SOIL CHEMISTRY AT IHIAGWA WASTEDUMP, SOUTHEASTERN NIGERIA

Nwachukwu, P. C., Popoola, J. O. and Uja, E. U.
Institute of Erosion Studies, Federal University of Technology, Owerri, Nigeria.
Corresponding Author: john4dday@gmail.com, +2348039490509

ABSTRACT

An assessment of soil chemistry within Ihiagwa waste dump, southeast, Nigeria was carried out using standard methods. Five (5) soil samples were collected at specific depths. The results obtained from the physico-chemical analysis show that except for the heavy metals, other parameters fall below the Federal Ministry of Environment (FME) 2006 standards for soil. The mean concentrations for the major cations (Ca, Na, Mg and K) were 67, 81.8, 5.46 and 9.2 mg/kg respectively, while mean concentration values for the major anions (HCO_3, NO_3, SO_4 and Cl^-) were 5.46, 12.9, 10.76 and 118.22 mg/kg respectively. The mean concentrations of present heavy metals (Pb, Zn, Cd, Cu and Hg) were 0.74, 8.6, 0.63, 2.49 and 0.015 mg/kg respectively and thus, does not conform to FME (2006) standards. The pH of the soil varies from 5.5 to 6.0 with a mean value of 5.76 which is acidic and falls below FME (2006) standards. The heavy metals (Pb, Zn, Cd, Cu, Hg) found in soil sample in and around the dumpsite were traced from the poor management and dumping of electronic waste in the area and they are toxic and very harmful to plants, animal and man. They are carcinogenic, cause renal impairment, brain disorder and possibly death with certain level of exposure. Standard waste management practices such as establishment of sanitary landfill should be put in place to mitigate such environmental threats as seen in cause of this research and future ones.

Keywords: *Solid waste, dumpsite, physico-chemical, Ihiagwa, landfill.*

1.0 INTRODUCTION

The management of solid waste in an area is a universal concern for both the developed and developing world. An important reason for exercising care in the dumps relates to land use. Waste soil consists of waste material such as concrete debris, decayed wood, plastics and others. The heterogeneous content of waste soil makes the properties difficult to categorize and analyze. The generation of waste by various human activities and the way in which the waste is disposed off can pose a risk to public health. Several waste materials from different sources end up at the dumpsites and due to the heterogeneity and complexity of wastes, these dumpsites contain a variety of contaminants which pollute the soil.

Landfills are the major pollution causing source in urban environment (Buteh, et al., 2013). The leachate generated from the landfills and open dumps pollute the soil, ground water and creates great environmental and health risk (Adamu, et al., 2014). The health risks are also associated with physical disturbances of landfill, the generation of leachate and soil and the groundwater contamination.

Improper and indecent disposal of solid waste on soil leads to spread of some communicable diseases and spoils the biosphere (soil and water) as a whole.

As observed by Amadi, et al. (2015) in their work, the practice has become a threat to the environment. In developing cities of the world, population explosion and urbanization have made waste management problems more complex by increasing the quantities and types of solid wastes produced (Verge and Rowe, 2013). Soils may become contaminated by the accumulation of heavy metals and metalloids through emissions from the rapidly expanding industrial areas, mine tailings, disposal of high metal wastes, leaded gasoline and paints, land application of fertilizers, animal manures, sewage sludge, pesticides, wastewater irrigation, coal combustion residues, spillage of petrochemicals, and atmospheric deposition (Akinbile and Yusoff, 2012). Obianefo, et al. (2017) revealed that the soil in solid waste dump sites has been observed to be rich in soil nutrients. Also show that soil particle size distribution is not been remarkably altered by the effect of solid wastes. Although, may also be a source of contamination to the groundwater resources in areas of shallow aquifer depth.

It was reported by Abur et al. (2014) that due to the poor management of municipal solid waste management in developing nations like Nigeria, conservation of the ecosystem and other vital resources has become a major challenge.

Ethnically, the beauty of any environment lies on its good sanitary condition. This is so because when an environment is clean, the lives of the citizenry are not threatened by illnesses and diseases (Ayuba, et al., 2013). Proper refuse disposal involves the dumping of wastes (solid, liquid or gaseous) from our houses, industries and public outfits, for example, hotels, hospitals and schools etc. at a specific place or in government provided containers and the control and removal of refuse from places where they can cause hazards to a place where they are less hazardous to public health (Singh, et al., 2011).

Ihiagwa is a town situated in Owerri West Local Government Area of Imo state, Nigeria (Figure 1). It is located 12km south of the capital city of Owerri. It is located within the geographical coordinates 5^{0} 23.86$^{|}$ and 7^{0} 0.68$^{|}$.

The town presents a ghastly picture, the neglect of filled refuse bins in recent time has its effect on the inhabitants. Many areas around the homes are littered with domestic refuse sewage waste, garbage and other wastes from domestic activities which are characterized by the generation of large volume of wastes in the form of solids, liquids and gases. Some of these wastes are toxic with negative impacts on the environment, land/soil, water and air.

Indiscriminate refuse dumping affects quality of water, air and soil of which the people seem not to be aware of. Public Educational Programs that enlighten the public on the health implications of indiscriminate refuse dump are almost non-existent. Mass media seem not to be doing enough to create awareness about implications of indiscriminate refuse dumping. Therefore, the adverse effects are noticed especially in the soil chemistry. It is against this that this research was embarked on.

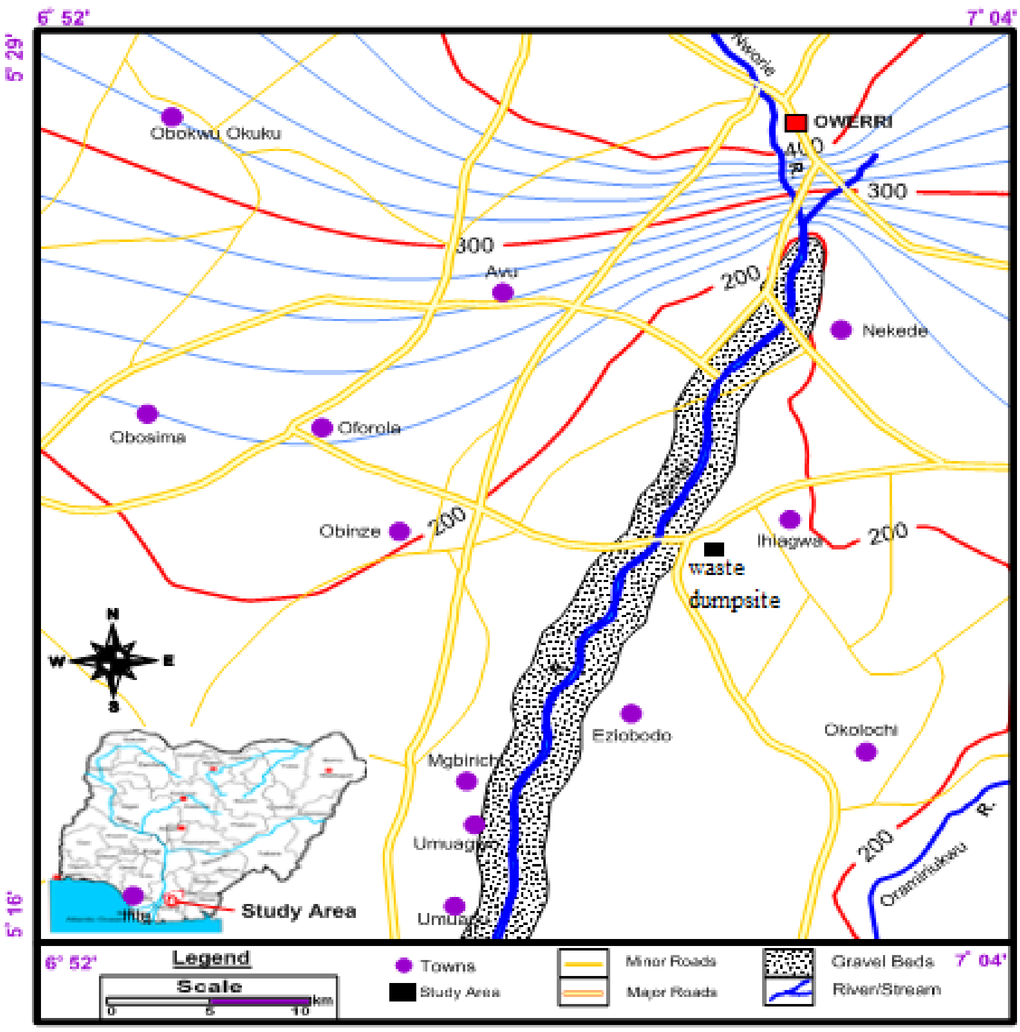

Figure 1: Topographical/location map of study area

In furtherance of the studies in this area of research, Babayemi and Dauda (2009) studied the Evaluation of Solid Waste Generation, Categories and Disposal Options in Developing Countries: A Case Study of Nigeria. They reported that the accumulation of heavy metals in agricultural sewage where irrigated soils has originated increased concern. Some of the heavy metals analysed with total concentration and chemical specification were Cd, Cr, Cu, Zn and Ni.

2.0 MATERIALS AND METHOD

Soil samples were collected from 5 different stations. For soil sample collection, clean new polyethene bags were used for collection. For ease of identification, the bags were labeled with names of the sampling stations and also the date of collection.

A total of five (5) samples were collected with the aid of a stainless hand auger for this study. These samples were collected at strategic points along the stretch of the dumpsite and at each point, GPS readings were taken. The table below summarizes this;

Table 1: GPS reading obtained from the different sampling points

S/N	Different points	Latitudes	Longitudes	Elevation(m)
1.	Point 1	N5^{0}23.295’	E6^{0}59.940’	56.6
2.	Point 2	N5^{0}23.293’	E6^{0}59.943’	57.9
3.	Point 3	N5^{0}23.290’	E6^{0}59.938’	57.9
4.	Point 4	N5^{0}23.290’	E6^{0}59.935’	59.7
5	Point 5	N5^{0}23.285’	E6^{0}59.930’	59.7

The sampling method used in collection of the samples from the dumpsite was targeted at some depth beneath the top soil. For this research, samples were collected from the main dump and at distances around the dumpsite. The soil sampling depth was about 17-20cm deep into the ground.

Different instruments were used in carrying out this study on the assessment of soil chemistry in the Ihiagwa dumpsite and they include; hand auger, GPS, sampling bags etc.

3.0 RESULTS AND DISCUSSION

The classification and result of soil analyses in comparison with the Federal Ministry of Environment (FME), 2006 standards are presented in Tables 2 and 3.

Table 2: Classification of wastes in the dumpsite

S/N	Type of Waste	Composition (%)
1.	Organics (Vegetable/Food)	47
2.	Plastics	6.00
3.	Electronic Waste (E-Waste)	10.00
4.	Textile	2.40
5.	Leathers	1.00
6.	Sand/Dirt	1.60
7.	Ashes	0.40
8.	Paper	7.00
9.	Metals	1.0
10.	Bottles/Glass	7.60
11.	Medical Waste	8.00
12.	Polyethene	8.00

Table 3: physico-chemical properties of waste dump soil

Parameters	Sampling Locations					Mean	5km Away	FME Standard (2006)
	1	2	3	4	5			
Coordinates	**N5^{0}23.295' E6^{0}59.940'**	**N5^{0}23.293' E6^{0}59.943'**	**N5^{0}23.290' E6^{0}59.938'**	**N5^{0}23.290' E6^{0}59.935'**	**N5^{0}23.285' E6^{0}59.930'**		**N5^{0}23.300' E6^{0}59. 980'**	
Elevation	56.6	57.9	57.9	59.7	59.7		60.0	
pH	5.70	5.80	5.80	6.00	5.50	5.76	6.50	6.50
Ca^{2+} , mg/kg	60	70	50	75	80	67	30	200
Na^{+} , mg/kg	84	90	70	80	85	81.8	60	NS
$K^{+,}$ mg/kg	7	8	10	9.00	12.00	9.2	4.00	100
Mg^{2+}, mg/kg	7.80	7.00	6.00	6.80	5.50	5.46	2.00	100
HCO_3^-, mg/kg	5.00	4.80	5.70	6.50	5.30	5.46	2.00	30
SO_4^{2-} ,mg/kg	12.80	13.00	10.00	9.40	8.60	10.76	6.40	100
NO_3^-, mg/kg	16	11.20	10.50	11.80	15.10	12.92	7.00	20
$Cl^{-,}$ mg/kg	100	130.6	140.50	120	100	118.22	57	250
PO_4^{3+}, mg/kg	46	35	50	43.80	56.50	46.26	24.40	100
Pb^{2+}, mg/kg	0.07	1.04	1.00	1.50	0.09	0.74	0.01	0.05
Zn^{2+}, mg/kg	8.80	7.60	10.90	8.00	7.70	8.6	2.00	5.00

Cd^{2+}, mg/kg	0.45.	0.50	0.90	0.70	0.60	0.63	0.02	0.10
Ni^{+}, mg/kg	0.08	0.07	0.08	0.06	0.09	0.076	0.03	0.05
Cn^{2+}, mg/kg	0.06	0.07	0.09	0.07	0.08	0.074	0..02	0.05
Cu^{2+}, mg/kg	2.20	2.30	2.45	2.40	2.10	2.49	1.30	2.00
Al^{3+}, mg/kg	0.009	0.006	0.008	0.006	0.008	0.037	0.003	0.01
Total iron, mg/kg	2.40	2.20	1.80	2.40	1.50	2.06	0.50	1.00
Hg^{2+}, mg/kg	0.003	0.003	0.002	0.004	0.003	0.015	0.0003	0.001
Total bacteria count, Cfu/g	$4x\ 10^4$	$5x\ 10^4$	$3.5x\ 10^4$	$4.5x\ 10^4$	$3x\ 10^4$		$1.1x\ 10^4$	NS

The data as shown in the above (Table 3) are the results of analysis done in the laboratory of the soil samples collected within the dumpsite and some distance away from the dumpsite. The sample collected and analyzed in the laboratory help the study to assess the soil chemistry in the study area.

DISCUSSION

The Ihiagwa dumpsite contains various kinds of wastes from the environment and waste disposals. The wastes dumped at the dumpsite are mainly organic wastes. The table below shows the percentage of different waste being dumped at the site.

From the table above (Table 3), it is deduced that the soil has different constituents such as cations, anions, trace elements, heavy elements.

Major Cations

The major cations highlighted in the results are calcium (Ca^{2+}), sodium (Na^{+}), potassium (K^{+}), Magnesium (Mg^{2+}) (Figure 2). The following pie charts explain the distribution of cations in the different soil samples;

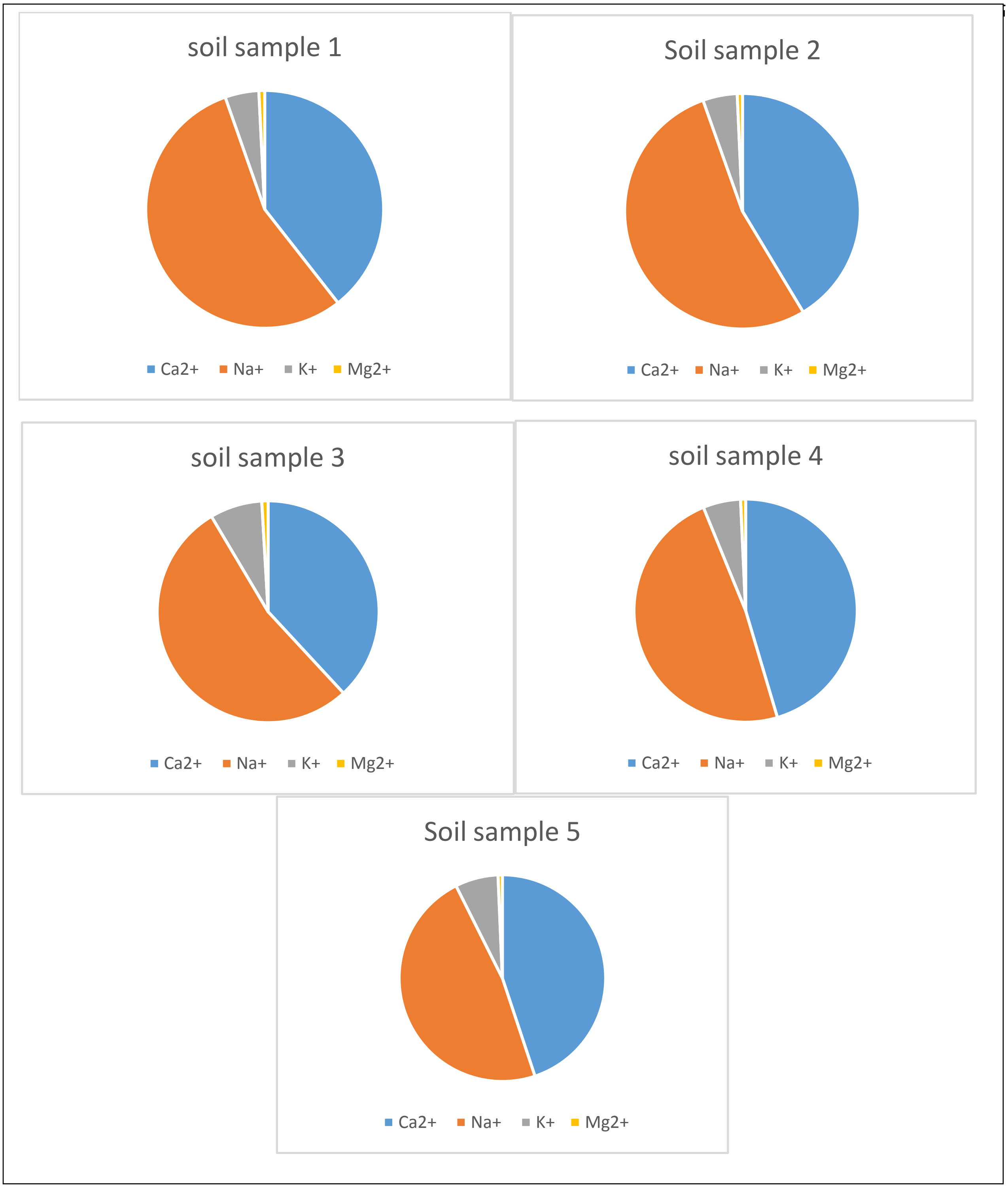

Figure 2: Cation distribution in soil samples

i. **Calcium (Ca^{2+}):** The calcium concentration ranges from 50 mg/kg to 80 mg/kg with an average mean of 67 mg/kg. The concentration of the soil samples in the five locations fall short of the FME standard which is 200mg/kg.

ii. **Sodium (Na^{+}):** The concentration of sodium falls between the ranges of 70 mg/kg to 90 mg/kg. The mean of the concentration of these samples is 81.8 mg/kg. The FME standard for sodium is **Not Specified,** therefore it falls in place with FME.

iii. **Potassium (K^+):** The Potassium concentration for the different soil samples is from 7 mg/kg to 12 mg/kg. The mean is 9.2mg/kg which is within the limits of FME standard.

iv. **Magnesium:** The Magnesium concentration is from 5.50 mg/kg to 7.80mg/kg. The mean average of this is 5.46 mg/kg which is within the FME standard of 100 mg/kg.

Major Anions

The Major anions are Bicarbonate (HCO3¯), Sulphate (SO42_), Nitrate (NO3-) and chlorine (Cl-) (Figure 3). The following pie charts explain the distribution of anions in the different soil samples.

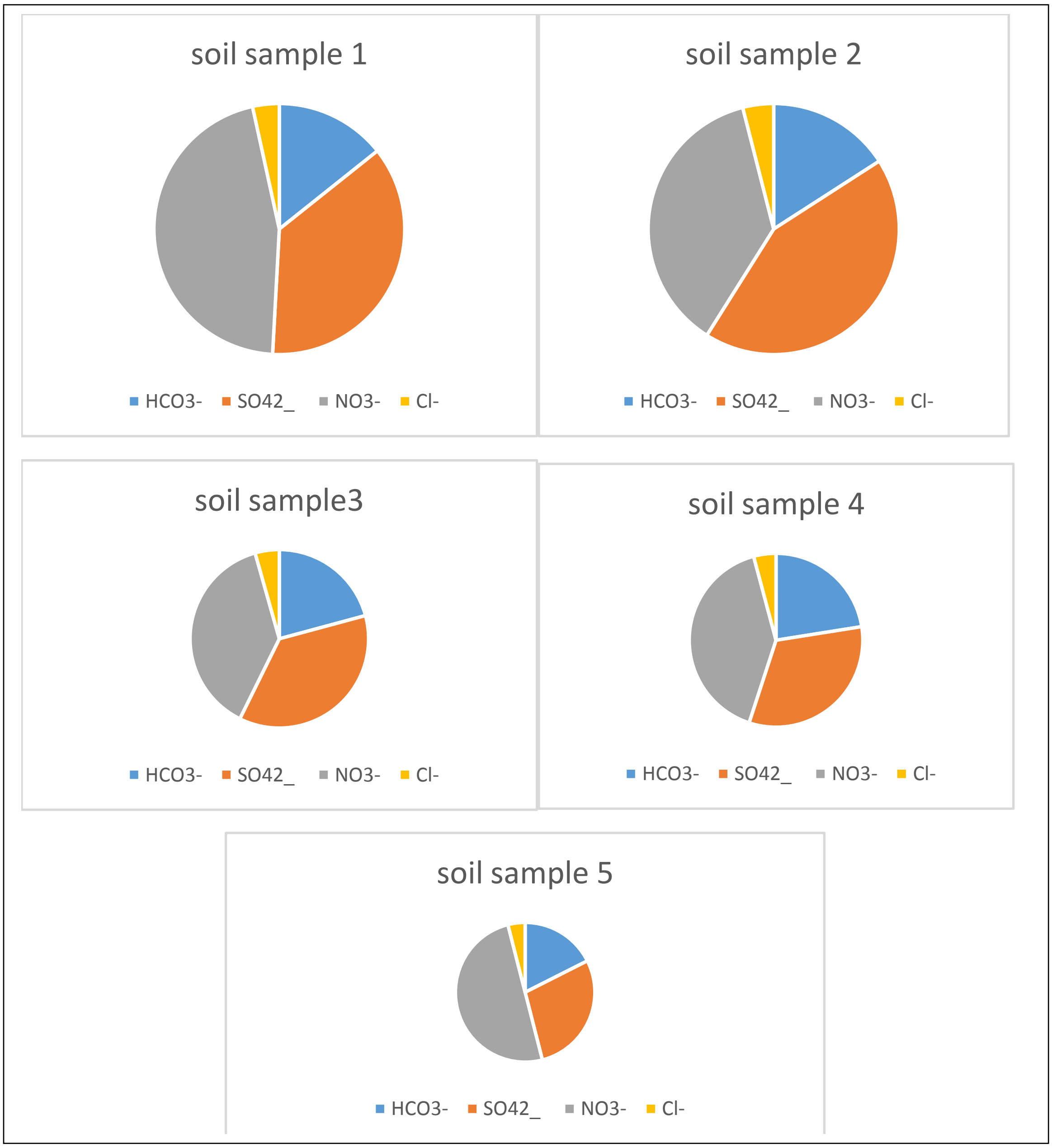

Figure 3: Anion distribution in soil samples

i. **Bicarbonate (HCO3¯):** The concentration of bicarbonate ranges from 4.80 mg/kg to 6.50 mg/kg with a mean concentration of 5.46 mg/kg. The FME standard for

Bicarbonate is 30 mg/kg which shows that bicarbonate in all the soil samples falls within this standard.

ii. **Sulphate (SO_4^{2-}):** The Sulphate concentration is from 8.60 mg/kg to 13.00 mg/kg. The mean average of the concentration is 10.76 mg/kg. The FME standard for sulphate is 100 mg/kg which implies that all the soil samples fall within this standard.

iii. **Nitrate (NO_3^-):** This ranges from 10.50mg/kg to 16mg/kg with an average of 12.92 mg/kg. The FME standard for nitrate is 20 mg/kg showing that nitrate for all samples fall into this range.

iv. **Chlorine (Cl^-):** The concentration of Chlorine ranges from 100 mg/kg to 140.5 mg/kg with a mean of 118.22 mg/kg. FME standard for Chloride is 250 mg/kg.

Heavy Metals

Metals in the soil: Although heavy metals are naturally present in the soil, geologic and anthropogenic activities increase the concentration of these elements to amounts that are harmful to both plants and animals. Some of these activities include mining and smelting of metals, burning of fossil fuels, use of fertilizers and pesticides in agriculture, production of batteries and other metal products in industries, sewage sludge and municipal waste disposal.

The main threats to human health from heavy metals are associated with exposure to lead, cadmium, mercury and arsenic. These metals have been extensively studied and their effects on human health regularly reviewed by international bodies such as the WHO. Heavy metals have been used by men for thousands of years. Although several adverse effects of heavy metals have been known for a long time, exposure to heavy metal continues and is even increasing in some parts of the world, in particular less developed countries.

The occurrence of different heavy metals such as Pb, Al, Cd, Ni, Zn, Cu, and Fe in the Ihiagwa dumpsite is shown in the result (Table 3). Since these contaminants affect the environmental qualities in and around such open dumpsites, monitoring of soil chemistry especially heavy metal content in dumpsite becomes necessary which can facilitate to recommend suitable remedial measures.

Lead: Lead in the soil samples ranges from 0.07 mg/kg to 1.50mg/kg with a mean value of 0.74 mg/kg. The lead concentration in all the soil samples are above the permissible limit of 0.05mg/kg given by FME, 2006 standard. Lead contaminated soil can result in water pollution or if soil runoff reaches a water source. Lead in the soil can also be hazardous for children who may be exposed to impacted areas. According to the EPA, one can get lead in the body by breathing or swallowing lead dust or soil which is extremely harmful to children and adults and can lead to nerve disorders, memory problems, high blood pressure and muscle pain among other consequences.

Zinc: Zinc in the soil samples ranges from 7.60 mg/kg to 10.90 mg/kg with an average mean of 8.6 mg/kg which is above the FME, 2006 standard which is 5.00 mg/kg. Based on the chemical reactions of zinc with the soil material and high concentrations of zinc in the dumpsite, there is every possibility that zinc may leach out and contaminate the ground water around the dumpsite. Toxic effects of this causes gastrointestinal and immunologic problems.

Iron: The concentration of Iron in the soil samples is from 1.50 mg/kg to 2.40 mg/kg with a mean average of 2.06 mg/kg. The limit which is allowed by FME, 2006 is 1.00 mg/kg but all the soil samples contain higher concentrations of iron which is a problem. Iron is toxic when it accumulates to high levels.

Copper: The concentration of copper contained in the five different soil samples ranges from 2.1 mg/kg to 2.45 mg/kg with an average value of 2.49 mg/kg. The five samples collected are above the FME, 2006 permissible standard of 2.00mg/kg.

Nickel: Nickel lies within the concentrations of 0.06 mg/kg to 0.09 mg/kg with an average mean of 0.07 mg/kg and this does not conform to the standard of the FME, 2006. Groundwater contamination around the dumpsite due to nickel is very high as it gets to leach into groundwater.

4.0 CONCLUSION AND RECOMMENDATIONS

The physico-chemical analyses of Ihiagwa dumpsite soil revealed that except the heavy metals, all other parameters including the major cations and the major anions are within the permissible limits of FME standards (2006).

The heavy metals (Pb, Cd, Cu, Fe, Ni) found in soil sample in and around the dumpsite were traced from the poor management and dumping of electronic waste in the area and they are toxic and very harmful to plants, animal and man. They are carcinogenic, cause renal impairment, brain disorder and possibly death with certain level of exposure. Although some of these heavy metals such as copper are biologically essential and play an important role in the growth of plants, animal and man if taken in moderate quantity. They can also be toxic when found in high concentration.

Certainly, future studies should determine the health impact of heavy metals on the human population living in Ihiagwa including the scavengers in the dumpsite area taking into consideration that such heavy metals can infiltrate into the unconfined aquifer in the area or accumulate in plants, making their way to human through the food chain. All efforts should be made to determine the accumulation rate of heavy metal on plants that grow in that area to know its quality.

Finally, standard waste management practices should be put in place to mitigate such environmental threats as seen in course of this research and future ones.

Recommendations

After this research has been conducted, the following recommendations were made:

- Proper environmental sanitation procedure in addition to government policies on waste disposal management should be enacted and strictly enforced.
- Indiscriminate dumping of waste along roads, riverbanks and unplanned refuse dumps should be discontinued so as to forestall the contamination of soil groundwater resources.
- Sanitary landfill should be employed in solid waste disposal so as to protect the groundwater in the area.
- Waste sorting policy should be introduced at point source to separate wastes as degradable and non-degradable. While degradable domestic wastes can be used as manure in farm land. Revitalizations and support of waste recycling and reuse at the waste dump is important.
- Metal waste should not be dumped indiscriminately; they should be recycled.
- A steady assessment and monitoring of soil chemistry around dumps be carried out due to environmental and other anthropogenic impacts.
- Recycling plants should be established so as to reduce the infiltration of metals into the groundwater resources.
- There is need for community policing and vigilante in Ihiagwa to help check indiscriminate dumping of waste in the site.
- The use of impermeable geomembrane is necessary for all dumpsites to minimize seepage of leachates from causing pollution of both surface and groundwater resources taking into account the possibility that the containment system may be threatened by any disaster.

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