International Journal of Advanced Research and Publications
ISSN: 2456-9992

Variation In Topsoil Electrcial Resistivity With Chromium Concentration

Arowosere, F.O., Jonah, A.G., Akintade, S.A., Akawu, P.I., Jakheng, W.E., Abdulwahab, S.
Email: arowosere@gmail.com

ABSTRACT: This study is focused at variation in topsoil electrical resistivity with chromium concentration in NILEST samara Zaria with an objective to propose adequate disposal method. The study focused on articulating the soil, sampling and assessing contaminated soil and uncontaminated soil, determining and comparing the soil characteristics of the contaminated and uncontaminated soil. The sample were collected in the institute and it was carried out in institute of agricultural research (I A R) A B U Zaria on soil PH and soil electrical resistivity. The result shows that there was a change in the PH level of the soil which was mostly alkaline to become acidic as a result of heavy metals. The result shows that they is increase in soil electrical resistivity 80%.Thus soil physical and general properties of soil leading to poor growth and death of living organisms. It is recommended that the tanneries and textile industries should developed a highly efficient method of treating chromium and other pollutant present to ensure that effluent are within the FEPA standard discharging in to the environment.

Keywords: Voltmeter, Ammeter, Long copper wire, Circular copper plate of different diameter with small hole at the centre, Hose of various lengths, Cross sectional copper wire, connecting wire, Clamp.

(1) INTRODUCTION

Top soil is the uppermost part of the earth in which several activities of plant and animal take place. It is a very vital section of the earth in which human activities such as agriculture, engineering, building commerce, and several others. Soil is formed by natural process of disintegration of rocks and decomposition of organic matter. The material derived from the parent rock constitutes the primary standard in the soil. There are three basic types of rocks namely the igneous rock, sedimentary rock and the metamorphic rock. The types of soil that may be formed include sandy, clay, silt and loamy soil. Top soil being nearest the atmosphere is mostly affected by some natural and man-made factors. The major of the factors is weathering, that is the gradual removal of topmost soil due to rain, wind or by same technical activities on earth sub-surface. Other factor may include plant which may be decomposed biologically to form part of the top soil and animal drums which may also decomposed form part of the top soil the properties which chemical, physical etc[1]. Pollution can be defined as the direct or indirect alternation of the physical, thermal biological or radioactive properties of any part of the environment in such a way to create hazard to our environment. Due to the fact that man engage in different activities on the top soil, the soil is then polluted mainly through industrial activities such a tanning of leather, drying of clothes by textiles, mining, steel making, chrome plating etc. The top soil is also polluted by agricultural practices such as the application of pesticide toxic chemical spills etc toxic chemical are synthesized commercially, and many eventually find their way into the top soil ecosystem, oil spills and effluent discharge from industries also causes pollution to the top soil thereby enhancing degradation of the top soil.

(2)Physical Changes on Top Soil

There are quite a number of factors that affect the top soil which may in turn have effects on the plant cultivation on it. Some of these factors include, soil temperature, soil aeration organic matter, humus and soil fertility.

(3)Soil Temperature

The chemical processes of activities of microorganism that convert plant nutrient to available from are affected by temperature. Temperature may varies at different time, day night and at different depth and it different season. Below freezing point and extreme high temperature, no biological activities, germination of seed and rout occur.

(4)Soil Aeration

Soil usually contains air in the pore spaces. Plant root and soil organisms take in the oxygen from this air for cellular respiration. Organisms such as termites and earth worms improve the circulation of air in the soil by their tunneling activities. Nitrogen in the air is used by bacteria in the rout nodules of legumes to produce nitrogenous compounds. Water logged soils are poorly aerated as the pore space are filled with water.

(5)Organic Matter

Decomposers like bacteria and fungi break down dead organic matter to form humus and soluble inorganic salts. These processes increase the nutrient content of soil, this improving its fertility it include animal manure, sewage sludge, compost, grass turf, straw and other crop residues which are applied to the soil to improve top soil structure and moisture holding capacity and to nourish soil life, which in turn nourishes plants [2].

(6)Humus

The decomposition of plant and animal remain from a layer of black, jelly-like organic material called humus on the top of the soil. This is drawn into the soil by soil organisms like the Earthworm. Humus increases the water retaining ability of the soil. It also improves soil structure as it help to keep the soil well-drained and aerated. The decomposers break down humus faster of high temperature. This is why tropical soil tent to have a lower humus content than temperate soil.

(7) Soil Fertility

A naturally fertile soil is one that has the correct property of sand and clay particles. Has adequate humus and minerals salts. Has a good crumb structure. Is well drained and aerated. Is neutral or slightly alkaline. Acidic soils are usually not fertile as acidity makes the mineral salt very soluble. Rain washed these salts into the deeper soil layers, out of reach of plant roots. In a natural ecosystem, soil fertility is maintained by the activities of the organisms living in it i.e. when they die, their remains broken down by decomposers. Also the soil fertility is also maintained by the addition of fertilizer The aim of this project is to investigate the electrical resistivity of the top soil polluted by industrial discharge base on the chromium concentration. The objectives of this project are: To investigate the effect of chromium deposited in tannery influence on soil electrical resistivity and to identify the contaminated and uncontaminated soil sample and to compare the result with standard Organization (FEPA) Federal Environment protection agency and to do a statistical analysis of leather industries. Soil electrical conductivity is defined as the ability of a soil to allow fire flow of electron when an electric current is passed through it. The conductivity is measured in Siemens per meter (s/m); the increase of conductivity is resistivity indiums per meter [3]. Most soils naturally contain varying amounts of electrolytes that conducts electricity. As a result, the addition of moisture will enhance or reduce the conductive properties of that soil. As general rule, soil with higher moisture content will have a lower electrical resistance and a higher electrical conductivity. Temperature can have a significant impact on resistivity. The soil rises dramatically upon react thing the freezing point. Upon reaching 32degree Fahrenheit, any soil moisture in the soil will begin to freeze, and upon freezing the soil resistance will increase by almost three times its normal value. Heavy clays, with highparticle-10-particle contact and high moisture holding capacity and highly conductive. Coarse sands with limited particle contact and moisture holding capacity are extremely poor conductors. In normal method of chrome tanning practiced in many tanneries i.e. 80% total tan float precede by formic/sulphuric acid pickle in the same bath it is estimated that about 33-35% of the offered chrome is left unbound by the pelts and remain as residual chrome in the bath and held unfixed within the tanned leathers. The entire amount of unfixed chrome is thus drained through the effluent stream. Through improved chrome tanning technique i.e. by employing short-float techniques (25-50% tan float) and concluding the tannage at an elevated temperature (35^0-45^0C) the chrome uptake on doubt improved but the uniflived chrome is still about one-fifth of the chrome offered to the pelt. If one assumes that 8% chrome powder (2% Cr_2O_2) is used for chrome tanning of 100kg pelts the loss may be estimated to be 1.6% chrome powder (400g $Cr_2O_{3)}$ for every 100kg pelt. The loss of expensive chrome, in our example is colossal. Regarding effluent, if the tannery use 5000 litre water for processing 100kg raw material (raw to finished) the discharged effluent will contain 400g Cr_2O_3 or 80mg Cr_2O_3 per litre. But environmental safety regulated will accept no more than 2 or maximum 4ppm chromium i.e. 2 to 4mg Cr^{+3} per litre it is established in the tannage in short-float at elevated temperature although induces higher chrome fixation and better bath exhaustion, is not sufficient to ensure reduction of chrome level in the effluent stream which may meet the standard. Conductivity (or Resistivity) as a Derivative or Ohm's Law Ohm's law which state that the potential difference between two terminals is directly proportional to the quality of electric current flowing through the circuit provided temperature and other physical conditions are kept constant.

Mathematically

$V \alpha I$

$V = IR$

The value for the resistance for each soil sample can be determined using the relation

$R = V/I$

V = potential different between two terminal measured by volt meter in volts (v).

I = quantity of electrical current measured by ammeter in ampere (A) knowing the value for resistance of each soil sample, the resistivity (P) can be calculated using the relation.

Resistivity (P) = RA/L or conductivity = L/RA

Conductivity is measured in siemen per meter (S/M)

A = cross – sectional area of the copper plate measured in meter square (m^2).

(9) Factors Affecting Soil Electrical Conductivity

The factor/properties affecting soil electrical conductivity are as follows: soil pit, temperature, porosity and texture, moisture content compatibility among other, cation exchange capacity etc. **(10) Soil PH** This is defined as the negative of logarithm of the molar hydrogen ion H^+ concentration. Mathematically PH = –log (H^+) [4]. Soil PH is a relative measure of the acidity of the soil i.e. the amount of hydrogen ion (H^+) present. When hydrogen ion dominates, PH less than 7u, the soil is classified as acid. When hydroxide ion (OH) dominates, PH greater than 7 then is classified as alkaline. Under acid condition, element such as iron, aluminum, manganese and other heavy metals such as zinc, copper and chromium etc become highly soluble and may create problem for vegetable. Aluminum at PH 4 is readily available and highly toxic to plants. [5]. High concentration of sodium for example will produce an alkaline soil reaction (PH > 8.5) when soluble salts dissolved in water to form irons, there is a decrease in electrical resistance [6].

(11) Temperature

This is an important factor which also affects soil electrical conductivity. Temperature is defined as the degree of hotness or coldness of a body/system. As temperature of a soil decreases towards freezing point that is 32^0F or water, soil electrical resistivity increase slightly this brings about decrease in electrical conductivity. Below freezing point, soil pores becomes increasingly insulated and soil electrical resistivity increase. At this temperature, therefore, many molecules of water begin to freeze and hence lead to decrease in the number of free moving electron [7].

(12)Moisture Content

This refers to the amount of water that may be present in a soil dry soil has been found to be highly resistive than a moist soil. The more the water in a soil the lower the electrical resistivity. Similarly, the higher the temperature of a soil the higher the rate of evaporation of water molecule from the soil and thereby leads to an increase in the resistivity of the soil.

(13)Compatibility

Compacted soil conducts electricity better than un-compacted soil, due to the elimination of air-spaces and the increased soil particle to particle contact. However electrical resistivity is increased with decrease in moisture content. It reaches a minimum value at approximately the optimum moisture content. Beyond that point, the electrical resistivity decrease slightly.

(14) Cation Exchange Capacity (CEC)

Mineral soil containing high level of organic matter (humus) and or 2; 1 ratio clay mineral ratio have a much higher ability to retain positively charged ions (such as Ca^{2+}, Mg^{2+}, K^{+}, Na^{+}, NH_4^{+}, or H^{+}) than soil lacking this constituents. The presence of these ions in the moisture filled soil, reduces soil electrical resistivity and leads to increase in soil electrical conductivity just as salinity does. Ionic content of the pore fluid determines soil electrical resistivity. An increase in ionic content or the amount of dissolved soil in the pores fluid will produce a decrease in electrical resistivity. However the electrical conductivity (EC) varies not only with the concentration of the salts present, but also with the chemical composition of the soil or matric solution.

(15) Soil Pollutants

Pollution can be defined as the direct or indirect alteration of physical biological or radioactive properties of any part of the environment in such a way as to create hazard or danger to health safety or welfare of any living species. In other words, it is the introduction of any harmful substance into the environment. Substances that cause pollution are called pollutants. There are three categories of pollutants namely bio-degradable, non-biodegradable and poisons.

Bio-Degradable

These are substance that are mainly organic products and can be broken down by natural process.

Non-Biodegradable

These are substance that cannot be broken down by any natural means or process e.g. scraps of metals, tins, cans, plastics etc. (16) **Poisons** This includes heavy metals and their salt e.g. lead, mercury, uranium, fungicides etc. Most of pollutants that constitute poisons are usually discharged from industries. There are many way in which pollutants are introduced into the soil. Some of these ways include industrial activities such as steel making, chrome plating, dyes and pigment, leather tanning process, wood preservation etc. this pollutants are discharged into the soil as effluent which are the resulting liquid flow from a waste water treatment. One of the common industries which introduce heavy metals into the top soil is tanning industry whose effluent constitutes high concentration of chromium.

(17) Chromium as an Industrial Effluent

Chromium is a natural occurring element found in rocks, animals, plants, soil and in volcanic dust or gases. It is a chemical element of group VI (b) of the periodic table, it is a hard, steel grey metal that a high polish surface and is used in alloys to increase strength and corrosion resistance. Chromium is the 17th most abundant element in the earth's crust; it has the atomic number of 24 and has a common oxidation state of +6, +3 and +2 respectively. A few unstable compounds of +5, +4, and + however, are known in the hexavalent state the most important, species formed by chromium are the chromate (VI), CrO_4^{2-} and dichromate $Cr_2O_7^{2-}$ ions. The ions form the basis for a series of industrially important salts. Among them are sodium chromate $NaCrO_4$ and sodium dichromate Na_2CrO_7 which are used in leather tanning in metal surface treatment, and as catalyst in various industrial processes. General, effluents have a standard for discharge into the environment (top soil) as give by the standards/guidelines for the discharge of effluent.

Methodology

Soil sample of both contaminated and uncontaminated sample by chromium solution from tannery effluent about 50g of soil sample was collected from different site within the institute the soil sample was taken to soil science department for electrical resistivity analysis at institute of agricultural research Ahmadu Bello University. The laboratory test was carried out according to standard.

Apparatus/equipment

PH meter
Distilled water
50cm^3 measuring cylinder
Weighing balance
Stirrer
Beaker
2 g of soil sample

Procedure

2 g of the soil sample was weigh using weighing balance and transfer into the beaker in which 50cm^3 of measuring cylinder is fill with 50cm^3 of distilled water, it was stirred for 5 minutes and allow it to settle for 1 to 2 hours. Finally, the supernatant of sample solution was decanted into other beakers and electrode of the PH meter was inserted partially into the water, so that the reading was taking.,

APPARATUS

Voltmeter
Ammeter
Long copper wire
Circular copper plate of different diameter with small hole the centre
Hose of various lengths
Cross sectional copper wire
Connecting wire
Clamp

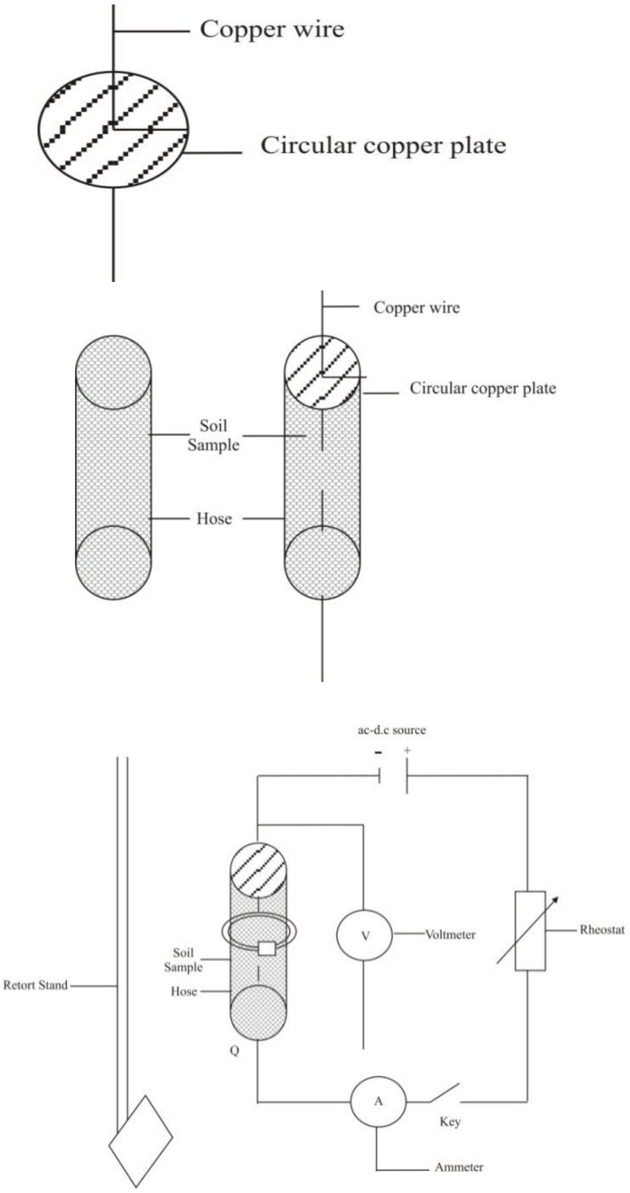
Procedure

Various lengths of 11.5cm, 9cm, 7cm, 5cm and 3cm of various hose of constant cross sectional area of 0.196cm^3

was use. Soil sample was fill in the hose in which both end was covered with a circular copper plate the matched with each of hose. A copper wire was passed through a small hose which was create on the circular copper plate which is just long enough to pass through soil sample at both end. Similarly various hose of cross-sectional area of $0.196cm^3$ $0.385cm^3$ and $0.502cm^3$ was also use with a constant length of 11.5cm was use and the experiment was carry out as shown below.

Cylindrical hose containing the samples

***Fig.1** the circuit diagram for the investigation*



As soon as the circuit is completed, the lock volt power supply which has the capacity of converting 4A A.C to 4A D.C with a manufactures name as griffin and George ltd was set in connection according to circuit above. The lock volt was calibrated as follows 2V, 4V, 6V, 9V, 12V, and 14V respectively. The key was close, current flows and the voltmeter (v) was recorded in the lock volt is varied, the corresponding p.d (v) and current (A) was well recorded. The procedure was repeated for various lengths at constant area.

RESULT

TABLE OF RESULT

S/N	SAMPLE	PH	ELECTRICAL CONDUCTIVITY (Ω^{-1})	ELECTRICAL RESISTIVITY(Ω)
1	Uncontaminated	7.14	0.25	4.5
2	Contaminated	8.15	2.00	0.5

Table 1

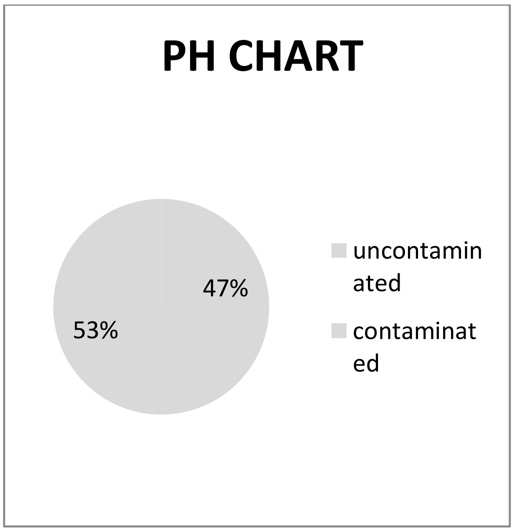


Fig. 2

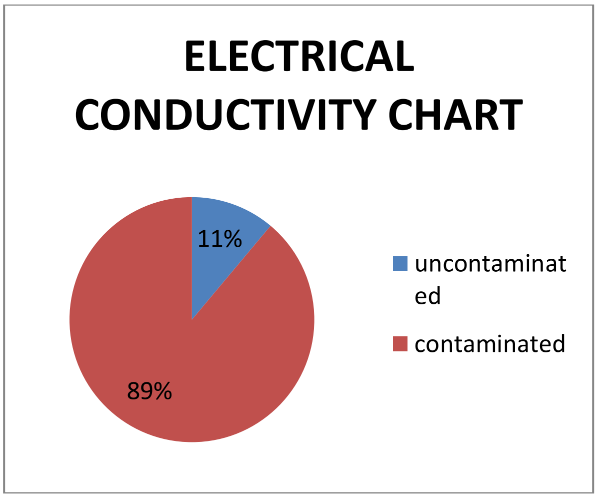
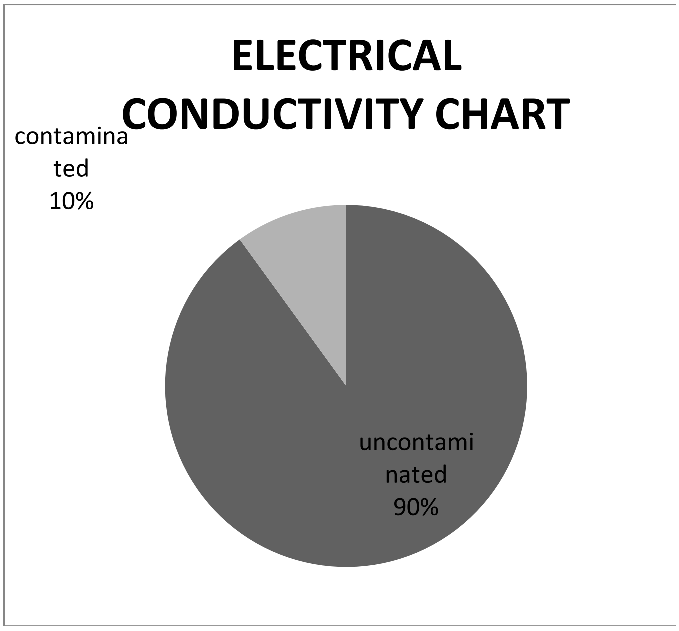


Fig. 3



DISCUSSION

The result in table 4.1 above indicates that the soil PH of the uncontaminated soil is around neutral on the PH scale .That is close to acidity. However when the soil become contaminated with tannary effluent the soil PH greatly increase to a alkaline value 8.15.the implication of this result is that plant nutrient become available according the soil PH level. most plant slightly acidic soil because that PH afford them as good access to all nutrients. By implication since the soil has become basic this will reduce the availability of plant to have access to the soil nutrient .yellowing between the veins of young leaves indicates an iron deficiency a condition arising not farm a lack of iron in the soil but from insufficient soil acidity to put iron in to a farm that a plant can absorb. Considering the table 1. above an electrical conductivity, the results shows that the soil conductivity increases for the uncontaminated to contaminate with a value of 80%. The electrical conductivity of water is actually a measure of salinity. Excessively high salinity can effect plant and cause specific toxicity of a particular ion and causes higher osmotic pressure around the root prevents an efficient water absorption by the plant. By implication soil resists the flow of electricity. It is a critical factor in design of systems that rely on passing current through the earth's surface. Soil electrical resistivity is necessary to design the grounding. System in a electrical substation or far lighting conductors the table above shows a 80% reduction in soil resistivity from uncontaminated to contaminated soil. This high value will affects soil moisture content reading to poor plant growth and death of living organisms.

CONCLUTION

The result from this study shows that the discharge of effluent into the environment in Nigeria institute of leather and science technology has a high degree of pollution due to following reason; The uncontaminated PH for the soil sample was around the neutral value (7.14) on the PH scale but become alkaline when contaminated .By implication a reduction of iron content in the soil. The electrical conductivity of the soil sample from uncontaminated to contaminate was raised to about 80%. This implies high salinity to plant ion and causes higher osmotic pressure around the roots. There is also reduction in electrical resistivity to about 80%. This result will affect soil moisture content leading to poor plant growth and death of living organism

REFERENCES

[1] Bouyocos, George john (2002). Hydrometer improviser for making particulate size analysis of soil page 464-465.

[2] Chairman P.E. V. and Murphy, B.W. Eds (2000). Soil properties and management soil conservation and handbook for New South Wales. Sydney University Press.

[3] Rhodes, J.D, N.A. Manteghi, P.K Shouse and W.J. Alves (2000). Soil electrical conductivity and soil salinity: new formulation and calibrations. Soil science. Soc Am J. 53 433-439.

[4] Darrell, D.E. (1993) General Principle Chemistry 4th Edition page 664.

[5] Patterson, R.A. (2008) Soil Capabilities for Onsite Waste Water Treatment and Diosposal. Lantax Laboratories Armidale.

[6] Patterson, R.A (1999) Production fn Environmental Monitoring Workshop Paper No. PEM 9 Soil and the Effect of Effluent Page 5.

[7] Tom Doerge (2009), Soil Electrical Conductivity Mapping. Crop in sights, Vol. 9 No. 9.