soil about 300 meters away from the dumpsite to serve as control samples at a depth of 0-30cm. The soil samples were placed inside polyethylene bags and covered with aluminum foil and transported in a cool box and stored under suitable temperature until analysis. The pretreatment of the soil specimen in the dumpsite which involve removal of metals and solid waste.

3.3 Laboratory Analysis

3.3.1 Particle size analysis

Particle size analysis was determined using the Bouyoucos (1951) hydrometer method as described by Udo *et al.,* (2009). After dispersing the soil particles with sodium-hexametaphosphate solution, the textural class of the soil was determined using textural triangle.

3.4 Chemical analysis

3.4.1 Soil pH

Soil pH was determined in water and in KCl using 1:2.5 soils to water suspension and the pH value was read using a glass electrode pH meter.

3.4.2 Electrical conductivity

Electrical conductivity was determined using a conductivity bridge as described by Udo *et al.,* (2009).

3.4.3 Organic carbon

Organic carbon was measured by the dichromate wet oxidation method of Walkey and Black (Nelson and Sommer, 1996).

3.4.4 Total Nitrogen

Total nitrogen was done by the kjedahl digestion and distillation method as described by Udo *et al., (*2009).

3.4.5 Available phosphorus

Available phosphorus was determined by the Bray P1 method. The phosphorus in the extract was measure by the blue method of Murphy and Riley (1962).

3.4.6 Exchangeable bases

Exchangeable bases (Ca, Mg, Na and K) was extracted using normal ammonium acetate (IN NH_4OAC) solution (Thomas, 1982). The exchangeable K and Na was obtained by flame photometer using atomic absorption spectrophotometer (Jackson, 1970).

3.4.7 Effective Cation Exchange Capacity (ECEC)

ECEC was obtained by summation method, i.e., the sum of the exchangeable bases and exchangeable acidity (IITA, 1979. Anderson and Ingram, 1993). Base saturation was calculated as follows;

$$\%BS = \frac{TEB}{ECEC \text{ X } 100}$$

Where;

TEB = Total exchangeable bases

BS = Base saturation

ECEC = Effective Cation Exchange Capacity

Each analysis was done in duplicate, and the average of results was taken. The result of the study was interpreted using the interpretation guide for evaluating soil chemical properties as adapted from Iren and Ediene (2017).

3.5 Data Analysis

The data obtained were analyzed using the SPSS statistical software 21 and the result was expressed as mean$\pm$standard error. As descriptive statistics; mean, standard deviation, standard error and coefficient of variance were employed to evaluate the data.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Results and Discussion

The physico-chemical characteristics of the investigated soils are discussed under the following headings;

- Soil pH
- Electrical conductivity (EC)
- Organic carbon content and organic matter
- Total nitrogen
- Available Phosphorus
- Exchange Acidity
- Exchangeable bases and percentage base saturation
- Available phosphorus
- Particle size distribution

4.2. Soil pH

The soils are generally acidic with mean pH value of 6.8$\pm$0.11 and the soil pH values for 0-10cm, 10-20cm, 20-30cm and control were 7.0 (P1), 6.7 (P2), 6.6 (P3) and 7.0 (control) respectively as shown in Table 1. The soils in the dumpsite are described as slightly acidic because of the low pH value and these low values may induce (EA) toxicity in the soils. The control soil is neutral with a pH of 7.0. These soils will require a remedial measure, for example; application of gypsum, organic fertilizers for commercial production of most crops, to be undertaken. These soils are called loamy sandy or acid sandy which have low activity sandy (LAS) soils. In a study conducted by Hanson and Essien (2013) indicated that values of pH in waste dumpsite site ranged from 7.13 – 7.92, which was higher than the surrounding soils indicating non-alkaline soil as a result of excessive rainfall-runoff saturation of soil resulting reducing clay content. The high pH (alkalinity) is attributed to the organic matter accumulated in the soils. This means that organic solid waste accumulation could significantly reduce soil acidity due to increased salinity of the soil as a result of accumulated municipal solid waste (Isirimah, 2000). The level of the salinity and pH however depends on the chemical composition of the solid waste (Tripathi and Misra, 2010; Isirimah, 2000).

4.3 Electrical Conductivity (EC)

Electrical conductivity (EC) is the evaluation of salinity, soil texture and cation exchange capacity (CEC) in soil (Ogala *et al.*, 2019). The mean value of electrical conductivity was 0.27±0.07ds/m. The electrical conductivity (EC) of the dumpsite was 0.14, 0.44 and 0.34ds/m for the 0-10cm, 10-20cm and 20-30cm depth as shown in Table 1 and figure 2. The controlled site had an electrical conductivity value of 0.15ds/m as shown in Table 1. The high electricity conductivity of the dumpsite may be attributed to the salinity content of the accumulated waste with which leachate infiltrated the in-situ soil causing increase in salt content in the waste dumpsite soil (Suresh, 2008, Essien and Hanson, 2013). Essien and Hanson (2013) in their study also noted that the values of electrical conductivity in a waste dumpsite soil ranged from 0.15 – 0.80 dS/m which is in contrast to that of the surrounding soil (0.03 – 0.06 dS/m), which indicates significant higher electricity conductivity at the dumpsite soil than the surrounding soil. Agunwam (2010) in his study in a dumpsite in Enugu state also observed that soil under accumulated municipal waste dumpsite was characterized with high electrical conductivity value, he also attributed this to increased salt content in the soil. The results also revealed that the effect of high electrical conductivity in the study dumpsite was due to the presence of ions in soil and in wet filled pore soil which improves soil electrical conductivity. In other words, it shows that the circulation of charged particles in soils around dumpsite is higher than the values in the control site

Table 1: Soil pH, Electrical conductivity, Organic Matter, Organic Carbon, Total Nitrogen and Available Phosphorus.

S/N	Sample ID	Depth (cm)	pH	Electrical conductivity (ds/m)	Organic carbon (%)	Organic matter (%)	Total Nitrogen (%)	Available phosphorus (mg/kg)
	Site Soil sample							
1	P1	0-10	7.0	0.14	1.16	2.00	0.05	38.686
2	P2	10-20	6.7	0.44	2.00	3.45	0.09	32.683
3	P3	20-30	6.6	0.34	1.18	2.04	0.05	32.016
	Surrounding soil sample							
4	Control	0-30	7.0	0.15	0.40	0.69	0.02	12.01
5	**Mean**		6.8	0.27	1.19	2.05	0.05	28.85
6	**S.D.**		0.21	0.14	0.66	1.13	0.03	11.60
7	**C.V**		0.03	0.52	0.55	0.55	0.60	0.40
8	**S.E**		0.11	0.07	0.33	0.57	0.01	5.80

***S.D-Standard Deviation *C.V.-Coefficient of Variance *S.E-Standard Error**

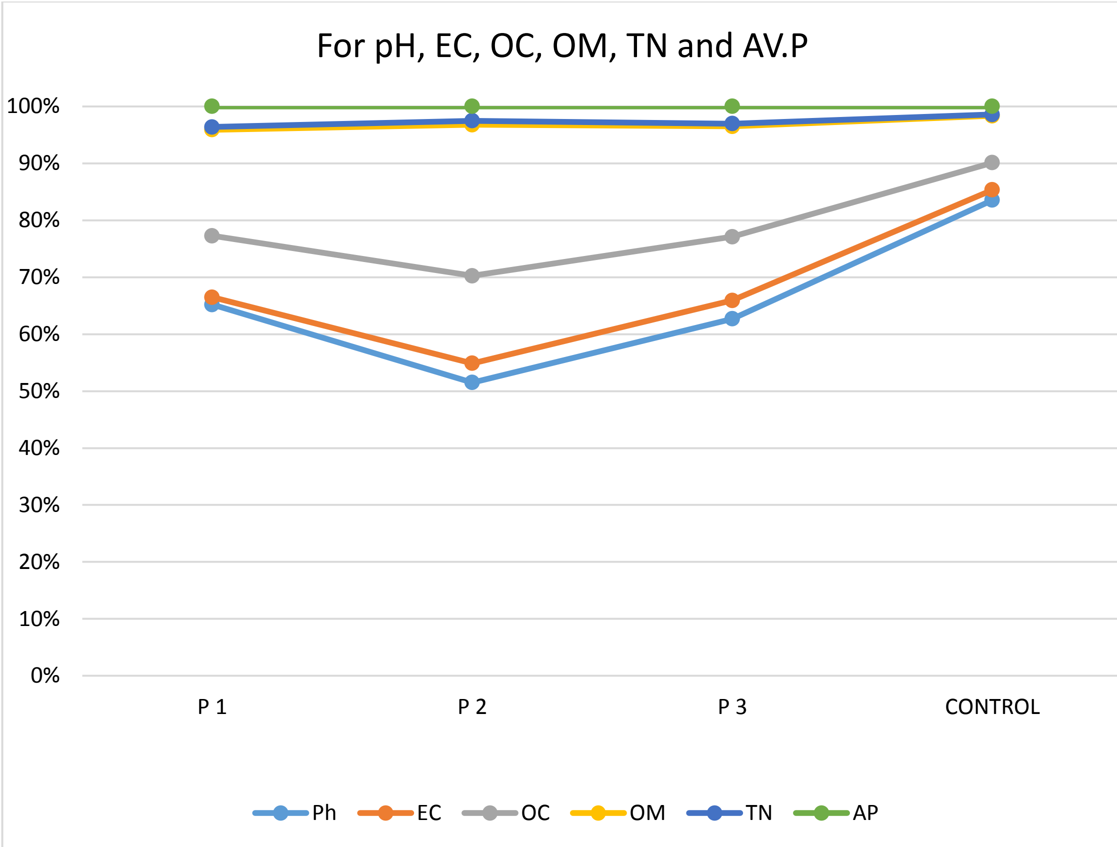

Figure 2; Soil pH, Electrical conductivity, Organic Matter, Organic Carbon, Total Nitrogen and Available Phosphorus Distribution in the study area.

4.4 Organic Carbon (OC) and Organic matter (OM)

The availability of organic carbon (OC) in soils has resulted in rise in the cation exchange capacity (CEC) which helps in the accumulation of nutrients taken in by plants (Ruth *et al.*, 2011). Organic carbon is the preserved carbon in organic matter (Ogala *et al.*, 2019). The organic carbon content varied widely within the soil depth with values of 1.16, 2.00, 1.18 for the dumpsite soils with a mean value of 1.19$\pm$0.33% and 0.40% for the control site as shown in Table 1 and figure 3, while values 2.00, 3.45, 2.04% were obtained in the dumpsite and 0.69% for the control soil as shown in figure 3, for organic matter with mean value of 2.05$\pm$0.57. Although all the soils had almost over 2.0% of organic matter at the surface and sub-surface soils. This indicates that the soil at the dumpsite are relatively high in the organic matter content and relatively low content in the control sample i.e., 0.69. The presence of low organic carbon in the studied dumpsite was attributed to high amount of sand fraction obtained from particle size distribution due to the non-degradation of compostable or solid waste found around dumpsites (Ruth *et al.*, 2011; Ogala *et al.*, 2019). This results corresponds with the observation of Anake *et al.*, (2009) and Ogala *et al.*, (2019) on municipal solid wastes dumpsite soils in Benin and municipal solid waste dumpsites in Kano and Kaduna, all in Nigeria. Organic matter (OM) improves the importance of soils for agricultural use. This result also corresponds with Oyedele *et al.*, (2008), which stated that the Organic matter is higher in dumpsite in comparison to control site, same with the study carried out by Amos–Tautua *et al.*, (2014) on municipal open waste dumpsite in Yenagoa, Nigeria. An increase in Organic matter (>2.0%) in soils is favorable for heavy metal chelation formation (Ayolaghaand and Onwugbata, 2001).

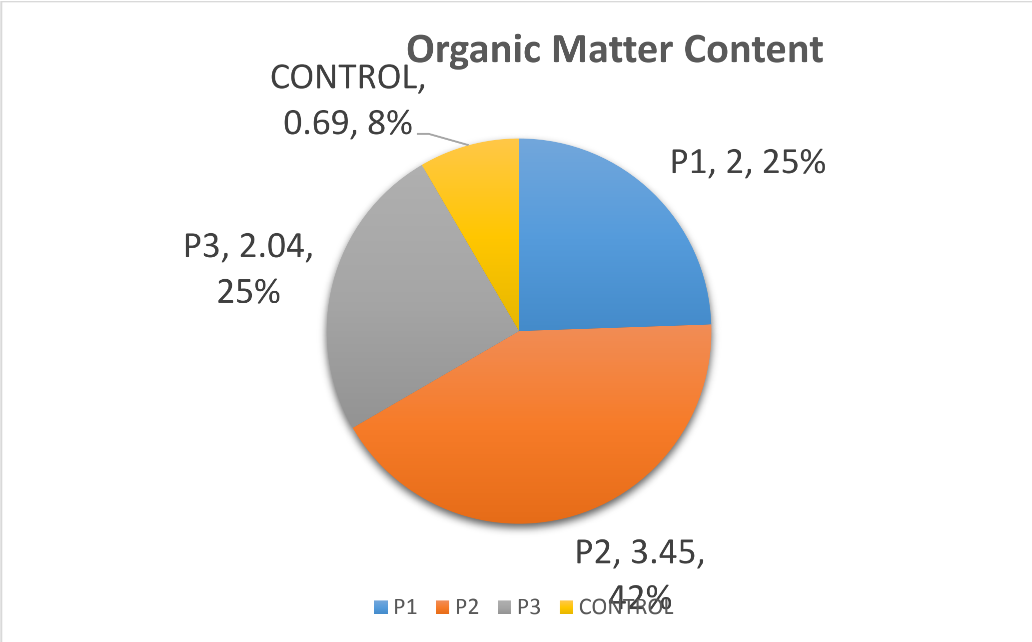

Figure 3; Pie chart illustrating the percentage organic matter content in the study area

4.5. Total Nitrogen (TN)

Total nitrogen values were very low in all the soils with a mean value of 0.05±0.01% as the individual sample values ranges from 0.02%, 0.05%, 0.05% (for dumpsite soils) and 0.09% (for the control soil) as shown in Table 1. The low value and low degradation of organic matter content in the studied dumpsite was due to decreased value of organic nitrogen content to a crucial stage of 1.0 to 2.0 g/kg (Ruth *et al.,* 2011). This result was in accordance with Eyankware *et al.,* (2015) as well as Oyedele *et al.,* (2008). Thus, since the value for studied dumpsite is greater than that of the controlled site, the waste dump is a major contributor to the low levels of these soil properties. These low levels of nitrogen will require application of nitrogen fertilizer along with organic waste if any commercial crop production is to be undertaken. Lack of adequate soil test and poor knowledge of the soils had limited effects of fertilizer nitrogen application. This low level of nitrogen is the most limiting element in arable crop production in these soils (Obigbesan *et al.,* 1981; Anake *et al.,* 2009).

4.6. Available Phosphorus

The Bray P-1 extractable phosphate values varies widely in the soil and ranges from 32.016 to 38.686 mg/kg for the dumpsite soil samples and 12.006 mg/kg for the control sample with a mean value of 28.85$\pm$5.80mg/kg as shown in Table 1. The values of available phosphorus in the studied dumpsite was higher than the control site. This low presence of Phosphorus value in some of the sampled soil around the dumpsite was due to higher content of non-biodegradable waste caused by microorganisms, non-degradation of organic matter (OM) and degradation of agricultural materials in both dumpsite and the controlled site (Ideriah *et al.,* 2006). This results corresponds with the results of Ruth *et al*., (2011); Ukpong *et al.,* (2013); All sampled soils have phosphorus value greater than 10 mg/kg. Therefore, the low Phosphorus value was also attributed to other soil parameters such as: low percentage of clay and sand fractions and low pH which reduces the binding sites of metals and also high leaching rate from sandy soils (Sandeep, 2019). According to FAO (1976) soil fertility evaluation rating, the soils are moderately suitable for crop production. These soils will require little additional application of phosphate fertilizer for optimum crop yield. However, liming this soil will make available large quantity of phosphorus to plant. Effiong and Akpabio (2000) had a direct correlation between the quantity of lime applied and yield of Okra and maize resulting from increased availability of phosphorus for plant intake.

4.7. Exchange Acidity (EA)

This is the concentration of acidic cation (H^+ and Al^{3+}) present in soil solution. Comparatively, they are used as anion balance for cations. The exchange acidity in the surface, sub-surface and control soil had a mean value of 0.68 ± 0.03cmol/kg were; 0.68, 0.60, 0.72cmol/kg is the value of EA for the dumpsite soil samples and 0.72 cmol/kg for the control soil sample respectively as shown in Table 2 and figure 4. This result corresponds with Essien and Hanson (2013). The high effect on the basic cations (Mg^{2+}, Ca^{2+}, K^+ and Na^+) by high torrential rainfall of the equatorial region, including this dumpsite, affected the Ca (Essien and Hanson, 2013). The rain water washed the basic cation on a normal soil (control soil) coupled with farming activities; hence, the higher concentration of Exchange Acidity (EA) (Al^{3+} and H^+) in control soil and sample P3 than in the other dumpsite soil (Essien and Hanson, 2013). This may be the reason concerning coastal plain soil in Akwa Ibom State and South Eastern Nigeria (this dumpsite inclusive) were observed to be low in fertility due to leaching of the basic cation in soil solution by rain and runoff infiltration, which also resulted in high concentration of acidic ions in the soil solution

(Edem, 2007). Hence, waste dumpsites had less concentration of acidic ions than normal soil.

4.8. Exchangeable Bases and Percentages Base Saturation

Exchangeable cation values are medium in the soils. This according to Enwezor (1990) may probably be due to kaolinitic nature of parent materials. It may also have resulted from the acidity content of the soil which causes leaching of base ions. The mean values for the exchangeable bases of these ions available in the soils is in the order; Ca^{2+} (4.80$\pm$0.94 cmol/kg)>K^{+} (3.37$\pm$0.90 cmol/kg) >Mg^{2+} (0.05$\pm$0.01cmol/kg)>Na^{2+} (0.02$\pm$0.03cmol/kg) with a mean ECEC value of 8.91+1.81 cmol/kg. The values for the exchangeable bases in the soils were respectively; 4.80, 6.00. 6.24 (dumpsite soils) and 2.16 cmol/kg (control soil) for Ca^{2+}; 2.99, 4.76, 4.74 (dumpsite soils) and 0.98 cmol/kg (control soil) for K^{+}; 0.050, 0.056, 0.021(dumpsite soils) and 0.054 cmol/kg (control soil) for $mg^{2+,}$ 0.024, 0.025, 0.020 (dumpsite soils) and 0.006 cmol/kg (control soil) for Na^{2+} (as shown in Table 2 and figure 4). The effective cation exchange capacity (ECEC) obtained by the summation of basic cations and exchangeable acidity of the soil is high and ranges from 11.74 to 8.54 cmol/kg and 3.92 which is low for the control sample respectively. The normal or medium will not affect percentage base saturation which is generally above 60% except in the control sample where the value is 81.63%. The soil has a wide range of percent base saturation ranging from 92.041 to 94.755 for the main sample and 81.63 for control respectively. The medium base saturation percentage in the soil in this case is described as fertile soil and not as drastic or potentially less fertile soil (Landon, 1984). Essien and Hanson (2013) studies in a dumpsite indicated that there is a higher Cation exchange capacity in waste dumpsites attributed to high basic cation content. This implies that the fertility status of waste dumpsite soil may be better than that of surrounding soil.

Table 2: Ca, Na, Mg, K ions concentrations; Exchange Acidity (EA), Effective Cation Exchange Capacity (ECEC) and Base Saturation (BS) as influenced by solid waste dump

S/N	Sample ID Site Sample	Depth (cm)	Na (cmol/kg)	Ca (cmol/kg)	Mg (cmol/kg)	K (cmol/kg)	EA (cmol/kg)	ECEC (cmol/kg)	Base Saturation (%)
1	P1	0-10	0.024	4.80	0.050	2.99	0.68	8.544	92.041
2	P2	10-20	0.025	6.00	0.056	4.76	0.60	11.44	94.755
3	P3	20-30	0.020	6.24	0.021	4.74	0.72	11.74	93.883
	Surrounding soil								
4	Control	0-30	0.006	2.16	0.054	0.98	0.72	3.92	81.63
5	**Mean**		0.02	4.80	0.05	3.37	0.68	8.91	90.6
6	**S. D.**		0.06	1.87	0.02	1.79	0.05	3.62	6.07
7	**C.V.**		3.00	0.39	0.40	0.53	0.07	0.41	0.07
8	**S.E.**		0.03	0.94	0.01	0.90	0.03	1.81	3.04

***S.D-Standard Deviation *C.V.-Coefficient of Variance *S.E-Standard Error *Na-Sodium *Ca-Calcuim *Mg-Magnesium *K-Potassium *EA-Exchange Acidity *ECEC-Effective Cation Exchange Capacity**

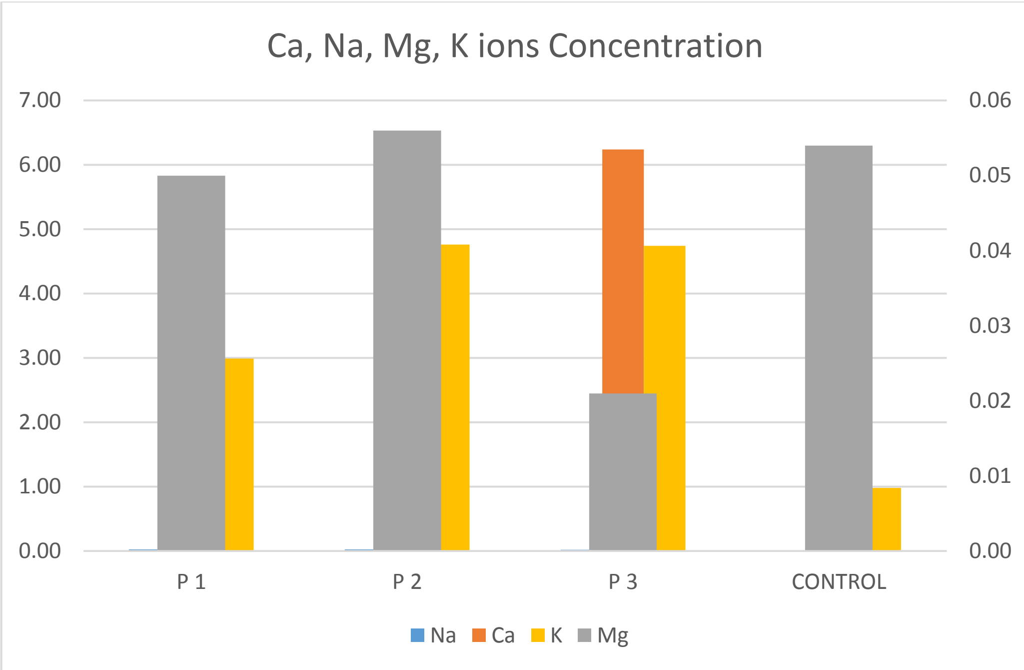

Figure 4: Bar Chart showing Ca, Na, Mg and K ions concentration in the Dumpsite Soil

4.9 Particle Size Distribution

The mean value for percentage sand, silt and clay was; 79.95$\pm$1.33%, 6.75$\pm$11.73% and 13.30$\pm$23.13% respectively. The results of the analyzed soil samples for particle size is as follows; sand; 80.90, 79.39, 82.84% (for the dumpsite soils) and 76.66% (for the control soil sample). Silt; 8.02, 5.77, 8.20% (for the dumpsite soils) and 5.02% (for the control soil sample) as shown in Table 3 and figure 5. The percentage clay; 11.08, 14.84, 8.96% (for the dumpsite soils) and 18.32% (for the control soil sample) respectively as shown in Table 3 and figure 5. Soil sampled result from dumpsite revealed that sand had a high percentage composition. This results corresponds with that of Ruth *et al.,* 2011 as well as Eyankware *et al.,* 2016. The soils are regarded as "loamy sandy". The higher increase in sand content in the studied dumpsite was due to the low contents of organic carbon (OC), organic matter (OM), cation exchange capacity (CEC) and nitrogenous component in soils around dumpsite. Additionally, an increase in sand fraction in the dumpsite causes leaching of high pollutant, because clay contents and organic matter in colloids are accountable for retaining metallic ions in soils (Eyankware *et al.,* 2016; Nyleand and Ray, 1999). This is because soils with excessive sand content with more than 75% have not too strong soil accumulation at the surface and thus liable to porosity, air circulation leaching and easily transportable (Gbadegesin and Abua, 2011; Eyankware *et al.,* 2016).

Table 3: Particle size Distribution of the Dumpsite soil.

S/N	Sample ID Site Soil	Depth (cm)	Sand (%)	Silt (%)	Clay (%)	TC
1	P1	0-10	80.90	8.02	11.08	Loamy sandy
2	P2	10-20	79.39	5.77	14.84	Loamy sandy
3	P3	20-30	82.84	82.00	8.94	Loamy sandy
	Surrounding Soil sample					
4	Control	0-30	76.66	5.02	18.32	Loamy sandy
5	**Mean**		79.95	6.75	13.30	
6	**S.D**		2.65	23.45	46.26	
7	**C.V**		0.03	3.47	3.48	
8	**S.E**		1.33	11.73	23.13	

***S.D-Standard Deviation *C.V.-Coefficient of Variance *S.E-Standard Error**

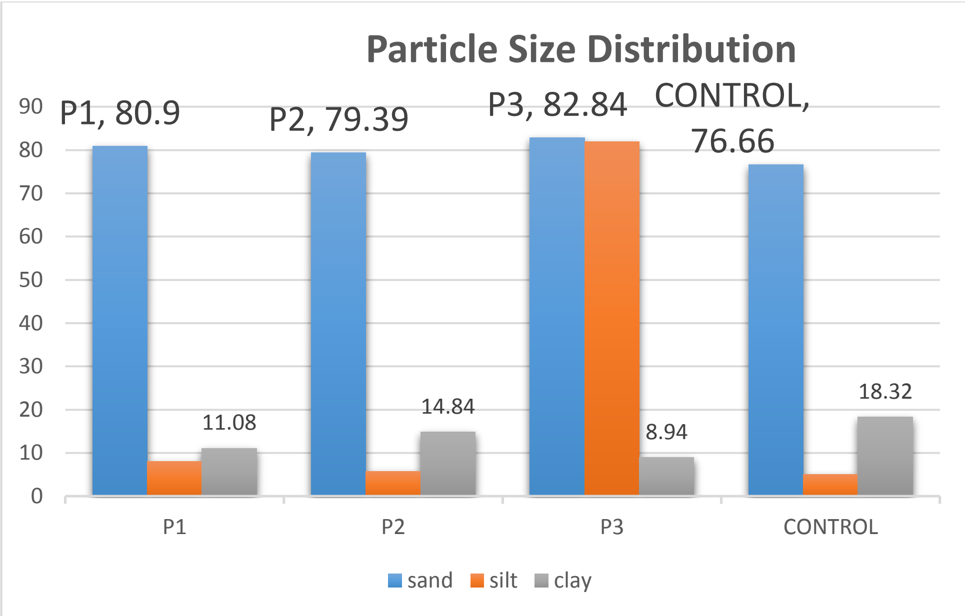

Figure 5: Bar chart illustrating sand, silt and clay fraction in the study area.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

The study of the soil chemical property of the dumpsite in Uyo village road have revealed that the soil pH is slightly acidic compared to the surrounding soil that is neutral. The study also revealed that the soil in the dumpsite was characterized with high electrical conductivity which is due to salt accumulation in the soil caused by leachate infiltration of the in-situ soil. Additionally, the study revealed that the soil in the dumpsite was characterized with high organic matter and low organic carbon content than surrounding soil. The high organic matter may be attributed to the organic nature of some solid agricultural waste present in the dumpsite. The low organic carbon content of the dumpsite could be anchored on the high content of sand fraction in the particle size distribution caused by non-biodegradable nature of solid wastes found in the dumpsite.

The study also revealed that the level of available phosphorus in the study was significantly high which could be attributed to the non-degradability of organic matter in the soil and the presence of non-biodegradable wastes.

The physical property of the soil is invariably dependent on soil chemical properties. Particle size distribution of the study area is attributed to organic matter and environmental factor (Rainfall – erosion and leaching).

5.2 RECOMMENDATION

From the results obtained from this study, it can be deducted that the discriminate disposal of industrial and domestic solid wastes have contributed to enhanced levels of physico-chemical property of the study area.

In view of the fact that soil chemical and physical properties is a major determinant of land utilization for agricultural purpose to ensure food sufficiency and productivity for a healthy population. As such, there is need to closely monitor the disposal of solid waste on dumpsites in the vicinity of Uyo village road to check and balance soil levels, preserve both the soil and the environment.

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