# DETERMINING THE PHYSICOCHEMICAL PROPERTIES OF SOIL IN THE SELECTED EROSION SITES IN THE RAINFOREST ECOSYSTEM IN ABIA STATE, NIGERIA

***Chikwendu, M. U.[1], Uchendu U. I.[2] and Ogbonna, A. N.[1]**

[1]Department of Forestry and Environmental Management, Michael Okpara University of Agriculture Umudike, Abia State.
[2]Department of Environmental Management and Toxicology, Michael Okpara University of Agriculture Umudike, Abia State.
***Corresponding author email:** *nwogwugwu.michael@gmail.com, udouche@yahoo.com;austinogb@yahoo.com*/08065254590

## *ABSTRACT*

***This study determined the physico-chemical properties of soil in selected erosion sites in rainforest ecosystem in Abia State Nigeria. Conventional analytical methods were employed for the determination of these physicochemical parameters. Sand content was highest at Ikwuano LGA (82.2%), Ossah-Ibeku (77.2%).0 Ahiaeke (75.20%) and Amigbo (70.20%) were statistically similar. Results of clay contents (%) were significantly different in the following order; Amigbo Ubakala (16.40%) > Ossah Ibeku (13.40%), =Ahiaeke Ntugbu (11.40%) = Oloko (10.40%).For Nitrogen content, the two depths 0-15cm and 15-30cm were statistically similar, while the location (L) x Soil depth (D)treatment interactions were significantly different. For phosphorus content, Ossah Ibeku (20.60%) > Amigbo (14.25%) > Oloko (13.60%) > Ahiaeke (11.74).The difference in the mean potassium (%) content in the locations sampled was significant at*** $P \geq 0.05$ ***except Amigbo-Ubakala in Umuahia south LG.A. and Oloko in Ikwuano LG.A. which had statistically similar values. Potassium (k) content at (15-30cm) soil depth (0.136%) was significantly different from the (0-15cm) soil depth (0.0950%).Sodium (%) contents in Ossah Ibeku and Oloko were statistically similar. Sodium (%) contents decreased with increasing soil depth; the 0-15cm soil depth had higher sodium content (0.13%) than the 15-30cm soil depth (0.12%).Calcium content also decreased with increasing soil depth from 0-15cm depth (5.20%) to 15 - 30cm (4.30%).No significant difference existed between the mean magnesium (%) content of the soil depths (0.15cm and 15.30cm). The EA (%) capacity increased with soil depth. Location x Soil Depth (LxD) treatment interactions, the 0-15cm soil depth generally gave lower EA capacity than the 15-30cm soil depth at*** $P \leq 0.05$.

**Keywords:** Soil erosion, Rainforest ecosystem, Erodibility

## INTRODUCTION

Soils in Nigeria are predominantly alluvium deposits, coastal plain sands, sand stones, basement complex material and older granite, these soils exhibit variables resistances to erosion with the sandy soil being more vulnerable to erosion than clay (Onweremadu, 2007). Soil erosion occurs when soil particles are carried off by water or wind and deposited somewhere else. Erosion begins when rain or irrigation water and wind detaches soil particles from the earth surface. Relf (2001) stated that when there is too much water on the soil surface, it fills surface depressions and begins to flow. With enough speed, this surface runoff carries away the loosed soil. According to Nyakatawa *et al*. (2001), soil erosion is a major environmental problem worldwide. Soil moved by erosion carries nutrients, pesticides and other harmful chemicals into rivers, streams and ground water resources. Population growth, urbanization, industrialization, mining, agricultural practices and anthropogenic activities, have led to the increase of soil erosion and land degradation, particularly in the arid and semi-arid regions of the world (Hammad *et al*., 2006). Soil can be described as an essential input in agricultural production. Agricultural production is crucial to food availability, sustenance of livelihoods and national prosperity.Majority of the population depend on naturally abundant resources which agriculture provides (Ubuoh *et al*., 2013).

Anthropogenic causes include farming and uncontrolled grazing practices, deforestation, and mining activities (Abdulfatai *et al*., 2014; Nuga *et* *al.*, 2006; Uwanuruochi & Nwachukwu, 2012). Soil erosion is considered to be a major environmental problem since it seriously threatens natural resources and the environment (Rahman *et al*., 2009). Soil erosion diminishes soil quality and reduces the productivity of natural, agricultural and forest ecosystem (Pimentel, 2006). The soil in the South-Eastern Nigeria is poorly drained and is subjected to permanent or periodic flooding (Hulugalle*et al.*, 1990). The communities living in these areas encounter adverse effect of soil erosion and degradation especially gully erosion. This problem is affecting the development of the area because infrastructures such as houses, roads and even life are lost yearly apart from constitutes an environmental menace (Abdulfatai*et al*., 2014; Idah*et al*., 2008). To effectively tackle this problem, there is a need to identify those factors which contributes to soil erosion using scientific knowledge through laboratory investigations, addressing the causes will ensure lasting solutions to the menace of erosion and degradation and prevent future damages to human and infrastructures of the region. Soil is a basic necessity for agricultural production. Factors that affect the soil also affect agriculture and therefore a solution to such factors will increase food production.

Gully erosion has been recognized as one of the major global environmental problems. Many States in Nigeria are currently under the threats of this phenomenal process, south-eastern part of the country being the most affected. It has numerous causes; and these causes can be both naturally and artificially-induced, but the underlying geology and the severity of accompany surface processes play a key role. Observations have shown clearly that gully erosion is more prevalent in sedimentary terrain than in the basement complex of Nigeria. This erosion activity at various scales has resulted in the loss of lives and properties almost on a yearly basis. Solutions that have been proffered include public awareness campaign, improved farming techniques, cultural method of gully control, enactment of laws against any activities that favour gully growth, and thorough implementation of suggested solutions (Montgomery, 2007).

Control measures to stem gully erosion that are incipient are most effective when erosion is still at an early stage (Obidimma and Olorunfemi, 2011). Organic carbon, textural characteristics and moisture content of the soil have been suggested as the most useful factors to be considered in a detailed survey and control of gully (Osadebe and Enuvie, 2008). According to Ufot*et al*., (2016) south eastern Nigerian soils are low in organic matter content, base status and water storage capacity with high susceptibility to accelerated erosion and land degradation. Ezezika and Adetona (2011) further states that the soils have low silt/clay content thus resulting in a sandy soil which isnon-cohesive, very permeable with very high infiltration rates.

## MATERIALS AND METHODS

### Study area

The research was carried out in Abia State in South Eastern Nigeria that is seriously ravaged by soil erosion. It lies between Latitudes 05° 25′N and Longitude 07° 30′E, it covers area of 6,320 km$^2$ and a population of 2,845,380.Ithas two district seasons in a year, rainy season and dry season. The mean annual climatic data in Abia State are as follows; maximum and minimum temperature 25$^o$C and 32$^o$C respectively; rainfall 2400mm; relative humidity 80-90% (Aregheore, 2005 and NPC, 2006). Abia State has three major agro ecological zones, fresh water swamp forest, rainforest and derived savannah. (Keay, 1959). The vegetation is predominantly secondary forest tending towards derived savannah because of repeated annual bush burning. (Aregheore, 2005).

The study was undertaken in the lowland agro-ecological zones of Abia State. Eleven local government areas were listed as high-erosion prone areas (Abia State Handbook1997), out of which four local government areas were randomly selected from for the study. The high erosion prone areas are; Umuahia South, Umuahia North, Ohafia, Bende, Ikwuano, Obingwa, Isikwuato, Arochukwu, Umuneochi, Isialangwa North, Isialangwa South and Aba North L.G.A.
Two Local Government Areas (LGAs) were randomly selected from the high-erosion prone sites in the rainforest ecosystems. The two LGAs selected in the rainforest zone are Umuahia South and Ikwuano LGAs
A 2x4 factorial experiment in randomized complete block design (RCBD) with three replications/blocks was used to determine the

physico-chemical properties of two soil depths horizon-factors A, top soil(0-15cm) and sub soil (15-30cm), and Four local communities (Factor B) in each of the two agro-ecological rainforest zones in Abia State, Nigeria.

The Soil particle size distributions were determined using the standard hydrometer and pipette technique (Kettler *et al*., 2001; Allision, 1973). The soil texture was determined using the soil textural triangle based on the percentages of the different soil particle size (Sutherland, 1990). The Dewis and Freitas (1990) and Min Liu *et al* (2004) procedures were used to determine the pH of each soil sample. Walkley and Blacks (1965) method as described by Allison (1973) was used to determine the organic carbon contents in each soil horizon per location. Percentage organic matter was considered to be the total carbon multiplied by a conversion factor of 1.72. Total N was determined using the micro Kjeldhal method (Jackson, 1964). Phosphorus (P) was determined spectrophotometrically by the Vanandemolybdate yellow method using the Bray No. 1 extraction method. Potassium and Sodium were determined by the flame emission photometer. Calcium and magnesium were determined using the ethylene-diamine–tetracettic-acid (EDTA) versanate complexometric titration method (Allison, 1973). Exchangeable acidity was measured with 0.1mlKCl extract and titrated with 0.lml NaOH. Effective Cation Exchange Capacity (ECEC) was obtained as the summation of exchangeable cations and exchangeable acidity. To calculate the percent base saturation, the sum of the Potassium (K)Magnesium (Mg)Calcium (Ca) and Sodium (Na) (the bases) in Meli equivalent per 100g of soil (Meg/100mg soil) was divided by the CEC and result was multiplied with 100%.

## RESULTS

In Table 1, Oloko in Ikwuano LGAhad the highest sand content (82.2 %), Amigbo -Ubakala recorded the lowest value (70.20%). Sand contents in the two soil depths were not significantly different. In terms of the treatment interactions between Location and Soil depth (LxD), the top soil of Ossah Ibeku, Oloko Ikwuano and the sub soil at Ahiaeke-Ntugbu were higher than the sub soil in other locations.Results of clay contents in the sampled locations were significantly different, the highest value was recorded at Amigbo Ubakala (16.40%) while Oloko (10.40%) recorded the lowest value.Also, there were significant differences between the clay contentsof the two soil depths in the study sites. Soil depth treatment interactions (LxD) also showed significant difference in their clay contents. Result for silt content shows that Ahiaeke-Ntugbu had the highest silt content(14.4 %), Olokorecorded the lowest value (8.4%).Silt contents in the two soil depths were not significantly different. In terms of the treatment interactions between Location and Soil depth (LxD) were not significantly different.

Results from Table 2 above shows that pH level in the soils of the study sites was not significantly different. Highest pH was observed in Ossah-Ibeku (6.02) while Amigbo-Ubakala (5.11) recorded the lowest value.Ossah-Ibeku had significantly higher Organic Carbon content (0.42%) than Ahieke-Ntugbuwhich recorded (0.2%). In terms of the two soil depths, the differences between the OC content in the top soil (0.42%) and sub soil (0.14%) were very significant. However, the organic carbon content of all the other Location × Soil depths treatment interactions (LxD) were significantly different.Organic matter contents in all locations sampled were statistically different at $P \leq 0.05$, also, the Organic Matter content at top soil (0.99%) was significantly different from that of sub soil (0. 24%). Similarly, the Organic matter contents in the location x soil depth (LxD) treatment interaction were significantly different in all the sites. The top soil depth in all the locations gave higher Organic Matter content than their corresponding sub soil depth in the study area.

**Table 1: Physical properties sand (%), silt (%) and clay (%) of two soil depths in the four locations.**

| Locations | Sand (%) | | | Silt (%) | | | Clay (%) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Soil depth (cm) | | | Soil depth (cm) | | | Soil depth (cm) | | |
| | **0 - 15** | **15 - 30** | **Mean** | **0 – 15** | **15 - 30** | **Mean** | **0 - 15** | **15 - 30** | **Mean** |
| Amigbo-Ubakala | 75.2 | 65.2 | 70.2 | 11.4 | 15.4 | 13.4 | 13.4 | 19.4 | 16.4 |
| Ossah-Ibeku | 83.2 | 71.2 | 77.2 | 7.4 | 11.4 | 9.4 | 9.4 | 17.4 | 13.4 |
| Oloko | 83.2 | 81.2 | 82.2 | 9.4 | 7.4 | 8.4 | 9.4 | 11.4 | 10.4 |
| Ahiaeke-Ntugbu | 67.2 | 83.2 | 75.2 | 19.4 | 9.4 | 14.4 | 13.4 | 9.4 | 11.4 |
| Mean (soil depth) | 77.2 | 75.2 | - | 11.4 | 10.4 | - | 11.4 | 14.4 | - |
| FLSD(0.05) L | | | 4.54 | | | NS | | | 1.23 |
| D | | | NS | | | NS | | | 0.87 |
| L×D | | | 6.41 | | | NS | | | 1.74 |

**Table 2: pH and mineral contents (organic carbon (%) organic matter (%)) of two soil depths in four locations.**

| Locations | pH | | | % Organic Carbon | | | % Organic matter | | |
|---|---|---|---|---|---|---|---|---|---|
| | Soil depth (cm) | | | Soil depth (cm) | | | Soil depth (cm) | | |
| | **0 – 15** | **15 – 30** | **Mean** | **0 – 15** | **15 – 30** | **Mean** | **0 – 15** | **15 – 30** | **Mean** |
| Amigbo-Ubakala | 5.34 | 5.11 | 5.22 | 0.51 | 0.05 | 0.28 | 0.81 | 0.09 | 0.45 |
| Ossah-Ibeku | 6.02 | 5.03 | 5.53 | 0.74 | 0.09 | 0.42 | 1.28 | 0.16 | 0.72 |
| Oloko | 5.14 | 5.23 | 5.53 | 0.37 | 0.09 | 0.23 | 0.64 | 0.16 | 0.4 |
| Ahiaeke-Ntugbu | 5.3 | 5.21 | 5.26 | 0.07 | 0.32 | 0.2 | 1.21 | 0.55 | 0.88 |
| Mean (soil depth) | 5.52 | 5.15 | - | 0.42 | 0.14 | - | 0.99 | 0.24 | - |
| **FLSD(0.05)L** | | | **NS** | | | **0.098** | | | **0.039** |
| **D** | | | **0.26** | | | **0.07** | | | **0.028** |
| **LXD** | | | **NS** | | | **0.14** | | | **0.06** |

Table 3 above shows that Oloko, Ahiaeke-Ntugbu, Amigbo- Ubakala were statistically similar in terms ofNitrogencontent of the soils while Ossah Ibeku in Umuahia South LGA gave statistically the least value (0.045%). The mean of Nitrogen content of the two depths were statistically similar, while the location (L) x Soil depth (D) treatment interactions was significantly different. The difference in the mean Potassium content was significant at P≥ 0.05 except Amigbo-Ubakala and Olokowhich had statistically similar values. The mean Potassium content at sub soil (0.136%) was significantly different from the top soil (0.095%). Sodium contents in Ossah Ibeku and Oloko were statistically similar. Sodium contents decreased with increasing soil depth; the top soil had higher sodium content (0.13%) than the sub soil (0.12%).
In terms of Calcium (Ca) contents, Table 3 shows that there were also significant differences between the study sites /locations and the soil depths at P≥ 0.05. The Calcium content decreased with increasing soil depth from top soil (5.20%) to sub soil (4.30%). The Ca contents in Ahiaeke sub soil and Oloko sub soil and Ossah sub soil were statistically similar. The table also shows that no significant difference existed between the mean Magnesium (%) content of the two soil depths. However, there was significant difference between the mean.

**Table 3: Mineral Elements (%) Nitrogen (N), Phosphorus (P) Potassium (K), Sodium (Na) Calcium (Ca) and Magnesium (Mg) of two depth in four location**

| Locations | % Nitrogen Soil depth (cm) | | | % Phosphorus Soil depth (cm) | | | % Potassium Soil depth (cm) | | | % Sodium Soil depth (cm) | | | % Calcium Soil depth (cm) | | | % Magnesium Soil depth (cm) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **0 – 15** | **15 – 30** | **Mean** | **0 – 15** | **15 – 30** | **Mean** | **0 – 15** | **15 – 30** | **Mean** | **0-15** | **15 – 30** | **Mean** | **0–15** | **15–30** | **Mean** | **0-15** | **15-30** | **Mean** |
| Amigbo-Ubakala | 0.11 | 0.08 | 0.1 | 13.6 | 14.9 | 14.25 | 0.04 | 0.06 | 0.05 | 0.09 | 0.13 | 0.11 | 6.80 | 5.70 | 6.00 | 5.20 | 4.00 | 4.60 |
| Ossah-Ibeku | 0.08 | 0.1 | 0.05 | 28.6 | 12.6 | 20.6 | 0.25 | 0.03 | 0.14 | 0.2 | 0.09 | 0.14 | 6.80 | 4.00 | 5.40 | 4.00 | 2.80 | 3.40 |
| Oloko | 0.11 | 0.2 | 1.56 | 13.6 | 13.6 | 13.6 | 0.05 | 0.05 | 0.05 | 0.11 | 0.16 | 0.14 | 3.00 | 4.00 | 3.20 | 2.00 | 2.00 | 2.00 |
| Ahiaeke-Ntugbu | 0.08 | 0.14 | 1.11 | 9.17 | 14.3 | 11.74 | 0.05 | 0.41 | 0.23 | 0.13 | 0.09 | 0.11 | 4.00 | 4.00 | 4.00 | 1.60 | 2.40 | 2.00 |
| Mean(soil depth) | 0.1 | 0.11 | - | 16.24 | 13.85 | - | 0.01 | 0.14 | - | 0.13 | 0.12 | - | 5.20 | 4.30 | - | 3.20 | 2.80 | - |
| **FLSD (0.05) L** | | | **0.02** | | | **1.72** | | | **0.033** | | | **0.1** | | | **0.24** | | | **0.57** |
| **D** | | | **NS** | | | **1.21** | | | **0.023** | | | **0.07** | | | **0.18** | | | **NS** |
| **LXD** | | | **0.02** | | | **2.43** | | | **0.05** | | | **0.02** | | | **0.37** | | | **0.81** |

*Magnesium (0.57) content in the four sampled locations using FLSD.*

Table 4 above shows that the study sites had significant differences in their mean Exchangeable Acidity (EA) capacity as well as in the soil depths sampled. The EA capacity increased with soil depth. The sub soil had a higher (0.78%) EA capacity than the top soil (0.42%). Similarly, in the Location x Soil Depth (LxD) treatment interactions, the top soil generally gave lower EA capacity than the sub soil at P≤ 0.05.Table 4 also indicates that the ECEC of the soil in the study sites were statistically different between Amigbo-Ubakala (11.32) which had the highest ECEC and Ossah-Ibeku at P≤ 0.05 while Ahiaeke Ntugbu and Oloko had similar values. Percentage Base Saturation (BS) content in the study sites showsno significant difference existed between the locations. However, there was significant difference between the soil depths. In the location x soil depth (LxD) treatment interactions all the samples were statistically similar except Ossah Ibeku sub soil with the least BS% (83.56) which was significantly different from all treatment samples.

**Table 4: Exchangeable Acidity (EA) %, Effective Cation Exchange Capacity (ECEC)% and Base saturation (BS)% of two depths in four locations.**

| Location | Exchange Acidity (EA) | | | ECEC | | | Base Saturation (BS) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Soil depth (cm) | | | Soil depth (cm) | | | Soil depth (cm) | | |
| | 0-15 | 15-30 | Mean | 0-15 | 15-30 | Mean | 0-15 | 15-30 | Mean |
| Amigbo-Ubakala | 0.56 | 0.72 | 0.64 | 12.68 | 10.11 | 11.32 | 95.59 | 92.88 | 94.24 |
| Ossah-Ibeku | 0.32 | 1.32 | 0.84 | 11.51 | 8.27 | 9.9 | 97.23 | 83.56 | 90.39 |
| Oloko | 0.4 | 0.48 | 0.44 | 5.76 | 6.69 | 6.22 | 93.06 | 92.82 | 92.74 |
| Ahiaeke-Ntugbu | 0.4 | 0.56 | 0.48 | 6.18 | 7.09 | 6.63 | 93.52 | 92.1 | 92.81 |
| Mean (soil depth) | 0.42 | 0.78 | 0.29 | 9.03 | 8.04 | 0.8 | 94.85 | 90.34 | 2.67 |
| **F LSD (0.05) L** | | | **0.42** | | | **1.14** | | | **NS** |
| **D** | | | **0.06** | | | **1.62** | | | **5.35** |
| **L×D** | | | **0.06** | | | **1.62** | | | **5.35** |
| **Interaction L×D** | | **0.06** | | **1.62** | | **5.35** | | | |

## DISCUSSION

The percentage sand contents of the two soil depths in the rainforest and derived savannah ecosystems were generally high. Soils with high sand content of 70% and above are regarded as sandy soils (Ola-Adams *et al.*, 1998; Uluocha *et al.*,2016). The mean values of rainforest and derived savanna of the study sites for silt and clay were 10% and 15%respectively. The results show that soil of the study area was well drained and aerated. This is in line with the findings of Ola-Adams *et al.* (1998) which stated that soils with mean clay values lower than 20% indicate good drainage andaeration. The low clay contents of some the study site could be attributed to the downward migration of clay due to high rain water percolation of the area. This feature tends to remove fine particles in runoff water and enhance the chemical destruction of 1:1 kaolinite clay which dominates the top soil (Ola-Adams *et al.* 1998; Uluocha *et al.*,2016).

The soils of the study area were generally acidic as the pH level ranging from 4.0 - 5.5. This range could be attributed to marked leaching of exchangeable base due to high intensity of rainfall. This is in line with the result of Osadebe and Enuvie (2008)which reported low pH in areas with high rainfall in Nigeria. The organic matter distribution in the sampled soils were generally low, however,the top soil in the rain forest ecosystem had high organic matter content. This could be attributed to decomposition of organic matterand mineralization of tree roots at the top soil (Ubuoh *et al.*, 2013).

The low Organic Carboncontents of the study sites could be as a result of low Organic Matter contents resulting from bush burning, soil erosion and unsustainable farming practices. Allison (1973) had earlier explained that soil Organic

Carbon content is a medium of storage of plant nutrients, energysourcefor soil microbes and binding agent in the development and stabilization of soil structure. The low Nitrogen (N) contents in the soil could be attributed to loss of mobile nitrates as a result of soil leaching. However, the higher Nitrogen values recorded at Oloko, Amigbo Ubakala and Ahiaeke-Ntugbu areas of the study which were all in the rainforest zone could be as result of decomposition of solid wastes materials around the erosion sites. The relatively high-levelPhosphorus (P) in the sampled sites showed it wasunder- utilized due to the near absence of tree species in the erosion sites. Aluko (2001) reported that trees depend on soil Phosphorus for biomass production. Some of the waste materials littered around the erosion areas could be rich in Phosphorus and therefore contributed to the high Phosphorus contents of the soil.

The concentration of Cation Exchange Capacity (CEC) K, Ca, Mg and Na appeared to decrease with soil depth except in the sub soil of the rainforest. Generally, low levels of exchangeable cations and effective cation exchange capacity (ECEC) recorded in the soils at various locations indicated that the soil wee infertile. The result was in agreement with Jimoh(2010) who obtained similar results and attributed the trend to the effect of human activities. The effective cation exchange capacity (ECEC) depends mainly on the soil organic matter level and clay fraction which control nutrient absorption and release (Jimoh,2010). The low ECEC contents could be attributed to the low organic matter and percentage clay content. Ufot *et al*., (2016) reported that the loss of organic matter and acidification result in the decrease in the ECEC and loss of Ca and Ma.

The results of the base saturation (BS) show that the erosion sites have potential for productivity if rehabilitated. Aina, (2008) reported that most agricultural crops grow best when the base saturation is 80% or more and the pH is 6 or above. With the exception of Amaekpu-Ohafia and Oruruala-Amiyi, all in the derived savannah, the mean base saturation (BS) of the sampled soils of the other locations of study were above 80%. Soil erosion, affects soil physical and chemical properties and undermines the biological processes supporting nutrient cycling in soils, and impairs the capacity of these resources to sustain long-term productions (Ogunkunle, *et al.*, 1992; Aina, 2008).

**CONCLUSION**

The result obtained from this study revealed that Oloko in Ikwuano LGA. had significantly the highest sand content. Also, there were significant differences between the clay contents (%) of the two soil depths in the study sites. pH level in the soils of the study sites/locations in the rainforest ecosystem were not significantly different. Sodium contents decreased with increasing soil depth. %). Calcium contents shows that there were also significant differences between the study sites. For BS% content in the study sites, no significant difference existed between the locations, however, there was significant difference between the soil depths. It is then concluded that agriculture land use in Nigeria often results in the degradation of natural soil fertility and reduced productivity. The causes of this degradation in Nigeria include both natural and anthropogenic sources. The impacts include loss of human and animal lives, loss of properties and land resources.

This study recommends improved farming techniques, cultural method of gully control, and enactment of laws against any activities that favour gully growth. Though, if all the suggested solutions are carefully looked into, it is believed that the incidence of gully erosion in Nigeria would be drastically reduced and the security of the lives of Nigerians and their properties will be guaranteed.

**REFERNECES**

Abdulfatai, I., Okunlola, I., Akande, W., Momoh, L., and Ibrahim, K. (2014). Review of gully erosion in Nigeria: causes, impacts and possible solutions. *Journal of Geosciences and Geomatics,* 2(3): 125-129.

Abia State Handbook (1997). Published by Ministry of Information, Culture and Sports Umuahia, Nigeria. 1991-1997.

Aina, P.O. (2008). Soil changes resulting from long-term management practices in Western Nigeria. *Soil Sci. Society of America continuer journal of agronomy* 2: 8-18.

Allison, F. E (1973) Soil organic matter and its role in crop production, Elsevier publishers, New York.

Aluko, A.P (2001) Impact of plantation forestry on nutrient status in degraded soil for environmental management at Onne, Rivers State, Nigeria. In Forestry and National Development (ed) L. Popoola, J.E Abu and P.I Oni 27th Annual Conf. Proceeding of FAN. Abuja Nigeria.

Aregheore,E.M. (2005) FAO Grassland and pasture crops, South pacific special.

Dewis, J. and Freitas, F. (1990) Physical and chemical methods of soil and water analysis, FAO Rome pp:275.

Ezezika, O.C and O. Adetona (2011). Resolving the gully erosion problems in southeastern Nigeria: Innovation through public awareness and connectivity-based approaches. *Journal of Soil Science and Environmental management* 2(10): 286-291.

Hammad, A.H.A., Børresen, T., and Haugen, L. (2006). Effects of rain characteristics and terracing on runoff and erosion under the Mediterranean. *Soil and Tillage Research*, 87(1), 39-47.

Hulugalle, N.R., Lal, R., andGichuru, M. (1990) Effect of five years of no-tillage and mulch on soil properties and tuber yield of cassava on an acid Ultisol in south-eastern Nigeria *Experimental Agriculture*.26(02), 235-240.

Idah, P.A; Mustapha, Musa,H.I and Dike, J.J (2008) Determination of erodibility indices for soil in Owerri West Local Government Area of Imo State, Nigeria, A.U.J.J: 130-133

Jackson, M, L (1964). Soil chemical analysis. Prentice Hal INC. Engelwood Cliff. *New Jersey pp*56-92.

Jimoh, H.I (2010). Managing landuse to control soil erosion problems in a part of Kwara State of Nigeria. *Journal of geography and Regional Planning*, 4(1): 36-41.

Keay, R.W.T. (1959). An outline of Nigerian vegetation 3rd edition Federal Ministry of Information printing division, Lagos.

Kettler, T.A, Doran, J.W. and Gilbert, T.L. (2001). A simplified method for soil quantity analysis. *Soil science of America journal, 65:859-852*

Min Liu, D, Kissel, E; Vendrell and Cabrera,M.L (2004) soil lime requirement direct filtration with calcium hydroxide. *Soil science of America Journals 68:1228-1233.*

Montgomery, D. R. (2007) Soil erosion and agricultural sustainability. *Proceedings of National Academy of Science. USA,*104, 13268–13272.

N.P.C (2006). National population commission

Nuga, B., Eluwa, N., Akinbola, G., &Wokocha, C. (2006). Characterization and Classification of Soils Along a Toposequence in Ikwuano Local Government Area of Abia State Nigeria*Agricultural Journal*, *1*(4), 192-197.

Nyakatawa, E.Z.; Reddy, K.C.; and Lemunyon, J.L. (2001). Predicting soil erosion in conservation tillage cotton production systems using the revised universal soil loss equation (RUSLE). Soil and Tillage Research 57(4): 213-24.

Obidimma, C. E. and Olorunfemi, A., (2011) Resolving the Gully Erosion Problem in Southeastern Nigeria*:* Innovation Through Public Awareness and Community – Based Approaches, *Journal of Soil Science and Environmental Management Vol 2(10), 286-291*

Ogunkunle, A.O. and Eghaghara, O.O. (1992) Influence of Land Use on Some Soil Properties in a Forest Region of Southern Nigeria. *Soil Use and Management*, 8(3), 121 – 125.

Ola-Adams, B.A,Ojo, P.A. and Adegunji, M.T. (1998) Accumulation of soil Nutrient under different Forest land-uses: *Nigerian Journal of Forestry*, 28 (1): 2:5-10.

Onweremadu, E. (2007). Pedology of near gully sites and its implications on the erodibility of soils in central South-Eastern Nigeria. *Research Journal of Environmental Science*, *1*(2), 71-76.

Osadebe, C. C. and Enuvie, G., (2008). Factor Analysis of Soil Spatial Variability in Gully Erosion Area of southeastern Nigeria: A Case Study of Agulu- Nanka-Oko Area, Scientia Africana, Vol. 7 (No.2), Pp. 45.

Pimentel, D., (2006). Soil erosion: a food and environmental threat. *Environment, Development and Sustainability* 8(1): 119-137.

Rahman, E.L., M.A. Abd, Ali, R.R, Hussain, M.A and M. A El-Semey (2009), Remote Sensing and GIS based physiography and soils mapping of the Idku-Brullus Area, North Delta, Egypt: *Egyptian Journal of Soil Science*,49 (3): 209-432.

Relf, D. (2001). Reducing erosion and runoff. Virginia Cooperative Extension, Publication No. 426-722, Virginia Polytechnic Institute and State University, Blacksburg, VA, USA.

Sutherland, R.A and Dejong, E (1990). “Estimation of sediment redistribution within agricultural field using Caesium-137, Crystal springs, Saskatchwan, Canada”. *Applied Geography,* 10: 205-221.

Ubuoh, E.A, Akhionbare, W.N, Onweremadu, E and O.A Onifade (2013), Characterization of Soil Quality in erosion prone environment of Ukpor, Nnewi-South L.G.A of Anambra State, Nigeria. *International Journal of Advances in Applied Sciences 2(1):1-8.*

Ufot, U.O., Iren, O.B., and C.U. Chikere-Njoku (2016). Effects of Land use on Soil physical and Chemical properties in Akokwa area of Imo State, Nigeria. *International Journal of Life, Science and Scientific Research, 2 (3):1-6.*

Uluocha, O. B., Udeagha, A. U. andUmeojiakor, A. O. (2016).Effect Of Land Use On Nutrient Content In Soil And Leaf Litter Under Bamboo Trees (BambusavulgairsShrad Ex J.CWendl) In South Eastern. *International Journal of Agriculture and Rural Development*, 19(1): 2511-2516.

Uwanuruochi, A., and Nwachukwu, O. (2012). Impact of erosion on selected soil structural indices of four Local Government Areas of Abia State, Nigeria. PAT, 8(2), 127-133.

Walkley, A. and Black, C.A. (1965) Organic Carbon, In: Black, C.A. (ed) Method of Soil analysis. Madson, *American Society of Agronomy*. *V(*4): 1372-1375.