ISSN (Print): 2734-259X | ISSN (electronic): 2734-2603

NIGERIAN JOURNAL OF ENVIRONMENTAL SCIENCES AND TECHNOLOGY (NIJEST)

In Affiliation with The Nigerian Environmental Society (NES)

https://www.nijest.com

Volume 4 | Number 1 | March 2020

NIJEST

NIJEST / Nig. J. of Env. Sci. & Tech. 4 (1), March 2020

www.nijest.com

NIGERIAN JOURNAL OF ENVIRONMENTAL SCIENCES AND TECHNOLOGY (NIJEST)

https://nijest.com

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A

PUBLICATION OF

FACULTY OF ENVIRONMENTAL SCIENCES

UNIVERSITY OF BENIN

IN

AFFILIATION WITH

THE NIGERIAN ENVIRONMENTAL SOCIETY

Published by:

The Faculty of Environmental Sciences

University of Benin

P.M.B 1154, Benin City, Edo State, Nigeria

E: editor-in-chief@nijest.com

In Partnership with

Mindex Publishing Co. Ltd.

22, Benin Technical College Road,

Ugbowo, P. O. Box 5089, Benin City, Nigeria

Tel: +234802 345 3848, 803 740 4398, 805 475 5695

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The Faculty of Environmental Sciences,
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Nigerian Journal of Environmental of Environmental Sciences and Technology (NIJEST)
Journal available online at http://www.nijest.com **Vol 4 No. 1 March 2020**
ISSN (Print): 2734-259X | ISSN (electronic): 2734-2603

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Nigerian Journal of Environmental of Environmental Sciences and Technology (NIJEST)
Journal available online at http://www.nijest.com Vol 4 No. 1 March 2020
ISSN (Print): 2734-259X | ISSN (electronic): 2734-2603

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www.nijest.com
ISSN (Print): 2734-259X | ISSN (electronic): 2734-2603
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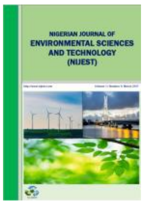

Assessment of Heavy Metals, Organic Carbon and Physico-Chemical Properties of Roadside Dust from a Nigerian School Campus

Olayinka O.D. [1,*], Nwosu F.O. [1], Ahmed S.O. [1], Fabiyi S.F.[2] and Ajala O.J.[1]
[1]Department of Industrial Chemistry, Faculty of Physical Sciences, University of Ilorin, Ilorin, Nigeria
[2]Department of Chemistry and Industrial Chemistry, Bowen University, Iwo, Osun State, Nigeria
*Corresponding Author: yinkaolusojid@gmail.com

https://doi.org/10.36263/nijest.2020.01.0140

ABSTRACT

University of Ilorin is one of the most populated Universities in Nigeria. Roadside dust was collected from the busiest roads of the university permanent site and level of heavy metals (Fe, Cu, Zn, Cd and Pb), organic carbon and physico-chemical properties of the dust were assessed. Atomic Absorption Spectrometry (Buck Scientific 210/211VGP) was used to analyse for heavy metals while appropriate standard methods were employed for the determination of organic carbon, pH, conductivity, particle density and bulk density of the roadside dust. The pH of dust from all roads was almost alkaline (7.2 – 7.6), particle density ranged from 1.60 - 2.14 gml^{-1}, bulk density ranged from 1.03 – 1.62 gml^{-1}, electrical conductivity ranged from 0.25 to 0.57μScm^{-1}, organic carbon (OC) content of all roadside dust ranged from 0.9 % - 1.2 %. While Pb was obtained to be absent in all the roadside dust samples, it was observed that the abundance of other heavy metals at all the various sampling points and control followed the order Fe >>>Zn >> Cu > Cd. The average level of Fe in the control site was 2443.85 mg/kg which was very lower to that from other sites in the study. The results for the metal pollution index (MPI) show that all the roads were polluted with Fe, Cu, Zn and Cd. The levels of the metals showed a dependence on anthropogenic pollution such as vehicle density compared with the control site.

Keywords: Roadside Dust, Heavy Metals, Organic Carbon, University Campus

1.0. Introduction

Particulate matter (PM) is the solid and liquid particles dispersed into ambient air. Roads are characterised by generation of PM inform of dust particles which have been realised to be popular form of air pollution in cities and towns. Road dust is generated by lifting of roadside soil particles as a result of movement by vehicles, pedestrian and other human activities. The dust usually deposits and accumulates on ground surfaces, along roadsides, which is usually contaminated by heavy metals and organic matters (Marchand *et al* 2011). Heavy metals are characterized by high stability in the environment and generally are not biodegradable or leached (Mmolawa *et al*., 2011). The ability of soil to accumulate heavy metals is associated with its type, texture and chemical properties as well as the nature of the individual heavy metal (Kabata-Pendias, 2011). Moreover, human activities contribute to the increase in the levels of metal contamination in the road dust due to vehicle exhaust particles, tire wear particles, weathered street surface particles, brake lining wear particles, emission from power plants, coal combustion, metallurgical industry, auto repair shop and chemical plant (Nasser *et al.*, 2012). Other anthropogenic activities include domestic emission, weathering of building and pavement surface, atmospheric deposition and so on (Nwosu and Olayinka, 2019). Accumulation of heavy metals in the soil disrupts the usual biochemical processes taking place in it, which can in consequence have a negative effect on the biological activity (Zawadzka and Lukowski, 2010). Road dust, particularly the fine particle, can get into human body through ingestion, inhalation, and dermal absorption, which consequently becomes hazardous to the body (Kinney and Lippmann, 2000). Therefore, the determination of metal in environmental samples like dusts is very necessary for monitoring environmental pollution.

Various studies outside Nigeria such as that of Obaidullah *et al.,* (2015) characterized indoor PM into three sizes of particles such as PM_1, $PM_{2.5}$ and PM_{10} at three different enclosed parking garages in two cities of Belgium with varying vehicle intensity and varying layout with results indicating average particles mass concentrations in garages ranging from 28 µg/Nm^3 to 50 µg/Nm^3 for PM_1, 43 µg/Nm^3 to 60 µg/Nm^3 for $PM_{2.5}$ and 58 µg/Nm^3 to 90 µg/Nm^3 for PM_{10}. Suryawanshi *et al.,* (2016) measured the concentration levels and sources of heavy metals contamination in road dust samples collected from industrial, highways, residential and mixed use in Delhi, India. Metal content in road dust was analyzed with results indicating high concentration levels of Ni, Cr and Pb in industrial areas. Also, the levels of toxic heavy metals like Pb, Cd, Co, Ni, Zn, Cr, Mn and Total Petroleum Hydrocarbons (TPH) were determined in the roadside topsoil collected near a national highway of Upper Assam-India by Arundhuti and Pranjal (2014). It was observed that heavy metal concentrations were higher in polluted sites than the control site.

Various studies in Nigeria like that of Mafuyai *et al.*, (2015) had observed Cu concentration to range from 24.5 – 67.0 mg/kg, Pb 25.0 – 66 mg/kg, Ni 1.23 – 3.88 mg/kg, Zn 35.0 – 123 mg/kg, Fe 48.5 – 125 mg/kg, Cd 1.54 – 2.58 mg/kg, Mn 1.15 – 2.58 mg/kg and Cr 1.13 – 2.79 mg/kg in the roadside dust from five major traffic roads in Jos metropolitan area which showed that accumulation of heavy metals in soil dust was greatly influenced by traffic volume and there was a significant reduction in roadside dust when moving away from the road. A study carried out by Nwosu *et al.,* (2016) to measure the heavy metal loading in dust fall from some universities in Nigeria and that carried out by Nwosu and Olayinka (2019) for chemical components of dust fall at various motor parks in the University of Ilorin had shown higher levels of metals. However, a minute study have been carried out to measure heavy metals in the road side dust in school campuses especially, University of Ilorin, Nigeria. This present study was carried out to investigate the levels of heavy metals from the busiest roads of University of Ilorin permanent site campus. The levels of Organic Carbon and physic-chemical properties of the dust were also obtained.

2.0. Materials and Methods

2.1. Study area

The University of Ilorin is an academic institution, located in Ilorin, Kwara State, North Central of Nigeria. The university is one of the most populated Universities in Nigeria with about 30,084 number of student as at 2017. This study was carried out in the permanent site of the University, located within the latitude (8^{o}30´N) and longitude of (4^{o}40´E). The roadside dust samples were collected from the busiest roads in the University (as provided in Figure 1) in November 2016 and February; April; May, 2017. Table 1gives the names and description of the sampling road sites.

2.2. Sampling method

The road side dust samples were collected from the side of the roads with clean plastic dust pan and brush (Nasser *et al*., 2012) while the surface soil was collected by sweeping the soil with new hard brooms to a debt of about 1cm. Each sample was taken by mixing together three sub-samples obtained at about 1m distance to each other along the sampling roads as shown in Figure 1. Such sampling strategy was adopted in order to reduce the possibility of random influence of urban waste (Glewa and Al-Alwani, 2012). The samples were transported into the laboratory in clean sealed polythene bags where they were air dried to get rid of moisture, grounded into fine powder using mortar and pestle. Dry samples were sieved with 0.125mm standard sieve and homogenized (Adaramodu *et al.,* 2012). The sieved samples were then packed in a properly tied polythene bag and ready for analysis.

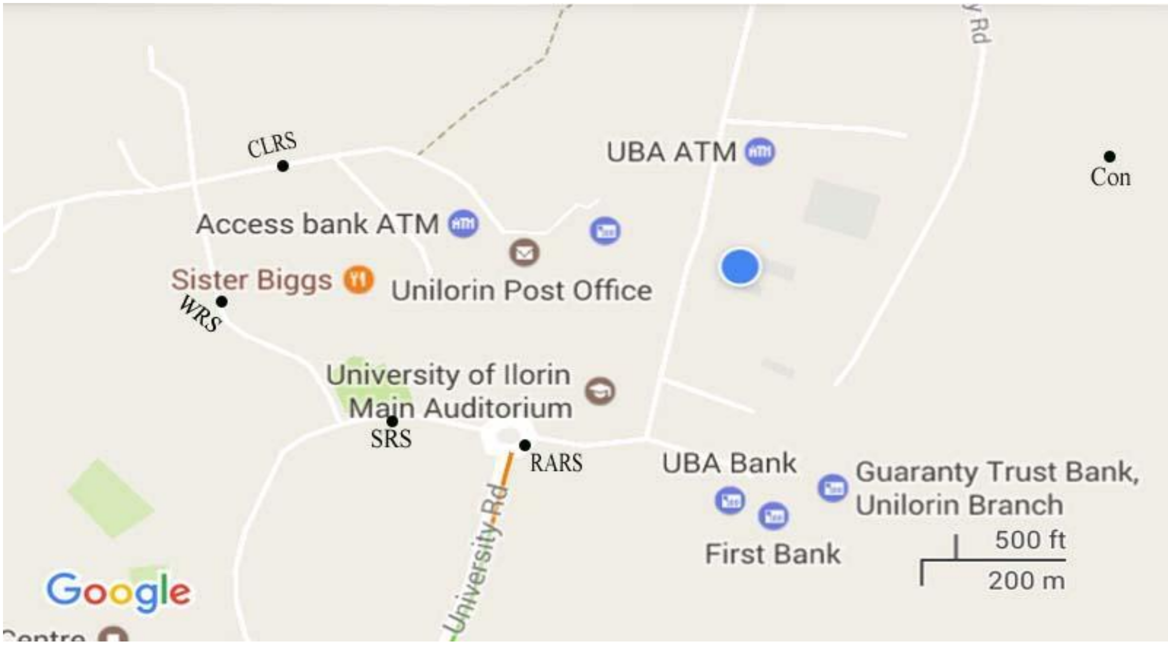

Figure 1: Map of University of Ilorin indicating the roads of study

Table 1: Names and description of sampling road sites

Sites	Name of sites	Traffic density (hr^{-1})	Description
WRS	West Park Road Side	1561	Characterised with roadside trees and connected the major motor parks to various food canteens on campus.
SRS	South Park Road Side	622	With high commercial activities in metal container shops and passed the side of the first park leading to the school auditorium.
CLRS	Clinic Road Side	53	Characterised by roadside trees and passed in front of the school clinic leading to the school library and the motion ground.
RARS	Round About Road Side	863	School central round - about, in front of the senate building where almost all the private vehicles must pass.
Con	Control	-	The control surface soil sample, Con was taken from an agricultural farmland at about 5 km from the road side.

2.3. Particle and bulk density determination

Bulk density of a substance is the mass per unit volume of dry soil in its natural state. For bulk density, soil mass was determined by subtracting the mass of an empty cylinder from the mass of the same cylinder when containing soil sample (after it's been stabbed on a table for 132 times). The volume of the sample was also noted on the cylinder after the stabbing on the table. Bulk density was then determined using Equation (1).

$$B_d\,(g/cm^3) = \frac{soil\ mas}{soil\ volume} \qquad (1)$$

Also, for particle density, the mass of sample was first determined by subtracting the mass of an empty curvet from the mass of the curvet when it was filled with sample. After this, a measuring cylinder was filled with water and the volume of water in the cylinder was noted. The same curvet while empty was dipped inside the cylinder containing water such that the increase in the level of water was recorded. The same curvet, after it was filled with dust sample was well dipped inside the measuring cylinder containing water. The increase in volume of water level in the cylinder was also noted. The volume of the sample was then determined by subtracting the increase in volume of water for the empty curvet from the increase in volume of water for curvet containing sample. The particle density was therefore calculated using Equation (2).

$$P_d(g/cm^3) = \frac{massofsample}{volumeofsample} \quad (2)$$

2.4. pH and conductivity

Soil pH is an indication of the acidity or alkalinity of the soil and is measured in pH units. The sample pH and conductivity were measured with well calibrated pH meter and conductivity meter respectively using sample slurry prepared with distilled water. The conductivity of soil sample was determined using the prepared sample for pH with a conductivity meter.

2.5. Organic carbon determination

The organic carbon content of the dust samples was determined following the Walkey-Black Procedure (Adedeji *et al*., 2013). A known mass of pulverised dust sample (2g) was weighed into a dry 250 mL conical flask. A 10 mL of 1 N $K_2Cr_2O_7$ was added and swirl gently to disperse the soil in the solution. This was followed by adding a 20 mL of concentrated H_2SO_4 with proper swirling until proper mixture. A 200°C thermometer was inserted into the mixture as the mixture was being heated and swirled on a hot plate until the temperature reaches 135°C. After this, the heated sample was set aside to cool slowly on an asbestos sheet in a fume cupboard. When cooled (20–30 minutes), it was diluted to 200 mL with deionised water and titrated with the 0.4 N $FeSO_4$ adding 3 or 4 drops "ferroin" indicator. As the end point is approached, the solution became greenish colour, changed to a dark green and finally until the colour changed sharply to reddish-grey. Two blanks were run in the same way to standardise the $FeSO_4$ solution. The Organic Carbon was then computed using the Equation (3).

$$Organic\ Carbon(\%) = \frac{[0.003g \times N \times 100ml \times (1 - T/S) \times 100]}{ODW} \quad (3)$$

Where N = Normality of $K_2Cr_2O_7$ solution, T = Volume of $FeSO_4$ used in sample titration (mL), S = Volume of $FeSO_4$ used in blank titration (mL), ODW = Oven-dry sample weight (g).

2.6. Digestion for heavy metals

A known mass (2g) of dust samples were treated by adding mixture of concentrated nitric acid (HNO_3), sulphuric acid (H_2SO_4) and hydrofluoric acid (HF) in10 ml, 2 ml and 1 ml respectively to the measured dust sample in a 250 ml beaker. The content of the beaker was heated up to 250ºC until partial dryness. The beaker was then cooled, washed with distilled water and filtered using Whatman filter paper (42). Clear solution (filtrate) was transferred into 25 ml standard volumetric flask and completed to the mark with double-distilled water (Nasser *et al.*, 2012). The concentration of heavy metals (Cd, Cu, Fe, Pb, Mn and Zn) in the samples was then determined using an Atomic Absorption Spectrometry (Buck Scientific 210/211VGP) instrument with a detection limit of 0.01, 0.005, 0.05, 0.08, 0.03, 0.005 mg/L for Cd, Cu, Fe, Pb, Mn and Zn respectively. A standard solution for each element under investigation was used for calibration of the instrument. Blank samples were also analysed.

2.7. Traffic density

The estimation of the traffic on various roads was conducted in duplicate during the periods of heavy traffic.

2.8. Contamination factor (C_F) and degree of contamination (C_D)

The contamination factor (Equation (4)) and degree of contamination (Equation (5)) as given by Khairy *et al.,* (2011) were followed.

$$C_f = \frac{C_s}{C_b} \tag{4}$$

$$C_d = \sum_{i=1}^{N} C_f \tag{5}$$

Where N is the number of metals analysed, Cs is the measured concentration of the examined metal in the dust sample and Cb is the geochemical background concentration or reference value for heavy metals in the uncontaminated soil (Khairy et al., 2011).

2.9. Modified contamination degree

The Modified Contamination Degree (mCd) is the degree of contamination C_d for a given set of pollutants divided by the number of analysed pollutants. The modified equation for a generalised approach to calculating the degree of contamination as given by (Alfred *et al*.; Sarala and Uma, 2013) is shown in Equation (6).

$$mCd = \frac{C_d}{N} \tag{6}$$

Where N is the number of metals analysed and C_d is calculated as in equation (5).

2.10. Metal pollution index

The MPI was obtained using the relationship given by Sarala and Uma, (2013).

$$MPI = \ log \sum_{i=1}^{N} \frac{x}{ref_i} \tag{7}$$

Where; ref_i represents a background or reference value for each of the analysed metals, N is the number of metals analysed and x represents mean value of metal concentration from the study area.

2.11. Geo-accumulation index (I_{geo})

The geo-accumulation index (Igeo) was estimated for the degree of contamination of various metals at various sites following the relationship given in Equation (8) (Nweke and Ukpai, 2016).

$$I_{geo} = \ log_2 \frac{C_i}{1.5Ref_i} \tag{8}$$

Where C_i is the concentration of i metal in the roadside and Ref_i is the background or reference concentration value of metal i and factor 1.5 is to minimise the effect of possible variations in the background values.

3.0. Results and Discussion

3.1. Physico-chemical properties of roadside dust

The Table 2 depicts the results of particle density. The value of particle density for November ranged from the values 1.69 ± 0.04 gml^{-1} for WRS to 1.92 ± 0.01 gml^{-1} for RARS, February ranged from the values 1.57 ± 0.01 gml^{-1} for CLRS site to 2.22 ± 0 gml^{-1} for RARS site, April ranged from values 1.58 ± 0.01 gml^{-1} for CLRS to 2.1 ± 0.02 gml^{-1} for RARS site and the May ranged from values of 1.52 ± 0.01 gml^{-1} for CLRS site to 2.31 ± 0.02 gml^{-1} for RARS site. The average particle density for all sites ranged from 1.60gml^{-1} for CLRS to 2.14 gml^{-1}for RARS. The particle density is higher if large amount of heavy minerals is available in the soil and therefore leads to decrease in the level of organic matter in the soil (MAIB, 2017). This means that the dust from RARS could contain more minerals than others while the CLRS had the least mineral content.

As given in Table 2, the values of bulk density for November ranged from the values 0.80 ± 0 gml^{-1} for Con site to 1.31 ± 0 gml^{-1} for RARS, February ranged from the values 1.07 ± 0.26 gml^{-1} for CLRS site to 2.07 ± 0.93 gml^{-1} for RARS site, April ranged from the values 0.89 ± 0.07 gml^{-1} for CLRS site to 1.05 ± 0.19 gml^{-1} for the Con site and the May ranged from the values of 1.06 ± 0.21 gml^{-1} for Con site to 1.45 ± 0.06 gml^{-1} for RARS site. The average bulk density for all sites ranged from 1.03 – 1.62 gml^{-1}. The bulk density of soil depends greatly on the mineral make up of soil and the degree of compaction (ScienceDirect, 2017). Bulk density decreases as the mineral soils become finer in texture and it gives a good estimate of soil porosity (MAIB, 2017). Meanwhile, the smaller the dust particle, the stronger its potential impact on human health because it can be more easily inhaled (USEPA, 2005). Therefore, the RARS with average bulk density of 1.62gml^{-1} could be more prone to health hazard.

The pH values for various sites are shown in the Table 1. The average pH for Con was observed to be 6.2 which indicate that the soil from the control site is slightly acidic. The pH from all the roads were almost alkaline 7.2 – 7.6. This indicates neutralizations as a result of alkaline deposition from the atmosphere. Also, metals and ash from anthropogenic could also be source of neutralization (Mafuyai *et al.,* 2015). High pH values might reduce the mobility of some metal species down the soil strata while low pH value usually enhances metals distribution and transport in soil (Idzi *et al,* 2013).

Table 2 shows the electrical conductivity (EC) from various sites. The average EC at various sites were obtained for RARS as 0.53µScm^{-1}, WRS as 0.29µScm^{-1}, SRS as 0.47µScm^{-1}, CLRS as 0.25µScm^{-1} and Con as 0.57µScm^{-1}. The electrical conductivity of a solution indicates the total concentration of ions. The highest EC being 0.57µScm^{-1} for Con shows that there were likely more ions in the Con sample than others. These ions which is necessary not of heavy metals could be of simple mineral elements like sodium, magnesium and others. However, samples RARS (0.53µScm^{-1}) and SRS (0.47µScm^{-1}) had values higher than .^{values} (ABW; 0.23 µScm^{-1}, BRR; 0.21 µScm^{-1}, MMW; 0.18 µScm^{-1}, YGW; 0.31 µScm^{-1} and GJR; 0.24 µScm^{-1} for some major traffic roads in Jos metropolitan area of Nigeria by Mafuyai *et al.,* (2015).

3.2. Total organic Carbon in roadside dust

As given in Table 2, the average organic carbon (OC) content of various roadside dust and control ranged from 0.9 % for RARS and Con to 1.2 % for CLRS. Decaying grasses and leaf shed from trees along the road could be the contributors to the level of organic carbon. The Bauchi Ring Road in the study of Mafuyai *et al.,* (2015) had 3.20% while it Con had 4.64% which were greater than that of this study in University of Ilorin roadside dust.

Table 2: Levels of physico-chemical properties at various sites (N=2)

Samples	Parameters	November	February	April	May	Average
RARS	pH	6.13 ± 0.01	6.86 ± 0.03	7.45 ± 0.01	8.23 ± 0.06	7.2
	EC (μScm^{-1})	0.32 ± 0.05	1.26 ± 0.03	0.40 ± 0.07	0.13 ± 0.01	0.53
	Particle Density (gml^{-1})	1.92 ± 0.01	2.22 ± 0	2.1 ± 0.02	2.31 ± 0.02	2.14
	Bulk Density (gml^{-1})	1.31 ± 0	2.07 ± 0.93	1.65 ± 0.01	1.45 ± 0.06	1.62
	OC (%)	1.19 ± 0.02	1.03 ± 0.03	1.14 ± 0.01	0.24 ± 0.01	0.9
WRS	pH	6.76 ± 0.06	7.10 ± 0.01	7.39 ± 0.01	8.87 ± 0.05	7.5
	EC (μScm^{-1})	0.25 ± 0.09	0.25 ± 0.01	0.58 ± 0.23	0.08 ± 0.01	0.29
	Particle Density (gml^{-1})	1.69 ± 0.04	1.63 ± 0.02	1.62 ± 0.02	1.58 ± 0.01	1.63
	Bulk Density (gml^{-1})	1.17± 0	1.23 ± 0.30	1.25 ± 0.15	1.39 ± 0.21	1.26
	OC (%)	1.21 ± 0.01	1.04 ± 0.01	1.03 ± 0.03	0.78 ± 0.04	1.02
SRS	pH	6.82 ± 0.03	7.63 ± 0.01	7.03 ± 0.03	8.54 ± 0	7.5
	EC (μScm^{-1})	0.77 ± 0.22	0.23 ± 0.01	0.81 ± 0.11	0.06 ± 0	0.47
	Particle Density (gml^{-1})	1.8 ± 0.01	1.72 ± 0.06	1.67 ± 0.01	1.71 ± 0.02	1.73
	Bulk Density (gml^{-1})	0.87± 0	1.32 ± 0.09	1.15 ± 0.25	1.44 ± 0.06	1.10
	OC (%)	1.18 ± 0.03	0.92 ± 0.03	1.22 ± 0.03	0.71 ± 0.03	1.0
CLRS	pH	7.26 ± 0.01	6.68 ± 0.03	7.49 ± 0.03	8.93 ± 0.03	7.6
	EC (μScm^{-1})	0.31 ± 0.02	0.31 ± 0.02	0.35 ± 0.04	0.04 ± 0	0.25
	Particle Density (gml^{-1})	1.74 ± 0.01	1.57 ± 0.01	1.58 ± 0.01	1.52 ± 0.01	1.60
	Bulk Density (gml^{-1})	0.92 ± 0	1.07 ± 0.26	0.89 ± 0.07	1.22 ± 0 .33	1.03
	OC (%)	1.30 ± 0.02	1.01 ± 0.06	1.26 ± 0.01	1.19 ± 0.01	1.2
Con	pH	6.24 ± 0.01	6.62 ± 0.02	7.15 ± 0.04	8.25 ± 0.07	6.2
	EC (μScm^{-1})	0.42 ± 0.06	0.65 ± 0.04	0.67 ± 0.03	0.53 ± 0.01	0.57
	Particle Density (gml^{-1})	1.83 ± 0.02	1.82 ± 0.01	2.1 ± 0.02	2.0 ± 0.04	1.94
	Bulk Density (gml^{-1})	0.80 ± 0	1.87 ± 0.34	1.05 ± 0.19	1.06 ± 0.21	1.20
	OC (%)	1.04 ± 0.01	0.84 ± 0.02	0.84 ± 0.02	0.89 ± 0.02	0.9

(EC) Electrical Conductivity, (OC) Organic Carbon, (±) Standard Deviation

3.3. Heavy metals in roadside dust

The results for monthly concentration of heavy metals in the road side dust samples and traffic density at various roads are as shown in the Table 3. Pb was observed to be absent in all samples from various sites. This could mean that Pb was not present in the campus soil or probably not generated by vehicular activities from the combustion engine of the vehicles because it was not present in their fuels. Although Fe is naturally abundant in the environment and it is needed in the body with its deficiency leading to anaemia, higher ingestion of Fe may acutely poison young children. It also causes conjunctivitis and retinitis if it continuously remains in the tissues after contact (Lenntech, 2005). In this study, Fe was found to be the major heavy metal which was in line with the observation of Shinggu *et al.*, (2007) in Adamawa, Nigeria. The average level of Fe in the control site was 2443.85 mg/kg which was very lower to that from other sites in this study. The average concentration of Cu for CLRS and Con were very close such that they had 2.7 and 2.8 mg/kg respectively which were lower than that of other sites with higher traffic densities. The average value of Zn for SRS (19.65 mg/kg) was lower than that of Con (25.1 mg/kg). However, that of Con (25.1 mg/kg) was very close to that of CLRS (28.95 mg/kg). A prolonged inhalation exposure to Cd can affect a variety of organs in the body with the kidney being the principal target (Glewa and Al-Alwani, 2012).

Table 3: Monthly levels of heavy metals (N=2), average heavy metals and traffic densities at various sites

Samples	Heavy metal	Nov (mg/kg)	Feb (mg/kg)	Apr (mg/kg)	May (mg/kg)	Average (mg/kg)
RARS	Fe	8990.81 ± 197.9	3380 ± 68.1	15116.13 ± 192	3917.38 ± 47.4	7851.1
	Cu	2.91 ± 0.06	5.28 ± 0.05	8.29 ± 0.05	1.61 ± 0	4.5
	Zn	18.78 ± 0.07	41.86 ± 0.06	58.16 ±0.06	5.99 ± 0.03	31.2
	Cd	< 0.01	< 0.01	< 0.01	0.86 ± 0.02	0.2
WRS	Fe	9350.38 ± 133.3	12795.81 ± 80.5	13586.25 ± 113	11575.38 ± 98.5	9491
	Cu	6.41 ± 0.009	3 ± 0.09	5.45 ± 0.02	6.9625 ± 0	13.8
	Zn	39.74 ± 0.04	14.97 ± 0.5	42.21 ± 0.5	28.59 ± 0.04	31.4
	Cd	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
SRS	Fe	4165.19 ± 17.4	5447.75 ± 13.3	1121.75 ± 4.8	27603.44 ± 226	9584.5
	Cu	0.51 ± 0.03	5 ± 0.1	2.24 ± 0.02	8.23 ± 0	4.0
	Zn	8.24 ± 0.02	39.88 ± 0.11	17.89 ± 0.1	12.6 ± 0.04	19.7
	Cd	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
CLRS	Fe	4640.88 ± 19.1	5097.94 ± 63.6	2559 ± 30.8	10473.56 ± 7.2	5692.8
	Cu	1.86 ± 0.02	0.84 ± 0.02	2.06 ± 0.03	6.11 ± 0.009	2.7
	Zn	13.33 ± 0.01	7.9 ± 0.4	39.72 ± 0.1	54.84 ± 0.03	28.9
	Cd	< 0.01	< 0.01	4.75 ± 0.2	< 0.01	1.2
Con	Fe	1242.94 ± 20.2	1299.56 ± 28.7	3852.94 ± 17.2	1242.9 ± 0.4	2443.9
	Cu	0.44 ± 0.03	0.75 ± 0	3.68 ± 0.02	1.51 ± 0.07	2.8
	Zn	5.66 ± 0.03	5.45 ± 0.05	41.56 ± 0.1	11.53 ± 0.02	25.1
	Cd	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01

(±) Standard Deviation, (-) Not Available

The least observed concentration in this study was that of Cd which was according to the observation of Nwosu et al., (2016) at Ilorin, Nigeria. It was observed that the abundance of other heavy metals at all the various sampling points and control followed the order Fe >>>Zn >> Cu > Cd.

Table 4 presents the comparison of average level of metal in roadside dust of university of Ilorin with some standards and roads from other cities in Nigeria and beyond. At university of Ilorin campus, average levels of metal in road dust were very low to USEPA standards. They were low to ROMANIA but Cd has closer value of 0.7 mg/kg. The average level of Cu and Zn were lower to that from other studies why Cd was more than obtained by Chen et al, (2010) for Beijing and Pranjal and Arundhuti, (2014) for India.

Table 4: Comparison of average metals from University of Ilorin campus road with standards and roads from other cities

Study	City/Site	Fe (mg/kg)	Cu (mg/kg)	Zn (mg/kg)	Cd (mg/kg)
This Study Average	Ilorin, Nigeria (University Campus)	8154.9	6.3	27.8	0.7
US-EPA Standard Maximum allowable limit	*	50000	4300	7500	85
Romania Standard for Normal Level	*	-	20	100	1
Mafuyai *et al.*, (2015)	Jos Metropolitan Area, Nigeria (Educational institutions, recreational centres, commercial centres)	123	64.2	123	2.1
Suryawanshi *et al.*, (2016)	Delhi (industrial, highways, residential and mixed use)	-	191.7	284.5	2.65
Aktas *et al.*, (2010)	Edrine, Turkey	-	20.04	242.46	-
Chen *et al.*, (2010)	Beijing	-	29.70	92.10	0.22
Bhattacharya *et al.*, (2011)	Anand City, India	-	83.6	66.6	-
Khan *et al.*, (2011)	Pakistan	-	12.98	56.72	0.84
Pranjal and Arundhuti, (2014)	Upper Assam, India (National Highway)	-	21.9	115.22	0.25

(*) Not applicable, (-) Not available

The Pearson Correlation coefficient was estimated to examine the level of relationship between metals as given in Table 5. Positive coefficients were observed for Fe-Cu (r = 0.587) and Cu-Zn (r = 0.422) which means that Fe-Cu and Cu-Zn could have originated from a common anthropogenic source, vehicular activities.

Table 5: Pearson Correlation between various metals in roadside dust of University of Ilorin

Pearson Correlation Coefficient (r)				
Metal	Fe	Cu	Zn	Cd
Fe	1.000	0.587	-0.348	-0.959
Cu		1.000	0.422	-0.526
Zn			1.000	-0.210
Cd				1.000

3.4. Heavy metals and pollution indexes

The world surface rock average concentration of Cu (11.2 mg/kg), Cd (0.3 mg/kg), Fe (46700 mg/kg), and Zn (95 mg/kg) for shale (Emad *et al.* 2012*;* Raju *et al.*, 2012) was considered as the background or reference values. Four classes of contamination factor (C_f) were employed in evaluating the metal contamination levels. These include; Low (C_f<1), Moderate ($1 \leq C_f < 3$), Considerable ($3 \leq C_f < 6$) and Very high ($6 \leq C_f$) (Loska *et al.*, 2004). Also, four categories of contamination degree (C_d) were employed to evaluate metal Contamination degree (C_d) which are; Low contamination degree (< 6). Moderate contamination degree (6-12), Considerable contamination degree (12-24) and Very high contamination degree (> 24) (Sarala and Uma, 2013).The classifications of modified contamination degree (mCd) are: very low ($mCd < 1.5$), low ($1.5 \leq mCd < 2$), moderate ($2 \leq mCd < 4$), high ($4 \leq mCd < 8$), very high ($8 \leq mCd < 16$), extremely high ($16 \leq mCd < 32$) and ultra high ($mCd \geq 32$). MPI distinguishes "polluted" from "non-polluted" environment. An environment is regarded as polluted if MPI > 1 because it means that it has elevated concentrations of trace metals (Sarala and Uma, 2013). The classes of I_{geo} have been given as; class 6; extremely contaminated (I_{geo}> 5), class 5; strongly to extremely contaminated (4 - I_{geo}- 5), class 4; strongly contaminated (3- I_{geo} -4), class 3; moderately to strongly contaminated (2- I_{geo} -3), class 2; moderately contaminated (1- I_{geo} -2), class 1; uncontaminated to moderately contaminated (0- I_{geo} -1) and class 0; uncontaminated (I_{geo} less or equals 0) (Nweke and Ukpai, 2016).

Table 6 shows the results for the pollution indexes. The contamination factors (C_f) for all the metals at all sampling sites showed a low contamination (C_f<1) while it was moderate for Cu (C_f = 1.2) at WRS.

The degree of contamination (C_d) was low (< 6) at all the sampling sites; the modified contamination degree ($_mC_d$) was very low (*mCd< 1.5*) at all the sampling sites. The results for the metal pollution index (MPI) show that all the roads were polluted with Fe, Cu, Zn and Cd (MPI > 1). The geo-accumulation Index (I_{geo}) for all metals at various sites showed that the roads were uncontaminated with the metals except that CLRS was moderately contaminated with Cd (I_{geo}= 1.4).

Table 6: Pollution indexes of metals at various sites

Sites	Fe		Cu		Zn		Cd		C_d	$_mC_d$	MPI
	C_f	I_{geo}	C_f	I_{geo}	C_f	I_{geo}	C_f	I_{geo}			
RARS	0.2	-3.2	0.4	-1.9	0.3	-2.2	0.7	-1.1	1.6	0.4	3.8
WRS	0.2	-2.9	1.2	-0.3	0.3	-2.2	0	*	1.8	0.4	3.9
SRS	0.2	-2.9	0.4	-2.1	0.2	-2.9	0	*	0.8	0.2	3.9
CLRS	0.1	-3.6	0.2	-2.6	0.3	-2.3	4.0	1.4	4.6	1.2	3.7

(*) Not available

4.0. Conclusion

This study has observed that the major roads in the University of Ilorin permanent site campus were not yet contaminated with individual heavy metals such as Fe, Cu, Zn, Cd and Pb because they were found to be below the limit of certain standards such as US-EPA and Romania. However, the results for the metal pollution index (MPI) which is for combination of all metals, showed that all the roads are polluted with heavy metals. There was elevated level of Fe at various roads in the University of Ilorin campus. The geo-accumulation Index (I_{geo}) for all metals at various sites showed that the roads were uncontaminated with the metals except that CLRS was moderately contaminated with Cd. The levels of the metals showed a dependence on anthropogenic pollution such as vehicle density compared with the control site. Therefore, there should be continuous monitoring and proper maintenance such as wetting and paving of various roads. Also, vehicles with old bodies should be avoided evacuated from roads in order to correct the level pollution.

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Cite this article as:

Olayinka O.D., Nwosu F.O., Ahmed S.O., Fabiyi S.F and Ajala O.J., 2020. Assessment of Heavy Metals, Organic Carbon and Physico-Chemical Properties of Roadside Dust from a Nigerian School Campus. *Nigerian Journal of Environmental Sciences and Technology*, 4(1), pp. 1-12. https://doi.org/10.36263/nijest.2020.01.0140

Nigerian Journal of Environmental Sciences and Technology (NIJEST)

www.nijest.com

ISSN (Print): 2734-259X | ISSN (electronic): 2734-2603

Vol 4, No. 1 March 2020, pp 13 - 20

Indoor Sound Pressure Level and Associated Physical Health Symptoms in Occupants within a Students' Housing Neighbourhood in Southwest Nigeria

Orola B. A.

Department of Architecture, Obafemi Awolowo University, Nigeria

*Corresponding Author: olabode.abiodun30@gmail.com

https://doi.org/10.36263/nijest.2020.01.0142

ABSTRACT

This study examined indoor sound pressure level in selected rooms within a students' housing neighbourhood in Nigeria; assessed the self-reported physical health symptoms of the occupants; and analysed the relationships between the two. Sound pressure level was measured in each of the randomly selected 22 rooms at 15-minute intervals between 7hours and 19hours daily through a period of four weeks each during the peaks of both dry and wet seasons. The measurement was done with Data Loggers placed at work plane at the centre of the rooms. Purposive sampling was used to select all the occupants in the selected rooms as well as the two adjoining rooms to fill a questionnaire. This amounted to 696 respondents. The questionnaire, elicited information regarding what each respondent regarded as the most prominent source of noise, their gender, age and complexion, as well as their self-reported physical health status. This study found that a significant 79% of the respondents identified indoor noise sources as the prominent contributor to the acoustic condition in the rooms; that the mean measured sound pressure levels in each room layout ranged from 27.75 dB to 56.29 dB; and that the self-reported physical health symptoms with significantly high percentage of observation were cold, fatigue, and headache. Correlation analysis showed that there was an inverse relationship between the sound pressure level in the rooms and the frequency of observance of cold, fatigue, and headache among the occupants. However, the relationship is more significant during the wet season, and more pronounced in female occupants than in male.

Keywords: Health symptoms, sound pressure level, self-reported health, students' housing, indoor environmental quality.

1.0. Introduction

Acoustic conditions in occupied spaces is one of the main aspects of Indoor Environmental Quality which most scholars agreed have great impact not only on occupants' comfort and performance, but also on occupants' health. However, a review of studies in Indoor Environmental Quality revealed that the relationship between indoor acoustic conditions and occupants' health seems not to have received adequate consideration (Frontczak and Wargocki, 2011). This is especially so in residences as well as other indoor environments outside the office space as evident in Aylward *et al*, (2005). The study remarked that regarding the relationships between aspects of the indoor environment and occupants' health, there has been considerable research into occupational (office or work) environments, while other indoor environments with significant potential health impacts have not enjoyed similar level of examination.

The few Indoor Environmental Quality studies carried out outside the work environment concentrated more on other aspects of the indoor environment aside the acoustic aspect. Oguntoke *et al*, (2010) examined the relationship between Indoor Air Quality and occupants' health; Turunen *et al*, (2014) concentrated on the effect of thermal environment and Indoor Air Quality and occupants' health; and Apte *et al*, (2000) concentrated on an aspect of the Indoor Air Quality. This apparent lack on emphasis on the health impacts of indoor acoustic conditions especially in residences and other non-industrial environments may not be unconnected with the research findings regarding occupants' assessment of different aspects of indoor environment.

Several Indoor Environmental Quality studies have found that out of the several aspects of the indoor environment, the acoustic condition is hardly at the fore front when occupants are asked to assess the relative significance of the different aspect to their health and comfort. Lai and Yik, (2009) showed that the acoustic condition was only next to the thermal condition as the most important contributor to the acceptance of the indoor environment by occupants. Frontczak and Wargocki, (2011) concluded that thermal comfort was ranked by occupants to be of greater significance when compared with other aspects of the indoor environment. Also, De Giuli *et al*, (2012) found that pupils in Italian primary schools complained mostly about thermal conditions especially in warm season. Furthermore, Xue *et al*, (2016) and Kamaruzzaman *et al*, (2016) confirmed that the acoustic condition in residential buildings is far from being regarded as the most significant by occupants.

This may not be enough to deemphasize the impact of the indoor acoustic condition on the physical health of occupants in residential buildings. This is because some other studies have observed significant relationships between the acoustic conditions of occupied spaces and the health of their occupants. Among such studies are Evans and Johnson, (2000), Ana *et al*, (2009) and Lee *et al* (2016). It is however apparent that most of the studies that established relationships between the acoustic environment and occupants' health were carried out within office space and school environments. The impact of the indoor acoustic condition on occupants' health may be better appreciated in residences. This is because that is where occupants of indoor spaces spend about 16 out of the 24 hours of the day and hence are more exposed to the effects of the indoor conditions (Godish, 2016).

One of such residential spaces is the rooms in the students' hostels which are often designed as a sleeping cum study space. Among other scholars, Dahlan *et al*, (2009) showed that the indoor acoustic condition was second in importance to occupants of hostel room spaces, and that it was more important to them than the visual environment. However, the potential impact of this indoor acoustic condition on the physical health of the occupants is yet to be fully explored.

This study therefore examined the relationships between the acoustic condition in the rooms and the self-reported physical health of the occupants within a student's housing neighbourhood in Ile-Ife, Nigeria. This was done through an identification of the most prominent sources of indoor and outdoor noise in the spaces; an examination of measured indoor sound pressure level in the spaces; an assessment of the self-reported physical health symptoms of the occupants; and an analysis of the relationships between the self-reported physical health symptoms and the measured sound pressure level in the spaces.

The studied student housing neighbourhood is within the campus of Obafemi Awolowo University which is located within Ile-Ife. The city is located in South-western Nigeria between latitudes 7^0 28' N and 7^0 34'N and longitudes 4^0 27'E and $4^0$35' E, with an elevation of about 275m above sea level. There are nine main hostel buildings within the students housing neighbourhood. They have a combined capacity of 10,344 students. These are the Murtala Mohamed Post-graduate hall, Adekunle Fajuyi hall, Moremi hall, Ladoke Akintola Hall, Alumni hall, ETF hall, Angola hall, Awolowo hall, and Mozambique hall.

Each hostel building has study cum sleeping rooms as the main spaces with other ancillary spaces like bathrooms, laundry and kitchenettes at one end of each of the block of rooms. Observation revealed that the walls are of sandcrete blocks rendered on both sides with cement and sand plaster and painted with matte finish. The windows are made of glass louver. With the exception of Angola and Mozambique halls which have ceiling fans installed in all the rooms, the rooms within most of the hostel buildings were designed with no mechanical ventilation system that can generate noise indoor. Their doors are timber flush doors. The roofs are made of corrugated asbestos with asbestos ceiling to minimise the noise impact of rain water on the roofing sheets. Among different design and layout features characterizing the different hostel buildings which might influence the quality of the acoustic environment in the spaces are terraces and balconies, as well as vegetation and green spaces that serves as a buffer from street noise. (Zhao et al 2009; Dzhambov and Dimitrova, 2014).

2.0. Materials and Methods

The measurements of indoor sound pressure level in the selected rooms were done with DT-173 High Accuracy Digital Sound Noise Level Data Loggers with a measuring range of 30 dB to 130 dB and a data memory of 129,920 samples. It has a dynamic range of 50 dB, a frequency range of 31.5Hz to 8kHz, and an accuracy of +/-1.4 dB. The data loggers were connected to Personal Computers (PC) and placed at work plane (1.0m above the finished floor level) at the center of the selected rooms. The data was taken in each of the rooms at 15-minute intervals between 07hrs and 19hrs daily through a period of four consecutive weeks each during both the peak of dry season (January to February 2018) and the peak of wet season (June to July, 2018). This was done to be able to examine the trend across the two prominent seasons in the neighbourhood. The data was then downloaded into PC using the sound data logger application software for analysis. There were 22 rooms randomly selected for the measurements. They were selected such that at least two rooms represented each of the nine different room layout types identified within the students housing neighbourhood. All the selected rooms have the same wall, window and ceiling material finishes. Physical measurements were done to capture the different fenestration area relative to the different external wall area of the rooms.

In order to make sure that the subjects were responding to the measured sound pressure level, purposive sampling was used to select all the occupants in the selected rooms as well as the two adjoining rooms to fill a questionnaire. This amounted to 696 respondents. The questionnaire, which was filled immediately at the end of the measurement, elicited information regarding the activities carried out in the rooms, their average length of stay in the rooms per day, and the frequency at which occupants opened the fenestrations. The same questionnaire was used to capture other data about the occupants' gender, age and complexion, as well as the occupants' self-reported physical health status. The respondents were asked to indicate how frequently they observed some physical health symptoms that are related the indoor environmental condition during the period when the sound pressure level was measured. These symptoms are nausea, eye irritation, skin irritation, vomiting, dizziness, headache, fatigue, sore throat, runny nose, cold, cough, and respiratory problem (Reynolds *et al*, 2001; Wong and Jan, 2003; Ana *et al*, 2009). The frequency of observance of each symptom was ranked from 0 for "not at all", 1 for "occasionally", 2 for "more than half of the period", and 3 for "almost every day". The data collected were subjected to statistical analysis using the IBM SPSS Statistics 22. Correlation analysis was carried out to explore the relationships between the measured sound pressure levels in rooms with different window to external wall area ratio and the self-reported physical health status of the occupants.

3.0. Results and Discussion

3.1. Most prominent sources of indoor and outdoor noise

Out of the 696 administered questionnaires, 576 were returned. After the questionnaires were sorted however, 462 were usable for the analysis resulting in a 66.38% response rate. All the respondents were either undergraduate or postgraduate students in the University with 62.8% being males while 37.2% were females. Tables 1 and 2 showed that 76% of the respondents indicated "room-mates chatting" and "people walking along the corridor" as the most prominent sources of noise indoor and outdoor respectively. However, this study found that a significant 79% of the respondents identified indoor noise sources, rather than outdoor, as the prominent contributor to the acoustic condition in the rooms.

Table 1: Most Prominent Indoor Noise Sources in the Spaces as Rated by Occupants

	Frequency	Valid Percent	Cumulative Percent
None	16	3.5	3.5
Roommates chatting	346	76.0	79.6
Door slamming	25	5.5	85.1
Noise from electronic gadgets	57	12.5	97.6
Phone calls	11	2.4	100.0
Total	455	100.0	

Table 2: Most Prominent Outside Noise Source in the Spaces as Rated by Occupants

	Frequency	Valid Percent	Cumulative Percent
None	14	3.1	3.1
Religious activity	33	7.4	10.5
Sporting activity	34	7.6	18.1
Common room activities	99	22.1	40.3
People walking along the corridor	242	54.1	94.4
Traffic noise	8	1.8	96.2
Power generator	16	3.6	99.8
Noise from next room	1	0.2	100.0
Total	447	100.0	

Correlation analysis however showed that the measured indoor sound pressure levels are strongly related to the outdoor noise source. This is because this study found that 46.7% of the respondents always opened all the window area during the period of measurement, and that the direct relationship between measured indoor sound pressure level and the window to external wall area ratio was at significant level ($\rho<0.1$, $r=0.45$).

3.2. Examination of measured indoor sound pressure level

The mean measured sound pressure levels in each room layout ranged from 27.75 dB to 56.29 dB, with an overall mean value of 48.77dB. Figure 1 showed that the highest measured sound pressure level during the entire study period was far lower than 90dB which was the maximum allowable limit value in such spaces according to FEPA, (1991). Moreover, this study that throughout the study period there was no single reading that exceeded the allowable limit, and that the highest mean measured sound pressure level was lower than the allowable limit by 37.45%. This suggests that the spaces should provide comfortable acoustic conditions for the occupants.

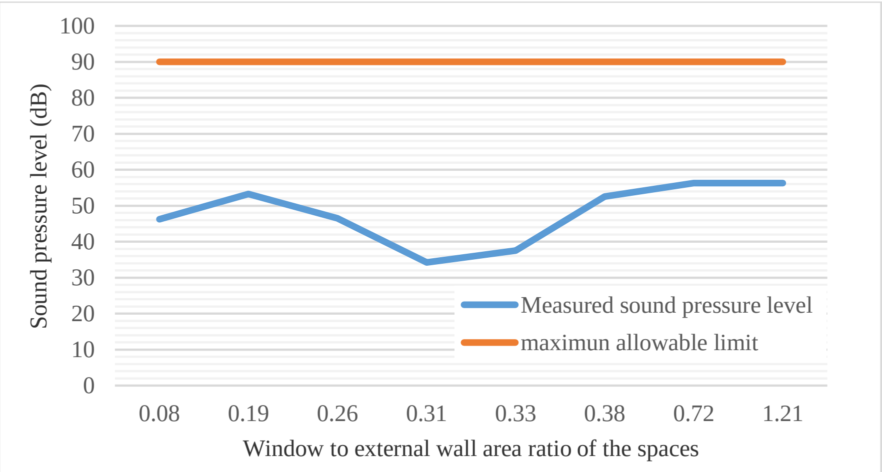

Figure 1: Mean Measured Sound Pressure Levels in the Different Room Layouts

3.3. Assessment of self-reported physical health symptoms of the occupants

During both the dry and wet seasons, this study found that the physical health symptoms with significantly high percentage of observation amongst the respondents were cold, fatigue, and headache. It was also observed that the frequency of observation of each of these three physical health symptoms was higher during the dry season as shown in Fig. 2.

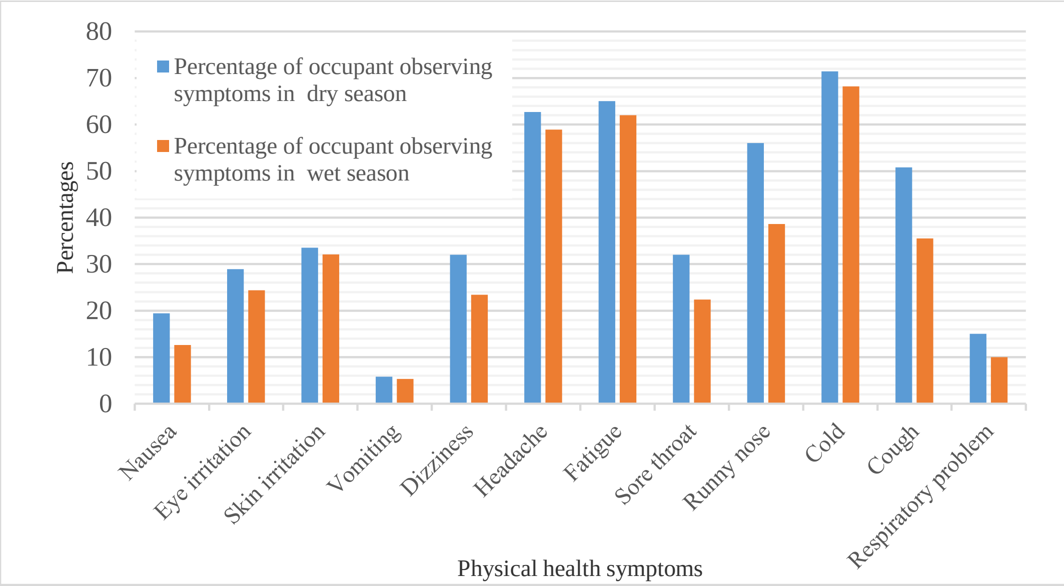

Figure 2: Frequency of Health Symptoms Observation among Occupants

3.4. Relationships between occupants' self-reported physical health symptoms and measured sound pressure level

During the dry season, correlation analysis revealed that the mean measured sound pressure level in the rooms had direct or positive relationships with the frequency at which occupants observed cold and fatigue but had an inverse relationship with frequency of observing headache. However, none of the relationships was found at a level that is statistically significant. Whereas during the wet season, the relationship between the mean measured sound pressure level and the frequency at which occupants observed the same three physical health symptoms became more significant.

This confirmed the position of World Health Organization (WHO) as presented by Schwela, (2001) which showed that headaches, fatigue and irritability are among health effects associated with the acoustic environment. Correlation analysis showed that the relationship between the observance of each of the three physical health symptoms and the mean measured sound pressure level was inverse. While the relationship was significant at $\rho<0.01$ for headache, and correlation coefficient of 0.24, it was significant at $\rho<0.05$ for both fatigue and cold with correlation coefficients of 0.16 and 0.20 respectively. This showed that during the wet season, the higher the sound pressure level, the less frequent occupants of the rooms observed headache, fatigue and cold. Analysis also revealed that this relationship was more pronounced for each of the health symptoms in female occupants than in male occupants. For example, while the correlation coefficient between mean measured sound pressure level and frequency of observation of headache was 0.15 among male respondents, it was 0.23 among the female respondent during the wet season.

This observed relationship was a bit different from the observations of Wong and Jan, (2003) as well as Turunen *et al*, (2014). Although both studies observed some relationships between sound pressure levels and some health symptoms in their subjects, the relationships were not inverse. While Turunen *et al*, (2014) established that fatigue and headache were among the most commonly reported symptoms among students in Finland when one of the most frequently reported indoor condition causing inconvenience was noise, Wong and Jan, (2003) found that the most common health symptoms reported by occupants were headache and cold among others, while the measured indoor noise level in many of the spaces studied was higher than the recommended value by 32%. However, Turunen *et al*, (2014) could not establish a significant relationship between the health symptoms and noise or sound pressure level as found in this study. While Wong and Jan, (2003) established some significant relationships between the health symptoms and some other indoor environmental condition, the study could not establish any link between the noise level in the spaces and the physical health symptoms reported by the occupants.

It is noteworthy that those studies were carried out not during the wet season. This may explain the agreement of their findings with that of this study during the dry season only. The main difference between the dry and wet seasons in southwest Nigeria is the increased solar radiation outdoor and subsequently indoor during the dry season (Ileoje, 2001). This suggests a possible interaction between the indoor sound pressure level and indoor temperature which might have de-emphasized the effect of indoor sound pressure level on the observed physical health symptoms as reported by the occupants during the dry season. This however need to be further explored.

Furthermore, in a study of associated health impact of noise in secondary schools at Ibadan, Nigeria, Ana *et al*, (2009) observed that at measured sound pressure level of between 68.3 and 84.7 dB, there was a direct relationship between the noise level and the level of tiredness or fatigue in the occupants. The relationship was different from the inverse relationship observed in this study, although the conclusion of Ana *et al*, (2009) was not expressed in quantitative terms. The difference may be due to the differences in the sources of noise in the study. Ana *et al*, (2009) identified vehicular traffic as the most significant source of noise in the schools studied.

Moreover, the inverse relationship between measured sound pressure level and the frequency of observance of some physical health symptoms during the wet season in this study was seemingly odd. This is so especially in view of the fact that most regulatory standards for indoor acoustic comfort stipulate the maximum allowable values, which suggests that the more the indoor sound pressure level approaches the maximum allowable limit, the more the occupants ought to report its negative impact on their well-being. However, this study found that the inverse relationships could be justified from the perspective of what the occupants regarded as the most prominent sound source indoor. Table 1 showed that during the study period, sound from electronic gadgets was regarded as the most prominent indoor sound source second to roommates chatting. Observation during the study revealed that both were not necessarily unwanted sound. This is especially so with sound from electronic gadgets which is entertaining, having a psychological soothing effect on the listeners. (Chang *et al*, 2008; Bonde, 2011; MacDonald *et al*, 2013). This therefore may rationalize why an increase in the sound pressure level in the space may lead to a decrease in the frequency with which occupants observed some physical health symptoms.

Since the mean measured sound pressure level in all the nine different room layouts was less than 90 dB, and there was even no single reading from the data logger that was up to this maximum allowable limit, it is therefore not apparent from this study if the inverse relationship observed above continues to hold at sound pressure levels beyond 56.29 dB. This may need to be further explored.

4.0. Conclusions

Cold, fatigue, and headache were confirmed as the most significant self-reported physical health symptoms with occupants' frequency of observance that is associated with the acoustic environment in the students' hostels. This study concluded that within the range of 27.75 dB and 56.29 dB measured sound pressure level during both dry and wet seasons, there is an inverse relationship between the sound pressure level in the rooms and the frequency of observance of cold, fatigue, and headache among the occupants. However, the relationship is more significant during the wet season, and more pronounced in female occupants than in male occupants.

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Cite this article as:

Orola B. A., 2020. Indoor Sound Pressure Level and Associated Physical Health Symptoms in Occupants Within a Students' Housing Neighbourhood in Southwest Nigeria. *Nigerian Journal of Environmental Sciences and Technology*, 4(1), pp. 13-20. https://doi.org/10.36263/nijest.2020.01.0142

Nigerian Journal of Environmental Sciences and Technology (NIJEST)
www.nijest.com
ISSN (Print): 2734-259X | ISSN (electronic): 2734-2603
Vol 4, No. 1 March 2020, pp 21 - 30

Effects of Garcinia hydroxybiflavanonol-1 (GB1) isolated from *Garcinia kola* Heckel (Guttiferae) seeds on reproductive toxicity induced with cadmium chloride ($CdCl_2$) in male Wistar rats

Uwagie-Ero E. A.[1,*] and Nwaehujor C. O.[2]
[1]Department of Surgery, Faculty of Veterinary Medicine, University of Benin, Benin City, Nigeria.
[2]Department of Biochemistry, Faculty of Basic Medical Sciences, P.M.B. 1115, University of Calabar, Nigeria.
*Corresponding Author: edwin.uwagie-ero@uniben.edu

https://doi.org/10.36263/nijest.2020.01.0166

ABSTRACT

To examine the effects of Garcinia hydroxybiflavanonol-1 (GB1) isolated from seeds of Garcinia kola Heckel (Guttiferae) on reproductive toxicity induced with cadmium chloride ($CdCl_2$) in male Wistar rats. Rats were randomly assigned to Groups 1 to 3 (n = 12) as follows; A: control, B: $CdCl_2$ only group, C: $CdCl_2$+GB1. Cadmium toxicity was induced by including 2.5 mg/kg of $CdCl_2$ into the rats' drinking water and GB1 was dissolved in 0.5 % Tween20 and administered per os daily for 90 days. Four (4) animals from each group was humanely euthanized every 30 days. The testes were exteriorized and sperm cells collected from the caudal epididymis for analysis and histology.The result showed accumulation of Cadmium (Cd) in the testes of Wistar rats and a significant decrease ($p< 0.05$) in sperm count and sperm motility in Group B compared to Groups A and C. There was also a significant increase ($p< 0.05$) in immotile sperm count, headless sperm count and sluggish sperm count in Group B. Histology results revealed that $CdCl_2$ significantly reduced the volume of spermatozoa in the seminiferous tubules and resulted in reduced spermatogenesis observed, in reduced number of sperm counts and histology. Amelioration with GB1 restored the testicles to normal spermatogenic activities after 90 days of treatment.

Keywords: *Garcinia kola* seeds, Garcinia hydroxybiflavanonol-1 (GB1), cadmium chloride ($CdCl_2$), toxicity, Wistar rats, male reproduction.

1.0. Introduction

Bioaccumulation of cadmium; a ubiquitous non-degradable environmental pollutant that enters the food chain is an issue of severe global concern. Its environmental accumulation is due to its increased industrial usage in mining, electroplating, dyeing, paints, just to mention a few, as well as its occurrence in agricultural fertilizers (Renugadevi and Prabu, 2009; Newairy et al., 2007). Cadmium is one of the elements found to damage antioxidant systems in mammals (Uwagie-Ero et al., 2019). In general cadmium pollution results from natural weathering of materials, forest fires and volcanoes, but much larger amounts are released by human activities (Morrow, 2001). Cadmium chloride used in photography, photocopying, dyeing, calico printing, vacuum tube manufacture pigment production, galvanoplasty, lubricants, ice-nucleation agents, drinking pipes and manufacture of special mirrors (Herron,2003) may easily enter the environment. Long-term ingestion of large amounts of cadmium has been observed in Japan (Massanyi et al., 2005). The exceptionally long half-life of cadmium in the human body of about 30 years (Kjellstrom et al., 2011), emphasizes the need for the effective assessment and treatment of cadmium toxicity. The reproductive potential of species and their survival have been threatened by an increased industrial and environmental contamination (Bu et al., 2011). Cadmium has been reported to contribute to male infertility via reducing sperm quality in humans and rats (Mendiola et al., 2011; Roychoudhury et al., 2010).

Oxidative stress is a condition associated with an increased rate of cellular damage induced by oxygen and oxygen derived oxidants commonly known as reactive oxygen species (Zikic et al., 1998). The cellular damage in the gonads may be due to an improper balance between ROS (reactive oxygen species) generation and scavenging activities (Pajavic and Saicic, 2008). Exposure to cadmium intoxication has been reported to cause damage to the reproductive tissues and gonads, cadmium toxicity targets the testes both in low and high levels of exposure (de Angelis et al., 2017). It is found to accumulate in the testis, resulting in oxidative stress and germ cell apoptosis, as well as suppression of spermatogenesis (Nna et al., 2017). To ameliorate cadmium toxicity and to prevent oxidative stress, natural products may be useful. The biflavinoid has been shown to improve negative effects of oxidative stress in lipids, proteins and DNA (Farombi et al., 2013).

Previous phytochemical investigations of *G. kola* resulted in the isolation of cycloartenol, 24-methylene-cycloartenol and kolanone (Hussain et al., 1982) from the light petroleum extract and C-3/8''-linked hydroxybiflavanonols from the ethylacetate extract of the seeds (Sonnenbichler et al., 1986).

The aim of the present study was to investigate the ameliorative effects of administration of Garcinia hydroxybiflavanolol-1 on the reproductive health of chronic cadmium chloride intoxicated male Wistar rats.

2.0. Materials and Methods

2.1. Chemicals

Cadmium chloride ($CdCl_2$), Tween20 used for this study were purchased from Sigma-Aldrich Co. (St Louis, MO, USA). All other reagents were of analytical grade.

Mature seeds of *Garcinia Kola* were purchased from a local Market in Calabar, and the seeds were identified by Dr. Michael Ekpo of the Department of Botany, University of Calabar, Nigeria. A voucher specimen was deposited in the herbarium of the department of Biochemistry, University of Calabar, Nigeria.

2.2. Extraction, fractionation of crude extract and Isolation of Garcinia hydroxybiflavanonol-1 (GB1)

This was done as described by Nwaehujor et al (2013) and isolates were identified as previously described Sonnebichler et al (1986).

2.3. Laboratory animals

Thirty-six (36) pathogen-free male adult Wistar rats (10 weeks old) and weighing 170 -190 g were obtained from the animal house of the Department of Biochemistry, College of Medical Sciences, University of Calabar, Nigeria. They were acclimatized for 7 days and were allowed *ad libitum* access to feed and water. Experimental animals were kept in accordance with the guidelines for animal care as contained in the animal ethics handbook of the Faculty of Basic Medical Sciences, University of Calabar, Nigeria.

2.4. Experimental design for Reproductive Toxicity assay

The rats were randomly assigned to Groups 1 to 3 (n = 12) as follows; A: control, B: $CdCl_2$ only group, C: $CdCl_2$+GB1 group. Group A rats were orally administered distilled water only, group B rats received $CdCl_2$ (2.5 mg/kg b.w. in drinking water), group C rats were treated with GB1 (2 mg/kg b.w./daily) and $CdCl_2$ (2.5 mg/kg b.w. day) in drinking water. Cadmium chloride ($CdCl_2$) was dissolved in the drinking water at a dose of 2.5 mg/kg and GB1 were dissolved in 0.5 % Tween20 and administered *per os* for 90 days. The dose for $CdCl_2$ was chosen from previous studies by El-Demerdash et al (2004) and Alkhedaide et al (2016) for cadmium chloride, and Nwaehujor et al (2013) for GB1. After every 30 days, 4 animals from each group was humanely euthanized under chloroform anesthesia. The experiment lasted for 90 days.

The testes were immediately exteriorized through a mid-caudoventral abdominal incision with sterile scalpel blade. Sperm cells were then collected from the caudal epididymis (Oyeyemi et al., 2011).

This was done by removing the caudal epididymis from the right testes and blotting with filter paper. The caudal epididymis was immersed in 5ml formal-saline in a graduated test tube and the volume of fluid displaced was taken as the volume of the epididymis. The content from the epididymis and the content from the caudal epididymis were poured into a ceramic mortar and homogenized into a suspension from which the sperm count was carried out using the improved Neubauer haemocytometer under the microscope (Zemjanis, 1977).

A small drop of sperm suspension was collected with fluid from the caudal epididymis via scalpel and dropped onto a slide. The diluents (buffered 2.9 % sodium citrate solution) kept at 37 °C was added to the sperm suspension until the desired dilution was obtained. Sperm motility was assessed by the method described by Zemjanis (1977). The motility of the epidydimal sperm was evaluated microscopically 2 - 4 minutes of their isolation from caudal epididymis and later expressed as percentages.

This was assessed by adding 2 drops of warm eosin nigrosin stain to the semen on a pre warmed slide, a uniform smear was made and dried with air and the stained slide was immediately examined under the microscope using x400 magnification. The live sperm cells were unstained while the dead sperm absorbed the stain. The stained and unstained were counted and the percentage calculated (Oyeyemi et al., 2011).

2.5. Testicular histopathology

Testes of each rat were fixed in bouins fluid, passed through ascending series of ethanol and then through xylene and embedded to paraffin wax. The tissues were sectioned at the thickness of haematoxylin and eosin and mounted. All sections were examined under light microscope at x100 and x400 magnifications. Photomicrographs of the lesions were taken for observation and documentation of histopathologic lesions.

2.6. Data analysis

The mean and standard error of mean were calculated for the semen characteristics and hormonal assay and were presented in percentages. One-way ANOVA (analysis of variance) and Duncan multiple comparison test was done using statistical package for social science (SPSS) v20 for Windows to establish any significant difference at 95 % confidence interval. Values of $p < 0.05$ were considered significant.

3.0. Results and Discussion

3.1. Identification of isolate

Garcinia hydroxybiflavanonol-1, GB1 was identified as previously described by Madubunyi (1983) and Sonnenbichler et al (1986), as shown in Figure 1. GB1 have shown antioxidant and anti-inflammatory potentials in pervious experiments. GB1 alone had significant quantity that was enough for animal treatment for the number of days the experiment lasted and so, was used for the experiment.

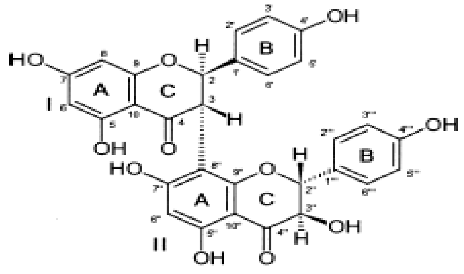
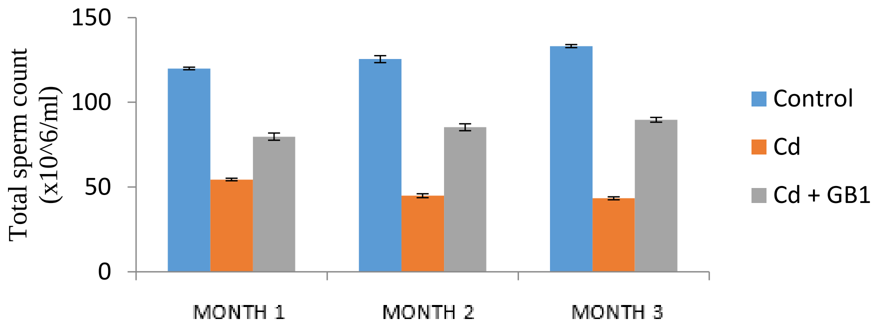


Figure 1: Chemical structure of Garcinia hydroxybiflavanonol-1

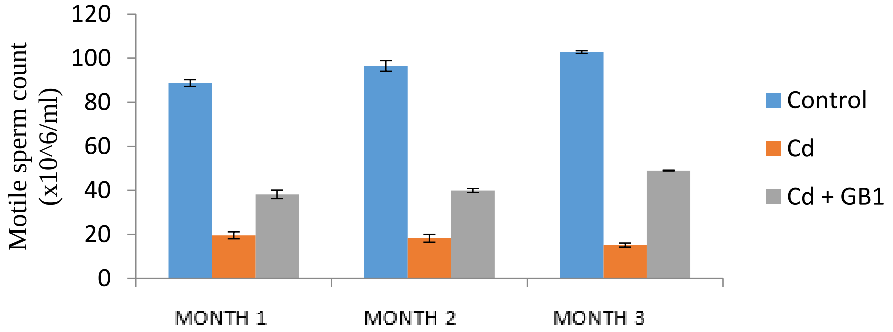
3.2. Sperm morphology

The chosen dose for cadmium chloride was shown to cause significant oxidative stress in various tissues of the body (El-Demerdash et al., 2004; Alkhedaide et al., 2016) while that of GB1 showed significant antioxidant effect (Nwaehujor et al., 2013; Uwagie-Ero et al., 2019). Results of this study showed a significant ($p<0.05$) reduction in sperm count, sperm motility, number of morphologically normal spermatozoa and a significant ($p<0.01$) increase in the number of morphologically abnormal spermatozoa in Wistar rats exposed to cadmium chloride when compared to control and GB1-treated groups (Figure 2a-d).

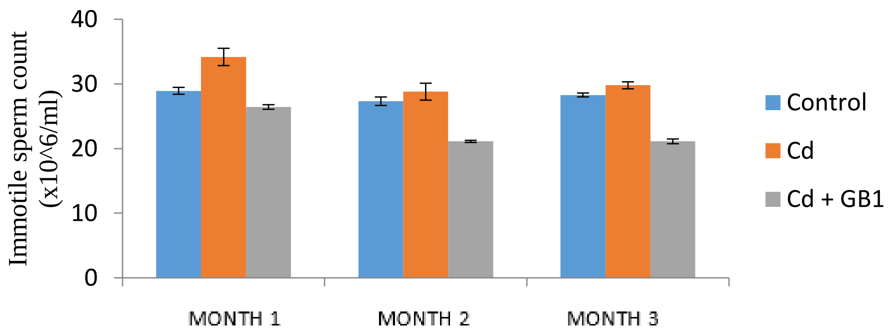
a)



b)



c)



d)

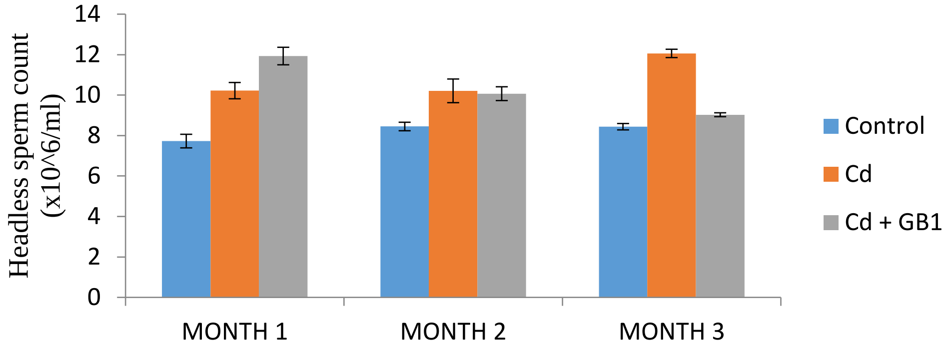


Figure 2: Ameliorative effect of Garcinia hydroxybiflavanonol-1 on cadmium-induced toxicity on a) total sperm count, b) motile sperm count, c) immotile sperm count and d) headless sperm count.

3.3. Testicular histopathology

Histologically, testes of Wistar rat revealed that; at month one the control and treated groups (Figure 3) showed no visible lesion (Figure 3C and C1) when compared with the control group (Figure 3 A and A1). However there was mild erosion of the germinal epithelium in the group treated with $CdCl_2$ as seen in (Figure 3B and B1). The structural integrity of the interstitium was intact across the groups.

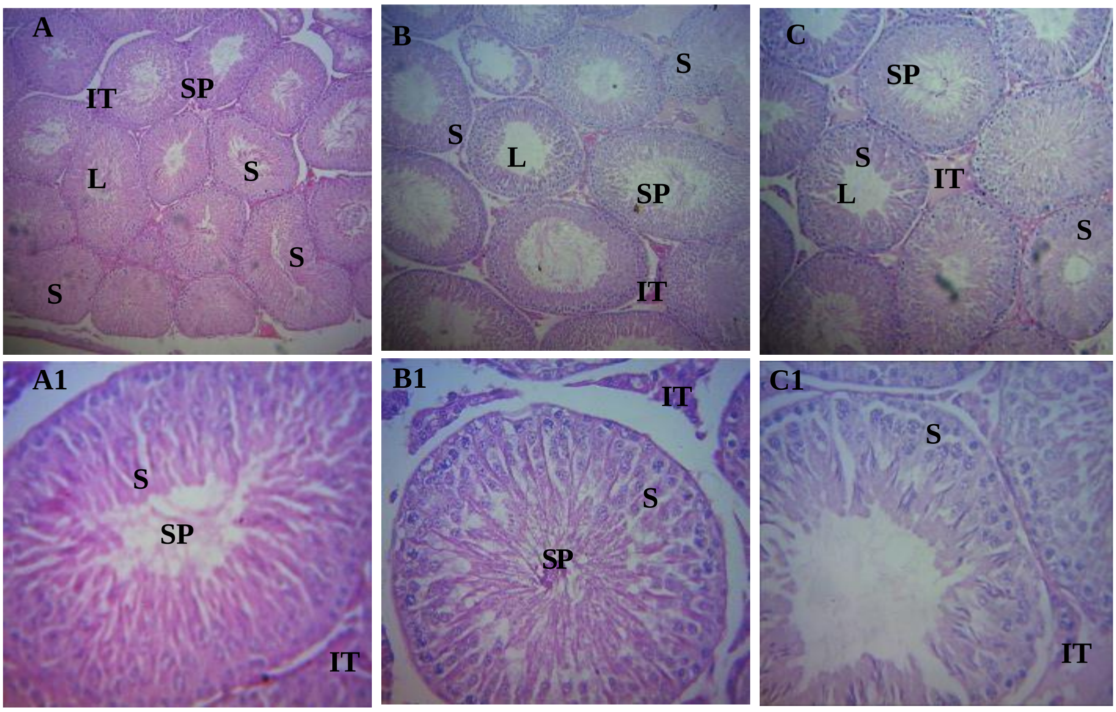


Figure 3: Photomicrograph of Wistar rat testis showing the control group (A and A1) and the $CdCl_2$ treated group (B and B1) and GB1 treated group (C and C1) at month 1 with the sperm cells (SP) in the lumen (L), the interstitial tissue (IT) of the seminiferous tubules (S).

In the treated group (B and B 1), there was no visible lesion observed in GB1 treated group (C and C1) when compared with the control group (A and A1). However, there was mild erosion of the germinal epithelium in the group treated with $CdCl_2$ (B and B1). Note the intact structural integrity of the interstitial tissue across the groups.

At month 2 however, the structural integrity of the interstitial tissues in the $CdCl_2$ treated group was severely compromised with widening of the interstitial space (Figure 4 - B and B1) but this was mild in the Garcinia hydroxybiflavanonol-1 treated groups (Figure 4 - C and C1) as compared to the control (Figure 4 - A and A1).

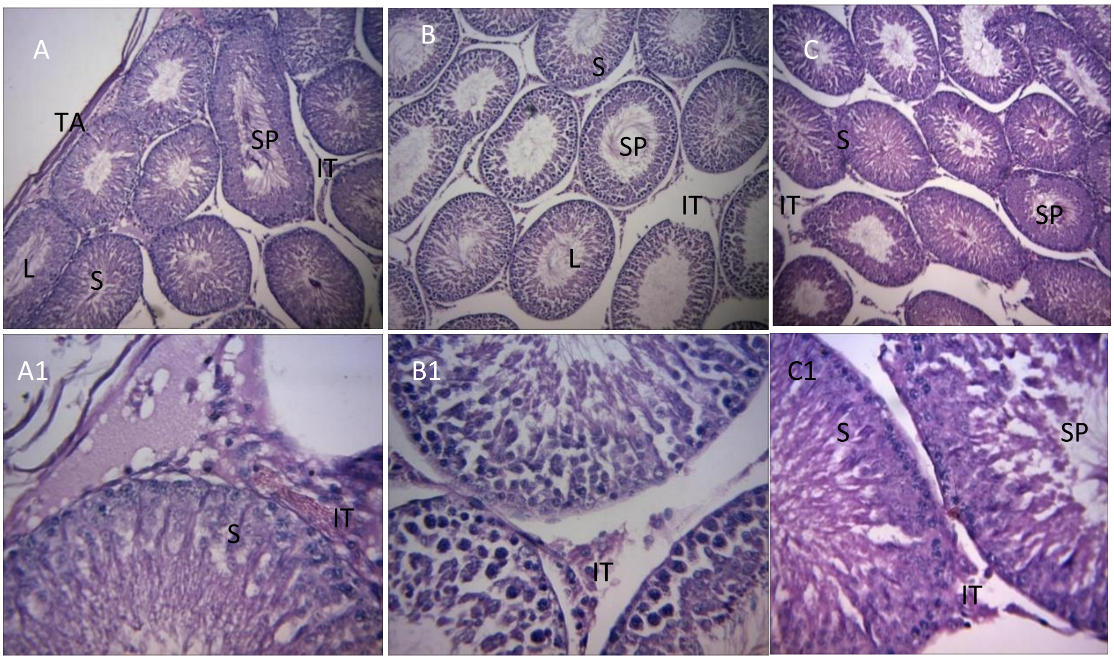


Figure 4: Photomicrograph of Wistar rat testis showing the control group (A and A1), $CdCl_2$ treated group (B and B1), and GB1 treated group (C and C1) and at month 2, with the sperm cells (SP) in the lumen (L), the interstitial tissue (IT) of the seminiferous tubules (S).

In the treated group (B and B1), there was no visible lesion as observed in (C and C1) when compared with the control group (A and A1). However, compromise in the structural integrity of the interstitial tissue in the $CdCl_2$ and GB1 treated groups compared to the control was observed. This compromise is pronounced in group (B and B1). By the third month, there was severe interstitial edema and spermatogenic arrest in the $CdCl_2$ treated group (Figure 5 - B and B1), whereas no visible lesion was observed in GB1 treated group (Figure 5 - C and C1) when compared with the control group (Figure 5 A and A1).

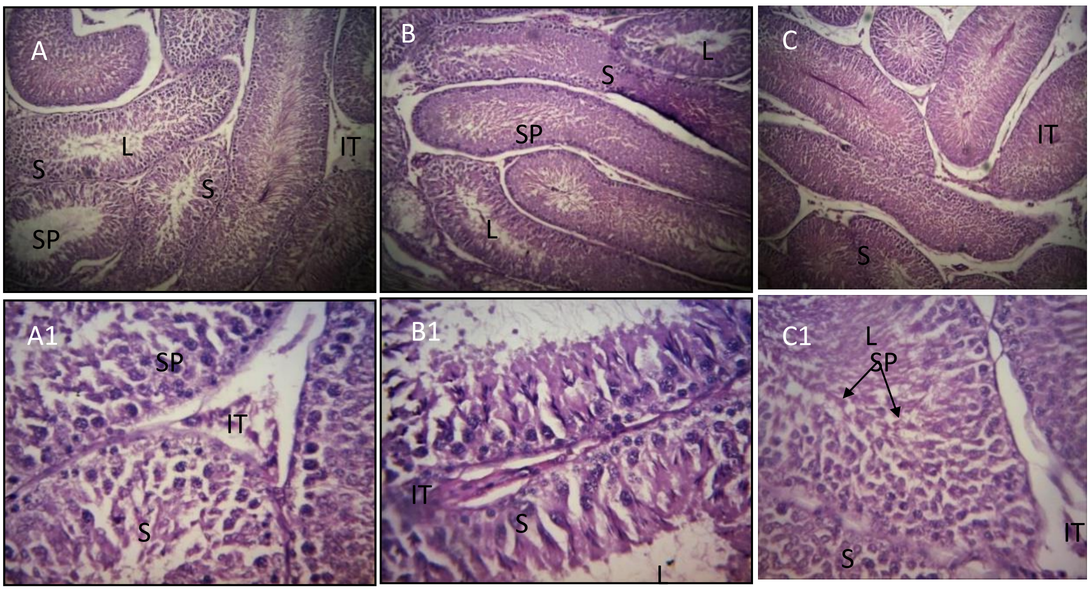


Figure 5: Photomicrograph of Wistar rat testis showing the control group (A and A1), $CdCl_2$ treated group (B and B1) and GB1 treated group (C and C1) at month 3, with the sperm cells (SP) in the lumen (L), the interstitial tissue (IT) of the seminiferous tubules (S).

There was no visible lesion observed in GB1 treated group (C and C1) when compared with the control group (A and A1). However, severe compromise in the structural integrity of the interstitial tissue in the $CdCl_2$ treated group (B and B1) was observed. This was mild in the GB1 treated group compared to the control.

3.4. Discussion

Spermatogenesis is a complex series of differentiation process that can be disrupted by toxic chemicals, heavy metals, heat, radiation, hormone deficiencies and deficiency in the immune system (Akunna et al., 2014; Khanna et al., 2016). Results of this study showed a significant ($p<0.05$) reduction in sperm count, sperm motility, number of morphologically normal spermatozoa and a significant ($p<0.01$) increase in the number of morphologically abnormal spermatozoa in Wistar rats exposed to cadmium chloride when compared to control and GB1-treated groups (Figure 2a-e). These results are in line with earlier studies which showed a degenerative reaction of testicular and epididymal tissues to cadmium thereby contributing to male infertility by reducing sperm quality in humans and rats (Mendiola et al., 2011; Roychoudhury et al., 2010).

Cadmium has been reported to cause spermatotoxicity either by causing a disruption of the hypothalamic-pituitary axis or by direct effect on spermatogenesis through oxidative damage (Roychoudhury et al., 2010; Xu et al., 2001). Since sperm cells and testicular leydig cell mitochondria are common body cells that are susceptible to cadmium-induced oxidative stress the latter represents the major factor (Khanna et al., 2016). Cadmium is known to affect reproductive organs (Massanyi et al., 2000; Toman et al., 2002). In the blood and tissues, Cadmium stimulates the formation of metallothioneins and reactive oxygen species (ROS), thus causing oxidative damage in erythrocytes and in various tissues. This produces a loss of membrane functions (Sakar et al., 1998).

It has been shown that GB1, an atropisomer in nature (Sonnenbichler et al., 1986) is the major component of *G. kola* seed (Cotterhill et al, 1978). This agent stimulates the synthesis of ribonucleic acids and proteins in primary cultured rat hepatocytes (Madubunyi, 1983; Cotterhill et al, 1978). Although the stimulatory effect on cell metabolism gives an insight into its mode of action, it does not fully explain the mechanism of action against such totoxins like D-galactosamine and the toxic constituents of the death-cup toadstool *Amanita phalloides,* especially phalloidin.

Testicular histology showed that the interstitial cells had a high degree of sloughing off and there was interstitial oedema in the $CdCl_2$-treated group (Figure 3) in the first month of treatment. No visible lesions were seen in the seminiferous tubules in the germinal epithelium but there was significant reduction in the accumulation of spermatozoa in the lumen of the seminiferous tubules (Figure 4) by month 2. Interstitial cell integrity was improved in GB1-treated and the control groups, and the germinal epithelial cells did not show any signs of degeneration by the third month (Figure 5). The experiments also showed patterns similar to direct and indirect effects of $CdCl_2$: - direct since Cd^{2+} replaces Ca^{2+} and Zn^{2+} by mimicking their physiological processes in the cells (Valko et al., 2005), and indirect since Cd in non-reproductive glands (e.g. the hypothalamus and pituitary) negatively affects reproductive function through suppressed release of FSH and LH (Hoyer et al., 2005). Clinical (Varga et al., 1993) and experimental (Massanyi et al., 2007) data have reported that Cd accumulates in the testes following oral exposure. Treatment with GB1 offered appreciable protection against Cd accumulation in this research, compared to the untreated groups. According to the trend of results, three mechanisms may likely be involved in GB1 ability to suppress Cd accumulation in the testes. It is possible that GB1 (a) altered $CdCl_2$ absorption in the gut or (b) enhanced its excretion through the kidneys or (c) acted as an antioxidant in the xenobiotic degradation or excretion of Cd.

It had earlier been reported that Kolaviron (a defatted ethanol extract from *G. kola* seed) elicit its protective action on liver cells by acting as membrane stabilizer (Iwu et al., 1990). However, this does not provide a concrete evidence to prove the “membrane stabilizing” action of the *Garcinia* hydroxybiflavanonols. Apart from stimulating metabolism in the testicular cells, and scavenging on free radicals, GB1 may also be acting by stabilizing the membranes of the spermatozoa and membranes of the Leydig cells which are involved in spermatogenesis. These findings demonstrate that the testicular protective activity of the *Garcinia* hydroxybiflavanonol-1 (GB1), could be explained, at least in part, by their ability to stabilize the membranes of the spermatozoa and those of cells involved in spermatogenesis.

4.0. Conclusion

The study concluded that Garcinia hydroxybiflavanolol-1 ameliorated the deleterious effects of cadmium chloride toxicity on the gonads of male Wistar rats. This stabilizing effect may find a beneficial application in the therapy for various testicular disorders especially those involving abnormal spermatozoa morphology and reduced fragility of the testicular membrane.

Declarations - Conflict of Interest(s)

Authors declare that they do not have any conflicting interest(s).

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Cite this article as:

Uwagie-Ero E. A. and Nwaehujor C. O., 2020. Effects of Garcinia hydroxybiflavanonol -1 (GB1) isolated from *Garcinia kola* Heckel (Guttiferae) seeds on reproductive toxicity induced with cadmium chloride (CdCl2) in male Wistar rats. *Nigerian Journal of Environmental Sciences and Technology*, 4(1), pp. 21-30. https://doi.org/10.36263/nijest.2020.01.0166

Nigerian Journal of Environmental Sciences and Technology (NIJEST)
www.nijest.com
ISSN (Print): 2734-259X | ISSN (electronic): 2734-2603
Vol 4, No. 1 March 2020, pp 31 - 39

Land Use Conflicts and Rights to Farm in an Urbanizing Environment

Oyedele J. B.[1,*], Alohan O. E.[2] and Edionwe O.[2]
[1] Department of Estate Management, Obafemi Awolowo University, Ile-Ife, Osun State, Nigeria
[2] Department of Estate Management, University of Benin, Benin City, Nigeria.
*Corresponding Author: joe_christ2001@yahoo.co.uk

https://doi.org/10.36263/nijest.2020.01.0150

ABSTRACT

This study examined agricultural land use conflicts and right to farm in an urbanizing environment. It also examined the implication of urbanization on farming activities. Three sub-urban communities currently undergoing urbanization were selected for the study. Primary and secondary data were collected. Primary data were obtained through the use of questionnaires and interviews. A total of 150 questionnaires were distributed out of which 139 were retrieved and analysed. This represents 92.67% of the total questionnaires distributed. Data collected were analysed using simple frequency distribution table and graphs. The results revealed that land use is gradually shifting from agriculture to residential land use, forcing the farmers to face increase in land value due to high demand for land, difficulty in accessing land for agriculture and land speculation.

Keywords: Urbanization, Urbanizing environment, Land use, Land use conflict, right to farm.

1.0. Introduction

Agriculture is the main stay of most communities and nations all over the world. Its importance cannot be over emphasized. In Africa, particularly in Nigeria before the discovery of crude oil, the main stay of the economy was agriculture. Agricultural activities were mainly practiced in the rural areas. Urban settlements depended and still depend on the rural settlements for food. However, land use in areas around the urban centres formally a rural area but now urbanizing areas is changing and these changes have resulted to several land use conflicts and community crises.

Urbanizing areas which are sometimes referred to as urban sprawl is currently undergoing land use changes due to increase in population and developments. The demand for land for developmental purposes is on the increase. In most cities, there is increased demand for land for construction of roads, building of residential and commercial properties by governments, private developers, cooperate bodies and individuals, building of schools, health centres and drainage systems and so on. All these activities coupled with increased population due to rural-urban drift has resulted to high pressure on land.

For urban expansion and development, attention is now been drawn to sub-urban environment for development. This development has resulted to land use conflicts between the original land owners, communities and other land users.

Many researchers have tried to explore the land use conflicts and probable measures of resolving such conflict (Deininger and Castagnini (2004); Magsi, *et al*. (2017); Lund, et al. (ND); Wu (2008)). Wu (2008) stated that land use change has social and environmental implications. He asserted that urbanization brought about many challenges such as destruction of crops and damage to farm equipment for farmers in the urban fringe and degradation in the ecosystem which altered the Earth's landscape. Magsi *et al*. (2017) examined the land use conflicts mainly caused by infrastructural development projects in some developing countries. They identified four driving forces on land use conflict as extracted from Daily Regional Press (DRP) but similar to their case study as: Land consumption due to over population and urbanisation, Resistance against misuse of power and corruption, Opposition to responsive decision of the institutions for development projects and Land protection for agriculture, farmer life and social safe. This study seeks to identify the land use changes taking place in the study area, its attendant effects on agricultural land use and the resulting land use conflicts arising from the land use changes.

2.0. Literature Review

Urbanizing environment otherwise known as urbanizing areas is that environment that is undergoing a process of transiting from rural area to urban area. This transformation is driving by population growth, household formation and economic growth (Ralph and William, 2001). Several nomenclatures have been giving to urbanizing environment such as urban spur, urban fringe, sub-urban, urban sprawl and many other names. Ralph and William (2001) defined urban fringe as that part of the city that is not settled densely enough to be called urban. They attributed urban fringe as those areas with low density development which has the capacity to grow farther into rural areas and increasing the density of settlement through new houses, roads, and commercial buildings.

The urbanization of suburban environment is a new phenomenon in most part of Nigeria. This new development has resulted in land use dispute and conflicts between farm owners, landlords and developers and has also resulted to land use change in such communities. For instance, in the United States, this phenomenon is not new. Between 1960 and 1990, urban land expansion claimed more than one million acres per year and was never seen as a threat to most farming activities (Ralph and William, 2001). Today many of the American farms now operate within the urban and or suburban areas which has affected the farmers and the urban neighbours (Alvin, 2000).

Several issues concerning the positive and negative impact of agriculture in urbanizing communities were raised (Alvin, 2000) and attempts were made to proffer solutions to the challenges. They are incompatible land uses, economic opportunities for local agriculture and urbanization and local attitudes and economies. Alvin (2000) opined that the state and the local authorities should minimize the negative interaction between farmers and the urban residents and to create conditions that is mutually beneficial for their coexistence.

The review of literature has also shown that there is a relationship between rural and urban households. Cecilia (1998) opined that urban and rural households rely on both agricultural and non-agricultural sources for their livelihoods and that a large number of families in the rural areas and those in the suburban centres rely on non-agricultural sources and services from the urban centres as well as their agriculture while families in urban areas rely on those in the rural and suburban areas for their agricultural supplies. This show the symbiotic relationship between the rural, suburban and the urban areas. Cecilia (1998) concluded that activities ascribed to rural or urban areas are linked across space and sectors and distinctions are usually arbitrary. Urban areas may vary in definition from one country to another while members of household residing in rural areas and some in urban areas engages in agricultural activities within the urban areas (Cecilia, 1998).

In a similar vein, Thomas (1999) was of the view that there is no decreasing farm land in the Suburban environment but rather there is an efficient transformation of land use from lower value to higher value.

2.1. Right to farm

In Nigeria, the demand for land is on the increase. The urbanization, population growth and increasing demand for food has assumed an alarming rate. In Benue state for instance, there has been several killings between Fulani herdsmen and farmers in the recent times as a result of land use conflict. Also, in 2012, there was a seemingly land conflict between farmers and Fulani herdsmen in Olobgo

Community of Edo state. The farmers accused the herdsmen of grazing cattle on their crops and destroying them, while the herdsmen accused the farmers of depriving them from feeding their cattle as they claim equal right to land. They also claimed that the community leaders have been settled in cash and in kind and as such, they have equal right to land as the indigenes of the community.

All over the country, the fight to own and possess land is on the increase. Yobe State has over the years had its own share of Fulani herdsmen and farmers conflicts in various part of the state. Alhassan (2013) reported that the major causes of herdsmen and farmers conflicts includes destruction of crops and other property by the herdsmen, and blockage of stock routes, water points and burning of rangelands by farmers, Other causes includes increased rate of cattle theft accompanied by violence and antagonistic perceptions and beliefs among farmers and herdsmen. Alhassan (2013) also, found that most of the Fulani herdsmen do not own or possess rights to land, they depend solely on open land to graze their cattle, resulting in intense pressure on land and further cumulating to conflicts. In the same vein Okoli and Atelhe (2014) sums up the result of conflict as having humanitarian, socio-economic, social and economic consequences on the people.

The Land Use Act of 1978 now CAP 202 LFN 1990 provides that all land in the territory of each State have been vested in the Governor, who holds the land in trust and administered them for the common goods and benefit of all. However, section 36 sub section 2 and 4 stated that occupier or holder of any agricultural land before the commencement of the Act shall continue to hold same. These places the right of ownership and use of such land to the farmers and land owners.

In Ghana, Fabian (2013), examined agricultural land use conflicts between land owners and migrant farmers. The study observed that the land owners accused the migrant farmers of not putting their land into efficient use, while on the other hand the migrant farmers accused the land owners of collecting greater percentage of their farm produce without contributing to the cost of production. From the foregoing, Fabian (2013) recommended that the land use dispute between the land owners and the migrant farmers can be resolved by putting in place measures to incorporate customary and statutory policies for efficient and appropriate land use.

2.2. Farming in urbanizing environment

There are several farming activities going on in urbanizing communities in Edo state. In communities like Evbuodia, Eyaen, Iduomwena, Utagban Ulemon and many other communities, there are several agricultural activities going on in these communities amidst development. According to Alvin (2000) farmers see urbanizing areas as more beneficial because of its closeness to market, access to labour and ease of transportation of products but this differs according to population size of neighbouring urban market.

Ralph and William (2001) stated that agricultural activities in the United States are influenced by closeness to urbanized areas and that the population concentration brought about by growth. However, as urbanizing areas grow landowners and land speculators may seek those activities that offer better returns to land with those from development (Ralph and William, 2001). Ralph and William, (2001) further stated that the economic changes farmers in the urban fringe face brings pressure on them to adjust to the changes while offering them opportunities and reward for the changes. They also advanced several benefits of farming from urbanization to include proximity of urban centres', greater off-farm employment opportunities, providing opportunities for farmers to grow new crops and increased house hold income. Although there are some economic benefits of farming within urbanized areas, there are also some disadvantages. Ralph and William (2001) stated some of the disadvantages include complaints about farm odours and chemical by the suburban residents, conflict between farm owners and dwellers, increase in real estate taxes due to rise in land prices, reduced crop yield due to urban smog, theft and vandalism, reduced market for dairy product or field crops and increase pressure from water and land use restrictions.

2.3. Land use and land use change

Urbanization and the growing deforestation in the country today has brought about land use change. Many studies on land use change in many parts of the world have been conducted by different researchers. Xiangzheng *et al.* (2008), Frapolli *et al.* (2007) and Reed-MD (2008) cited by (Bello and Arowosegbe, 2014) reported that demand for residential and industrial land are the main causes of land use changes. Although urbanization brings about growth and development, the spate of urbanization is affecting agricultural land user particularly at the sub-urban areas or urban sprawl. It could be noted that human use of land has altered structure and functioning of the ecosystem. Globally, the most important use of land include cultivation, land reserves, construction, timber extraction and protected lands (Vitonset *et al.*, 2007; Turner II *et al.*, 2007) cited by (Bello and Arowosegbe, 2014). In the developing regions, (Bello and Arowosegbe, 2014) also observed that settlements and sprawl development are becoming active land use change.

Bello and Arowosegbe, (2014) opined that increase in population created adjustment and re-adjustment of human and land use activities within urban systems. The population increase within the city or urban centres is forcing urbanization to the sub-urban areas. Most of our cities is been taking over by commercial and industrial activities, compelling residential land use to shift towards the city edges or sub-urban areas, bringing about land use change in these areas. Bello and Arowosegbe (2014) in their study identified four factors affecting land use change on property values in Nigeria which they classified as; government and real estate policy, attraction factors of the country and crude oil, people and regional conditions and the law of the strength structure.

3.0. Materials and Methods

This paper reports the Land Use Conflicts and Rights to Farm in an Urbanizing Environment. Primary data used for this study were gathered from land owners, community leaders and individual developers through the use of questionnaires and personal interview. A total of 150 questionnaires were distributed among farmers, land owners, community leaders and individual developers who are civil servants and traders/businessmen in three communities out of which a total of 139 questionnaires representing 92.67% were retrieved. The questionnaire contains information on the type of land ownership that subsist in the community, the agency in charge of land administration in the community and types of land use before the process and during the process of urbanization. The respondents were also asked to rank the various types of land use in their community before and during the process of urbanization. Furthermore, they were asked to identify the various conflicts that were prominent in their community and state their effect on land use. Data were analysed using descriptive statistical tool such as frequency distribution and percentage table.

4.0. Results and Discussion

4.1. Analysis of results

The results of the research are presented in tabular form and graphs and discussed in this section. Table 1 showed the characteristics of the respondents. Statistics showed that 112 were males while 27 were females, representing 80.58% and 19.42% respectively. The respondents include traders, farmers and civil servants. 36.69% were farmers, 28.78% traders/business men while 14.29% are civil servants. 29.50% of the respondents have lived in the community for over 26 years, 17.27% have lived there for between 21-25 years and 18.70% have lived there for between 16-20 years. Other respondents have lived in the community for 1-5yrs, 6-10yrs and 11-15yrs respectively. These represents 7.19%, 16.55% and 10.79% respectively.

Table 1: Characteristics of the respondents in the study area

Characteristics	Category	Frequency	Percentage
Sex of respondent	Male	112	80.58
	Female	27	19.42
Occupation of respondent	Trading/businessmen	40	28.78
	Farming	51	36.69
	Civil servant	20	14.39
	Trading/farming	28	20.14
Duration of living in the community	1-5yrs	10	7.19
	6-10yrs	23	16.55
	11-15yrs	15	10.79
	16-20yrs	26	18.70
	21-25yrs	24	17.27
	Above 25yrs	41	29.50

Source: *Field survey, 2015*

Table 2: Types of land ownership in the study area

Types of land ownership	Frequency	Percentage
Family Land	28	20.1
Community Land	45	32.4
Individual	66	47.5
Government	00	00.0
Total	**139**	**100.0**

Source: *Field survey, 2015*

Table 2 revealed that three types of land ownership exist in the study area. That is, land is owned by the community, family and individuals. The study revealed that most of the land in the study area belong to individuals who bought from the community, representing 47.5%. 32.4% and 20.1% of the land belong to the community and family heads who got their land through inheritance respectively. This implies that land in the study areas are owned by individuals who acquired land by purchase, gift and or inheritance, families who are indigenes of the communities and community land which is administered by the community leaders for the benefit of all indigenes of that community.

Table 3: Land administrators in the study area

Land administrators	Frequency	Percentage
Family heads	32	23.02
Community leaders	105	75.54
Government	2	1.44
Total	**139**	**100.00**

Source: *Field survey, 2015*

From Table 3, it was observed that community leaders (75.54%) were the sole administrators of land in the study area. This implied that community leaders were more preferred to be custodian of lands on the communities which is what is more obtainable in Edo state at large. However, the administration of family land is left in the hands of the family heads on behalf of other members of the family.

Table 4: Types of land use in the study area before urbanization

Land use before urbanization	Frequency	Percentage
Agriculture	78	56.12
Residential development	47	33.81
Infrastructure development	14	10.07
Total	**139**	**100.00**

Source: *Field survey, 2015*

Findings showed that the three communities were basically rural areas but due to urban expansion, the communities are having their share in transiting from rural to urban. Before the process of urbanization started, the major land use was agriculture which represents 56.12% while residential development is 33.81% and infrastructure development is 10.07%. This implied that the communities engaged on more agrarian activities before the advent of urbanization. Table 5 illustrate the ranking of the land use in the communities before and during the process of urbanization. Before the process of urbanization, Agriculture tops the rank being that the land use in these communities was predominantly agriculture. This was closely followed by residential developments while infrastructure ranks least. It was observed that there are no good roads leading to the communities. This implies that in terms of infrastructural development, the communities are lacking. As the level of urbanization increases, the land use in the communities were observed to be changing gradually. A critical examination of table 5 indicates that land use for agriculture has dropped from 56%, 58.70% and 53.50% to 40.00%, 39.10% and 39.50% while the land use for residential building has increased from 26.00%, 30.40% and 46.50% to 42.00%, 50.00% and 60.50% respectively in the communities.

Table 5: Ranking of land use type in the communities before the process of urbanization

		Before Urbanization			**Process of Urbanization**		
Community	**Land use type**	**Frequency**	**(%)**	**Rank**	**Frequency**	**(%)**	**Rank**
Evbuodia	Agriculture	28	56.00	1st	20	40.00	2nd
	Residential Development	13	26.00	2nd	21	42.00	1st
	Infrastructure Development	9	18.00	3rd	9	18.00	3rd
	Total	**50**	**100**		**50**	**100**	
Utagban	Agriculture	27	58.70	1st	18	39.10	2nd
	Residential Development	14	30.40	2nd	23	50.00	1st
	Infrastructure Development	5	10.90	3rd	5	10.90	3rd
	Total	**46**	**100**		**46**	**100**	
Ulemon	Agriculture	23	53.50	1st	17	39.50	2nd
	Residential Development	20	46.50	2nd	26	60.50	1st
	Infrastructure Development	0	0.00	3rd	0	0.00	3rd
	Total	**139**	**100**		**43**	**100**	

Source: *Field survey, 2015*

This clearly indicates that there is an increased in land demand for residential development in the study areas. However, infrastructure development such as roads remains at its lowest ebb.

Table 6: Summary of land use before and during urbanization

Type of land use	Land use before urbanization		Land use during urbanization		
	Frequency	Percentage	Frequency	Percentage	Percentage change
Agriculture	78	56.12	55	39.57	16.55
Residential development	47	33.81	70	50.36	16.55
Infrastructure	14	10.07	14	10.07	0.00
Total	**139**	**100.00**	**139**	**100.00**	

Source: *Field survey, 2015*

Table 6 illustrates the summary of the changes in percentages of the land use in the three communities before and during urbanizing process. From Table 6, agricultural land use was 56.12% before urbanization process sets in has dropped to 39.57%. Similarly, residential development is fast growing from 33.81% to 50.36%. An indication that land use in the communities are gradually changing from agriculture to residential.

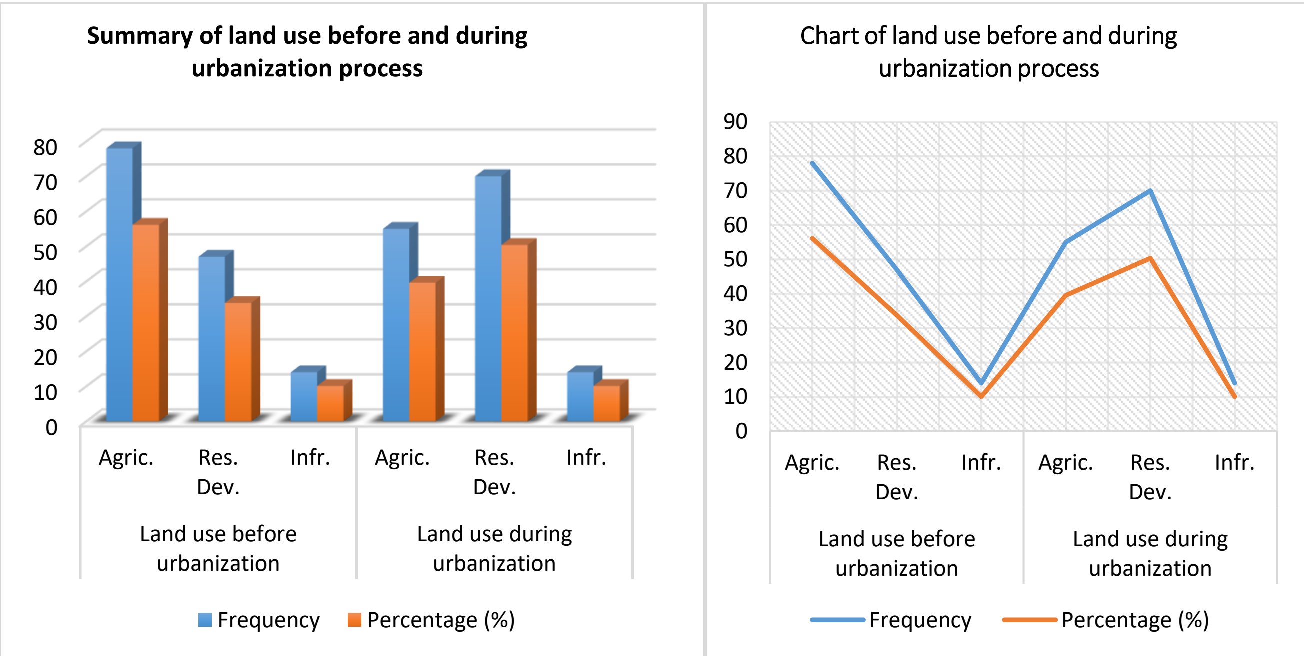

Figure 1: Type of land use before and during urbanization

4.2. Land use conflicts due to land use change

Farmers in urbanizing environment are faced with several challenges. The results from the interview conducted revealed that the challenges span from land speculation, arbitral increase in land values, insecurity of land titles, access to agricultural land among others. Land owners finds it more profitable to change their land use from agricultural use to developmental purposes. Rather than give it to farmers who cannot pay so much, they prefer selling to land developers who are ready and willing to pay more to satisfy their immediate gains. By such practice, farmers in the study areas are gradually losing their farm lands to land developers and speculators. These challenges are discussed as follows:

i. Land speculation: As urbanization is spreading to the urban sprawl, people are now more involved in land speculation in these areas. Land speculators sells one piece of land for several unsuspecting individuals. This action usually leads to land conflicts amongst the buyers. Sometimes the individuals engage in serious fight leading to killings. In some cases the community leaders wade into the conflict with a view of settling the disputing parties. In the study areas, land value is also rising high due to urbanization (increasing demand for land for residential development) and speculation beyond the rich of farmers.

ii. Security of land title: the incidence of multiple sales of land to several persons has forced people to use every means within their reach to secure their lands in the study areas. At the point of purchase, the buyers insist on collecting the conveyance document and receipt from the community or the individual seller as proof of ownership in case of dispute. Some would survey the land and register it with the ministry of lands and survey as a means of securing their interest.

iii. Increased land value: the high demand for land in these areas due to urbanization has brought about increase in land prices. For instance, land price for a plot of land in Evbuodia community has risen to about ₦2, 000,000.00 as at today. This is far beyond the rich of farmers, only very few farmers can pay such for agricultural lands.

iv. Accessibility to agricultural land: Because of the high income land owners receive from the sales of their lands, farmers finds it difficult to access land for agricultural uses. This is affecting agriculture in the study areas. Land use are changing fast from agriculture to residential development (see tables 4, 5 and 6). It is believed that with the passage of time, most of the agricultural lands in these areas will change to residential areas, thus reducing the land areas for agricultural uses.

5.0. Conclusions and Recommendations

Farmers in an urbanizing environment experience one form of land use conflicts or the other. Basically, the study revealed that land use which was mainly agriculture is gradually changing to residential land uses. These changes (Thomas, 1999) regarded as the efficient transformation of land use from lower value to higher value uses. This has affected the ease of access to agricultural land as most land owners prefer the alternative land use which in their opinion pays better and gives them immediate lump sum of money for other investments. The change in land use has also brought about land speculation, multiple sale of a particular land to different persons resulting to land conflicts and lastly increased land values. Furthermore, the study recommends that farmers in the urban sprawl be given alternative farm land in areas farther from the urban fringe when their farm land is been acquired for a higher value use. They should also be provided with incentives that would facilitate their ease of movement from the former location to another.

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Cite this article as:

Oyedele J. B., Alohan O. E. and Edionwe O., 2020. Land Use Conflicts and Rights to Farm in an Urbanizing Environment. *Nigerian Journal of Environmental Sciences and Technology*, 4(1), pp. 31-39. https://doi.org/10.36263/nijest.2020.01.0150

Nigerian Journal of Environmental Sciences and Technology (NIJEST)
www.nijest.com
ISSN (Print): 2734-259X | ISSN (electronic): 2734-2603
Vol 4, No. 1 March 2020, pp 40 - 53

Remote Sensing and GIS Application to Erosion Risk Mapping in Lagos

Makinde E.O[1,2,*] and Oyebanji E.I[2]
[1]KITE Group, Environment Department, University of York, UK
[2]Department of Surveying and Geoinformatics, University of Lagos, Akoka, Lagos state, Nigeria
*Corresponding Author: estherdanisi@gmail.com; eomakinde@unilag.edu.ng

https://doi.org/10.36263/nijest.2020.01.0081

ABSTRACT

Increased population, unhealthy agricultural practices, indiscriminate land clearing and illegal structures have led to an increase of erosion in Nigeria and Lagos State in particular. This research focused on identifying land use/land cover changes in Eti-Osa LGA of Lagos State and estimating the actual erosion risk using Remote Sensing and Geography Information System. In addition, this research evaluated the perception of communities within the study area with the view to understanding the risk involved in erosion. Maximum Likelihood Algorithm was the classification method applied on the Landsat imageries (1986-2016) to identify the changes on the land use/land cover types. Analysis of Variance (ANOVA) was used to evaluate the perception of communities within the study area and Revised Universal Soil Loss equation (RUSLE) model was used to estimate the actual erosion risk. The result showed that the sediment yield of the study area was estimated to be between 0 to 48ton/ha/yr. The estimated soil losses were higher in Eti-Osa West compared to other parts of Iru/Victoria Island, and Ikoyi/Obalende areas which recorded low losses. Land uses mostly affected by very high and severe erosion are the bare soils and the crop lands having about 3% to 4% respectively. It can be concluded that rainfall, lack of cover for the surface soil were the major causes of soil loss in the study area.

Keywords: Remote Sensing, Geographic Information System, Risk Mapping, Soil Erosion, RUSLE, Nigeria Meteorological Agency (NiMet), Shuttle Radar Topographic Mission (SRTM), Landsat images

1.0. Introduction

Coastal erosion is experienced in almost all the sections of Nigeria's coastal zone, thus the quest for a lasting solution (Etuonovbe, 2006). The social and economic consequences of coastal erosion can be substantial in many cases such as causing dis3placement of a whole community, including the loss of lives, loss of port facilities, infrastructures, recreational facilities, industrial and residential land due to coastal erosion as the case with Ogulaha community in Forcados South Point, Delta State, Nigeria (Etuonovbe, 2006). In coastal cities, certain important factors such as rainfall amount and precipitation intensity, which are called rainfall erosivity can results into soil erodibility IPCC (2007).The consequences of these have been reflected in the severe loss of lives and properties especially in Lagos State where the coastal zone contributes to a major part of the nation's income (Etuonovbe, 2006).

Assessing the soil erosion rate is essential for the development of adequate erosion prevention measures for sustainable management of land and water resources (Alaaddin *et al.*, 2008). Pandey *et al.*, (2007) describe soil erosion as serious environmental problem as it removes soil rich in nutrients and increases natural level of sedimentation in the rivers and reservoirs reducing their storage capacity and life span. In urban areas like Lagos, population explosion, rapid urbanization, climate change, increased rainfall, poor agricultural practices etc. are factors that contribute to soil erosion, it is also of universal importance as man‘s activities, directly or indirectly, depend on the soil. Soil erosion thus constitutes a national hazard, which containment is a prerequisite to national development (Isikwue *et al.*, 2012).

Different models have been adopted to assess and study soil erosion. The Universal Soil Loss Equation (USLE) model was suggested first based on the concept of the separation and transport of particles from rainfall in order to calculate the amount of soil eroded in agricultural areas (Wischmeier and Smith, 1965).The USLE has been enhanced during the past 30 years by a number of researchers to Modified Universal Soil Loss Equation (MUSLE) and Revised Universal Soil Loss Equation RUSLE (Williams, 1975, Renard *et al.*, 1997).RUSLE added many factors such as the revision of the weather factor, the development of the soil erosion factor depending on seasonal changes, the development of a new calculation procedure to calculate the cover vegetation factor, and the revision of the length and gradient of slope (Renard *et al*., 1997).

Remote sensing (RS) is the science of obtaining data/information about the earth's surface without directly being in contact with it, this is done by sensing and recording reflected and emitted energy and processing, analyzing, and applying that information (Sabins, 1997). Geographic Information System (GIS) is an arrangement of computer hardware, software, and geographic data that people interact with to integrate, analyze, and visualize data; identify relationships, patterns, and trends; and find solutions to problems. The system is designed to capture, store, update, manipulate, analyze, and display studied data and used to perform analyses (ESRI, 2005).The Remote Sensing (RS) technology has been used to provide the land use/cover information by using digital image processing techniques (Alaaddin *et al.*, 2008). There have been many studies on modeling soil erosion by utilizing Remote Sensing and Geographic Information System (GIS) technologies (Demirci *et al.*, 2012; Ganasri *et al.*,2016).The capabilities of these technologies even increase when they are integrated with empirical erosion prediction models (Alaaddin *et al.*, 2008). While soil erosion models only calculate the amount of soil erosion based on the relationships between various erosion factors, Remote Sensing and Geographic Information System (GIS) integrated erosion prediction models do not only estimate soil loss but also provide the spatial distributions of the erosion (Alaaddin *et al.*, 2008). Generating accurate erosion risk maps in Geographic Information System (GIS) environment is very important to locate the areas with high erosion risks and to develop adequate erosion prevention techniques (Alaaddin *et al.*, 2008).Sazbo *et al.*,(1998) conducted a study where Remote Sensing and GIS technologies were successfully used for land degradation and erosion mapping. Another study by Bojie *et al.*, (1995) also indicated that Geographic Information System (GIS) analysis provide satisfactory results in developing erosion surveys and risk maps by using Geographic Information System (GIS) data layers such as DEM, slope, aspect, and land use (Alaaddin *et al.*, 2008).This paper assessed the problem of erosion in Eti-Osa Local Government Area, Lagos State, Nigeria, mapped out areas prone to erosion, and assessed the perception of occupants and their interplay in the study area. This research work applied RS and GIS techniques in modeling erosion in the study area.

2.0. Materials and Methods

2.1. The study Area

Eti-Osa Local Government Area is located between 6^0 15’ and 6^0 17’and longitude 3^0 3’ East and 3^0 3’ East. It is bounded in the south by Atlantic Ocean, in the east by Ojo Local government, north by Lagos lagoon and part of Mainland and Island local government and in the west by Ibeju-Lekki Local Government (Odumosu *et al*., 1999).

The topography is between 3-15m above sea level (Akoteyon and Soladoye, 2011). The geology consists of quaternary alluvial deposits such as red-yellow, red-brown, grey and sandy-clays, silt, sand, gravels, and other detrital material (Akoteyon and Soladoye, 2011).The study area occupies an area of about 193.460km^2 (National Population Commission, 2006).The population is about 283,791 with density of 1,467 people per km^2 (National Population Commission, 2006). The climate is tropical type with an average rainfall of 2500mm and temperature of 30^{0}C (Akoteyon and Soladoye, 2011). The vegetation pattern reflects its coastal location with mangrove swamp trees being the dominant type (Akoteyon and Soladoye, 2011).

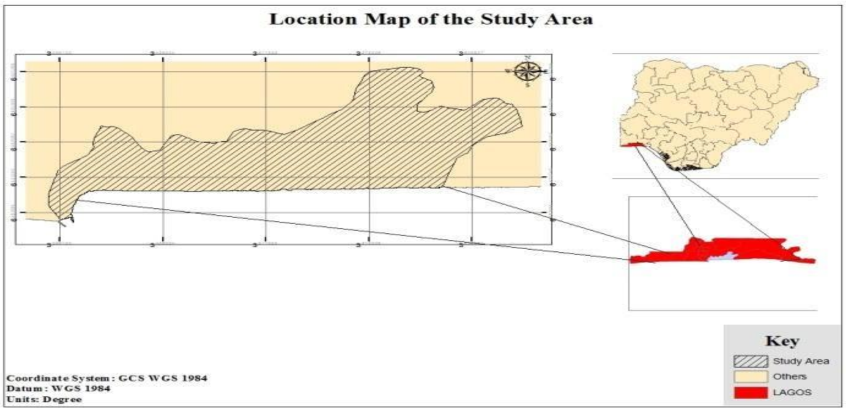


Figure 1: Map of the location of the Study Area

2.2. Data Acquisition and Processing

The data used in executing this study are of three groups: satellite imageries, field data and questionnaires. Landsat images (30m) for 1986, 2000, 2002, 2006 and 2016 (Table 1) were obtained from Global land cover facilities (http://www.glovis.usgs.gov/) and subjected to digital image processing (DIP). Maximum Likelihood Algorithm was the classification techniques performed on the images and thus a land use/cover management and support practice maps were produced. And subsequently, the cover management factor (C) and support practice factor (P) were estimated. The utilization of data include: soil data from soil test, hydrological data from Nigeria Meteorological Agency (NiMet), Shuttle Radar Topographic Mission (SRTM) data for DEM and Landsat images. The soil data was obtained from soil test carried out at the Department of Civil Engineering, University of Lagos and the precipitation data from Nigerian Meteorological Agency. The soil test data was reprocessed into a rasterized soil map, delineating six different soil types in Eti-Osa Local Government.

Table 1: Acquisition dates of the Landsat Imageries used

Year	Sensor	Spatial Resolution	Acquisition Date
1986	Landsat 5 TM	30m	December 24
2000	Landsat 7 ETM+	30m	February 6
2002	Landsat 7 ETM+	30m	December 28
2006	Landsat 7 ETM+	30m	December 7
2016	Landsat 8 OLI	30m	December 26

2.3. Soil Erosion Risk Mapping using RUSLE Model

The revised universal soil loss equation (RUSLE) was used to assess the areas of erosion risk in the study area. The RUSLE equation is defined by the following parameters (Zhang *et al.,* 2004; Wischmeier, 1979).

$$A = R \times K \times L \times S \times C \times P \quad (1)$$

Where: A = average soil loss; R = erosivity factor (derived from rainfall data); K = soil erodibility factor (derived from soil data); L = slope length factor (obtained from DEM); S = slope steepness factor (obtained from DEM); C = cover management factor and P = support practice factor.

2.4. Calculation of RUSLE Factors

2.4.1. Rainfall - Runoff Erosivity (R)

Rainfall and runoff (volume, peak discharge) are factors of erosivity (Wischmeier and Smith, 1978; Arnoldus, 1980). Roose (1977) model for estimating values of rainfall erosivity from rainfall amounts for West African climates was adopted. The equation is given as:

$$R = (0.55 \times Pa) \qquad (2)$$

where: R is the rainfall erosivity factor [MJ mm ha-1h-1yr-1], Pa is the Annual average rainfall amount (mm).

The long-term non recording rain gauge data ranging from 1986 to 2014 were used to compute long – term averages for the study area. Each of the rainfall charts was analyzed by summing up the monthly averages to the yearly averages. To obtain rainfall amount in mm, the rainfall from January – December averages years, the values of the rainfall records in the study (Table 2) were used to generate the rainfall map. R factor was determined for the selected rainfall gauging stations using the Equation 2 above. However, due to data gaps, the available data was projected for the two stations and their averages used and the rainfall map (Figure 2) extracted. Isohyet maps for R factor were generated using ArcGIS10.2.

Table 2: Surrounding Rainfall Stations and their Annual Averages

No	Stations	X	Y	Annual Average	R Factor
1	Lagos Marine	3.4	6.41667	202.0917	111.15
2	Lagos Roof	3.430933	6.441077	129.275	71.1

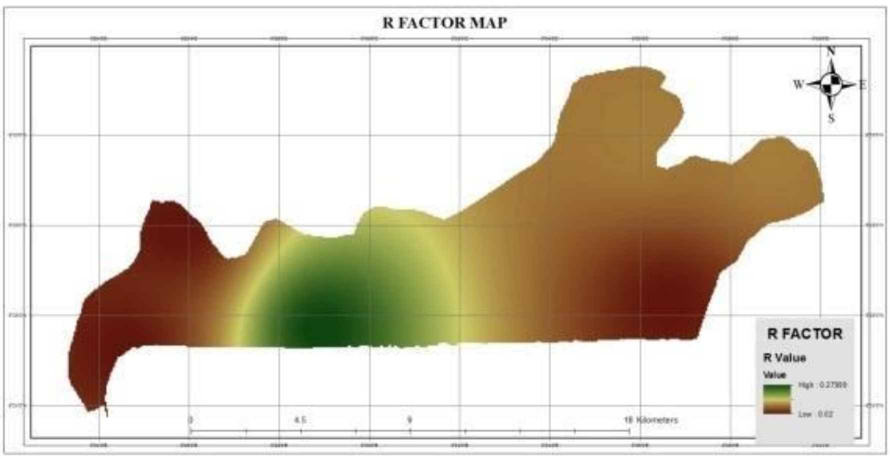


Figure 2: R Factor Map

2.4.2. Soil Erodibility Factor (K)

Soil erodibility (K) represents the susceptibility of soil or surface material to erosion, transportability of the sediment, and the amount and rate of runoff given a particular rainfall input, as measured under a standard condition (Weesies, 1998. For a standard plot as earlier defined, soil erodibility factor, K, is calculated from the equation:

$$K = A/R \tag{3}$$

where: A is amount of soil loss and; R is rainfall erosivity factor in the USLE (Wischmeier and Smith, 1965; 1969).

For this study, soil samples of various horizons (and based on stratified random sampling technique) were collected from these locations: Ajah roundabout, Badore axis, Sangotedo axis, Ogomu axis, Ikoyi/Obalende axis and Iru/Victoria-island axis and analyzed in the Laboratory of the Department of Civil Engineering, University of Lagos to correctly assign soil erodibility values (Table 3). These soil samples were assessed using the Wischmeier *et al.,* (1971) nomograph. The nomograph relates the K factor to five soil profile parameter (Zhang, *et al.*, 2012). The soil properties – percentage of silt (0.002- 0.05mm) plus percentage of very fine sand (0.05 – 0.01mm) and the percentage of sand (0.1-2mm) needed for the estimation of K using the nomograph was adopted from Agada (2015). The estimated soil erodibility laboratory test result ranged from 0.02 to 0.28 (Table 4). For this study, K factor shape file was added as a layer into ArcGIS 10.2, the soil map attribute table was edited by adding a new field of K values under the Edit menu at attribute view before K factor was produced (Figure 3). The K factor for the various soil classes was added.

Table 3: Soil Sample

Soil sample stations	Soil percentage (%)		
	Sand	Silt	Gravel
Eti-osa	99	1	-
Badore	99	-	1
Sangotedo	99	-	1
Ogomu	97	-	3
Ikoyi/Obalende	94	5	1
Iru/Victoria-Island	97	-	3

Table 4: K Factor

Soil Type	K factor
Sand	0.02
Fine sand	0.1
Very fine sand	0.28

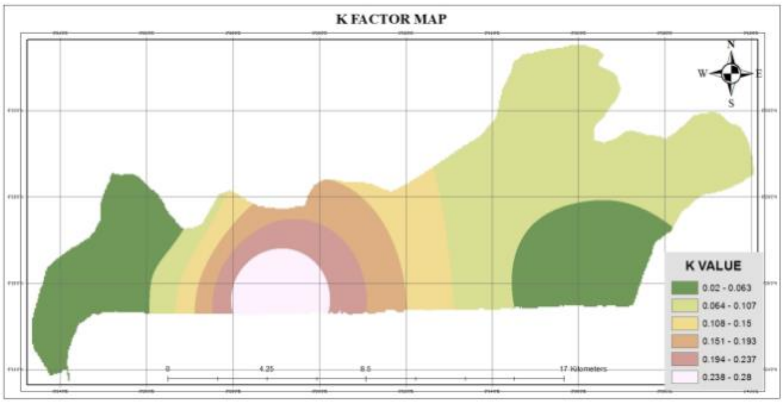


Figure 3: K Factor Map

2.4.3 Slope Length and Steepness Factor (LS)

The effect of topography on soil erosion is accounted for by the LS factor in RUSLE, which combines the effects of a slope length factor, L, and a slope steepness factor, S (Zhang *et al.*, 2012. As the slope steepness (S) increases, the velocity and erosivity of runoff increase. Slope length (L) is defined as the ratio of soil loss from the field slope length to that from a 22.1 m length under otherwise identical conditions (Wischmeier and Smith, 1978). The L and S factors are usually considered as single topographical factor and can be estimated using the equation:

$$LS = (x/22.13)^m\ [(0.065 + 0.045(s) + 0.0065(s^2)] \tag{4}$$

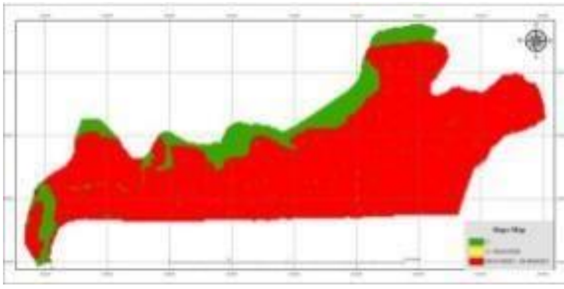
where: LS is topographical factor and is dimensionless, x is slope length (meter), m is an exponent whose value depends slope gradient and, s is slope gradient (percent), Current recommendations (Wischmeier and Smith, 1978) for the exponent m are as follows: $m = 0.5$ if slope ≥ 5 percent, $m = 0.4$ if slope < 5 percent and > 3 percent, $m = 0.3$ if slope ≤ 3 percent and ≥ 1 percent, $m= 0.2$ if slope < 1 percent.

$$x = (\text{flow accumulation} \times \text{cell value}) \tag{5}$$

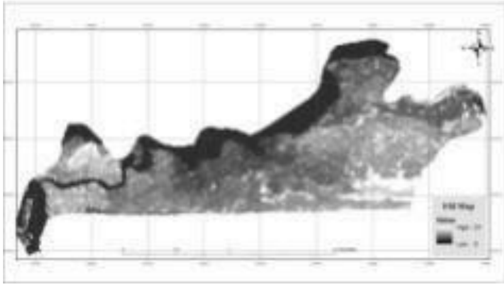
By substituting x value, LS equation will be:

$$LS = \frac{(\text{Flow Accumulation x Cell Value})^{m}\ [(0.065 + 0.045(s) + 0.0065(s^2)]}{22.13} \tag{6}$$

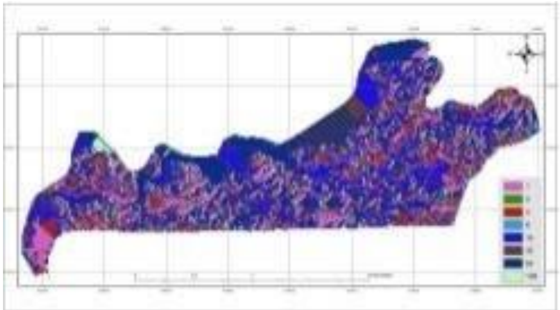
The DEM of the study area was extracted from shuttle radar topographic mission data. This was achieved by using the extraction by mask Spatial Analyst tool of ArcGIS. DEM represents the surface terrain of the study area and permits to retrieve geographical information. Slopes of DEM in percentage were also generated using Surface Analysis under the Spatial Analyst function. Surfacing function was used to generate a DEM and to represent as a surface or one-band image file where the value of each pixel was a specific elevation value. A gray scale was used to differentiate variations in terrain. The Slope map was generated in ArcGIS 10.2 software by using DEM. As the first step, the elevation value was modified by filling the sinks in the grid. This is done to avoid the problem of discontinuous flow when water is trapped in a cell, which is surrounded by cells with higher elevation. This was done by using the Fill tool under Hydrology section found under Spatial Analyst Tool Function in ArcGIS 10.2. Then, Flow direction was generated from the Fill grid. The Flow direction tool takes a terrain surface and identifies the down-slope direction for each cell. This grid shows the on surface water flow direction from one cell to one of the eight neighboring cells. This was done by using the Flow direction tool under Hydrology section found under Spatial Analyst Tool Function in ArcGIS. Based on the Flow direction, Flow accumulation was calculated (Figure 4). Flow accumulation tool identifies how much surface flow accumulates in each cell; cells with high accumulation values are usually stream or river channels. It also identifies local topographic highs (areas of zero flow accumulation) such as mountain peaks and ridgelines. This was done by using the Flow accumulation tool under Hydrology section found under Spatial Analyst Tool Function in ArcGIS 10.2. Finally, the Raster calculator function under Spatial Analyst feature (Map Algebra) was used to input the equation 4 to compute LS factor. Themes of slope of DEM in percentage and flow accumulation were activated to run the process as shown in equation 5 and 6. Cell value of 20m was utilized in Equation 5. The m value of 0.5 was selected for equation 4 because about 80% of the terrain of the study was steeper than 20º. LS values ranged from 0 to 12.83.



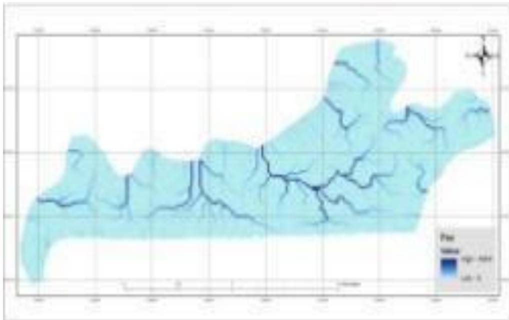
(a) Slope Map



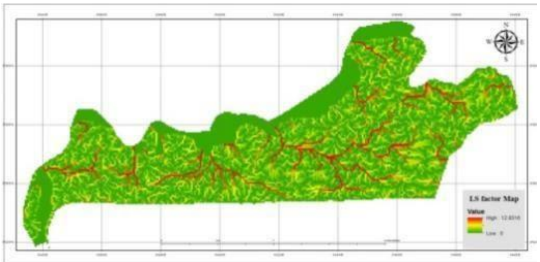
(b) Fill Map



(c) Flow Direction



(d) Flow Accumulation



(e) LS Factor Map

Figure 4: Maps predicted from SRTM DEM - (a) Slope Map, (b) Fill Map, (c) Flow Direction and (d) Flow Accumulation (e) LS Factor Map

2.4.4 Cover Management Factor (C)

The cover management factor (C) represents the effects of vegetation, management, and erosion control practices on soil loss (Narain *et al.,*1994). As with other RUSLE factors, the C value is a ratio comparing the existing surface conditions at a site to the standard conditions of the unit plot. RUSLE uses a sub factor method to compute soil loss ratios (SLR), which are the ratios of soil loss at any given time in the cover management sequence to soil loss from the standard condition. The sub factors used to compute a soil loss ratio value are prior land use, canopy cover, surface cover, surface roughness, and soil moisture (Renard *et al.,* 1991). C value is equal to 1 when the land has continuous bare fallow and have no coverage. C value is lower when there is more coverage of a crop for the soil surface resulting in less soil erosion (Soo, 2011). Characteristics of the land surface, including natural and artificial cover were considered. Existing land use practices were investigated through field survey, and training sites for different land uses were marked to derive information about land use activities and land cover for plotting land use land (LULC) cover map. A maximum likelihood supervised classification was then applied to the imagery using the ArcGIS 10.2 software with the following training sites namely; Built-up, Water body, Light Forest, Bare land and Swampy. From the LULC map (Figure 5) derived C factor values were assigned for the various classes (Table 5) based on previous research findings (Lee and Lee, 2006) and a C factor map (Figure 6) was produced.

Table 5: Cover and Management Factor Values (Adapted from Lee and Lee, 2006)

Code	Land Use	C Factor
1	Water body	0.000
2	Bare land	0.500
3	Built up	0.003
4	Light Forest	0.050
5	Swampy	0.002

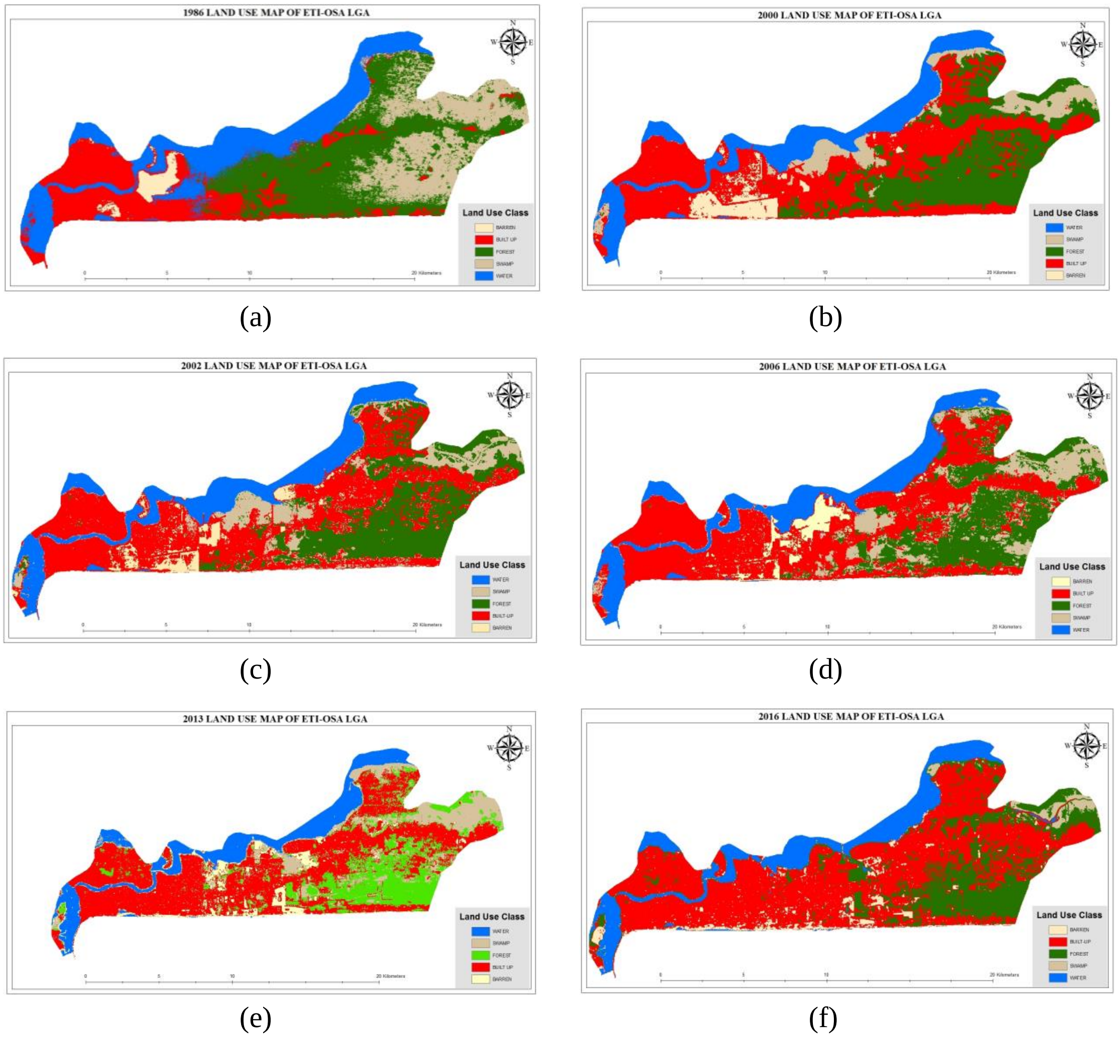


Figure 5: Land Use Classification Map (a) 1986 (b) 2000 (c) 2002 (d) 2006 (e) 2013 (f) 2016

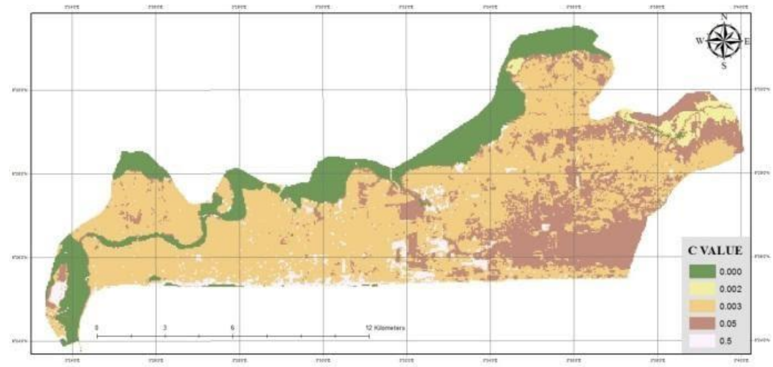


Figure 6: C Factor Map

2.4.5. Support Practice Factor (P)

Conservation practice factor (P) in the RUSLE model (Figure 7) expresses the effect of conservation practices that reduce the amount and rate of water runoff, which reduce erosion. It includes different types of agricultural management practices such as: strip-cropping, contouring and terracing (Farhan *et al.*, 2013). The P value range is between 0 to 1 where 0 represents very good man-made erosion resistance facility and 1 represents no man-made erosion resistance facility. The classification techniques performed on the images and thus a land use/cover management and support practice maps was produced. And subsequently, the cover management factor (C) and support practice factor (P) were estimated. P value is lower and less than 1 when the adopted conservation practice reduces soil erosion.

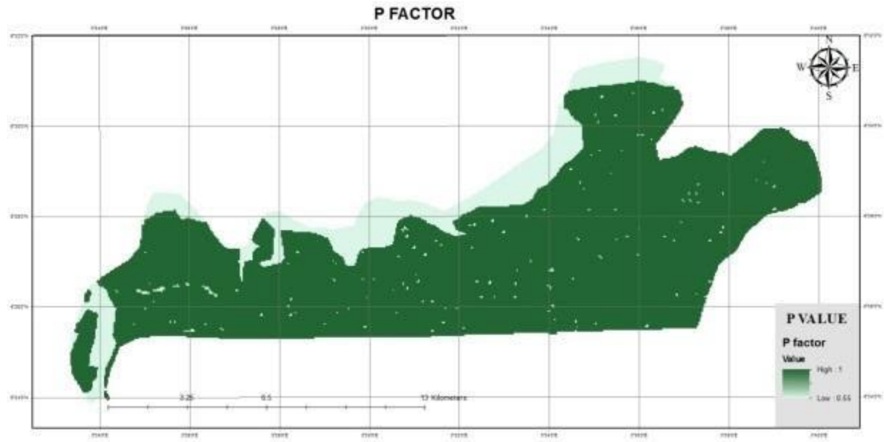


Figure 7: P Factor Map

2.4.6. Questionnaire administration

Structured questionnaires were administered to elicit information on the communities' perception of the causes and impact of erosion on the environment. Stratified random sampling and random sampling techniques were the sampling techniques used. The settlements were grouped into four strata based on the Local Council Development Area (LCDA/Ward) and then the questionnaires administered randomly in each stratum. Information obtained from the questionnaire administration were subjected to statistical analysis test using the Analysis of Variance (ANOVA) (Omodanisi *et al.*, 2013) as shown in Tables 6 and 7. Also, focus group discussion was held with some of the occupants in the community with the view of acquiring information on the perceived causes and impact of erosion in the community.

Table 6: Perception of occupant based on occupation

Question	Grouping	Sum of Squares	df	Mean Square	F	Sig.
How long have you been living in your community?	Between Groups	10.292	4	2.573	2.242	.066
	Within Groups	218.046	190	1.148		
	Total	228.338	194			
What land is dominant in your area?	Between Groups	20.646	4	5.162	2.905	0.23
	Within Groups	337.641	190	1.777		
	Total	358.287	194			
What do you understand by erosion?	Between Groups	7.570	4	1.893	3.898	.005
	Within Groups	92.245	190	.486		
	Total	99.815	194			
Has there been any incident of erosion in the community	Between Groups	.708	4	.177	.701	.592
	Within Groups	48.010	190	.253		
	Total	48.718	194			
If yes, Since when?	Between Groups	13.239	4	3.310	1.752	.145
	Within Groups	179.511	95	1.890		
	Total	192.750	99			
How often or what is the frequency of occurrence?	Between Groups	16.140	4	4.035	2.106	.086
	Within Groups	182.050	95	1.916		
	Total	198.190	99			
What do you think is the cause of the erosion?	Between Groups	3.982	4	.995	1.370	.250
	Within Groups	69.008	95	.726		
	Total	72.990	99			

Table 7: Perception of occupant based on education

Question	Grouping	Sum of Squares	df	Mean Square	F	Sig.
How long have you been living in your community?	Between Groups	17.626	4	4.406	3.973	.004
	Within Groups	210.713	190	1.109		
	Total	228.338	194			
What land is dominant in your area?	Between Groups	8.632	4	2.158	1.173	.324
	Within Groups	349.655	190	1.840		
	Total	358.287	194			
What do you understand by erosion?	Between Groups	6.965	4	1.741	3.563	.008
	Within Groups	92.850	190	.489		
	Total	99.815	194			
Has there been any incident of erosion in the community	Between Groups	1.197	4	.299	1.196	.314
	Within Groups	47.521	190	.250		
	Total	48.718	194			
If yes, Since when?	Between Groups	2.754	4	.688	.344	.847
	Within Groups	189.996	95	2.000		
	Total	192.750	99			
How often or what is the frequency of occurrence?	Between Groups	12.000	4	3.000	1.531	.199
	Within Groups	186.190	95	1.960		
	Total	198.190	99			
What do you think is the cause of the erosion?	Between Groups	2.088	4	.522	.699	.594
	Within Groups	70.902	95	.746		
	Total	72.990	99			

3.0. Result and Discussion

3.1. Classified Images

Figure 5 revealed that between 1986 and 2016, considerable changes had occurred in most parts of the area and that there was an expansion in the area cover by built-up from 21.65% to 41.03%. Between

2000 and 2002, the water body and the natural forest shrank from 17.8% to 17.19% and from 27.27% to 23.8% respectively. However, between 2002 and 2006, the built-up area increased from 42.9% to 45.28% reducing the water body and natural forest from 17.19% to 16.15% and 23.8% to 21.06% respectively. In the last three years of the study period (between 2013 and 2016), the built-up area and light forest expanded from 46% to 55.96 and 18.69% to 21.78% respectively, while the barren land and swamp reduced from 7.12% to 4.72% and 13.08 to 1.87% respectively. This is a very clear indication of increase in the human population of Eti-Osa.

3.2. The Soil Loss Rate

The data layers (maps) obtained for K, LS, R, C, and P factors of the RUSLE model were integrated to produce the erosion risk level (Figure 8) and then draped with cadastral map (Figure 9) in order to quantify, evaluate, and generate the potential soil erosion risk map for Eti-Osa LGA. In the study, the annual soil loss map of Eti-Osa was produced based on the combination of the RUSLE factors. For ease of interpretation, the value of the potential soil erosion risk was reclassified into 5 severity zones ranging from extreme to very low. The Soil erosion Map of Eti-Osa Local Government Area in figure 8 showed flashes of yellow, orange and red, which indicate moderate, high and extreme erosion sites. From result, it can be seen that the bare lands close to ocean and crop lands were mostly eroded. This can be attributed to the high rainfall and less vegetation cover to protect the soil. There are signs of erosion within the urban areas and sites close to the water body. The soil loss in the vegetated areas can be attributed to logging activities as noticed during field visits. When the area is deforested, the land is exposed and bare, the C and P value becomes high, posing huge erosion risks.

Most of the erosion hotspots were located around the Eti-Osa West (Lekki, Ajah settlements) which agrees with recent occurrence of erosion and ocean surge in Okun Alfa community. In this community, long and continuous human disturbance and deforestation, with the combined effect of K, LS and C factors, account for high level of soil loss across the area. The areas with extreme severity clearly correlated with slope steepness. Other categories of high and moderate erosion were observed in some parts of Iru/Victoria Island. This can be ascribed as a result of percentage of gravel in Iru/Victoria Island. At Eti-Osa East and Ikoyi/Obalende, parts of Badore and Sangotedo areas seemed to record low losses which were largely due to the evenness of the topography, crop cover C and support practice factor P. The type of soil in the area and more surface cover from developed urban environments, less logging, less open spaces and the urban factor could be another reason. Areas with a vegetal cover or some form of covering which could be infrastructure, buildings etc. can reduce the impact of erosion on the surface soil. In general, findings revealed that the land use type mostly affected were the waste land and the crop lands. The urban and vegetated/forested areas were least eroded or had low to moderate erosion though there are signs that the vegetated areas may be experiencing high erosion. The findings in this study agree with the research work of Ibitoye, (2010) who reported that land exposure and soil erosion in part of humid region of Southwest Nigeria had appeared to be an urban phenomenon and has been occurring at unprecedented rates.

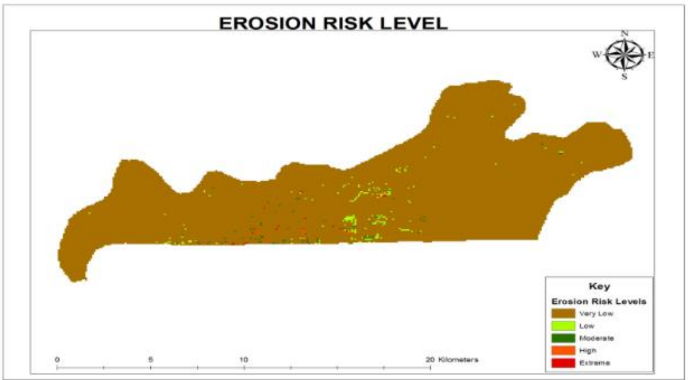


Figure 8: Erosion Risk Level

Figure 9: Erosion Risk Level draped with the Cadastral Map

3.3. Questionnaire Result

Occupant perception was analyzed through the administration of questionnaires. 40% of the occupants confirmed that there has been an incident of erosion in their community while 60% said there has not been any incident of erosion in their community. Over 25% of the occupants thinks the major cause of the erosion is poor drainage system, 5.2% thinks climate changes causes erosion in their community, 4.8% linked the cause of erosion to badly planned sea defenses while 2.4% thinks construction close to the sea and others factors contributed to the erosion in the community.

The result of the Analysis of variance (ANOVA) showed that the responses of the occupants were influenced by their occupation. The ANOVA result indicated a significant differences in the opinions of the respondents as regards what they perceived the term erosion ($P=3.898$, $p>0.005$). That is, their occupation affected the way they responded to some of the questions. Also, the education of the respondents affected the way they perceived erosion. The significance value of how long they have lived in the community is 0.004 (i.e., $p = 0.004$), which is below 0.005. Therefore, there is a statistically significant difference in how long they have lived in the community and their educational background. Previous research findings (Makinde, 2014; Tologbonse, 2018) have shown that factors such as education and occupation influence the way respondents perceive certain environmental challenge confronting their communities.

4.0. Conclusion

This research applied Remote Sensing and GIS techniques in erosion risk modeling in Eti-Osa LGA. The study was carried out in order to determine the major factors causing soil erosion the study area. The RUSLE model was combined with RS and GIS techniques to analyze the annual average soil loss rates caused by the various factors which influence soil erosion: rainfall, soil erodibility, topographical factors and the cover and support practices within the study area and to evaluate the spatial distribution of soil loss rates under different land uses.

It can therefore be concluded that high erosive rainfall, poor cover management, support practices, sand filling, land clearing in Eti-Osa for urbanization and infrastructure development have resulted in widespread soil erosion over the land surface. The extent of soil erosion occurring in the area is still increasing and is now a major cause for concern. From the results of the study, it can be concluded that combination of rainfall, lack of cover for the surface soil, were the major causes of soil loss in the study area.

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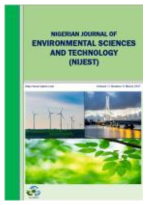
Cite this article as:

Makinde E.O and Oyebanji E.I., 2020. Remote Sensing and GIS Application to Erosion Risk Mapping in Lagos. *Nigerian Journal of Environmental Sciences and Technology*, 4(1), pp. 40-53. https://doi.org/10.36263/nijest.2020.01.0081

Nigerian Journal of Environmental Sciences and Technology (NIJEST)
www.nijest.com
ISSN (Print): 2734-259X | ISSN (electronic): 2734-2603
Vol 4, No. 1 March 2020, pp 54 - 69



Determination of Heavy Metal Contamination in Soil and Accumulation in Cassava (*Manihot Esculenta*) in Automobile Waste Dumpsite at Ohiya Mechanic Village

Ogbonna P.C.[1,*], Osim O.O.[2] and Biose E.[3]
[1]Department of Environmental Management and Toxicology, Michael Okpara University of Agriculture, Umudike, Abia State, Nigeria
[2]Department of Geography, University of Nigeria, Nsukka, Enugu State, Nigeria
[3]Department of Environmental Management and Toxicology, University of Benin, Edo State, Nigeria
*Corresponding Author: Ogbonna_princewill@yahoo.com

https://doi.org/10.36263/nijest.2020.01.0173

ABSTRACT

Human health challenges resulting from consumption of food contaminated by heavy metals necessitated the investigation of soil and cassava plants around automobile waste dumpsite at Ohiya mechanic village, Abia State, Nigeria. Soil and cassava samples collected randomly at the site were analyzed for cadmium (Cd), copper (Cu), lead (Pb) and chromium (Cr). The values of highest concentration of Cu and Pb in soil was recorded in 0-10 cm, Cr was obtained in 21-30 cm while Cd was in 11-20 cm soil depth. The concentration of Cd (0.11±0.00 to 0.26±0.00 mg/kg) in soil exceed maximum permitted level of 0.1 mg/kg (Cd) by FAO/WHO. The concentration of Pb (0.01±0.001 to 3.24±0.00 mg/kg) and Cd (0.07±0.00 to 2.08±0.00 mg/kg) in cassava plants exceed the permissible limit of 0.3 mg/kg (Pb) and 0.2 mg/kg (Cd) set by FAO/WHO. The Pearson correlation analysis show very strong positive relationship between Cu and Cu (r=0.996) and Pb and Pb (r=0.986) while strong negative relationship exist between Cr and Cr (r= -0.686) and Cd and Cd (r= -0.981) in soil and plant. Based on our findings, the concentrations of Cd in soil vis-à-vis Pb and Cd in plants which exceed maximum permitted level set by Codex Alimentarius Commission FAO/WHO will expose man and animals that relied on soil and cassava plants for food to serious health risks. Consequently, Abia State government should prevent farmers' access to the site by fencing round the automobile waste dumpsite.

Keywords: Automobile waste, dumpsite, heavy metals, soil, cassava plants, Ohiya

1.0. Introduction

The environment is continuously being contaminated by various human activities such as industrial production, agricultural processes, mineral exploitation, food processing, commercial, social, and domestic activities that generate contaminants like heavy metals (Ogbonna *et al*., 2018a). Continual loading of pollutants into the environment is of great concern to man since contaminants such as heavy metals persist in the environment due to its chemical structure (Ali *et al*., 2013; Hashem *et al*., 2017). Such contaminants include lead, cadmium, mercury and dioxin that never go away or degrade for long time. Over a long period of time, a large fraction of these contaminants may become buried in soil and even small residual amounts of these contaminants are a concern (Sakan and Dordevic, 2010).

Human health challenges in recent times have been attributed to consumption of food contaminated with heavy metals. Food contamination by human activities (Ogbonna *et al*., 2012; Ogbonna *et al*., 2013) is becoming very alarming due to quest to cope with high rate of food insecurity as well as other myriad of human needs in Nigeria. Cassava (*Manihot esculenta* Crantz) is considered the most essential staple root crop in the world and ranked as one of the most vital food crops grown in the tropics (Droppelmann *et al*., 2018; Olutosin and Barbara, 2019; Lawal *et al*., 2019). Besides playing a crucial role in food security, it is the cheapest source of industrial starch the world over (Zainuddin *et al*., 2019; Oyeyinka *et al*., 2019), alternative feedstock in many industrial applications like industrial baking flour, drug manufacturing, ethanol production among others due to its availability and low comparative cost (Anyanwu *et al*., 2015; Lawal *et al*., 2019). As a result of land hunger especially in the South east Nigeria, farmers are constrained to farming on lands adjoined to sources of pollution without considering the health implications of consuming crops grown on such lands (Ogbonna *et al*., 2018b). One of such adjoining sources of pollution is the mechanic village where automobile waste of various shapes, sizes and volumes are generated over a period of time (e.g. four years and above) and dumped at nearby lands. The corrosion of scrap metals as well as wear and tear due to rain (i.e. moisture) may release heavy metals into the soil. Plants growing on metal contaminated soil tend to absorb metals from soil solution via the roots and translocate it to the stems and the leaves (Ogbonna *et al*., 2018b). The use of plant parts is an effective indicator to monitor atmospheric pollution (Goodman and Robert 1971; Onder and Dursun 2006) but the distribution of heavy metals between soil and plants is a key issue in assessing the impact of anthropogenic activities, such as mechanic village on the ecosystem.

Quite a number of research on mechanic village or artisanal activities have been carried out in terms of heavy metal contamination in soil in Cape Coast metropolis, Ghana (Nyarko *et al*., 2019) Shashemane City, Ethiopia (Demie, 2015), Akure, Ondo State (Oguntimehin and Ipinmoroti, 2008), Imo river basin, Imo State (Nwachukwu *et al*., 2010), Gboko and Makurdi, Benue State (Pam *et al*., 2013; Luter *et al*., 2011), Anyigba, Kogi State (Ogunkolu *et al*., 2019), Abakaliki, Ebonyi State (Wilberforce, 2016), Port Harcourt, River State (Iwegbue *et al*., 2007), Okitipupa, Ondo State (Adebayo *et al*., 2017), Oghara, Delta State (Anegbe *et al*., 2018), Benin City, Edo State (Idugboe *et al*., 2014), soil and underground water (Owoso *et al*., 2017), soil and maize (*Zea mays*) Gwagwalada, Abuja (Okpanachi *et al*., 2016), pawpaw (*Carica papaya* Linn.) Port Harcourt metropolis, Rivers State (Eludoyin and Ogbe, 2017) in Nigeria. Despite the research, literature search show that no such work on heavy metal contamination of important root crop and staple food such as cassava has been carried out at any mechanic village site the world over. The objective of this study, therefore, is to investigate the level of concentrations of heavy metals in soil and their accumulation in cassava grown around automobile waste dumpsite at Ohiya mechanic village and compare the values with the maximum permissible limits of FAO/WHO, Dutch criteria for soil, the accepted limits of Federal Environmental Protection Agency (FEPA) and National Environmental Standards and Regulations Enforcement Agency (NESREA) of Nigeria. The results of this research will provide the background information on the levels of concentrations of heavy metals in the soil and plants and serve as an important document for proper dissemination of information to farmers by the Agricultural Development Programme (ADP), Abia State, thus, enhancing farmers knowledge on the possible health risk associated with farming on land in proximity with the mechanic village.

2.0. Materials and Methods

2.1. Study area

This study was carried out at the automobile waste dumpsite at Ohiya mechanic village in Umuahia South, Abia State, Nigeria. The Ohiya mechanic village was commissioned by the Abia State government on 6th Novermber, 2014. Umuahia is the capital city of Abia State in Southeastern Nigeria and it has an area of 140 km² and a population of 138,570 at the 2006 census (NPC, 2006). Ohiya is within the lowland rainforest zone of Nigeria (Keay, 1959; Ogbonna *et al*., 2018c) which lies on latitude 05°28'N and longitude 07°26'E. The area has a mean annual rainfall of 2133 mm distributed over eight months of rainy season period (March to October) with bimodal peak in July and September. The soil is ultisol while the minimum and maximum temperature is 21°C and 30°C respectively, with relative humidity of 60-70%. The main food crops grown by farmers include cassava, maize, yam, vegetables as fluted pumpkin, bitter leaf, okra; cash crops such as oil palm fruits, groundnuts among others.

2.2. Collection of samples and analysis

Soil samples were collected with Dutch soil auger from nine (9) different sampling points (A_1, A_2, A_3; B_1, B_2, B_3, C_1, C_2, and C_3) at 0 - 10, 11 - 20, 21 - 30, 31 - 40 and 41 - 50 cm soil depth in three sampling positions (i.e. three sampling points each at entry point (A_1, A_2 and A_3), middle point (B_1, B_2 and B_3), and exit point (C_1, C_2 and C_3)) of the 64 m x 87 m dump site. The control sample was collected in an upland two (2) years bush fallow “at Uzo-Okpulo” which is about 1.5 km from the automobile waste dumpsite where there was no visible source of contamination. Samples from each particular soil depth (e.g., 0-10 cm at entry point, middle point and exit point) were bulked together to form a composite sample and were placed in cellophane bags (about 35 g) well labelled, placed in a wooden box and covered to avoid contamination from external sources. The samples in the wooden box were transferred to the laboratory for pre-treatment and analysis. Each bulked soil sample was freed from foreign objects (roots, pebbles, etc.) and air-dried to a constant weight in an oven of 30^0C with a circulating air. The samples were subjected to crushing, grinding and then homogenized using a porcelain pestle and mortar. The homogenized soil samples were sieved through a 2.0 mm sieve pore, giving rise to the actual workable samples, which were then placed in their labelled cellophane bags respectively and stored at room temperature for the next level of the analytical process (Garcia *et al.*, 2004). Two (2 g) of the dried samples each was weighed out into a digestion flask and added 20 ml of the acid mixture (650 ml conc HNO_3; 80 ml perchloric acid; 20 ml conc. H_2SO_4), then allowed for about 20 min. The digestion flask containing the weighed out soil sample was heated until a clear digest is obtained. The clear digest was allowed to cool for 10 min, filtered into 50 ml standard flask with Whatman No. 41 filter paper, and then diluted with deionized water to the 100 ml mark (Adrian, 1973) and analysed for Pb, Cd, Cr, and Cu. In order to check for background contamination by the reagents, blanks were prepared from only reagents without sample. Triplicate digestion of each sample was carried out. The digested samples were then subjected to analysis of heavy metals (Pb, Cd, Cr, and Cu) using the Atomic Absorption Spectrophotometer (Model: Perkin Elmer, USA).

Cassava samples for determination of heavy metals content was collected from fifteen (15) months old Cassava plant grown about 1 m away from the dumpsite. Control cassava samples were collected from a farmland about 1.5 km away from the experimental farmland where there was no visible source of contamination. Samples of cassava were collected randomly in the month of September from the 54 m x 72 m farmland, using well cleaned secateurs at various sampling points, three (3) points at each sampling positions (entry point (within 5 m from the dumpsite, middle point (25 m away from the dumpsite) and exit point (50 m away from the dumpsite)) in the farmland. Samples were bulked together and separated into roots, stems and leaves, well labelled and transferred to the laboratory for pre-treatment and analysis.

Samples were cleaned with deionized water to remove dust and debris after which they were oven-dried at 60^oC for 72 hr. The roots, stems and leaves of the cassava plant samples were milled separately with Thomas Wiley milling machine to fine powder. The oven-dried, ground and sieved samples were accurately weighed and digested in a 1:1 mixture of concentrated nitric acid and perchloric acid (Oyelola *et al.*, 2009). A 5 ml of the mixture of concentrated nitric acid (HNO_3) and per chloric acid (HCL_4) was added to 2 g of each sample and heated on a hot plate at 105^oC for an hour to dryness, allowed to cool for 10 mins, and then transferred to a volumetric flask. Exactly 1 M HNO_3 was added to make up the solution to the mark of 50 ml volumetric flask. The solution was centrifuged for 45 min and transferred to sampling bottles for analysis. In order to check for background contamination by the reagents, blanks were prepared from only reagents without sample. Triplicate digestion of each sample was carried out. The digested samples were then subjected to analysis of heavy metals (Pb, Cd, Cr, and Cu) using the Atomic Absorption Spectrophotometer (Model: Perkin Elmer, USA).

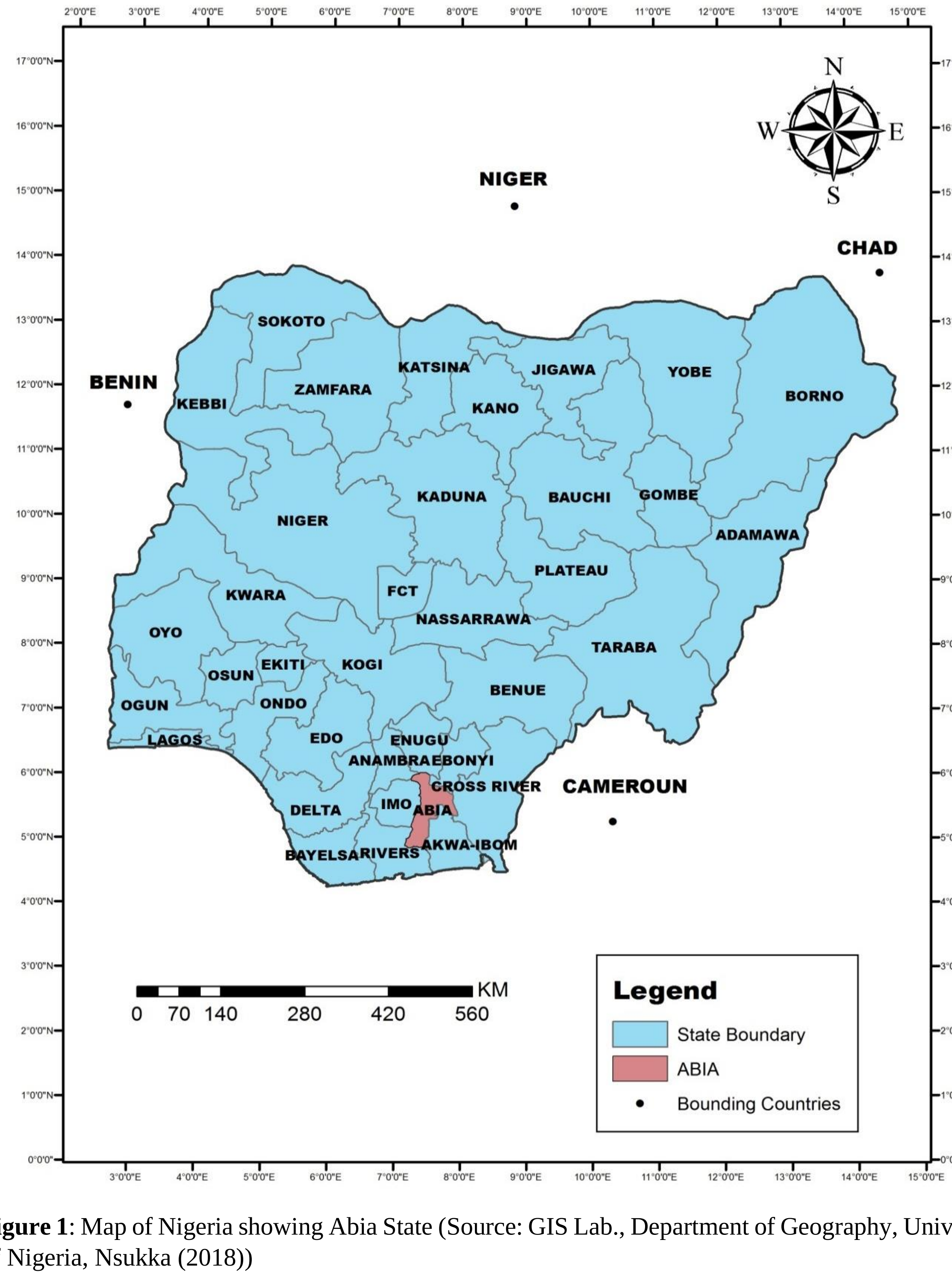


Figure 1: Map of Nigeria showing Abia State (Source: GIS Lab., Department of Geography, University of Nigeria, Nsukka (2018))

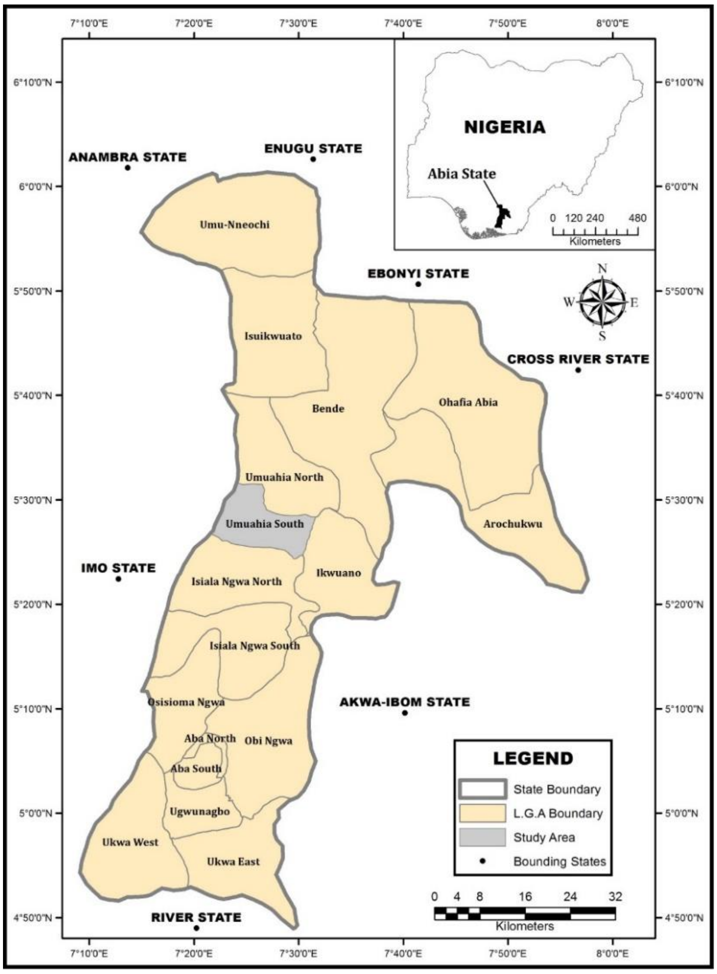


Figure 2: Abia State showing Umuahia South (Source: GIS Lab., Department of Geography, University of Nigeria, Nsukka (2018))

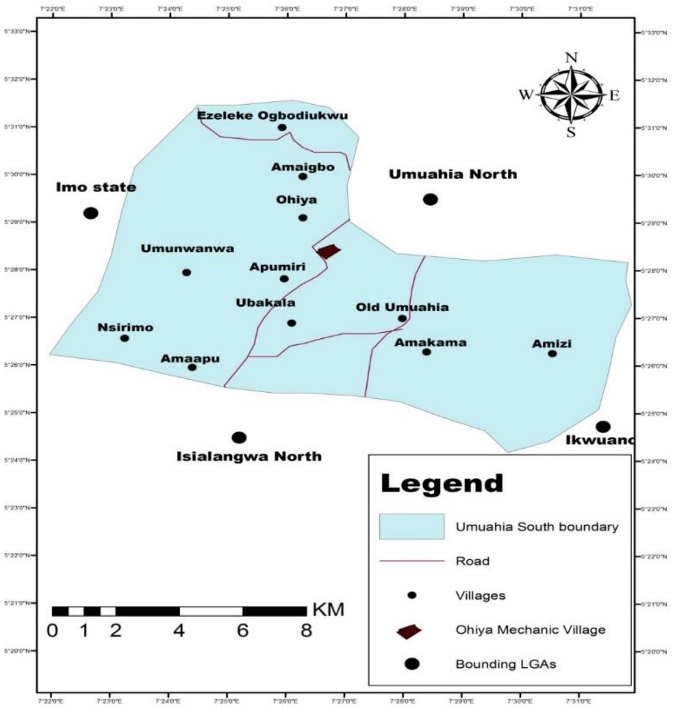


Figure 3: Map of Umuahia South LGA showing Umuahia mechanic village (Source: GIS Lab., Department of Geography, University of Nigeria, Nsukka (2018))

2.3. Analysis of heavy metals

Digested soil and plant samples was conducted using Agilent FS240AA Atomic Absorption Spectrophotometer according to the method of American Public Health Association, APHA (1995). Atomic absorption spectrophotometer's working principle is based on the sample being aspirated into the flame and atomized when the AAS's light beam is directed through the flame into the monochromator, and onto the detector that measures the amount of light absorbed by the atomized element in the flame. Some metals have their own characteristic absorption wavelength, a source lamp composed of that element is used, making the method relatively free from spectral or radiational interferences. The amount of energy of the characteristic wavelength absorbed in the flame is proportional to the concentration of the element in the sample. The instrument settings and operational conditions were in accordance with the manufacturer's specifications. The instrument was calibrated with analytical grade standard metal solutions.

2.4. Statistical analysis and experimental design

A simple factorial experiment was conducted in a randomized complete block design with five replications in soil depth. Data generated from the experiment were subjected to one way analysis of variance (ANOVA) using special package for social sciences (SPSS) v. 16 and means were separated (Steel and Torrie, 1980) at $P<0.05$ using Duncan Multiple Range Test (DMRT) while Correlation analysis was used to determine the relationship between the means of the parameters analysed in soil and cassava plant.

The comparison and interpretation of the results of different parts of *Manihot esculenta* (cassava) analyzed in this study is based on the control values, the values of concentration of heavy metals in plants in similar studies, standards set by international agency such as Codex Alimentarius Commission as well as national agencies such as Federal Environmental Protection Agency (FEPA) and National Environmental Standards and Regulations Enforcement Agency (NESREA) of Nigeria.

3.0. Results and Discussion

3.1. Concentration of heavy metals in soil

The values of the concentration of heavy metals in the different soil depths in automobile waste dumpsite at Ohiya mechanic village are summarized in Table 1. Heavy metal concentration in soil in this study were raised to different levels and the significant differences was evidenced amongst the different soil depths at study site. The various anthropogenic activities such as panel beating, servicing of car engines and changing of electrical component of vehicles among other resulted to generation of heavy metal contaminated materials that are discarded at the dumpsite. The results indicate that the highest and lowest heavy metal concentrations in soil were obtained at the scrap metal dumpsite and control site, respectively for Cd, Pb, Cu and Cr. Some pollution surveys showed that soil within or around source of pollutants had high concentrations of heavy metals (Davila *et al*., 2006; Nwachukwu *et al*., 2010; Ogbonna *et al*., 2013; Ogbonna *et al*., 2018a). Since there were no other sources of contamination in the area, the high concentrations of heavy metals in soil of the automobile waste dumpsite (unlike the control) may be attributed to leaching of the heavy metals (Cd, Pb, Cu and Cr) from the large volume of waste from Ohiya mechanic village waste dumpsite.

The concentration of heavy metals was observed to peak within 21-30 cm depth for Cr while Cd had its concentration within 11-20 and 21-30 cm depths unlike Cu and Pb that had their highest concentrations in 0-10 cm depth. The pattern of leaching or migration of heavy metals in the soil suggest that Cr and Cd were relatively more mobile than Pb and Cu at the study site. Cadmium is known to be highly mobile in soil (Ogbonna and Okeke, 2011) and its mobility at the automobile waste dumpsite peaked within 11-20 and 21-30 cm depths. The high concentrations of Pb and Cu in 0-10 cm depth may be attributed to presence of organic matter since heavy metals are bound to topsoil by organic matter (Sukkariyah *et* *al*., 2005) hence reducing the leaching of heavy metals into the lower depths (Ogbonna *et al*., 2018b). Organic matter waste residue from effluent oil and oil spills adds organic matter and carbon to the soil (Anegbe *et al*., 2018).

The highest concentration of Cd (0.26±0.00 mg/kg) was jointly recorded in 11-20 and 21-30 cm depths, and the value is significantly ($P<0.05$) higher than values observed for Cd in 0-10 cm (0.3±0.00 mg/kg), 31-40 cm (0.20±0.00 mg/kg), 41-50 cm (0.11±0.00 mg/kg) and control (0.16±0.03, 0.15±0.01, 0.05±0.00, 0.02±0.00 and 0.00±0.00 mg/kg, respectively for 0-10, 11-20, 21-30, 31-40 and 41-50 cm). The heavy metals from the scrap metal at the dumpsite may have provided a source for continued dispersion and have resulted to various degree of contamination of Cd in the soil depths. For instance, Ogbonna and Okezie (2011) in their study of roadside soils reported that Cd is released from the wearing of paints on the metal parts of vehicles. The values of the concentration of Cd in automobile waste dumpsite soils of Ohiya mechanic village was 0.11±0.00 to 0.26±0.00 mg/kg, which is well below 31.5 to 47.5 mg/kg (Nwachukwu et al., 2010), 26.0 to 48.0 mg/kg (Iwegbue *et al*., 2007), 19.86 to 21.421 mg/kg (Idugboe *et al*., 2014) and 0.87 to 2.55 mg/kg (Anegbe *et al*., 2018) but higher than 0.01 to 0.12 mg/kg (Adebayo *et al*., 2017) in their studies of heavy metals in soils. The low concentration of Cd in soils of Ohiya mechanic village may be attributed to short period of time of its existence (i.e. 015 till date) as well as the type and volume of waste at the automobile dumpsite. Nwachukwu *et al*. (2010) opined that the type of automobile waste at dumpsite, volume of waste and length of time the dump has been in use influence the release of metals. The concentration of Cd (0.26±0.00 mg/kg) in 11-20 and 21-30 cm depth was found to be 1.13, 1.30, 2.36 times higher than its values in 0-10, 31-40 and 41-50 cm at the dumpsite and 1.63, 1.73, 5.2, 13 and 26 times higher than 0-10, 11-20, 21-30, 31-40 and 41-50 cm at the control site, respectively.

The highest concentration of Pb (2.57±0.00 mg/kg) and Cu (1.28±0.00 mg/kg) were recorded in 0-10 cm depth and the values are significantly ($P<0.05$) higher than their corresponding values in 11-20 cm (1.34±0.00 and 0.50±0.00 mg/kg), 21-30 cm (1.92±0.00 and 0.57±0.00 mg/kg), 31-40 cm (0.93±0.00 and 0.27±0.00 mg/kg), 41-50 cm (0.93±0.00 and 0.41±0.00 mg/kg) and control (1.36±0.01 and 1.03±0.01, 0.59±0.00 and 0.01±0.00, 0.79±0.00 and 0.32±0.02, 0.31±0.01 and 0.03±0.00, 0.23±0.02, and 0.01±0.00 mg/kg, respectively for Pb and Cu in 0-10, 11-20, 21-30, 31-40 and 41-50 cm depths). The concentration of Pb in soil may be attributed to lead-acid batteries, adhesion of lead halides from petroleum motor spirit (PMS) and spent lubricating oil used for cleaning engines and other vehicular parts during servicing and are discarded at the automobile dumpsite. Lead (Pb) is part of the composition of lubricating oil and galvanized parts of vehicles (Falahi-Ardakani, 1984; Zechmeister *et al*., 2005). It (Pb) is also released from babbit metal bushings (Oguntimehin and Ipinmoroti, 2008) that are discarded at automobile waste dumpsite in Ohiya mechanic village. The concentration of Pb in 0-10 cm depth (2.57±0.00 mg/kg) was found to be 1.92, 1.34, 2.76 times higher than its corresponding values in 11-20, 21-30, 31-40, 41-50 cm depth at the study site and 1.89, 4.36, 3.25, 8.29 and 11.7 times higher than its values in 0-10, 11-20, 21-30, 31-40 and 41-50 cm depths at the control site, respectively. The concentration of Pb in soils of the automobile dumpsite at Ohiya mechanic village was 0.93±0.00 to 2.57±0.00 mg/kg, which is higher than 0.01 to 0.80 mg/kg (Adebayo *et al*., 2017) but well below 283.7±127 to 665±912 mg/kg (Pam et al., 2013), 0.055±0.008 to 21,200±90 mg/kg (Owoso *et al*., 2017), 18.25 to 15,100 mg/kg (Adelekan and Abegunde, 2011), 268.12±46.8 to 664.62±52 mg/kg (Wilberforce *et al*., 2016) and 1.66 to 172.76 mg/kg (Luter *et al*., 2011).

The high concentration of Cu in soil at the dumpsite (unlike the control plot) may be attributed to presence of car brake and metal bearing at the automobile waste dumpsite. Copper is included in car brake (Falahi-Ardakani, 1984) and metal bearing (Oguntimehin and Ipinmoroti, 2008) which are gradually released and leached into the soil at the Ohiya mechanic village dumpsite. Copper in soil may also be attributed to automobile wastes containing electrical and electronic parts like copper wires and pipes, electrodes and alloys from corroding vehicle scraps (Pam *et al*., 2013) that are leached into the soil (Nwachukwu *et al*., 2011; Adebayo *et al*., 2017). The concentration of Cu in soils of Ohiya mechanic village was 0.41±0.00 to 1.28±0.00 mg/kg, which is well below 375 to 1,281 mg/kg (Nwachukwu *et al*., 2010), 28.26 to 44.35 mg/kg (Anegbe *et al*., 2018), 16.270 to 22.83 mg/kg (Idugboe *et al*., 2014) and 210 to 630.1 mg/kg (Adebayo *et al*., 2017) in their studies of heavy metals in soils of mechanic villages. The concentration of Cu in 0-10 cm (1.28±0.00 mg/kg) was found to be 2.56, 2.25, 4.74 and 3.12 times higher than its corresponding values in 11-20, 21-30, 31-40 and 41-50 cm depth at the study site and 1.24, 128, 4, 42.67 and 128 times higher than its values in 0-10, 11-20, 21-30, 31-40 and 41-50 cm depth at the control site, respectively.

Table 1: Heavy metals concentration (mg/kg) in soil

Soil depths (cm)	Cr	Cu	Pb	Cd
0 – 10	$0.01^{e} \pm 0.00$	$1.28^{a} \pm 0.00$	$2.57^{a} \pm 0.00$	$0.23^{b} \pm 0.00$
11 – 20	$0.05^{c} \pm 0.00$	$0.50^{d} \pm 0.00$	$1.34^{c} \pm 0.00$	$0.26^{a} \pm 0.00$
21 – 30	$0.13^{a} \pm 0.00$	$0.57^{c} \pm 0.00$	$1.92^{b} \pm 0.00$	$0.26^{a} \pm 0.00$
31 – 40	$0.04^{cd} \pm 0.00$	$0.27^{g} \pm 0.00$	$0.93^{d} \pm 0.00$	$0.20^{c} \pm 0.00$
41 – 50	$0.08^{b} \pm 0.00$	$0.41^{e} \pm 0.00$	$0.93^{d} \pm 0.00$	$0.11^{f} \pm 0.00$
C. 0 – 10	$0.00^{f} \pm 0.00$	$1.03^{b} \pm 0.01$	$1.36^{c} \pm 0.01$	$0.16^{d} \pm 0.03$
C. 11 – 20	$0.03^{d} \pm 0.01$	$0.01^{i} \pm 0.00$	$0.59^{f} \pm 0.00$	$0.15^{e} \pm 0.01$
C. 21 – 30	$0.11^{ab} \pm 0.02$	$0.32^{f} \pm 0.02$	$0.79^{e} \pm 0.00$	$0.05^{g} \pm 0.00$
C. 31 – 40	$0.01^{e} \pm 0.00$	$0.03^{h} \pm 0.00$	$0.31^{g} \pm 0.01$	$0.02^{h} \pm 0.00$
C. 41 – 50	$0.03^{d} \pm 0.00$	$0.01^{i} \pm 0.00$	$0.23^{h} \pm 0.02$	$0.00^{i} \pm 0.00$

Note: Values are mean ± standard deviation of 3 replicates; ^{a,b,c,d,e,f,g,h,i} means in the same column with different superscripts are significantly different (P<0.05) and C = mean of the Control plot

Table 2: Comparison with international and national standards

Source	Cr	Cu	Pb	Cd
This study	0.01 – 0.13	0.41 – 1.28	0.93 – 2.57	0.11 – 0.06
Dutch criteria (target value), mg/kg	100	36	85	0.8
FAO/WHO 2001, 2006, 2007	100	100	50	0.1
FEPA 1999	NA	70-80	1.6	0.01
NESREA 2011 standard, mg/kg	100	100	NA	3
*UK	400	135	300	3
*Netherlands	30	40	40	0.5
*France	150	100	100	2
*Sweden	60	40	40	0.4

**Source: ECDGE (2010); NA = Not available*

The highest concentration of Cr (0.13±0.00 mg/kg) was recorded for 21-30 cm depth and the value is significantly (P<0.05) higher than values recorded for Cr in 0-10 cm (0.01±0.00 mg/kg), 11-20 cm (0.05±0.00 mg/kg), 31-40 cm (0.04±0.00 mg/kg), 41-50 cm (0.08±0.00 mg/kg) and control (0.00±0.00, 0.03±0.01, 0.11±0.02, 0.01±0.00 and 0.03±0.00 mg/kg, respectively for Cr in 0-10, 11-0, 21-30, 31-40 and 41-50 cm depths). The concentration of Cr in 21-30 cm depth (0.13±0.00 mg/kg) was found to be 13, 2.6, 3.25 and 1.63 times higher than its corresponding values in 0-10, 11-20, 31-40 and 41-50 cm depths at the automobile waste dumpsite and 13, 4.33, 1.18, 13 and 13 times higher than its values in 0-10, 11-20, 21-30, 31-40 and 41-50 cm depth at the control site, respectively. The concentration of Cr in soils of the automobile waste dump at Ohiya mechanic village was 0.01±0.00 to 0.13±0.00 mg/kg, which is well below 3.313 to 9.92 mg/kg (Idugboe *et al*., 2014), 1.14±0.12 to 6.18±0.18 mg/kg (Wilberforce *et al*., 2016), 40.98 to 57.28 mg/kg (Luter *et al*., 2016), 0.219±0.003 to 4,850±17 mg/kg (Owoso *et al*., 2017), 2.00 to 29.75 mg/kg (Adelekan and Abegunde, 2011), 6.98 to 21.10 mg/kg (Iwegbue *et al*., 2007), 16.8 to 38 mg/kg (Nwachukwu *et al*., 2010) and 0.01 to 0.42 mg/kg (Adebayo *et al*., 2017). In this study, it was observed that the highest value of Cr at the control site was obtained in 21-30 cm depth (0.11±0.02 mg/kg), which is similar to the highest value (0.13±0.00 mg/kg) obtained in soils at the automobile waste dumpsite. This indicate that the level of Cr in soil may be attributed to natural processes rather than anthropogenic activities at the mechanic village.

The concentration of Pb, Cu, and Cr in automobile waste dumpsite soils of Ohiya mechanic village in Umuahia south, Abia State, Nigeria were 0.93±0.00 to 2.57±0.00, 0.41±0.00 to 1.28±0.00 and 0.01±0.00 to 0.13±0.00 mg/kg, respectively, which are well below the accepted limits (i.e. target value) and maximum permitted levels of 85 and 50 mg/kg (Pb), 36 and 100 mg/kg (Cu) as well as 100 and 100 mg/kg (Cr) as described by Dutch criteria (Ogbonna *et al.*, 2018b) and established by the Codex Alimentarius Commission (FAO/WHO, 2001) (Table 2), respectively. Similarly, the concentrations of Cu (0.41±0.00 to 1.28±0.00 mg/kg) and Cr (0.01±0.00 to 0.13±0.00 mg/kg) in this study are well below the accepted limits of 100 and 100 mg/kg as described by National Environmental Standards and Regulations Enforcement Agency (NESREA, 2001) of Nigeria for Cu and Cr, respectively. However, the concentration of Cd (0.11±0.00 to 0.26±0.00 mg/kg) in soil at the automobile waste dumpsite is above the maximum permitted level of 0.1 mg/kg (Cd) established by the Codex Alimentarius Commission (FAO/WHO, 2001) and 0.01 mg/kg (Cd) set by the Federal Environmental Protection Agency (FEPA, 1991) of Nigeria. The level of Cd in soils at the automobile waste dumpsite can pose a serious health risk to living organisms. For instance, earthworms are important bait in fishing as well as food material for fish production in south eastern Nigeria (Ogbonna *et al*., 2013; Ogbonna *et al*., 2019), prey to many amphibian, reptile, bird, and mammalian species (OECD, 2004). Hence, heavy metal pollution of earthworm at the study site can trigger death of animals living within and around the vicinity of the automobile waste dumpsite of Ohiya mechanic village, *inter alia,* decimation of fauna species along the food chain. It can also lead to decline in ecological processes taken place at the site since earthworm plays vital role in organic matter decomposition. The order of abundance of the four (4) heavy metals tested in this study that may be causing soil pollution within and around the automobile waste dumpsite at Ohiya mechanic village are as follows: Pb>Cu>Cd>Cr.

3.2. Concentration of heavy metals in cassava plants

The concentration of four (4) heavy metals in different parts of *Manihot esculenta* sampled from the automobile waste dumpsite and control site of Ohiya mechanic village, Umuahia south are summarized in Table 3. The results indicate that heavy metal concentrations differed significantly ($P<0.05$) among the different parts of *Manihot esculenta* tested in this study and that the highest and the lowest heavy metal concentrations in cassava plants were recorded for the automobile waste dumpsite and control site, respectively. The highest values of Cr (0.051±0.002 mg/kg), Cu (4.01±0.00 mg/kg), Pb (2.08±0.00 mg/kg) and Cd (3.24±0.00 mg/kg) recorded in cassava root sampled at the automobile waste dumpsite were significantly ($P<0.05$) higher than the highest corresponding values of Cr (0.011±0.002 mg/kg in stem), Cu (1.01±0.002 mg/kg in root), Pb (1.12±0.002 mg/kg in root) and Cd (1.00±0.002 mg/kg) in root) at the control site. The highest values of Cr, Cu, Pb and Cd in *M. esculenta* collected from the automobile waste dumpsite exceeded their corresponding values at the control site by 4.64, 3.97, 1.86 and 3.24 times, respectively. The result corroborates with the findings of Okpanachi *et al*. (2016) and Eludoyin and Ogbe (2017) who reported that the concentration of heavy metals in plants at mechanic workshops and village is higher than the concentration in plants at the control sites.

The concentration of Pb was 0.07±0.000 (stem) to 2.08±0.00 mg/kg (root), which is well below 5.48± to 33.28 mg/kg in maize plant (Okpanachi *et al*., 2016) and 18.40 to 80.30 mg/kg in pawpaw plant (Eludoyin and Ogbe, 2017) at mechanic workshop and village, respectively. The concentration of Cd was 0.01±0.001 (stem) to 3.24±0.00 mg/kg (root) and this is well below 1.75 to 10.56 mg/kg in maize plant (Okpanachi *et al*., 2016) and 2.3 to 18.0 mg/kg in pawpaw plant (Eludoyin and Ogbe, 2016). Similarly, the values of the concentration of Cu was 0.01±0.000 (leaf) to 4.01±0.00 mg/kg (root), which is well below 25.38 to 79.42 mg/kg in maize (Okpanachi *et al*., 2016) and 15.6 to 88.0 mg/kg in pawpaw (Eludoyin and Ogbe, 2017) while the values of the concentration of Cr was 0.001±0.000 (root) to 0.051±0.002 mg/kg (root). The low values of the concentration of Pb, Cd, Cu and Cr in this study may be attributed to the short length of time the automobile waste dumpsite at Ohiya mechanic village has been in use.

Table 3: Means and Standard deviation of heavy metals content (mg/kg) in *Manihot esculenta*

Plant parts	Cr	Cu	Pb	Cd
Root	$0.051^a \pm 0.002$	$4.01^a \pm 0.00$	$2.08^a \pm 0.00$	$3.24^a \pm 0.00$
Stem	$0.018^b \pm 0.001$	$0.17^c \pm 0.00$	$0.82^d \pm 0.00$	$0.21^c \pm 0.00$
Leaf	$0.020^b \pm 0.001$	$0.10^d \pm 0.00$	$1.23^b \pm 0.00$	$0.20^c \pm 0.00$
C. Root	$0.001^e \pm 0.000$	$1.01^b \pm 0.002$	$1.12^c \pm 0.002$	$1.001^b \pm 0.002$
C. Stem	$0.011^c \pm 0.002$	$0.03^e \pm 0.000$	$0.07^e \pm 0.000$	$0.01^f \pm 0.001$
C. Leaf	$0.002^d \pm 0.001$	$0.01^f \pm 0.000$	$072^e \pm 0.001$	$0.02^e \pm 0.001$

Values are mean ± standard deviation of 3 replicates; [a,b,c,d,e,f,g,h,i] Means in the same column with different superscripts are significantly different (P<0.05) and C = mean of the Control plot

Table 4: Comparison with international and national standards

Source	Cr	Cu	Pb	Cd
This study	0.001 – 0.051±0.002	0.01 – 4.01	0.07 – 2.08	0.01±0.001 – 3.24
Similar studies (Eludoyin & Ogbe (2017))	NA	15.60 – 88.0	18.40 – 80.30	2.30 – 18.0
Similar studies (Okpanachi *et al*. (2016))	NA	25.38 – 79.42	5.48 – 33.28	1.75 – 10.56
FAO/WHO 2001, 2006, 2007	2.3	40	0.3	0.2
FEPA 1999	NA	NA	NA	NA
NESREA 2011	NA	NA	NA	NA

NA = Not available

In comparing the concentration of heavy metals in soil with the values of the concentration in cassava plants, the results indicate that the concentration of Pb (2.57±0.00 mg/kg) and Cr (0.13±0.00) were higher in soil than in cassava plants for Pb (2.08±0.00 mg/kg) and Cd (0.051±0.002 mg/kg). The concentration of Pb and Cr in soil were 1.24 and 2.55 times higher than their corresponding values in cassava plants, respectively. In contrast, the values of the concentration of Cu (4.01±0.00 mg/kg) and Cd (3.24±0.00 mg/kg) in cassava roots were higher than their values in soil (1.28±0.00 mg/kg and 0.26±0.00 mg/kg). The concentrations of Cu and Cd in cassava roots were 3.13 and 12.46 times higher than their corresponding values in soils of the automobile waste dumpsite at Ohiya mechanic village. The soil is implicated for the concentrations of Pb and Cr in cassava plants while inherent ability of cassava roots to absorb and store Cd and Cu over time may be responsible for the higher concentration of Cd and Cu in cassava plants. The shallow root system of cassava plants might have facilitated the absorption of the heavy metals (Cu and Cd) in soil solution and accumulation in cassava roots since Cu and Cd recorded the highest values of their concentrations in soil within 0-10 and 21-30 cm depths, respectively. The rate of movement of heavy metal in plant tissues varies depending on plant organ, age and element involved (Kabata-Pemdias, 2000). The concentration of Cd increased from 0.01±0.001 in cassava stem to 3.24±0.00 mg/kg in cassava root, which is well above the permissible limit (PL) of 0.2 mg/kg set by Codex Alimentarius Commission (FAO/WHO, 2007) (Table 4) for vegetables and root crops. The values of the concentration of Pb increased from 0.07±0.000 in cassava stem to 2.08±0.00 mg/kg in cassava root and the level is well above the permissible limit (PL) of 0.3 mg/kg set by Codex Alimentarius Commission (FAO/WHO, 2001). The utilization of cassava roots at the automobile waste dumpsite for man and animal consumption could be a route of entry of Cd and Pb in man as well as livestock that will be fed with the peels from such metal contaminated cassava roots. For instance, serious systemic adverse health consequences develop from excessive dietary accumulation of toxic metals in humans (Oliver 1997; Li *et al*., 2009). The prevalence of upper gastrointestinal cancer in the

Van region of Turkey has been linked to metal pollution in soil, fruits and vegetables (Turkdogan *et al*., 2003). Soil and vegetables polluted with Pb and Cd in Romania significantly decreased human life expectancy by reducing the average age at death by 9–10 years (Carafa *et al*., 2009) while in the city of Kabwe, Zambia, mining and smelting operations led to widespread Pb and Cd contamination of soil (Fulekar and Jadia, 2009) and children living in the vicinity of a former smelter had high blood Pb levels in France (Pruvot *et al*., 2006) and Brazil (Bosso and Enzweiler, 2008). Lead and Cd are potential carcinogens and are associated with adverse effects on blood, kidneys, bone, as well as cardiovascular, and nervous system (Jarup, 2003).

Similarly, the dependent of wild animals such as *Thryonomis swinderianus* (grasscutter), *Cricetomys gambianus* (African giant pouched rat), *Francolinus squamatus* (Scaly francolin) among others on such contaminated cassava roots in farm at Ohiya mechanic village may lead to bio-magnification of Cd and Pb in the food chain with the concomitant effect of possible ecological imbalance in the natural environment. Copper increased from 0.01±0.000 in cassava leaf to 4.01±0.00 mg/kg in root. The level of Cu in cassava plants is well below the permissible limit (PL) of 40 mg/kg (FAO/WHO, 2006) for vegetables and root crops. Chromium increased from 0.001±0.000 in root to 0.051±0.002 in cassava root but the level of Cr in cassava plants is well below the permissible limit (PL) of 2.3 mg/kg (FAO/WHO, 2006). The order of abundance of the four heavy metals tested in various parts of cassava plant in this study is as follows: Cu>Cd>Pb>Cr.

3.3. Pearson correlation analysis between heavy metals in soil and plants

The result of the Pearson correlation analysis of heavy metals in soil and plants is summarized in Table 5. The result show very strong positive relationship as well as strong negative relationship between heavy metals in soil and plants. For instance, very strong positive relationship exist between Cu in soil and Cu in plants ($r=0.996$, $p<0.05$) and Pb in soil and Pb in plants ($r=0.986$, $p<0.05$) which suggest that increase in Cu and Pb in soil might have resulted to their (Cu and Pb) increase in cassava plants. Strong negative relationship exist between Cr in soil and Cr in plants ($r= -0.686$, $p<0.05$) and Cd in soil and Cd in plants ($r= -0.981$, $p<0.01$). However, there were strong positive relationship between Cu in soil with Cr in plants ($r=0.997$, $p<0.01$), Cu in soil with Pb in plants ($r=0.970$, $p<0.01$) and Cu in soil with Cd in plants ($r=0.997$, $p<0.01$) while strong negative relationship occurred between Cd in soil with Cr in plants ($r= -0.990$, $p<0.01$), Cd in soil with Cu in plants ($r= -0.979$, $p<0.01$) and Cd in soil with Pb in plants ($r= -0.987$, $p<0.01$).

Table 5: Correlation result between heavy metals in soil and heavy metals content in *Manihot esculenta*

	Cr (soil)	Cu (soil)	Pb (soil)	Cd (soil)	Cr (plant)	Cu (plant)	Pb (plant)	Cd (plant)
Cr (soil)	1	-.445	-.163	-.002	-.686*	-.738*	-.473	-.731*
Cu (soil)		1	.926**	.341	.997**	.996**	.970**	.997**
Pb (soil)			1	.576*	.904**	.875**	.986**	.880**
Cd (soil)				1	-.990**	-.979**	-.987**	-.981**
Cr (plant)					1	.995**	.961**	.995**
Cu (plant)						1	.943**	1.000**
Pb (plant)							1	.947**
Cd (plant)								1

**Correlation is significant at the 0.05 level (2-tailed); **Correlation is significant at the 0.01 level (2-tailed).*

4.0. Conclusion

The investigation of heavy metals contamination in soil and cassava plants at automobile waste dumpsite in Ohiya mechanic village, Abia State, Nigeria showed that artisanal activities generate wastes that release contaminants such as heavy metals. The values of highest concentration of heavy metals (Cd, Cu, Pb and Cr) occurred within 0 to 30 cm depth. The heavy metals that are leached into the soil profile are taken up by cassava plant, especially the root. The values of the concentration of Cd in soil exceed maximum permitted level set by Codex Alimentarius Commission (FAO/WHO) while the values of the concentration of Pb and Cd in cassava plants exceed the permissible limit set by Codex Alimentarius Commission (FAO/WHO). The level of Cd in soil and Pb and Cd in cassava plant is a serious concern to man and animals' health as well as ecological processes taken place in the soil ecosystem. Therefore, it is recommended that rural farmers are informed the consequences of using such adjoining lands for farming activities. More so, efforts should be geared towards using wire gauze to fence round the dumpsite so that animals may not have access to the polluted soil and plants. Abia State Environmental Protection Agency and the leadership of the Automobile and Technician Association should monitor the activities of artisans to ensure strict compliance to industrial and environmental laws and regulations. For example, collection and recycling of spent oil and proper disposal of spent electrolyte to reduce heavy metal contamination in soil and biomagnification in flora and fauna.

Acknowledgement

We wish to acknowledge the Technologist that carried out the laboratory analysis of the soil and plant samples. We also acknowledge the Management of Ohiya mechanic village for allowing access to the automobile waste dumpsite.

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Cite this article as:

Ogbonna P.C., Osim O.O. and Biose E., 2020. Determination of Heavy Metal Contamination in Soil and Accumulation in Cassava (*Manihot Esculenta*) in Automobile Waste Dumpsite at Ohiya Mechanic Village. *Nigerian Journal of Environmental Sciences and Technology*, 4(1), pp. 54-69. https://doi.org/10.36263/nijest.2020.01.0173

Nigerian Journal of Environmental Sciences and Technology (NIJEST)
www.nijest.com
ISSN (Print): 2734-259X | ISSN (electronic): 2734-2603
Vol 4, No. 1 March 2020, pp 70 - 76

Application of R-Squared (R^2) in The Analysis of Estimated Water Encroachment into a Reservoir

Oloro O. J.
Department of Chemical and Petroleum Engineering, Faculty of Engineering, Delta State University, Oleh Campus, Nigeria
*Corresponding Author: olorojo@delsu.edu.ng

https://doi.org/10.36263/nijest.2020.01.0155

ABSTRACT

The purpose of this paper is to apply R-squared in the analysis of estimated water encroachment into the reservoir. The data used for this work were gotten from records and these data were used to estimate water encroachment using Van Everdingen-Hurst (VEH) and Carter-Tracy models. The R-squared was obtained by plotting the value of estimated water encroachment against time. The results show that all the R-squared gotten in this work are more than 90% as indicated in all the graphs plotted. These results indicated that the variables involved in the computation of water encroachment are all considered, and the results also show that VEH is more reliable since it has higher R-squared. This method of analysis is faster and easy when compared with other methods like Durbin Watson and t-test.

Keywords: Aquifer, boost, petroleum, reservoir oil, water encroachment, model.

1.0. Introduction

Water aquifers which surround oil reservoirs help to boost the reservoir pressure through water encroachment. When there is a pressure decline in the oil reservoir, the water aquifer responds to make up pressure decline by water encroachment into the reservoir (Amer et al.,2015). In the petroleum industry, different Models are used to calculate water encroachment (Klins et al.,1988; Oloro et al.,2011; Van Everdingen et al.,2015). In this paper, Van Everdingnen-Hurst and the Carter-Tracy Unsteady – state models were used (Carter and Tracy, 1960).

The Van Everdingnen-Hurst (VEH) mode (Van Everdingen et al.,2015) is the most complex of all these models. Its main benefit is it's realistic. Originally, its major disadvantage was it is difficult in the usage. Charts had to be repeatedly consulted to perform a calculation (Anthony, 2015**)**. To handle this problem, Fetkovich and Carter-Tracy models were used without tables and charts (Carter andTracy, 1960**;** Fetkovich, 1971). However, these models were only overviews of the VEH model. Since the VEH tables and charts were digitized, the prerequisite for the previous one has diminished.

R-squared (R^2) measures the percentage of dependent adjustable described by suggested explanatory variables that fall on the regression line. For an instant, 80% means that 80% of the variation of water encroachment values around the mean is explained by other values. In other words, 80% of the values fit the model (Abraham, 1983; Jean, 2011; Ross, 2019; John, 1974). The literature review revealed that different methods or Models (Durbin Watson t-test) (Montgomery et al., 2001) have been used to analyze the effectiveness of water encroachment model but they are unreliable, cumbersome and time-consuming. Hence in this study, estimation of water invasion into the reservoir will be carried out using Van Everdingen-Hurst unsteady-state and Cater-Tracy Unsteady-state models and the results will be analyzed using R- squared (Lee, 2006).

2.0. Materials and method

In this study, data were gotten from (Oloro et al., 2009) and these data were used to calculate water encroachment using Van Everdingen-Hurst and Carter-Tracy models (Van Everdingen and Hurst, 2015; Carter and Tracy, 1960**)**. The results were plotted on the graph sheet to determine R^2. The R squared was analyzed to determine which of the model is more effective for determining water encroachment into the reservoir.

The information in Table 1 was obtained from Oloro and Rai (2009) and was used with Equations 1 to 5 to compute the water encroachment using Van Everdingen-Hurst Model. In using the Carter-Tracy Model, Equation 6 and 7 was included to the equations.

Table 1: Pressure history of reservoir and aquifer properties

Time (days)	Pressure (Pisa)	Properties of the Aquifer	
0	3450	$R_{r(ft)}$	6642.5
18	3350	$\mu(C_p)$	0.17
26	3262	h(ft)	222
34	3154	Θ	165
42	3032	k(md)	2160
50	2904	ϕ	0.21
58	2780		
66	2698		

The following steps are followed using the Van Everdingen-Hurst Model:

Step1: Find water encroachment constant β using Equation 1.

$$\beta = 1.19\emptyset c_t h r_r^2 \left(\frac{\theta}{360}\right) \tag{1}$$

Step 2: For each period, compute ΔP using Equation 2.

$$\Delta P_N = \frac{1}{2}(P_{N-2} - P_N) \tag{2}$$

Step 3: Compute dimensionless time's t_D using Equation 3.

$$t_D = \frac{0.00633Kt}{\mu C_t r_r^2} \tag{3}$$

Step 4: Compute dimensionless cumulative water encroachment (Q_{PD}) using the values of t_D calculated in step 3. Because we are assuming an infinite-acting aquifer, we can use Equation 3 since the value of t_D is greater than 0.001 and also lesser than 200 we can use Equation 4.

$$Q_{PD} = \frac{1.2839{t_D}^{1/2} + 1.19328t_D + 0.26987{t_D}^{3/2} + 4)}{1 + 0.616599{t_D}^{3/2} + 0.0413008t_D} \tag{4}$$

Step 5: Compute W_e using Equation 5.

$$W_e(t_{DN}) = \beta \sum_{t=1}^{n} \Delta P_i Q_{PD}(t_N - t_{i-1})_D \tag{5}$$

The following steps are followed using the Carter-Tracy model:

Step 1: Find water encroachment constant β using Equation 1

Step 2: For every time period, compute ΔP using Equation 6.

$$\Delta P_n = Paqi - P_n \tag{6}$$

Step 3: Compute dimensionless time's t_D using Equation 3.

Step 4: Compute dimensionless pressures at every of dimensionless time computed in step3. The dimensionless pressures are calculated with Equation 7.

$$P_D(t_D) = \frac{716.441+46.7984t_D{}^{1/2}+270.038t_D+71.0098t_D{}^{3/2}}{1296.86t_D{}^{1/2}+1204.73t_D{}^{3/2}+538.072t^2+142.41t_D{}^{5/2}} \tag{7}$$

Where β=water encroachment constant, c_t = total aquifer compressibility, c_f = aquifer rock compressibility, c_w = aquifer water compressibility, h = net formation thickness, e_w = water influx rate from aquifer, P_{aq} = aquifer pressure, P_D = Dimensionless pressure, P_r = Pressure at aquifer/reservoir interface, ΔP = Difference between initial aquifer pressure and pressure at original reservoir/aquifer boundary, r_r = radius to aquifer/reservoir interface ra = radius of the aquifer , Φ = Porosity of the aquifer ,We = Cumulative water influx, K = permeability, n = refers to the current time step.

3.0. Results and discussion

From Figure 1, it can be observed that water encroachment into the reservoir computed by Carter-Tracy Model is more than that of Van Everdingen-Hurst (VEH). The R-squared obtained were above 90%. This is an indication that all the variables that are involved in water encroachment computation were highly considered. R squared of VEH is higher than that of Carter-Tracy, hence Van Everdingen-Hurst Model is more reliable (Krause et al., 2005).

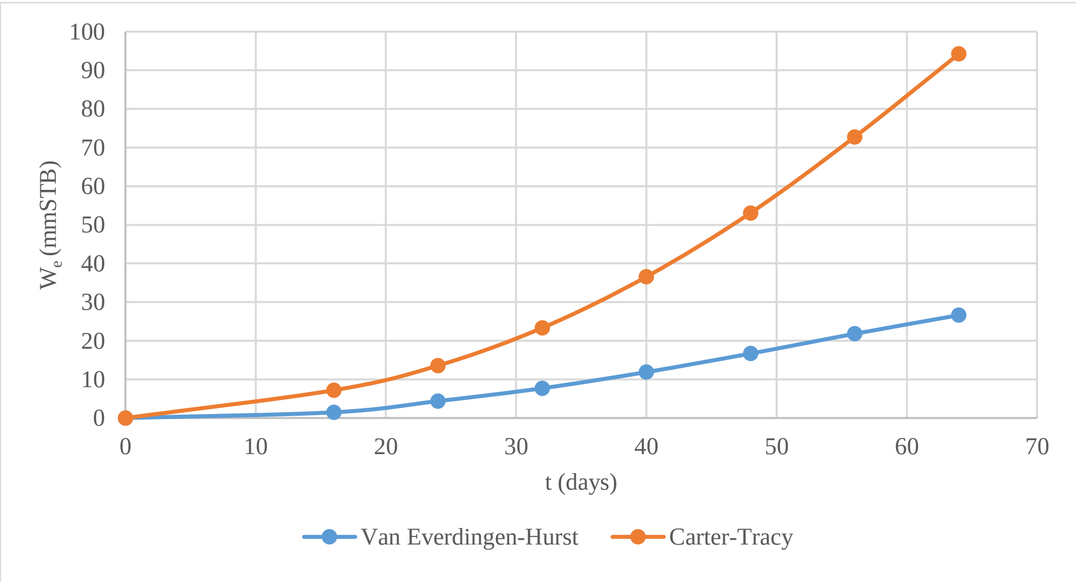

Figure 1: Results for Van Everdingen-Hurst and Carter-Tracy models

The relationship between W_e and time including the corresponding R^2 value is shown in Fig. 2 for Van Everdingen-Hurst model. It can be seen that water encroachment increases with time and it is dependent on the reservoir pressure. If the reservoir pressure is low, more water will encroach into the reservoir to counterbalance the decline in pressure.

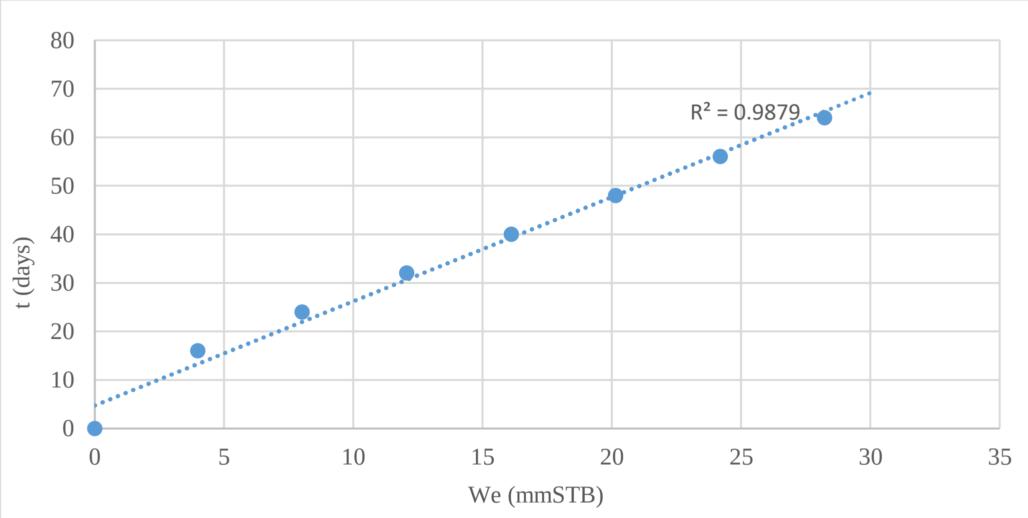

Figure 2: R^2 for Van Everdingen-Hurst model

The high value of R^2 obtained implies a high degree of acceptance and reliability while the low value of R^2 means that all the variables that are involved in water encroachment computation were not highly considered. From literature, it has been confirmed that Van Everdingen is more reliable (Joao and Osvair, 2007).

Comparing the R^2 values of Figure 2, Figure 3, Figure 4 and Figure 5 of the two Models, Van Everdingen-Hurst unsteady state Model compared better. This implies that VEH is more reliable for estimation of water encroachment (Khulud, et al., 2013).

Figure 4 and Figure 5 demonstrate the effect of pressure on water encroachment using Van Everdingen-Hurst and Carter-Tracy Models. It shows that as the production of oil is increasing the pressure will decline. This, therefore, necessitates the encroachment of more water from the aquifer into the reservoir to offset the imbalance. R^2 for both Models shows that VEH is more effective according to Joao and Osvair**.**

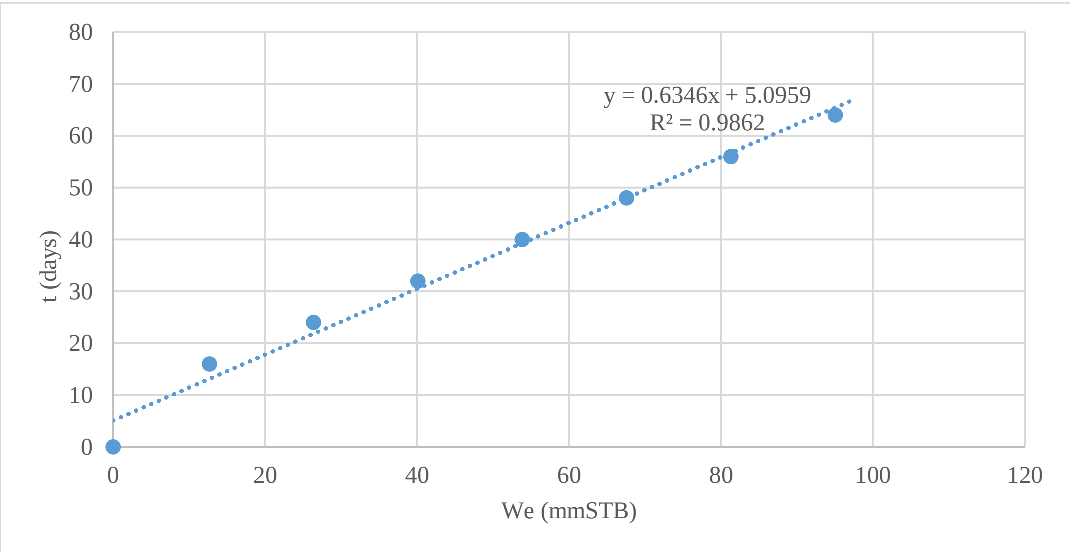

Figure 3: R^2 for estimated Carter-Tracy model

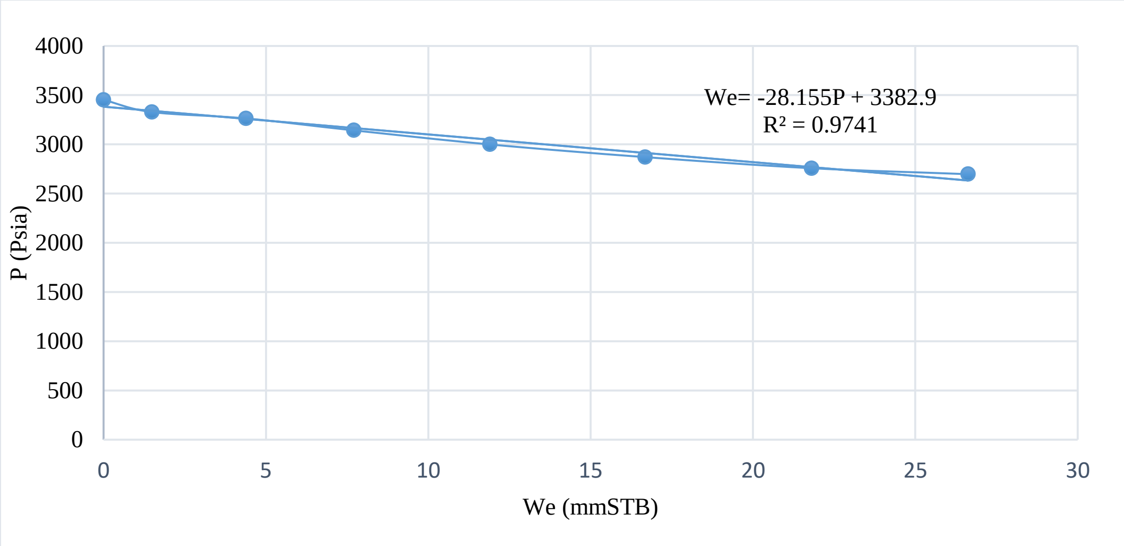

Figure 4: Effect of Pressure on Oil Recovery using Van Everdingen-Hurst Model

Figure 6 shows the behavior of pressure with time. It can be observed that pressure decreases with time, and this is an indication that oil recovery is inversely proportional to the time and corroborates the earlier report by Khulud et al., 2013. Production of oil from a reservoir is divided into 3 methods: primary, secondary and tertiary recovery. Numerous factors regulate the production flows in most oil fields. Basic understanding of these is necessary for better understanding of decline and depletion behavior. Actually, oil recovery involves fluid flows through the porous material that makes up the oil field. Fluid movements in a reservoir hinge on several factors which include a decline in pressure that is explained more comprehensively by Satter et al. (2008).

Primary recovery occurs naturally by energy such as reservoir pressure, to drive oil to the surface. Oil is simply allowed to flow on its own pressure except fluids are injected into the reservoir. However, the pressure gradient reduces as oil is produced **(**Daniel, et al., 2010).

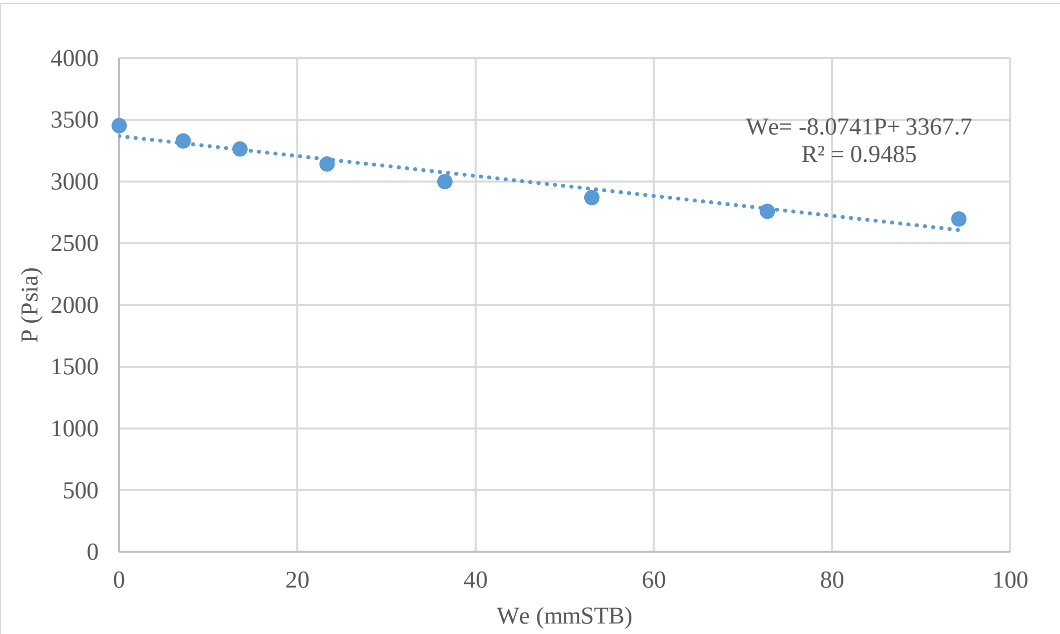

Figure 5: Effect of pressure on oil recovery using Carter-Tracy model

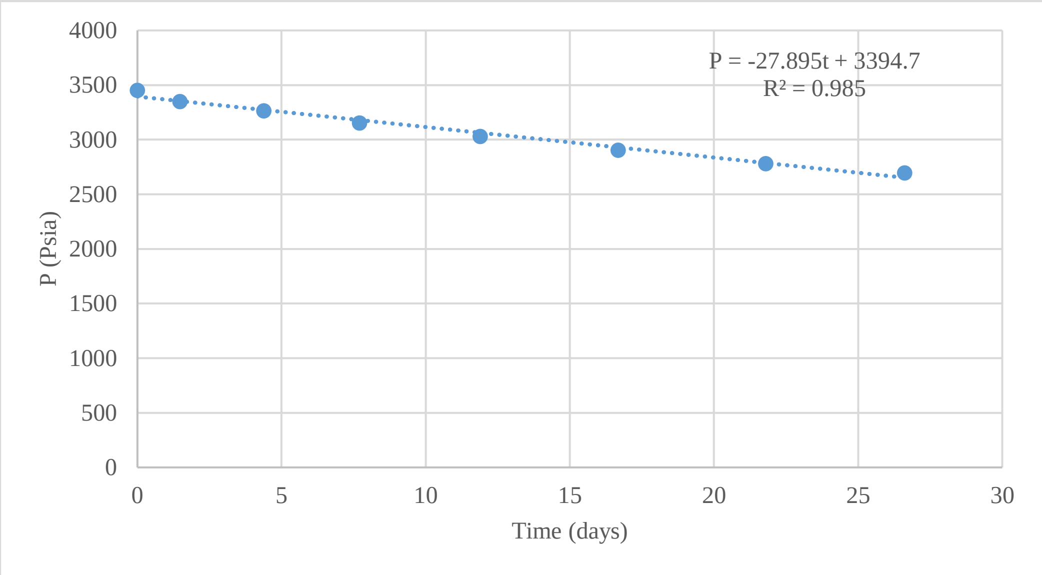

Figure 6: Behavior of pressure with time for VEH

4.0. Conclusions

Two models were used to estimate water encroachment and the R-squared was obtained by plotting the value of estimated water encroachment against time. The results of application of R-squared in the analysis of estimated water encroachment into the reservoir show that Van Everdingen-Hurst Model is more reliable.

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Cite this article as:

Oloro O. J., 2020. Application of R-Squared (R^2) in The Analysis of Estimated Water Encroachment into a Reservoir. *Nigerian Journal of Environmental Sciences and Technology*, 4(1), pp. 70-76. https://doi.org/10.36263/nijest.2020.01.0155

Nigerian Journal of Environmental Sciences and Technology (NIJEST)
www.nijest.com
ISSN (Print): 2734-259X | ISSN (electronic): 2734-2603
Vol 4, No. 1 March 2020, pp 77 - 86

Community Participation in Wildlife Management in Baturiya Sanctuary, Northwestern Nigeria

Karkarna M.Z.[1,*] and Danjuma M.N.[2]
[1]Department of Environmental Management, Bayero University, Kano, Nigeria
[2]Department of Geography, Bayero University, Kano, Nigeria
*Corresponding Author: mzkarkarna@gmail.com

https://doi.org/10.36263/nijest.2020.01.0169

ABSTRACT

Human benefits from wildlife are apparently declining over decades as the extent and intensity of threat to protected areas continue. This study assessed nature of community participation in wildlife management in Baturiya Sanctuary with a view to providing information for active participation of communities in the management of this area. A total of five communities namely: Shinge (4km west), Illala (12km west), Kokiro (3km east), Zigobiya (7km east) and Abanaguwa (5km north) were purposively sampled based on their proximity to the sanctuary. Snowball sampling technique was used to select fifty-seven (57) participants for the survey. Questionnaire and Interview were conducted to elicit the knowledge and perspectives of participants on the role of community in wildlife management. Numerical values were analysed in percentage while chi-square was used to test the levels of participation among communities. Findings of this study indicate that only 18 of the 57 sampled participants are involved in wildlife management. It also shows that there is decrease and extinction of wildlife especially birds, primates and reptiles in the sanctuary. The study also found four categories of participants: active-voluntary, active-institutional, passive-voluntary and passive-institutional. It shows that 37.50% active and 62.50% are passive participants respectively. Benefits of community participation include control of poaching (43.85%) and control of trade in parts of animals (25%). Majority of the participants (83.33%) engage in wildlife management voluntarily based on perceived benefits derived from the sanctuary. Poor governance (43.85%) and weak community institutions (31.57%) are the main limitations to community participation in wildlife management. This study therefore recommended that community leaders and youth should be strengthened and officially recognized as stakeholders in wildlife management and governance of natural resources in Nigeria at large.

Keywords: Sanctuary, biodiversity, migratory birds, Nigeria.

1.0. Introduction

Nigeria is endowed with diverse earth's resources that can guarantee sustainable economic growth and development (Danjuma, 2017). According to the International Union of Conservation of Nature, Nigeria has a total of 309 threatened species in the the following taxonomic categories: Mammals (26), Birds (19), Reptiles (8), Amphibians (13), Fishes (60), Molluscs (1) and Invertebrates (14) (Sedghi, 2013). This provides diverse socio-economic and ecological functions to support livelihoods in the country. Over the years, these resources are highly threatened by unprecedented land use changes resulting from the needs of a burgeoning population to expand farms, illegal activities such as logging, poaching and deforestation (David, 2008; Al-Amin, 2013; Ola and Benjamin, 2019). This has created enormous problems and substantial holes in the path of sustaining Nigeria's natural resources base. In Nigeria some iconic biodiversity habitats remain important centres of species conservation and protection (Ezebilo and Mattsson, 2010; UNEP-WCMC, IUCN and NGS, 2018). Such areas include Kainji Lake (Fingesi et al., 2019), Kamuku (Abdulkadir, 2015), Falgore (Badamasi, 2014), Baturiya (Blench, 2013) as well as Gashaka-Gumti (Yager et al., 2018) which have recorded significant achievements despite serious challenges and especially the adoption of approach that tends to exclude local communities.

The Baturiya wetland for instance is crucial because of its unique fauna and flora and a huge collection of terrestrial, arboreal and aquatic species (BirdLife International, 2015). The Sanctuary is a protection area under the RAMSAR convention (Ramsar Bureau, 1994). It is unique interms of flora and fauna diversity including endemic primates, fishes, toads, snakes and most importantly birds of various categories. The majority of the migratory birds found in the sanctuary are from Europe, Latin America and Asia in addition to several indigenous species (Ringim et al., 2015). The sanctuary has remained bountiful and hotspots of birds' diversity for decades until recently when the status of species has significantly dwindled (Oduntan et al., 2010). Olalekan et al. (2014) reported that local communities continue to invade parts of the Baturiya sanctuary for settlements, farming, cattle grazing and fishing, as well as exploitation of the natural resources. Other resources include firewood, Doum palm, fish, and many waterfowls being illegally hunted for live trade such as ibises, storks, jacanas, and spur-wing geese, while many people engage in egg collection during the breeding season (Ogunkoya and Dami, 2007; Blench, 2013).

Beyond anthropogenic influences, the colonial era policies of centralization have also undermined biodiversity conservation in rural African landscapes (Neumann, 1998). Colonization by European powers and the accompanying spread of their conservation practices did not encourage traditional rights (Roe et al., 2009). However, the American approach of pristine wild conservation practices suffered setbacks due to rise of community-based approaches in the 1980s (Chambers, 1997). The widespread adoption of community participation in the 1980s began to be disillusioned the view that communities in Africa were behind the worsening conditions of biodiversity in different ecological and cultural settings (Diaz et al., 2006). Various studies have shown that success in conservation is often predicated by local support which is influenced by perceptions of the impacts that are experienced by local communities and opinions of management and governance (Bennett and Dearden, 2014). Engagement with diverse groups is now being increasingly considered as essential for natural resources conservation on the landscape scale in both developed and developing countries (Vos et al., 2001).

The emergence of community participation in Nigeria has played a key role in shaping initiatives in community-based wildlife management in forest neighboring communities. However, despite the long-lived intention by the government to enhance community participation, there is still inadequate involvement of people in decision making regarding protected areas in Nigeria (). The non-involvement of communities in decision making process often causes the people to lose interest in government conservation programmes, which increases over exploitation of resources. There have been relatively few cases of communities obtaining rights over resource use in Nigeria. According to Federal Government of Nigeria (2015) low public awareness on biodiversity conservation and lack of capacity for law enforcement agents to deal with issues of concern has remained relatively fundamental challenge to conservation of natural resources in Nigeria. Neglecting local communities in management itself is a threat to the areas. It can lead to deliberate (illegal) actions that can be detrimental to the protected area resources as well as a setback to the sustainability of the areas (Holmes, 2013).

Empirical evidences have shown nuanced picture of the long-term engagement and strong relationships of local people living around protected areas and wildlife. However, the strong positive relationship is now dwindling thereby undermining the future of fauna which is appearing bleak (Saidu, 2017). Similar reports showed that several villages have engaged in hiring farmlands outside their once owned lands to rice farmers who want to cling to the recent Jigawa State campaign of cluster rice initiative which significantly affects the status and diversity of wildlife in Baturiya area over the last 5 years. Although plethora of works were carried out on species composition and diversity in Baturiya sanctuary (Babura, 2015; Ringim et al., 2015; Zakari, 2015), there appears to be insufficient data and information on the role of communities in wildlife management hence few attempts were made to develop mechanisms to promote greater participation among communities located around the area. Despite the obvious contribution of biodiversity to rural livelihood, there is currently no comprehensive and reliable data on community participation in wildlife in Nigeria. This study was conducted to assess the roles of local people in wildlife management in Baturiya Sanctuary, northwestern Nigeria with a view to providing information for developing new strategies for successful re-connection of the communities with the once beautiful natural endowment.

1.1. Study area

Baturiya Wetlands Game Reserve is located in the northeast of Jigawa State, Nigeria (Figure 1). It lies on latitude 12°31'N and 12°39'N and longitude 10°29'E and 10°31'E. It covers an area of 1010.95 km². The reserve is located in Kiri Kasamma LGA and covers an area of 320 sq. km with a buffer zone of a half kilometre. It stretches along the Kafin Hausa River, to the west of the Hadejia Nguru Wetlands. Baturiya Bird Sanctuary provides a natural habitat for over 378 species of migratory birds from places as far as Europe and Australia (BirdLife International, 2015). The area is an important bird nesting and breeding ground which lost its significance owing to encroachment and neglect by authorities.

The climate of the wetland is characterized by two distinct seasons; wet (May-September) and dry season (October-April), rainfall is between 500- 600 mm, whereas temperature ranges from 12°C during harmattan season (cold) to about 40°C during hot season, rainfall is between 500- 600 mm, with mean minimum temperature of 12°C during the month of December to January, to a maximum of 40°C during the month of April (Ogunkoya and Dami, 2007). The ecosystem comprises permanent lakes and seasonally flooded pools connected by a network of channels. The ecosystem is an important site for biodiversity, especially migratory water birds from Palearctic regions. The area uses to harbor populations of 15 migratory birds of European descend (Ringim et al., 2015).

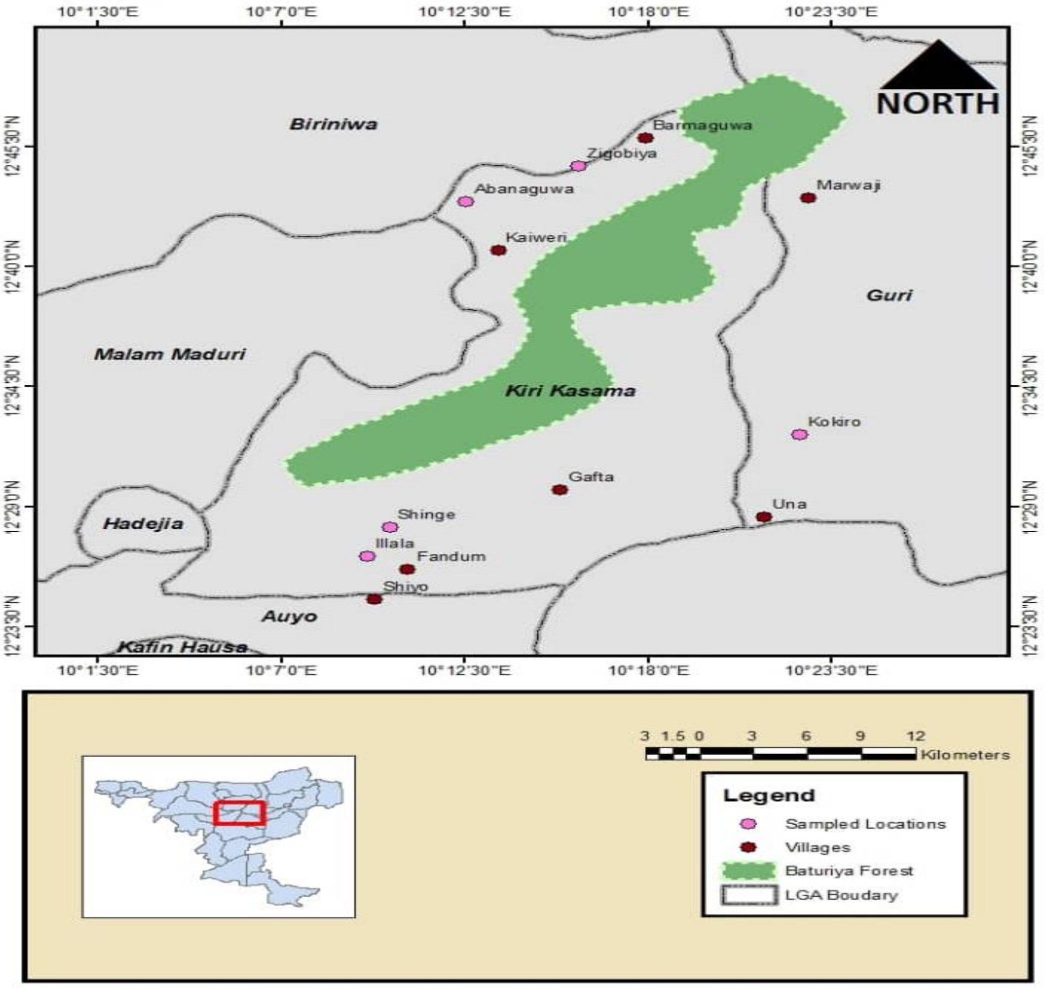

Figure 1: Map of Baturiya sanctuary, northwestern Nigeria

2.0. Research Methods

The Baturiya sanctuary is surrounded by many communities that rely heavily on natural resources for a living. The study area covered all communities located within 12km radius of the sanctuary namely Gafta (6km west), Shiyo (5km southwest), Shinge (4km west), Illala (12km west), Fandum (11km west), Kaiwari (4km north), Kokiro (3km east), Marawaji (4km east), Zigobiya (7km east), Una (3km east), Barmaguwa (5km east), and Abanaguwa (5km north) as sampling frame. However, Shinge, Illala, Kokiro, Zigobiya and Abanaguwa were purposively sampled. Snowball sampling technique was used to select fifty-seven participants for the survey. These fall into: Fourty eight male of between 24 and 62 years old and nine females (15.79%). Quantitative and qualitative data were obtained from questionnaire and interview. Numerical values were analysed in percentage while qualitative data was sorted, coded and presented in textual form. Chi-square was also used to test the levels of participation among communities.

Table 1: Socio-demographic Characteristics of Participants

SN	Study location	Total No. of Participants	No of males	No of females
1	Shinge	7	5	2
2	Illala	9	9	0
3	Zigobiya	16	13	3
4	Kokiro	11	9	2
5	Abanaguwa	14	12	2
	Total	57	48	09
	(%)	100	84.21	15.79

3.0. Result and Discussion

Biodiversity conservation ranked 14 and 15 in the sustainable development goals yet Nigeria's effort in this regard remains frustratingly weak partly due to relegation of communities in decision-making process. This section presented results and discussions on issues relating to wildlife management in Baturiya Sanctuary, Jigawa State, Nigeria

3.1. Local perception on status of wildlife in the sanctuary

Biodiversity is an important source of livelihoods and income generation to communities worldwide. Status of species has been an indicator of ecosystem's health and vital ingredient for protection and sustainable management of the flora and fauna of an area. Traditional knowledge however is vital for conservation of species in protected areas. Findings of this study on status of wildlife around baturiya sanctuary have shown nuanced perceptions where 8% of the participants indicated that reptiles and rodents are observed to be increasing (Table 2). It further showed that there is significant decrease and extinction of wildlife especially birds and reptiles.

Table 2: Status of wildlife

Wildlife categories	Status		
	Increasing	Decreasing	Extinct
Primates	0	6	2
Birds	0	22	2
Reptiles	1	16	0
Rodents	4	4	0
Total	05	48	04
Percentage	8.77	84.21	7.02

The work of David (2008) and Fingesi et al. (2019) have corroborated the research findings that there are substantial decline in wildlife in Nigeria's protected areas. Similarly, researchers have shown that despite the number of protected areas in Nigeria, their management status remains questionable (Abdulaziz et al., 2015), hence in practice most protected areas are referred to as "paper parks" (IUCN, 1998).

3.2. Level of community participation

Protected areas still have value regarding wildlife conservation especially because of growing awareness of the close links between biodiversity loss and human population growth. Table 3 present the distribution of participants by levels of participation in management of wildlife in Baturiya sanctuary. The table reveals that few respondents (28.07%) engaged in wildlife management which suggests a low level of participation. The participants indicated that there is variation in community engagement, and they were not carried along in major decision-making regarding the use and management of wildlife and land despite their closeness to the sanctuary.

Federal Government of Nigeria (2015) reported that the National Parks that are repository of much of the country's biodiversity have faced serious threats of poaching in recent years, losing not only wildlife but also rangers. The reported indicated that biodiversity related laws are broken openly in the face of low public awareness on biodiversity conservation and lack of capacity for law enforcement agents to deal with issues of concern. This work corroborated Chirenje et al. (2013) and Isougo and Obioha (2015) who reported that if communities living close to protected areas (who believed that they should receive higher benefits than those who do not live far) are alienated from use and participation in resources governance, there will be lack of commitment to any programme aimed at conservation of the areas. Similarly, Oladeji and Fatukasi (2017) reported low participation (25%) in Osse River Park despite huge investment in park protection and surveillance. In all the communities, majority of the participants (60%) had not participated in wildlife management except Shinge where there is harmonious relationship between the village head and the local people.

Table 3: Level of Participation in Wildlife Management

Study locations	No. of participants that do not engage in wildlife management		No. of participants who take part in wildlife management	
	N	%	N	%
Shinge	4	57	3	43
Illala	7	78	2	33
Zigobiya	12	86	4	14
Kokiro	9	81	2	18
Abanaguwa	9	64	5	36
Total	41		16	

3.3. Nature of participation

Nature of participation is essential in achieving sustainable integration of communities in the management of protected areas in Nigeria. This study found two categories of participants in wildlife management in the study area namely: active/passive and voluntary/institutional (Table 4). The findings indicated that majority (62.5%) are passive (81.25%) and voluntarily participants. Evidently the weak performance of communities in the area is due to the fact that local people view wildlife resources as belonging to the State and they do not have the right to use wildlife directly while others have. This work showed in significant variation in the nature of participation of category two among the villages. Chi square value for active and passive (0.67) as well as voluntary and institutional (1.02) participations are not significant at $p < .05$ (Table 4). Hence there is no significant variation in the nature of participation among the communities. In Nigeria, Sam et al. (2014) showed that as a result of high level of active participants in conservation organization, areas of high biodiversity in Cross River Parks have regained their species composition.

Table 4: Categories of Participation in Wildlife Management

Study locations	Types of Participation							
	Category 1 (n=16)				Category 2 (n=16)			
	Active	%	Passive	%	Voluntary	%	Institutional	%
Shinge	1	6.25	2	12.5	3	18.75	0	0.0
Illala	1	6.25	1	6.25	2	12.5	1	6.25
Zigobiya	1	6.25	3	18.75	4	25.0	0	0.0
Kokiro	1	6.25	1	6.25	1	6.25	1	6.25
Abanaguwa	2	12.5	3	18.75	3	18.75	1	6.25
Total	6	37.5	10	62.5	13	81.25	3	18.75
X^2	0.67				1.02			

This finding is in line with Murombedzi (1999) who reported that communities in Zimbabwe continued to view wildlife resource as belonging to the Rural District Councils or State and were thus focusing on land-uses that are incompatible with wildlife. Barrow et al. (2001) reported that overwhelming majority of participants in natural resources management in East Africa is passive and most time voluntary. Skidmore et al. (2006) have indicated that for effective engagement and improved community participation, that local people should not be forced but rather be given opportunity to participate and involve in projects which affect their lives.

3.4. Benefits of community participation in wildlife management

Local communities bear the brunt of fence and fine hence poaching and the conversion of land to more profitable land uses is on the rise in the area. Generally, wildlife products are traded in local markets (e.g. bushmeat) and internationally (e.g. animal parts for medicines). Table 5 shows the distribution of participants on wildlife management. The table indicated that majority of the participants (75%) combats poaching of wildlife in the area. According to the participants poaching has been so limited to particular areas beyond the village boundaries of the neighboring communities. There is also restriction to trade in parts of animals.

Table 5: Direct Wildlife-related Benefits of Community Participation

Benefits	Total Number of Participants	%
Control of poaching	12	75
Control of trade in parts of animals	4	25
Total	16	100

In line with Obour et al. (2016) community anti-poaching activities in Mole National Park (MNP) Ghana have impacted positively on the general numbers of the fauna species, especially the large mammals. It has lessened the levels of poaching in the park resulting in reduced illegal activities and an increase in large mammal numbers. Communal Area Wildlife Conservancies in Namibia are considered a major success story as the result of reduced illegal wildlife use and recovery of game populations (Weaver and Petersen, 2008).

3.5. Factors limiting participation in wildlife management

Local participation in biodiversity management and enhancement of community livelihoods is limited by factors such as poor governance and weak land and resource tenure as well as community institutions and policies. Table 6 identifies three key challenges to community participation in wildlife management in the area. It shows that poor governance (43.85%) and weak community institutions (31.57%) are the most limiting factors of community participation in the area.

Table 6: Key Challenges of Participation in Wildlife Management

Study Locations	Factors (n=57)		
	Poor governance	Insecurity	Weak Community Institutions
Shinge	71.42	28.57	0.00
Illala	55.55	22.22	22.22
Zigobiya	18.75	25.00	56.25
Kokiro	63.63	27.27	9.09
Abanaguwa	35.71	21.43	42.85

This finding corroborates Barrett et al. (2001) who reported that weakness of existing institutions at all levels including community was the greatest challenge for achieving sustainable tropical biodiversity conservation. Zyambo (2018) also concluded that poor governance is a major limitation to natural resources management in Zimbabwe. The increased participation of local communities, NGOs and private companies in wildlife management and forest activities in the sub-region is seriously impeded by inappropriate official policies and deficient and by the lack of capacities and resources (Zeba, 1998).

4.0. Conclusions

This work highlights the nature of role of communities in management of wildlife through diverse practices in Baturiya sanctuary. The work reveals the communities still participate both actively and passively in wildlife management and that their actions were typically not destructive to nature. Most communities around the sanctuary as noted contributed to the preservation of primates and reptiles hence their population is significantly high. This study recommended that a new strategy should be developed to improve engagement among stakeholders in wildlife management based on the understanding that the government programmes and policies cannot be successful if community participation is missing. A model should be developed to strengthen community leaders and youth capacities and officially recognized them as stakeholders in wildlife management and governance of natural resources in Nigeria at large. Strict laws should be in place to prevent hunting or poaching of wildlife in the sanctuary area and more so communities should be involved in the management process.

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Cite this article as:

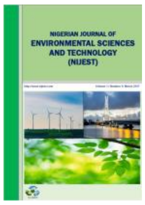
Karkarna M.Z. and Danjuma M.N., 2020. Community Participation in Wildlife Management in Baturiya Sanctuary, Northwestern Nigeria. *Nigerian Journal of Environmental Sciences and Technology*, 4(1), pp. 77-86. https://doi.org/10.36263/nijest.2020.01.0169

Nigerian Journal of Environmental Sciences and Technology (NIJEST)

www.nijest.com

ISSN (Print): 2734-259X | ISSN (electronic): 2734-2603

Vol 4, No. 1 March 2020, pp 87 - 96



Impact of Urbanizing Ovia-North East on the Quality of Groundwater using Water Quality Index

Rawlings A.* and Ikediashi A. I.

Department of Civil Engineering, Faculty of Engineering, University of Benin, Benin City, Edo State, Nigeria

Corresponding Author: *seghosimeh@gmail.com

https://doi.org/10.36263/nijest.2020.01.0180

ABSTRACT

Due to increasing population and industrialization in urban areas, the environment has become so vulnerable as a result of unhygienic practise by the populace (particularly in developing country). Thus, making groundwater to be more vulnerable to pollutants from the environment. In this study, groundwater samples were collected from twelve different boreholes (six domestic boreholes and six bakery boreholes) in Ovia North-East Local Government Areas and assessed for their suitability in domestic and industrial purposes. These samples were collected between September and October, 2019 (peak of rainy season). The samples were analysed for fourteen physiochemical parameters, namely: pH, Electrical Conductivity (EC), Total Dissolved Solids (TDS), Turbidity, Bicarbonate (HCO_3^-), Chloride (Cl), Ammonium Nitrogen (NH_4N), Total Hardness (TH), Temperature, Odour, Iron (Fe), Zinc (Zn), Lead (Pb) and Cadmium (Cd). All the laboratory analyses were conducted in accordance with the techniques described by American Public Health. Statistical analyses such as correlation matrix (Pearson's Correlation) and water quality index (WQI) were used in this study. Results of physiochemical analysis revealed that of all the parameters examined, pH, Pb and Cd were not within acceptable limits. The correlation matrix indicated that TDS shows a highly positive correlation (0.99) between EC and NH_4N respectively and also Temperature shows a highly negative correlation (0.80) between EC, TDS and NH_4N respectively. The WQI indicated that the groundwater samples ranged from excellent to good indicating that the water is fit for drinking, domestic and industrial purpose. The physiochemical and correlation analyses revealed that the quality of groundwater in Ovia- North East LGA has slightly deteriorated and might be prone to contamination (by anthropogenic activities). Hence, it is recommended that there should be regular monitoring of the groundwater quality so as to sustain and improve the water quality and that the water should be treated before use.

Keywords: Groundwater, Pollution, Physiochemical parameter, Acceptable limit, Water Quality Index

1.0. Introduction

Developing countries (particularly in Sub-Sahara Region) are faced with the problem of accessing portable water and this is attributed to the fact that they get their water from poor sources. Surface water which is an easy source of water mainly used in developing countries get easily contaminated due to its exposed nature, hence the people in these countries have started resorting to ground water as their major source of portable water due to its low levels of impurities (Akpoveta, 2011; Patil *et al.*, 2015) and the populace of Benin City are not left out on this. Therefore, groundwater has become a vital renewable resource that needs to be monitored and protected (Usman *et al.*, 2014).

Groundwater is the water found underground in the cracks and spaces in the soil, sand and rock. It is stored in and moves slowly through geologic formations of soil, sand and rocks called aquifers (NGWA, 2019). Groundwater supplies are replenished, or recharged, by rain and snow melt that seeps down into the cracks and crevices beneath the land's surface (Mukherji, 2006). Groundwater serve various purposes including public and domestic water supply system, irrigation and livestock watering, industrial, commercial and mining purposes (USEPA, 2002, Usman *et al.*, 2014). When groundwater is contaminated, its quality cannot be restored by controlling or stopping the contaminant from the source (Khwaja and Aggarwal, 2014) and as such it may become unusable for decades leading to loss of well-water supplies (Nicole, *et al.*, 2019) and migration of contaminants to other water bodies such as lakes and rivers as groundwater passes through the hydrologic circle (Conant *et al.*, 2004). Contaminated water has a great potential for transmitting a wide variety of diseases (Ogbeifun *et al.*, 2019). About 80% of the diseases that affect the global population today and more than one-third of the deaths in the developing countries are all attributed to contaminated water (Adegbite *et al.*, 2018). These diseases are as a result of drinking contaminated water (Chan *et al.*, 2007). Thus, tremendous concern is now being raised on the deterioration of groundwater quality considering the fact that it is the major source of portable water supply.

As the population of Nigeria continue to grow, a lot of people are increasingly moving from rural to urban centres, making cities with greater population density to be larger than ever before. Benin City is one of such cities as it comprises of different local government areas (LGAs), including Ikpoba Okha, Oredo, Egor and Ovia North East Local government areas (Balogun and Orimoogunje, 2015) each of which is experiencing a tremendous increase in Urbanization. Lately, Ovia North East LGA of Benin City in Edo State, Nigeria has been experiencing rapid urbanization which is one of factor that is responsible for rapid deterioration of water quality (Ogendegbe and Akinbile, 2004; Christopher and Olatunji, 2018). Increased population, urbanization and industrialization has been attributed to increased anthropogenic activities which has been identified as major source of pollution of water bodies (Kumar and Kumar, 2013). It has been shown that anthropogenic activities in all sectors impact and alter the natural water cycle and subsequent groundwater quality. These alterations can largely affect the environment and human health (Nicole *et al.*, 2019).

As Ovia North East LGA is experiencing rapid urbanization, human activities (including soil fertility remediation, indiscriminate refuse and waste disposal, and the use of septic tanks, soak-away pits and pit latrines) and industrial activities are on the increase. These activities are capable of producing leachates into the groundwater formation that serve as a major source of drinking water to the inhabitants in this LGA. And this often renders the water unfit for use. Hence, it is imperative to regularly monitor the water quality of water resources in order to safeguard public health and secure water resources for portable water supply. Although numerous studies have assessed the groundwater quality in southern Nigeria (Erah *et al.*, 2002; Omoigberale *et al.*, 2009; Akpoveta *et al.*, 2011; Orjiekwe *et al.*, 2013; Omorogieva *et al.*, 2016; Adegbite *et al.*, 2018; Foka *et al.*, 2018; Ogbeifun *et al.*, 2019). However, no study has been reported on the groundwater quality in Ovia North East despite the rapid urbanization that has occurred in this area over the years. Therefore, this study aimed at assessing the impact of urbanizing Ovia North East LGA of Benin City on the quality of groundwater using water quality index. This study will provide data and information that will be useful to the government and other authorities concerned for future water monitoring in the LGA.

2.0. Methodology

2.1. Study area

Ovia North-East Local Government Area has its headquarters in Okada town and it has an area of 2,301 square kilometres (Akinbo and Okaka, 2010). It is bounded by longitude 5° 45' and 6° 15' east and latitude 5° 15' and 6° 45' north of the central province of Edo state. The main river, Ovia River flows through all the communities in the LGA (Akinbo and Okaka, 2010). The Local Government Area (Ovia North East) is situated in Benin City and Benin City is located within the rainforest zone of Nigeria with mean annual rainfall in the range of 1500 mm to 2500 mm and the mean monthly temperature varying from 25°C to 28°C (http://www.edoworld.net/Edotourismweather.html). The Benin Region is underlain by sedimentary formation of the South Sedimentary Basin (Ikhile, 2016) and it constitute part of the Benin formation which is made up of over 90% massive, porous, coarse sand with thick clay/shale interbeds having high groundwater retention capacity (Adegbite *et al*., 2018). The geology is generally marked by top reddish earth, composed of ferruginized or literalized clay sand (Ikhile, 2016). Benin City has two distinct seasons. These are the wet (rainy) season and the dry season. The rainy season occurs between the months of March and October with a short break in August. The dry season on the other hand lasts from November to February with dry harmattan winds between December and February, but with the effect of global warming and climate change, rains have been observed to fall irregularly almost in every month of the year with double peak periods in

July and September. At present the population of Benin City is estimated to be about 1.75 million (projected from 2015 population figures).

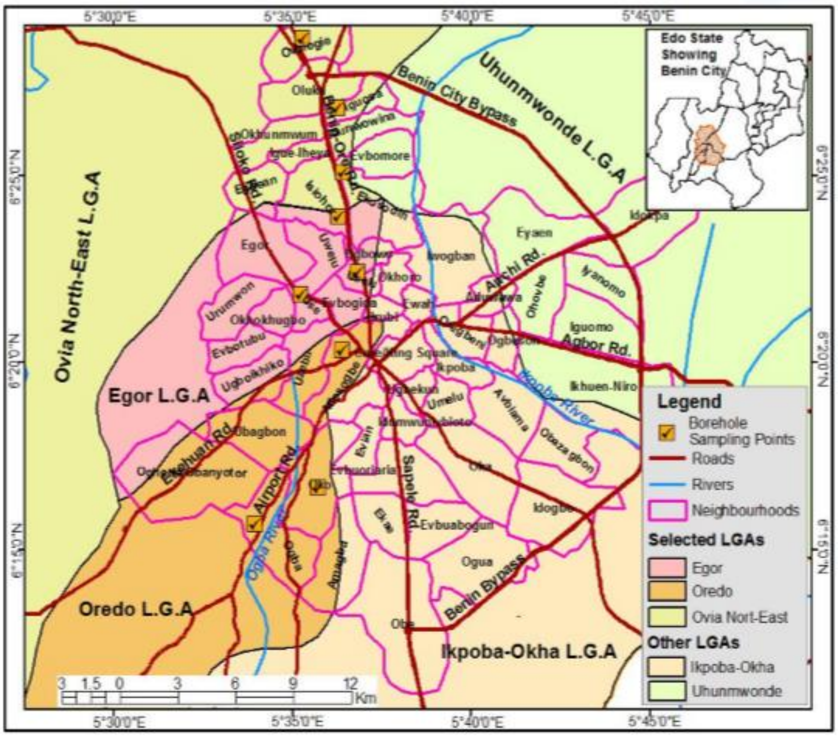


Figure 1: Map of Benin City showing Ovia North-East LGA and other Local Government Areas (Source: Ogbeifun *et al*., 2019)

Figure 2: A map showing the location of Ovia-North East LGA (Source: Google Earth)

2.2. Sample collection and physiochemical analysis

Groundwater samples were collected from twelve different boreholes (through tap: six samples from domestic boreholes and six samples from bakery boreholes) in Ovia North-East LGA. These samples were collected towards the ending of September and beginning of October, 2019 (peak of rainy season). The samples were labelled and transported to the laboratory for analysis. It was ensured that the sample bottles were properly cleaned and sterilized before use. The samples were analysed for fourteen physiochemical parameters, namely: pH, Electrical Conductivity (EC), Total Dissolved Solids (TDS), Turbidity, Bicarbonate (HCO_3^-), Chloride (Cl), Ammonium Nitrogen (NH_4N), Total

Hardness (TH), Temperature, Odour, Iron (Fe), Zinc (Zn), Lead (Pb) and Cadmium (Cd). All laboratory analyses were conducted in accordance with the techniques described by American Public Health (APHA, 1985 and 2005) and the methods adopted for analysing the groundwater quality parameters are shown in Table 1.

Table 1: Analytical methods for water quality parameters

Parameters	**Analytical Methods**
pH	Flame Photometric Method
Electrical Conductivity (EC)	Flame Photometric Method
Total Dissolved Solids (TDS)	Flame Photometric Method
Turbidity	Spectronic 20D$^+$ Spectrophotometry Method
Bicarbonate (HCO_3^-)	Titrimetric Method
Chloride (Cl)	Titrimetric Method
Ammonium Nitrogen (NH_4N)	Titrimetric Method
Total Hardness (TH)	Titrimetric Method
Temperature	Thermometer Method
Odour	Human Olfaction Method
Iron (Fe)	Spectrophotometry Method (Atomic Absorption Spectrophotometer)
Zinc (Zn)	Spectrophotometry Method (Atomic Absorption Spectrophotometer)
Lead (Pb)	Spectrophotometry Method (Atomic Absorption Spectrophotometer)
Cadmium (Cd)	Spectrophotometry Method (Atomic Absorption Spectrophotometer)

2.3. Statistical analysis

Primary data (groundwater quality data from laboratory analysis) were analysed statistically and these analyses include correlation matrix and water quality index (WQI). The correlation matrix involves Pearson's correlation using statistical package for the social sciences (SPSS) and the water quality index (WQI) was carried out using Microsoft excel (2013 version). According to Gogtay and Thatte (2017), the end result of a correlation analysis is a Correlation coefficient whose values range from -1 to +1. This value shows how good the correlation is (and not how steep the line is) and whether it is positive or negative (Mohamed, 2015). WQI reduces the bulk of data into a single value in order to express the data in a simplified and logical form and demonstrate annual cycles, spatial and temporal variation and trends in water quality at low concentrations (Shweta *et al*., 2013). Pius *et al*. (2012) describe WQI as a single unit number (of less than 100) that sorts out the quality of water source. The maximum permissible value of this WQI is 100 (for the water to be fit for drinking), thus values greater than 100 indicates signs of pollution and as such the water becomes unfit for human consumption (Mohammad and Amba, 2018). Weight arithmetic WQI method classified the water quality according to the degree of purity, using the most commonly measured water quality variables (Paiu and Breaban, 2010). The weighted arithmetic index method from Brown *et al*. (1972), Tyagi *et al*. (2013) and Egun and Ogiesoba-Eguakun (2018) was used for the calculation of the WQI of the groundwater. From this method, the quality rating (q_n) was calculated using the following equation:

$$q_n = 100\frac{[V_n - V_i]}{[S_n - V_n]} \tag{1}$$

where,

q_n = Quality rating

V_n = observed value

V_i = ideal value

S_n = Standard value for the nth parameters

W_n = Unit weight for the nth parameters, which is $\frac{K}{S_n}$

K = constant for proportionality.

The overall WQI was then calculated by the equation:

$$WQI = \frac{\sum q_n \times W_n}{\sum W_n} \qquad (2)$$

Based on the WQI values gotten from the above equation, the groundwater type was classified as indicated in Table 2.

Table 2: Water quality rating based on the weighted arithmetic water quality index method (Tyagi *et al*., 2013; Egun and Ogiesoba-Eguakun, 2018)

Range	**Rating of Water Quality**
0 - 25	Excellent
25 – 50	Good
51 - 75	Poor
76 - 100	Very poor
>100	Unsuitable for drinking

3.0. Results and Discussion

Results from both physiochemical and statistical analyses are presented in Tables 3, 4, 5, 6 and 7. The Comparison of Physiochemical Parameter Analysis with Nigerian Standard for Drinking Water Quality (NSDWQ, 2015) and World Health Organisation (WHO, 2011) Standard are presented in Table 3. Table 4 shows the Physiochemical Parameters Analysis of Groundwater Quality in Ovia-North East LGA and Table 5 and 6 shows Pearson's Correlation Matrix of both Bakery and Domestic Boreholes (in Ovia- North East LGA) Water Quality Parameters. Table 7 present the results of WQI of the groundwater samples (both bakery and domestic).

Table 3: Comparison of physiochemical parameter analysis with NSDWQ (2015) and WHO (2011)

Parameters	**Acceptable Limit NSDWQ (2015)**	**Acceptable Limit WHO (2011)**	**Groundwater Samples Analysis**
pH	6.5-8.5	6.5-8.5	4.7-5.5
EC (µS/cm)	1500	1500	11.2-32.4
TDS (mg/L)	500	500	5.5-20
Turbidity (NTU)	5	1-5	ND
HCO_3^- (mg/L)	500	500	10.1-42.7
Cl (mg/L)	250	250	35.5-68.6
NH_4N (mg/L)	0.5	0.5	0.114-0.480
TH (mg/L)	200	200	0.47-1.88
Temperature (°C)	Ambient	30	25.2-27.4
Odour	Odourless	Odourless	Odourless
Fe (mg/L)	0.3	0.3	0.311-1.633
Zn (mg/L)	3	3	0.265-0.741
Pb (mg/L)	0.01	0.01	0.030-0.111
Cd (mg/L)	0.003	0.003	0.008-0.054

EC: Electrical Conductivity; TDS: Total Dissolved Solids; HCO_3^-: Bicarbonate; Cl: Chloride; NH_4N: Ammonium Nitrogen; TH: Total Hardness; Fe: Iron; Zn: Zinc; Pb: Lead; Cd: Cadmium; ND: Not Detected

Table 4: Physiochemical parameter analysis of groundwater quality in Ovia-North East LGA

Sampling Points	**pH**	**EC (µS/cm)**	**Temp. (°C)**	**Turb. (NTU)**	**Odour**	**TDS (mg/L)**	**HCO_3^- (mg/L)**	**Cl (mg/L)**	**NH_4N (mg/L)**	**Fe (mg/L)**	**Zn (mg/L)**	**Pb (mg/L)**	**Cd (mg/L)**	**TH (mg/L)**
DBH_1	5.3	11.2	27.4	ND	Odourless	5.5	10.1	35.5	0.114	0.311	0.187	0.030	0.008	0.47
DBH_2	5.1	16.9	27.1	ND	Odourless	8.4	18.3	35.5	0.212	0.501	0.300	0.055	0.015	0.94
DBH_3	5.1	15.3	27.1	ND	Odourless	7.7	12.2	43.2	0.204	0.447	0.285	0.051	0.018	0.91
DBH_4	4.7	14.3	26.8	ND	Odourless	7.2	12.2	35.5	0.192	0.332	0.271	0.047	0.011	0.78
DBH_5	4.7	27.9	26.4	ND	Odourless	12.6	30.5	50.9	0.360	1.480	0.584	0.094	0.036	1.41
DBH_6	5.3	19.2	26.4	ND	Odourless	9.6	18.3	43.2	0.276	0.631	0.318	0.045	0.010	1.77
BBH_1	4.7	20.5	26.1	ND	Odourless	10.3	18.3	43.2	0.281	0.754	0.364	0.057	0.025	1.14
BBH_2	4.8	20.7	26.3	ND	Odourless	10.3	18.3	43.2	0.284	1.351	0.571	0.084	0.032	1.24
BBH_3	4.9	11.8	25.7	ND	Odourless	5.9	12.2	35.5	0.123	0.314	0.265	0.038	0.010	0.67
BBH_4	4.8	40.1	25.3	ND	Odourless	20.0	42.7	68.6	0.480	1.633	0.741	0.111	0.054	1.88
BBH_5	5.3	27.2	26.2	ND	Odourless	13.6	18.3	43.2	0.351	0.901	0.515	0.070	0.028	1.30
BBH_6	5.5	32.4	25.2	ND	Odourless	16.1	36.6	68.6	0.370	1.532	0.666	0.102	0.041	1.75

DBH: Domestic Borehole; BBH: Bakery Borehole; Temp.: Temperature; Turb.: Turbidity

Results from Table 3 and 4 shows that all parameters examined were within NDSWQ and WHO acceptable limits except for pH, Lead (Pb) and Cadmium (Cd). This indicates that the groundwater is slightly acidic and contains high amount of heavy metals (Pb and Cd). Lower values of pH might be attributed to anthropogenic activities (pollution) within the study area and these values might be responsible for the increased heavy metals (Pb and Cd) in the groundwater, as too high or low pH is known to affect the solubility and toxicity of heavy metals. The acidic nature of groundwater quality in Benin City has been noted by several researchers (Omoigberale *et al.,* 2009; Orjiekwe *et al.,* 2013; Ogbeifun *et al.,* 2019). Though pH has no direct effect on human (Ogbeifun *et al.,* 2019) but all the biochemical reactions are however pH dependent. Acidic water might occur naturally as a result of mixture of volcanic gases, gaseous emanations in geothermal areas (Osei, 2004) or due to alteration of groundwater by anthropogenic activities as stated by (Umar and Absar, 2003) and may result in serious health complications such as irritation in the eyes, skin and mucous membrane (Karunakaran, 2008). Also lower pH levels enhance the corrosive characteristics of water resulting in contamination of drinking water and adverse effect on its taste and appearance (WHO, 2007; Egun, and Ogiesoba-Eguakun, 2018). Higher levels of heavy metals (Pb and Cd) in drinking water pose threat to human health (Erah *et al.,* 2002). In contrast, Adegbite *et al.* (2018) show that the level of Lead (Pb) in the groundwater in Egbeta was within WHO acceptable limit, this might be attributed to the fact that at the time of assessment, this area has not experience rapid urbanization and as such human activities was not on the increase. Higher levels of Pb and Cd in groundwater quality in some areas in Benin City have also been noted by some researchers (Omoigberale *et al*., 2009 and Erah *et al*., 2002).

Table 5: Pearson's correlation matrix for bakery boreholes water quality parameters

Parameters	pH	EC	Temp.	TDS	HCO_3^-	Cl	NH_4N	Fe	Zn	Pb	Cd	TH
pH	1											
EC (µS/cm)	-0.4842	1										
Temp (^oC)	0.4064	-0.8028	1									
TDS (mg/L)	-0.4531	0.9934	-0.8380	1								
HCO_3-(mg/L)	-0.4531	0.9804	-0.7265	0.9654	1							
Cl (mg/L)	-0.2988	0.8682	-0.7000	0.8592	0.7789	1						
NH_4N (mg/L)	-0.4583	0.9767	-0.8960	0.9924	0.9289	0.8647	1					
Fe (mg/L)	0.4832	0.9713	-0.6926	0.9388	0.9646	0.8767	0.9049	1				
Zn (mg/L)	-0.6020	0.9824	-0.7351	0.9606	0.9610	0.8598	0.9376	0.9809	1			
Pb (mg/L)	-0.6770	0.9354	-0.6208	0.9109	0.9240	0.7892	0.8784	0.9349	0.9770	1		
Cd (mg/L)	0.6165	0.8782	-0.4872	0.8375	0.8599	0.7954	0.7954	0.9225	0.9411	0.9707	1	
TH (mg/l)	0.3284	0.9731	-0.5546	0.9718	0.9405	0.9408	0.9562	0.9303	0.4595	0.9658	0.9744	1
Min	4.700	11.800	25.200	5.900	12.200	35.500	0.1230	0.3140	0.2650	0.0380	0.0100	0.6700
Max	5.500	40.100	26.300	20.000	42.700	68.600	0.4800	1.6330	0.7410	0.1110	0.0540	1.8800
Mean	5	25.450	25.800	12.700	24.400	50.380	0.304	1.081	95.592	0.077	0.031	1.330
Median	4.85	23.950	25.900	11.950	18.300	43.200	0.284	1.126	0.591	0.077	0.030	1.270
Sekwness	0.537	0.119	-0.119	0.118	0.500	0.427	-0.0330	-0.2640	1.3610	-0.0990	0.0720	

Results from Table 5 and 6 shows that, in both the bakery and domestic boreholes (in Ovia- North East LGA) water quality parameters, a high positive correlation (0.99) exist between TDS and EC; NH_4N and TDS. Also, a high negative correlation (0.80) exists between Temp. and EC; TDS and Temp.; NH_4N and Temp. The positive correlations existing between parameters implies that they might be of the same source and that they increase and decrease together (Izeze and Adipere, 2018), thus this might help to trace the source of the slight amount of these parameters present in the water. Also the strong positive correlation relationship between NH_4N and TDS might be an indication that the groundwater is prone to contamination by anthropogenic activities. Similar strong positive correlation existing between groundwater quality parameters was reported by Omorogieva *et al*. (2016) for water quality in Okhuahe Community in Edo State, Nigeria and Umamaheswari *et al*. (2015) for groundwater quality in Gudiyattam and Vaniyambadi blocks of Vellore district, Tamil Nadu, India.

Table 6: Pearson's correlation matrix for domestic boreholes water quality parameters

Parameters	**pH**	**EC**	**Temp.**	**TDS**	**HCO_3^-**	**Cl**	**NH_4N**	**Fe**	**Zn**	**Pb**	**Cd**	**TH**
pH	1											
EC (µS/cm)	-0.4841	1										
Temp (°C)	0.4064	-0.8028	1									
TDS (mg/L)	-0.4531	0.9934	-0.8389	1								
HCO_3-(mg/L)	-0.4531	0.9804	-0.7264	0.9655	1							
Cl (mg/L)	-0.2988	0.8682	-0.7000	0.8592	0.7789	1						
NH_4N (mg/L)	-0.4583	0.9767	-0.8906	0.9924	0.9259	0.8647	1					
Fe (mg/L)	-0.4832	0.9713	-0.6926	0.9388	0.9646	0.8767	0.9049	1				
Zn (mg/L)	-0.6020	0.9824	-0.7351	0.9606	0.9610	0.8598	0.9376	0.9809	1			
Pb (mg/L)	-0.6770	0.9354	-0.6207	0.9109	0.9240	0.7892	0.8754	0.9349	0.9770	1		
Cd (mg/L)	-0.6165	0.8782	-0.4872	0.8375	0.8599	0.8253	0.7954	0.9228	0.9411	0.9707	1	
TH (mg/l)	-0.0146	0.7329	-0.8962	0.7927	0.6664	0.6893	0.8369	0.5977	0.6062	0.4786	0.3786	1
Min	4.700	11.200	27.100	5.500	10.100	35.500	0.114	0.311	0.187	0.030	0.008	0.4700
Max	5.300	27.900	27.400	12.600	30.500	50.900	0.360	1.480	0.584	0.055	0.036	1.7700
Mean	5.033	17.4667	26.867	8.500	16.933	40.633	0.226	0.617	0.3242	0.0537	0.0163	1.0467
Median	5.100	16.100	26.950	8.050	15.250	39.350	0.208	0.474	0.2925	0.049	0.013	0.9250
Sekwness	-0.2905	0.7418	-0.0648	0.4749	0.7868	0.4763	0.2977	1.1539	0.9952	0.8596	1.0136	

Results from Table 7 indicated that the WQI range from excellent to good. It was observed that DBH_1 and BBH_2 fall in the excellent category with WQI values of 15.336 and 22.288 while the rest sample points fall in the good category with WQI values greater than 25 and less than50 (as indicated in Table 7 above). The water quality type was determined based on the weighted arithmetic method classification table (Table 2). The WQI of all water samples which range from excellent to good suggest that the water is suitable for drinking, domestic and industrial (bakery) use. Although all borehole water samples (both domestic and bakery) had excellent and good water quality, the slightly high WQI values (within the range of 25-50) that was observed in some borehole water samples is an indication that the groundwater is prone to contamination by anthropogenic activities. Almost similar range of WQI values (9.17–10.40) and (11.24–16.15) were reported by Egun and Ogiesoba-Eguakun (2018) and Oboh and Agbala (2017) for water bodies in Edo State, Nigeria. However, Omorogieva *et al*. (2016) reported high WQI values (78.38-95.58) and (112.27-103679.10) for river and some selected boreholes water samples in Okhuahe Community in Edo State, Nigeria. These WQI values are indicative of very poor and unsuitable drinking water quality which according to the author is attributable to the unprotected landfill at the centre of the study site. Also, Etim *et al*. (2013) reported high WQI values (55.05–84.94) for some water bodies in the Niger Delta region, which is an indication of poor drinking water quality attributable to the exploration and refining of crude oil in the region (Egun and Ogiesoba-Eguakun, 2018).

Table 7: Water Quality Index (WQI) of groundwater samples

Groundwater Sample Points	**WQI of Groundwater Samples**
DBH_1	15.336
DBH_2	29.183
DBH_3	29.164
DBH_4	33.388
DBH_5	36.198
DBH_6	37.664
BBH_1	36.292
BBH_2	22.288
BBH_3	34.848
BBH_4	31.956
BBH_5	29.445
BBH_6	27.760

DBH: Domestic Borehole; BBH: Bakery Borehole

4.0. Conclusions

This study has assessed the impact of urbanizing Ovia- North East LGA of Benin City on the groundwater quality (for its domestic and industrial purpose) using WQI. Results of physiochemical analysis revealed that of all the parameters examined pH, Pb and Cd were not within acceptable limits. The correlation matrix indicated that TDS shows a highly positive correlation (0.99) between

EC and NH_4N respectively and also Temperature shows a highly negative correlation (0.80) between EC, TDS and NH_4N respectively. The WQI indicated that the groundwater quality ranged from excellent to good. Although, the groundwater quality in Ovia- North East LGA ranged from excellent to good indicating that it is fit for drinking, domestic and industrial purposes, however the physiochemical and correlation analyses have revealed that the groundwater quality has slightly deteriorated and might be prone to contamination either by natural or anthropogenic activities. Hence, it is suggested that there should be regular monitoring of the groundwater quality in Ovia-North East LGA of Benin City and that the groundwater should be treated before use.

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Cite this article as:
Rawlings A. and Ikediashi A. I., 2020. Impact of Urbanizing Ovia-North East on the Quality of Groundwater using Water Quality Index. *Nigerian Journal of Environmental Sciences and Technology*, 4(1), pp. 87-96. https://doi.org/10.36263/nijest.2020.01.0180

Nigerian Journal of Environmental Sciences and Technology (NIJEST)
www.nijest.com
ISSN (Print): 2734-259X | ISSN (electronic): 2734-2603
Vol 4, No. 1 March 2020, pp 97 - 110

Application of Tasselled-Cap Transformation to Soil Textural Mapping of a Semi-Arid Environment: A Case of Usmanu Danfodiyo University Main Campus, Sokoto, Nigeria

Eniolorunda N. B.* and Jibrillah A. M.
Department of Geography, Faculty of Social Sciences, Usmanu Danfodiyo University, Sokoto, Nigeria
Corresponding Author: *nathaniel.bayode@udusok.edu.ng

https://doi.org/10.36263/nijest.2020.01.0158

ABSTRACT

Information on soil attributes still largely relies on traditional methods of point sampling and subsequent laboratory test which are time and resource consuming. Thus, this study tested the applicability of Kauth-Thomas Tasseled-Cap Transformation (TCT) to soil textural mapping on the main campus of Usmanu Danfodiyo University, Sokoto as a faster method. The study hypothesized that the TCT-Brightness image had no relationship individually with soil particle size and Land use/ Land Cover (LUC). Landsat 8 of 22-03-2019 was preprocessed with QGIS and subjected to TCT in Idrisi Terrset to produce the TCT-Brightness image. Soil samples were collected at 91 points based on stratified random sampling at 0-15cm depth. Soil particle size was determined by Bouyoucos Hydrometer method. Simple linear regression analysis was used to model soil particle sizes from the TCT-Brightness image, while soil textural map was produced in SAGA. LUC of the area was mapped at Level III within the Google Earth Engine (GEE). Cross map-tabulation was carried out to test for the relationship between LUC and soil texture. Four textural classes were obtained namely sandy-clay-loam, loamy sand, sand and sandy-loam, with sand being dominant. Soil particle sizes were modeled at 99.85% accuracy, while soil textural mapping yielded 95% accuracy. Five LUC classes namely: built-up area, wetland, upland forest, bare surface and riparian forest, were mapped at 98.3% accuracy, with bare surface being dominant. A significant (p<0.01) relationship between LUC and soil texture was obtained at 0.85 Kappa Index of Agreement. The study concluded that the TCT is sufficient for predicting soil texture in a largely sandy semi-arid environment. A repeat of this study for the wet season was recommended.

Keywords: Soil Texture, Tasseled Cap Transformation, Soil Brightness Image, Landsat, Kappa

1.0. Introduction

The coupling of anthropogenic pressure and climate change on the landscape in the 21st century has necessitated good and sustainable soil management which is critical to successful agriculture (Zribi *et al.*, 2011). Understanding soil attributes and types within an area in a short time will be critical to making best land-use decisions as changes in landscape are expected to accelerate with time (Menezes *et al.*, 2014; Silva *et al.*, 2014). Thus, information on soil must be timely and of high fidelity for quick decision making. Besides agriculture, soil information is needed for policy-making, land resource management, and monitoring of the environmental impact of development projects (Mulder *et al.*, 2011). The traditional way of getting soil data in most countries of the world requires recurrence of point sampling and subsequent laboratory determination of both the physical and chemical properties. This procedure is time and resource consuming especially where information is needed urgently and resources are limited.

The need for crop production maximization and sustainable use of agricultural land in the face of growing population calls for smart methods of soil data collection and analysis. In the last four decades, there has been great interest in the development of inexpensive and rapid soil mapping methods, and remote sensing of soil is particularly valuable and handy to fill the gap (Casa *et al.*, 2013). The reflected or emitted radiation by soil varies according to a range of chemical and physical characteristics of the soil matrix which makes it possible for discrimination between different soil surfaces across different wavelengths or a combination of spectral bands (Dewitte *et al.*, 2012).

Remote sensing of surface soil properties with space borne or airborne approaches dates back to 1980s, and today, several methods of image processing have been used to extrapolate soil data (Hartemink and Minasny, 2014). Although optical remote sensing can penetrate only few centimeters into the ground, it has been suitably used for mapping soil mineralogy, texture, soil iron, soil moisture, soil organic carbon, soil salinity and carbonate content (Hartemink and Minasny, 2014).

In Nigeria, most remote sensing studies have concentrated on discriminating among the earth surface materials such as vegetation, Land Use/Land Cover (LUC), bare surface and erosion mapping; in very few of them has remote sensing been used for soil property mapping. For example, Eniolorunda *et al.* (2015) identified colluvial sand in the Rima river floodplain based on LUC mapping, while Aizebeokhai *et al.* (2018) performed soil characterization in some parts of the southwestern Nigeria using remote sensing technique. Fasina *et al.* (2015), in their study, combined the conventional and remote sensing methods for soil characterization and classification in Ijebu East of southwestern Nigeria. The above studies used proximate methods to delineate soil boundaries, which are also computationally rigorous and time consuming. In this study, a direct and cheaper method is proposed where the brightness image of Kauth-Thomas Tasseled Cap Transformation (TCT) is used to present soil textural information. Features derived from TCT can be directly associated with important physical parameters of the land surface that are more easily understood (Liu *et al.*, 2015). The aim of this study is to test the applicability of Kauth-Thomas TCT to soil textural mapping on the main campus of Usmanu Danfodiyo University, Sokoto. The objectives include derivation of the Kauth-Thomas TCT image, determination of soil particle size and Land use/ Land Cover mapping. We hypothesized that the brightness image of the study area has no correlation with soil particle size on the one hand and that soil texture has no relationship with LUC on the other hand.

2.0. Methodology

2.1. Study area

The study was conducted on the main campus of Usmanu Danfodiyo University, Sokoto. It is located within latitude 13° 6' 30" - 13° 08' 30" North and longitudes 5° 11' 30" – 5° 14' 30" East (Figure 1). It lies in the north of Sokoto-Rima river floodplain with land area of 697 km^2. The area lies within the Iullemeden basin which is underlain by Precambrian basement complex. It is covered by a series of sedimentary rocks which have been deposited over time. These sediments were laid down under varied environmental situations ranging from continental to marine events. The study area is located within the Kalambaina formation which is aquieferous. It has an altitude of 312m above sea level. The soil type found at the site is regosol. This type of soil is weakly developed due to slow soil formation process as water cannot easily drain through the profile. The top soil is generally sandy, resulting from sand dune deposition from the far away Sahara desert, while the subsoil is clayed due to illuviation of clay materials from the topsoil. In some places, soil profile is characterized by absence of *A* horizon due to removal by human activities and erosion. What appears as the topsoil is the *B* horizon which is in two layers: B_1 and B_2. The former is found within 0-35cm; it is sandy clay with blocky structure, bulk density of 1.43 g/cm^3 and soil moisture content of 1.3%. The latter is found within 35-150cm; it is clay with platy structure, bulk density of 1.47 g/cm3 and 11.61% soil moisture content.

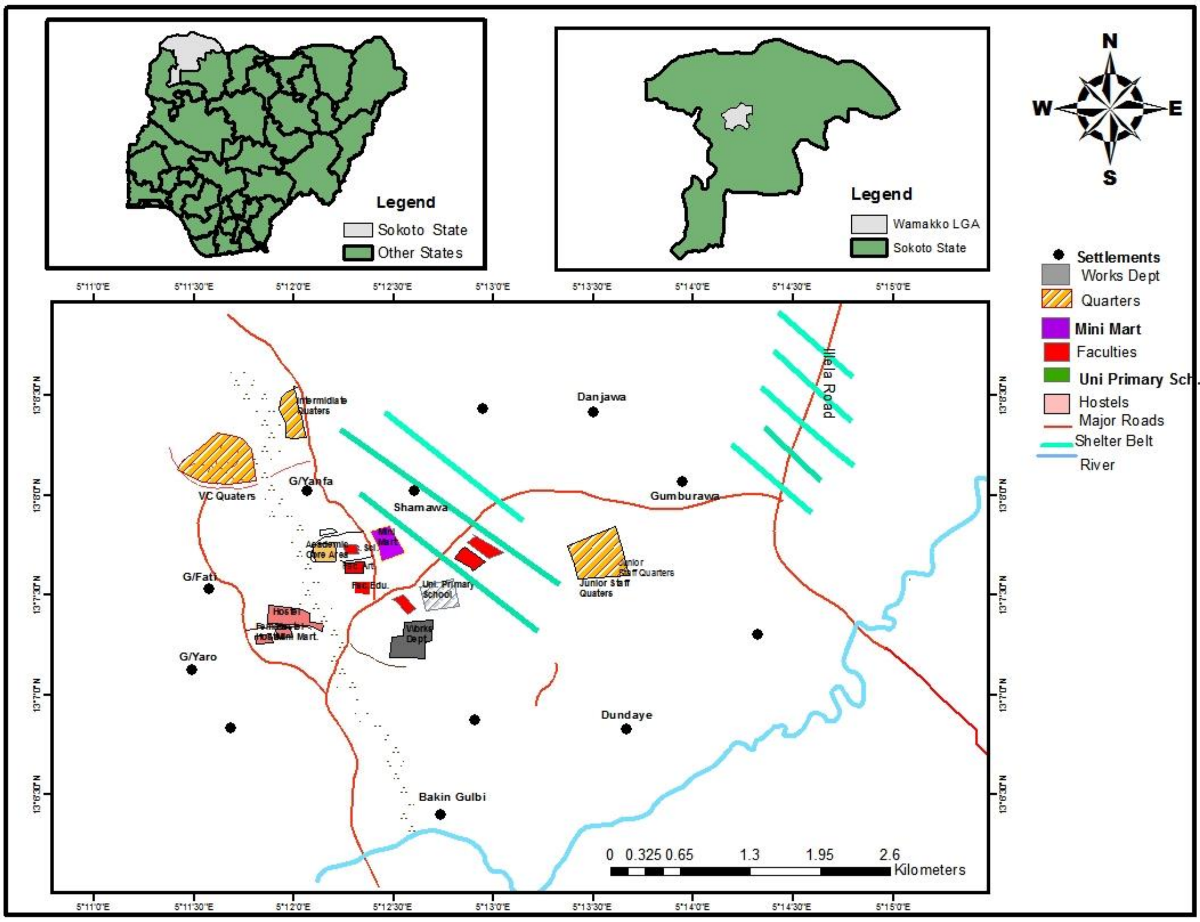

Figure 1: Map of the study area

The area is located in the semi-arid region of Nigeria. With an annual average temperature of 28.3 °C (82.9 °F), Sokoto is one of the hottest states in Nigeria, however the maximum daytime temperatures are generally under 40 °C (104.0 °F) most of the year, and the dryness makes the heat unbearable. The warmest months are February to April, where daytime temperatures can exceed 45 °C (113.0 °F). The highest recorded temperature is 47.2 °C (117.0 °F). The rainy season ranges between June and October.

The area has population of 176,619 at the 2006 census and mainly populated by rural dwellers most of whom are farmers and herders

2.2. Methods

2.2.1 Image processing

Landsat 8 OLI-TIRs of 22-03-2019 (path/row 191/051) was downloaded from the United States Geological Survey Department (USUGS) Earth Explorer site: *earthexplorer.usgs.gov*. Using the attendant metadata, Bands 2 to 7 were converted into top-of-atmosphere (TOA) reflectance images for atmospheric correction (Liu *et al*., 2015; Yarbrough *et al*., 2014), carried out within the QGIS software. Reflectance rescaling coefficients found in the metadata MTL text file were applied. This saw the conversion of the 12-bit OLI bands into 8-bit. The size of the study area was subsequently sub-mapped from all the six bands (bands 2- 7), after which they were geometrically corrected at Root Mean Square (RMS) error of 0.03 using the method described by Eniolorunda *et al.* (2017). Kauth-Thomas Tasseled Cap Transformation was performed on the six bands to extract three index bands of the OLI. The Brightness image refers to soil brightness, while the Greenness band, sometimes referred to as Green Vegetation Index or GVI, which highlights green vegetation cover or biomass above ground (Eastman, 2017). The Wetness image represents soil moisture. The formulas are as written in Equations 1 to 3 as proposed by Baig *et al.* (2014) written as:

$$OLI\ Bright = (Band2 * 0.3029) + (Band3 * 0.2786) + (Band4 * 0.4733) + (Band5 * 0.5599) + (Band6 * 0.5080) + (Band7 * 0.1872) \quad (1)$$

$$OLI\ Green = \left(Band2 * (-0.2941)\right) + \left(Band3 * (-0.2430)\right) + \left(Band4 * (-0.5424)\right) + (Band5 * 0.7276) + (Band\ 6 * 0.0713) + \left(Band7 * (-0.1608)\right) \quad (2)$$

$$OLI\ Wet = (OLI2 * 0.1511) + (OLI\ 3 * 0.1973) + (OLI4\ * 0.3283) + (OLI5\ * 0.3407) + (OLI6\ * (-0.7117)) + (OLI7\ * (-0.4559)) \quad (3)$$

where:
OLI Bright, OLI Green and OLI Wet are the Brightness, Greenness and Wetness images respectively.

In this study, the brightness image was used for soil texture mapping.

2.2.2 Unsupervised classification

The brightness image, hereafter referred to as TCT-Brightness image, was subjected to unsupervised classification using cluster algorithm within the Idrisi Terrset environment. The resultant map was used as the template for identifying the locations for soil sampling based on stratified random sampling method.

2.2.3 Soil sampling and laboratory treatment

Locations of sites for soil sampling were identified on the map produced by unsupervised classification. Soil samples were collected using stratified random sampling at 91 points, excluding the built-up areas. For each location which is a 30m*30m quadrat, four subsamples were collected randomly, bulked and homogenized (Pennock *et al.*, 2006). Soil particle size was determined using Bouyoucos Hydrometer method as described by Kroetsch and Wang (2006).

2.2.4 Soil particle size modelling

A model was developed for each of the particle sizes using simple linear regression equation:

$$Y = a + bX \quad (4)$$

where:

Y particle size (dependent variable),
X TCT image (independent variable),
a value of Y when X is zero,
b coefficient of X

The particle sizes of the sampled points and their corresponding pixel values form the inputs to the model. The regression analysis was differently performed for sand, silt and clay to obtain three different models.

2.2.5 Soil textural mapping

In mapping the soil texture, the above model was applied to develop particle size map for each of the soil separates. These were then combined within the SAGA environment to produce the textural map.

2.2.6 Land Use/ Land Cover (LUC) classification

Land Use/Land Cover (LUC) for the year 2019 was used in this study for comparison with soil textural map. The LUC mapping of the study area was performed using the Classification and Regression Tree Machine Learning within the Google Earth Engine (GEE) as described by Farda (2017), Kumar and Mutanga (2017). Landsat 8 Collection 1 Tier 32-Day TOA Reflectance Composite covering between 06/03/2019 and 07/04/2019 was accessed via GEE for the mapping at Level II of Anderson *et al*. (1976) scheme.

2.2.7 Relationship between soil texture and LUC

Cross-Map Tabulation (CMT) was carried out between the LUC and soil texture maps. Cramer's V and Kappa index of agreement were used to either accept or reject the null hypothesis that LUC does not affect soil texture

3.0. Results and Discussion

3.1 Kauth-Thomas Tasseled Cap Transformation (TCT) brightness image

The TCT-Brightness image was derived by combining the six bands of the Landsat 8 image. Figure 2 shows a 12 to 8-bit calibration based on TOA conversion. Thus, the brightness image pixel values range between 109.14 and 197.74, while most of the values hover around 151.31 (Figure 3). A standard deviation of 11.81 suggests high spatial variability in soil texture of the area. This reasonably hints of the heterogeneity of Land Use/Land Cover (LUC) types in the area as opposed to homogeneity that generally characterizes such a semi-arid environment particularly when vegetation is not in the high biomass period (Liu *et al*., 2015). Liu *et al*. (2015) further argued that the outcome of TCT can be influenced by season. Although TCT output may vary temporally, the dry season textural information derived from the brightness image of the study area can be valid as soil textural changes require long periods of time with the active function of other factors of soil formation. This is in conformity with the submission of Abdulrashid and Yaro (2014) and Abdulrashid and Mashi (2014) on soil textural change in the semi-arid environments.

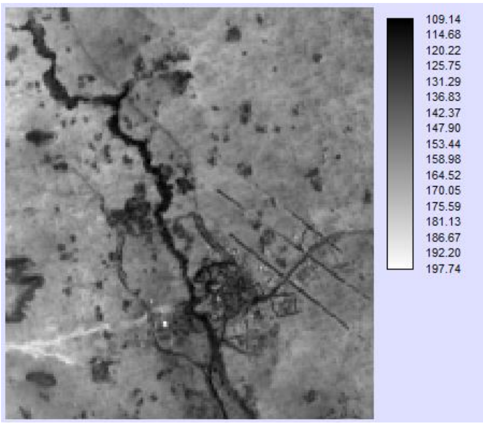

Figure 2: TCT-Brightness image

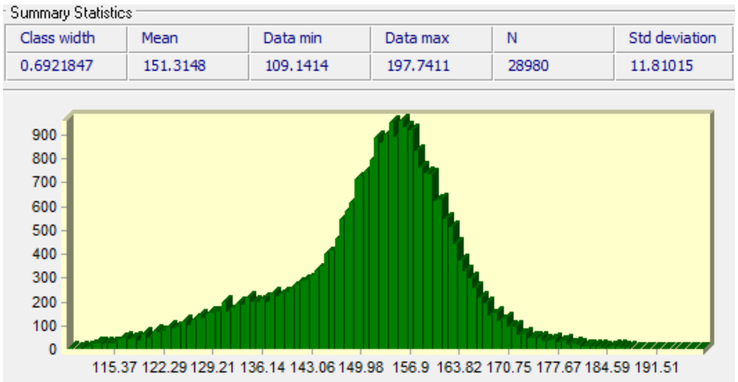

Figure 3: Histogram of TCT-Brightness image

3.2 Soil particle size determination and modelling

3.2.1 Soil particle size determination

The unsupervised classification carried out on the TCT-Brightness image is presented in Figure 4. The map which has 5 clusters was used to guide in the selection of soil samples which were collected based on stratified random sampling. The descriptive statistics of the textural classes derived from the samples and their corresponding pixel values are presented in Table 1. Four soil textural classes are observed in the area: loamy sand, sand, sandy-clay-loam and sandy loam. Sand particles have the highest mean pixel value of 170.22, followed by loamy sand with 149.26. Sandy loam particles have a mean value of 135.39, while sandy clay loam particles have the least mean value of 111.10. Spectral reflectance patterns of soil separates indicate that sand is the most reflective, followed by silt; clay has the least reflectance across wavelengths (Thomasson *et al.*, 2013). It is plausible to opine in this study that the less the sand particles the less the spectral value in the TCT-Brightness image. In other words, the more the clay content available in the soil the less the reflectance.

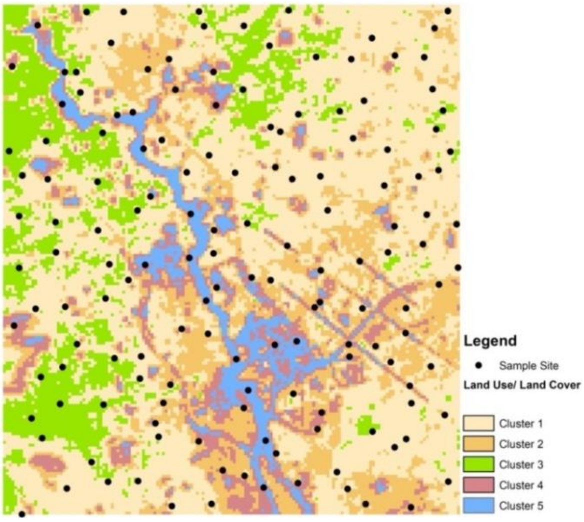

Figure 4: Sample locations on unsupervised classification map

Table 1: Soil textural classes and descriptive charateristics of corresponding brightness pixel values

Texture	Sample Size	Brightness Image Mean Pixel Value	Standard Deviation of Pixel Values
Sandy Clay Loam	22	111.10	4.15
Loamy Sand	17	149.26	1.63
Sand	34	170.22	6.80
Sandy Loam	18	135.39	4.85

3.2.2 Soil particle size modelling

The TCT-Brightness image was used to model particle size in this study. Thus, particle sizes were differently regressed on brightness pixel values. The regression outputs for sand are contained in Table 2. It can be seen that R which represents the correlation coefficient between the independent variable (TCT-Brightness image values) and the dependent variable (%Sand) is positive and high (0.904). The R squared shows that about 82% of the variance in the %Sand is explained by the TCT-Brightness image values. That $P < 0.01$ for F value indicates the regression is significant and TCT-Brightness image values can be used to predict %Sand in the study area. The model is therefore shown in Equation 5 as:

$$\%Sand = 0.547 * (brightness\ image) - 10.195 \quad (5)$$

The model for silt can also be extracted from the regression outputs in Table 3. Although R = 0.82, the Standardized Coefficients (Table 3) indicates that the correlation between the TCT-Brightness image values and %Silt is negative, while the R squared indicates that 67.2% of the variance in the %Silt is explained by the brightness image values. The regression is significant where $P<0.01$ for F value, indicating that brightness image can be used to predict the %Silt composition. Thus, the regression equation is shown in Equation 6 as:

$$\%Silt = 47.985 - 0.225 * (brightness\ image) \quad (6)$$

The %Clay was also regressed on TCT-Brightness pixel values, and the outputs are presented in Table. Similarly, the brightness image negatively correlates with % Clay, as the Standardized Coefficients value is -0.898 (Table 4), explaining about 81% of the variation in %Clay. The overall regression is significant ($P < 0.01$), and the model can be written thus:

$$\%Clay = 62.21 - 0.323 * (brightness\ image) \quad (7)$$

Table 2: Regression output for sand

Model Summary					
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	
1	0.904[a]	0.817	0.815	6.21164	
a. Predictors: (Constant), Reflectance Value of Brightness Image					

ANOVA[a]					
Model	Sum of Squares	df	Mean Square	F	Sig.
1 Regression Residual Total	15346.837 3434.023 18780.860	1 89 90	15346.837 38.585	397.746	0.000[b]
a. Dependent Variable: %of Sand b. Predictors: (Constant), Reflectance Value of Brightness Image					

Coefficients[a]					
Model	Standardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
1 (Constant)	-10.195	4.443		-2.294	0.024
Reflectance Value of Brightness Image	0.547	0.027	0.904	19.944	0.000
a. Dependent Variable: % of Sand					

Table 3: Regression output for silt

Model Summary					
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	
1	0.820[a]	0.672	0.668	3.77195	
a. Predictors: (Constant), Reflectance Value of Brightness Image					

ANOVA[a]					
Model	Sum of Squares	df	Mean Square	F	Sig.
1 Regression Residual Total	2590.779 1266.257 3857.037	1 89 90	2590.779 14.228	182.095	0.000[b]
a. Dependent Variable: % of Silt b. Predictors: (Constant), Reflectance Value of Brightness Image					

Coefficients[a]					
Model	Standardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
1 (Constant)	47.985	2.698		17.784	0.000
Reflectance Value of Brightness Image	-0.225	0.017	-0.820	-13.494	0.000
a. Dependent Variable: % of Silt					

Table 4: Regression output for clay

Model Summary					
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	
1	0.898[a]	0.806	0.804	3.79450	
a. Predictors: (Constant), Reflectance Value of Brightness Image					
ANOVA[a]					
Model	Sum of Squares	df	Mean Square	F	Sig.
1 Regression Residual Total	5326.468 1281.445 6607.913	1 89 90	5326.468 14.398	369.938	0.000[b]
a. Dependent Variable: % of Silt b. Predictors: (Constant), Reflectance Value of Brightness Image					

Coefficients[a]					
Model	Standardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
1 (Constant)	62.210	2.714		22.919	0.000
Reflectance Value of Brightness Image	-0.323	0.017	-0.898	-19.234	0.000
a. Dependent Variable: % of Clay					

3.2.2.1 Model test

For assurances that the TCT-Brightness image can be used to predict soil texture for the study area, the predictive models for the particle sizes in Equations 5, 6 and 7 were put to test using arbitrarily selected values from the TCT-Brightness image one after the other. Table 5 describes the outcomes. Since the particle sizes must add up to 100%, the total in Table 5 can be taken for the accuracy of the models. An error range of between 0.1 and 0.2 is unaccounted for. Thus, it is plausible to rewrite the equations as:

$$\%\, of\ Sand = 0.547 * (brightness\ image) - 10.195 + E \tag{8}$$
$$\%\, of\ Silt = 47.985 - 0.225 * (brightness\ image) + E \tag{9}$$
$$\%\, of\ Clay = 62.21 - 0.323 * (brightness\ image) + E \tag{10}$$

where E is the inherent error.

In this study, E is calculated as an average of the above stated errors which is 0.15. This value is added in the computation of each soil separate map. Figures 5, 6 and 7 are the maps of soil separate for the study area. In each of the images, areas of dark tones are of low values for that particular variable. When combined, the pixels in the three images will complementarily add up to 100% to produce the soil textural map for the area.

Table 5: Outputs of model test

Number	Brightness Value	% Sand	% Silt	% Clay	Total	Textural Class
1	120	55.445	20.985	23.45	99.9	Sandy Clay Loam
2	130	60.915	18.735	20.22	99.9	Sandy Clay Loam
3	140	66.385	16.485	16.99	99.9	Sandy Loam
4	150	71.855	14.235	13.76	99.9	Sandy Loam
5	160	77.325	11.985	10.53	99.8	Sandy Loam
6	170	82.795	9.735	7.3	99.8	Loamy Sand
7	180	88.265	7.485	4.07	99.8	Sand
8	190	93.735	5.235	0.84	99.8	Sand

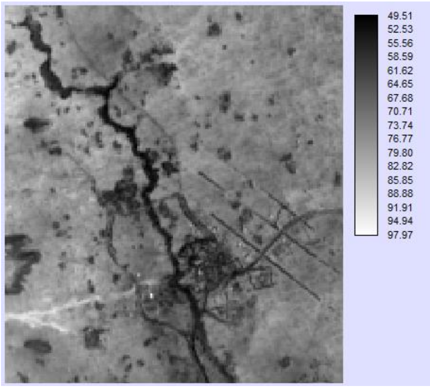

Figure 5: %Sand

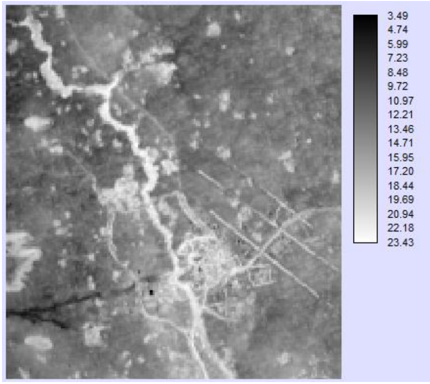

Figure 6: %Silt

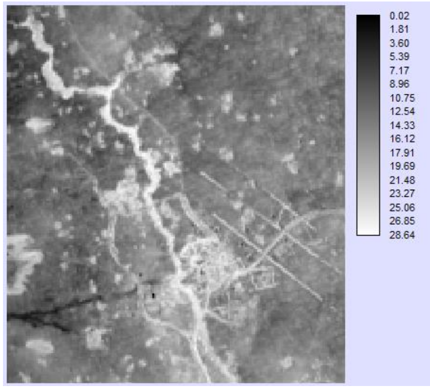

Figure 7: %Clay

3.2.3 Soil textural mapping

The maps of soil separates (Figures 5, 6 and 7) were combined within the SAGA environment to produce the textural map (Figure 8). The accuracy test of the textural map was performed by purposively sampling five points from each of the textural classes for ground verification. Table 6 presents the error matrix. The overall accuracy which is the proportion of the selected samples correctly mapped is given as:

OA = number of correctly classified pixels*100/sample size

where OA is the Overall Accuracy.

Table 6: Error Matrix: Ground Truth 2019 (Columns) against Textural Classes 2019 (rows)

	SCL	LS	S	SL	Total
SCL	**05**	00	00	00	05
LS	00	**04**	00	00	04
S	00	00	**05**	00	05
SL	00	01	00	**05**	06
Total	05	05	05	05	**20**

Overall Accuracy = 95%

In this case, the OA is 95%, and this implies that the soil texture of the area is accurately mapped. Although there is no universal benchmark for accuracy assessment in image classification (Eniolorunda *et al.*, 2017), the value obtained in this study is above the usually referenced 85% in the literature.

Figure 8 and Table 7 show that sandy soil is dominant in the study area. Studies have indicated that the top soil in most parts of Sokoto State is generally sandy, resulting from sand dune deposition from the far away Sahara desert. The sandy nature of the area can also be attributed to the low rate of soil formation in the environment due to low annual rainfall amount and temporal spread. Soil texture is an important physical characteristic of soil which has great significance in land use management (Mohamed and Abdo, 2011). Soils dominated by sand particles drain water very quickly but have lower fertility.

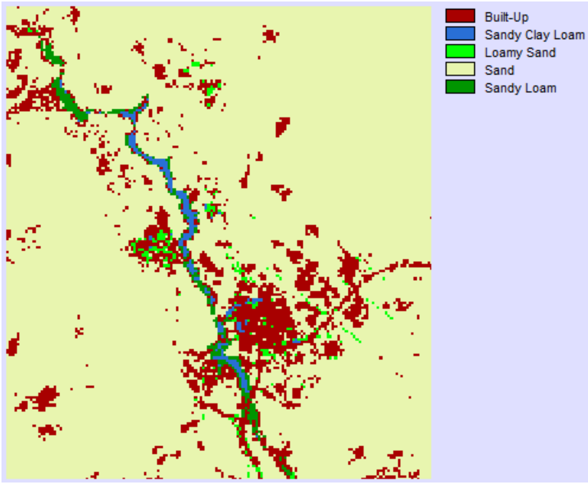

Figure 8: Soil textural map of the study area

Table 7: Area coverage of Soil Texural Classes

Texture	Area Coverage (Ha)	Percent
Built-up Area	272.97	10.47
Sandy Clay Loam	23.76	0.91
Loamy Sand	23.22	0.89
Sand	2,255.31	86.47
Sandy Loam	32.94	1.26
Total	**2608.20**	**100**

3.3 Land Use/ Land Cover Mapping

The Land Use/Land Cover (LUC) mapping was carried out at level III of Anderson *et al.* (1976) Classification scheme with the Landsat 8 of 2019 using the Classification and Regression Tree Machine Learning within the Google Earth Engine (GEE) as described by Farda (2017) and Kumar and Mutanga (2017). Five classes were derived namely: Built-up area, Wetland, Upland Forest, Bare Surface and Riparian Forest (Figure 9 and Table 8). A classification accuracy of 98.3% was automatically reported.

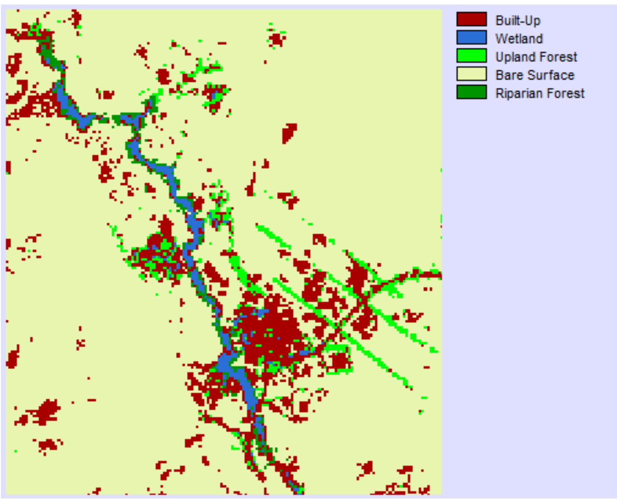

Figure 9: LUC of the study area

Table 8: Description of LUC

LUC	Hectares	Percentage Coverage
Built-Up	273.69	10.49
Wetland	44.01	1.69
Upland Forest	78.75	3.02
Bare Surface	2177.37	83.48
Riparian Forest	34.38	1.32
Total	2608.20	100

The built-up area covers about 10.5% of the area; it is made up of the university structures and the surrounding settlements which are largely agrarian. The university serves as a spring board for the growth and expansion of old surrounding settlements as well as an impetus for emergence of new ones. Thus, rate of LUC change is expectedly high, thereby impacting on the soil surficial texture and structure. The wetland traverses diagonally through the area with northwest-southeast orientation, accounting for 1.69% of the area. It is cultivated with food crops all the year round. The upland forests are greenbelts that are essentially composed of *Azadirachta indica* (neem) (Dóógón yááròò). Because they grow upland, rate of addition and decay of organic matter is slow; thus, soil texture expectedly improves slowly. However, the forests protect the soil against wind and water erosion. The bare surface has the largest coverage of about 2, 177ha (83.5%). It is largely farmland which during the rainy season is either grassy or grown with grains but left bare in the dry season after harvest. The top soil undergoes mixing through the process of cultivation and herding. Because the surface is bare, it is unprotected from erosion and deposition. The riparian forests are associated with the wetland in the study area, occupying 34.4ha (1.32%). They are essentially composed of *Mangifera indica* (mango) (Màngwàrò). The input of organic matter from this species is higher than that of *Azadirachta indica*. The coupling of high organic matter input and wetness of soil will affect soil texture (Stanchi *et al.*, 2015; van-Hall *et al.*, 2017).

3.4 Relationship between Soil Texture and Land Use Land Cover

A visual comparison shows that Figures 8 and 9 are similar. The Built-Up class was masked from both maps as it was not sampled. Cartographic overlay shows that sandy-clay-loam is associated with wetland, while loamy sand is related to upland forest; sand is largely associated with bare surface, while sandy loam is related to riparian forest. To statistically establish these relationships, cross map-tabulation of the soil texture map (Figure 8) and LUC map (Figure 9) was carried out. Figure 10 and Table 9 present the results.

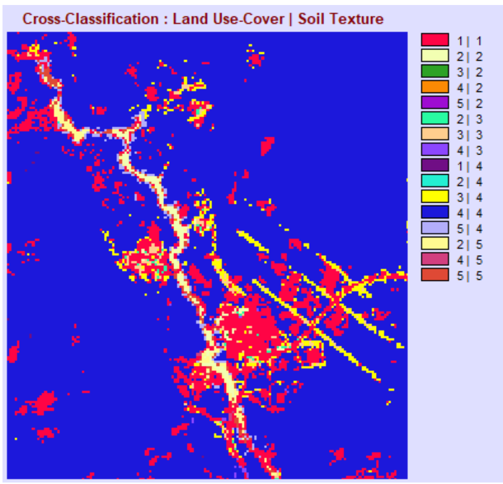

Figure 10: Cross-Tabulation Map

Table 9: Pixel Cross-tabulation Using Land Use-Cover (columns) vs. Soil Texture (rows)

Category	1	2	3	4	5	Total
1	3033	0	0	0	0	3033
2	0	257	1	4	2	264
3	0	45	192	21	0	258
4	8	1	682	24150	218	25059
5	0	186	0	18	162	366
Total	3041	489	875	24193	382	28980

Chi-square = 59632.1055, df = 16, P-Level = 0.0000, Cramer's V = 0.7172, Overall Kappa: 0.8465

The diagonal values in Table 9 are the number of pixels in agreement in both maps, while off-diagonals are outlying pixels. An overall Kappa Index of Agreement (KIA) of 0.85 confirms a significantly ($p<0.01$) high relationship between texture and LUC, as Viera and Garrett (2005) submitted that a KIA above 0.8 is almost a perfect agreement. In a previous study of land use land cover change effect on soil characteristics around the study area, Eniolorunda (2016) observed different soil textural classes across the LUC classes. Relatedly, Biro *et al.* (2011) observed changes in soil texture due to land use land cover change (LUCC) in an agricultural area in the dry land of Sudan, while Majaliwa *et al*. (2011) also observed variation in clay fraction in different LUCs in Uganda. In a study conducted on the effects of land-use changes on soil properties in a Humid Northern Blacksea Region, Yuksek *et al.*(2009) established a relationship between land use change and soil texture change. Land use and land use change has an adverse effect on soil characteristics such as permeability, soil texture and aggregate stability (Jeloudar *et al.,* 2018). Soil texture is an important physical characteristic of soil which has great significance in land use management (Mohamed and Abdo, 2011).

4.0. Conclusions

The study tested the applicability of Kauth-Thomas TCT for soil textural mapping in the study area. TCT-Brightness image was derived from the original bands of the OLI image. Soil particle sizes were determined by soil sampling which yielded sandy-clay-loam, loamy sand, sand and sandy loam. Simple linear regression analysis was used to model soil particle sizes from the TCT-Brightness image with an average accuracy of 99.85%. Soil textural map was produced by combining maps of soil separates at 95% accuracy. Land use/ Land Cover (LUC) of the area was mapped at 98.3% of accuracy within the GEE environment to produce 5 classes namely built-up area, wetland, upland forest, bare surface and riparian forest. Cross map-tabulation was carried out to test for the extent of relationship between LUC and soil texture with an overall Kappa Index of Agreement of 0.85, attesting to an almost perfect relationship. This study concludes that the Kauth-Thomas Tasseled-Cap Transformation (TCT) can be used for rapid soil textural assessment in the study area especially in the dry season. We recommend a repeat of this study for the wet season.

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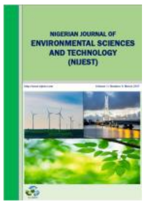
Cite this article as:
Eniolorunda N. B. and Jibrillah A. M., 2020. Application of Tasseled-Cap Transformation to Soil Textural Mapping of a Semi-Arid Environment: A Case of Usmanu Danfodiyo University Main Campus, Sokoto, Nigeria. *Nigerian Journal of Environmental Sciences and Technology*, 4(1), pp. 97-110. https://doi.org/10.36263/nijest.2020.01.0158

Nigerian Journal of Environmental Sciences and Technology (NIJEST)

www.nijest.com

ISSN (Print): 2734-259X | ISSN (electronic): 2734-2603

Vol 4, No. 1 March 2020, pp 111 - 118



Fabrication of Copper Nano-Filter Membrane and its use in the Purification of Contaminated Water

Abdulwahab K. O.[1,]*, Otusote C. M.[2] and Adams L. A.[3]

[1,2,3]Department of Chemistry, Faculty of Science, University of Lagos, Akoka, Lagos State, Nigeria

Corresponding Author: *kabdulwahab@unilag.edu.ng

https://doi.org/10.36263/nijest.2020.01.0177

ABSTRACT

Copper nanoparticles were synthesised by the green method using African spinach and peppermint leaves extract as both reducing and capping agents. The synthesized nanoparticles were then characterized by Energy Dispersive Spectroscopy, (EDS), Scanning Electron Microscopy (SEM) and Fourier Transform Infra-Red Spectroscopy (FTIR). EDS confirmed the formation of copper nanoparticles and SEM images showed spherical nanoparticles with an average size of 3.44 μm. FTIR showed that the functional groups on the leaves' extracts were capped on the surface of the nanoparticles. The nanoparticles were then casted into a nano-filter membrane using cellulose actetate and used to filter contaminated water gotten from a canal at the University of Lagos. The filtration efficiency of this nano-filter was compared with the ordinary cellulose acetate membrane and the result showed that the copper nano-filter membrane gave an odourless, cleaner water than that of ordinary cellulose acetate membrane. The microbial analysis also revealed that about 96.5 % of the bacteria was removed using the copper nano-filter membrane.

Keywords: Green synthesis, Copper nanoparticles, Waste water purification, Nano-filter membrane, Antimicrobial

1.0. Introduction

Globally, there is a general problem of water pollution. Most of our water bodies are polluted and are not fit for usage. As a result, a lot of water treatment methods have been developed. However, most of these methods are very expensive, not easily available and some of them are not as efficient. Therefore, there is need to provide easy, cost friendly and environmental benign method of treating our water. This can be achieved with the use of copper nanoparticles.

Copper nano particles possess unique characteristics which include catalytic (Judai *et al*., 2011), high electrical conductivity (Din and Rehan 2017), magnetic (Ghasemi *et al*., 2011) optical (Wu *et al*., 2010) and antibacterial/antifungal activities (Ramyadevi *et al.*, 2012, Zain *et al*., 2014). The antimicrobial activity has led to numerous applications such as in cosmetics, food processing (Pal, 2017) drug delivery (Varshney *et al*., 2012, Kailasa *et al*., 2018) sensors (Ghotto *et al*., 2019) and in water treatment (Chen *et al*., 2014). In comparison with precious metals, such as gold, silver, or platinum, copper has the advantage of being in high abundance and it is cheap. The property of copper nanoparticles mainly depends on the synthesis route and their reaction parameters. Various synthetic routes have been employed for the synthesis of copper nanoparticles including chemical reduction (Dong *et al*., 2018, Gajera, 2014), electrochemical (Fernandez *et al*., 2017), hydrothermal (Seku *et al*., 2018), microwave assisted techniques (Galletti *et al*., 2013) and biological synthesis (Kulkarni and Kulkarni, 2013).

These days, the emphasis has been shifted towards the green synthesis of Cu-NPs by using plant extracts as stabilizers and reducing agents (Subbaiya and Selvam, 2015). This will eliminate the use of toxic chemicals and so promote environmental friendliness. In this research, copper nanoparticles were prepared using the green synthesis method. The copper nanoparticles were synthesized from copper sulphate solution with African spinach and peppermint leaves extract as capping/reducing agents under nitrogen to prevent oxidation of the copper nanoparticles. The synthesized nanoparticles were then characterized by Energy Dispersive Spectroscopy (EDS), Scanning Electron Microscopy (SEM) and Fourier Transform Infra-Red Spectroscopy (FTIR). The synthesized copper nanoparticles were made into a nano-filter membrane filter using cellulose acetate as support. The nano copper filter membrane was then tested by using it to filter water collected from a canal in the University of Lagos. The efficiency of this nano-filter membrane was compared with the ordinary cellulose acetate membrane by studying the extent to which they can successfully treat colour, odour and micro - organisms.

2.0. Methodology

2.1. Preparation of spinach and peppermint leaves extract

Fresh African Spinach and peppermint leaves were bought from a local market in Lagos. The leaves were washed several times with distilled water and were air dried for a few days. Then the leaves were ground to a fine powder and kept separately in different air-tight containers. 5 g of spinach or peppermint powder was weighed and transferred to a beaker. 50 ml of distilled water was measured and transferred to the beaker. It was placed on a hot plate and allowed to boil for 15 minutes. After boiling, it was allowed to cool and filtered using a filter paper. The filtrate was kept in a bottle and kept refrigerated until needed (Abdulwahab *et al*., 2019).

2.2 Preparation of precursor solutions

Copper sulphate pentahydrate salt was weighed (0.50 g, 0.04 M) and dissolved in 10 ml distilled water in a beaker. The resulting mixture was transferred into a 50 ml standard flask and distilled water was added up to the mark. 5 g of ascorbic acid was dissolved in 50 ml dissolved water. It was stirred until a clear solution was obtained.

2.3 Green synthesis of copper nanoparticles with peppermint and spinach extracts

50 ml of the copper sulphate pentahydrate solution was measured into a three-necked round bottom flask. Then 50 ml ascorbic acid was added to the copper sulphate solution followed by 25 ml of the extracts (peppermint and spinach). The resulting mixture was heated on a hot plate for 1 hour with rapid stirring at 80 °C using a magnetic stirrer under nitrogen atmosphere (Abdulwahab *et al*., 2019).

On the addition of ascorbic acid, the colour changes from blue to light green. The green solution now turned reddish brown after adding the extracts indicating the formation of copper nanoparticles. The brown solution was then centrifuged, washed with distilled water and left to dry completely.

2.4 Casting of cellulose acetate membrane

The casting of cellulose acetate membrane was carried out following procedure in literature but with modifications (Kaiser *et al*., 2017). 5 g of cellulose acetate was weighed into a conical flask and 75 ml of acetone was added and stirred using a magnetic stirrer for 1 hour. After 1 hour, 3 g (0.05 mole) of sodium chloride and 3 ml of glycerol were added to the mixture and was left to stir for 30 minutes. The resulting polymer was casted onto the glass plate and left to dry. The dried glass plate containing the membrane was put into a tray of distilled water for 10 minutes to etch out the sodium chloride so that pores can form on the membrane to enable filtering.

2.5 Casting of copper nano-filter membrane

0.1 g of copper nanoparticles was dissolved in 3 ml of dimethyl sulphoxide and then added to the already made polymer solution and was stirred for 30 minutes. The functionalized polymer mixture was the casted onto a glass plate and left to dry. The copper nano-filter membrane was then put in a tray of distilled water for 10 minutes to etch out the sodium chloride and create pores in the nano-filter cellulose acetate membrane to enable it filter.

The ordinary cellulose membrane and the copper nano-filter membrane were then used to filter contaminated water from a canal by passing a 100 ml of the water each through the ordinary membrane and the copper nano-filter membrane.

2.6 Microbiological analysis of water

The microbial activity was determined using the pouring plate counting method. The media used for the bacteriological analysis of water include plate count agar (PCA), nutrient agar (NA), potato dextrose agar (PDA) and eosin methylene blue agar (EMB). All the media used were weighed out and prepared according to the manufacture's specification, with respect to the given instructions and directions. The microbes present in the sample were determined by plating out 0.1ml of 10^{-1} dilution series of water sample on the nutrient agars. Duplicates were made and incubated aerobically at 37 ºC for 24 hours (nutrient agar plates) while the potato agar plates were incubated at room temperature for 3 – 5 days. The thermo-tolerant bacteria were incubated at 44 ºC (Bartram and Pedley 1996). The pure cultures of the isolates were subjected to various morphological and biochemical characterization tests to determine the identity of the isolates with reference to Bergey's Manual of Determinative Bacteriology (Buchanan and Gibbons, 1974).

3.0. Results and Discussion

3.1 Characterization of copper nanoparticles

After copper nanoparticles have been successfully synthesized from African spinach and peppermint leaf extracts, the brown coloured powder obtained was characterized by Fourier transform infrared spectroscopy (FTIR), scanning electron microscope (SEM) and energy dispersive spectroscopy (EDS). The EDS and FTIR results are similar to what was obtained in an earlier study by the authors (Abdulwahab *et al*., 2019) on copper nanoparticles using the same procedure.

3.2 Fourier Transform Infrared Spectroscopy

The peak at 3321 cm^{-1} is attributed to OH stretching. This peak became broadened and there is a shift in the IR spectrum of nanoparticles capped with extract indicating that there is adsorption of OH bond on the surface of the nanoparticles (Figure 1). The C=O stretching peak (1637) found in the extract disappeared in the synthesized nanoparticles capped with extract suggesting that oxidation must have taken place, hence confirming the use of the extracts as reducing agent.

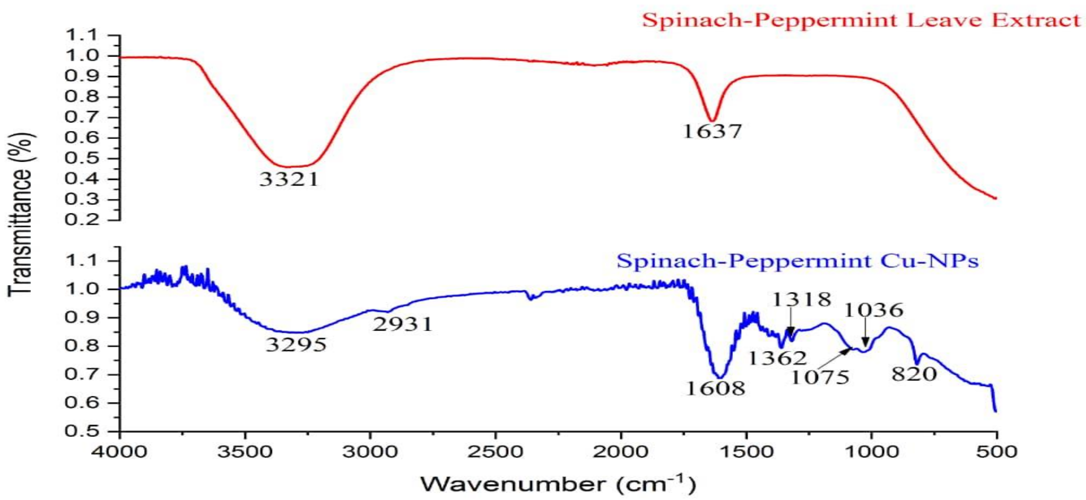


Figure 1: FTIR spectra of spinach-peppermint leave extracts (top) and spinach-peppermint capped Cu-NPs (bottom)

3.3 Energy dispersive spectroscopy (EDS)

The EDS result of the copper nanoparticles for the peppermint and spinach leaves was done. The result showed 55% of copper (Figure 2). The presence of oxygen showed it has undergone some form of oxidation. The carbon can be attributed to the organic compounds present in the peppermint and spinach leaf extracts which is confirmed by the FTIR result in Figure 1. In comparison with similar method reported earlier by Aher *et al.* (2019), they got 39.16 % of copper. This shows that the leaf extracts used in this study were better at reducing the copper ions and stabilizing them.

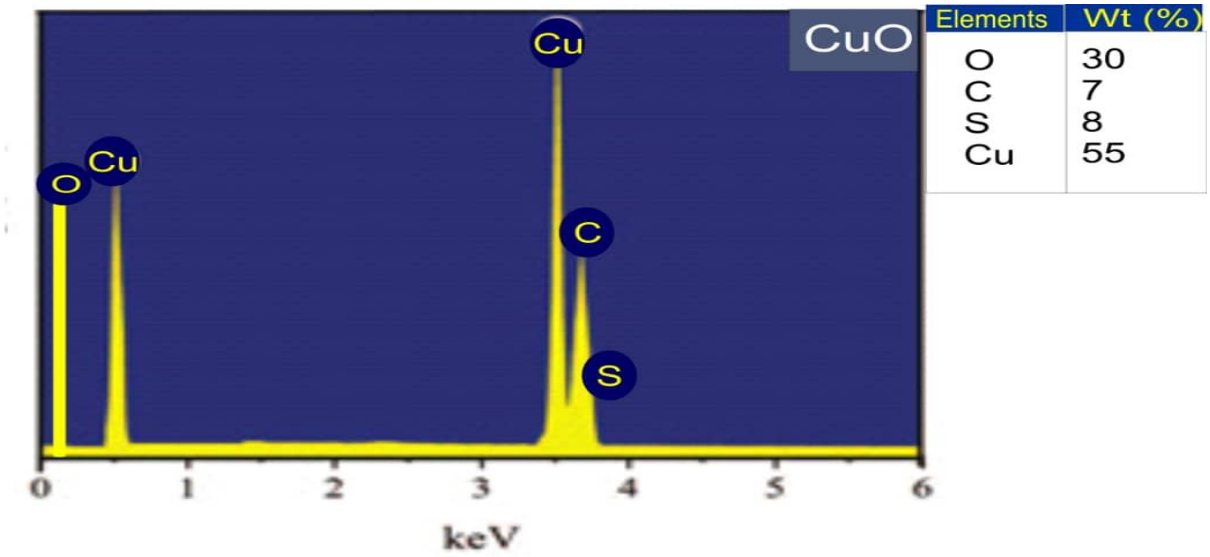


Figure 2: EDX spectrum of copper nanoparticles capped with spinach and peppermint leaves extracts

3.4 Scanning electron microscopy (SEM)

The SEM images are shown in Figure 3. The copper nanoparticles are spherical in shape and are evenly distributed with an average size of about 3.44 µm.

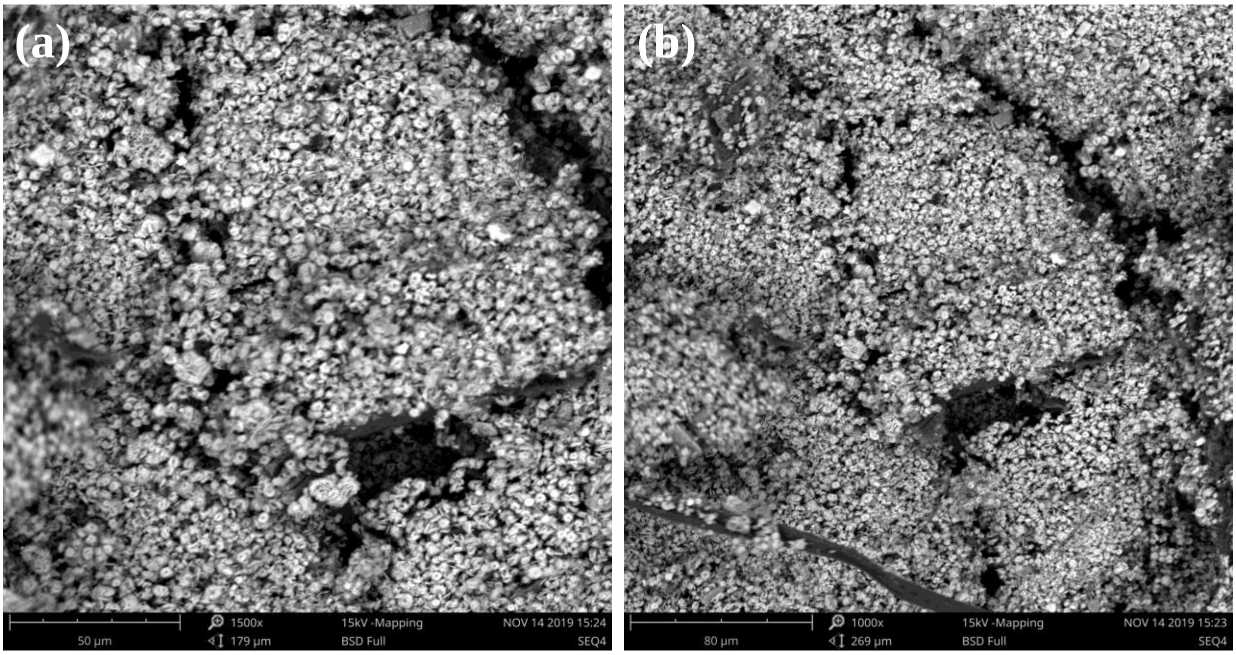


Figure 3: SEM images of copper nanoparticles at different magnifications (a) at 50 µm and (b) 80 µm

3.5 Comparison of the efficiency of ordinary cellulose acetate membrane with nano-filter membrane in the treatment of dirty canal water

Contaminated water was collected from a canal on campus and purified to study the efficiency of nano-filter membrane in the removal of colour, odour and micro-organisms. The filtrate collected using copper nano-filter membrane was clean, odourless and colourless while the filtrate collected using ordinary cellulose acetate membrane still had odour and was not as clean as that obtained from the nano -filter (Figure 4).

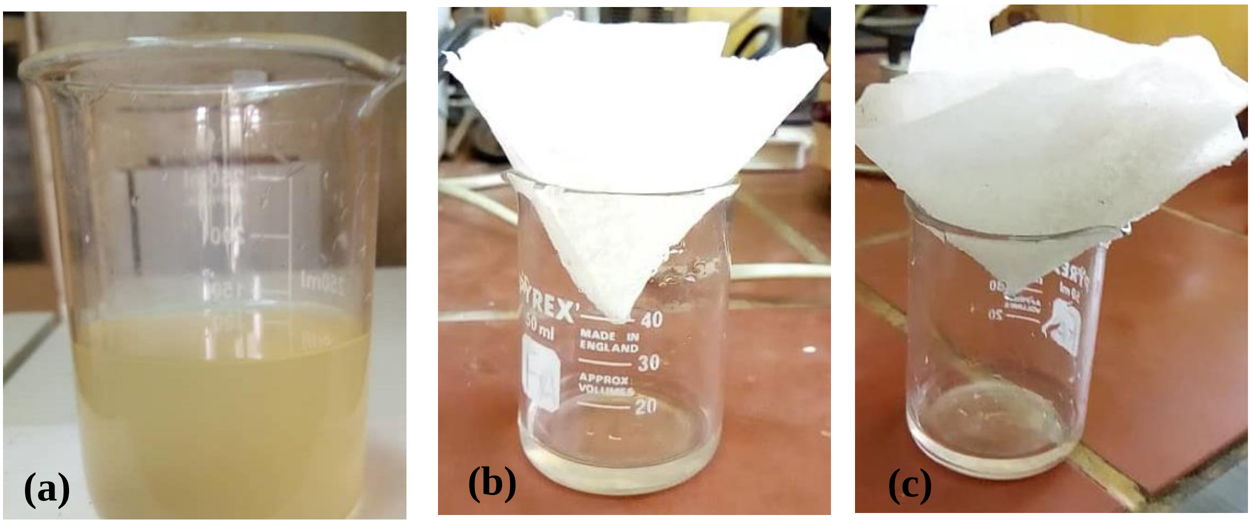


Figure 4: (a) water sample before purification (b) filtrate obtained using ordinary cellulose membrane (c) filtrate obtained using nano-copper filter membrane

Table 1: Microbial analysis obtained for the water before and after treatment

Sample	Total Heterotrophic Bacteria (cfu/ml)	Total Heterotrophic Fungi (cfu/ml)	Total Faecal Coliforms (cfu/ml)	Predominant Species
Canal water (before filtration)	2.30×10^5	3.0×10^4	1.10×10^3	*Aspergillus niger* *Fusarium spp* *Pseudomonas aerugious,* *Staphylococcus aureus* *Escherichia coli* *Bacillus sps*
Water filtered through ordinary membrane	1.10×10^4	0.00	0.00	*Bacillus spp*
Water filtered through copper nano-membrane	8.0×10^3	0.00	0.00	*Bacillus spp*

The microbial analysis done on the water before and after treatment revealed that the contaminated water was heavily contaminated with lots of disease-causing bacteria such as *Escherichia coli* (an indicating organism) that shows the water sample is heavenly polluted with faecal contaminants. Also isolated in the contaminated water are *Pseudomonas aerugious*, *Staphylococcus aureus* and *Aspergillus niger* (*Fungus*) which secretes Alflotoxin that affects the nerves of humans. In the treated water only *Bacillus* sps was isolated. All the fungi and faecal contaminants have been removed in the process of treatment.

The contaminated water was found to have a total count of 230,000 cfu/ml for heterotrophic bacteria; while in the treated water a total count of 8000 cfu/ml was obtained from water treated with copper nano-filter membrane and 11,000 cfu/ml was obtained from water treated with ordinary cellulose membrane. These results show that the nano-filter membrane not only succeeded in removing poisonous bacteria but also has removed 96.5 % of the heterotrophic bacteria found. The killing of 96.5 % microbes within a short contact time (less than 10 minutes) shows that the nanofilter membrane is very efficient as compared to method reported in literature that requires a longer contact time for this to be achievable (Jia *et al.*, 2012). This indeed revealed the potency of copper nanoparticles as anti-microbial and antifungal substance as sighted in literatures (Yoon *et al.*, 2007, Camacho-Flores *et al.*, 2015). Research has shown that one of the mechanisms by which copper carries out its antimicrobial property involves the release of copper ions into the water resulting in rapid membrane damage and DNA degradation of the microbes when they come in contact with the copper surface (Ren *et al*., 2009, Santo *et al*., 2012, Zain *et al.*, 2014).

4.0. Conclusions

Copper nanoparticles were successfully synthesized from copper sulphate salt by the green method using peppermint and African spinach leaves extracts as natural reducing and capping agents. The copper nanoparticles were characterized using SEM, FTIR and EDS.

The synthesized copper nanoparticles were casted into a nano-membrane and then tested as filter for waste water. Its efficiency was tested for waste water filtration by comparing with ordinary cellulose acetate membrane and was found to give cleaner and odourless water than that obtained from ordinary cellulose acetate membrane. The microbial analysis also revealed that the poisonous micro-organisms were removed during filtration showing the anti-microbial potency of copper nanoparticles. This nano-filter is very efficient in removing about 96.5 % of the microbes.

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Cite this article as:
Abdulwahab K. O., Otusote C. M. and Adams L. A., 2020. Fabrication of Copper Nano- Filter Membrane and its use in the Purification of Contaminated Water. *Nigerian Journal of Environmental Sciences and Technology*, 4(1), pp. 111-118. https://doi.org/10.36263/nijest.2020.01.0177

Nigerian Journal of Environmental Sciences and Technology (NIJEST)
www.nijest.com
ISSN (Print): 2734-259X | ISSN (electronic): 2734-2603
Vol 4, No. 1 March 2020, pp 119 - 126

Stormwater Runoff Treatment Using *Moringa Oleifera* Seed Extract as a Natural Coagulant

Bobor, L. O.[1,]* and Aghedo, A. G.[2]
[1,2]Department of Civil Engineering, Faculty of Engineering, University of Benin, Benin City, Edo State, Nigeria
Corresponding Author: *lulu.akhigbe@uniben.edu

https://doi.org/10.36263/nijest.2020.01.0192

ABSTRACT

Uncontrolled stormwater runoff poses a serious threat to aquatic ecosystems due the presence of harmful pollutants. Effective treatment is important prior to discharge. This study investigated the performance of Moringa oleifera seed extract as a coagulant for the reduction of turbidity, chemical oxygen demand (COD) and total suspended solids (TSS) in stormwater runoff. Stormwater samples were treated with Moringa oleifera seed extract solution at varied coagulant doses (0.5-10%), pH (3-10) and settling durations (20-60 minutes). The samples were analyzed before and after treatment to determine the coagulation efficiencies. There were improvements in stormwater quality, with up to 88%, 70% and 89% reduction in turbidity, COD and TSS levels achieved. Removal efficiencies increased with increase in coagulant dose and settling time. The results of the study indicate that Moringa oleifera can be used in the treatment of stormwater runoff for safe discharge into the aquatic environment.

Keywords: Stormwater runoff, *Moringa oleifera*, Coagulation, Turbidity, TSS, COD

1.0. Introduction

Stormwater runoff contains several pollutants, which are detrimental to aquatic systems and consequently humans and animals. Hence, the reduction of pollutant loads before discharge is a critical component of storm water management in addition to flood control. Methods that have been employed in treatment include the use of detention ponds, infiltration basins, wetlands, etc. (Price and Yonge, 1995; Nystrom, 2019). Detention ponds provide some level of pollutant removal through sedimentation, though smaller particle fractions are not efficiently removed. Coagulation and flocculation is effective in the removal of these smaller particle fractions (colloidal particles) (Price and Yonge, 1995; Nystrom, 2019). Coagulation is the destabilization of the insoluble dispersed negatively charged particles present in a suspension by the addition of a coagulant while flocculation is the process by which the destabilized particles come in contact to form larger flocs (Bratby, 2016). Chemical coagulants such as aluminum sulphate (alum) and ferric sulphate have been used in stormwater treatment with significant reductions in turbidity, TSS, COD, total phosphorus (Heinzmann, 1994; Price and Yonge, 1995; Harper *et al*., 1999; Harper, 2007; Kang *et al*., 2007; Nystrom *et al*., 2019). In practice, these coagulants have been used in stormwater runoff treatment via automatic chemical injection systems into the receiving water bodies (Harper and Herr, 2000) or diversion into settling basins for coagulant dosing, mixing and settling before discharge (Brown and Caldwell, 2016). Disadvantages associated with chemical coagulation include high costs, large volumes of sludge, changes in pH and toxicity to aquatic organisms at certain doses (Lopus *et al.*, 2009; Bakare, 2016; Dehghani and Alizadeh, 2016; Shan *et al.*, 2017). Natural coagulants such as *Moringa oleifera* are safe low-cost alternatives.

Moringa oleifera is a widely cultivated tropical tree with diverse nutritional and water treatment applications. It is biodegradable, has a natural buffering capacity and lower sludge volume with no known toxic effects (Lea, 2010; Bakare, 2016; Dehghani and Alizadeh, 2016; Shan *et al*., 2017; Diaz *et al*., 2018). The *Moringa oleifera* seed consists of 34.1% protein, 15% carbohydrate and 15.5% lipids (Olayemi and Alabi, 1994; Lea, 2010). The active agents present in the seeds have been identified as proteins with cationic peptides consisting of positively charged amino acids and glutamine residues with molecular weights ranging from 6-16kDa (Ndabigengesere *et al.* 1995; Idris *et al.*, 2016). The use of *Moringa oleifera* seeds and/or leaves as a natural coagulant for turbidity removal from water has been investigated (Ali *et al.*, 2009; Lea, 2010; Bakare, 2016; Dehghani and Alizadeh, 2016; Adeniran *et al.*, 2017; Shan *et al.*, 2017). These studies have focused on applications in water and wastewater treatment; however the present study focuses on the treatment of stormwater runoff using the natural coagulant.

The aim of this study is to investigate the performance of *Moringa oleifera* seed extract as a natural coagulant for stormwater treatment. The impact of coagulant dose, pH and settling time on the removal of turbidity, chemical oxygen demand (COD) and total suspended solids (TSS) will be evaluated.

2.0. Methodology

2.1. Preparation of Moringa oleifera seed extract.

Moringa oleifera seeds were removed from mature pods, de-husked and dried for one day. The dry seeds were pulverized to a fine powder using a domestic blender. The powder was sieved through a 0.8mm sieve, dried at 40 °C for 10 min to reduce the moisture content and packed in an airtight container on cooling. A 2% suspension of *Moringa oleifera* seed powder in distilled water was agitated for 5 mins and left to settle for 10 minutes to obtain the seed extract (Lea, 2010).

2.2. Stormwater sampling and analysis

Stormwater runoff was obtained from Isihor, Benin City. The map of the study area is shown in Figure 1. Grab samples were taken from an unlined ditch adjacent to the Benin-Lagos highway after a storm event in October, 2019. This was one of the improvised flood control measures near a bad section of the road at the time of this study. The samples were collected using clean plastic bottles and taken to the laboratory for physicochemical analysis in accordance with standard methods for the examination of water and wastewater (APHA, 2005).

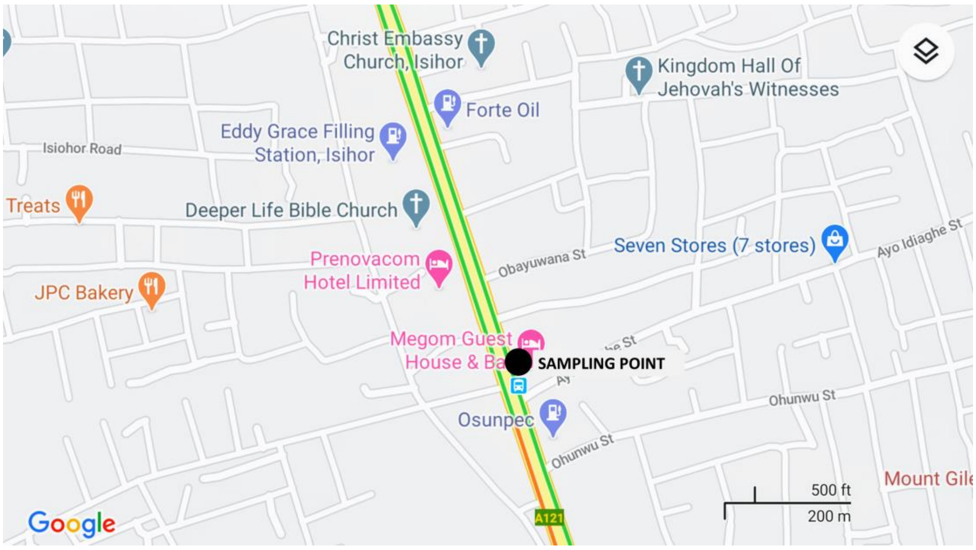

Figure 1: Map of the study area
(Source: Google Maps)

The pH was determined using a pH meter calibrated with standard solutions (pH 4.0, 6.8 and 9.2) before measurements. Turbidity was measured using the Hach turbidimeter. The chemical oxygen demand (COD) was determined using a Hach UV spectrophotometer. Standard gravimetric analysis was used to determine the TSS and TDS based on weight difference. The TSS was determined by passing a known amount of water through a pre-weighed glass fibre filter paper which was dried at 105 °C and then weighed. The increase in the weight of the filter per volume of sample filtered was determined. The TDS was measured by passing a known amount of water through a glass fibre filter paper. The filtrate was placed in a pre-weighed dish, dried at 105 °C and the weight of dry residue per sample volume was determined (APHA, 2005). The concentration of metals (Pb, Cd and Zn) was determined using a Unicam 929 atomic absorption spectrometer (AAS).

2.3. Jar tests

Jar tests were conducted using a conventional jar test apparatus consisting of four 1000mL beakers with rotating paddles. The different coagulant concentrations were added to water samples, which were rapidly mixed at 125rpm for 5 minutes followed by 30 minutes of slow mixing at 50rpm. The samples were left undisturbed for the specified settling time before collection for physicochemical analysis. The effects of coagulant dose (0.5-10% suspensions), pH (3-10) and settling time (20, 40 and 60 minutes) on the removal of turbidity, TSS and COD were investigated.

3.0. Results and Discussion

3.1. Stormwater quality parameters

The stormwater runoff was characterized before treatment with results shown in Table 1. These values were compared with the physicochemical ambient water quality criteria for surface water as stipulated in the National Environmental (Surface and Groundwater Quality Control) Regulations (Federal Republic of Nigeria Official Gazette, 2011) and the United States Environmental Protection Agency (US EPA) multi-sector permit for stormwater discharge (USEPA, 2008).

Table 1: Comparison of stormwater quality parameters obtained from grab sampling with standards.

Parameter	Stormwater Runoff	*NIG (2011)	USEPA (2008)
Turbidity (NTU)	358.41		50
Chemical Oxygen Demand (COD) (mg/l)	162	30	
Total Suspended Solids (TSS) (mg/l)	750		100
Total Dissolved Solids (TDS) (mg/l)	75		120
pH	8.7	6.5-8.5	6.0-9.0
Lead (mg/l)	0.21	0.1	
Zinc (mg/l)	1.93	0.2	
Cadmium (mg/l)	0.06	0.01	

Note: these values from grab sampling are a snapshot of the stormwater quality at a specific time and location and unsuitable for regulatory purposes
**Federal Republic of Nigeria Official Gazette, 2011*

The turbidity and TSS exceeded the US EPA guideline values for stormwater discharge, while the COD, lead, cadmium and zinc levels did not comply with the (Nigerian) physicochemical ambient water quality criteria for surface water. Stormwater pollution may be attributed to the prevalent anthropogenic activities and land-use in the study area (Nystrom, 2019; Song *et al.*, 2019). Atmospheric depositions from high vehicular traffic on the major highway and adjoining streets are conveyed in stormwater runoff. Furthermore pavement failure due to poor drainage has resulted in the release and conveyance of large amounts of debris in flood waters. The erosion of several unpaved roads in the area aggravated by storm events is a continuous source dust and sediments. Soil, dust and debris from construction and agricultural activities and indiscriminate solid waste disposal are also major sources of pollution. The presence of pollutants which are detrimental to receiving water bodies highlights the need for an integrated approach to water resources management which includes stormwater quality monitoring and treatment in addition to flood control.

Jar tests were conducted to evaluate the performance of *Moringa oleifera* seed extract and the effect of operating conditions on the coagulation process. The reduction in turbidity, TSS and COD levels as a function of coagulant dose, pH and settling time are shown in Table 2. These three parameters were selected for ease of measurement and because they were far above the guideline values/surface water quality criteria

3.2. Effect of coagulant dose

The effect of varying the coagulant dose on the removal of turbidity, COD and TSS is shown in Figure 2 and Table 2. There was a general decrease in contaminant levels (increased removal) as the coagulant dose was increased up to the maximum concentration of 10% used in this study. The turbidity of stormwater runoff decreased from 358.41NTU to 44.72NTU (87.52% removal) at the maximum coagulant dose of 10%. Similarly the COD decreased from 162mg/L to 52mg/L (67.90%) and TSS decreased from 750mg/L to 80mg/L (89.33% removal).

Similar trends have been reported with the use of *Moringa oleifera* seeds for the treatment of highly turbid river water (Bakare, 2016), oil-refining wastewater (Dehghani and Alizadeh, 2016). Adeniran *et al.* (2017) also reported in a study that there was a reduction in the levels of COD, TSS and turbidity present in domestic sewage as the applied coagulant (*Moringa oleifera*) dose increased. *Moringa oleifera* seeds contain natural soluble cationic polyelectrolytes, which were released into the extract. These polyelectrolytes are natural flocculating agents that bind colloids present in the stormwater, resulting in the formation of large flocs (Lea, 2010). The mechanisms involved in the coagulation process include neutralization of negatively charged colloidal particles (destabilization), flocculation, interparticle bridging and adsorption (Shin *et al.*, 2008; Sotheeswaran *et al.*, 2011; Dehghani and Alizadeh ,2016).

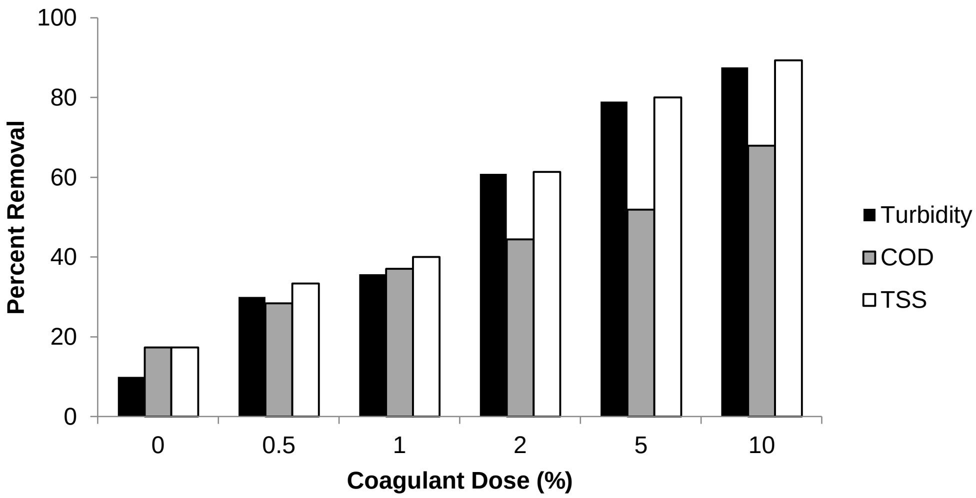

Figure 2: Effect of coagulant dose on the percent reduction in turbidity, COD and TSS

Table 2: Effect of *Moringa oleifera* on turbidity, TSS and COD levels in stormwater runoff

	Turbidity (NTU)		COD (mg/l)		TSS (mg/l)	
Coagulant Dose (%)	Initial	Final	Initial	Final	Initial	Final
0.5	358.41	250.91	162	116	750	500
1	358.41	230.48	162	102	750	450
2	358.41	140.4	162	90	750	290
5	358.41	75.47	162	78	750	150
10	358.41	44.72	162	52	750	80
pH						
3	358.41	40.85	162	48	750	60
5	358.41	43	162	52	750	78
7	358.41	53.32	162	62	750	92
10	358.41	72.03	162	78	750	110
Settling Time (Mins)						
0	358.41	154.8	162	96	750	340
20	358.41	119.97	162	88	750	218
40	358.41	79.12	162	82	750	142
60	358.41	45.58	162	54	750	88

3.2. Effect of pH

The effect of pH on the removal of turbidity, COD and TSS is shown in Figure 3 and Table 2. The coagulation efficiencies varied from 79-88% for turbidity, 51-70% for COD and 85-92% for TSS, with optimum coagulation observed at pH 3. The results indicate a decrease in removal efficiencies with increase in pH levels (particularly at pH>7). Similarly observations have been reported for pH values ranging from 6 to 9. In a study investigating the influence of pH on the treatment of wastewater from oil refining using *Moringa oleifera,* It was observed that after an initial increase across pH 5 to 6, the removal efficiencies of TSS, COD and turbidity decreased as the pH was increased from 6 to 9 (Dehghani and Alizadeh, 2016). However, the optimal pH range for coagulation depends on the specific pollutants present in the water and their interactions. Furthermore, it has been reported that the structure and surface charges of organic coagulants such as *Moringa oleifera* seeds tend to be altered by changes in pH, thus influencing the coagulation process (Naceradska *et al.*, 2019).

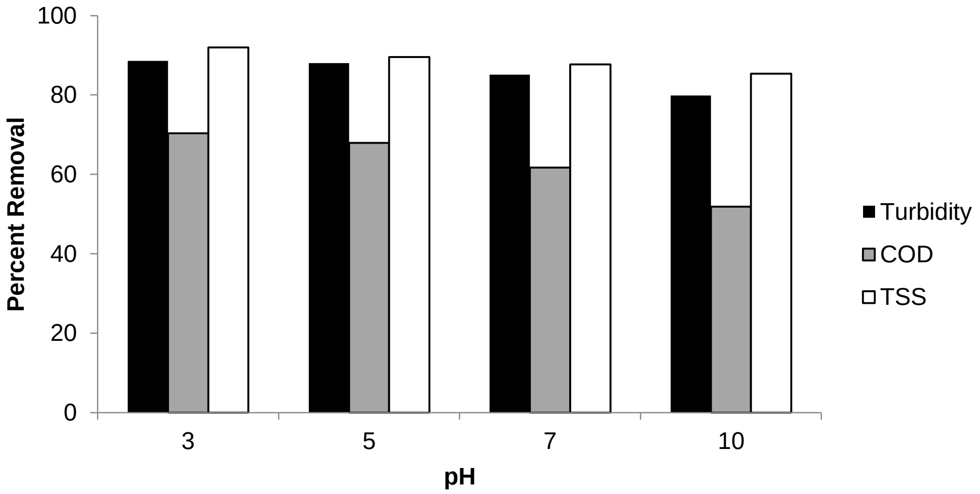

Figure 3: Effect of stormwater pH on the percent reduction in turbidity, COD and TSS

3.2. Effect of settling time

The impact of settling times (0-60 minutes) on the treatment process was evaluated with results showing a gradual increase in pollutant removal as the settling time increased as shown in Table 2. The removal efficiencies were 87.28, 66.67 and 88.27% for turbidity, COD and TSS respectively after 60 minutes of settling as shown in Figure 4. Similarly, it has been reported in the literature that turbidity removal from water increased with settling time (Kang and Trevino, 2017).

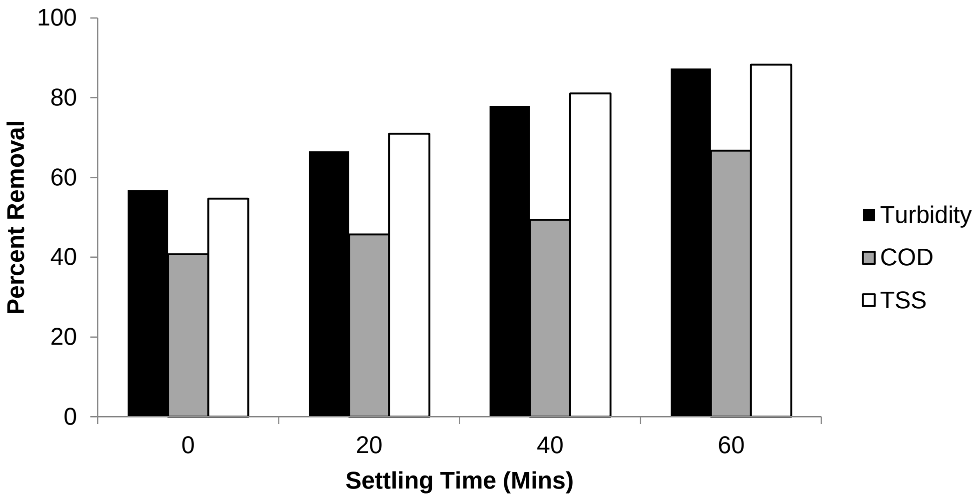

Figure 4: Effect of settling time on the percent reduction in turbidity, COD and TSS

Overall removal efficiencies of up to 88, 70 and 89% for turbidity, COD and TSS respectively were recorded. These findings are generally in agreement with studies on the use of Moringa *oleifera* in the treatment of different contaminated aqueous streams (Dehghani and Alizadeh, 2016; Adeniran *et al*., 2017; Shan *et al*., 2017). *Moringa oleifera* seed reduced turbidity in river water samples by 85-94% (Shan *et al*., 2017). The observed reduction in turbidity levels (up to 88%) is comparable with the 90% reduction reported in a recent study involving the use of chemical coagulants for the treatment of stormwater runoff (Nystrom *et al.,* 2019). These findings demonstrate the suitability of this coagulant as a cost-effective eco-friendly alternative for stormwater treatment.

4.0. Conclusions

The use of *Moringa oleifera* seed extract as a natural coagulant for stormwater runoff treatment was investigated in this study. Maximum coagulation efficiencies of 88, 70 and 89% for turbidity, COD and TSS respectively were achieved. The results showed that coagulation efficiency was influenced by coagulant dose, pH and settling time. The maximum turbidity removal achieved was comparable with the performance of chemical coagulant used in stormwater treatment in a similar study. *Moringa oleifera* can be used as a cheaper and safer alternative to chemical coagulation for stormwater treatment, as part of an integrated stormwater management system.

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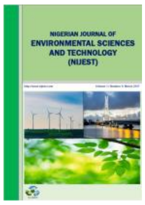
Cite this article as:
Bobor, L. O. and Aghedo, A. G., 2020. Stormwater Runoff Treatment Using *Moringa Oleifera* Seed Extract as a Natural Coagulant. *Nigerian Journal of Environmental Sciences and Technology*, 4(1), pp. 119-126. https://doi.org/10.36263/nijest.2020.01.0192

Nigerian Journal of Environmental Sciences and Technology (NIJEST)
www.nijest.com
ISSN (Print): 2734-259X | ISSN (electronic): 2734-2603
Vol 4, No. 1 March 2020, pp 127 - 137



Perception of Stakeholders on Factors Responsible for Sports Facilities Defects in Selected Universities in South Western Nigeria

Oseghale G. E.[1,]* and Ikpo J. I.[2]
[1,2]Department of Building, Obafemi Awolowo University, Ile-Ife, Nigeria
Corresponding Author: *oseghaleehis@oauife.edu.ng

https://doi.org/10.36263/nijest.2020.01.0187

ABSTRACT

The study assessed the perceptions of stakeholders on factors causing sports facilities defects in selected universities established between 1957 and 1962 in South-West Nigeria by examining the strength of the identified factors responsible for sports facilities' defects in the selected universities. Data were collected using a structured questionnaire which was administered on sports men and women and maintenance personnel. The study incorporated all the fifteen sports featured at the Nigeria University Games Association (NUGA) competitions. Three federal universities were purposively selected because these have facilities for all the fifteen sports and have hosted national and international sporting events. Data obtained were analyzed using frequency distribution, percentages, mean response analysis and factor analysis. Using the mean response analysis, the result showed that the most severe factors responsible for sports facilities' defects were design deficiencies (3.67), intensity of use (3.53), level of exposure to climatic condition (3.41), inadequate maintenance funding (3.19), vandalism (3.18), moisture (3.17) and inadequate cash flow analysis (3.16). The study recommends that users of the facilities should be carried along at the designs stage to minimize design errors and also adequate fund should be provided to maintenance unit to guarantee adequate maintenance of sports facilities for optimal performance.

Keywords: Defects, Factors, Facilities, Sports, Stakeholders, Universities

1.0. Introduction

"Sports for all'' is a stated goal of both governments and sports organizations the world over (Tangen, 2004; Spaaijj *et al*., 2018). Large grants and huge investments are used for the construction, maintenance and rehabilitation of different forms of sports facilities (Tangen, 2004). It is generally accepted that participation in sports provides an extensive range of benefits to individuals and the community as a whole. Engagement in sports is advised because it provides a variety of physiological, psychological and social benefits (World Health Organization (WHO) 2010; World Health Organization (WHO) 2014; Department of Health South Africa (DOHSA) 2015; Mthethwa, 2017). Involvement in physical activities has been revealed to decrease the risks of lifestyle related diseases such as cardiovascular diseases, obesity, hypertension, cancer and diabetes mellitus (WHO, 2010; McGuirk and Prentice, 2012).

Acknowledging the value of physical activities, tertiary institutions have invested massively in sports facilities and recreation resources (Webber and Mearman, 2005; Soleymani *et al*., 2012; Desrochers, 2013; University of the Western Cape (UWC), 2014; Mthethwa, 2017). Therefore, in order to achieve a balanced upkeep of these sports facilities including the structures, Robert (1995) emphasized the need for the crew to comprise personnel with appropriate technical knowledge and skills. The inference here is that for a bi- dimensional setting as this, the experts should have both the technical (engineering) and sports administration background (Adeniran and Ikpo, 2001). This may demand the incorporation of sports administrators into the engineering-based maintenance organization or conversely, contracting some workload requiring specialist attention if the organization is primarily managed by sports experts.

Perhaps the greatest concern to the management of public utilities such as sports facilities is security of the facilities. Studies have shown that these facilities are prone to vandalism, graffiti, and theft, management inability to forecast in scientific terms the fund required periodically for maintenance (Seeley, 1987; Anderson, 1999; Akinpelu, 2002), probably because of the non-availability of facilities condition assessments data. Intensity of use of sports facilities could be a major source of defect, since usage of the sports facilities cannot practically be limited by management and this generate increasing failure rate of composite items such as closets, including septic tank, concrete and timber finishing surfaces where applicable, and the second aspect relates to trespassers who not only add to the design target but also use the area for other non-conforming purposes (Adeniran and Ikpo, 2001; Oseghale *et al*., 2019). Also, physical aggression and abrasion on the sports surfaces from athletes and vibrations induces on the sports building structures as a result of their trainings are other sources of deterioration on the sports facilities (Fischer *et al*., 2020). Corrosion of steel reinforcement especially from combine effects of chemicals such as chlorides, sulphate, acids are other sources of deterioration of sports facilities (Rossi *et al.*, 2019).

The personality of an estate is marked by physical appearance. Most sports structures suffer severe exposure, which tells quickly on the finishing materials. The two most common materials (reinforced or plain concrete and timber) become unsightly when exposed to moisture and solar radiation. For concrete finishes, moss, lichens, moulds, plant growth and so on, mar appearance. Timber members rot due to fungi attacks and plant life, such as ivy and are completely destroyed by insects especially termites (Ikpo, 1990; Oseghale and Ikpo, 2014).

According to Adeniran and Ikpo (2001), client's brief for a new sporting facility often determines the long-term maintenance needs of the facility. The brief should indicate performance requirements and possible changes in use, as well as the future policy for operating, clearing and maintaining the facility. The effects of deterioration can be reduced by serious commitment towards maintenance by the users of the facility. The problem of deterioration can also be increased due to delay in responding to the problem by indifferent users. When maintenance is ignored (delayed or not executed at all) the effect is to aggravate it or increase the rate of sports facilities deterioration from year to year (Al-Sultan, 1996; Olubodun, 1996; Brumaru, 2002; Oseghale, 2016).

Neglecting maintenance of sport facilities imply increase in cost of operating facilities and a waste of related natural and financial resources (Jackson, 1989). This view was backed by Banful (2004) who noted that the financial effects of not attending to maintenance are often not only seen in terms of decreased asset life and premature replacement but also in increased cost of maintenance, operation and waste of related natural and financial resources. Most developing countries neglect maintenance and have no policy in dealing with deteriorating facilities (Oyenuga *et al*., 2012).

Maintenance organizations have always been complaining of inadequate funding. The implication of this is that the limited resources of the maintenance department have to be judiciously managed. Inadequate funding of maintenance activities all over the world made prioritization of maintenance demand a critical issue (Berger *et al.*, 1991; Oladapo, 2004; Wing *et al.*, 2016; Iversen, 2018; Parnell, *et al.*, 2018; Lovett *et al*., 2020). Though the expenditure on maintenance is inadequate, poor management of the resource and maintenance services are also contributing greatly to spots facilities defects, poor service delivery, the spate of maintenance backlogs and poor user satisfaction (Olarewaju, 2011).

Defects in sports facilities can occur as a result of extreme environmental conditions such as solar radiation, moisture, wing, driving rains, high velocity water, soil erosion, frost, soil condition and lack of maintenance (Lavy and Bilbo, 2009; Oseghale, 2012). US Department of Education (2003a), noted that most of the facility problems are not only as a result of geographic or social-economic factors; but they are identified with maintenance staffing level, training and management practices.

Deficiencies in the design, poor detailing of working drawings, poor specification of construction materials, construction faults and maintainability issues if not attended to will result in more damages and costly repair works of sport facilities (Ikpo, 2006; Oseghale, 2012, Suffian, 2013; Oseghale and Ikpo, 2014). Also, the problem of poor workmanship, poor material specifications and design deficiency leads to distress in spalling bricked wall and causes vapour infraltration in buildings

(Anderson, 1999; Muhamad, 2019; Yacob *et al*., 2019 and Ahmed, 2019). While, Atkinson (2003), Tayeh *et al*. (2019) and Ibitayo *et al*. (2020) noted that managerial errors accounted for more than 82% of all errors committed during construction of buildings.

It has been observed that in most organization, maintenance is perceived as merely about the mechanical and electrical system repairs and replacements in the facilities without much consideration given to civil and structural elements of the building. The implication of this is that the other elements and components in the facilities (e.g. building) unattended to deteriorate at a faster rate and more costly to maintain at a later date when it has completely failed or cease to perform the design function. Previous studies focused on deterioration of facilities and various maintenance practices in other sectors. Studies that have examined the deterioration and maintenance of sports facilities especially in tertiary institution are scanty. Also studies on the relationship between sport facilities defects and their maintenance are limited, hence this study. This paper therefore examines the strength of identified factors responsible for sports facilities defects in selected universities in South-West, Nigeria.

2.0. Methodology

The study population includes sportsmen and women and staff of maintenance department in the selected universities in South-West, Nigeria. The sampling frame covered all the universities in Southwestern Nigeria accredited by the National University Commission (NUC). Based on information provided on the Web of NUC (32) universities were identified in South Western Nigeria which includes; Seven Federal universities, nine State universities and sixteen private universities. 15 games featured by the Nigeria University Games Association (NUGA) namely: badminton, basketball, chess, cricket, football, handball, hockey, judo, squash racket, swimming, table tennis, taekwondo, tennis, track and field and volleyball were also included in the sampling frame.

The sample size includes; all NUGA sports and the attendant facilities, however, purposive sampling was used in the selection of the institutions. The choice of Universities selected for this study was dependent on the Universities having facilities for all the 15 NUGA sports, have participated in all the games and have hosted National and International sporting events.

A pilot survey conducted for this study revealed that only three federal universities [Obafemi Awolowo University, Ile-Ife; University of Ibadan and University of Lagos] had all the facilities for the 15 different sports and had hosted National and International sporting events. The respondents include: four members of NUGA technical committee, two coaches from each of the fifteen games in each university, the Director of Sports, two other members of the Sports Council, and two grounds-men from each University. From each selected University the Director of Works, four maintenance supervisors, two administrative staff, and eighteen maintenance operatives were selected from the Maintenance Units. From the user's perspective, six sports men and women (4 male, 2 female) were selected from each of the fifteen games in the selected Universities. The total sample size for the respondents was four hundred and fifty-four.

3.0. Results and Discussion

The respondents were asked to indicate their perception in a 5-point scale ranging from 1 – very low, 2 – low, 3 – moderate, 4 – high and 5 – very high on the strength of factors responsible for sports facilities defects. The result of the frequency of occurrence of the factors is evaluated in Table 1.

Table 1: Factors responsible for sports facilities defects as perceived by respondents

Factors	Mean	Standard deviation	Ranking
Design deficiencies	3.6667	4.5935	1
Intensity of use	3.5256	1.2031	2
Level of exposure to climate condition	3.4125	1.2895	3
Inadequacy of maintenance funding	3.1923	1.2899	4
Vandalism	3.1818	1.3546	5
Moisture	3.1728	1.3397	6
Inadequate cash flow analysis	3.1605	1.3082	7
Chang of use of facilities	3.1519	1.2618	8
Plant growth	3.1235	1.3075	9
Maintainability issues	3..0988	1.4018	10
Construction faults	2.9877	1.2698	11
Driving rain	2.9877	1.2196	11
Solar radiation	2.9750	1.1360	13
Wind	2.9750	1.2425	13
Attack by insect	2.9750	1.3310	13
Lack of maintenance	2.9383	1.4521	16
Corrosion	2.9375	1.2049	17
Vibration	2.9103	1.2399	18
Soil condition	2.8642	1.2425	19
Attack by Rodents	2.8642	1.2723	19
Poor specification of materials	2.8312	1.2503	21
Termite attack	2.8101	1.2411	22
Dusting	2.7375	1.2091	23
Physical aggression	2.7284	1.2749	24
Chemical agencies	2.7250	1.2726	25
Attack by algae, mosses	2.7051	1,2495	26
Damage cause by high velocity water	2.6914	1.2614	27
Abrasion	2.6456	1.3111	28
Inadequate detailing of working drawing	2.6250	1.2157	29
Attack by fungi	2.6173	1.2406	30
Sulphate attack	2.5750	1.1883	31
Erosion	2.5556	1.2247	32
Crystallization of salts	2.5443	1.2890	33
Frost	2.4375	1.2411	34
Acid attack	2.3250	1.2890	35

The analysis revealed that the highest rated factors were found to be design deficiencies (3.67), intensity of use (3.53), level of exposure to climatic condition (3.41), lack of maintenance funding (3.19), vandalism (3.18), moisture (3.17), inadequate cash Flow analysis (3.16), change of use (3.15), plant growth (3.12), maintainability issues (3.10), driving rain (2.99), construction faults (2.99), wind (2.98), attack by insect (2.98) and lack of maintenance (2.94).

The study explored factor analysis to reduce the factors to principal components. The value of Kaiser – Meyer – Olkin (RMD, 0.710) measure of sampling adequacy test carried out (Table 2) showed that the data collected were adequate for the analysis and the Barlett's test of sphericity (0.000) was highly significant. Thus, the data upon which the analysis was carried out were reliable. The total variance explained by the factors (35 factors) is shown in Table 2. In all (7) components were extracted via principal component analysis with Eigen values greater than 1.000. The extracted seven (7) components explain approximately 69% variability in the original thirty five (35) variables. The rotation sums of squared loadings revealed percentage of variables accounted for by extracted components as listed in a uniformly distributed manner of 37.87%, 6.97%, 6.33%, 5.67%, 4.72%, 4.02% and 3.82% respectively (Table 3).

Table 2: Factor analysis - KMO index

Kaiser-Meyer-Olkin and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.710
Bartlett's Test of Sphericity	Approx. Chi-Square	1538.319
	Df	595
	Sig.	.000

Table 3: Factor analysis - total variance explained

Factor	Total	Percentage of Variance	Cumulative percentage
Biological Agencies	13.256	37.874	37.874
Human error related factors	2.441	6.974	44.847
Chemical and Physical Agencies	2.215	6.327	51.175
Physical Agencies	1.984	5.670	56.844
Climatic Agencies	1.650	4.715	61.560
Chemical Agencies	1.406	4.016	65.576
Maintenance factors	1.338	3.824	69.399

By considering a cut-off point for the score loading with absolute value greater than 0.500, the components and the corresponding critical factors loading are presented in Table 4.

Table 4: Factor analysis - rotated component matrix

	Components						
Factors	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7
Termite attack	.853						
Attack by insect	.818						
Attack by Algae and Mosses	.752						
Attack by Rodents	.731						
Attack by fungi	.563						
Inadequate detailing of working drawings		.724					
Poor specification of materials		.704					
Inadequate cash flow analysis		.642					
Lack of Maintenance		.604					
Construction faults		.593					
Vibration		.551					
Vandalism		.532					
Abrasion			.832				
Physical Aggression			.823				
Acid attack			.806				
Crystallization of salts			.678				
Damage caused by high velocity water				.808			
Erosion				.806			
Dusting				.744			
Plant growth				.534			
Wind					.762		
Moisture					.653		
Soil Condition					.635		
Solar Radiation					.593		
Driving Rain					.513		
Chemical agencies						.685	
Corrosion						.611	
Intensity of Use							.787
Maintainability issues							.511

The first component in the analysis is mostly correlated with attack of the sports facilities by biological agencies. This component has Eigen value of 13.26 and percentage variance of 37.87% with factors including termite attack (0.853), attack by insect (0.818), attack by algae and mosses (0.752) attack by rodents (0.731) and attack by fungi (0.563). The outcome of the study reveals that the material used for the construction of the floors of indoor sports hall, roof truss, skirting boards, office furniture and doors were majorly timber. There are over 2000 known species of termites in the tropics and they are broadly classified as dry wood and subterranean termites. Dry wood termites confine themselves entirely within the timber and need no contact with the ground, while the subterranean are more wide spread and need to maintain contact with the soil. They both infested and cause destruction of timber by constructing tubes in the internal structure of timber. These reasons underscored the higher scoring of termites as a factor responsible for sports facilities defects.

Insect attack is generally confined to timber, but some other materials derived from organic fibers may be infected. Beetles of one kind or another infest timber because the organic nature of the material is favourable to the grub's life cycle of hatching, growing and emerging. The effect is to reduce the cross-sectional area of the timber and also reduce its strength and therefore shorten the durability of the material. Algae growth resembles dirt deposit on external paint surface and porous concrete. Plant life in the form of moss if allow to develop will cause deterioration of material for the construction of sports buildings. The damage is done by the penetration of roots into the crevices as they grow to extract moisture from the damp materials. Rodents may cause considerable damage to timber and other organic materials. Fungi are parasitic and attached themselves to the surfaces which supplies nutrients. Fungi attack occurs only in the presence of sufficient persistent moisture, oxygen, and cellulose in the timber, and they are the chief causes of decay of timber. Findings agreed with Ikpo (1990) & (2006), Adeniran and Ikpo (2001), Oseghale (2014) and Oseghale and Ikpo (2014).

The second component is highly correlated with man-oriented decay. This component has Eigen value of 2.44 and percentage variance of 6.97% with inadequate detailing of working drawings (0.724), poor specification of materials (0.704), inadequate cash flow (0.642), and lack of maintenance (0.604), construction faults (0.593), vibration (0.551) and vandalism (0.532). The constructional details of working drawings dictate to the builder what to build. Examples are non – adherence to the recommended minimum eaves projection of 600mm that expose external walls to significant moisture resulting from driving rain. Depths and widths of footings, specific foundation types, and degree of inclination of elements such as roofs are details commonly observed to be missing in working drawings. These inadequacies in detailing of working drawings lower the quality of the final product. Poor specification of composite building materials may produce devastating results. The findings agree with Watt (1999), Calder (1997) and Ikpo (2006) who opined that inappropriate materials applied to building and poor expert decision making caused building defects and lower construction quality. Inadequate cash flow agreed with Ikpo, (2006) who opined that cash constraints lead to project delays and in extreme cases abandonment. Neglecting maintenance of sports facilities and delay in attending to the problem of indifferent users as in the case of sports facilities could heighten the problem of deterioration. This finding is in agreement with Al-Sultan (1996), Olubodun (1996) and Brumaru (2002) who opined that the effects of ignoring maintenance is to aggravate or increase the rate of facilities deterioration from year to year. Fault construction from site personnel can promote the deterioration of sports facilities through bad workmanship, inadequate supervision and the substitution of poor materials. This finding agreed with Atkinson (2003), Tayeh *et al*. (2019) and Ibitayo *et al*. (2020) who found that managerial errors accounted for more than 82% of all errors committed during construction of buildings. The finding also agreed with Anderson (1999), Muhamad (2019), Yacob *et al*. (2019) and Ahmed (2019) who found that distress on the spalling brick wall that caused vapour infiltration in building was due to deficiencies in workmanship, material and design.

The third component is most highly correlated with chemical and physical agencies that cause decay of sports facilities. The component has Eigen value of 2.22 and percentage variance of 6.33%. It is clustered around with abrasion (0.832), physical aggression (0.823), acid attack (0.806) and crystallization of salts (0.678). Abrasion caused by either athletes, pedestrians or equipment continuously passing over timber and concrete floor particularly in play surfaces, are subject to wear. Physical force imposes by the athletes continuous sliding on the concrete and timber finished surface during training and competition accelerate the process of deterioration of these materials. This underscores the high rating of physical aggression as a factor responsible for sports facilities defects which agreed with the findings of Fischer *et al*. (2020). Atmospheric gases such as sulphur dioxide, carbon dioxide in the presence of moisture contribute to the formation of acid that attack certain materials such as metals which are used in the fencing of outdoor courts and concrete for hard courts areas. Crystallization of salts may be present initially in certain building materials or may be conveyed into them by movement of moisture from the ground. When crystallization of salt occurs within the pores of the surface layer it may cause gradual erosion or flaking of the finished materials such as paints and surface disfiguration, but when it takes place below the surface it can cause more serious problem. This agrees with the findings of Rossi *et al*. (2019) who opined that deterioration of sports facilities as a result of the corrosion of steel reinforcement were from the combine effects of chemicals such as chlorides, sulphate and acids attacks.

The fourth component is highly correlated with environmental factors. This component has Eigen value of 1.98, percentage variance of 5.67% and had factor loading of damage by high velocity water (flooding) (0.808), erosion (0.806), dusting (0.744) and plant growth (0.534). In places where drainages and water channels are not properly constructed or not constructed at all flooding and erosion have serious consequences and damaging effects on the fields and concrete courts. Dusting is most encountered on floors where traffic and abrasion are heavy such as basketball, handball, tennis and volleyball courts. Also increased water at the surface of the courts after rainfall raised the water cement ratio and reduced the strength of that portion of concrete and subsequently subjected to abrasion. Trees also grow around buildings and outdoor hard court areas, and at times have their roots shooting gradually along horizontal plane. The effects on the building and hard courts areas are that the foundation walls within the areas suffer severe damage and manifest in the form of cracks. These underscore the very high rating of these factors as responsible for sports facilities defects.

The fifth component is most highly correlated with climatic factors with Eigen value of 1.65, and percentage variance of 4.72%. This component has wind (0.762), moisture (0.653), soil condition (0.635), solar radiation (0.593) and driving rain (0.513). Wind causes direct physical damage by the removal of parts of the roof or the whole roof of sports buildings and covered pavilions. This finding agreed with Ikpo, (2006) who opined that wind cause serious damage on poorly secured roof structures. Moisture is the principal agent of deterioration and probably also the agent with the greatest influence on the properties of materials. The finding is in agreement with Son and Yuen (1990); Ikpo (1990); Obiegbu (2003); 1kpo (2006); Oseghale (2014); and Oseghale and Ikpo (2014). Soil movement which may result from geological processes such as folds, faults, compression of layers of peats, swelling and shrinkage of clay soils adversely affects the foundations of sport buildings and hard courts areas. Solar radiation causes thermal expansion which in buildings manifests as thermal expansion cracks in brickwork, blockwork and concrete if ends were restrained. The effect of driving rain is that the vertical surface facing the received rainwater at an angle. The resultant stresses set up may lead to disintegration of the surface layer.

The sixth component which mostly correlated with chemical agencies has Eigen value of 1.41 and accounted for 4.02% of the total variance. This component has the factor loadings of chemical agencies (0.685) and corrosion of metals (0.611). Metal poles and wire gauze were predominately used in the fencing of outdoor courts in the study areas. When metals are exposed to moisture in the presence of oxygen corrosion takes place. This is in agreement with Rossi *et al*. 2019.

The seventh component in the analysis is most highly correlated with maintainability issues and intensity of use. This component has Eigen value of 1.34 and percentage variance of 3.82% with intensity of use (0.787) and maintainability issues (0.511). Intensity of use of sports facilities could be a major source of defects. The high scoring of intensity of use is justified because sports facilities like any other hospitality facilities are such that provide services (round the clock) all the time. The findings agreed with Ikpo (1990), Adeniran and Ikpo (2001), Ikpo (2009) and Oseghale (2016). Indoor sports buildings are usually design with a high head room to enable athletes have their games. Some of the maintainability issues commonly observed were failure to provide accessibility to ceiling space for the purposed of maintenance.

4.0. Conclusions

The study assessed the strength of each of the identified factor responsible for sports facilities defect. The finding revealed that the most severe factors responsible for sport facilities defects were: design deficiencies, intensity of use, and level of exposure to climatic condition, vandalism, moisture and inadequate cash flow analysis. The study found that attack of sport facilities by biological agencies were the first components correlated in the analysis, while the second component was highly correlated with man-oriented decay. And the third component was most highly correlated with chemical and physical agencies that cause decay of sports facilities. Physical force imposes by the athletes continuous sliding on the concrete and timber sports finished surface during training and competition accelerate the process of deterioration of these materials. The study found design defects, high intensity of use, high level of sports facilities exposure to climatic and environmental condition and poor maintenance funding as the most influencing factors responsible for sports facilities defects. The study, therefore, recommends that the users of sports facilities (athletes and members of sports council) be carried along in the design of sports facilities to improve their designs and adequate fund be made available by the government to enable maintenance units to stockpile the materials that fail frequently as a result of the high intensity of use of these facilities to minimize maintenance downtime and improve their reliability.

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Cite this article as:

Oseghale G. E. and Ikpo J. I., 2020. Perception of Stakeholders on Factors Responsible for Sports Facilities Defects in Selected Universities in South Western Nigeria. *Nigerian Journal of Environmental Sciences and Technology*, 4(1), pp. 127-137. https://doi.org/10.36263/nijest.2020.01.0187

Nigerian Journal of Environmental Sciences and Technology (NIJEST)
www.nijest.com
ISSN (Print): 2734-259X | ISSN (electronic): 2734-2603
Vol 4, No. 1 March 2020, pp 138 - 151

Application of Geospatial Techniques and Logistic Regression Model for Urban Growth Analysis in Limbe, Cameroon

Adzandeh E. A.[1], Alaigba, D.[2] and Nkemasong C. N.[3,*]
[1,2,3]African Regional Institute for Geospatial Information Science and Technology (AFRIGIST), Obafemi Awolowo University, Ile-Ife, Osun State, Nigeria
Corresponding Author: *nkemcelesto@gmail.com

https://doi.org/10.36263/nijest.2020.01.0193

ABSTRACT

Little is known about the nature of ecosystem loss, rampant changes in land use and land cover (LULC) and urban growth taking place in Limbe. The aim of this study is to analyze urban growth in Limbe, Cameroon from 1986-2019 using geospatial techniques and Logistic Regression Model (LRM). Landsat Thematic Mapper (1986), Enhanced Thematic Mapper+ (2002) and Operational Land Imagery/Thermal Infrared Sensor (2019) were utilized in this study. The images were classified into land cover classes using supervised image classification algorithm in ENVI software. The classification output was subjected to LRM application to evaluate urban growth. Image difference of urban growth between 1986 and 2019 was calculated as dependent variable and the independent variables were produced by calculating the Euclidean distance and Buffer of built-up, waterbody, road and farmland as driving factor for urban growth. Future urban growth was determined for 2035 using the Land Change Modeler in IDRISI Selva. Classification overall accuracy for the three date were not less than 99%. LRM results show a good fit with relative operation characteristic of 0.8344 and Pseudo R^2 of 0.21. Analysis of LULC shows that built-up increased from 3.5% (1986) to 17.6% (2019). An urban land expansion rate of about 23% was observed for 2035. Transition probability matrix revealed high probability (0.6345) of build-up to remaining build-up by 2035, while the probability for it changing to waterbody, bare land, farm land and vegetation are 0.1099, 0.0459, 0.1939 and 0.1221, respectively. This study successfully demonstrates the application of geo-spatial techniques and LRM for land use/land cover change detection and in understanding the urban growth dynamics. It also identifies the potential areas of future urban growth, which can help land use policy planners for making optimum decisions of land use planning and investment.

Keywords: Limbe, Logistic Regression Model, Spatial Analysis, Urban Growth

1.0. Introduction

City landscapes have been rapidly changing in the last few decades in response to accelerated population growth and the transition from rural to urban areas (Omar *et al.*, 2017). Urban growth has been accelerating with the significant increase in urban population. Human transformation of the ecosystems and landscapes are the largest source of change in the natural systems on Earth, affecting the ability of the biosphere to sustain life (Yu Nong, 2011). Anjolajesu (2016) submitted that man depends on the environment for survival, and the environment also depends on man for sustenance.

Rapidly growing urbanization of our cities and villages overpowers the meager resources by encroaching them which leads to unmanaged and unsustainable development situation. We can manage Urban Growth in a planned way by planning future scenarios for which land use land cover area change dynamics is crucial to understand (Ankita, 2016). To achieve a sustainable development, cities must be planned and managed to form a balance between human beings and natural environment by using resources carefully and transferring them to the next generation. According to (UN-Habitat, 2017), localization of Sustainable Development Goals (SDGs) in cities demands up-to-date spatial information to accommodate changes in planning, monitoring, and evaluation of urban planning.

Sustainable development must meet "the needs of the present without compromising the ability of future generations to meet their own needs (UN-WCED, 1987). According to (UN, 2016), cities in developing countries are struggling to provide up-to-date spatial information reflecting urban dynamics in order to protect and enhance environmental conditions. Geographic Information Systems (GIS) and remote sensing techniques provide effective tools in studying and monitoring land-use/land-cover change over space and time (Addae, 2019).

Urban growth when occurs in an unplanned and unmanaged way it will hamper the quality of growth in a region. Impacts on wildlife and ecosystem in areas where sprawl is not controlled would lead to disturbances in ecosystem and processes (Grimm *et al*., 2000). Urban sprawl decreases the amount of agriculture, forests and water bodies (Hedblom, 2010). Urban sprawl is also blamed for the poor health of society due to increased pollution (Brueckner, 2011). LRM was chosen because The Relative Operation Characteristic (ROC) is an excellent method to compare a map of "reality" versus a suitability map according to (Hossein, 2019). ROC of 1 indicates no growth while 1 indicates the presence of urban growth.

This study is to detect and analyze the spatio-temporal changes in the urban LUC of Limbe between 1986-2019, examines the driving factors that influence urban growth and predict LUC in 2035 using Logistic Regression Model (Arafan, 2017). This is in line with the Cameroon Vision 2035 that outlines the goals and priorities for the country in becoming an emerging economy by 2035. This study is different from others in that it uses the 4 variable model which has a greater impact on urban growth. This study shows that urban growth is gearing towards built up areas, farm lands, waterbodies and roads. This will go a long way to help land use policy planners for making optimum decisions of land use planning and investment.

2.0. Methodology

2.1. Description of the study area

Limbe is a seaside city located along the coastal area of Fako Division, South-Western region of Cameroon. The study area lies within Latitudes 4°4′4.3″ N and 3°56′53.8″N; Longitudes 9°11′43.9″ E and 9°12′45.6″ E (see Figure 1). It has a surface area of 185 km^2 and a population of 120,000 inhabitants in 2014 statistics, with tropical equatorial climate of hot, moist, and dry conditions (Ndille *et al.*, 2014 and Folack, 2003). The topography is characterized by low-lying coastal plain, rising to a chain of horseshoe shaped hills with slopes of varying intensities with the highest points reaching 362 m above sea level (Njabe, 2006). It is only about 10 miles from Dibuncha and is the second wettest place in the world after Cherrapunji in India (UNU-EHS, 2010). Limbe experiences very heavy torrential rains in the long rainy season (March–October) with the highest average monthly precipitation of about 700 mm recorded in June, July, and August (Roland, 2014).

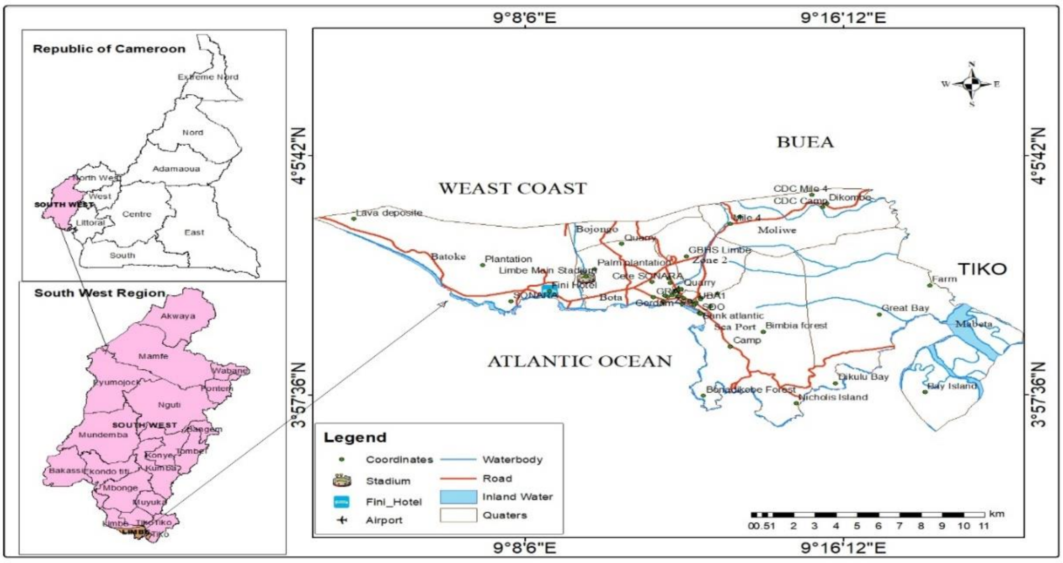

Figure 1: Study area

2.2. Data collection

Two types of data were used in this research. Satellite data that comprised of three years' multi-temporal satellite imageries (LANDSAT_5 for 1986, LANDSAT_7 for 2002 and LANDSAT_8 for 2019) and Global Positioning System (GPS) coordinates acquired from field survey. The Landsat images were acquired during the day in the months of January and December from the United States Geological Surveys (USGS) official website. Detailed information regarding the Landsat characteristics is provided in Table 1.

Table 1: Characteristics of Landsat dataset for the study period

Data	Path and Row	Type	Resolution	Image date
Landsat 5 TM	187 057	Raw data	30m	1986/12/12
Landsat 7 ETM+	187 057	Raw data	30m	2002/01/30
Landsat 8 OLI/TIRS	187 057	Raw data	30m	2019/01/05

Field survey data is very important for ground trothing. It is used to assess the accuracy of the classified land cover map. A total of 40 selected ground truth points were collected and used to ground check the zones using a held GPS Garmin of 2m accuracy.

2.3. Land use/land cover characterization between 1986-2019

Three Landsat images of 1986, 2002 and 2019 were used to analyze the spatial pattern of expansion of Limbe City for a period of 33 years. The LULC classification rules for satellite imagery were followed according to the manual of Nation-wide LULC mapping, National Remote Sensing Agency (NRSC, 2014). The datasets were preprocessed in ENVI 5.1 software environment for colour composite, image sub-setting on the basis of Region of Interest (ROI) followed by band combination and layer stacking. Supervised Maximum Likelihood classification was used because it is popular and the most common method in remote sensing image data analysis (Rawat, 2015). This was done to draw out useful thematic information (Boakye, 2008).

Table 2: Land cover class and definitions for supervised classification

S/N	Land cover classes	Description
1	Farmland	The land which is mainly used for growing food crops such as maize, green grams, beans, cassava, mangos
2	Build up Area	This class describes the land covered with buildings in the rural and urban. It includes commercial, residential, industrial and transportation infrastructures
3	Bare Land	This describes the land left without vegetation cover. This result from abandoned crop land, eroded land due to land degradation and weathered road surface.
4	Vegetation	Deciduous forest land, evergreen forest land, mixed forest land, orchards, groves, vineyards, nurseries, ornamental horticultural area
5	Waterbody	This class of land cover describes the areas covered with water either along the river bed or man-made earth dams, filled sand dams and ponds.

Source: Steven and Burian, 2002

2.4. Analysis of urban growth using logistic regression model

Urbanization rate involves the analysis of the rate of expansion by using the build-up land cover class. Here we calculate the area gain and loss by build-up class from and to other land use /land cover classes for the study periods of 1986-2002, and 2002-2019 (Eastman, 2015). The land cover maps produced from previous process were reclassified into two main land cover types: urban area and non-urban area. The urban growth analysis conducted resulted in urban growth image which happened between 1986-2019, its transition matrix and the probability of change. Only the transition matrix and change probability of urban growth were used as dependent variable to build the logistic regression of urban growth.

2.4.1 Logistic Regression

A logistic regression model was used to model urban growth and generate an urban growth map. This regression model is useful for predicting the presence or absence of a characteristic or outcome based on values of a set of predictor variables. The dependent variable represents urban growth results, Y has a binary value of 1 and 0 for Yes and No, respectively. Actually, the probability reflects in what extend Y will change into 1, as shown in Equation 1 (Nong, 2011). P could be very close to 0 or 1.

$$P(Y = 1|X_1, X_2, \ldots X_n) = \frac{1}{1 + e^{\alpha \sum_1^n \beta_1 x_1}} \quad (1)$$

Where:
$P(Y = 1|X_1, X_2 \ldots X_n)$ is the probability of Y given by $X_i(i = 1, 2 \ldots n)$ and changes from non-urban to urban land. Moreover, 1−P is the probability of presence of no urban growth. The logistic transformation is shown in Equation 2:

$$ln(\frac{p}{1-p}) = \alpha + \beta_1 X_1 + \cdots + \beta_n X_n \quad (2)$$

The urban growth in this research was done using the statistical logistic regression method which uses the net urban growth of the year 1986 and 2019 as dependent variable and the driving factors as independent variables. The dependent variable was produced by calculating the image difference of urban growth between 1986 and 2019. While the independent variables were produced by calculating the buffer and Euclidean to built-up, waterbody, road and agriculture land which were the socio-economic driving factor for urban growth (Ashfa, 2015). The result was then used as input for building the logistic regression model.

2.5. Future growth prediction for the year 2035

The Markov Chain Analysis was used to model land use change. It is a process in which the future state of a system can be modeled on the basis of the immediately preceding state by developing a transition probability matrix from period one to period two which shows the nature of change but no knowledge of spatial distribution. The above prediction date was chosen in line with the Cameroon Vision 2035 that outlines the goals and priorities for the country in becoming an emerging economy by 2035.

Markov modules from TerrSet were used to calculate the probability of a Markov transition and to generate a transition probability matrix. Markov transition probabilities were calculated from cross tabulations using beginning LUC (2002) and end LUC (2019). Figure 2 shows a breakdown of the methodology adopted for the study.

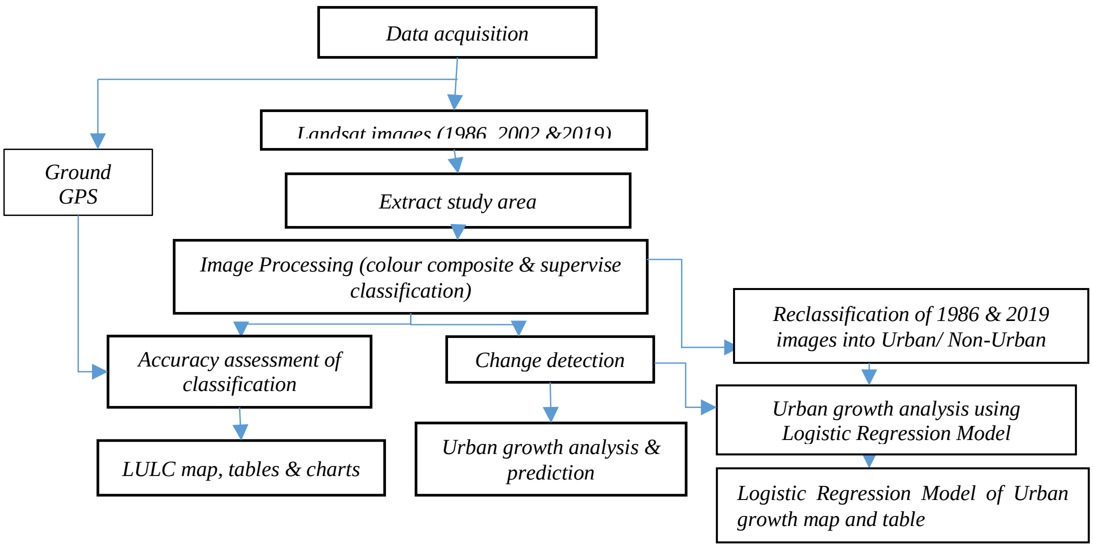

Figure 2: Flow chart methodology

3.0. Results and Discussion

3.1. Analysis of land use/land cover

Landsat images of 1986, 2002 and 2019 were classified using ground truth information and visual interpretation into built up, waterbody, farm land, bare land and vegetation. The results of image classification conducted in 1986, 2002 and 2019 for this study is presented in Table 3. Accuracy assessment was performed for the three dates and result not less than 99% (Zheng *et al*., 2015). Figures 3 to 5 depicts the LULC maps for the three dates (1986, 2002 and 2019).

Table 3: Analysis of LULC distribution (1986-2019)

LULC	1986 Area (km^2)	(%)	2002 Area (km^2)	(%)	2019 Area (km^2)	(%)
Built up	7.88	3.58	26.45	12.01	38.76	17.60
Waterbody	3.22	1.46	4.16	1.89	3.39	1.54
Bare land	22.14	10.06	53.90	24.48	0.91	0.41
Farm land	11.85	5.38	17.17	7.80	31.01	14.08
Vegetation	175.13	79.53	118.54	53.83	146.14	66.37
Total	220.22	100	220.22	100	220.22	100
	Overall accuracy = 99.3180% Kappa = 0.9882		Overall accuracy = 99.8245% Kappa = 0.9974		Overall accuracy = 99.8844 Kappa = 0.9984	

The classification results indicate that Built-up area in 1986 occupies 3.58% of the total land. Vegetation has the highest area class with 79.53%, due to the fact that the town is located at the coast mostly inhabited by the white men. Bare land has the second highest with 10.06% while farm land was 5.38%. In 2002, built up area occupies 12.01% as a result of increase in population and development associated with urbanization where rooms were made for the Cameroon Development Cooperation to surrender part of the Palm plantation for the creation of layouts. Farming activities seems to have increased by 2.42%, this can be attributed to rural exodus. The bare land covers 24.48% compared to 10.06% in 1986 which was as a result of the June 2001landslides that took placed in Limbe destroying over 120 houses and transforming vegetation and some built up into bare land. Vegetation cover reduced to 53.83% as compared to 79.53% possibly as a result of the above-mentioned landslides (Ayonghe et al, 2004), bush fire and deforestation. Also, the water percentage rose to 1.89% compared to 1.46% in 1986 due to the deposition of magma flow in to the Atlantic Ocean from the Mount Cameroon Volcanic eruption of the year 2000 causing a rise in the sea level.

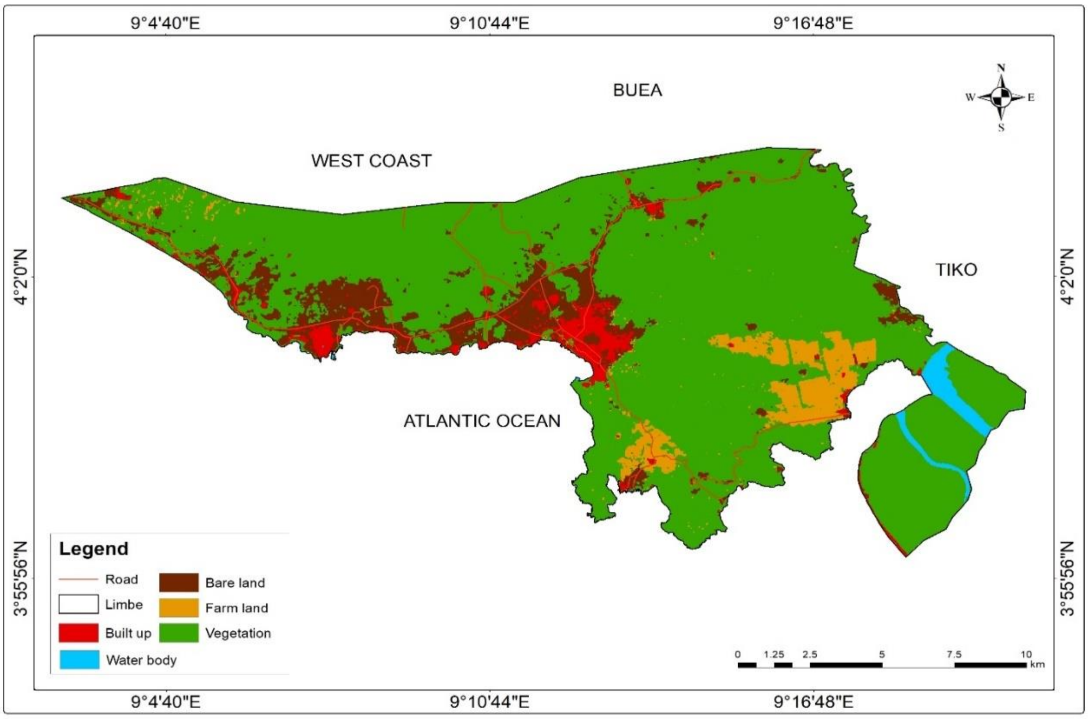

Figure 3: Land use/land cover map of 1986

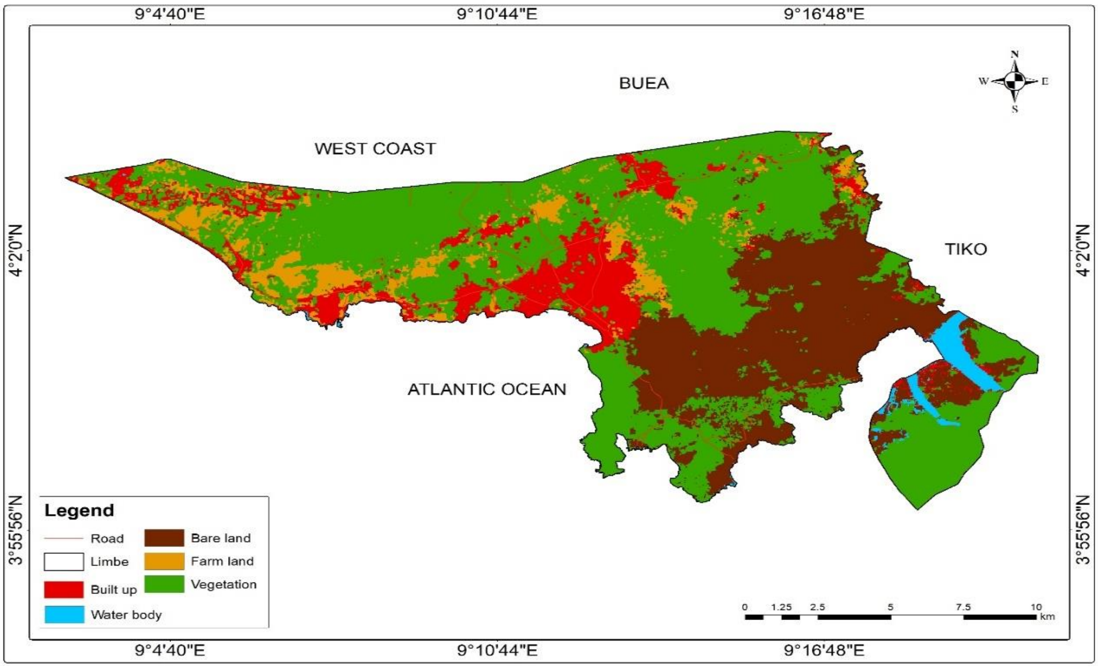

Figure 4: Land use/land cover map of 2002

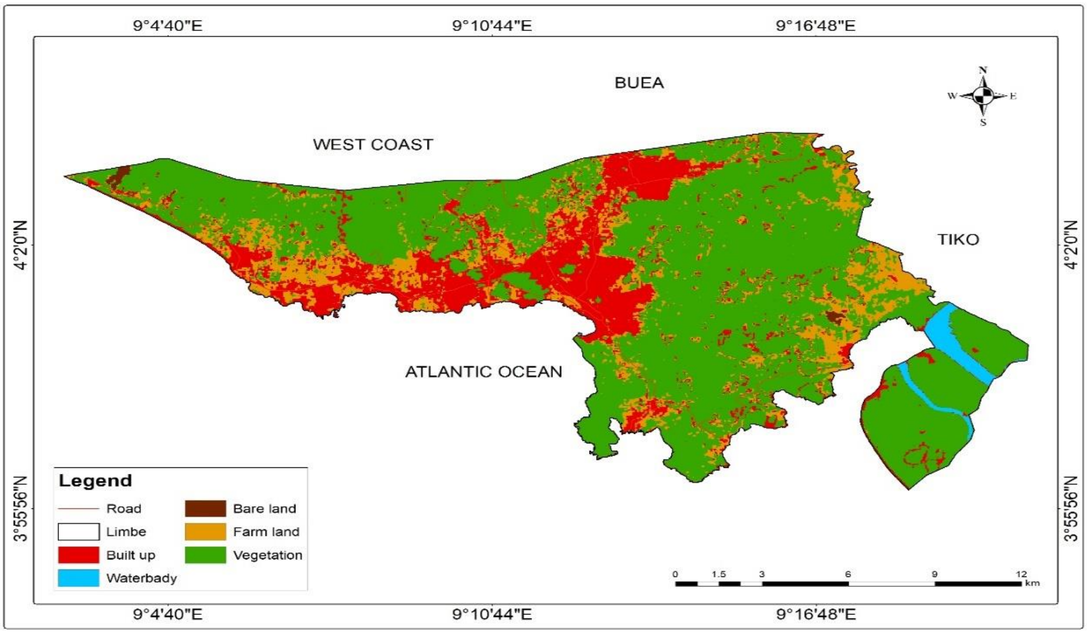

Figure 5: Land use/land cover map of 2019

By 2019, built up area has increased to 17.60% as the second highest. This is probably based on many factors such as establishment of schools, creation of social amenities, good security, construction of new roads, Stadia and creation of new layouts. Farmlands increase to 14.08% because of increase in population and also the fact that many indigenes of Limbe are farmers. Bare land reduced to 0.41% as to 24.48% in 2002 because of development associated with urbanization creation of layouts, construction of new Stadia as well as state low income houses and other social amenities not forgetting the sociopolitical crises that chased so many people away from the surrounding villages of Limbe. This also affected the vegetation positively as well. People fled from their homes as a result, vegetation covered the built up, bare land and farm lands. This can be observed in Table 3.

3.2. Land use/land cover change detection of Limbe city (1986-2019)

Change in this study refers to the expansion and contraction of the various land use types between 1986 to 2002 and 2002 to 2019. The change detection analysis was done by subtracting the classification results of 1986 from 2002 and 2002 from 2019. Table 4 shows the matrix of transition from 1986-2019 and the changes are presented in area (km^2).

Table 4: Matrix of transition for 1986-2019

1986-2002						
Classes	Built up (km^2)	Waterbody (km^2)	Bare land (km^2)	Farm land (km^2)	Vegetation (km^2)	Row total (km^2)
Built up	6.4323	0.072	8.0694	0.4104	11.9538	26.93
Waterbody	0.0576	2.8053	0.0018	0	1.4427	4.30
Bare land	0.4347	0	0.8145	9.0351	43.425	53.70
Farm land	0.2043	0	2.9619	0.3501	14.6403	18.15
Vegetation	0.8352	0.4104	10.4625	3.2166	102.4029	117.32
Class Total	7.9641	3.2877	22.3101	13.0122	173.8647	220.22
2002-2019						
Classes	Built up (km^2)	Waterbody (km^2)	Bare land (km^2)	Farm land (km^2)	Vegetation (km^2)	Row total (km^2)
Built up	13.3893	0.7839	1.4454	1.602	6.8454	24.06
Waterbody	0.0495	2.7099	0	0	0.4005	3.15
Bare land	0.3681	0.0135	0.2178	0.0126	0.0522	0.66
Farm land	0.5958	0	2.2779	1.4373	3.6504	7.96
Vegetation	12.5955	0.8136	49.7682	15.1047	106.3962	184.67
Class Total	26.9982	4.3209	53.7093	18.1566	117.3447	220.22

From 1986-2002, the change analysis result shows that a total of 6.4323 km^2 out of 7.9641 km^2 remain built up. Built up gained 0.072 km^2 from waterbody, 8.0694 km^2 from bare land, 0.4104 km^2 from farm land and 11.9538 km^2 from vegetation (as shown in Figure 6). This can be attributed to increasing level of urbanization within the study period.

From the year 2002-2019 built up maintain an area of 13.3893km^2 and loses up to 12.5955km^2 to vegetation. This situation is as a result of the socio-economic crises in the English-speaking part of Cameroon which started in 2016 and is ongoing which led to the burning of houses and abandonment of farm lands for safety. Built up gained 0.7839 km^2 from waterbody, 1.4454 km^2 from bare land, 1.602 km^2 from farm land and 6.8454 km^2 from vegetation, as shown in Table 4 and Figure 7.

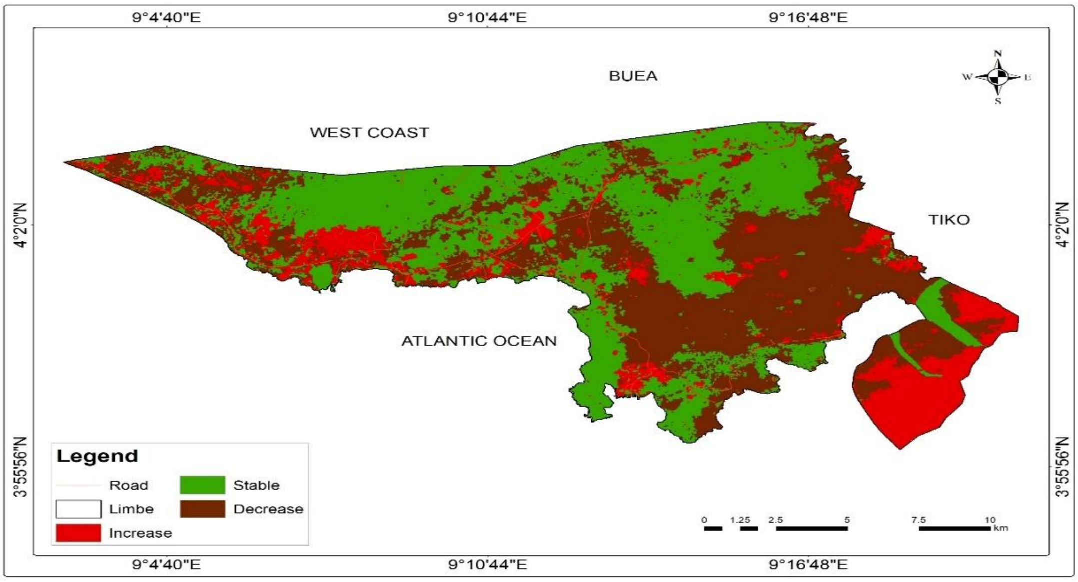

Figure 6: Change analysis for 1986-2002

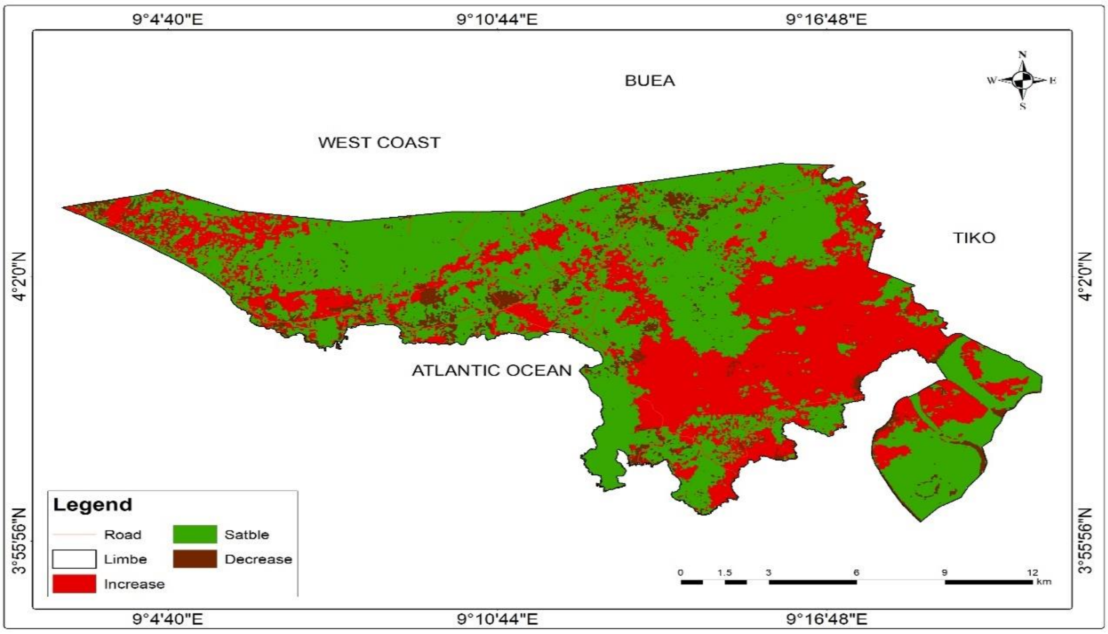

Figure 7: Change analysis for 2002-2019

3.3. Urban growth modelling

Urban growth analysis is conducted by developing comparison matrix of land cover for the year 1986 and 2002, 2002-2019. The matrix of land cover change shows that urban area gains about 10km^2 from other land covers such as vegetation, farm land, bare land and waterbody between1986-2002, waterbody and vegetation being the highest contributor to this gain. Waterbody within this same period gain the highest 110km^2 while farm land and bare land followed with 41km^2 and 30km^2 respectively. From 2002-2019, the built up step up to about 19.5km^2 gain, bare land being the highest contributor of 13km^2. Vegetation had 170km^2 gain, while farm land recorded 9km^2. Figure 8 shows the gains and losses between 1986 and 2019.

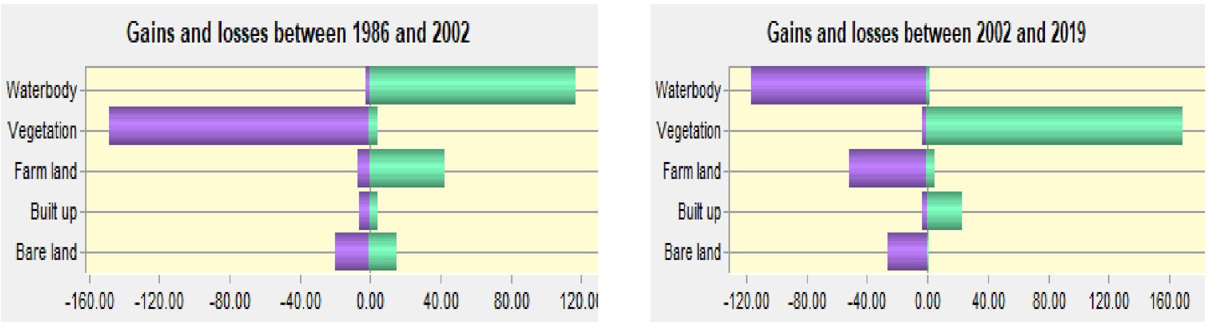

Figure 8: Change analysis of gain and loss bar graph between 1986-2002 and 2002-2019

3.4. Logistic Regression Model

Urban growth in this research is done using logistic regression model which calculates dependent and independent variables of urban growth. Urban growth data during 1986-2019 acts as dependent variable of logistic regression model, and suggested driving factors which drive urban growth as independent variables (Arsanjani *et al*., 2013). Table 5 and 6 indicate the individual regression coefficient and the logistic regression equation respectively.

Table 5: Individual regression coefficient

Factors	Variables	Coefficient
Intercept	Intercept(β0)	-4.8112
Distance from Urban area	Urbandist(β1)	-1.4094
Distance form Agriculture	Agricdist(β2)	2.2039
Distance from Road	Roaddist(β3)	18.2941
Distance from River	Riverdist(β4)	2.2193

Table 6: Logistic regression equation

The Logistic function: $f(z) = \frac{1}{1+e^{-x}}$
Z variable is defined as: Z= -4.8112 - 1.4094*Urbandist + 2.2039*Agricdist + 18.2941*Roaddist + 2.2193* Waterdist

Source: Karsidi, 2011

The calculation of logistic regression model produces Pseudo R^2 which indicates the fitness of relationship of the model. Thus, when pseudo R^2 = (0.2-0.4), indicates a perfect fit, whereas pseudo R^2 = 0 indicates no relationship (Asep, 2011). The result shows that, Pseudo R^2 = 0.21 while ROC was 0.8344 indicating the model was slightly a good fit; this is in line with (Karsidi, 2011). The results from Table 5 shows that the proximity variable, distance to roads (β_3 = 18.2941) had the highest coefficients, distance to river variable (β_7 = 2.2193) follow by distance to agriculture (β_4 = 2.2039) showing the model had a best fit. The Relative Operation Characteristic (ROC) is an excellent method to compare a map of "reality" versus a suitability map according to (Hossein, 2019). ROC value ranges from 0 to 1, where 1 indicates a perfect fit and 0.5 indicates a random fit. A ROC value between 0.5 and 1 indicates some association between the X variables and Y. The larger the ROC the better the fit. Figures 9 to 14 shows the various independent variables used in building the Logistic Regression Model while Figure 15 shows the Logistic Regression Map.

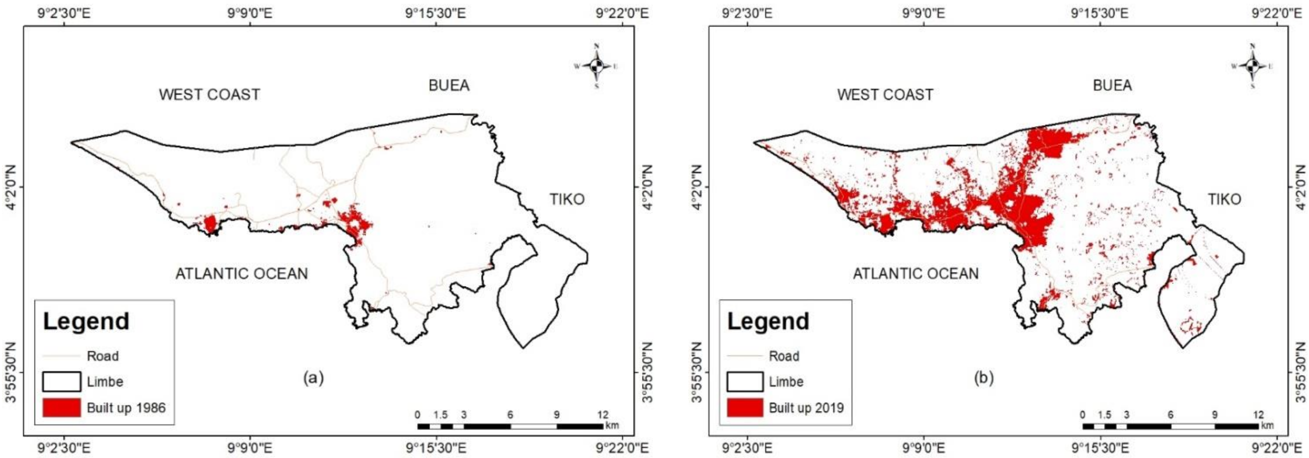

Figure 9: (a) Urban growth, 1986 and (b) Urban growth, 2019

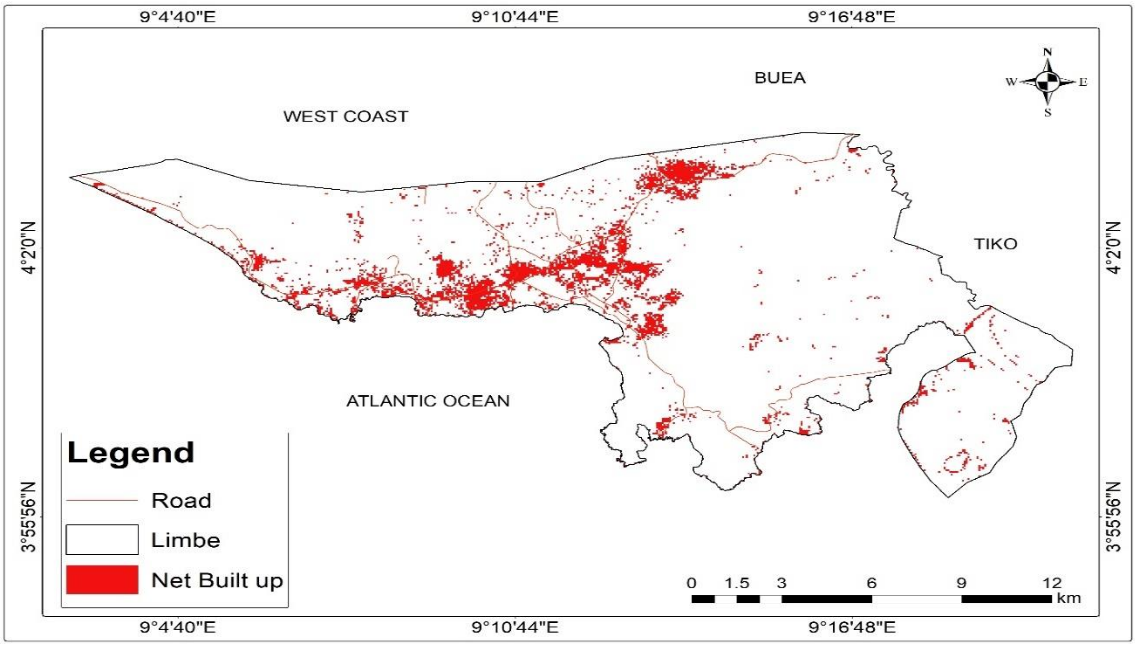

Figure 10: Net urban growth of Limbe during 1986-2019

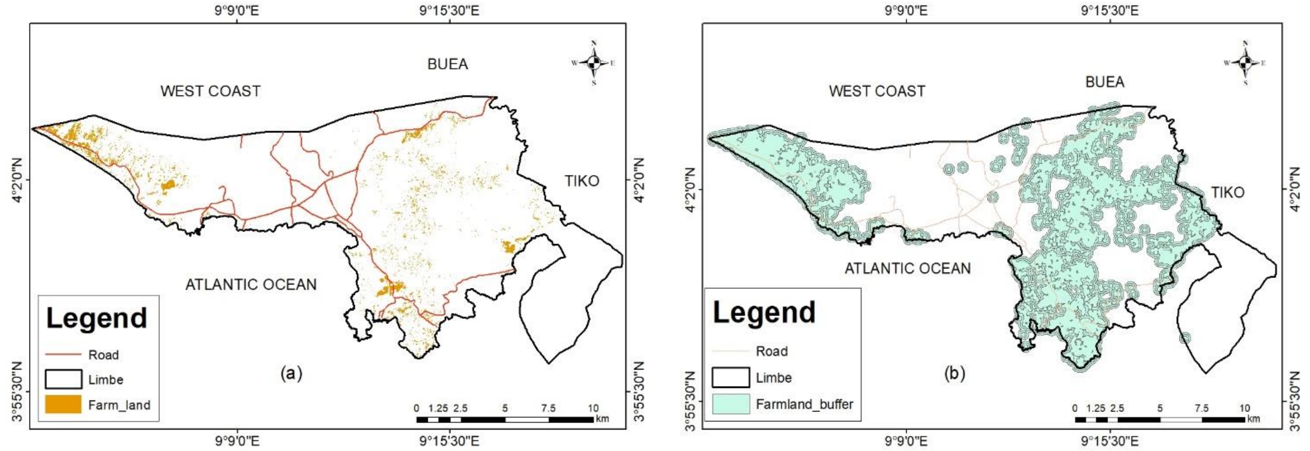

Figure 11: (a) Agriculture area map 2019 and (b) Agriculture area buffer

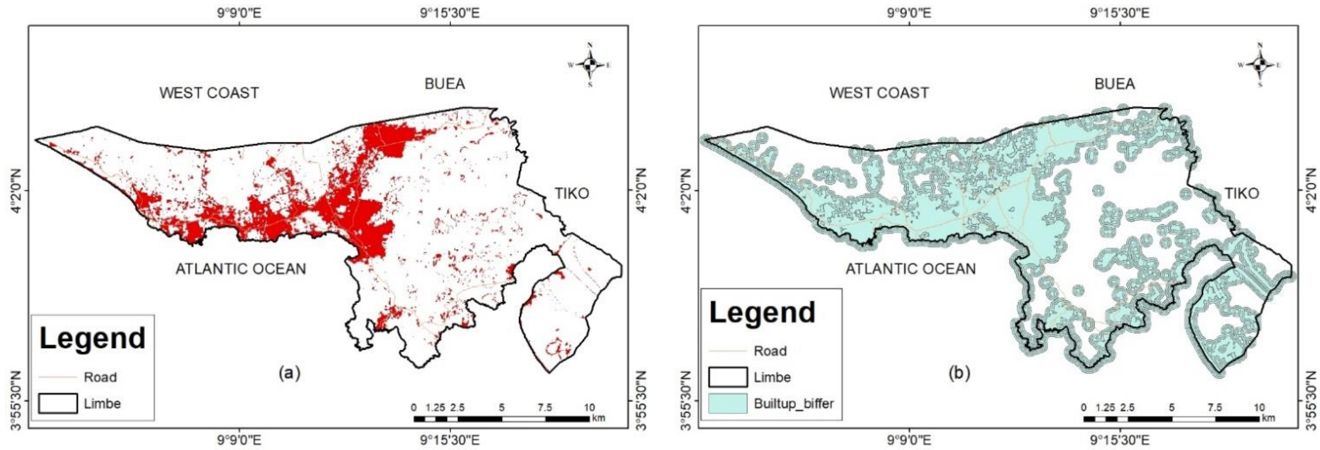

Figure 12: (a) Urban area map 2019 and (b) Urban area buffer

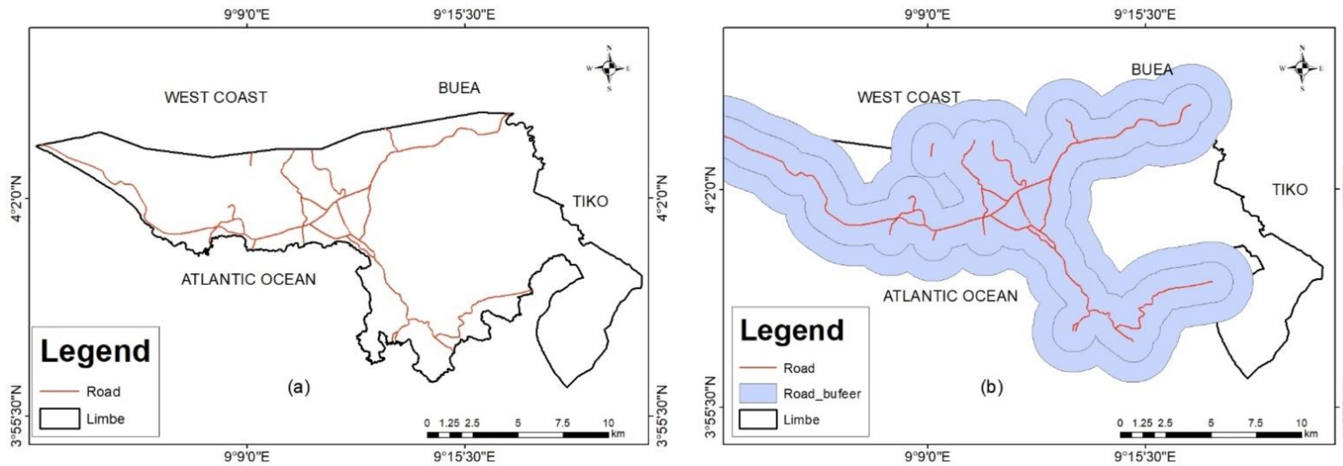

Figure 13: (a) Road map 2019 and (b) Road buffer

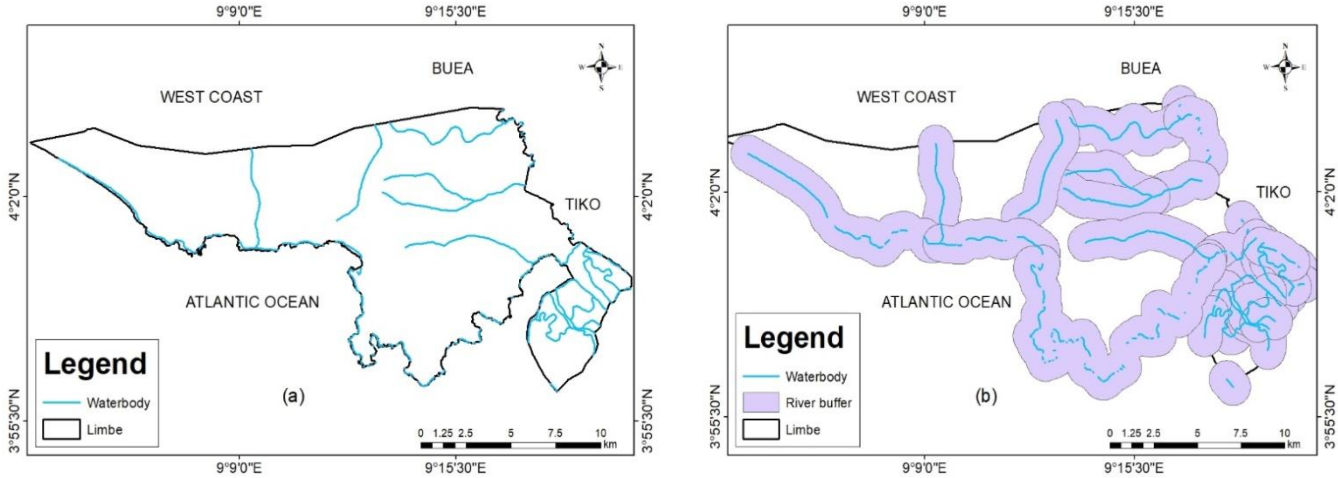

Figure 14: (a) River map 2019 and (b) River buffer

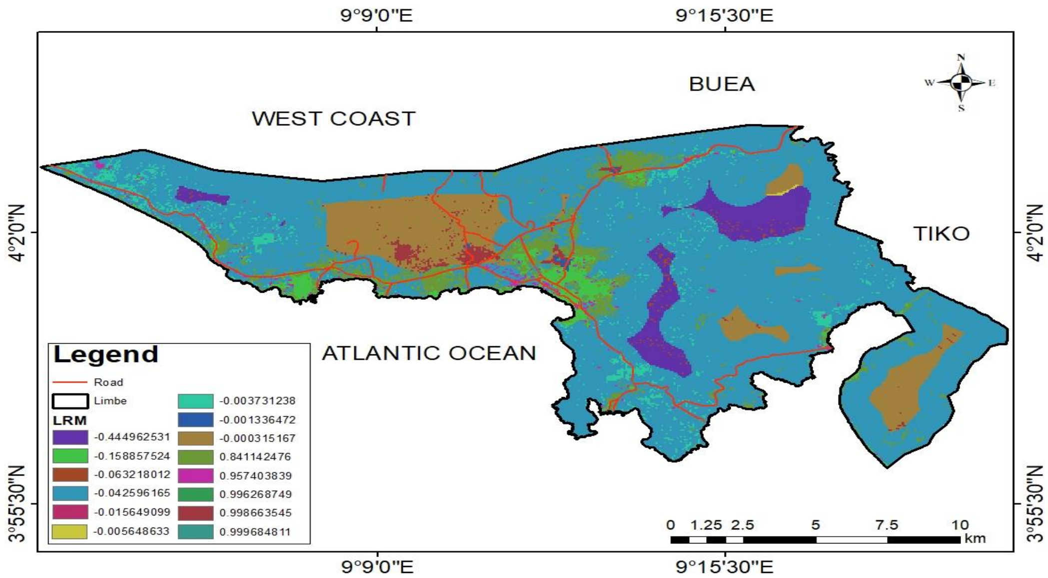

Figure 15: Logistic regression map for 1986-2019

Figure 9 and 10 shows the dependent variables which are maps of the urban growth area for 1986, 2019 as well as the net urban growth for the study period. Figure 11-14 are the maps showing the independent variables which include the agriculture area, river, road and urban maps and their buffers. Figure 15 indicates the LRM map for the study period.

3.5. Land use/land cover prediction of Limbe for year 2035

The prediction of land use for Limbe in 2035 is presented in transition probability matrix on table 7. From the probability table, the probability for build up to remain build up by 2035 appears to be quite high at 0.6345, while the probabilities for it changing to waterbody, bare land, farm land and vegetation are, 0.00, 0.0174, 0.0171 and 0.9805 respectively. The probability of vegetation remaining vegetation is 0.9408 and the probability of it changing to build up, waterbody, farm land, bare land and vegetation stands at 0.1099, 0.0459, 0.1939 and 0.1221, respectively.

Also, the probability of farm land remaining farm land is below average 0.0056. The probability for bare land to remain bare land is very slim, 0.3121 as indicated in Table 7. This may be attributed to the fact that much of the bare lands will be converted to layouts for construction purpose. This is because the probability of bare land changing to build up is 0.3380 which is very high. Figure 16 shows the prediction expansion map of Limbe for the year 2035.

Table 7: MARKOV transition probability matrix table

Classes	Farm land	Built up	Bare land	Vegetation	Waterbody
Farm land	0.0056	0.0459	0.1421	0.8064	0.0000
Built up	0.0175	0.6345	0.0856	0.2601	0.0023
Bare land	0.0000	0.1939	0.3121	0.4941	0.0000
Vegetation	0.0009	0.1221	0.1305	0.7430	0.0035
Waterbody	0.0053	0.1099	0.0000	0.1672	0.7177

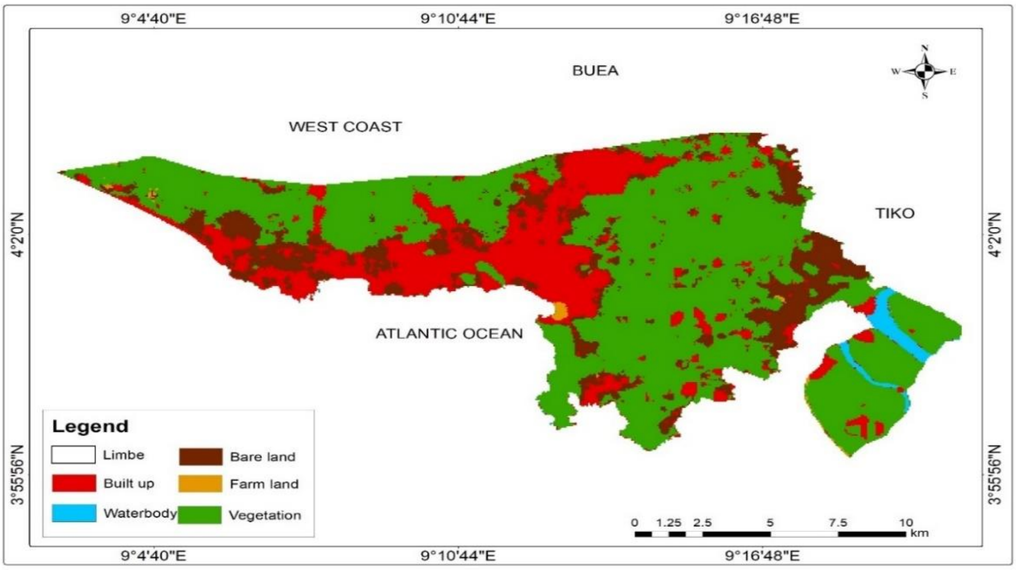

Figure 16: CA-MARKOV land use land cover for 2035

4.0. Conclusions

Urbanization is an inevitable process which increases with increase in population growth, industrialization and migration of people from rural areas in search of better living conditions. The aim of the present study is to form synergy with GIS and RS techniques and LRM to analyze and quantify urban growth patterns in Limbe city. This study specifically characterizes changes in LULC for the study period, model urban growth in the investigated area using LRM as well as project future growth rate for the year 2035. The projection date was chosen sequel to the Cameroon Vision 2035 that outlines the goals and priorities for the country in becoming an emerging economy by 2035. The LULC change results indicated patterns of a degraded and disturbed LULC and a continuous increase in urban land area. LRM was used in modeling the urban growth process. This implies that, a high probability of urban growth areas is near major roads, rivers, and towards agriculture zone. The transition probability matrix projected for 2035 reveal high probability (0.6345) for build up to remain build up by the year 2035. This study is successful in demonstrating the application of geo-spatial techniques and LRM for land use/land cover change detection and in understanding the urban growth dynamics. The study also helped in identifying the potential areas of future urban growth, which can help land use policy planners for making optimum decisions of land use planning and investment.

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Cite this article as:
Adzandeh E. A., Alaigba, D. and Nkemasong C. N., 2020. Application of Geospatial Techniques and Logistic Regression Model for Urban Growth Analysis in Limbe, Cameroon. *Nigerian Journal of Environmental Sciences and Technology*, 4(1), pp. 138-151. https://doi.org/10.36263/nijest.2020.01.0193

Nigerian Journal of Environmental Sciences and Technology (NIJEST)

www.nijest.com

ISSN (Print): 2734-259X | ISSN (electronic): 2734-2603

Vol 4, No. 1 March 2020, pp 152 - 159

Effect of Local Binary Mixtures of Coarse Aggregates on the Compressive Properties of Concrete

Eze O. K. and Nwankwo E.*

Department of Civil Engineering, Faculty of Engineering, University of Benin, Benin City, Edo State, Nigeria

Corresponding Author: *nwankwoebuka@yahoo.co.uk

https://doi.org/10.36263/nijest.2020.01.0172

ABSTRACT

Aggregates, though considered inert, are the primary components that define concrete's thermal and elastic properties. It has been shown that factors such as maximum aggregate size, grading, shape, strength, water absorption capacity of coarse aggregates affect the properties of concrete. However, improper grading of coarse aggregate could have adverse effect on the amount of cement and water requirement for concrete production. Thus, impacting on the workability, pump-ability and durability of concrete. By maintaining a slump of 50 mm, the effect of varying sizes of coarse aggregates – 10 mm, 14 mm, 20 mm, and combination of these sizes – on the mechanical properties of concrete was obtained. Aggregates, which were used in this work, were sourced from quarries located in Auchi area of Edo State and had impact values between 16% and 28%. It was observed that the higher the coarse aggregate sizes the lower the water – cement (w/c) ratio required to obtain adequate workability. Also, the compressive strength of concrete was observed to be a function of the size of the coarse aggregates used in the concrete mix. It was observed that concrete made with equal proportions of 10 mm and 14 mm coarse aggregate had lower strengths compared to concrete made with 14 mm and 20 mm aggregates. This implies that combination of large sizes of aggregates produced stronger concrete when compared to combinations of smaller sizes of aggregates. It was also observed that density of concrete increased with increasing size of aggregates.

Keywords: Aggregate, Grading, Regression, Compressive strength

1.0. Introduction

Aggregates constitute basic component of concrete usually constituting about 75 percent of the volume. The volume occupied by aggregates in concrete underscores its importance. The grading of fine aggregates (size less than 4.7 mm) and coarse aggregates (size greater than 4.7 mm) are generally required in concrete production.

Experiments have shown that the size, type, shape and grading of aggregates have significant impact on the mechanical properties of concrete (Molugaram *et al*., 2014; Vilane and Sabelo, 2016; Czuryszkiewicz, 1973; Ogundipe *et al*., 2018; Kalra and Mehmood, 2018; Tsiskreli and Dzhavakhidze, 1970). Many researchers have also investigated the effect of type and source of aggregate on the mechanical properties of concrete (Al-Oraimi *et al*., 2006; Ahmad and Alghamdi, 2012). Wu *et al*. (2019) investigated the effect of using crushed quartzite, crushed granite, limestone, and marble as coarse aggregate on the on the mechanical properties of high-performance concrete. They observed that the strength, stiffness, and fracture energy of concrete for a given water/cement ratio depend on the type of aggregate.

Bilal El-Ariss (2006) investigated the influences of the water/cement (W/C) ratio, coarse and fine aggregates (FA), CA/total aggregate (CA/TA) ratio, TA/C ratio, and curing methods (air curing, oven curing, and water curing) on the compressive strength of concrete. This work went on to develop mathematical formula for calculating concrete strength as a function of CA quantity that ranges from the standard quantity to null, and another formula was developed for the quantity of FA as a function of compressive strength. In-depth analyses have been conducted by researchers to establish the effect of aggregates on concrete. By using advanced image analysis technique, it was observed that aggregates with limestone geology and shape characteristic (i.e. with higher circularity and aspect ratio) performed well in the production of higher strength concrete in comparison to other aggregates (Sadiq *et al*., 2019).

It has been established that aggregates have significant effect on other mechanical properties of concrete, apart from basic properties related to compressive strength. The effect of aggregate size on fracture energy, tensile strength and elasticity modulus of concrete has also been investigated (Rocco and Elices, 2009; Arslan and Kamas, 2017). Rocco and Elices (2009) found that concrete made with crushed aggregate shows slightly higher fracture energy than concrete made with spherical ones. Their work showed that fracture energy increases with aggregate size for both types of aggregates. Also, it has also been shown that in a concrete beam made with fine fractions of coarse aggregate, the fracture energy, final displacement at the mid-span and splitting tensile strength are higher than those of the concrete with coarse fraction (Akcay and Tasdemir, 2006).

It has also been observed that grading and source of granite have significant effect on the strength of concrete. Okonkwo and Arinze (2015) observed that concrete with coarse aggregate sizes of 20 mm exhibited higher compressive strength than concrete made aggregates of lower sizes. However, this work does not show the effect of combining various sizes of aggregate on the compressive of concrete.

2.0. Methodology

Ordinary Portland Grade 30 cement (which confirms to ASTM 150 standards) was used in this research. Accompanying coarse and fine aggregates were obtained from Okhuahia in Edo State and Auchi in Edo State, respectively. Sieve analysis -using BS 410:1986- was conducted for aggregates obtained as shown in Figures 1 and 2. From the aggregates obtained for this study, uniform grade sizes of 10 mm, 14 mm and 20 mm were obtained.

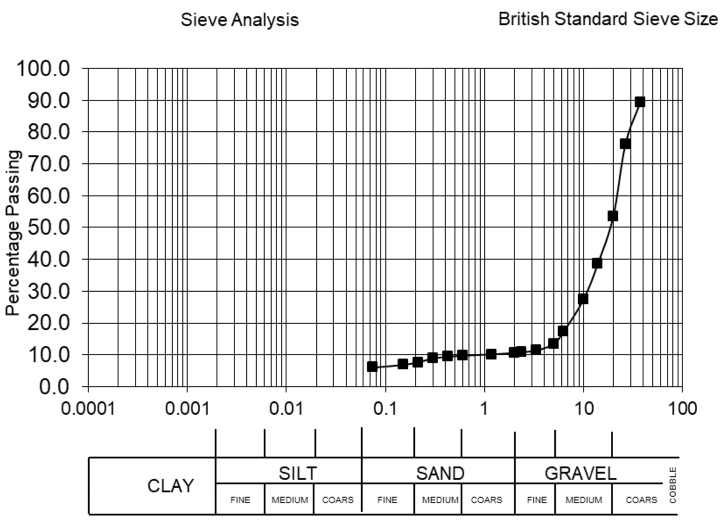

Figure 1: Sieve analysis for coarse aggregate used

The mix design method adopted is the British method of mix design restricted to designing concrete mixes to meet workability, compressive strength and durability requirements using Ordinary Portland cements complying with BS 12 or BS 4027 and natural aggregates complying with BS 882. Table 1 shows the mix ratios used in batching a cubic meter of concrete. The mix ration adopted in Table 1 is equivalent to the mix ratio obtained for Grade 40 concrete in (Hamad and Dawi, 2017).

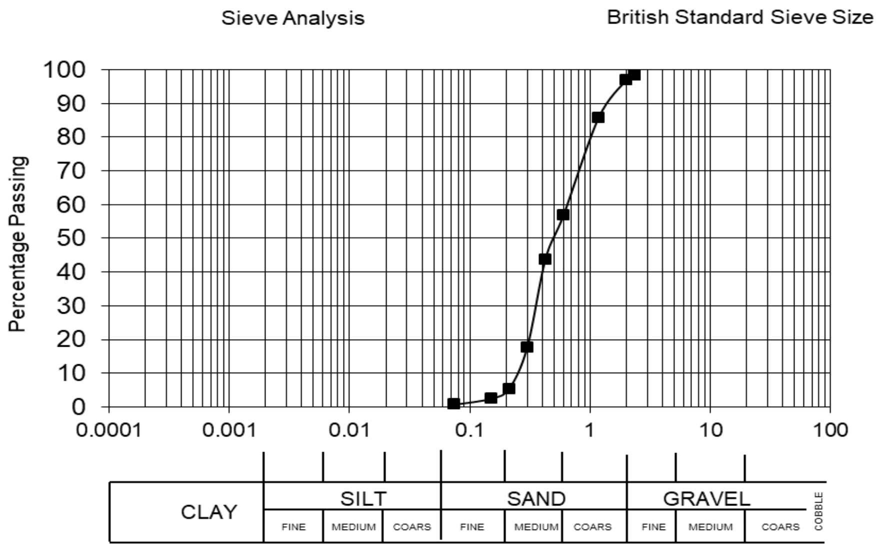

Figure 2: Sieve analysis for fine aggregate used

Table 1: Mix design used for research

Cement (kg/m^3)	Fine aggregate(kg/m^3)	Coarse aggregate (kg/m^3)
420	708	1062

Slump test was conducted on samples in accordance with BS EN 12350-2:2009. The mould used for the slump test was a conical frustum, 300 mm high. The mould was placed on a smooth surface with the smaller opening at the top and filled with concrete in three layers. Each layer was tamped 25 times with a standard 16 mm diameter and 60 cm long steel tamping rod, rounded at the end and the top surface of the final layer was smoothened with a trowel. The mould was firmly held against its base during the entire operation. Immediately after filling was done, the cone was slowly lifted and the unsupported concrete was slumped, hence, the name slump test. The decrease in height of the highest part of the slumped concrete is called the slump and is measured to the nearest 5 mm. In practice, concrete with slump between 50 -90 mm are generally regarded as concrete with medium workability. In this work, a fixed workability of 50 mm was used for all concretes.

The compressive strength of cast concrete cubes, after curing, was obtained by crushing after 7, 21 and 28 days, respectively. Curing was achieved by placing cast concrete cubes in a pure water curing bath. Cubes were removed from curing bath and allowed to dry, weighed and placed in the compression machine for crushing according to specification of BS 1881 part 1, 1970. The crushing load was applied at a rate of 15 N/mm^2 per minute. A total of 42 cubes were tested for each concrete made with the following aggregate sizes and combinations: 10 mm, 14 mm, 20 mm, 10/14 mm, 14/20 mm, 10/20 mm and 10/14/20 mm.

3.0. Results and Discussion

The specific gravity of coarse aggregates used ranged between 2.72 and 2.86. The average aggregate impact value of coarse aggregate used is 21.84%. Average values of compressive strengths from samples were used to establish points on Figures 3 to 8. The average values used to establish points were between ±3% of the largest and minimum values obtained for each point.

Table 2 shows the different water cement ratios required to achieve a slump of 50 mm for the various concrete mixes with varying aggregates sizes. It was observed that workability is a function of coarse aggregate size in a mix. It was observed that the higher the coarse aggregate sizes the lower the water – cement ratio required obtain adequate workability. This is because the water content required to produce a workable concrete is less for concrete made with large coarse aggregate size than the water content to produce a concrete of same workability with smaller size coarse aggregate.
Figure 3 shows that the compressive strength of concretes – with the same slump -- made with varying sizes of aggregate. As shown in Figure 3, compressive strength increases as the size of aggregates increased.

Table 2: Water cement ratio for different aggregates

Aggregate sizes in mm	Water Content (kg/m^3)	w/c ratio
10	210	0.5
14	195	0.48
20	180	0.44
10/14	195	0.48
10/20	185	0.45
14/20	185	0.45
10/14/20	195	0.48

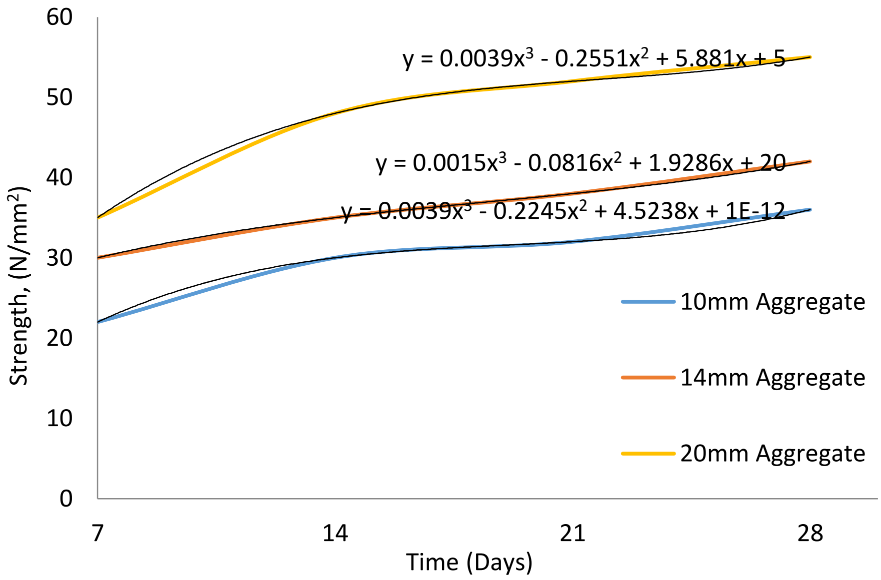

Figure 3: Compressive strength test result of made with same size coarse aggregate grade

Figure 4 shows the effect of combining other sizes of aggregates with 14 mm and aggregates. It is observed that combining 14 mm and 20 mm sized aggregates, in equal weights, produced concrete with higher strengths when compared combinations with 10 mm and the 10 mm/14mm/20 mm combination.

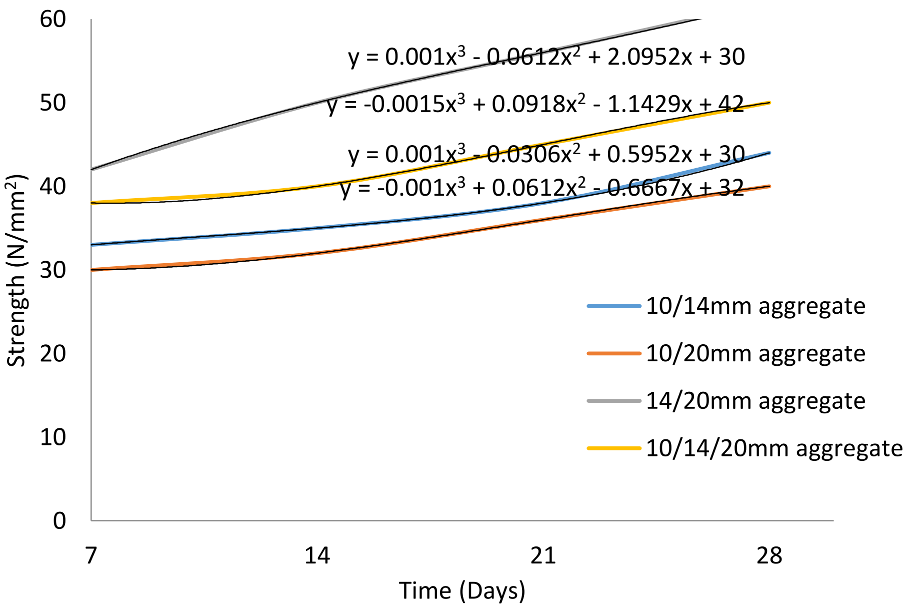

Figure 4: Trendlines for compressive strength test result of concrete made with different sizes of aggregate and grading

Figure 5 shows the effect of combining other sizes of aggregates with 10 mm and aggregates. It is observed that combining 10 mm, 14 mm and 20 mm sized aggregates, in equal weights, produced concrete with higher strengths when compared to individual combinations with 14mm and 20 mm aggregates.

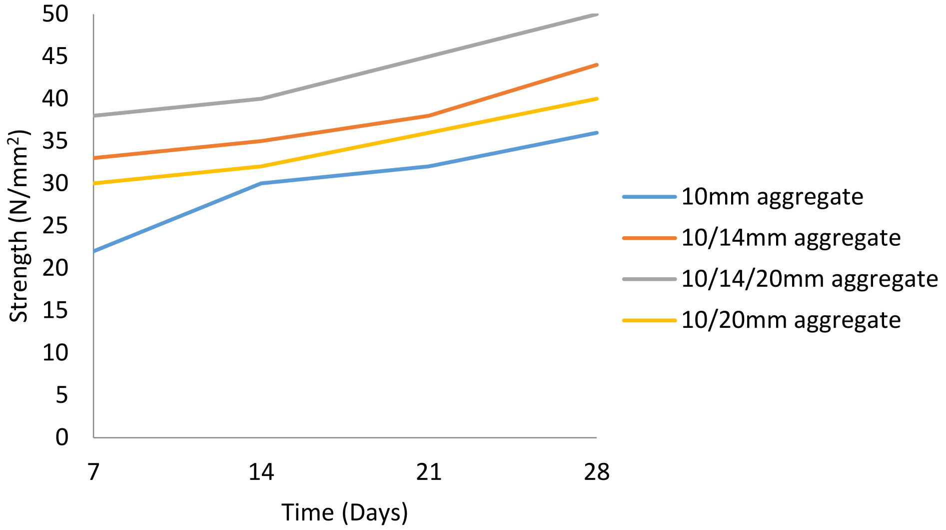

Figure 5: Comparison between concrete made with 10 mm aggregates and varying proportions of higher sizes

Figure 6 and 7 show that combining 14 mm and 20 mm sized aggregates, in equal weights, produced concrete with higher strengths when compared 10 mm/14mm and 10 mm/14 mm /20 mm combinations aggregates.

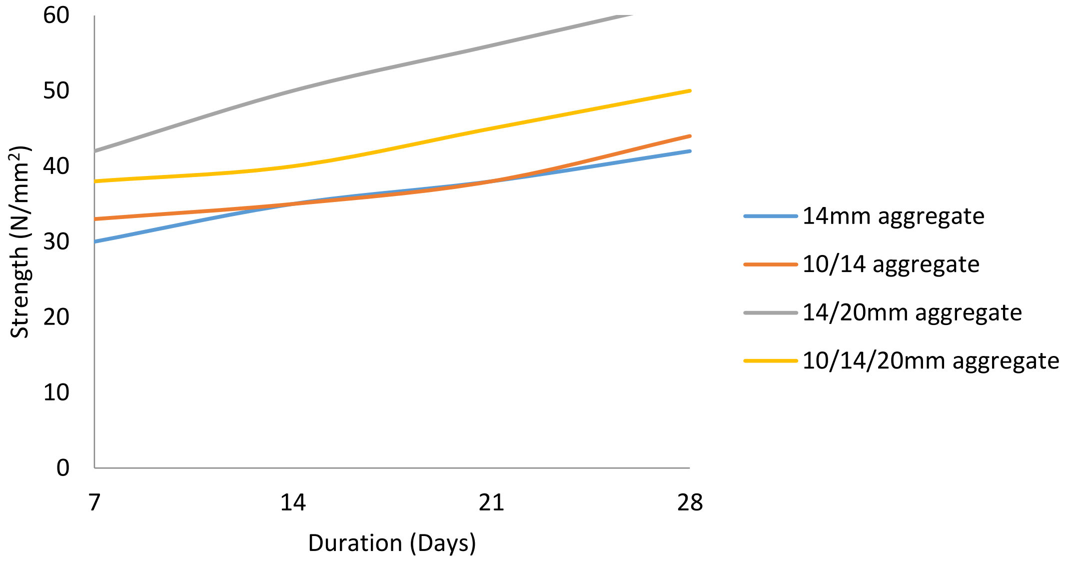

Figure 6: Comparison between concrete made with 14 mm aggregates and varying proportions of other sizes

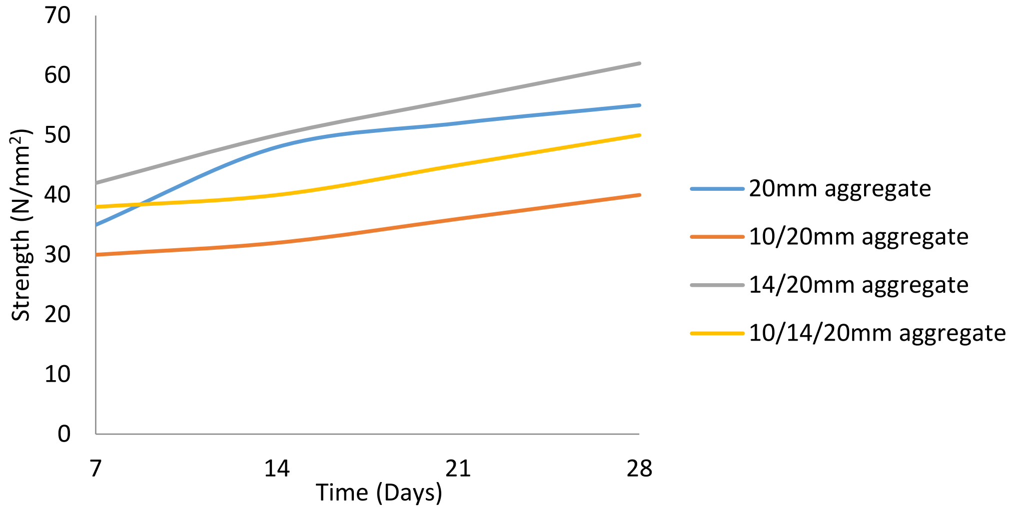

Figure 7: Comparison between concrete made with 14 mm aggregates and varying proportions of other sizes

Figure 8 shows the density of concrete increases as the sizes of aggregates used increases.

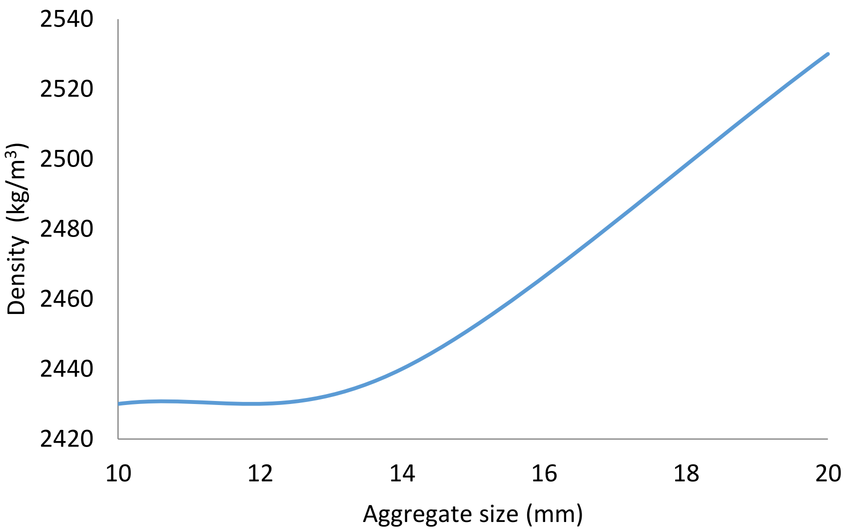

Figure 8: Varying density of concrete prepared with different aggregate

4.0. Conclusions

10 mm, 14 mm and 20 mm aggregates are the prevalent coarse aggregate used in local construction in Nigeria. Preparation of concrete for local construction usually involves proportioning these common sizes to produce concrete. Thus, it is imperative to understand how the combination of these aggregates impact on the compressive strength of concrete. It was observed that the higher the coarse aggregate sizes the lower the water – cement ratio required to obtain adequate workability. This is traced to surface area of the coarse aggregate. The smaller the aggregate size in a grade the greater the surface area needed to be wetted which is a function of the water requirement. It is important to note that the water absorption rates of the aggregates were not investigated in this work. However, all aggregates used in this work were sourced from the same source.

Experimental results obtained from using these sizes of aggregates and show that:

1. The density of concrete produced increases as the sizes of aggregates increased. Concrete made with single aggregates sizes of 20 mm showed significant increase in density when compared to concrete made with less sizes of single aggregates
2. Compressive strength increases as the size of aggregates increased.

3. Concrete with graded aggregates having aggregate sizes of 20 mm showed improved compressive strengths when compared to concretes made with graded aggregates with lower sizes

Concrete made with graded aggregates show higher strengths when compared to concrete made with single sized aggregate. This can be explained by the fact that well graded aggregates produce well compacted and denser concrete by ensuring that voids within the concrete are at a minimum.

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Cite this article as:
Eze O. K. and Nwankwo E., 2020. Effect of Local Binary Mixtures of Coarse Aggregates on the Compressive Properties of Concrete. *Nigerian Journal of Environmental Sciences and Technology*, 4(1), pp. 152-159. https://doi.org/10.36263/nijest.2020.01.0172

Nigerian Journal of Environmental Sciences and Technology (NIJEST)
www.nijest.com
ISSN (Print): 2734-259X | ISSN (electronic): 2734-2603
Vol 4, No. 1 March 2020, pp 160 - 171

GIS based Flood Vulnerability Studies for Ife Central Local Government Area, Osun State, Nigeria

Ijaware V. A.
Department of Surveying and Geoinformatics, Federal University of Technology, Akure, Ondo State, Nigeria
Corresponding Author: vaijaware@futa.edu.ng

https://doi.org/10.36263/nijest.2020.01.0184

ABSTRACT

Flood has negatively affected Ife Central Local Government Area of Osun State, Nigeria. This work is aimed at mapping the vulnerability of the area flood. Its objectives addressed the ranking of various natural and artificial factors causing flood, the determination and delineation of vulnerability to flood in the study area. Using remote sensing and GIS techniques, coordinates of flooded sites were acquired with Global Navigation Satellite Systems receiver; Landsat 8 data were acquired from the USGS website. To map land use, elevation data were acquired from the Shuttle Radar Topographic Mission Digital Elevation Models, soil data was obtained from the Nigerian Geological Survey website, and rainfall data was acquired from Tropical Rainfall Measuring Mission satellite. Using Pairwise Comparison, the various weights of factors constituting flood in the area were acquired. Weighted Linear Combination and Analytical Hierarchical Process was used in producing the flood hazard and flood vulnerability maps. ArcGIS10.2 Software was used in spatial and attribute data acquisition, processing, and information presentation. The Pairwise Comparison method adopted was validated and observed to have a consistency ration of 0.003. Results obtained show that 9.2% of the study area is highly prone to flood hazards, 20.4% is prone to flood hazard and 44.3% is moderately prone to flood hazard. The method adopted correctly identifies all existing flood incidence areas within the flood-prone areas in the hazard map. The maps produced will serve as an effective tool to aid the prevention and mitigation of flood disaster in the flood-prone area.

Keywords: AHP, Flood Vulnerability, Remote Sensing, GIS, Shuttle Radar Topographic Mission

1.0. Introduction

Flooding is the overflow of water where it is not wanted, a scenario that occurs when part of the earth's surface which is usually dry is covered with water due to high rainfall or other water body overflow substances. Flood is a major disaster that affects many countries of the world annually. The threat to lives and properties by flood is an annual event in urban centres of many countries. Flooding is frequently triggered by heavy rainfall on relatively flat terrains, failure of reservoirs, volcano, snow and/or glaciers melting, etc. To evaluate the impact of flood in a society, a flood risk assessment is usually carried out. Flood risk assessment is based on the history of several variables which include; rainfall, river flow, tidal surge information, topography, flood-control measures, and alterations due to flood plain construction and growth etc. Amidst the variables that cause flooding, heavy rainfall invariably precedes them in Nigeria. Other causes of flooding include moderate to serious water winds, uncommon elevated tides, tsunamis caused by undersea earthquakes, dam breaks or failures, levees, retention ponds or lakes, and other water-retaining infrastructure. In towns and outskirts, pavement and rooftops contribute to the inability of the soil to absorb rainfall, thereby leading to flooding in the Urban Centres (Dor, 2017).The attendant negative effects of floods on man and his environment make it quite important to map vulnerability to flooding.

Flood disasters have affected the lives of several people more than most natural disasters (Klemas, 2015; Komolafe *et al*., 2015; Orimoogunje *et al*., 2016). The negative effects of flooding are most times irreversible. Several works have been done to identify flood risk, map flood hazard, and assess vulnerability to flooding globally and locally. Of significance is the review of Klemas (2015) on the remote sensing of flood and flood-prone areas. Modelling techniques for forecasting vulnerability to flooding were discussed and rules of thumb were represented for forecasting vulnerability to flooding; part of the methods presented are implemented in this research. Furthermore, Ouma and Tateishi (2014) presented a methodological overview of multi-parametric AHP and GIS techniques in carrying out an Urban flood vulnerability assessment and risk mapping.

Unfortunately, the repetitive flooding of Ile-Ife has continued to grow regardless of the existence of literature to curb its effects. The problem has been that of non-implementation of existing principles, part of which includes the assessment of vulnerability to flooding, and the implementation of knowledge gained from such assessment. Negative effects of flooding have continued to impact lives and properties in Ife Central LGA. Alfred (2018) explained a situation where communities within Ife Central LGA such as Aserifa, Damico, Ede Road, Mayfair and Parakin were impacted by the flood disaster in the year 2018, leading to the submerging underwater of several shops and homes. This work adopts the multi-parametric AHP and GIS techniques of Ouma and Tateishi (2014) using AHP and Multi-Criteria Decision Analysis to map flood hazard and determine vulnerability to flooding in Ife Central LGA.

2.0. Methodology

2.1. Study Area

Ife central as shown in Figure 1 is a Local Government Area in Osun State, having its headquarters in the city of Ile Ife to the south of the area, which is part of Ife (an ancient Yoruba city in south-western Nigeria). Ife central LGA has a population of 167, 254 according to 2006 population census and with an area of 110 square kilometres and approximately lies within Latitudes and Longitudes (7°34', 4°29'), (7°37', 4°32'), (7°32', 4°35'), and (7°28', 4°34').

The climate of Ife Central LGA is characterized after the tropical rainforest of rainy wet and dry seasons. The rainy season lasts between April and October, while the dry season extends from November to March annually. The annual rainfall of Ife-Central is around 1340 mm and the mean annual temperature fluctuates around26.2°C (Climate-Data.org, n.d.). The elevation ranges between 236m - 449m above mean sea level.

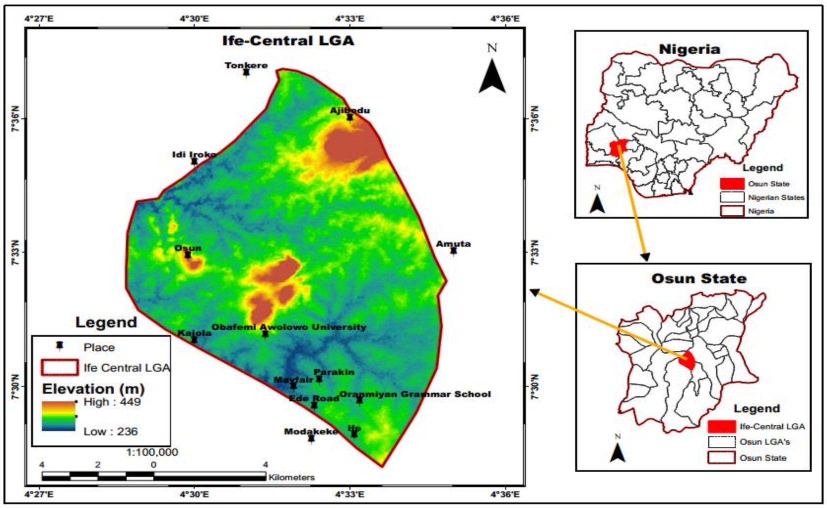

Figure 1: Study area map

2.2. Data Source

Coordinates of places with prior history of flooding within the study area were acquired using GARMIN Etrex 20 handheld GNSS receiver. Shuttle Radar Topography Mission (SRTM) Digital Elevation Model (DEM) data was acquired from the United States Geological Survey (USGS) website; annual rainfall data for the year 2018 was obtained from Tropical Rainfall Measuring Mission (TRMM) satellite data, Landsat 8 was acquired from the USGS website for land use/land cover mapping; Soil vector data was acquired from the Nigerian Geological Survey, and the administrative boundary was obtained from the Office of the Surveyor-General of the Federation

(OSGOF). Table 1 shows the type of the data acquired for the flood mapping, their format, scale/resolution, year of acquisition and source.

Table 1: Flood mapping data sources

S/N	Type	Format	Scale/ Resolution	Year	Source
1	Shuttle Radar Topography Mission	Digital	30m	2018	United States Geological Survey (USGS)
2	Landsat OLI/TIRS	Digital	30m	2018	United States Geological Survey (USGS)
3	Rainfall	Digital	30m/ Annual Rainfall Data	2018	Tropical Rainfall Measuring Mission (TRMM)
4	Soil Map	Digital	Vector File/ No Resolution		Nigerian Geological Survey
5	Administrative Map	Digital	Vector File/ No Resolution	2017	Office Of The Surveyor General Of The Federation (OSGOF)
6	GPS Coordinates	Digital		2019	Field Data

2.3. Methods

Figure 2 shows the method adopted for this study.

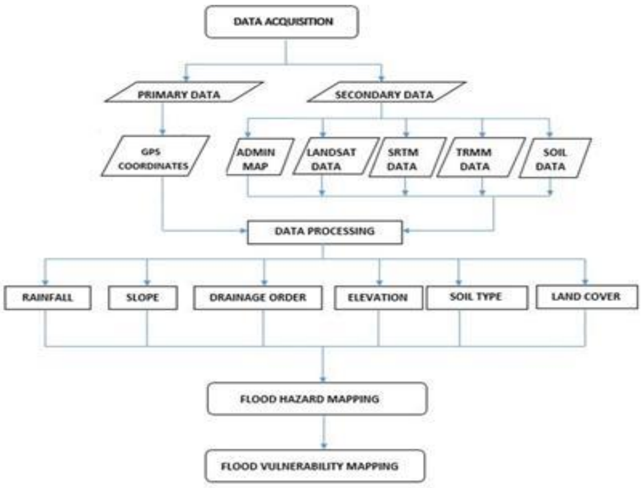

Figure 2: Flood hazard and vulnerability mapping methodology flow

2.3.1. Flood risk criteria data acquisition and processing

Ife-Central L.G.A, Osun State, and Nigeria shapefile were identified from the Administrative vector file acquired from OSGOF to produce the study area map shown in Figure 1 on ArcGIS software. Figure 2 shows the flow of methods applied in carrying out the flood hazard and vulnerability mapping. UTM Coordinates of existing flood sites were acquired using the GARMIN Etrex 20 handheld GNSS receiver. The elevations of the study area were mapped out from the obtained SRTM 30M DEM data in ArcGIS 10.4.1 environment. The Digital Elevation Model (DEM) of the study area was used to extract slope and drainage as input in the analysis. The slope of the area was mapped from the DEM extracted from SRTM using the spatial analysis tool of the ArcGIS toolbox. The rainfall data were extracted from the TRMM satellite data. The X, Y, and Z (Rainfall) were imported into the ArcMap environment. Inverse Distance Weighted (IDW) spatial interpolation technique was employed in the arc-tool box to produce a surface map of the rainfall.

Soil types of the study area were extracted from the soil map of the Nigerian Meteorological Agency (NIMET). The soil map of the area was further reclassified based on the infiltration rate to incorporate the Spatio-temporal infiltration rate of the area into the flood hazard and vulnerability determination process. The land use/land cover map for the study area was produced from Landsat 8. The Landsat data acquired in 2018 was processed in ArcGIS 10.4.1 environment. Having obtained data of different coordinate systems from disparate sources, all the data were converted into Universal Transverse Mercator (UTM) WGS84 datum in the ArcMap environment to have a uniform coordinate system and to aid correct overlay of the data.

2.3.2. Flood risk criteria ranking

Six (6) of the different criteria identified were considered as the main factors necessary for assessing flood risk and measuring its hazard for the study. The factors include; elevation, drainage density, precipitation amount (rainfall), slope, soil type, and land cover. All criteria were reclassified, and a linear function was used to assign preference value to different classes. The unified preference value ranges from 1 to 4, which is equivalent to 25 to 100. 1(25) is the minimum preference value and 4(100) signifies high preference value. The unified preference values for classes in every criterion are shown in Table 2 to Table 7.

Elevation:

The elevation of the study area derived from SRTM DEM is shown in Figure 3. The elevation was reclassified based on their effect on flooding. Areas with the least elevation were ranked 4 while areas with the highest elevation were ranked 1. Red in Figure 3 shows elevation ranges between 236m-270m, pink shows elevation between of 271m-298m, yellow shows elevation within 299m-353m and Blue shows elevation range of 354m-449m. Table 2 shows the elevation ranges, preference value, and flood hazard class of the elevation criteria.

Table 2: Unified preference value for elevation

Elevation (m)	Preference Value	Unified Value	Flood Hazard class
236-270	4	100	Very high
271-298	3	75	High
299-353	2	50	Moderate
354-449	1	25	Low

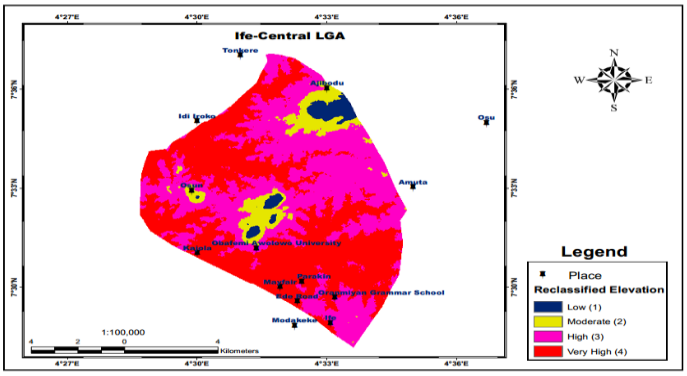

Figure 3: Elevation of the study area

Slope:

Figure 4 shows the slope of the reclassified slope map of the study area as derived from the SRTM DEM using ArcGIS software. Table 3 shows the preference value of degrees of slope areas with the lowest degree of slope (0-23) were ranked high preference value for slope while areas with 55-85 were ranked lowest.

Table 3: Unified preference value for degree of slope

Slope (degree)	Preference Value	Unified Value	Flood Hazard class
0-23	4	100	Very high
24-38	3	75	High
39-54	2	50	Moderate
55-85	1	25	Low

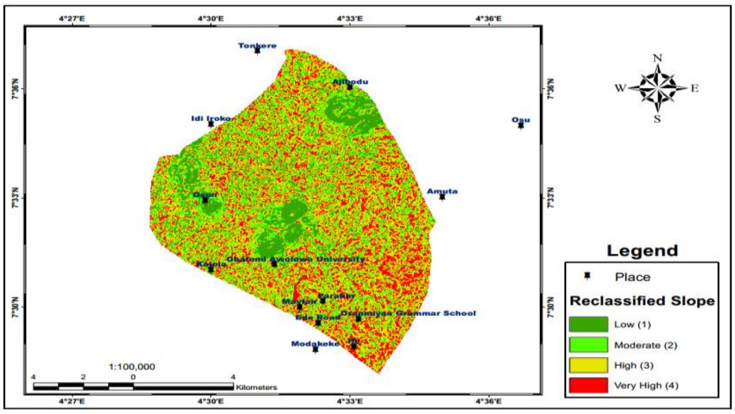

Figure 4: Slope map of the study area

Drainage density:

A drainage density map was produced for the study area and the layer was further reclassified in four preference classes. Areas with very low drainage density are dry areas which were ranked as 4 and those with very high drainage density are wet areas, which were ranked with a value of 1 as depicted in Table 4 and Figure 5. The higher the density, the higher the catchment area is prone to flood, resulting in sedimentation at the lower grounds.

Table 4: Unified preference value for drainage density

Drainage density (m)	Preference Value	Unified Value	Flood Hazard class
1-108	1	25	Low
109-173	2	50	Moderate
174-239	3	75	High
240-358	4	100	Very high

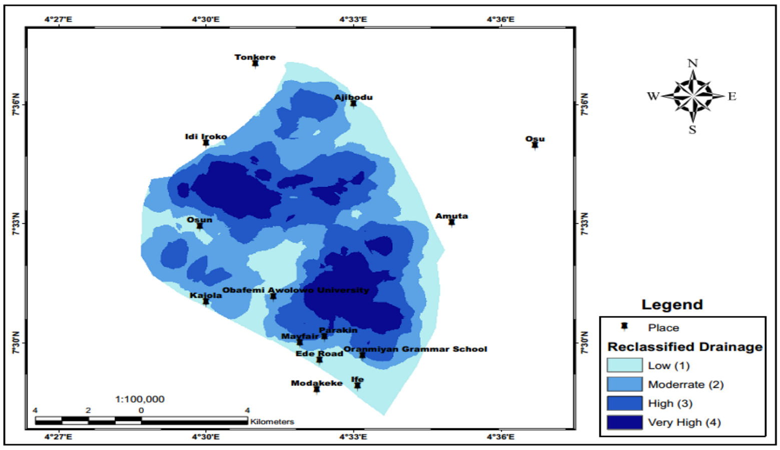

Figure 5: Drainage density map of study area

Rainfall:

The annual rainfall for the year 2018 ranges between 1278mm – 1344mm. The rainfall was reclassified based on the ranges. The preference value was ranked based on the increase of precipitation values. Places with high rainfall are more prone to flood while areas with a low amount of rainfall are less prone to flood. The rainfall distribution and unified preference values are shown in Table 5 and Figure 6.

Table 5: Unified preference value for rainfall distribution

Rainfall distribution (mm)	Preference Value	Unified Value	Flood vulnerability class
1,278-1,290	1	25	Low
1,291-1,307	2	50	Moderate
1,308-1 ,330	3	75	High
1,331-1,334	4	100	Very high

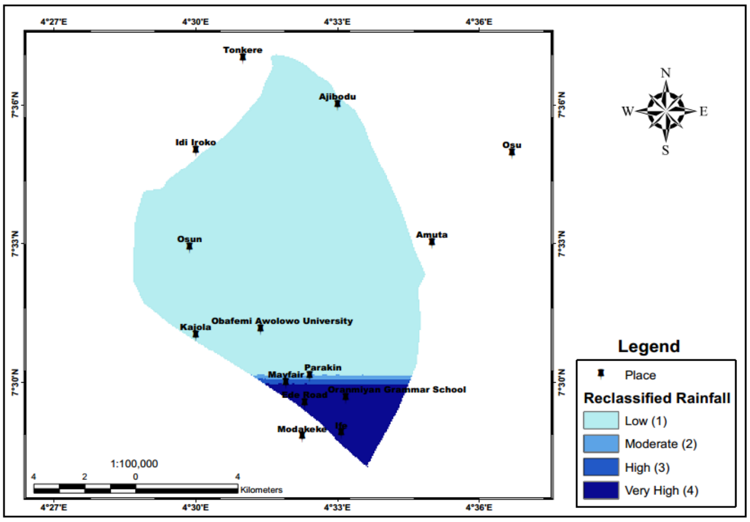

Figure 6: Reclassified rainfall distribution map

Soil:

The soil map of the study area shows two major types of soil, which are loam and sandy loam as shown in Figure 7. Preference value was assigned to soil types based on their infiltration rate as shown in Table 6.

Table 6: Unified preference value for soil type

Soil Type	Infiltration Rate (mmhr^{-1})	Preference Value	Unified Value	Flood vulnerability class
Sandy Loam	20-30	1	25	Low
Loamy Sand	15-20	2	50	Moderate

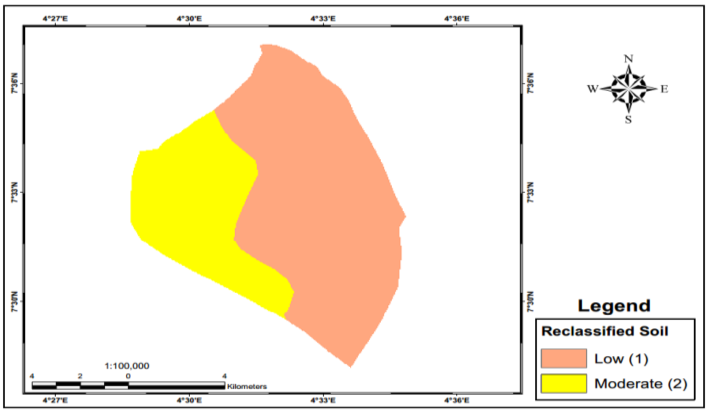

Figure 7: Soil type of the study area

Land cover:

The land use land cover assessment carried out showed six classes, which include; water body, built-up areas, bare land, grassland, bushland and forest covers as shown in Figure 8. Forest, bush-land/grassland stores water and reduce the runoff of rainwater. Land cover classes were reclassified according to their respective preference values. Figure 9 shows the reclassified land cover map.

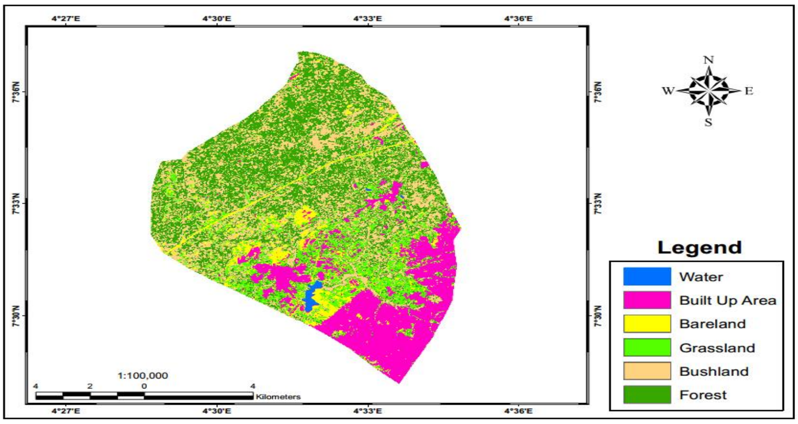

Figure 8: Land cover map of the study area

Table 7: Unified preference value for land cover

Land cover	Preference Value	Unified Value	Flood vulnerability class
Forest	1	25	Low
Bushland	1	25	Low
Grass Land	2	50	Moderate
Bare surface	3	75	High
Built-up Area	3	100	High
Water	4	100	Very high

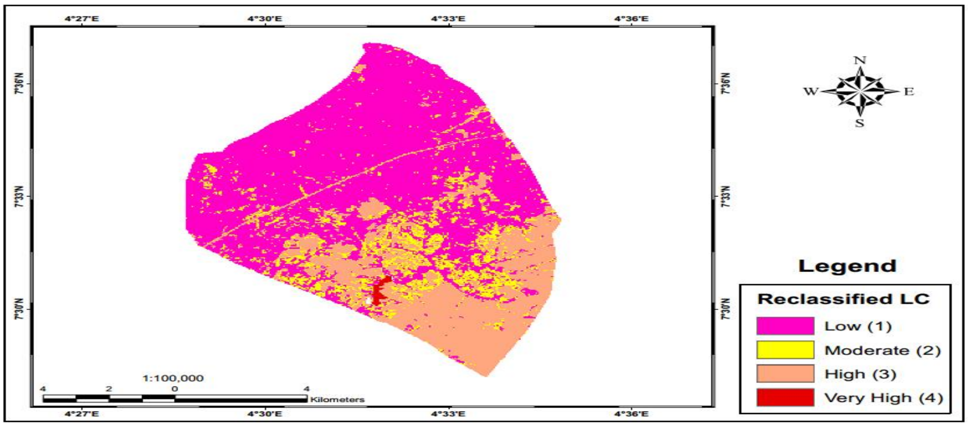

Figure 9: Reclassified land cover map of the study area

2.4. Multi-criteria decision making

Using the Weighted Linear Combination (WLC) method, all the map layers (the factors) were overlaid in the final GIS spatial analysis for flood vulnerability zones simulation. The WLC technique was carried out using ArcGIS software. The output of this WLC method produced a map that simulated the most potential flood susceptible zones for flood vulnerability mapping.

2.5. Data quality

To ensure the quality of the data utilized, accuracy assessments were carried out on the land cover classification. The overall classification accuracy was 86.8%. Furthermore, rainfall station data of some points (10 points) within the study area obtained from the Nigerian Meteorological (NIMET) Agency were plotted against the rainfall data obtained from the Tropical Rainfall Measuring Mission (TRMM) to validate the accuracy of the rainfall data obtained from TRMM. The correlation coefficient (r^2) between the TRMM data and NIMET data was 0.85, indicating that there was a strong or almost perfect positive correlation between the rainfall data from both sources. Also, elevation data obtained through ground technique were used in validating the accuracy of the elevation data obtained from the Shuttle Radar Topography Mission (SRTM). The correlation coefficient (r^2) between the SRTM and ground data was 0.76, thereby indicating a strong positive correlation between the two data from disparate sources. Ground truthing was carried out to validate the flood hazard maps produced from the AHP model.

3.0. Results and Discussions

Datasets including coordinates of points, DEM, soil, land use, and precipitation were structured, reclassified and symbolized using ArcGIS 10.4. The results of the processes show the criteria for flood risk and various ranking of each objective. Subsequent steps show how the flood hazard maps and flood risk vulnerability maps were produced using.

3.1. Pairwise comparison

Table 8, Table 9 and Table 10 shows the results of the pairwise comparison, ranking of the criterion and the interpretation of symbols used in depicting the different factors.

$$\begin{matrix} E_{(1,1)}\ E_{(1,2)}\ \ E_{(1,3)}\ \ \dots E_{(1,n)} \\ E_{(2,1)}\ E_{(2,2)}E_{(2,3)}\ \ \dots E_{(2,n)} \\ E_{(n,1)}\ E_{(n,2)}\ \ (E_{(n,3)}\ \ \dots E_{(n,n)} \end{matrix} \tag{1}$$

Table 8: Matrix of pair-wise comparisons of the six criteria for the AHP process

	C1	C2	C3	C4	C5	C6
C1	1.00	2.00	3.00	4.00	5.00	6.00
C2	0.50	1.00	1.50	2.00	2.50	3.00
C3	0.33	0.67	1.00	1.33	1.67	2.00
C4	0.25	0.50	0.75	1.00	1.25	1.50
C5	0.20	0.40	0.6	0.80	1.00	1.20
C6	0.17	0.33	0.5	0.67	0.83	1.00
SUM	2.45	4.90	7.35	9.80	12.25	14.70

(Source: Author, 2018)

Table 9: Determined relative criterion weights

	C1	C2	C3	C4	C5	C6	WEIGHTS	PERCENT%
C1	0.41	0.41	0.41	0.41	0.41	0.41	0.41	41%
C2	0.20	0.20	0.20	0.20	0.20	0.20	0.20	20%
C3	0.14	0.14	0.14	0.14	0.14	0.14	0.14	14%
C4	0.10	0.10	0.10	0.10	0.10	0.10	0.10	10%
C5	0.08	0.08	0.08	0.08	0.08	0.08	0.08	8%
C6	0.07	0.07	0.07	0.07	0.07	0.07	0.07	7%
SUM	1.00	1.00	1.00	1.00	1.00	1.00	1.00	100%

(Source: Author, 2018)

Table 10: Interpretation of criteria symbols

Criteria no.	Criteria	Weight
C1	Rainfall	0.41
C2	Land cover	0.20
C3	Slope	0.14
C4	Elevation	0.10
C5	Drainage density	0.08
C6	Soil type	0.07

(Source: Author, 2018)

3.2. Flood hazard of Ife-Central L.G.A.

The combination of all parameters was carried out in GIS using the WLC method. This was based on the weights generated from the AHP. The WLC formula is shown in Equation 2.

$$WLC = \frac{1}{n}\sum_{i=0}^{n} DiWi \tag{2}$$

where:

WLC	Weighted linear combination
n	Numbers of parameters,
D_i	Decision parameter and
W_i	AHP weight (Ouma and Tateishi, 2014).

Using the raster calculator of ArcGIS, the calculated weights obtained from pairwise matrix of AHP for each criterion was applied on the various raster criteria in the WLC equation to obtain the flood hazard associated with every location in Ife-Central LGA. From the flood hazard map shown in Figure 10, areas with very high hazard are shown in red, and areas associated with low flood hazard are shown in white.

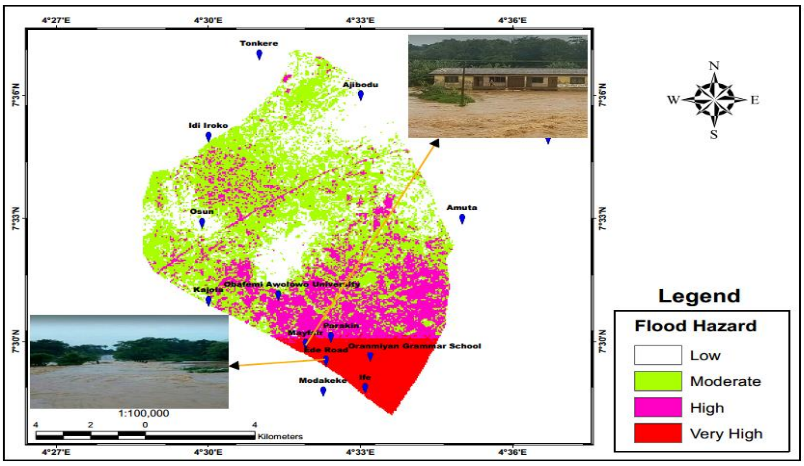

Figure 10: Flood hazard map of Ife Central L.G.A

The very high hazard areas covered 10.113 km^2 (9.2%), the high hazard areas covered 22.545 km^2 (20.4%), the moderate hazard areas covered 48.968 km^2 (44.3%) and the low hazard areas covered 28.813 km^2 (26.1%) as shown in Table 11. The percentage of various classes of flood hazard is shown in Figure 11.

Table 11: Flood vulnerability area

Flood hazard class	Area (sq. km)	Area (%)
Low	28.813	26.1
Moderate	48.968	44.3
High	22.545	20.4
Very high	10.113	9.2

(Source: Author, 2018)

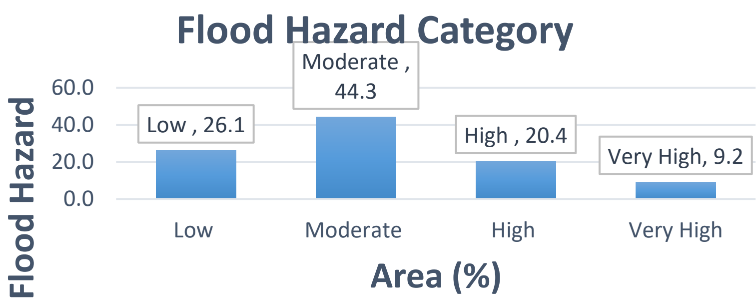

Figure 11: Percentage of flood hazard

3.3. Flood vulnerability of Ife-Central L.G.A.

A flood vulnerability map was produced in order to determine, delineate and map the spatial extent of water coverage and vulnerability to flooding in the area. The built-up area within the study area was overlaid on the flood hazard map to view and calculate the extent of the built-up area vulnerable to flood. Based on the land cover classification exercise carried out, the total area of built-up area in Ife

Central LGA is 20.897 km^2. The area of the built-up that falls under very high hazard category is 4.764 km^2 and 5.100 km^2 area of the built environment falls under high hazard category making those areas vulnerable to flood. The vulnerability of built-up areas to flooding was produced in a map shown in Figure 12 and the percentages of built-up vulnerable to flood are shown in Table 12.

Table 12: Built-up areas vulnerable to flood

Flood hazard class	Area (sq. Km)	Area (%)
High	5.100	24.4
Very high	4.764	22.8

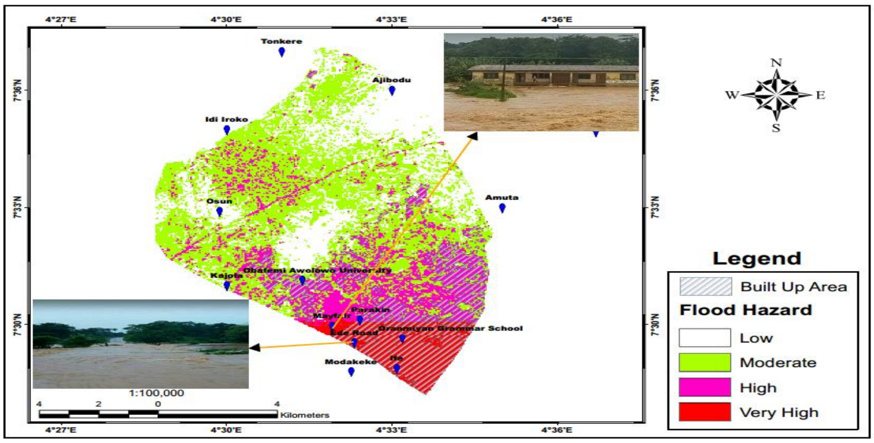

Figure 12: Vulnerability to flooding in Ife Central L.G.A

It was deduced that 47.2% of the total built-up areas in the study area are vulnerable to flood.

3.4. Validation of pairwise matrix of the AHP model

The results of the AHP model were validated using the Consistency Ratio index shown in Equation 4. Table 13 shows the determining of Consistency Ratio and Table 14 shows the Random Inconsistency Indices: Where, C1 = Rainfall; C2 = Land cover; C3 = Slope; C4 = Elevation; C5= Drainage density; C6= Soil.

The final consistency ratio (CR), from which the evaluations of the pairwise comparison matrix were determined was obtained as the ratio of the Consistency Index and the Random Index (RI).

Table 13: Determined consistency index (CI)

Step 1						
C1	1.00	2.00	3.00	4.00	5.00	6.00
C2	0.50	1.00	1.50	2.00	2.50	3.00
C3	0.33	0.67	1.00	1.33	1.67	2.00
C4	0.25	0.50	0.75	1.00	1.25	1.50
C5	0.20	0.40	0.6	0.80	1.00	1.20
C6	0.17	0.33	0.5	0.67	0.83	1.00

Weight	0.41	0.20	0.14	0.10	01.08	0.07

STEP 2: SUM 1/WEIGHT

							SUM 1				
C1	0.41	0.40	0.42	0.40	0.40	0.42	2.45		0.41		5.98
C2	0.21	0.20	0.21	0.20	0.20	0.21	1.23		0.20		6.15
C3	0.14	0.13	0.14	0.13	0.13	0.14	0.81	/	0.14	=	5.79
C4	0.10	0.10	0.11	0.10	0.10	0.11	0.62		0.10		6.20
C5	0.08	0.08	0.08	0.08	0.08	0.08	0.48		0.08		6.00
C6	0.07	0.07	0.07	0.07	0.07	0.07	0.42		0.07		6.00

=

Sum 2	36.12

Table 14: Random index (RI) used to compute consistency ratios (CR)

N	1	2	3	4	5	6	7	8	9	10
Random index (RI)	0	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49

Source: (Ouma and Tateishi, 2014; Saaty, 2008)

The measure of departure from consistency (Consistency Index) was as well calculated using Equation 3.

$$CI = \frac{\lambda - n}{n - 1} \tag{3}$$

where:
n Number of factors (i.e. 6), and
λ Average value of the consistency vector determined in the above step.

λ = 5.98+6.15+5.79+6.20+6.00+6.00=36.12/6=6.02
Based on Equation (3) CI= 6.02-6/6-1= 0.004

In order to assess the robustness of the expert view, the Consistency Ratio (CR) was calculated using Equation 4.

$$CR = \frac{CI}{RI} \tag{4}$$

Where:
RI Random Inconsistency Index whose value depends on the number (n) of factors being compared; for n = 6, RI = 1.24 as illustrated in Table 14

Using Equation (4),

$$CR = \frac{0.004}{1.24} = 0.003$$

Thus, since 0.003 < 0.1, it indicates that there is a realistic degree of consistency in the pairwise comparison and as a result, the weights 0.41, 0.20, 0.14, 0.10, 0.08, 0.07 (i.e. 41, 20, 14, 10, 8 and 7% respectively) can be assigned to rainfall, land cover, slope, elevation, drainage density and soil type respectively.

4.0. Conclusion

Based on the results of this case study, the aim of the project has been achieved by producing the flood hazard and vulnerability maps of Ife Central LGA showing areas prone to flood, which will help both decision-makers and inhabitants of the areas that fall under high prone areas within the study area. The result showed very high hazard areas covered 10.113 km^2 (9.2%), the high hazard areas covered 22.545 km^2 (20.4%), the moderate hazard areas covered 48.968 km^2 (44.3%) and the low hazard areas covered 28.813 km^2 (26.1%). The method adopted correctly identifies all existing flood incidence areas within the flood-prone areas in the hazard map. It was discovered that based on the land cover classification exercise conducted, areas prone to flood are basically areas with low elevation. Out of the total area of built up in Ife Central LGA which is about 20.897 km^2,the area of the built-up, that falls under very high hazard category is 4.764 km^2 (24.4%) and 5.100 km^2 (22.8%) area of the built environment falls under high hazard category making these areas vulnerable to flood.

Flood hazard and vulnerability maps are valuable tools used by planners, insurers and emergency service operators for assessing flood. Decision-makers need to assess risk for more than one scene so as to take appropriate measures in alleviating the problem. In the light of the above discussion, flood mapping, being an important measure of flood management technique will go a long way in reducing flood damages in areas frequently affected. Flood frequency analysis of peak hydrological data yields the return periods of major peak discharges and the probability of occurrence of flood; specified return period helps to provide preparedness to cope with such peaks. Flood model combined with GIS was found to be very important to map out the likely inundated areas of a given catchment. The study has shown that a flood vulnerability map can be produced for flood-prone areas in a short time with the use of GIS and Remote Sensing. Thus, the appropriate and early solution could be implemented and can increase public awareness of flood event.

The study further recommends that:

i. Proper awareness of various practices that aid flooding such as; dumping of refuse on water channels, erection of structures on water channels, etc. should be conducted in affected communities i.e. communities that fall under high and very high flood hazard classes.
ii. The Government should assist inhabitants of the affected communities by constructing new drainages and rehabilitating the existing drainages which will channel runoffs in the area efficiently to proximate streams.

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Cite this article as:

Ijaware V. A., 2020. GIS based Flood Vulnerability Studies for Ife Central Local Government Area, Osun State, Nigeria. *Nigerian Journal of Environmental Sciences and Technology*, 4(1), pp. 160-171. https://doi.org/10.36263/nijest.2020.01.0184

Nigerian Journal of Environmental Sciences and Technology (NIJEST)
www.nijest.com
ISSN (Print): 2734-259X | ISSN (electronic): 2734-2603
Vol 4, No. 1 March 2020, pp 172 - 181

Effect of Alternate Wetting and Drying on some Properties of High Strength Concrete in Tropical Coastal Environments

Durojaye O. M.[1] and Ogirigbo O. R.[2,*]
[1,2]Department of Civil Engineering, Faculty of Engineering, University of Benin, Benin City, Edo State, Nigeria
Corresponding Author: *okiemute.ogirigbo@uniben.edu

https://doi.org/10.36263/nijest.2020.01.0189

ABSTRACT

Concrete is one of the most used construction materials in the world, due to its good durability and fire resistance properties, versatility in forming various shapes, abundance of raw materials and low manufacturing and maintenance costs. High strength concrete, which is a type of concrete, finds its application in construction of high rise buildings, bridges, highways, etc. Its physical properties are greatly affected by the method of curing and the environment in which it is placed. This study investigated the effect on the compressive strength and some transport properties of high strength concrete subjected to alternate wetting and drying exposure, which may be due to intermittent rains, or rise and fall in tides of the sea, an exposure type that is commonly experienced in coastal areas. High strength concrete samples were prepared and subjected to two different curing regimes, one in which the concrete samples were cured continuously under water, and the other in which the concrete samples were subjected to 12-hr curing under water followed by 12-hr curing under ambient air. Various tests such as ultrasonic pulse velocity (UPV), compressive strength, water and chloride ingress tests were conducted on the cured concrete samples. The results obtained from the tests conducted, generally showed that the strength and transport properties of the high strength concrete was greatly affected by the alternate wetting and drying curing method. The effect was seen to be more adverse at the later ages than at the early ages.

Keywords: Compressive strength, Cyclic curing, Marine environment, Water ingress, Chloride ingress, Niger Delta

1.0. Introduction

High strength concrete is mostly used for high rise structures, bridges, etc. It is often sticky and very difficult to be handled and placed. This is usually the condition even if plasticizers are used. This condition is mainly due to the high cement content in it. Due to the superior mechanical properties and the significant economic savings offered by high strength concrete, the use of it has accelerated. For instance, the use of high strength concrete can shorten turnover times of casting beds and speed up construction time. It can also allow for the use of more slender members, thus reducing the dead load of sections (French and Mokhtarzadeh, 1993).

Concrete strength is determined by the force required to crush it and this strength can be affected by cyclic changes in moisture and temperature. Hence, the environment in which concrete is placed after mixing is of great importance (Kamran, 2015). Thus, if high strength concrete is allowed to dry prematurely, it can experience unequal tensile stresses that in an imperfectly hardened state cannot be resisted. The strength of concrete improves with proper curing after it is cast. Generally, it is good practice to maintain a temperature between about 5°C and 20°C during the first half day after placing the concrete. During this initial period, a much higher temperature might retard the later development in strength, while a much lower temperature (such as would cause the fresh concrete to freeze) might permanently impair the strength. After this initial period, the strength development increases with the maturity of the concrete i.e. the product of age and temperature (Neville, 1996).

Temperature variation can cause changes in concrete volume. Increasing the temperature can result to an increase in the volume of the concrete. On the other hand, when the temperature falls, the concrete contracts, and this is typically what happens in coastal regions. If the concrete is unrestricted then the volume changes will not have too many consequences. However, the concrete is always restrained by foundations, reinforcement or connecting members, and as a result of this, the change in volume will produce significant stress in the concrete that may result in the formation of cracks (Sidney, 1979).

In coastal regions where the concrete is close to the sea, it is bound to experience alternate wetting and drying as a result of the rise and fall in tides of the sea or ocean. This alternate wetting and drying can have adverse effect on the properties of the concrete. These effects have been studied by several researchers e.g. Jaya *et al*., 2014; Garzon-Roca *et al*., 2015; Sobhan *et al*., 2015; Tang *et al*., 2018. However, in all these studies, very little attention was given to coastal regions in tropical environments. This is significant, as coastal regions in tropical environments like Nigeria are well known for their peculiar temperature ranges. For example, in Lagos, Nigeria, the temperature ranges from ~23°C to ~33°C. Hence, there is need to understand how alternate wetting and drying exposure conditions will impact on the properties of concrete in such regions.

In this study, the strength and some transport properties of high strength concrete cured under alternate wetting and drying conditions is compared with that cured under ideal conditions (i.e. continuously under water). The outcome of this study is significant as it will give more understanding about the performance of concrete structures in the coastal regions of Nigeria – a region that has a coastline of over 1,000 km and houses many marine concrete structures such as harbours, jetties, quays, seaports and breakwaters.

2.0. Methodology

2.1. Materials

2.1.1 Cement

The cement used for the study was procured from a local vendor. It had a strength grade of 42.5 and conformed to the specifications given in BS EN 196-1:2016. The physical and chemical properties of the cement are shown in Tables 1 and 2 respectively.

2.1.2 Aggregates

The fine aggregate used for the study was obtained from a quarry site at Ugbioko community at Edo State, Nigeria. Sieve analysis conducted on it placed it at Zone II, with a maximum particle size of 4.75 mm. Grading of the fine aggregates conformed to BS EN 12620:2002+A1. The coarse aggregate used was crushed granite, with particle size ranging from 14 – 20 mm, and a specific gravity of 2.71. The properties of the fine and coarse aggregates used for the study are shown in Table 3.

Table 1: Physical properties of the cement

Property	Value
Average fineness (%)	7
Normal consistency (mm)	33
Setting time	
Initial (minutes)	85
Final (minutes)	240

Table 2: Chemical properties of the cement

Property	%
Lime (CaO)	60.87
Alumina (Al_2O_3)	5.36
Soluble silica (SiO_2)	20.55
Iron oxide (Fe_2O_3)	4.00
Chloride (Cl_2)	< 0.1
Magnesia (MgO)	0.74
Sulfuric Anhydride (SO_3)	1.83
Insoluble residue	2.93
Al_2O_3/Fe_2O_3	1.34

Table 3: Properties of the aggregates

Property	Fine aggregate	Coarse aggregate
Specific gravity	2.60	2.71
Density	1.52	1.61
Zone	II	N/A
Crushed/uncrushed	N/A	Crushed
Maximum size of aggregate	4.75 mm	20 mm

2.1.3 Water

Potable water as obtained from the University's main water supply was used for mixing the concrete. The water was free from all forms of impurities and organic matter.

2.1.4 Salt solution

The salt solution used for the chloride ingress studies was prepared in the laboratory by mixing 30g of salt (sodium chloride) in 1 litre of water. This has similar chloride concentration as that of Atlantic seawater, which is about 18g/l (Hewlett, 2004).

2.2. Concrete mix design and sample preparation

The concrete mix used for the study was that for a high strength concrete (with 28-day strength > 40 MPa). The mix ratios of the various constituents are shown in Table 4.

Table 4: Mix proportions of the starting materials

Water/cement ratio (w/c)	Cement (kg/m^3)	Fine Aggregates (kg/m^3)	Coarse Aggregates (kg/m^3)
0.51	461	597	1107

The various constituents (cement, water and aggregates) were weighed separately and placed in the concrete mixer. After mixing, the concrete was placed into 100 mm cube moulds. The moulds were covered with thin polythene sheets and left to cure in the laboratory for at least 24 hrs, after which the cubes were demoulded and taken to the various curing environments. A total of 36 concrete cubes were used in the study.

2.3. Details of curing conditions

Two different curing methods were selected for this study. They are described as follows:

1. Continuous Wet Curing (WC): Immediately after demoulding, samples to be cured under this method were taken and placed under water in curing tanks for a period up to 28 days at a temperature and relative humidity of 25°C and 99% respectively.
2. Alternate Wetting and Drying (W+D): After demoulding, these samples were subjected to a cyclic wet-dry curing condition. This involved placing the concrete samples under water for a period of 12 hrs (at a temperature and relative humidity of 25°C and 99% respectively), followed by allowing them to dry under air in the laboratory for 12 hrs (at a temperature and relative humidity of ~35°C and ~65% respectively). This represents the typical environmental conditions of the tropical coastal areas of Nigeria. This wetting and drying cycle was repeated daily for 28 days.

2.4. Test methods

Ultrasonic pulse velocity (UPV) test was conducted on triplicate samples of the concrete at ages of 3, 7, 14 and 28 days. UPV is a non-destructive test that enables the strength and quality of the concrete to be assessed. The test was conducted by passing a pulse of ultrasonic through the concrete to be tested and measuring the time taken by the pulse to pass through the concrete. The pulse velocity was obtained using the expression below:

$$V = \frac{W}{t} \quad (1)$$

where:

V pulse velocity in m/s

W width of the concrete cube in m

t time taken for the pulse to pass through the concrete cube in secs

Compressive strength was determined on triplicate samples using a cube crusher, at specific ages of 3, 7, 14 and 28 days, to study the effect of the alternate wetting and drying curing condition on the early and later strength of the concrete. A total of 24 concrete cubes were used for the compressive strength tests; 12 of these were cured under water while the other 12 were subjected to alternate wetting and drying method of curing. At the test age, the concrete cubes were brought out from their respective curing environment, surface dried (as applicable), and weighed before testing. The compressive strength (in MPa) was taken as the average failure load (in kN) divided by the cross sectional area of the concrete cube (in mm^2), as shown in the expression below:

$$P = \frac{F}{A} \tag{2}$$

where:

P compressive strength in MPa
F failure load in kN
A cross sectional area of concrete cube in mm^2

Water ingress tests were carried out according to BS1881-122:2011, on triplicate concrete cubes cured under the two curing conditions adopted in the study. After 28 days of curing under the various curing regimes, the concrete samples were immersed completely in water for 24 hrs. The mass of the samples were recorded before and after immersion in the water, and the water absorbed (W_a) as a percentage was obtained using the expression below:

$$W_a = \frac{(M_t - M_d)}{M_d} \times 100 \tag{3}$$

where:

M_d dry mass of the sample in grams
M_t mass of the sample after time t, in grams
W_a water absorbed in %

The depth of chloride ion penetration was determined using the silver nitrate colouration technique as used by (Güneyisi and Mermerdaş, 2007; Ogirigbo and Inerhunwa, 2017). The concrete cubes after curing in the various curing regimes, were exposed to the salt solution for a period of 56 days. At the end of the exposure period, the samples were withdrawn and split in half. Thereafter, the surfaces of the freshly split samples were sprayed with a 0.1M silver nitrate ($AgNO_3$) solution. The presence of free chlorides was indicated by the formation of a white precipitate of silver chloride, while in the absence of free chlorides the reaction between silver nitrate and portlandite results in a brown colouration (as shown in Figure 1). The depth of free chloride penetration was then obtained by taking linear measurements from the edge of the specimen up to the colour change boundary. Six to eight measurements were taken per sample, and the average was taken as the depth of free chloride penetration.

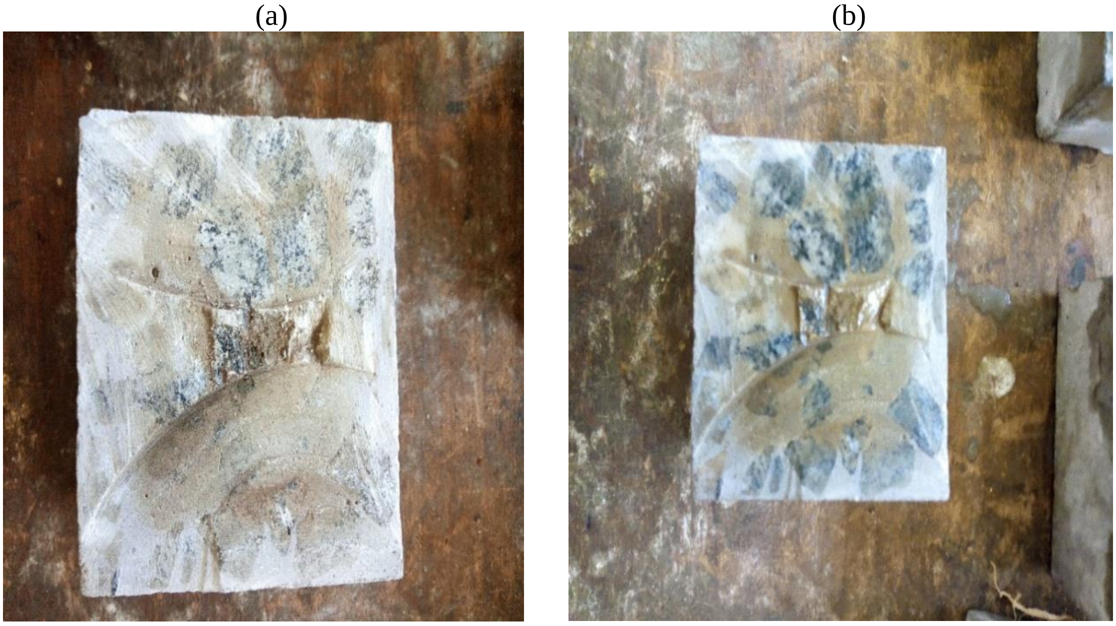

Figure 1: (a) before the application of silver nitrate (b) after the application of silver nitrate

3.0. Results and Discussion

3.1. Ultrasonic pulse velocity

Figure 2 shows the pulse velocity obtained for concrete cubes at the ages of 3, 7, 14 and 28 days. Irrespective of the curing method, the pulse velocity was seen to increase with the age of the samples, thus indicating that the strength and quality of the concrete samples increased with age. Comparing both curing methods, it can be seen that the concrete samples that were cured continuously under water had higher pulse velocities than those that were subjected to the alternate wetting and drying curing method. Higher velocities indicate good quality and continuity of the material, while slower velocities may indicate concrete with many cracks or voids. Thus, the concrete samples subjected to continuously curing under water are of a higher quality.

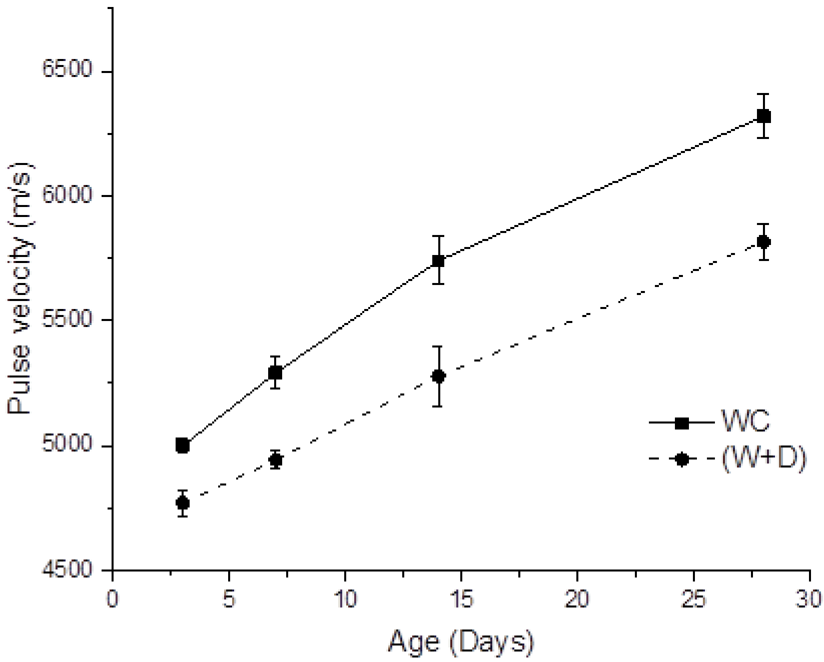

Figure 2: Pulse velocity readings of the mixes

At the early age of 3 days, the pulse velocity of the WC samples was about 250 m/s higher than that of the (W+D) samples, but at later ages of 28 days, this difference became about 500 m/s. This seems to suggest that the quality of the concrete samples worsened or did not improve very much with time, when they were cured under the alternate wetting and drying curing condition as against when they were cured continuously under water.

3.2. Compressive strength

The compressive strength of the concrete cubes obtained at 3, 7, 14 and 28 days, are shown in Figure 3. From the figure, it can be seen that the compressive strength of the concrete samples cured continuously under water are higher than those cured by the alternate wetting and drying curing method, especially at the later ages. This correlates with the ultrasonic pulse velocity results shown in Figure 2, and shows the negative impact of the alternate wetting and drying curing method on the strength development of the concrete samples. Similar findings were also reported by (Mohr *et al*., 2005; Kampala *et al*., 2014).

Strength deterioration ratios (SDR) were computed for the concrete samples cured using the alternate wetting and drying curing method. SDR is defined as the ratio of the strength loss of the (W+D) samples relative to the strength of the samples cured continuously under water (WC) at the same age (Seleem *et al*., 2010). The computed SDRs are shown in Table 5. From the table, the SDR can be seen to increase with age. At the early age of 3 days, only a 12.98% reduction was observed in the strength of the (W+D) cured samples; but at the later age of 28 days, a higher percentage of 21.25% was observed. In a similar study by El-Ashkar *et al*. (2002), where the durability of pulp fiber-cement composites subjected to wet/dry cycling was investigated, it was observed that the average peak load was significantly reduced when the composites were subjected to the wet/dry cycling. The reason for this deterioration in strength can be attributed to the effect of thermal cracking. When high-strength concrete is allowed to dry prematurely, it can experience unequal tensile stresses that in an imperfectly hardened state cannot be resisted. This can result in the formation of thermal cracks, which is a common cause of deterioration in concrete structures that are exposed to environments where there are temperature changes as is the case of the (W+D) curing condition used in this study (Chai *et al*., 2012).

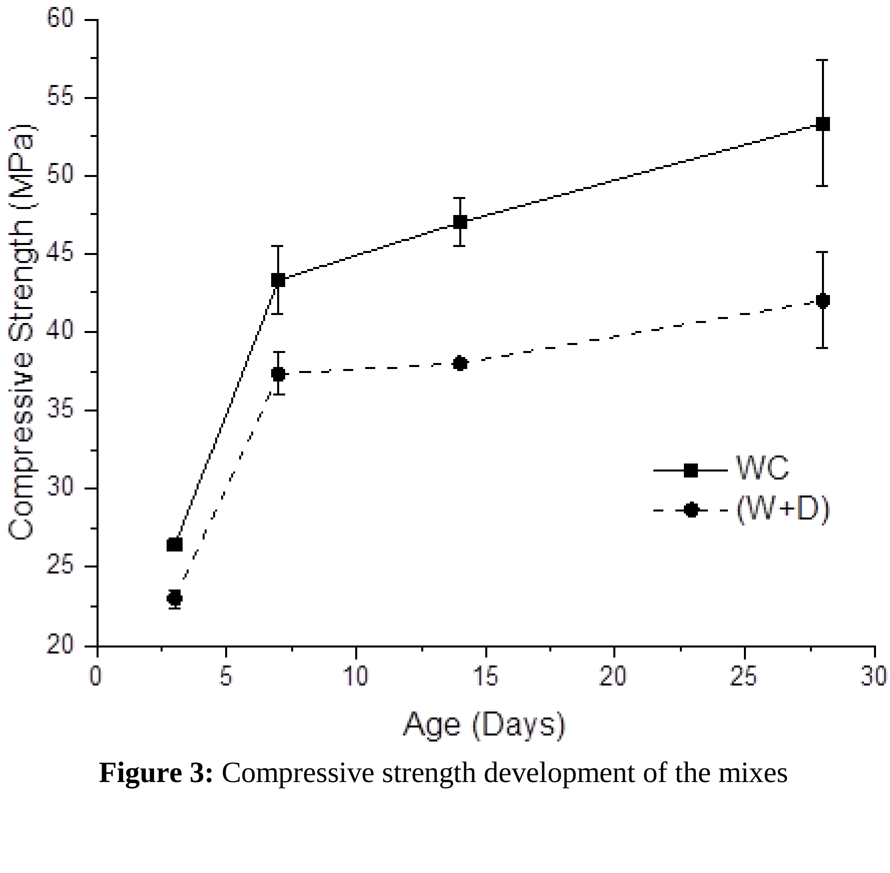

Figure 3: Compressive strength development of the mixes

Table 5: Computed strength deterioration ratios (SDR) for (W+D) cured concrete samples

Age (days)	Strength deterioration ratio (%)
3	12.98
7	13.85
14	19.15
28	21.25

3.3. Water ingress

Table 6 and Figure 4 shows the percentage of water absorbed by the concrete samples after they had been cured in their respective curing regimes for 28 days, and immersed completely in water for 24 hrs. From the figure, it can be seen that the concrete samples that were subjected to the (W+D) curing regime, absorbed more water than those that were cured continuously under water. This implies that the pore structure of the (W+D) cured concrete samples was more porous than that of the WC cured concrete samples. This correlates with the UPV and compressive strength results shown in Figure 2 and 3 respectively.

Several studies (Röβler and Odler, 1985; Igarashi *et al.*, 2004; Ogirigbo, 2016) have shown that there is a negative correlation between porosity and compressive strength. Hence, a concrete with a higher porosity will exhibit a low strength, and vice versa. The higher porosity of the (W+D) cured samples evidenced by the higher percentage of water absorbed by these same samples, can thus be said to be the reason for their low strengths.

Table 6: Weights of concrete samples before and after immersion in water

Curing Method	Dry weight (M_d)	Wet weight (M_t)	Water ingress (W_a) (%)	Average water ingress (%)	Standard deviation
WC	2.435	2.525	3.696	3.663	0.26
	2.535	2.635	3.900		
	2.505	2.590	3.393		
(W+D)	2.430	2.630	8.230	5.652	2.45
	2.395	2.505	4.593		
	2.420	2.520	4.132		

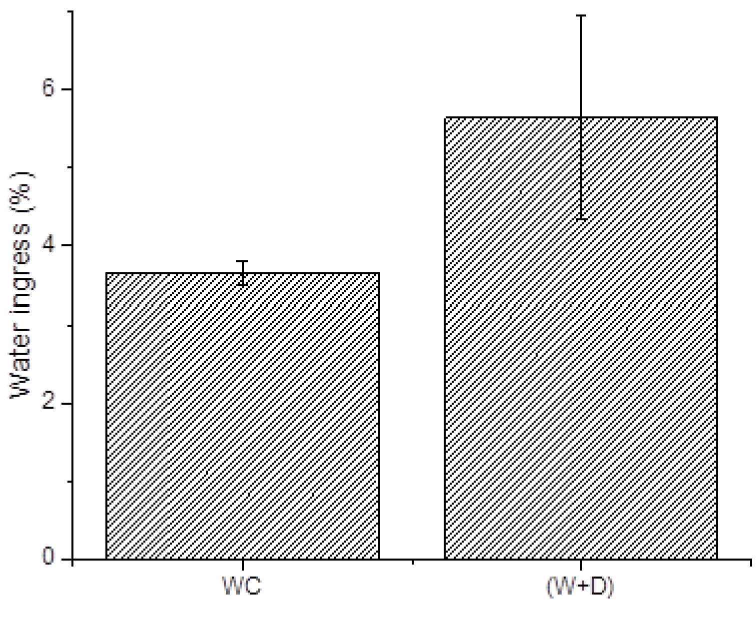

Figure 4: Percentage of water absorbed by concrete samples after 28 days of curing

3.4. Depth of chloride penetration

The results of the depth of chloride penetration obtained after 56 days of immersion of the concrete samples in the salt solution is shown in Figure 5. As was observed in the water ingress test result shown in Figure 4, the concrete samples that were cured by the alternating wetting and drying curing method recorded higher depths of chloride penetration than those that were cured continuously under water. The depth of chloride penetration for the (W+D) cured concrete samples was about 13 mm, whereas that of the WC cured samples was about 5 mm. This shows that concrete samples subjected to alternate wetting and drying are more susceptible to chloride penetration or ingress. This is to be expected, given that they will have higher porosities (as seen in the percentage of water absorbed in Figure 4) and thus will be less resistant to the penetration of the chloride ions. This altogether shows the deleterious impact of this method of curing on the durability of high strength concretes.

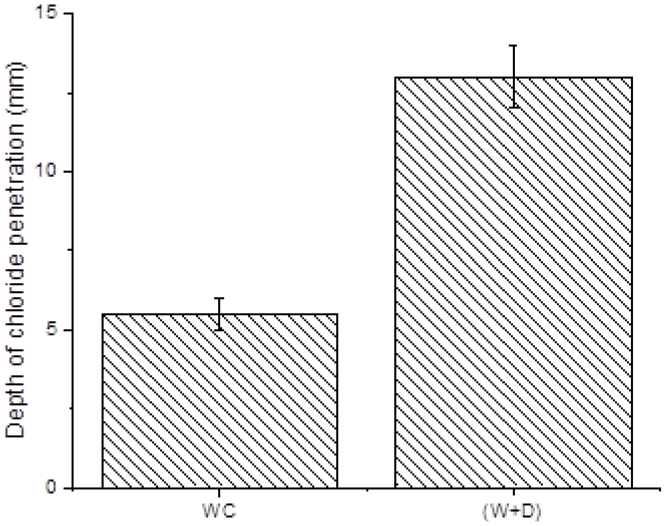

Figure 5: Depth of chloride penetration into concrete samples after immersion in salt solution for 28 days

4.0. Conclusion

This research focused on studying the effects of alternate wetting and drying method of curing on the strength and transport properties of high strength concrete. The results obtained from this study has shown that curing under alternate wetting and drying conditions can have adverse effect on the strength properties of high strength concrete, especially at the later ages. This is because of the effect of the premature drying of the concrete samples during the drying cycle, which can result in the formation of thermal cracks within the concrete. Pulse velocity measurements that were taken on the concrete samples indeed confirmed this, when higher pulse velocity readings were obtained for the concrete samples that were cured continuously under water as against those that were subjected to the alternate wetting and drying curing method. Similar observations were also made in the transport properties of the concrete which was studied via water and chloride ingress tests. The results of both tests generally showed that the pore structure of the concrete samples that were cured by the alternate wetting and drying curing method, were more susceptible to the penetration of water and chloride ions. It should be noted that other factors such as the duration of the wetting or drying cycle as well as the chloride concentration of the salt solution, can affect the properties of the concrete; however, these were not investigated in this study.

Overall, the results of this study implies that for coastal regions in tropical environments, the importance of ideal curing i.e. curing continuously under water, cannot be overemphasised, especially for high strength concretes. Since most concrete structures constructed in these areas are usually of high strength, it is therefore recommended that they are properly cured to ensure that they have good strength and transport properties.

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Cite this article as:
Durojaye O. M. and Ogirigbo O. R., 2020. Effect of Alternate Wetting and Drying on some Properties of High Strength Concrete in Tropical Coastal Environments. *Nigerian Journal of Environmental Sciences and Technology,* 4(1), pp. 172-181. https://doi.org/10.36263/nijest.2020.01.0189

Nigerian Journal of Environmental Sciences and Technology (NIJEST)
www.nijest.com
ISSN (Print): 2734-259X | ISSN (electronic): 2734-2603
Vol 4, No. 1 March 2020, pp 182 - 196

Assessment of particulate matter ($PM_{2.5}$, PM_{10}) in air, elemental composition of granite and weather parameters at a quarry site in Ngwogwo, Ebonyi State, Nigeria

Ogbonna P. C.[1,*], Ukpai N. P.[2] and Ubuoh E. A.[3]
[1,2,3]Department of Environmental Management and Toxicology, Michael Okpara University of Agriculture, Umudike, Abia State, Nigeria
Corresponding Author: *ogbonna_princewill@yahoo.com

https://doi.org/10.36263/nijest.2020.01.0199

ABSTRACT

The World Health Organization opined that suspended particulate matter (e.g. $PM_{2.5}$, PM_{10}) are affecting more people worldwide than any other pollutant. This study aimed to determine the status of particulate matter, elemental composition of granite and weather parameters via sampling and analysis of samples from different locations at quarry site in Ebonyi State, Nigeria. The highest concentrations of Pb (2.00±0.05 mg/kg), Zn (6.85±0.06 mg/kg), Mn (94.21±0.13 mg/kg), Fe (3,461.65±3.61 mg/kg), Ca (5.41±0.01 %) and K (0.24±0.02 %) in different sizes of granites were recorded in dust particles. The order of abundance of the elemental composition in granites is: Fe > Mn > Zn > Ca > Mg > Pb > Co > As > Na > K. The highest temperature (45.88±0.53 °C) and relative humidity (49.05±0.21 %) was recorded close to the conveyor belt and walk way to pit, respectively. The concentration of $PM_{2.5}$ (69.00±1.41 µg/m^3) and PM_{10} (2,829.50±12.02 µg/m^3) were highest at the chippings deposition cum collection point. The concentration of $PM_{2.5}$ is higher than the permissible limit set by United States Environmental Protection Agency (USEPA) and World Health Organization (WHO). The concentration of PM_{10} is substantially above the permissible limit set by WHO. This suggest that quarry workers, and the wider community are subjected to prevailing environmental health threat. This emphasizes the need for rigorous implementation of existing environmental legislations established to protect the environment and public health.

Keywords: Quarrying, Granite, Particulate matter, Elemental composition, Weather, Ngwogwo

1.0. Introduction

Quarrying as a land-use practice is the extraction of non-fuel and non-metal minerals from rock deposited in the earth's crust (Okere *et al*., 2001; Ogbonna *et al*., 2011). Quarrying activities involve diverse surface methods like sand and soil excavation, solution mining, rock blasting and alluvial dredging that generate aggregate used for building and other civil construction like highways or concrete and in bitumen plants and rail track construction (Keeperman, 2000; Nwachukwu *et al*., 2018). The mining of precious metals and other types of solid minerals forms an important part of many countries' economy (Ogbonna *et al*., 2011). Notwithstanding this, rock and mineral resources cannot be extracted from the earth without some environmental impacts (Nwachukwu *et al*., 2018) and high exploitation of solid minerals may lead to generation of environmental pollutants that are left behind in tailings scattered in open and partially covered pits, while some are transported by wind and flood, resulting in various environmental problems (Ogbonna *et al*., 2011). The atmosphere is one of the major pathways for transport of dust contaminated with heavy metals and the major external input of bio-available metals in the environment, which are potential threats to the health and survival of people (Ogbonna *et al*., 2018) living in proximity to quarry sites. This may be because quarry atmosphere is submitted to large inputs of heavy metals arising from stationary source such as blasting of rock and large volume of tailing dust at quarry site.

The production of quarry rocks ranks third in terms of volume and fourth in terms of value of all non-fuel mineral commodities over the world (Gunn and Gajen, 1987; Gunn *et al*., 1997)). Suspended particulate matter is quite outstanding among all pollutants emanating from quarrying operations (USEPA, 2008). Solid materials in the form of smoke, dust and also vapour generated during quarrying operations are usually suspended over a long period in the air (Oguntoke *et al*., 2009). Fine particulate matter ($PM_{2.5}$) causes reduction in visibility, has an adverse influence on human health, and is known to be related to global climate change (Zhu *et al*., 2016; Wang *et al*., 2020). Long-term exposure to air pollution particulate matter increases the risk of lung cancer, respiratory diseases and arteriosclerosis, and short-term exposure can exacerbate several forms of respiratory diseases, including bronchitis and asthma, as well as cause changes in heart rate variability (Liu *et al*., 2005; Garcon *et al*., 2006; Lu *et al*., 2007; Pope III *et al*., 2009; Peacock *et al*., 2011; Raaschou-Nielsen *et al*., 2011). The 2015 Global Burden of Disease (GBD) study established that 4.2 million deaths were caused by $PM_{2.5}$ pollution, accounting for 7.6% of total deaths and making $PM_{2.5}$ pollution the fifth most common cause of death for people of all ages worldwide (Xie *et al*., 2018). Similarly, a report by the Environmental Working Group in California showed that respiratory illnesses caused by particulate matter are responsible for more than 10,000 deaths and 16,000 hospital admissions. The health care cost of these illnesses was put at $132 million, in addition to millions of missed work days and school absences each year (Deborah, 1996; Douglas, 1996; USEPA, 1996; www.angelfire.com).

In Nigeria, Ebonyi State is one of the States endowed with abundant solid minerals such as granites. Hence, a lot of quarry industries exploring, mining and processing granites for various purposes are located in various parts of Ebonyi State. Quarrying as a land use has provided employment opportunities to both the youth and adults from the local community and it has also serve as a source of income to the rural women and children that sell cooked food, fruits, snacks, minerals etc. at the China quarry site in Ngwogwo in Ishiagu, Ebonyi State, Nigeria. Notwithstanding this, quarrying activities may be releasing air pollutants such as $PM_{2.5}$ and PM_{10} and contaminants like heavy metals into the surroundings with its concomitant effects on the people.

Literature search showed that very little research has been carried out on the concentration of particulate matter in air at quarry site over the world. These studies are effects of quarry activities on some selected communities in the lower ManyaKrobo District of the Eastern Region of Ghana (Nartey *et al*., 2012), environmental impact of aggregate mining by crush rock industries in Akamkpa local government area of Cross River State, Nigeria (Ukpong, 2012), air quality assessment in the vicinity of quarry site in Ogun State, Nigeria (Bada *et al*., 2013), estimation of air quality status due to quarrying activities and its impacts on the environment and health of the people in Umuoghara in Abakiliki, Ebonyi State, Nigeria (Onwe, 2015), geospatial and geostatistical analyses of particulate matter concentrations in Imo State, Nigeria (Opara *et al*., 2016), environmental impact assessment of quarries and stone cutting industries in Jammain, Palestine (Sayara, 2016), stone quarrying impact on air, soil, water in Akpoha and Ishiagu, Ebonyi State, Nigeria (Peter *et al*., 2018) and environmental impact of stone quarrying activities in Akpoha and Ishiagu in Ebonyi State, Nigeria (Kalu, 2018), but none of these studies determined the ambient temperature and elemental composition of granites in their study sites. In addition, the authors but for Bada *et al*. (2013) did not consider $PM_{2.5}$ (which is more hazardous than PM_{10} because of its smaller size). This study, therefore, is aimed to determine the level of particulate matter ($PM_{2.5}$, PM_{10}) in air, the elemental composition of granite and some weather parameters at a quarry site in Ngwogwo in Ebonyi State, Nigeria. The results of this study will provide Ebonyi State Government information to improve enforcement of health and safety legislation to protect quarry workers, the wider community and the future generation against the hazards posed by mining activities in the State.

2.0. Methodology

2.1. Study area

The study was carried out at China quarry in Ngwogwo in Ishiagu, Ebonyi State, Nigeria. Ishiagu is made up of seventeen villages and it is one of the largest communities in Ivo Local Government Area of Ebonyi State. It is located on the plains of the south-eastern savannah belt and lies within latitudes 5°51' and 5°59'N and longitudes 7°24' and 7°40'E. The dry season start from December and end in March while the wet season commence from April and end in November with annual precipitation of about 1,925 mm and average temperature of 27°C (Ofomata, 2002). The highest elevation is about 110 m above sea level and formed by erosion-resistant igneous intrusive while the lower areas are underlain by soft rocks (Edeani, 2015). Ishiagu is drained by a number of rivers such as Ikwo River, Ivo River, Odu River and Ihetutu streams. The main river Ivo takes its source from the Udi-Okigwe cuesta and then splits into smaller streams such as Ikwo, Ngado, Ihetutu and Eku rivers that create dendritic drainage pattern (Edeani, 2015). The major occupation of the individuals in the community is stone crush work, lead mining, trading and farming. The crops commonly grown are rice, yam, cassava, and vegetables such as *Telfaria occidentales* (fluted pumpkin), *Vernonia amydalina* (bitter leaf) etc.

2.2. Sample collection and analysis

Reconnaissance survey was carried out prior to sample collection to identify or determine wind direction, the different sizes of chippings and the different points of major activities in the study area, among others. Air samples were collected using an absolute instrument system, AIS (model Aerocet 5315) to measure the total concentration of particulate in the air. The air samples were randomly collected from nine (9) different sampling points (quarry entrance, first dust heap, before change room, $^{3}/_{7}$ chipping heap, close to conveyor belt, chipping deposition and collection point, walk away to pit, Truck Park, and pit). The control was taken 4 km from the quarry site where there was no visible sign of contamination since some quantities of particulate matter are known to be suspended in air several kilometres from its source of generation before deposition on soil, plants, and water bodies or inhaled by man. The instrument was held 2 m above the ground and at stability, readings for particulate matter (respirable and inhalable particulates $PM_{2.5}$ and PM_{10}), air temperature and relative humidity were taken. The air monitor was calibrated according to the manufacturer's directions before being deployed for the air quality sampling. Sampling was carried out for one hour (1 hour) each day for a period of three (3) days during the afternoon in each of the nine (9) air monitoring points. The 3 days serves as replicates and the average of the means for the three days were determined as concentrations for $PM_{2.5}$ and PM_{10}, temperature and relative humidity. Other parameters measured include air temperature with Digital thermometer (model Omron MC-246) and relative humidity with hygrometer (Cigar Oasis Caliber 4R Gold Digital/Analog).

2.3. Collection of granite chippings and analysis

Different sizes of chippings such as 0.50 unmixed, 0.50 mixed, 3/8 inch, 1/2 inch, 1 inch, hard-core, and dust were collected from China quarry site. Dust samples were collected by placing five (5) white cardboard papers at five (5) different positions at the quarry site and the dust deposited on the cardboard sheets for three different days were emptied into a polythene bag. About one (1) kilogram samples of 0.50 unmixed, 0.50 mixed, $^{3}/_{7}$ inch, $^{1}/_{2}$ inch, 1 inch, and hard-core were randomly collected from China quarry site, placed separately in plastic buckets with cover, labelled well, placed in wooden box and transported to the laboratory. Each of the chippings were further crushed into smaller sizes, sieved, and measured into conical flask prior to digestion. Exactly 0.5 g of each sample was measured into Teflon crucible and 20 ml of aqua–regia (HCl: HNO_3 solution in the ratio of 3:1) was added, then a 10 ml of hydrofluoric acid was added. The preparations were covered and heated in the oven at about 100 ^{o}C in a fume cardboard until the solution became clear. The preparations after heating were cooled in a desiccators and transferred to 250 ml volumetric flask (Hambidge and Krebs, 2007), and thereafter, determination of the amount of each heavy metal and macronutrient were carried out using Atomic Absorption Spectrophotometer (AAS). The elements that were determined were nickel (Ni), cadmium (Cd), arsenic (As), lead (Pb), zinc (Zn) and iron (Fe), manganese (Mn), cobalt (Co), sodium (Na), potassium (K), calcium (Ca), and magnesium (Mg).

For quality assurance and control (QA/QC) measures, high purity reagents of analytical grades were obtained from British Drug Houses (BDH) Chemicals Ltd., UK. All glassware was thoroughly washed and oven-dried and cooled in a desiccator. Reagent blanks and a series of standard solutions of 0.5, 1.0, 2.0, 5.0, 10.0 and 100 mg/l were prepared from the stock standard solution of each test metal by diluting known volumes of the stock solution in 100 ml volumetric flasks using distilled water. The blanks and standard solutions were aspirated directly into the atomic absorption spectrometer.

2.4. Experimental design and statistical analysis

A simple factorial experiment was conducted in a randomized complete block design with three replications in dust particles. Data generated from the experiment were subjected to one way analysis of variance (ANOVA) using statistical package for the social sciences (SPSS) v. 20 and means were separated (Steel and Torrie, 1980) at $P < 0.05$ using Duncan's Multiple Range Test (DMRT) while Correlation analysis was used to determine the relationship between the means of the parameters analysed in soil and cassava plant.

3.0. Results and Discussion

3.1. Elemental composition of granite chippings

The result of heavy metal concentration in various sizes of chipping extracted from the china quarry at Ngwogwo in Ivo Local Government Area of Ebonyi State, Nigeria is presented in Table 1. The result shows different level of significance among the various sizes of chipping ranging from dust particles size to hard-core (granite) size at the study site. The result indicates that the highest concentration of Pb (2.00±0.05 mg/kg), Zn (6.85±0.06 mg/kg), Mn (94.21±0.13 mg/kg) and Fe (3461.65±3.61mg/kg) were obtained in the dust particle size collected from the china quarry site at Ngwogwo and the values are significantly (P < 0.05) higher than their corresponding values in the 0.50 unmixed size (0.73±0.04, 3.97±0.01, 90.68±0.00 and 2.415.60±36.20 mg/kg), the 0.50 mixed size (1.73±0.23, 5.71±0.39, 93.20±0.27 and 3154.71±28.72mg/kg), the $^3/_7$ inch size (0.72±0.01, 3.72±0.04, 90.43±0.11 and 2332.20±60.95 mg/kg), the ¾ inch size (0.70±0.00, 3.63±0.12, 91.55±0.35 and 2,517.25±5.73 mg/kg), the ½ inch size (0.61±0.05, 6.15± 0.06, 92.23±0.32 and 2592.63±12.13 mg/kg), the 1 inch size (0.69±0.00, 5.76±0.06, 92.17±0.33 and 2389. 65±2.05 mg/kg) and the hard-core (0.47±0.01, 4.27±0.02, 84.80±0.42 and 2427.55±1.06 mg/kg), respectively for Pb, Zn, Mn and Fe. The high concentration of Pb (2.00±0.05 mg/kg), Zn (6.85±0.06 mg/kg), Mn (94.21±0.13 mg/kg) and Fe (3461.65±3.61 mg/kg) in the dust particle size is 2.74, 1.16, 2.78, 2.86, 3.28, 2.90, and 4.26 times for (Pb); 1.73, 1.20, 1.84, 1.89, 1.11, 1.19 and 1.60 times for (Zn); 1.04, 1.01, 1.04, 1.03, 1.02, 1.02 and 1.11 times for (Mn) and 1.43, 1.10, 1.48, 1.38, 1.34, 1.45 and 1.43 times for (Fe) higher than their corresponding values in the 0.50 unmixed size, the 0.50 mixed size, the $^3/_7$ inch size, the ¾ inch size, the ½ inch size, the 1 inch size and the hard-core size, respectively for Pb, Zn, Mn, and Fe.

The concentration of Pb increased from 0.47±0.01 (hard-core) to 2.00±0.05 mg/kg (dust particle size) and the values is well below 14.30 to 23.99 mg/kg reported in branded gneiss, granite and quartzite at Okemesi-Ijero area South Western Nigeria (Ayodele *et al*., 2018), 21.3 to 184.0 mg/kg in biotite granite and 6.0 to 39.5 mg/kg in mica granite in the Variscan Erzgebirge, Germany (Forster *et al*.,1998), 2.0 to 24.0 mg/kg in volcanic rocks (Husin *et al*., 2015) but relatively lower than 3.0 mg/kg in igneous rock (Alloway, 1995). The differences in the concentration of the heavy metals may be attributed to locational and or environmental differences vis-à-vis differences in heat and pressure brought about by weathering processes, erosion and by compression during rock formation. The highest concentration of As (0.47±0.00 mg/kg) is obtained in the ½ inch size of chippings and the value is significantly ($P < 0.05$) higher than its corresponding values in the dust particle size (0.33±0.01 mg/kg), the 0.50 unmixed size (0.42±0.00 mg/kg), the 0.50 mixed size (0.40±0.01mg/kg), the 1inch size (0.32±0.01 mg/kg) and the hard-core (0.39±0.00 mg/kg). The concentration of As in the ½ inch size of chippings is 1.43, 1.12, 1.18, 1.12, 1.15, 1.47 and 1.21 times higher than values obtained from dust particle size, the 0.50 unmixed size, the 0.50 mixed size, the $^3/_7$ inch size, the ¾ inch size, the 1 inch size and the hard-core, respectively. The concentration of As increased from 0.32±0.01 (1 inch size) to 0.47± 0.00 mg/kg (the ½ inch size) which is relatively lower than 0.23 to 0.90 mg/kg in branded gneiss, granite and quartzite (Ayodele *et al*., 2018) and 1.5 mg/kg in igneous rock (Alloway, 1995) but well below 5 to 10 mg/kg in volcanic rocks in Tawau, Sabah in Malaysia (Husin *et al*., 2015).

The highest concentration of Co (1.92±0.02 %) was obtained in the 0.50 mixed size and the value is significantly ($P < 0.05$) higher than its corresponding values for dust particle size (1.40±0.04 %), the 0.50 unmixed size (1.72±0.01 %), the $^3/_7$ inch size (1.54±0.08 %), the ¾ inch size (1.36±0.01 %), the ½ inch size (1.40±0.01 %), the 1 inch size (1.62±0.01 %) and the hard-core granite (1.53±0.01 %) (Table 2). The values of Co increased from 1.36±0.01 % (¾ inch) to 1.92±0.02 % (0.50 mixed size). The highest value of Ca (5.41±0.01 %) is observed in the dust particle size but the value is statistically ($P < 0.05$) not different from values recorded for the 0.50 unmixed size (5.32±0.01 %) and the 0.50 mixed size (5.36±0.06 %) but significantly ($P < 0.05$) higher than values observed in the $^3/_7$ inch size

(5.28±0.08%), the ¾ inch size (5.20±0.01 %), the ½ inch size (5.00±0.00 %), the 1 inch size (5.11±0.09 %) and the hard-core (4.42±0.00 %) (Table 2).

Table 1: Heavy metals concentration (mg/kg) in chippings

Samples	Pb	As	Zn	Fe	Cd	Ni
Dust	$2.00±0.05^{a}$	$0.33±0.01^{e}$	$6.85±0.06^{a}$	$3,461.65±3.61^{a}$	$0.03±0.01^{b}$	$0.62±0.01^{b}$
0.50 (unmixed)	$0.73±0.04^{c}$	$0.42±0.00^{b}$	$3.97±0.01^{de}$	$2,415.60±36.20^{e}$	$0.02±0.00^{b}$	$0.48±0.00^{bc}$
0.50 (mixed)	$1.73±0.23^{b}$	$0.40±0.01^{c}$	$5.71±0.39^{c}$	$3,154.71±28.72^{b}$	$0.09±0.02^{a}$	$1.44±0.03^{a}$
3/8 inch	$0.72±0.01^{c}$	$0.42±0.00^{b}$	$3.72±0.04^{e}$	$2,332.20±60.95^{f}$	$0.01±0.00^{b}$	$0.57±0.01^{b}$
3/4 inch	$0.70±0.00^{c}$	$0.41±0.00^{bc}$	$3.63±0.12^{e}$	$2,517.25±5.73^{d}$	$0.02±0.00^{b}$	$0.42±0.00^{bc}$
½ inch	$0.61±0.05^{cd}$	$0.47±0.00^{a}$	$6.15±0.06^{b}$	$2,592.63±12.13^{c}$	$0.03±0.01^{b}$	$0.60±0.01^{b}$
1 inch	$0.69±0.00^{c}$	$0.32±0.01^{e}$	$5.76±0.06^{c}$	$2,389.65±2.05^{ef}$	$0.03±0.01^{b}$	$0.44±0.01^{bc}$
Hardcore	$0.47±0.01^{d}$	$0.39±0.00^{d}$	$4.27±0.02^{d}$	$2,427.55±1.06^{e}$	$0.01±0.00^{b}$	$0.39±0.00^{bc}$

Source: Ogbonna et al. (2020)
Values are mean ± standard deviation of 3 replicates
^{a,b,c,d,e,f,g,h} *Means in the same column with different superscripts are significantly different (P < 0.05)*

Table 2: Macronutrient content in granite chippings

Samples	Ca (%)	Mg (%)	K (%)	Na (%)	Co (%)	Mn (mg/kg)
Dust	$5.41^{a} ± 0.01$	$3.23^{ab} ± 0.01$	$0.24^{a} ± 0.02$	$0.42^{a} ± 0.00$	$1.40^{e} ± 0.04$	$94.21^{a} ± 0.13$
0.50 (unmixed)	$5.32^{ab} ± 0.01$	$3.16^{d} ± 0.00$	$0.13^{d} ± 0.00$	0.29c ± 0.02	$1.72^{b} ± 0.01$	$90.68^{e} ± 0.00$
0.50 (mixed)	$5.36^{ab} ± 0.06$	$3.20^{bcd} ± 0.01$	$0.22^{a} ± 0.01$	$0.41^{a} ± 0.00$	$1.92^{a} ± 0.02$	$93.20^{b} ± 0.27$
3/8 inch	$5.28^{bc} ± 0.08$	$3.11^{e} ± 0.01$	$0.18^{b} ± 0.01$	$0.41^{a} ± 0.00$	$1.54^{d} ± 0.08$	$90.43^{e} ± 0.11$
3/4 inch	$5.20^{cd} ± 0.01$	$3.17^{cd} ± 0.00$	$0.15^{c} ± 0.00$	$0.41^{a} ± 0.01$	$1.36^{e} ± 0.01$	$91.55^{d} ± 0.35$
½ inch	$5.00^{e} ± 0.00$	$3.21^{bc} ± 0.02$	$0.14^{cd} ± 0.01$	$0.40^{a} ± 0.00$	$1.40^{e} ± 0.01$	$92.23^{c} ± 0.32$
1 inch	$5.11^{de} ± 0.09$	$3.36^{a} ± 0.04$	$0.14^{cd} ± 0.00$	$0.42^{a} ± 0.01$	$1.62^{c} ± 0.01$	$92.17^{cd} ± 0.33$
Hardcore	$4.42^{f} ± 0.00$	$3.04^{f} ± 0.00$	$0.23^{a} ± 0.00$	$0.33^{b} ± 0.01$	$1.53^{d} ± 0.01$	$84.80^{f} ± 0.42$

Values are mean ± standard deviation of 3 replicates
^{a,b,c,d,e} *Means in the same column with different superscripts are significantly different (P<0.05)*

The values of Ca increased from 4.42±0.00 (hard-core) to 5.41±0.01 % (dust particle size) which is well below 37.6 to 43.1 % in sedimentary rocks of the Kaštela Bay coastal area, Croatia (Mikelić *et al*., 2013) but higher than 0.00438 % reported by Tossavainen (2000) and 0.2700 % in carbonate rocks (Halamic and Miko, 2009). The highest value of Mg (3.36±0.04 %) is recorded for the 1 inch size of chippings but the value is statistically (*P* > 0.0.5) not different from the value obtained in the dust particle size (3.23±0.01%) but significantly (*P* < 0.05) different from values observed in the 0.50 unmixed size (3.16±0.00%), the 0.50 mixed size (3.20±0.01 %), the $^{3}/_{7}$ inch size (3.11±0.01 %), the ¾ inch size (3.17±0.00 %) the ½ inch size (3.21±0.02 %), and the hard core (3.04±0.00 %). The values of Mg increased from 3.04±0.00 (hard-core) to 3.36±0.4 % (1 inch size) (Table 2) which is higher than 2.09 % (Pidwirny, 2006). The highest value of K (0.24±0.02 %) is obtained in the dust particle size but the value is statistically (*P* > 0.05) not different from values recorded for the 0.05 mixed size (0.22±0.01 %) and the hard-core (0.23±0.00 %) but it is significantly (*P* < 0.05) higher than values observed in the 0.50 unmixed size (0.13±0.00 %), the $^{3}/_{7}$ inch size (0.18±0.01 %), the ¾ inch size (0.15±0.00 %), the ½ inch size (0.14±0.01 %) and the 1 inch size (0.14±0.00 %) (Table 2). The value of K increase from 0.13±0.00 (0.50 unmixed) to 0.24±0.02 % (dust particle size) which is lower than 0.06 to 0.54 % in sedimentary rocks of the Kaštela Bay coastal area, Croatia (Mikelić *et al*., 2013) and 0.27% in carbonate rocks (Halamic and Miko, 2009). The value of Mn (94.21±0.13 mg/kg) in dust particles is significantly (*P* < 0.05) higher than its corresponding values in 0.50 mixed (93.20±0.27 mg/kg), ½ inch (92.23±0.32 mg/kg), 1 inch (92.17±0.33 mg/kg), 3/4 inch (91.55±0.35 mg/kg), 0.50 unmixed (90.68±0.00 mg/kg), 3/8 inch 90.43±0.11 mg/kg) and 84.80±0.42 mg/kg). The value of Mn increased from 84.80 (hardcore) to 94.21 mg/kg (Dust) and the values are lower than 130 to 210 mg/kg reported in sedimentary rocks of the Kaštela Bay coastal area, Croatia (Mikelić *et al*., 2013) and 0.07% in carbonate rocks (Halamic and Miko, 2009). The highest value of Na (0.42±0.00 %) is jointly recorded for the dust particle size and the 1 inch size but the value is statistically (*P* > 0.05) not different from values obtained in the 0.05 mixed size (0.41±0.00 %), the $^{3}/_{7}$ inch size (0.41±0.00 %), the ¾ inch size (0.41±0.01 %) and the ½ inch size (0.40±0.00 %) but are significantly (*P* > 0.05) higher than values obtained for hard-core (0.33±0.01%) and the 0.05 unmixed size (0.29±0.02 %) (Table 2). The values of Na increased from 0.29±0.02 % (0.50 unmixed sizes) to 0.42+0.00 % (dust particle/the 1 inch size) which is lower than 2.83 % (Pidwirny, 2006). In this study, the order of abundance in the elemental composition of the chippings is: Fe > Mn > Zn > Ca > Mg > Pb > Co > As > Na > K.

3.2 Particulate matter ($PM_{2.5}$ and PM_{10}) in air, temperature and relative humidity

Table 3 summarized the concentration of particulate matter in air, temperature and relative humidity at the quarry and control sites. The concentration of $PM_{2.5}$ and PM_{10} in μg/m^3 respectively were 15.00±1.41 and 56.50±6.36 for quarry entrance, 21.50±2.12 and 133.00±2.83 for first dust heaps, 13.00±2.83 and 67.00±2.83 before change room, 14.50±2.12 and 88.50±2.12 for $^3/_7$ chippings heaps, 17.50±2.12 and 197.00±4.24 for truck park, 15.50±2.12 and 232.00±4.24 for close to conveyor belt, 69.00±1.41 and 2,829.50±12.02 for walk way to the pit, 17.50±3.54 and 86.00±5.66 for the pit, as well as 12.00±1.41 and 60.00±2.83 for the control site. The concentration of $PM_{2.5}$ and PM_{10} were highest detected at the chippings deposition cum collection point with the values (69.00±1.41 and 2,829.50±12.02 μg/m^3), respectively. At the China quarry site, the highest and lowest concentration of $PM_{2.5}$ occurred at chippings deposition cum collection point and before change room while the highest and lowest concentration of PM_{10} were observed at the chippings deposition cum collection point and quarry entrance, respectively. The concentration of $PM_{2.5}$ increased from 13.00±2.83 (before change room) to 69.00±1.41 μg/m^3 (chippings deposition cum collection point) and the values is higher than the permissible limit of 35 μg/m^3 and 25 μg/m^3 ($PM_{2.5}$) set by United States Environmental Protection Agency (USEPA, 1996) and World Health Organization (WHO, 2005).

Further, the value of $PM_{2.5}$ (13.00±2.83 to 69.00±1.41 μg/m^3) in this study is higher than the Control Standards of 35, 25, 15, 12 and 8 μg/m^3 ($PM_{2.5}$) set by the People Republic of China, European Union, Japan, United States of America and Australia, respectively (Table 4). Consequently, the concentration of the particulate matter released from China quarry site into air may trigger serious health challenges to both workers at the quarry site and inhabitants of Ngwogwo in Ishiagu of Ebonyi State, Nigeria since they are living not too far from the quarry site. Data for Nigeria's air quality status contained in the Little Green Data Book puts the population exposed to air pollution at $PM_{2.5}$ levels, and exceeding WHO guidelines, at 94% (WHO, 2015). This number is above the 72% Sub-Saharan Africa average (WHO, 2015). Thus, the discharge of airborne particulate matter (dust) in the environment poses health threats to people in mining communities and its surroundings. Air pollution is one of the anthropogenic activities where particulate matter (dust) with diameter 1 to 75 μm are generated and found in the surrounding areas of such activities (Sayara, 2016). Particles with aerodynamic diameters of less than 10 μm termed PM_{10} (inhalable particles) can be transported over long distances (Nickling and Boas, 1998), enter the human respiratory system (Ferris *et al*., 1979) and cause lung damages and related respiratory problems (Last, 1998). Chen *et al*. (2013) found that the average life expectancy in northern China was shortened by five years due to air pollution while Liu *et al*. (2016) established that in 2013 the number of adults who died of $PM_{2.5}$ pollution reached 1.37 million based on ground-level monitoring data. Some ecological studies show that particulate matter (PM) is associated with increased morbidity and mortality from respiratory (Ignotti *et al*., 2010; Silva *et al*., 2010) and cardiovascular diseases (Nunes *et al*., 2013; Rodrigues *et al*., 2015) in children and the elderly, especially during the dry season in the Brazilian Amazon and Cerrado (Rodrigues *et al*., 2017). The concentration of PM_{10} increased from 56.50±6.36 (quarry entrance) to 2,829.50±12.02 μg/m^3 (chippings deposition cum collection point) and the values are substantially well above the permissible limit 50 μg/m^3 (PM_{10}) set by World Health Organization (WHO, 2005). The results suggested that the air within and around the quarry area is subjected to high level of pollution, which can be detrimental to the health of man, animals and plants inhabiting the Ngwogwo area. Based on data from 22,905 subjects between 1982 and 2000 in Los Angeles, Jerrett *et al*. (2005) found that mortality rate increased by 1.17% for each 10 μg/m^3 increase in $PM_{2.5}$ concentration, while Jeremy and Nicholas (2014) used meta-analysis to evaluate 367,251 participants in Europe, finding that each 5 μg/m^3 increase in $PM_{2.5}$ concentration increased mortality rate by 1.07%.

Table 3: Particulate matter ($PM_{2.5}$ and PM_{10}) in air, temperature and relative humidity

Sample Location	$PM_{2.5}$ (µg/m^3)	PM_{10} (µg/m^3)	Temperature (°C)	Relative humidity (%)
Quarry entrance	15.00±1.41^{c}	56.50±6.36^{f}	42.97±0.54^{ab}	41.30±0.14^{c}
Dust	21.50±2.12^{b}	133.00±2.83^{d}	41.32±1.43^{b}	40.85±1.34^{c}
Before change room	13.00±2.83^{c}	67.00±2.83^{f}	43.12±0.16^{ab}	39.80±0.57^{d}
3/8 chipping heap	14.50±2.12^{c}	88.50±2.12^{e}	42.63±1.88^{ab}	39.95±0.64^{c}
Truck park	17.50±2.12^{bc}	197.00±4.24^{c}	42.69±1.36^{ab}	38.60±0.71^{ed}
Close to the conveyor belt	15.50±2.12^{c}	232.00±4.24^{b}	45.88±0.53^{a}	36.90±1.27^{e}
Chipping deposition and collection	69.00±1.41^{a}	2,829.50±12.02^{a}	45.17±0.37^{a}	37.10±1.27^{e}
Walk-way to pit	17.00±2.83^{bc}	68.00±2.83^{f}	38.13±1.80^{cd}	49.05±0.21^{a}
Pit	17.50±3.54^{bc}	86.00±5.66^{e}	40.96±0.35^{bc}	43.50±0.42^{b}
Control	12.00±1.41^{cd}	60.00±2.83^{f}	37.03±2.87^{d}	48.60±0.85^{a}
WHO Standard	*25 µg/m^3	*50 µg/m^3	NA	NA
USEPA 1996	*35 µg/m^3	NA	NA	NA

*WHO (2005), NA = Not available.

Further studies by Puett *et al*. (2011), Turner *et al*. (2011), and Hoek *et al*. (2013) concluded that increased $PM_{2.5}$ concentrations result in higher mortality rates due to cardiovascular, respiratory, and lung cancer causes based on epidemiological analysis. The prevalence of respiratory diseases among quarrying communities has been attributed to presence of suspended particulate matter in air (Omosanya and Ajibade, 2011). Thus, dust emission is one of the major effects of quarrying activities (Nartey *et al*., 2012) since pollution of water, soil, or air by particulate matter of the wider inhabited area around a quarry or mine can affect the local food sources and hence diet, with immediate and long-term effects (Abdullah *et al*., 2016).

In comparison with similar studies, the concentration of $PM_{2.5}$ (13.00±2.83 to 69.00±1.41 µg/m^3) in this study is well above <0.01±0.00 to 0.130±0.010 mg/m^3 reported for FW SAN HE CONCEPTS LTD quarry site in Ogun State, Nigeria (Bada *et al*., 2013) and 0.0045 to 0.1960 mg/m^3 recorded for quarry site in Southern part of Nablus district in the West bank, Palestine (Sayara, 2016) (Table 5). Similarly, the concentration of PM_{10} (56.50±6.35 to 2,829.50±12.02 µg/m3) in this study is well above 0.030±0.021 to 0.231±0.018 mg/m^3 observed at FW SAN HE CONCEPTS LTD quarry site in Ogun State, Nigeria (Bada *et al*., 2013) and 0.0580 to 3.1853 mg/m^3 recorded for quarry site in Southern part of Nablus district in the West bank, Palestine (Sayara, 2016). The differences in the results obtained in this study with these other studies may be attributed to the fact that chemical composition of particulate matter (PM) can vary widely as a function of emission source and the subsequent chemical reactions which take place in the atmosphere (Mishra and Tripathi, 2008; Engelbrecht *et al*., 2009; Olatunji *et al*., 2018), fluctuations in time of the year or seasons (Ibe *et al*., 2016), difference in the ambient temperature, relative humidity and wind speed including wind direction could also vary the concentration of atmospheric pollutants over the seasons (Kim *et al*., 2015) and possibly locational difference. The order of abundance of $PM_{2.5}$ in air sampled from the various sections of the China quarry site is as follows: chipping deposition cum collection point > first dust heaps > truck park/pit > walk way to the pits > close to conveyor belt > quarry entrance > $^{3}/_{7}$ chipping heaps > before change room while the order of abundance of PM_{10} is as follows: chipping deposition cum collection point > close to conveyor belt > truck park > first dust heaps > $^{3}/_{7}$ chipping heaps > pits > walk away to pit > before change room >quarry entrance.

Table 4: Overall changes in number of deaths and mortality rates under different standards for $PM_{2.5}$ for some countries

Country	Deaths/person	Morality rates/‰	Control Standards	Release time	Character of Standard
China	1,670,200	1.22	35 µg/m³	2012	Mandatory
European Union	1,098,100	0.80	25 µg/m³	2010	Mandatory
Japan	526,200	0.38	15 µg/m³	2009	Mandatory
America	354,500	0.26	12 µg/m³	2012	Mandatory
Australia	125,800	0.09	8 µg/m³	2003	Mandatory

Source: Xie et al. (2018.

At the China quarry site in Ngwogwo, the highest temperature value (45.88±0.53 °C) was recorded close to the conveyor belt but the value is statistically the same with values obtained at the chippings deposition/collection point (45.17±0.37 °C), before change room (43.12±0.16 °C), quarry entrance (42.97±0.54 °C), truck park (42.69±1.36 °C) and $^{3}/_{8}$ chippings heaps (42.63±1.88 °C) but significantly

(P < 0.05) higher than temperature values recorded at the dust heaps (41.32±0.43 °C), at the pit (40.96±0.35 °C), walk way to pit (38.13±1.80 °C) and control (37.03±2.87 °C) (Table 3). The different levels of temperature at the quarry site may pose a serious health risk to the quarry workers since temperature is a modifier for particulate matter (PM) such as $PM_{2.5}$, PM_{10}. Temperature is an important modifier for particulate matter, which has a great impact on mortality (Sun *et al*., 2015). Thus, Sun *et al*. (2015) reported greater mortality effects of $PM_{2.5}$ in low temperature than that in high temperature for all natural and respiratory mortality and their findings is in conformity with the results of a study conducted in Shanghai, which found higher PM_{10} effects in low temperature for all natural, cardiovascular, and respiratory diseases. However, some authors have observed that adverse effects of particulate matter may be more apparent at higher temperatures. For instance, Ren and Tong (2006) reported high mortality from cardiovascular disease related to PM_{10} on days with temperature above 27°C in Brisbane, Australia while Meng *et al*. (2012) observed high mortality from cardiovascular disease related to PM_{10} on days with temperature above 30°C in China. There is significant interaction between PM and temperature (P < 0.05), with stronger health effects of PM in high temperature days for cardiovascular mortality (Li *et al*., 2011). In contrast, Cheng and Kan (2012) found significant interaction (P < 0.05) with higher PM effects in low temperature days for all natural and respiratory mortality. The temperature values obtained at the China quarry ranged from 38.13±1.80 °C (pit) to 45.88±0.53 °C (conveyor belt) and the values are higher than 21 to 37.2 °C (Jayamurugan *et al*., 2013), -0.10 to 26.8 °C (Tecer *et al*., 2008), -10.1 to 32.1 °C (Guo *et al*., 2013), and 13.3 to 42.3 °C (Rodrigues *et al*., 2017) in related studies. The order of increase of temperature at the China quarry site is in the order: walk way to the pit < pit < dust heaps < 3/8 chippings heaps < truck park < quarry entrance < before change room < chippings deposition/collection point < close to the conveyor belt.

Table 5: Comparison between results of this study ($PM_{2.5}$, PM_{10}) and other studies

Reference	$PM_{2.5}$	PM_{10}	Temperature	Relative humidity	Study area
This study	13 – 69	56.50 – 2,829.50	38.13 – 45.88	36.90 – 49.05	Ngwogwo in Ivo LGA, Ebonyi State, Nigeria
Sayara (2016)	0.0045 – 0.1960	0.0580 – 3.1853	–	–	Quarry site in Jammain, Palestine
Sun *et al*. (2015)	5.4 – 179.7	7.9 – 573.0	8.2 – 31.8	27.5 – 98.1	Hong Kong
Bada *et al*. (2013)	<0.01 – 0.130	0.030 – 0.231	–	–	Quarry site in Odeda LGA in Ogun State, Nigeria
Nartey *et al*. (2012)	–	54.6 – 125.0	–	–	Limestone quarry in ManyaKrobo District of the Eastern Region of Ghana
Wang *et al*. (2020)	125.9	–	–	–	Beijing, China
Rodrigues *et al*. (2017)	0.10 – 172.3	–	13.30 – 42.30	35.0 – 97.0	Municipalities of Cuiabá and Várzea Grande, State of Mato Grosso, Brazil
Tecer *et al*. (2008)	4.55 – 95.65	12.0 – 200	-0.10 – 26.80	29.0 – 95.0	Coal-mining area in Zonguldak, Turkey
Enotoriuwa *et al*. (2016)	3.1 – 75.7	10.8 – 211.9	29.8 – 33.9	57.8 – 82.8	Oil operating areas in Obigbo and its environs in River State, Nigeria
Choi *et al*. (2012)	41.9	–	–	–	Korea
Akinfolarin *et al*. (2017)	2.9 – 300.35	5.65 – 1926.30	–	–	Three emerging industrial sites in Port Harcourt, Rivers State, Nigeria
Yu *et al*. (2019)	50-53 53-55 54-56	67-71 93-102 87-94	–	–	Shanghai Nanjing Hangzhou
Xu *et al*. (2012)	44.3	–	–	–	Fuzhou
Ubong *et al*. (2015)	2.2 – 59.7	10.3 – 367.5	–	–	Port Hacourt in River State, Nigeria
Ukpong (2012)	–	–	–	56.9 – 91.3	Stone quarrying in Akamkpa, Cross River State, Nigeria
Li and Bai (2009)	117	–	–	–	Tianjin
Opara *et al*. (2016)					Air pollution in Orlu city, Owerri municipality and a quarry site in Okigwe, Imo State, Nigeria
Zhang *et al*. (2009)	63.9	–	–	–	Beijing, China
Oguntoke *et al*. (2009)		3.67 – 26.03	–	–	Quarry site in Abeokuta, Ogun State, Nigeria
Jayamurugan *et al*. (2013)	–	–	21 – 37.2	44 – 98	Coastal urban area in North Chennai, India
Li *et al*. (2010)	38.8	–	–	–	Changbai mountain Nature Reserve
Guo *et al*. (2013)	0.7 – 517.7	10.0 – 600.0	-10.1 – 32.1	8.0 – 97.0	Main campus of Peking University in Beijing, China
Onwe (2015)	–	138.71 – 176.29	–	–	Quarry site in Umuoghara in Abakiliki, Ebonyi State, Nigeria
Li *et al*. (2010)	89.2	–	–	–	Shanghai
Kalu (2018)	–	20.0 – 860	–	–	Stone quarrying activities in Akpoha and Ishiagu in Ebonyi State, Nigeria
Peter *et al*. (2018)	–	15 – 860	–	–	Quarry site in Akpoha and Ishiagu in Ebonyi State, Nigeria
Tanner *et al*. (2004)	19	–	–	–	Tennessee

In this study, the highest value of relative humidity (49.05±0.21 %) was obtained at the walk way to pit but the value was not different (P < 0.05) from the values obtained at the control site (48.60±0.85 %) but significantly (P < 0.05) higher than values of relative humidity recorded at the pit (43.50±0.42 %), quarry entrance (41.30±0.14 %), dust heaps (40.85±1.34 %), $^3/_7$ chippings heaps (39.95±0.64 %), before change room (39.80±0.57 %), truck park (38.60±0.71 %), chippings deposition/collection point (37.10±1.27 %), and close to the conveyor belt (36.90±1.27 %) (Table 3). The levels of relative humidity at the China quarry site may expose quarry workers to respiratory and cardiovascular diseases since the values of relative humidity in this study are below 54.5 % and 80 %. The findings of Rodrigues *et al*. (2017) noted that the action of $PM_{2.5}$ on hospitalizations and mortality from cardiovascular disease can be exacerbated on days of low relative humidity below 54.5 % while Qiu *et al*. (2013) observed an increase in emergency hospitalizations for ischemic heart diseases related to PM_{10} on days when relative humidity was below 80 % in China. The values of relative humidity in this study ranged from 36.90±1.27 to 49.05±0.21, which are lower than 56.9 to 91.3 % at stone quarrying site in Akamkpa, Cross River State, Nigeria (Ukpong, 2012), 29.0 to 95.0 % (Tecer *et al*., 2008), 35.0 to 97.0 % (Rodrigues *et al*., 2017), 8.0 to 97.0 % (Guo *et al*., 2013), and 44.0 to 98.0 % (Jayamurugan *et al*., 2013) in a related study. The order of increase of relative humidity at the China quarry site is in the order: close to conveyor belt < chippings deposition/collection point < truck park < before change room < 3/8 chippings heaps < dust heaps < quarry entrance < pit < walk way to the pit.

4.0. Conclusion

The highest concentrations of Pb, Zn, Mn, Fe, Ca, K, and Na in granites were recorded in dust particles at China quarry site in Ngwogwo in Ishiagu, Ebonyi State. The order of abundance of the elemental composition in granites is: Fe > Mn > Zn > Ca > Mg > Pb > Co > As > Na > K. The highest concentration of $PM_{2.5}$ and PM_{10} were detected at the chippings deposition cum collection point. The concentration of $PM_{2.5}$ is higher than the permissible limit set by United States Environmental Protection Agency (USEPA), World Health Organization (WHO) as well as the Control Standards set by the People Republic of China, European Union, Japan, United States of America and Australia. The concentration of PM_{10} are substantially well above the permissible limit set by World Health Organization (WHO).

Acknowledgement

The authors acknowledge the Manager of China quarry for given us access to the various sampling positions in this study. The services of Mr. Emebu, Prosper Kome (statistical analysis of the data) are also appreciated.

Conflict of interest

There is no conflict of interest associated with this work.

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Cite this article as:
Ogbonna P. C., Ukpai N. P. and Ubuoh E. A., 2020. Assessment of particulate matter ($PM_{2.5}$, PM_{10}) in air, elemental composition of granite and weather parameters at a quarry site in Ngwogwo, Ebonyi State, Nigeria. *Nigerian Journal of Environmental Sciences and Technology*, 4(1), pp. 182-196. https://doi.org/10.36263/nijest.2020.01.0199

Nigerian Journal of Environmental Sciences and Technology (NIJEST)
www.nijest.com
ISSN (Print): 2734-259X | ISSN (electronic): 2734-2603
Vol 4, No. 1 March 2020, pp 197 - 203

Improving the Cultural and Historical Tourism Resources for Sustainable Development in Ondo State – A Survey of Idanre Hills and Resort Centre, Idanre

Ikusemiju T. M.[1,]* and Osinubi O. B.[2]
[1,2]Department of Hospitality, Leisure and Tourism Management, School of Applied Sciences, Federal Polytechnic Ede, Osun State, Nigeria
Corresponding Author: *toluwalase20002000@gmail.com

https://doi.org/10.36263/nijest.2020.01.0182

ABSTRACT

It has been observed that necessary attention has not been given to Idanre hills and resort centre as tourists' attraction and its sustainability is being threatened. Thus, this paper revealed that many studies have been carried out on Idanre hills and resort centre but had only focused on its beautifications, geo – tourism potentials, landscape management, maintenance and tourists' patronage pattern. Hence, the objectives of this study revealed possible strategies of making the cultural and historical tourism attraction of Idanre hills and resort centre sustainable for both this generation and the future generation and how these strategies can specifically be of economic and social benefits to the residents of Idanre community for sustainable livelihood. The study adopted oral interview, personal observation and administration of questionnaire for data collection of which 200 questionnaires were administered and 188 were returned representing 94.00%. Meanwhile, the questionnaires were presented and analyzed with the use of simple percentage method while percentage point of t – test distribution (One - tailed) analysis was adopted in validation of the hypothesis. The result indicated that t (calculated) was 0.13 and was greater than t (tabulated) of -2.92; thus, the null hypothesis was rejected, while the alternative hypothesis was accepted, which states that there are promising economic and social benefits of specifically developing and sustaining the cultural and historical tourism resources of Idanre hills and resort centre. The study concluded that if Ondo State Government and relevant tourism stakeholders should put the necessary strategies in making the cultural and historical tourism resources of Idanre hills and resort a haven in place; its development will have specific economic and social benefits such as economic stability and social integration etc. on the residents of Idanre community and Ondo State at large by stimulating its local economy both directly and indirectly through multiplier effects.

Keywords: Cultural, Historical, Economy, Social, Sustainable development and Tourism Resources

1.0. Introduction

Tourism comprises the multidimensional activities of people travelling to and staying in places outside their usual place of residence for a specified period of twenty four hours and not more than one consecutive year for leisure, business, sightseeing and other purposes not related to activity remunerated from within the place visited. The activities spread across economic, social, cultural and environmental nature of many lives and communities (Sudhir, 2007).

The tourism industry is one of the world's largest industries with a world trade contribution (direct, indirect and induced) of over 7.6 trillion U.S. dollars in 2016 ranged in terms of accommodation, transportation, entertainment etc. of which 2.3 trillion U.S dollars came as a result of direct contribution to the economy. A number of countries such as France, Egypt and the United States of America are consistent popular tourism destinations but other, less well-known countries as Nigeria are quickly emerging in order to reap the economic benefits of the tourism industry. Thus, the tourism industry globally has continued to experience steady growth almost every year with international tourist arrivals increased from 528 million in 2005 to 1.19 billion in 2015 with global international tourism revenue reaching approximately 1.26 trillion U.S. dollars, having almost doubled since 2005. Figures were forecasted to exceed 1.8 billion by 2030 (Makoondlall-Chadee *et al*., 2017).

Cultural and historical resource has always been a major objective of travel as the development of the tourism industry from the 16th century till date attest to the fact that cultural and historical attractions of the industry play an important role in tourism at all levels from the global highlights of world culture to attractions that strengthen local identities. Also, in recent years cultural and historical resources has been rediscovered as an important marketing tool to attract those travellers with special interests in heritage and arts (Richard, 2016). Similarly, Jin (2002) quoting Hollinshed (1993) stated that cultural and historical tourism is the fastest growing segment of the tourism industry because there is a trend toward an increase specialization among tourists.

Cultural and Historical tourism also known as heritage tourism or diaspora tourism is a derivative of tourism industry geared towards the cultural and historical heritage of a locality. Thus, The National Trust for Historic Preservation describe heritage tourism as traveling to experience historical places, places of artifacts and activities that authentically represent the stories and people (Wall and Mathieson, 2016).

Accordingly, cultural and historical tourism is important as it has positive economic and social impacts, it establishes and reinforces identity, it preserve the cultural and historical heritage with culture and histories as instrument to facilitate harmony and understanding among the people (Suleiman, 2010).

The trend aforementioned have been observed as the number of tourists / visitors who seek adventure, culture, history and interaction with local people of Idanre is increasing on regular and daily base.
Hence, for sustainable development of Ondo State; Idanre hills in the context of cultural and historical tourism resources has a number of objectives which include the conservation of cultural and historical attractions, accurate interpretation of cultural attractions, value for money / visitors experience. The utilization of the earned revenues of cultural and historical resources for economic and social benefits of the community and the nation as whole must be met within the perspective of United Nations Sustainable Development Goals (SDGs) and these are decent work and economic growth (Goal number 8), Industrial Innovation and Infrastructure (Goal number 9), Sustainable cities and communities (Goal number 11) and Partnership for the goals (Goal number 11) (Rieder, 2012).

In Nigeria, tourism industry and its derivatives has the capability of huge relief of providing employment, revenue, social cohesion among others if necessary attention of sustainable tourism practices is given. Thus, for economy wellbeing of the host community (Goal 8), Idanre hills has the capability of generating a lot of direct revenue into treasury of Ondo State government.

The study is imperative for the reason that many different cultural and historical tourism resources in different places such as Idanre hills and resort centre have not been given adequate attention and advancement by the government even as many have been ignored, threatened or gone into extinction as a result of lack of commitment by the government. Also, persistence political instability and change of government, inadequate infrastructural facilities do have negative impacts on the cultural resources.

It has been observed that numerous studies such as (Anifowose and Kolawole, 2014) and (Nwanne, 2017) have been carried out on Idanre hills and resort centre but these studies only focused on its beautifications. Also, Ogunbodede (2012) only focused on the pattern of patronage of tourists to Idanre hills and its importance to future generations. Likewise, Adebayo (2019) basically focused on how issues of sustainability are being conceptualized by tourism officials that are responsible for managing Idanre hills and resort centre and how such ideas are incorporated into tourism development. Similarly, Aremu and Lawal (2018) simply focused on the influence of tourism on the sustainable economic development of Idanre residents. Also, Adeniyi *et al*. (2018) basically focused on the importance of maintaining the infrastructural facilities and monuments on Idanre hills and resort centre.

Thus, all the aforementioned did not focus on strategies of making the cultural and historical tourism resources of Idanre hills and resort centre a haven and how these strategies can specifically be of economic and social benefits to the residents of the study area. Consequently, this study tends to reveal possible strategies of making the cultural and historical Tourism attractions such as Idanre hills and resort centre to be sustainable for both this generation and the future generation and to disclose how these strategies can specifically be of economic and social benefits to the residents of Idanre community for sustainable livelihood.

The null hypothesis of the study states that there are no promising economic and social benefits of specifically developing and sustaining the cultural and historical tourism resource of Idanre hills and resort centre while the alternative hypothesis states that there are promising economic and social benefits of specifically developing and sustaining the cultural and historical tourism resource of Idanre hills and resort centre.

2.0. Methodology

2.1. Study area

The Idanre Hill is one of the most beautiful natural landscapes in Ondo State. It consists of high plain with spectacular valleys interspersed with iceberg of about 3,000 ft above sea level and houses a unique ecosystem upon which the cultural landscape has integrated. It is located in Idanre town of land area 1,914 km^2 (739 sq mi) and on the coordinates 7°05′32″N and 5°07′56″E with a population of 129,024 based on the 2006 population census (Adisa, 2019).

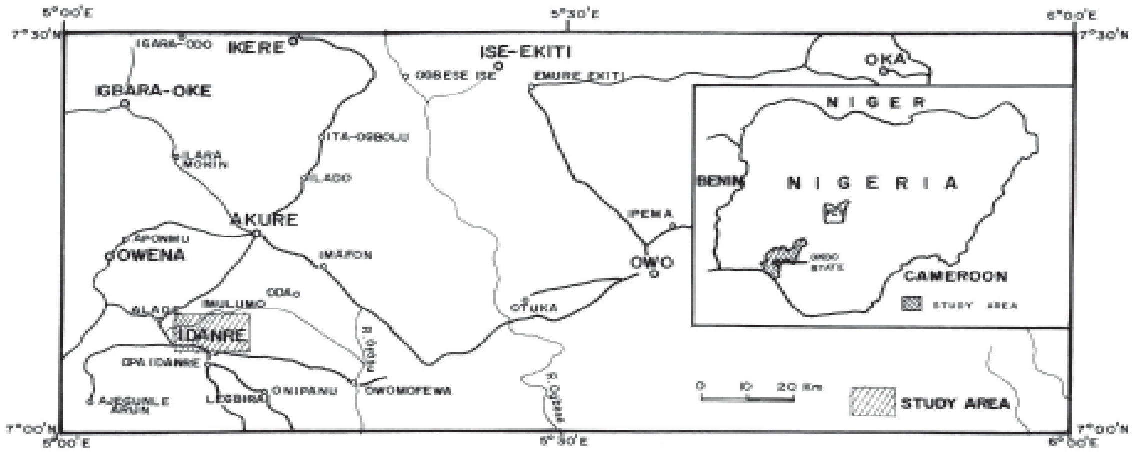

Figure 1: Map of the location of the study area

2.2. Methods

The population of the study was a survey of Indigenes / Residents of Idanre, Staff and Tourists at the Idanre hills and resort. The researchers utilized stratified sampling method in the selection of two hundred (200) respondents that encompassed 100 indigenes / residents, 10 staff and 90 tourists. The data gathered through the administration of 200 questionnaires of which only one hundred and eighty eight (188) were returned representing 94.00% were presented and analyzed with the use of simple percentage method. Meanwhile, the study used Percentage point of T – test distribution (One tailed) in the validation of hypothesis because the standard deviation of the population is unknown (Srivastava, 2019) which assisted the study in a logical conclusion.

However, the sample size of the study was determined by using the Yamane Taro model (Grupta and Kapoor, 2014) based on National Population Commission, 2006 Census in Ondo State.

$$Sample\ size\ (n) = \frac{N}{1 + N(e)^2} \quad (1)$$

where:

N Population of the study

e Sampling error (5%)

$$Sample\ size\ (n) = \frac{129024}{1 + 129024(0.05)^2} = 200$$

3.0. Results and Discussion

3.1. Making the Cultural and Historical Tourism Resources

Table 1 reveals that 180 of respondents representing 90.00% agreed that of the strategies to upholding the cultural and historical tourism resources of Idanre hills is provision of promotional materials such as souvenirs that will contain the designed and known brand name. Also, 179 respondents representing 89.50% agreed that one of the ways to enhance Idanre hills as a cultural and historical tourism resource is to maximize fully; the different seasons of the year. Thus, 184 respondents representing 92.00% believed in uncompromised marketing and publicity while 172 respondents representing 86.00% agreed that powerful media coverage will greatly enhance the promotion of Idanre hills. Nevertheless, 181 respondents representing 90.50 % were of the opinion of aggressive public, private and community partnership and 187 respondents representing 93.50% agreed that dependable infrastructural development would be of great support.

Table 1: Strategies of making the cultural and historical tourism resources of Idanre Hills and resort centre a haven

Variables	Frequency (Agreed)	Percentage (%)
Provision of Promotional material	180	90.00
Maximizing the different seasons of the year	179	89.50
Uncompromised marketing and publicity	184	92.00
Powerful media coverage	172	86.00
Aggressive Public, Private and community partnership	181	90.50
Dependable infrastructural development	187	93.50

Source: Fieldwork (2019)

In discussion, the strategies stated above hold that good cultural and historical conservation strategies require a better appreciation of the heritage asset and integration of such strategies within the larger process of planning and development of urban areas and these include infrastructural/service provision, community participation and urban identity (Srinivas, 2015).

Also, the above is in line with Fadipe (2007); that advocated that strategies to achieve a preferred tourist destination (sustainable development) include the following among others:

1. Concession on existing tourist attractions and provision of infrastructural facilities.
2. Encouraging private sector involvement in tourism and launching awareness campaign within and outside Nigeria.

3.2. Economic and Social Benefits of enhancing Idanre Hills as a Resort Centre

Table 2 shows that 178 respondents representing 94.60% agreed that improving the cultural and historical tourism resources of Idanre hills will add to the economic development of the destination and its stability. Similarly, 184 respondents respecting 98.00% were of the opinion that cultural and historical tourism resources will help improve physical infrastructure and social integration and strengthen the community identity. Thus, 169 respondents representing 90.00% believed that its improvement would enhance understanding of environmental and ethic conservation while 185 respondents representing 98.40% established that its development will stimulate thought of personal responsibility using cultural resources for improved quality of life.

Table 2: The Economic and Social Benefits of enhancing Idanre Hills as a Resort Centre

Variables	Frequency (Agreed)	Percentage (%)
Adds to economic development and stability	178	94.60
Improves physical infrastructural and social integration	184	98.00
Enhances and strengthen community identity	184	98.00
Enhances understanding of environmental and ethic conservation	169	90.00
Stimulate thought of personal responsibility using cultural and historical tourism resources for improved quality of life.	185	98.40

Source: Fieldwork (2019)

The above findings is supported by Dumcke and Gnedovsky (2013) that state that cultural and historical tourism resource of Idanre Hills and Resort centre if properly managed can be instrumental in enhancing social inclusion, improving quality of the environment, creating jobs and enhancing investment climate.

3.3. Validation of hypothesis

Using the Table 3 below to test the hypothesis, let p = probability that there are promising economic and social benefits of specifically developing and sustaining the cultural and historical tourism resources of Idanre hills and resort centre to the development of Ondo State.

Table 3: Developing Idanre hills and resort centre will help stimulate the local economy.

Opinion	**Frequency**	**Percentage (%)**
Agreed	166	88.00
Disagreed	16	9.00
No Response	6	3.00
Total	**188**	**100**

Source: Fieldwork (2019)

Therefore, the sample size (n) = 188 and degree of freedom (that is, number of columns minus 1; 3 - 1) is 2 and level of significance is 0.05.

Thus, H_0: p = 0.88 (meaning that the population affirmation has not changed)
H_1: p ≠ 0.88 (meaning that the population affirmation has changed)

$$T_c = \frac{x - np}{\sqrt{np(1-p)}} \tag{2}$$

$$T_c = \frac{166 - 188(0.88)}{\sqrt{188(0.88)(1-0.88)}}$$

$$T_c = \frac{0.56}{\sqrt{19.85}}$$

$$T_c = \frac{0.56}{4.46}$$

$$T_c = 0.13$$

Decision Rule: Reject H_o if T_c is less than -2.92 (T - tabulated) and thus, accept H_1 if T_c greater than -2.92 (see Figure 2).

Decision: Since T_c is 0.13 and is greater than -2.92, therefore, the researchers reject H_o and thus, accept H_1. That is, there are promising economic and social benefits of specifically developing and sustaining the cultural and historical tourism resources of Idanre hills and resort centre to the development of Ondo State.

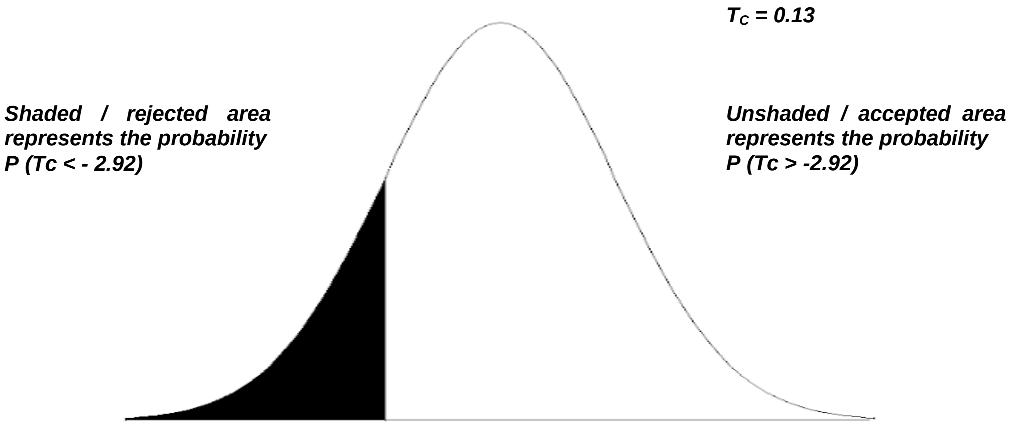

Figure 2: Percentage point of T – test distribution (one tailed) showing the acceptance area

3.4. Summary of findings

From the study, it was discovered that the rational responses of the residents, staff and tourists about Idanre hills and resort centre showed clearly their level of understanding that if cultural and historical tourism resources of Idanre hills and resort centre is properly harnessed, it will be of great economic and social benefits to individuals and the government of Ondo State.

4.0. Conclusions

Tourism industry and its derivatives is an inevitable sector that must be sustainable development activated to help stimulate the economic and social wellbeing of the society. The Idanre hills and resort centre have come of age and of which necessary attention and advancement have not being given by the Ondo State government towards its development.

Thus, study concluded that if Ondo State government and relevant tourism stakeholders should put the necessary strategies in making the cultural and historical tourism resources of Idanre hills and resort a haven in place; its development will have specific economic and social benefits such as economic stability and social integration etc on the residents of Idanre community and Ondo State at large by stimulating its local economy both directly and indirectly through multiplier effects.

Based on the study, the researchers recommended the following:

- Strategies for making cultural and historical tourism resources of Idanre hills and resort centre should be encouraged and implemented by Ondo State Government in partnership with relevant tourism stakeholders.
- Basic infrastructural facilities should be provided by the Ondo State Government to enhance sustainable development of Idanre hills and resort centre.
- The strategies required in harnessing the cultural and historical tourism resource of Idanre hills for sustainable development should be integrated with adequate planning, control and development.

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Cite this article as:

Ikusemiju T. M. and Osinubi O. B., 2020. Improving the cultural and historical tourism resources for sustainable development in Ondo State – A survey of Idanre Hills and resort centre, Idanre. *Nigerian Journal of Environmental Sciences and Technology*, 4(1), pp. 197-203. https://doi.org/10.36263/nijest.2020.01.0182

Nigerian Journal of Environmental Sciences and Technology (NIJEST)
www.nijest.com
ISSN (Print): 2734-259X | ISSN (electronic): 2734-2603
Vol 4, No. 1 March 2020, pp 204 - 213

The Contributing Effects of Human Activities to Flooding in Ota, Ogun State

Oseni A. E.[1,]* and Bamidele E. T.[2]
[1,2]Department of Surveying and Geoinformatics, Bells University of Technology, Ota, Ogun State, Nigeria
Corresponding Author: *ayo_oseni@yahoo.com

https://doi.org/10.36263/nijest.2020.01.0195

ABSTRACT

Flood is considered to be a major natural disaster occurrence that affects human existence and the environment in many parts of the world. The objective of this study is to analyze the flood-prone areas and determine their spatial locations using GPS and also determine the causes of flooding in the study area through questionnaires. To achieve this, primary source data like fieldwork was used and secondary source data like administration of questionnaires was also used. A Survey of 120 randomly sampled respondents was conducted in different flood-prone locations and 100 responded. The data obtained from the questionnaires was analyzed for the determination of the flood-prone areas in Ota, Ogun State. The result reveals that human activities like the dumping of refuse in drainage, bad road network, lack of proper drainage is majorly responsible for the areas to be at risk of flood prone. It was recommended that the government should create public awareness and sensitization campaigns should be embarked on to prevent the occurrence of this hazardous event in the future.

Keywords: Flood, GPS, Data, Drainage, Refuse

1.0. Introduction

Flood is a hazardous type of natural disaster which is a flow of water that rises above carrying capacity of a channel. It is also defined as a large amount of water that covers an area that was usually dry (Olajuyigbe *et al*., 2012).

There are different occurrences of floods in Nigeria due to heavy rainfall and excess releases from dams with low capacities to cope with a high inflow of water into their reservoir areas to safe the dams whose failure could be more epidemic than the consequences of the releases, however, this can destroy houses, properties, farm produce, and animals. This natural event has caused loss of thousands of lives and millions of naira worth of properties. Flood in the cities has led to high level of water overflowing into the streets and roads, thus causing many problems like collapse of bridge, building damage and traffic problems. The risks of floods are possible to avoid and prevented from occurrence. Managing flood and other disasters focus on proper measures on reducing the socioeconomic impacts of these disasters through mobilizing relief materials with little investments into research efforts which aim at understanding the dynamics of these natural events and reducing the impacts of future flood events.

Sharma and Sharma (2000) stated that effort to control flood and its impact has led to the development of technologies for analyzing and assessment of flood and flood prone areas. New technologies such as Geographic Information Systems (GIS), measurement of rainfall, stream discharge and soil moisture by radar, remote sensing using camera and geophysical sensors from satellites and aircrafts, processing and retrieval by use of digital computers, automation of data storage, electric analogs, were employed to predict hydrology.

During a flood, agricultural crops and household items including food items, rugs, television sets, fridges, chairs, tables and other expensive electronics can be damaged when water from the river

submerged most of the houses. Several mechanic workshops, grocery stores and pharmaceutical shops, structures like churches, mosques and private buildings can also be affected during the flood.
There has been different incidence of floods and its negative effects in most of the urban centers of developing countries. For example, in Nigeria, it has been reported that terrible flood disaster had occurred in Ibadan (1985, 1987, 1990, and 2011), Osogbo (1992, 1996, 2002, and 2010), Yobe (2000), Akure (1996, 2000, 2002, 2004 and 2006) and the coastal cities of Lagos, Ogun, Port Harcourt, Calabar, Uyo, Warri among others (Olaniran, 1983). This calamity claimed many lives and properties worth millions of naira. Several anthropogenic factors have contributed to the incidence of flood. Part of these factors is the penetration of development and urbanization to flood prone areas. The encroachment into such areas has being on-going until now because of unprecedented urbanization and industrialization which has undoubtedly resulted into high rate of deforestation, loss of surface vegetation and farmlands. The unplanned and uncontrolled development, and industrialization into urban infrastructure facilities, violate the major objectives of physical planning and consequently result into misuse of land thereby creating disorderly arrangement of urban landscape and the occurrence flood that is mostly evident in cities of third world countries.

Etinosa (2006) in a discussion paper on “dams are unrenewable” reported that over 26 villages including Galadima Kogo, Gofa, Kusasun, Pai, Lagado, Nakpinda and Karai in Kede, Lakpma and Shiroro Local Government in Niger State were flooded by the waters from Rivers Niger and Kaduna. The flood which struck in the early hours of Saturday 11th September, 2003 resulted from a heavy rainfall and the release of excess water from the Shiroro Hydro-Electric Dam by the National Electric Power Authority (NEPA). The flood displaced about 10,000 persons in Ketsho in Kede Local Government, while other 13,500 persons in Lakpam and Shiroro were rendered homeless. The Ogun-Osun river systems on which we have Oyan and Ikere Gorge dams are characterized by annual flood occurrences, flooding Abeokuta and Lagos each year. River Benue is also not left out of flooding, washing away the bridge at Jimeta in 2005.

According to Etinosa (2006), water will always find its way if not well channeled. Its choice route often poses problems to man by tampering with his physical environment, health and products of agriculture, urbanization and industrialization. This has created a lot of social and economic cost on the environment. Few among these social and economic impacts on the environment are: outbreak of health diseases, infrastructure failure, mental health effects, building collapse, destruction of agricultural farmland and products. Flood has been reported as a major and devastating problem in some sectors of the economy (Petak and Atkisson, 1982). Its effects are very severe to virtually all forms of land use. The severity of its impact is also reflected on the rate of development of most nations that experience such. Thus if adequate attention in terms of preventive measures are not put in place towards controlling its sporadic occurrence and its associated impacts particularly during rainy season, its incidence can turn a developed nation back into a developing nation.

Many researchers have stated that flood is an overflow of an expansion of water that submerges land, The European Union (EU) Flood directive (2007), defines a flood as a temporary covering by water of land that is not normally covered by water. In the sense of "flowing water", the word may also be applied to the inflow of the tide. This water comes from the overflow of sea, lakes, rivers, canals, sewers or from rainwater. Flooding is normally caused by natural weather events such as heavy rainfall and thunderstorms over a short period, prolonged rainfall or extensive rainfall. It can also be caused by high tide combined with stormy conditions. It is predicted that climate change will increase the risk of flooding in the UK and other parts of the world (Petak and Atkisson, 1982). There is risk whenever heavy downpour of rainfall flows overland from the area it first precipitated to become runoff.

Odunuga *et al*. (2012) also established flood it is an unusual high stage of water usually above the bank of its flow path (artificial or manmade). When it causes damage to goods and properties or impairs human activities, it becomes a hazard. Olajuyigbe *et al.* (2012) stated that flood may also result from overflowing of a great body of water over land and extreme hydrological events or an unusual presence of water on land to a depth which affects normal activities. Flood occurs as a result of combination of meteorological and hydrological extremes as well as activities of man on drainage basin (Adeaga, 2008).

The problems of areas prone to flooding in Ado-Odo Ota have been considered as the serious problems in the area especially during the raining season. This periodic flooding in Ota is a perpetual event which happens during the period of heavy rainfall in which most of the drainages exceed their normal channel capacity and frequently overflow causing loss of properties and more havoc in the community. The areas that are mostly flooded are those that lack proper channeled drainage and those that are occupied by domestic refuse.

2.0. Methodology

2.1. Study area

The study area is depicted in Figure 1, showing the Ogun State within the Nigeria federation, Figure 2, showing the Ado-Odo Ota Local Government within Ogun State, and Figure 3, showing the satellite image of the studied location within Ado-Odo Ota Local Government. The studied locations in Ado-Odo Sango-Ota Local Government include Oju-ore, Joju, and Ijoko Road. The study area, Ado-Odo Ota Local Government Area, Ogun State**,** is in the South Eastern part of Nigeria. It is located between the Latitude 6.611719 and the Longitude 3.05762. It borders Lagos State to the South, Oyo State and Osun State to the North, Ondo State to the East and the Republic of Benin to the West. Figure 4, therefore, shows points of data measurements for this work, in the study area.

Figure 1: Map of Nigeria showing Ogun State, the study area

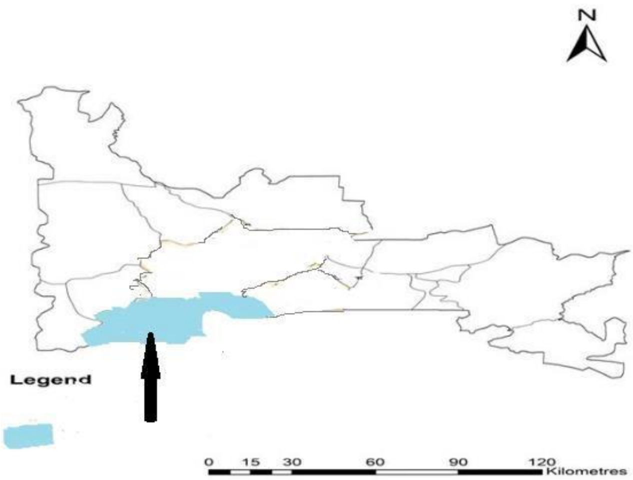

Figure 2: Map of Ogun State showing Ado-Odo Ota L.G.A

Figure 3: Satellite image of Oyede Crescent at Oju-Ore

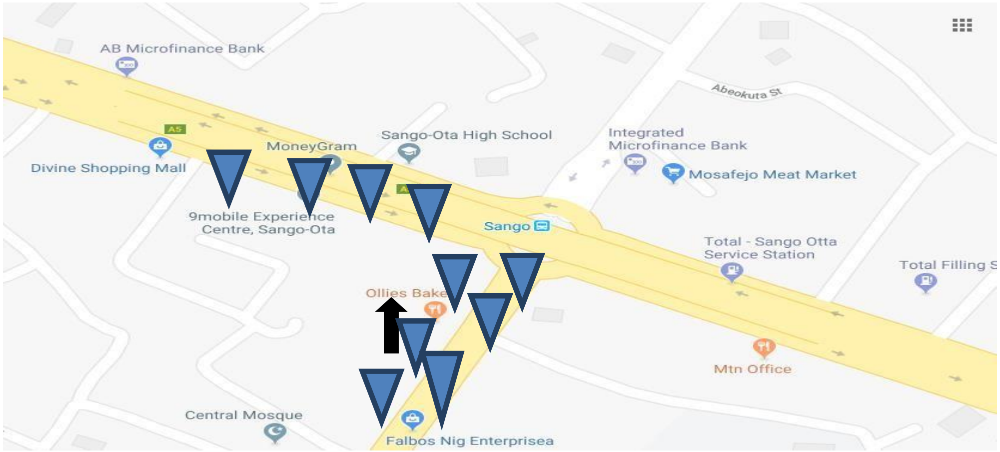

Figure 4: Map showing study locations

2.2. Reconnaissance for a GPS survey

Reconnaissance is one of the most important parts of a GPS survey. For the actual collection of GPS data, the observing station must have a clear view of the sky when satellites are passing over the job site. It involves site visit and selection of the best location for the control point.

2.3. Data Source

The sources of data employed for this research includes both secondary and primary data sources. The secondary data include information obtained from publications such as journals, official documents, previous research works as well as newspapers on the various occurrences of flood disasters and pertinent issues relating to the subject and the primary source of data were extracted from field survey, personal interviews and through questionnaires administration.

A structured questionnaire was prepared and administered to the residents residing in the flood prone area within the Ado-Odo Ota Local Government. Interview was conducted with selected respondents who were unable to fully comprehend and answer the questionnaire provided, while, field survey was done for inspection of some areas that are prone to flood so as to obtain direct information. The data collected were analyzed using chi square to examine the variation between independent and dependent variable.

2.4. Data collection

The data used in this study came from using GPS to acquire coordinates of points. The sample selection includes four areas, based on the locations of the areas, the areas were assessed one after the other for the survey process, and the questionnaires were collected and checked for the completeness and validity of collected questionnaires. Before each interview began, the purpose of the investigation and confidentiality principles were verbally explained by the investigators and practiced for perfection. The participation of the respondents in this study was voluntary and consented, and enough time was given. Any confusion of the questions during the survey was explained by the investigators and the respondents had the rights to refuse to participate or withdraw from the survey at any time. At least, 120 questionnaires were distributed, 110 were collected, and the number of valid responses after the subtraction of incomplete questionnaires was 100 (the response rate was 83.3%).

2.5. Sample selection

Five areas were chosen as survey sampling locations that are event to flood. Sango, Oju- Ore, Joju, Ijoko and Abeokuta road are the urban centers of Ota in Ado-Odo Local Government. A questionnaire was designed to investigate the flood event areas. Respondents with different educational levels were included in the questionnaire, and their feedbacks on the details of the questionnaire were harvested. Based on these responses, the language used was simple and easy to understand. In the first part of the questionnaire, the purpose of the investigation and the relevant confidentiality principles were highlighted. This was used to inform respondents that the survey is anonymous with the data collected.

The main content of the questionnaire was divided into three main parts (Table 1). Each part had several objects for measurement. The first part included six items determining the most important socio-demographic factors of the respondents such as place of residence, gender, age, education level, occupation, and income per month (Kellens *et al*., 2013). The second section was other four important factors that could influence the flood event. The four impact factors were flood experience, flood knowledge education, flood protection responsibility, and believe in government. One impact factor consists one item. The third section was the measurement of public flood vent. The impact and likelihood are most often used variables to measure the flood event areas as the flood risk is usually defined by the product of the likelihood of flood disaster with its consequences (effects) (Kellens *et al.*, 2013).

In this research some areas in Ota suffers from the flood almost every year. Therefore, the impact of the flood was more important to focus on.

Table 1: Definition of the measured and impact factors of flood prone areas

Category	Description	Content
Socio-demography	Characteristics respondents	Areas Genders Age Level of education Occupation Income per month
Other vital impact factors	Flood experience by respondents	The rate of experience respondents have on flood disaster
	Flood protection obligation	The obligation of flood protection agency
	Flood education knowledge	The knowledge about education that respondents have on flood
	Believe in government responsibility	They believe of respondents in government on flood risk management
Flood risk events	Respondents perceived flood risk	The effect of flood disaster

2.6. Data processing

Quantitative and descriptive statistics were applied to reveal the features of the socio-demographic characteristics of the respondents and their impact factors like flood protection responsibility, flood knowledge education, flood experience, and trust in government. A statistical analysis was carried out under a significance test value of 0.05 to confirm whether these impact factors affected the flood Occurrence. Impact factors with the significance value of less than 0.05 were considered to be significantly influential to flood risk conception.

3.0. Results and Discussion

In this research, 100 survey questionnaires were analyzed. These results were presented in tables containing data of responds and the subsequent analyses.

3.1. Data analysis

The Chi-square analysis was employed as the statistical too for this study. The results obtained from the analyses are presented in Table 2, for analyses from respondents based on flood occurrence, in Table 3, for analyses from respondents based on flood education awareness, and in Table 4, for analyses from respondents based on flood protection agencies.

Table 2: Chi square analysis for percentages and number of respondents on flood occurrence

	Percentages and number of Respondents on Flood occurrence				
	Oju-Ore	Sango	Joju	Total	
Less than once in a year	2 *2.50* (0.10)	3 *4.50* (0.50)	5 *3.00* (1.33)	10 *10.00* (0.00)	20
Once in a year	5 *4.25* (0.13)	5 *7.65* (0.92)	7 *5.10* (0.71)	17 *17.00* 0.00	34
One or two times in a year	8 *7.00* (0.14)	12 *12.60* (0.03)	8 *8.40* (0.02)	28 *28.00* (0.00)	56
More than two times in a year	10 11.25 (0.14)	25 20.25 (1.11)	10 13.50 (0.91)	45 45.00 (0.00)	90
	25	45	30	100	200

$\chi 2 = 6.042$; df = 9; χ^2/df = 0.67; P ($\chi^2 > 6.042$) = 0.7357
Where df = degree of freedom, χ^2 = Test statistic, P = probability.

Table 3: Chi square analysis for percentages and number of respondents on flood education awareness

	Percentages and number of respondents on flood education awareness				
	Oju-Ore	Sango	Joju	Total	
Never	10 *11.62* (0.23)	22 *20.93* (0.06)	13 *13.95* (0.06)	48 *46.50* (0.05)	93
Few	7 *6.38* (0.06)	13 *11.47* (0.20)	7 *7.65* (0.06)	24 *25.50* (0.09)	51
Medium	5 *4.75* (0.01)	8 *8.55* (0.04)	6 5.*70* (0.02)	19 *19.00* (0.00)	38
High	3 *2.25* (0.25)	2 *4.05* (1.04)	4 *2.70* (0.63)	9 *9.00* (0.00)	18
	25	45	30	100	200

$\chi 2 = 2.781$; df = 9; χ^2/df = 0.31; P ($\chi^2 > 2.781$) = 0.9724

Table 4: Chi square analysis for percentages and number of respondents on flood protection agencies

Agencies	Percentages and number of Respondents on Flood Protection				
	Oju-Ore	Sango	Joju	Total	
Government	5 *2.50* (2.50)	3 *4.50* (0.50)	2 *3.00* (0.33)	10 *10.00* (0.00)	20
Flood protection management	5 *5.50* (0.05)	11 *9.90* (0.12)	6 *6.60* (*0*.05)	22 *22.00* (0.00)	44
Company	10 *10.75* (0.05)	20 *19.35* (0.02)	13 *12.90* 0.00	43 *43.00* (0.00)	86
Community	3 *4.*00 (0.25)	8 *7.20* (0.09)	5 *4.80* (0.01)	16 *16.00* (0.00)	32
General public	2 *2.25* (0.03)	3 *4.05* (0.27)	4 *2.70* (0.63)	9 *9.00* (0.00)	18
	25	45	30	100	200

$\chi 2 = 4.904$; $df = 12$; $\chi^2/df = 0.41$; $P(\chi^2>4.904) = 0.9611$

3.2. Data presentation

The data obtained from respondents were presented in Table 5. In this table, the summarized numbers of responses for each area are presented as well as the socio-demographic variables of the respondents. The data therefore shows that numbers of respondents in Sango area were higher, i.e. more responses were collected, than in the other areas for the study. Table 6 summarized the distribution of other vital impact factors (flood experience, flood knowledge education, flood protection responsibility, and believe in government). Table 7 shows the UTM coordinate systems of each location at the study area.

Table 5: Ages and standard of living of the respondents

Variable	Ota area	Oju-Ore	Sango	Joju
Total number of respondents	100	25	45	30
Age				
16-20	12	2	8	3
21-40	32	12	16	12
41-60	33	5	12	9
61-70	15	4	3	4
70- above	8	2	6	2
Educational level				
Primary school and below	16	2	8	9
Middle school	33	8	12	9
High school Middle school	37	11	18	8
Bachelor	8	3	2	2
Master and above	6	1	5	2
Occupation				
Government work	15	3	5	4
Company work	31	6	8	6
Self-employed	35	9	18	10
Students	11	4	7	4
Retired person	5	2	4	4
Others	3	1	3	2
Income per month/ naira				
0-20,000	30	8	11	6
21,000-50,000	53	11	19	13
51,000-100,000	10	4	10	9
100,000 above	7	2	5	2

Table 6: Percentages and number of respondents on flood occurrence

Location (Ota area)	Oju-Ore	Sango	Joju	Total (100)%
Number of respondents (%)	25	45	30	100
Flood experience (%)				
Less than once in a year	2	3	5	10
Once in a year	5	5	7	17
One or two times in a year	8	12	8	28
More than two times in a year	10	25	10	45
Flood education awareness (%)				
Never	10	22	13	48
Few	7	13	7	24
Medium	5	8	6	19
High	3	2	4	9
Flood protection agency (%)				
Government	5	3	2	10
Flood protection management	5	11	6	22
Company	10	20	13	43
Community	3	8	5	16
General public	2	3	4	9

Table 7: UTM coordinate system

Location	Northing (mN)	Easting (mE)	Height (m)
Oju-Ore			
1	739300.49	525279.92	69.4
2	739301.81	525281.02	69.2
3	739310.11	525282.13	69.0
4	739323.70	525281.01	67.8
5	739324.14	525279.91	68.4
6	739337.41	525270.51	68.6
7	739351.56	525272.05	70.7
8	739372.88	525257.34	68.3
9	739384.15	525246.50	68.6
10	739399.96	525232.35	68.1
Sango			
1	741610.73	526317.72	79.1
2	741600.79	526337.62	73.3
3	741593.17	526358.62	73.4
4	741582.01	526370.79	76.4
5	741561.03	526418.65	75.1
6	741540.05	526457.12	74.0
7	741494.22	526564.24	76.6
8	741479.64	526589.66	75.8
9	741462.76	526640.51	77.0
10	741445.52	526664.61	79.4
Joju			
1	741331.62	526800.39	72.3
2	741318.35	526795.31	73.6
3	741306.30	526794.87	72.5
4	741289.27	526782.06	78.1
5	741282.63	526781.29	78.6
6	741274.34	526773.34	78.5
7	741254.55	526766.72	77.3
8	741247.25	526759.98	79.1
9	741235.42	526751.14	78.9
10	741206.45	526740.10	74.9

As illustrated in Table 6, higher respondents confirmed that flood occurs more than once in a year (45%) in the study area, also a larger number (48%) lacks flood education while only few (9%) respondents have education on flood. A larger response shows the availability of agency responsible for flood protection are private organization like company that is (43%) while (10%) is from government.

3.3. Flood induced by man's activities

The result of the questionnaire given on the causes of flood revealed that a large portion of the respondents believed that man induced activities resulted in 40% of flooding due to dumping of waste material and refuse into water channels while (27%) of the respondent confirmed that it is caused by non-functional drainage. A high proportion of respondents, (10%) perceived that flood is caused by overflowing of water bodies. While a lesser proportion (8%) perceived that the cause of flood is the encroachment of buildings on the flood plain, about (15%) are functional. This study is an indication that a lot of human attitudes has contributed immensely to flood occurrence in the study area (Table 8).

Table 8: Causes of flood in the study area

Causes of flood	Percentage (%)
Functional Drainage	15
Non –Functional Drainage	27
Overflow of Water Bodies	10
Encroachment of Building to Floodplain	8
Indiscriminate Dump of Waste into Water channel	40

4.0. Conclusion

Water will always find its own path if not properly channelled by man. The need to study the flood prone areas and causes of causes of flood and provide adequate flood management strategies is an aspect of surveying and Geo-informatics that surveyors must pay good attention to. The improvement of roads for accessibility in cities, provision of funds and equipment for disaster management agencies is vital in prevention of disasters in the Nigerian urban environment and even in the rural areas. In both the developed and developing world, the problems associated with flooding constitute a growing hazard to human activities as population densities increase.

Based on the assessment in different areas, which show that, a hundred percent (100%) success could not totally be achieved in elimination of flood problems especially in urban environment, but their negative effects can be mitigated through proper management measures given by government or affected communities. These must be effectively and economically supervised and supported.
This study was able to discover the causes of flood in Ota at different locations and the possible solutions to prevent future occurrence of flood.

Based on the findings of this study, there are some recommendations that are possible solutions that would allow immediate remedial and preventive measures to reduce flood problems observed in the study area. Therefore, the following measures are recommended:

1. There is a need for provision of standard infrastructural facilities by the government. These facilities include good surface drainage, potable water supply for consumption and other supporting facilities
2. Repair and construction of drainages where necessary should be embarked on to further ease the flow of storm water. And excavation of solid waste and other deposits which are present in the existing drainage
3. Environmental sanitation program must be made compulsory and appropriate agency should be vested with the power to punish residents who fail to adhere to the rule of sanitation. There should be fines and penalties for people who fail to comply with the sanitation program
4. Adequate awareness and orientation should be given to people on the dangers of dumping refuse in the drains and the damaging effect of such actions to the community.

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Cite this article as:
Oseni A. E. and Bamidele E. T., 2020. The Contributing Effects of Human Activities to Flooding in Ota, Ogun State. *Nigerian Journal of Environmental Sciences and Technology*, 4(1), pp. 204-213. https://doi.org/10.36263/nijest.2020.01.0195

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$$y = A + Bx_1 + Cx_2 + Dx_3 \tag{1}$$

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All reference works cited in the paper must appear in a list of references that follow the formatting requirements of NIJEST given below. References not cited should not be listed. Citing and Listing of references should be according to the following:

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ISSN 2734-259X
9 772616 051004 04
(Print)
ISSN 2734-2603
9 772616 050007 04
(Electronic)