LABORATORY STUDY OF CONDUCTIVE PROPERTIES OF CONTAMINATED SOIL FROM MAIGANGA COAL MINE SITE AND KUMO TOWN OF GOMBE STATE, NIGERIA

RABIU, JAMI'U ARIYO* AND JOHN KEVIN

Department of Physics, Federal University of Kashere, P.M.B. 0182. Kashere, Gombe State
*Corresponding author

ABSTRACT

As industrial activities increase, the risk of contamination of soil in Maiganga coal mine site and Kumo town of Akko Local Government Area of Gombe state in Nigeria is becoming higher. In this study, a laboratory test of the conductive properties of contaminated soil from Maiganga coal mine site and kumo town was conducted. Five (5) soil samples were collected from Maiganga coal mine site and five (5) from Kumo town of Akko local government, Gombe state. The samples were collected manually, transferred into plastic containers, and transported to the laboratory. The conductive properties of the soils were obtained in their natural states before it was determined after the samples have been treated with varying concentration of engine oil, detergent and animal dung. Electrical conductivity meter was used to determine the electrical conductivity. After treatment of the samples with different concentration of the contaminants, it was found that electrical conductivity increases with increase in concentration of the contaminants in all the samples. Exceptional cases were found in sample 5 and 8, sample 5 from Maiganga and sample 8 from Kumo. The electrical conductivity of the samples was determined by varying the concentration of contaminants. From the data obtained electrical conductivity increases with increase in the concentration of determinants. Based on the major findings secured, general conductive properties of contaminated soil samples have been determined in this study to investigate variation with contaminants concentrations.

Keyword: soil, conductivity, electrical conductivity, contaminants concentration.

INTRODUCTION

Urbanization is usually associated with the problem of waste disposal generated by human activities. The recognition of the connection between human activities and pollution and need to protect human health and environment, led to the early development of water quality regulations and monitoring methods (USEPA, 2007). The need for socio-economic advancement has led to rapid expansion of the industrial sector in developing countries like Nigeria. These waste disposal sites are neither properly designed nor constructed. After some years a dumpsite undergoes biologically, chemically, geologically and hydro geologically mediated changes resulting in a weathering process and consequently it becomes point source for pollution of the aquiferous units close to them (Arienzo *et al.*, 2001).

Pollution of the soil environment with animal dung, detergents, and hydrocarbons such as engine oil are some of the factors expressing anthropogenic degradation of the environment. Due to its toxicity, widespread presence and complex nature, this type of pollution is a serious problem, one reason being that as the modern civilization, urbanization and mechanization develop, the use of engine oil and detergent products grows. (Jørgensen *et al.*, 2000). Engine Oil**:** The disposal of spent engine oil (SEO) into gutters, water drains, open vacant plots and farms is a common practice in Nigeria especially by motor mechanics. This oil, also called spent lubricant or waste engine oil, is usually obtained after servicing and subsequently draining from automobile and generator engines (Anoliefo and Vwioko, 2001) and much of this oil is poured into the soil. There are relatively large amounts of hydrocarbons in the used oil, including the highly toxic polycyclic aromatic hydrocarbons (Wang *et al.*, 2000). Also, most heavy metals such as V, Pb, Al, Ni and Fe, which were below detection in unused lubricating oil, have been reported by Whisman et al. (1974) to give high values (ppm) in used oil. These heavy metals may be retained in soils in the form of oxides, hydroxides, carbonates, exchangeable cations, and/or bound to organic matter in the soil (Yong, *et al.*, 1992). Nevertheless, this is dependent on the local environmental conditions and on the kind of soil constituents present in the soil-water system.

Animal Dung: As livestock production increases worldwide, livestock waste is becoming a serious environmental hazard. In some cases, the damage has been spectacular and even tragic. Environmental hotspots for poultry production reflect the environmental distortion and interference caused by livestock production. Surveys conducted in Benin City, Nigeria showed that although economic performance is competitive, most producers are operating outside the boundaries of sustainability because of inadequate waste management and excessive waste produced in small geographical areas, beyond the assimilation capacity of the local environment. With smallholders' farmers, waste could be applied to land used to produce food and other crops. But with development and specialization in livestock production that requires large herds, waste may exceed the carrying capacity of local ecosystem and are a potential cause of a number of pollution and health problems related to their organic matter, nutrients, pathogens, odours, dust and air borne micro-organisms (Zlang & Felmann, 1997).

In developing countries, the disposal of greywater into soil drainage is a common practice. However, these practices have become unacceptable in many of the developed countries due to the distribution of pollutants such as chemical agents, OMPs, and pathogens into the natural water and soil and then the transmission into the human via food chain. Besides, the high salinity of laundry greywater which is derived from detergents is a major concern. The determination of soil salinity is used to assess the presence or absence of the adverse efects resulting from the utilization of greywater in the irrigation. The level of salinity is quantifed based on the sodium adsorption ratio (SAR) index (Lazarova and Asano 2005). The SAR in laundry greywater might reach 12.32 mg L^{-1} which results from the utilization of detergent with concentrations of 3000 mg L^{-1}(Abu-Zreiget *et al.* 2003). It has demonstrated that the increase of SAR causes a decrease in saturated hydraulic conductivity (Ksat) in the soil (Gross *et al.* 2008). The irrigation of soil with greywater contains high levels of sodium (Na), which causes degradation of the soil composition and permeability.

MATERIALS AND METHODS

Study Area

The study took place in Maiganga coal mine site (which is nine kilometers away from kumo town) as well as Kumo town (10.04^0 N, 11.21^0 E) of Akko L.G.A both in Gombe state. Five (5) soil samples were collected from Maiganga coal mine site and five (5) from Kumo town of Akko local government, Gombe state. The samples were collected manually, transferred into plastic containers, and transported to the laboratory.

Sample collection and Conductive Properties Determination

The samples collected were thoroughly washed to remove any hidden contaminants, air dried and sieved to ensure uniform grain size. Ten (10) grams of each soil sample was measured using digital scale and transferred into ten (10) different beakers. Each of the measured soil sample was dissolved with ten mills of distilled water before the test of conductive properties was conducted using the conductivity meter. The conductivity meter was first switched on, tuned to the conductivity mode before applying the electrode into the samples and the natural conductivity of the soil sample was obtained. Five (5) mill of each contaminant (engine oil, detergent and animal dung) was added and mixed thoroughly, after which electrical conductivities were measured. The concentration of the contaminant was increased by the same volume and each experimental set-up until twenty-five (25) mill was achieved which was the fifth (5th) concentration. At each stage of the concentration, the corresponding conductivities obtained were recorded. The results obtained are measured in micro simens/cm (which is the unit of conductivity).

Mathematically;

Conductivity (σ) is the inverse of specific electrical volume resistivity (ρ)

But;

$$\rho = \Delta U * A / I * L$$

Where;

ρ= specific electrical volume resistivity (Ωm)

ΔU= voltage (V)

A= specimen cross section area perpendicular to the electrical current flow (m^2)

I= applied electrical current (A)

L= length of specimen (m)

Therefore;

$$\sigma = \frac{1}{\rho} \text{ [S/m]}$$

RESULTS

Table 1: Samples, location and natural conductivities values

Samples	Location	Electrical conductivity (*μs/ cm)*	Coordinates
1	Maiganga	1220	Lat. 9^{0} 59^{1} $26.60^{''N}$ Long. 11^{0} 9^{1} $20.54^{''E}$ Alt.: 426m
2	Maiganga	1323	Lat. 9^{0} 59^{1} $25.48^{''N}$ Long. 11^{0} 9^{1} $18.64^{''E}$ Alt.: 425m
3	Maiganga	1249	Lat. 9^{0} 59^{1} $18.81^{''N}$ Long. 11^{0} 9^{1} $18.91^{''E}$ Alt.: 426m
4	Maiganga	1100	Lat. 9^{0} 59^{1} $31.25^{''N}$ Long. 11^{0} 9^{1} $19.13^{''E}$ Alt.: 422m
5	Maiganga	2210	Lat. 9^{0} 59^{1} $39.94^{''N}$ Long. 11^{0} 9^{1} $19.54^{''E}$ Alt.: 421m
6	Kumo town	1100	Lat. 10^{0} 2^{1} $50.64^{''N}$ Long. 11^{0} 12^{1} $23.54^{''E}$ Alt.: 399m
7	Kumo town	1141	Lat. 10^{0} 2^{1} $52.93^{''N}$ Long. 11^{0} 12^{1} $24.85^{''E}$ Alt.: 399m
8	Kumo town	2010	Lat. 10^{0} 2^{1} $46.90^{''N}$ Long. 11^{0} 12^{1} $26.11^{''E}$ Alt.: 399m
9	Kumo town	1141	Lat. 10^{0} 2^{1} $53.62^{''N}$ Long. 11^{0} 12^{1} $31.99^{''E}$ Alt.: 413m
10	Kumo town	1184	Lat. 10^{0} 2^{1} $57.49^{''N}$ Long. 11^{0} 12^{1} $35.22^{''E}$ Alt.: 399m

Table 2: Values of electrical conductivity Vs Concentration of 5 contaminants for Sample 1

Concentration of contaminants in (ml)	Electrical conductivity (μ s/cm) for engine oil	Electrical conductivity (μ s/cm) for animal dung	Electrical conductivity (μ s/cm) for detergent
5	1460	1440	1320
10	1600	1608	1410
15	1815	1820	1530
20	2000	2080	1625
25	2220	2290	1720

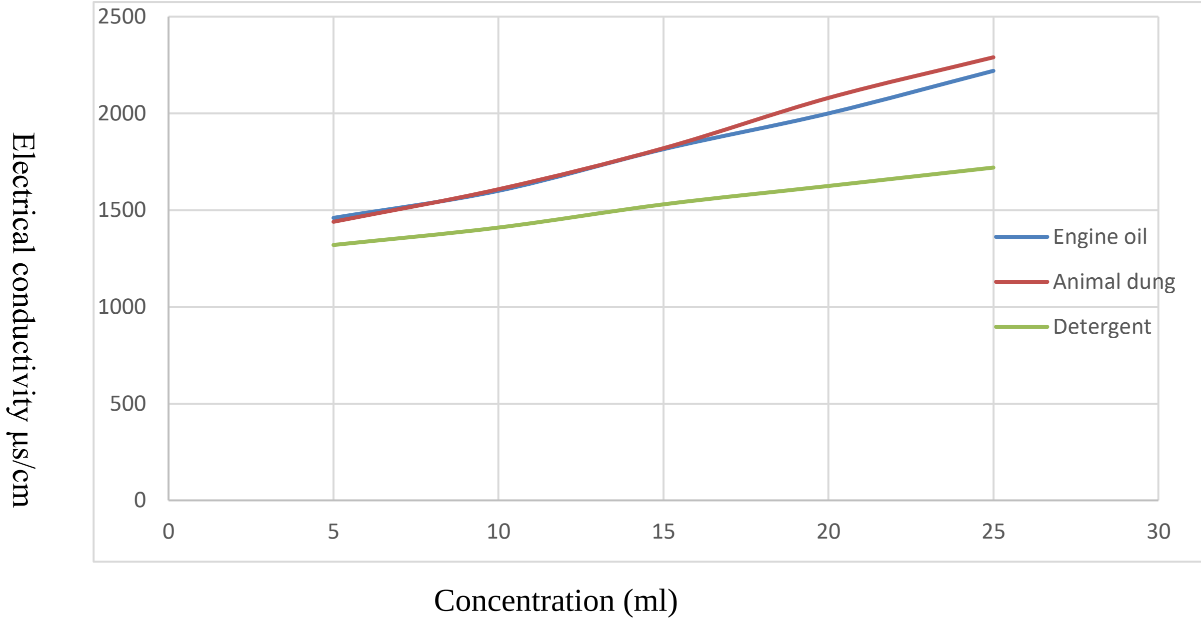

Figure 1: Effect of concentration of contaminants on electrical conductivity of sample 1

Table 3: Values of electrical conductivity Vs Concentration of 5 contaminants for Sample 2

Concentration of contaminants in (ml)	Electrical conductivity (µ s/cm) for engine oil	Electrical conductivity (µ s/cm) for animal dung	Electrical conductivity (µ s/cm) for detergent
5	1458	1550	1425
10	1520	1630	1528
15	1625	1835	1624
20	1730	2093	1730
25	1820	2210	1818

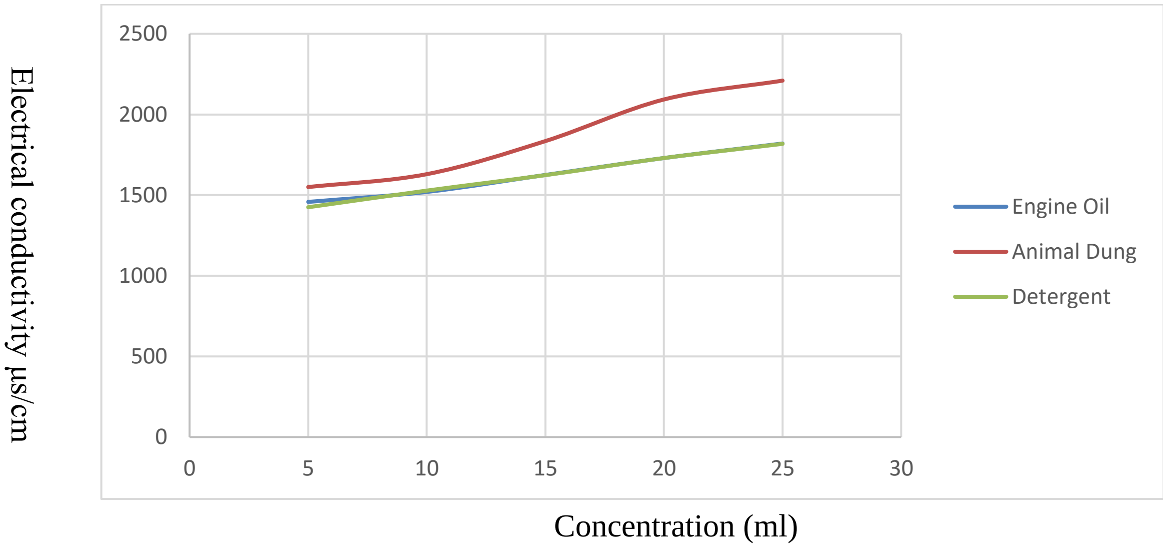

Figure 2: Effect of concentration of contaminants on electrical conductivity of sample 2

Table 4: Values of electrical conductivity Vs Concentration of 5 contaminants for Sample 3

Concentration of contaminants in (ml)	Electrical conductivity (µ s/cm) for engine oil	Electrical conductivity (µ s/cm) for animal dung	Electrical conductivity (µ s/cm) for detergent
5	1358	1450	1350
10	1460	1649	1453
15	1559	1852	1552
20	1662	2010	1650
25	1761	2230	1749

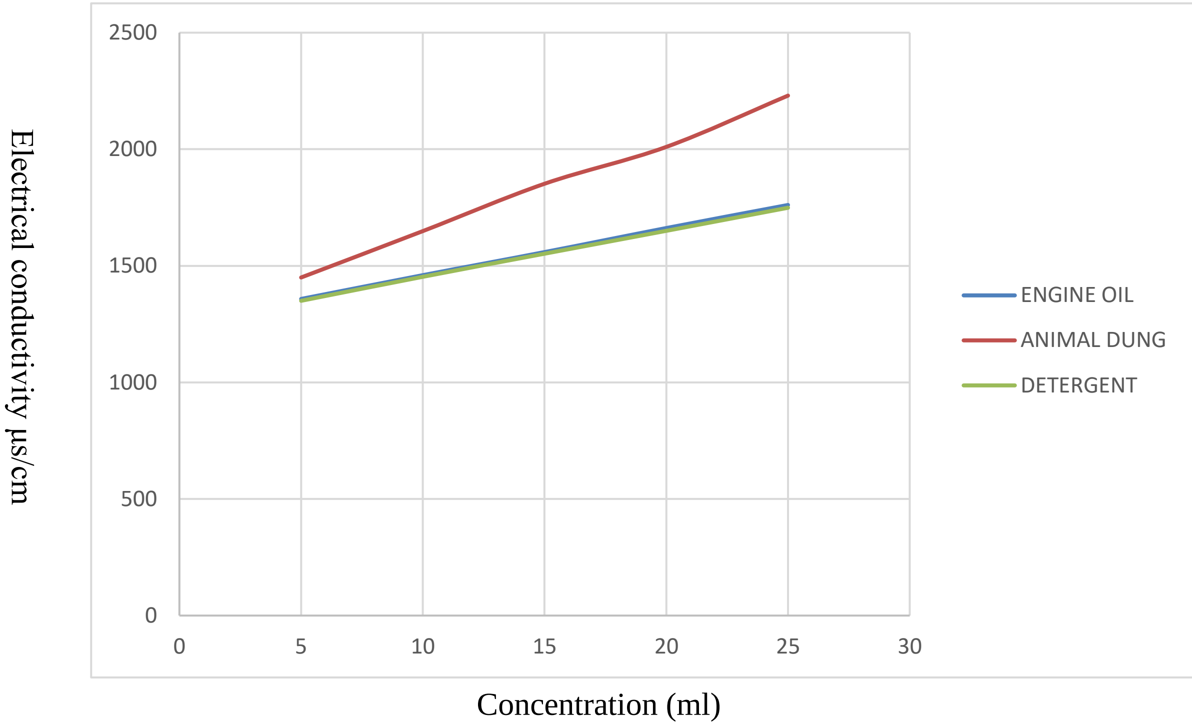

Figure 3: Effect of concentration of contaminants on electrical conductivity of sample 3

Table 5: Values of electrical conductivity Vs Concentration of 5 contaminants for Sample 4

Concentration of contaminants in (ml)	Electrical conductivity (µ s/cm) for engine oil	Electrical conductivity (µ s/cm) for animal dung	Electrical conductivity (µ s/cm) for detergent
5	1230	1320	1200
10	1335	1510	1300
15	1418	1712	1420
20	1523	1925	1510
25	1617	2100	1619

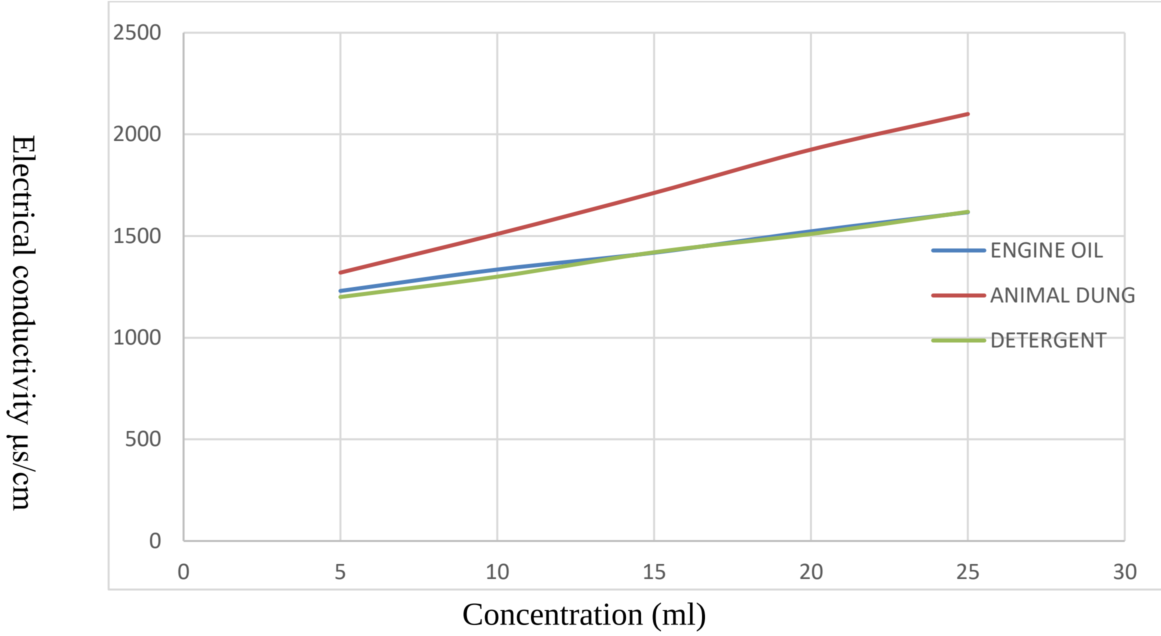

Figure 4: Effect of concentration of contaminants on electrical conductivity of sample 4

Table 6: Values of electrical conductivity Vs Concentration of 5 contaminants for Sample 5

Concentration of contaminants in (ml)	Electrical conductivity (µ s/cm) for engine oil	Electrical conductivity (µ s/cm) for animal dung	Electrical conductivity (µ s/cm) for detergent
5	2337	2410	2310
10	2440	2617	2413
15	2539	2815	2512
20	2641	3017	2609
25	2738	3210	2711

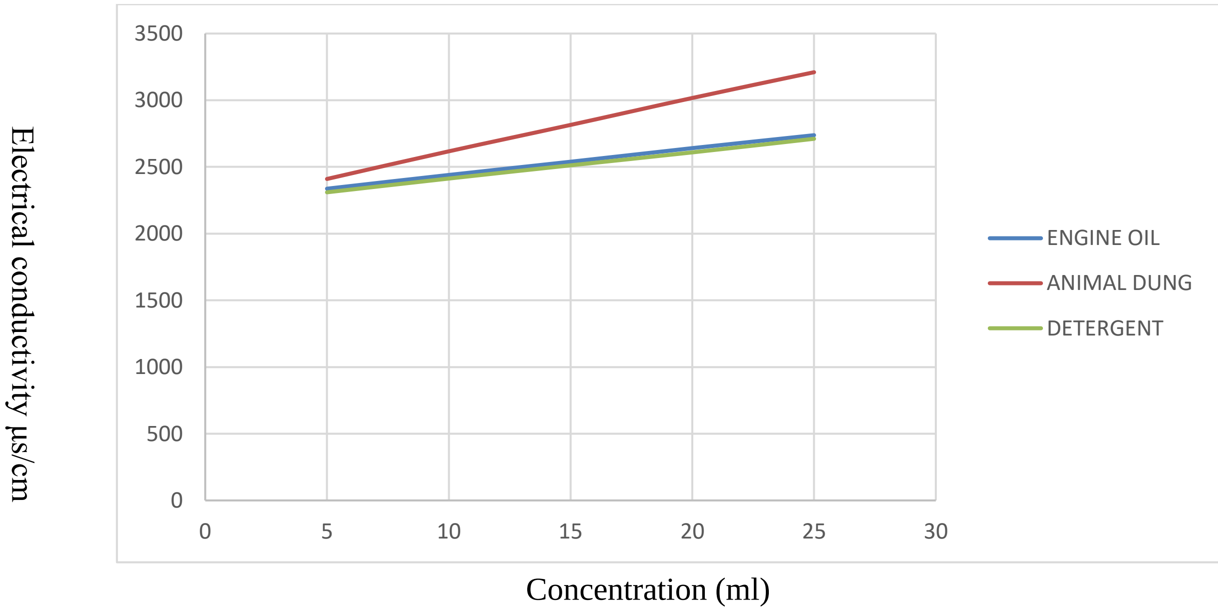

Figure 5: Effect of concentration of contaminants on electrical conductivity of sample 5

Table 7: Values of electrical conductivity Vs Concentration of 5 contaminants for Sample 6

Concentration of contaminants in (ml)	Electrical conductivity (μ s/cm) for engine oil	Electrical conductivity (μ s/cm) for animal dung	Electrical conductivity (μ s/cm) for detergent
5	1300	1345	1200
10	1400	1450	1302
15	1602	1639	1401
20	1805	1842	1503
25	2001	2020	1600

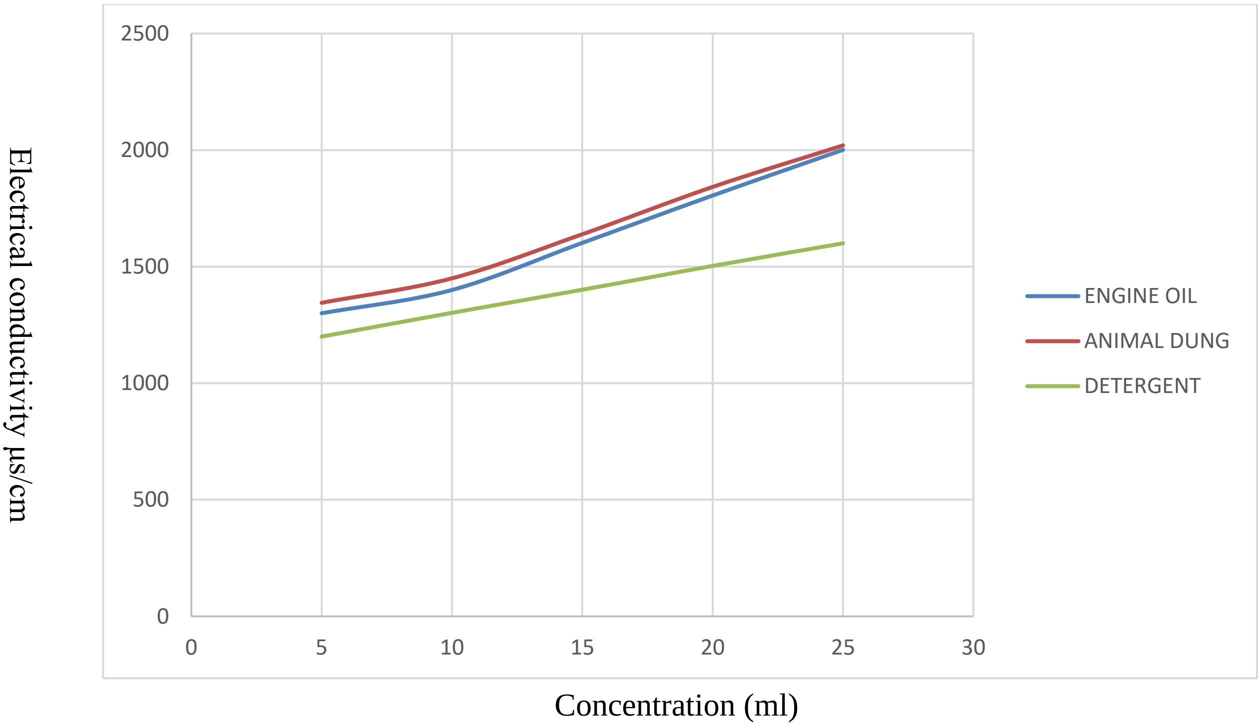

Figure 6: Effect of concentration of contaminants on electrical conductivity of sample 6

Table 8: Values of electrical conductivity Vs Concentration of 5 contaminants for Sample 7

Concentration of contaminants in (ml)	Electrical conductivity (μ s/cm) for engine oil	Electrical conductivity (μ s/cm) for animal dung	Electrical conductivity (μ s/cm) for detergent
5	1272	1352	1240
10	1380	1539	1339
15	1478	1740	1441
20	1581	1923	1540
25	1677	2019	1641

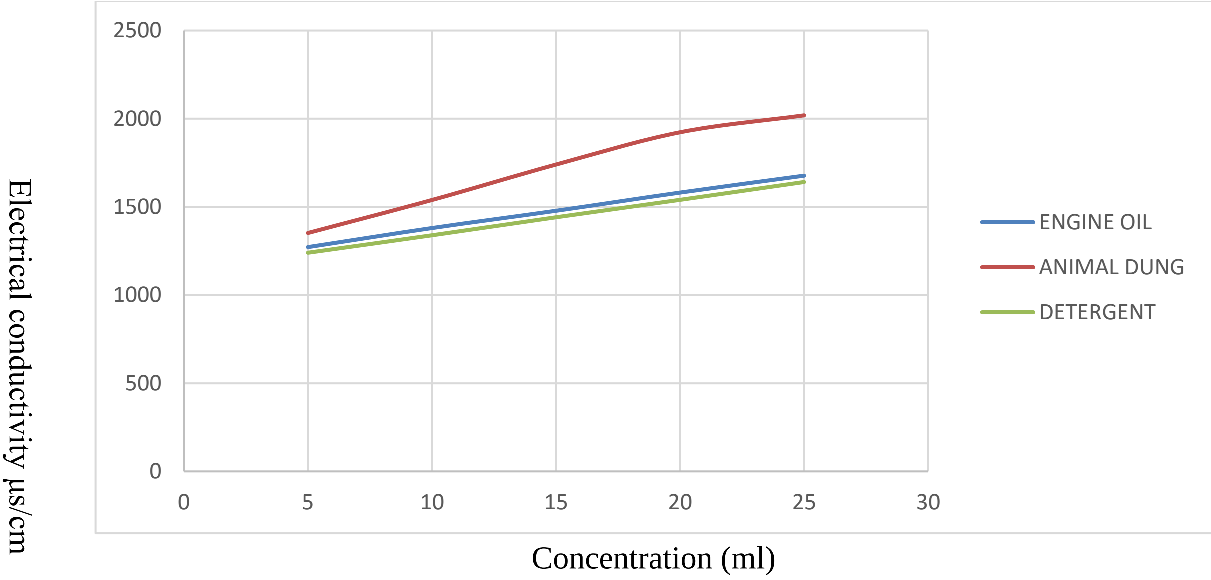

Figure 7: Effect of concentration of contaminants on electrical conductivity of sample 7

Table 9: Values of electrical conductivity Vs Concentration of 5 contaminants for Sample 8

Concentration of contaminants in (ml)	Electrical conductivity (µ s/cm) for engine oil	Electrical conductivity (µ s/cm) for animal dung	Electrical conductivity (µ s/cm) for detergent
5	2120	2212	2110
10	2232	2415	2212
15	2324	2609	2310
20	2435	2811	2409
25	2539	3001	2508

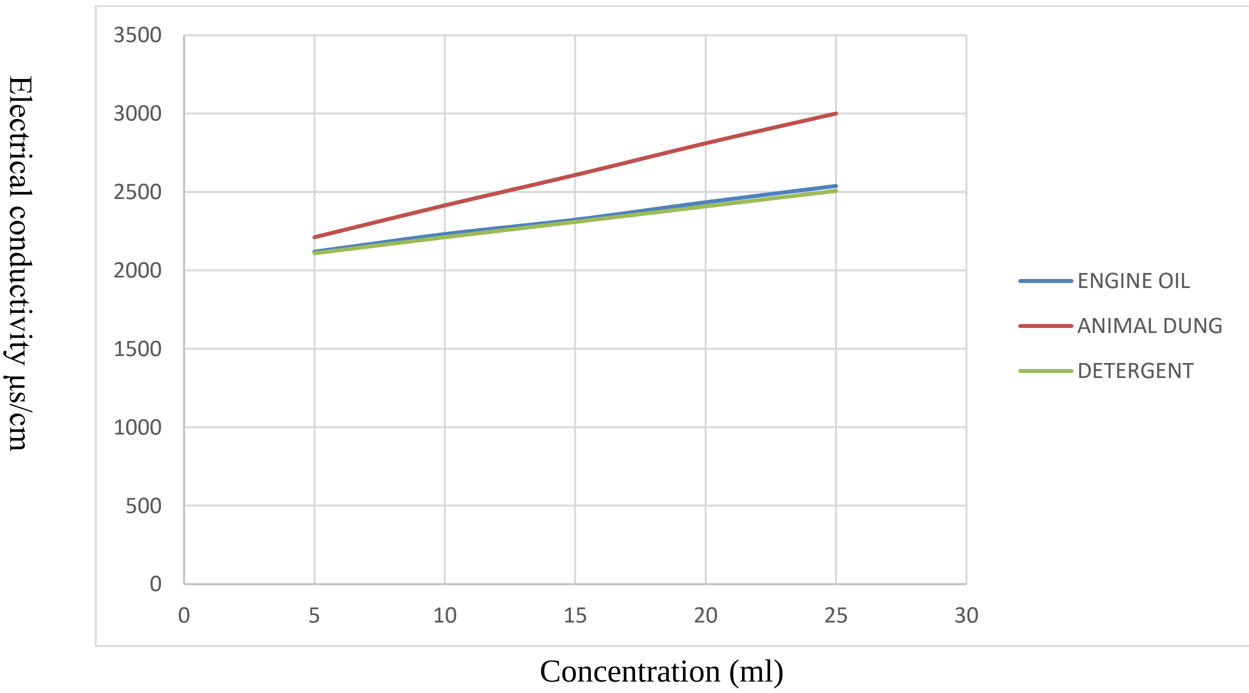

Figure 8: Effect of concentration of contaminants on electrical conductivity of sample 8

Table 10: Values of electrical conductivity Vs Concentration of 5 contaminants for Sample 9

Concentration of contaminants in (ml)	Electrical conductivity (µ s/cm) for engine oil	Electrical conductivity (µ s/cm) for animal dung	Electrical conductivity (µ s/cm) for detergent
5	1260	1250	1239
10	1358	1453	1343
15	1462	1638	1442
20	1561	1830	1541
25	1660	1999	1638

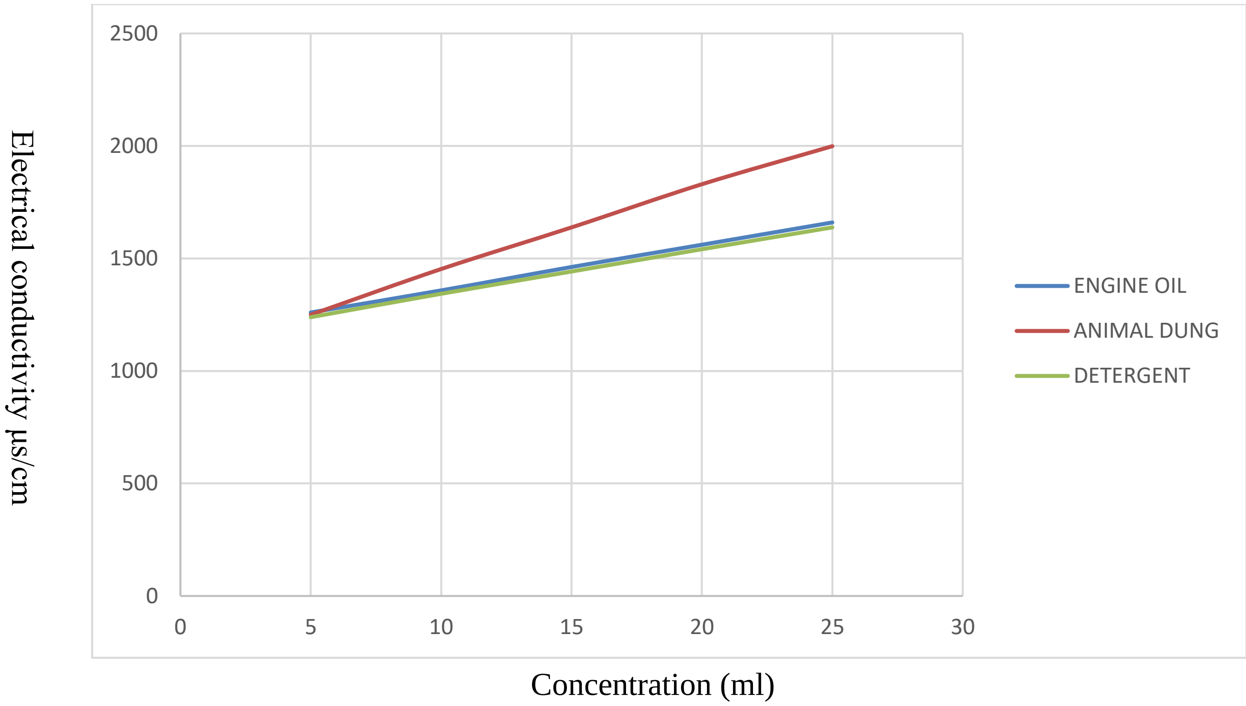

Figure 9: Effect of concentration of contaminants on electrical conductivity of sample 9

Table 11: Values of electrical conductivity Vs Concentration of 5 contaminants for Sample 10

Concentration of contaminants in (ml)	Electrical conductivity (µ s/cm) for engine oil	Electrical conductivity (µ s/cm) for animal dung	Electrical conductivity (µ s/cm) for detergent
5	1340	1400	1300
10	1445	1601	1401
15	1556	1800	1500
20	1670	2000	1603
25	1758	2199	1700

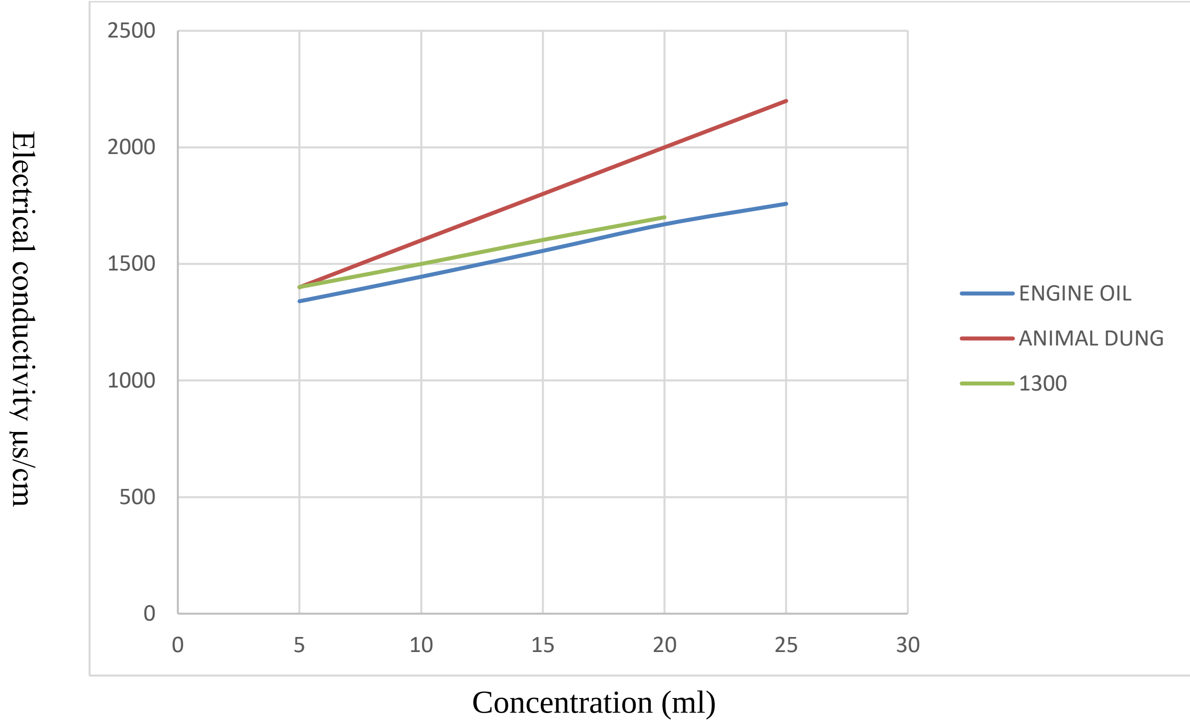

Figure 10: Effect of concentration of contaminants on electrical conductivity of sample 10

DISCUSSION

Generally, the natural conductivity of the samples was obtained and from the results from Maiganga coal mine has the highest conductivity due to the coal mine activity. Exceptional cases were found in sample 5 and 8, sample 5 from Maiganga and sample 8 from Kumo. The electrical conductivity of the samples was determined by varying the concentration of aminants. From the data obtained electrical conductivity increases with increase in the concentration of determinants. The contaminant with highest conductivity was the animal dung which increases rapidly as the concentration of the contaminate was added (Wang *et al.*, 2000).

CONCLUSION

Based on the major findings secured, general conductive properties of contaminated soil samples have been determined in this study to investigate variation with contaminants concentrations. Electrical conductivity varies with respect to contaminants present in porous media. Conductivity increased with increase in the concentration of the contaminants (engine oil, detergents and animal dung) as observed in the tables. It was also already observed for all the samples investigated; conductive properties varied linearly with the increase in concentration. Soil pollution is one of the major problems which threatens plant and people lives. Soil electrical conductivity (EC) is one of the soil physical properties, which have a good relationship with the other soil characteristics. Measurement of apparent soil electrical conductivity is one of the easiest ways to get suitable information about soil characteristics. Beside easiness, the low price of measuring apparent soil electrical conductivity introduces it as the best way for obtaining useful information about soil pollution condition.

REFERENCES

"Current Electricity - Lesson 3 - Electrical Resistance". The physics classroom. Retrieved 20 August 2014.

"Current versus Drift Speed". The physics classroom. Retrieved 20 August 2014.

Adeniyi, A. A., Yusuf, O. O., & Okedeyi, O. O. (2008). Assessment of the exposure of two fish species to metals pollution in the Ogun river catchments, Ketu, Lagos, Nigeria. *Environ Monit Assess., 137*(1-3), 451-458. http://dx.doi.org/10.1007/s10661-007-9780-5

Arienzo, M., Adamo, P., Bianco, M. R., & Violante, P. (2001). Impact of land use and urban run-off on the contamination of the Samo river basin in southwestern Italy. *Water Air Soil Pollut., 131*(1-4), 349-366. http://dx.doi.org/10.1023/A:1011908019933

Awofolu, O. R., Du Plessis, R., & Rampedi, I. (2007). Influence of discharged effluent on the quality of surface water utilized for agricultural purposes. *Afr. J. Biotech.,* 6(19), 2251-2258.

Awofolu, O. R., Mbolekwa, Z., Mtshemla, V., & Fatoki, O. S. (2005). Levels of trace metals in water and sediment from Tyume river and its effects on an irrigated farmland. *Water S. Afr., 31*(1), 87-94.

Eric Bogatin (2004). *Signal Integrity: Simplified*. Prentice Hall Professional. pp. 114–. ISBN 978-0-13066946-9.

Farouki, O. T. (1986). Thermal properties of soils. *Rock and Soil Mechanics*, Vol. 11, Trans Tech Publications, Clausthal-Zellerfeld, Germany. p. 1-136.

Lowe, Doug (2012). *Electronics All-in-One for Dummies*. John Wiley & Sons. ISBN 978-0-470-14704-7.

Lowrie (2007-09-20). *Fundamentals of Geophysics*. Cambridge University Press. pp. 254–. ISBN 978-1-13946595-3.

Narinder Kumar (2003). *Comprehensive Physics XII*. Laxmi Publications. pp. 282–. ISBN 978-81-7008592-8.