Geotechnical and Water Quality Assessment of Erosion-Prone Umuagu Village, Ufuma, Southeastern Nigeria

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ABSTRACT

Umuagu village is located in Ufuma town which is one of the sixteen communities in Orumba North Local Government Area of Anambra State. It is located between latitude 6° 05'N and 7° 11"E. The developing erosion site which is the subject of this work runs along the Etiti to Obuagu collector road, commencing off the Ekwulobia/Umunze Road and all five gullies found in Umuagu-Ufuma are road-bound, active and disruptive. A total of three (3) soil and three (3) water samples were collected and analysed using standard method. The result of the soil analyses shows that the soil at Uphill Etiti Umuagu contains 88.2% sand, 6.8% silt and 5.0% clay. In the Middle Course Etiti Umuagu, the soil contains 56.4% sand, 18.5% silt and 15.1% clay while in the Down Stream Course Obuagu Umuagu, the soil samples contain 62% sand, 25% silt and 13% clay. From the obtained result, it is apparent that the entire sequence is sandy and loose; a condition that favours easy soil dispersal and erosion. Physical observation of the water samples shows that the water samples are clean, colourless and had no odour. The pH of the water samples was 6.40, 6.5, 6.30 for borehole, river, and stream waters respectively. The total dissolved solids, total hardness and conductivity contents were within the WHO/ FMEnv limits, with concentrations of 002mg/l, 003mg/l and 003mg/l; 48mg/l, 28mg/l and 30mg/l; and 15.60 µs, 14.60 µs and 16.20 µs for the borehole / river/ stream respectively. The values of the heavy metals detected were: Lead 1.690/ 0.9740/ 0.8612; and Chromium 0.020/ 0.00/ 0.00 (these were above the WHO standard except concentration of Lead in the borehole) while there was no trace of Cobalt, Silver, Tin and Aluminium in the water, except for Magnesium and Molybdenum. The concentration of coliform counts was observed to exceed the value of 102 cfu/ml recommended by the World Health Organisation.

INTRODUCTION

Gully erosion and mass wasting are common natural hazards peculiar to many parts of Nigeria. They are natural geologic hazards which arise due to persistent loss of soils. This geologic hazard has been a serious environmental problem in South-eastern Nigeria, causing the degradation of arable lands, destruction of civil engineering infra-structures and underground utilities; silting and pollution of surface water bodies, loss of estates and resident lands. Various researches conducted in this region reported that several factors, such as poor soil engineering properties, inadequate road construction, poorly constructed and poorly maintained surface drainage facilities, poor land-use practices and poor vegetation cover, etc., contribute to the continuous soil erosion and the development and expansion of erosion gullies in this part of Nigeria (Emeh and Igwe, 2017, 2018; Igwe, 2012; Igwe and Egbueri, 2018; Nwajide, 2013; Okoyeh *et al.,* 2014).

According to Obidimma and Olorunfemi (2011), the preponderance of gully erosion in Southeastern Nigeria may also be attributed to the inherent geotectonic, geologic, and geo-hydrologic characteristics of the area. Other factors include unplanned sand mining and urbanization, shortened fallow length or continuous cropping, inadequate biomass turnover, cultivation along slopes, numerous (compacted) footpaths, etc. (Osuji *et al.*, 2002; Madueke et al., 2021b). These issues are exacerbated by the very high rainfall amount and intensity in the region necessitating effective land evaluation, land use planning and land allocation. Therefore, the characterization of the nature and properties of soils is a fundamental requirement for sustainable land use planning.

The gully erosion site under study is a subject of the current NEWMAP intervention and it runs along the Etiti to Obuagu collector road, starting from the Ekwulobia/Umunze Road. Although the gullying process commenced upslope, the gully head becomes more prominent at the abrupt drainage termination at the bifurcation to Awulu village, about 65 m from the Federal Polytechnic gate. Umuagu is a rural community with evidence of increasing land use development trailing the siting of the Ufuma Campus of the Federal Polytechnic, Oko which has engendered dense population movement into the village in particular and Ufuma in general. As a consequence, buildings for tenement, renting and shops sprang up at a rapid rate within the project community. Many of the buildings nearest to the access road are undermined or suffer structural damage as a result of the gully erosion. Many are accessed through wooden foot bridges. With the siting of the Ufuma Campus of the Federal Polytechnic, Oko in Umuagu Village, there has been population movement into Umuagu in particular and Ufuma in general. As a consequence, houses and shops of all sorts sprang up on every available space without regard and compliance to development controls and other environmental regulatory frameworks. Many roofed development initiatives are found throughout the sub-watershed, with many premises completely paved. The impervious surfaces harvest and discharge concentrated storm runoff into access road, instigating the gullies and extending it following rainfall events. Many of these buildings and shops are located right on the road shoulders without adequate setbacks. Hence many are undermined and/or destroyed by gully erosion such that they only accessed their compounds through rickety wooden footbridges.

METHODOLOGY

Soil and water samples were collected around the gully site and were analysed for various physicochemical parameters by using standard method. The soil samples were collected at uphill Etiti Umuagu, Middle course Etiti and the Down Stream course to ensure a representative sample. Each sample was taken from top to a depth of 15cm to 15 – 30cm and analysed according to standard method. The samples were packaged in polyethylene bags and taken to laboratory for analyses. Equally, water samples were collected with clean plastic bottles from surface and groundwater sources. The plastic bottles were rinsed with the water before collection of samples. For surface water, the sample bottles were fully submerged before collecting the samples. However, for groundwater, the water is allowed to discharge for about five minutes before collection to ensure freshwater from the aquifer is collected. The sample bottles were covered with the plastic bottle cover. All the samples were appropriately labelled before being taken to the laboratory. The results were compared with WHO standard (2011) and NSDWQ, (2015).

Location of the Study Area

Umuagu in Ufuma Town is one of the villages, is one of the sixteen communities of Orumba North Local Government Area, which has its headquarters at Ajalli. It is located between latitude 6^0 03' and 6^0 05'N and 7^0 10' 0" and 7^0 12' 0"E (Fig. 1). It is bounded in the East and West by Inyi and Ndiokpaleke; to the Northwest and southwest, by Omogho and Ndiokpaleze, respectively and in the North by Awa, and shares its Southern boundaries with Ajalli.

Geology of the study area

The study area lies in the Niger Delta basin (precisely on the Nanka Formation (Fig. 2)). Outcropping stratigraphic units of the Niger Delta overlying the Anambra Basin are comprised of four lithostratigraphic units: the Imo Formation with an average thickness of ~1000 m; the Ameki Group with thickness that ranges from 1400 to 1900 m; the Ogwashi Formation with estimated thickness of ~250 m and the Benin Formation that is about 2000 m thick at the depocenter (Simpson, 1955; Reyment, 1965; Nwajide, 1980; Arua, 1986; Nwajide,2006; Ekwenye *et al.,* 2015). The Imo Formation forms the basal outcropping stratigraphic unit of the Niger Delta. It widens eastwards, swings southwards, and narrows and tapers off northwest of Odukpani, an area in Calabar Flank, where it is overlapped by the Benin Formation across an age gap of 15 Ma of the Ameki Group and the Ogwashi Formation (Nwajide, 2013). The facies of the Ameki Group conformably overlie the Imo Formation and contains three stratigraphic components: the Ameki Formation, the Nanka Formation and the Nsugbe Formation (Figure 2), which pinch out in both westwards and eastwards (Nwajide, 1980, 2013). The

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Imo Formation is the mappable equivalents of the Akata Formation and the Ameki Group and Ogwashi Formation are the mappable equivalents of the Agbada Formation of the subsurface stratigraphic units of the Niger delta (Short and Stauble, 1967). The Imo Formation is the oldest stratigraphic unit in the Niger Delta Basin (Short and Stauble, 1967; Petters, 1991) and is composed of blue-grey shales with sand lenses, marl and fossiliferous limestones (Reyment 1965; Short and Stauble, 1967; Nwajide, 2013, Nwajide, and Reijers, 1996). The Ameki Formation is estimated to range from 1200 – 1500 m thick, and comprises mainly of sands, minor silt with thin shelly limestone and calcareous clay intercalations (Reyment, 1965; Arua, 1986; Nwajide, 2013). The Nanka Formation is estimated at 305 m thickness, is mainly sands and minor calcareous clay/mud with heterolith (Nwajide, 1980, 2013; Ekwenye *et al.*, 2014).

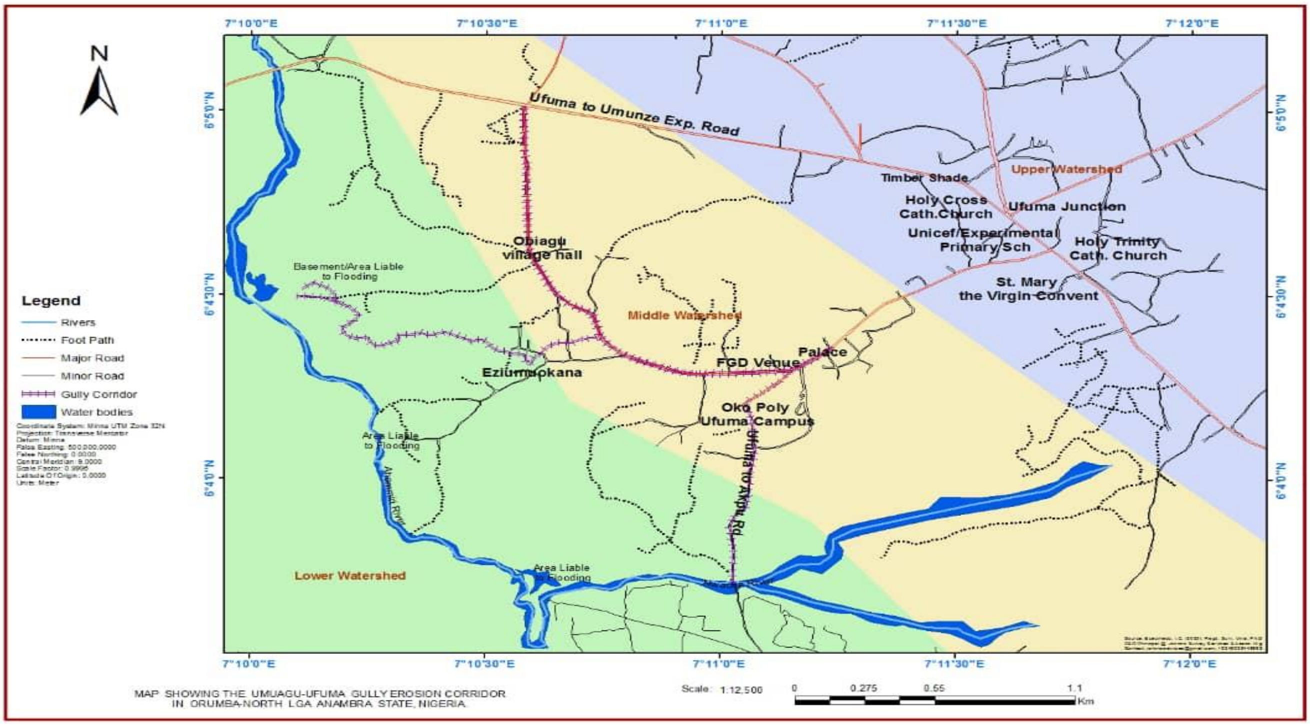

Fig. 1**:** Location map of the study area

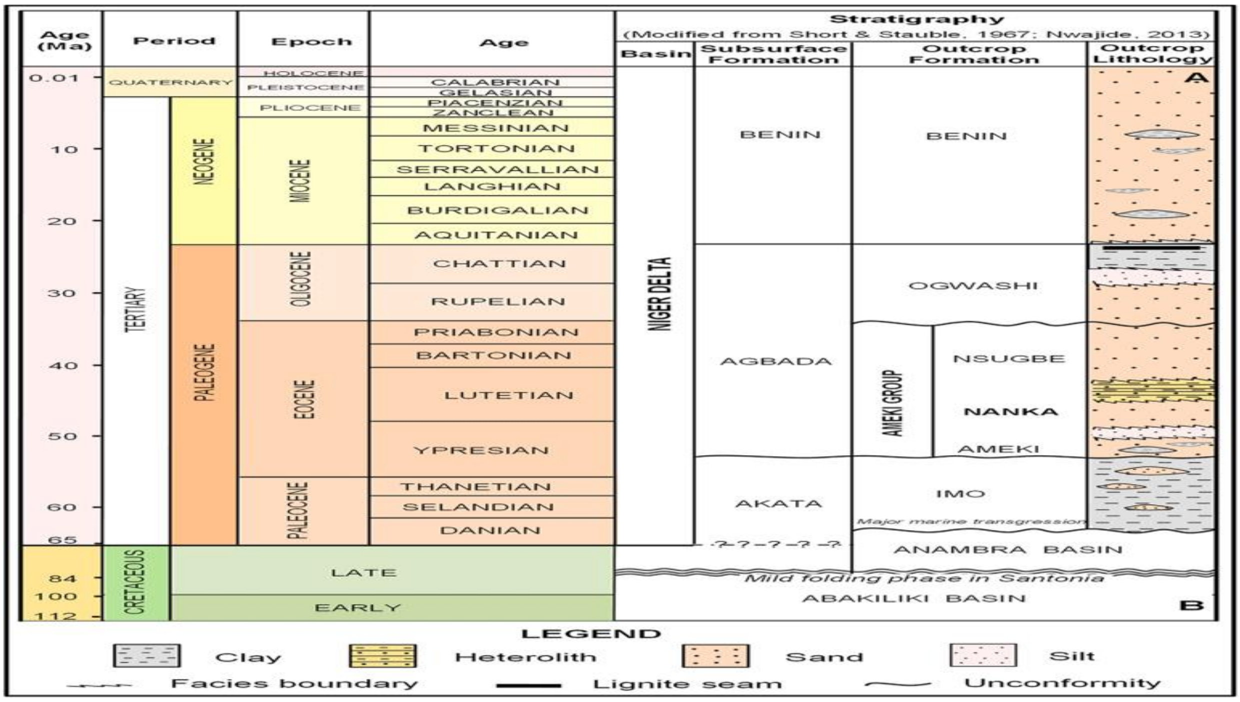

Fig. 2: Chrono-Stratigraphic succession of the Cenozoic Niger Delta Basin outcropping in southeastern Nigeria, overlying the Upper Cretaceous Anambra Basin (modified from short and Stauble, 1967; Nwajide, 2013)

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RESULTS AND DISCUSSION

Geotechnical and Hydrogeological Analysis: Soil Analysis

The result of the soil analysis is presented in Tables 1a and 1b below;

Table 1a: Result of the soil analysis of the collected samples

Location	GPS Coordinate	Depth (cm)	Sand %	Silt %	Clay %	Sample description
Uphill Etiti Umuagu – Point A	N06^0 04' 19''	0-15	88.2	6.8	5.0	Sandy Loam
	E07^0 11' 05''	15-30	85.8	7.5	6.7	
Middle Course Etiti Umuagu - Point B	N 06^0 04' 20''	0-15	56.4	18.5	15.1	Sandy Loam
	E 07^0 10' 49''	15-30	58.8	15.0	14.2	
DownStream Course - Point C	N 06^0 04' 27''	0-15	62.0	25.0	13.0	Sandy Loam
	E 7^0 10' 40''	15-30	62.8	24.3	12.0	

Table 1b: Result of the soil analysis of the collected samples (cont.)

Parameters	Point A	Point B	Point C
pH	7.4	6.4	6.70
Density g/ml	1.839	1.336	1.678
Organic carbon %	0.1602	0.847	0.034
Nitrogen %	1.736	1.456	1.176
% Particulate matter	3.668	4.33	4.69
Exchangeable acidity mg/kg	332.8	115.2	120.8
pH in $CaCl_2$	9.6	8.9	9.2
pH in water	7.4	6.4	6.7
Organic matter %	1.354	1.693	1.896
Sulphur %	2.304	2.502	1.909
% silt	6.80	18.5	25
% sand	88.20	56.40	62
% clay	5	15.10	13
Nitrate mg/kg	18.938	11.754	6.820
Phosphate mg/kg	7.780	7.671	7.660
Acidity mg/kg	17.5	22.5	12.5
Chloride mg/kg	130	161	173
Alkalinity mg/kg	200	107.5	220
Conductivity us/cm	94.2	88.8	91.0
Total base cmol/kg	0.01966	0.0914	0.0515

CEC mg/kg	332.81	115.29	120.85
Base saturation cmol/kg	0.00591	0.0793	0.0426
Calcium ppm	6.024	1.367	1.484
Aluminum ppm	4.306	11.786	12.828
Selenium ppm	0.00	0.00	0.00
Arsenic ppm	0.690	0.187	0.293
Molybdenium ppm	0.278	0.198	0.832
Magnesium ppm	12.898	2.127	10.974
Zinc	2.624	3.336	2.398
lead ppm	1.123	0.525	0.5924
Silver ppm	0.136	0.057	0.00
Colbalt ppm	1.926	1.125	0.423
Nickel ppm	2.100	1.491	1.036
Manganese ppm,	1.620	1.640	1.232
Iron ppm	19.220	19.592	19.164
Chromium ppm	0.272	0.136	0.00
Copper ppm	0.406	0.441	0.299
Mercury ppm	0.675	0.145	0.042
Sodium ppm	13.858	12.458	11.484
Potassium ppm	18.848	19.338	18.084

The soil at Uphill Etiti Umuagu contains 88.2 % sand, 6.8 % silt and 5.0 % clay. In the Middle Course Etiti Umuagu, the soil contains 56.4 % sand, 18.5 % silt and 15.1 % clay while in the Down Stream Course Obuagu Umuagu, the soil samples contain 62 % sand, 25 % silt and 13 % clay. From the obtained result, it is apparent that the entire sequence is sandy and loose; a condition that favours easy soil dispersal and erosion. This makes the soil easily erodible and this is in agreement with the findings of Abdulfatai, *et al.*, (2014). The concentration of heavy metals such as Iron, mercury, silver, lead, arsenic, nickel and chromium were all found to be above the acceptable limits and this can be attributed to be as a result of the various anthropogenic activities going on in the area.

Water Quality Analysis

The results of the physicochemical and microbiological analysis of the borehole, river and stream, samples are presented in Table 2. Physical observation of the water shows that the water samples were clean, colourless and had no odour. The pH of the water samples was 6.40, 6.5, 6.30 for borehole, river, and stream waters. The total dissolved solids, total hardness and conductivity contents were within the WHO/ FMEnv limits, with concentrations of 002mg/l, 003mg/l & 003mg/l; 48mg/l, 28mg/l & 30mg/l; and 15.60 µs, 14.60 µs & 16.20 µs for the borehole / river/ stream respectively. These findings were observed to be similar with the observation of Madu, *et. al.,* 2022 and Okolo, *et. al.,* 2023.

The background concentrations of heavy metals in the Borehole, River, Stream were analysed. The values of the heavy metals detected were: Lead 1.690/ 0.9740/ 0.8612; and Chromium 0.020/ 0.00/ 0.00 (these are above the WHO standard except concentration of Lead in the borehole) while there was no trace of heavy metals such as Cobalt, Silver, Tin and Aluminium in the water, except for Magnesium and Molybdenum. The concentration of coliform counts was observed to exceed the value of 10^2 cfu/ml recommended by the World Health Organisation

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and this indicates that the water is unfit for consumption (Madu, *et. al.*, 2022).

Table 2: Water Analysis result

Parameters	**Concentrations**			**Reference value (WHO)**	**Reference value**
	Pt. A Borehole (Mr. Iyke Orji's Residence) (N 06^0 04' 21'' E 07^0 10' 48'')	**Pt. C Agho Mmiri water (N 06^0 04' 13'' E 07^0 10' 14'')**	**Pt. B Agho Mmiri Stream (N 06^0 04' 13'' E 07^0 10' 14'')**		**NIS/FMEnv STD**
pH	6.4	6.5	6.3	6.58-8.5	6.5-8.5
Turbidity NTU	47.0	65.5	49.1	5	5.0
Conductivity us/cm	15.6	14.6	16.2	≤500us/cm	1000us/cm
Chloride mg/l	71	74	97	≤200mg/l	100
Hardness mg/l	48	28	30	≤70ppm	100
TDS mg/l	20	30	20	≤500mg/l	500
Sulphate mg/l	1.943	1.905	1.760	≤200mg/l	100
Alkalinity mg/l	5.6	3.4	3.0	100max	100
Acidity mg/l	50	27.5	60	100max	-
Nitrate mg/l	3.5	4.1	3.9	≤5mg/l	10
Phosphate mg/l	0.408	0.637	0.381	5	5.0
TS mg/l	20.08	30.06	20.08	250max	10mg/l
TSS mg/l	0.08	0.06	0.08	≤250mg/l	500
OD_1 mg/l	21.3	14.3	11.2	50mg/l	50mg/l
OD_5 mg/l	19.5	11.6	10.6	-	-
COD mg/l	253.3	142.6	222.6	250	200
BOD mg/l	36	60	8	30 (30) at 20^{o}C	500
Calcium ppm	2.328	1.178	2.370	10.0max	10
Aluminium ppm	0.00	0.00	0.00	0.00max	0.02 mg/l
Selenium ppm	0.00	0.00	0.00	0.1max	-
Arsenic ppm	0.275	0.00	0.00	0.01	0.05
Molybdenium ppm	0.00	1.594	0.00	0.00	0.01 mg/l
Magnesium ppm	3.556	0.848	3.604	2.0	10
Zinc ppm	0.00	0.00	0.291	≤5ppm	5.0
Lead ppm	1.690	0.9740	0.8612	≤0.05ppm	0.01
Silver ppm	0.00	0.00	0.00	0.05max	0.00 mg/l
Cobalt ppm	0.089	0.316	0.00	0.03max	0.00 mg/l
Nickel ppm	0.356	0.076	0.141	≤0.03ppm	0.01

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Manganese ppm	0.196	0.00	0.00	≤0.05ppm	2.0
Iron ppm	0.544	0.373	0.507	≤1.00ppm	0.3
Chromium ppm	0.020	0.00	0.00	≤0.005ppm	0.01
Copper ppm	0.032	0.00	0.00	≤1ppm	1.0
Mercury ppm	0.065	0.025	0.087	≤0.03ppm	0.001
Sodium ppm	5.783	7.893	10.921	5.0max	100 mg/l
Potassium ppm	11.823	17.373	12.383	5.00max	10 ppm
Coliform count cfu	4×10^4	4×10^3	4×10^3	0 (Nil)	10^2

CONCLUSION

The study of Umuagu village in Ufuma town, located in Orumba North Local Government Area of Anambra State, has highlighted significant environmental concerns, particularly related to soil erosion and water quality. The soil analysis revealed a predominance of sandy and loose soil compositions throughout the erosion sites at Uphill Etiti, Middle Course Etiti, and Down Stream Course Obuagu. This sandy texture, which comprises up to 88.2% sand in some areas, contributes to the susceptibility of the soil to erosion, leading to the formation of active and disruptive gullies along the Etiti to Obuagu collector road.

Water quality analysis indicated that, although the physical characteristics of the water samples appeared satisfactory, the chemical analysis raised several red flags. While the pH levels, total dissolved solids, total hardness, and conductivity of the water samples fell within the permissible limits set by WHO and FMEnv, the concentrations of heavy metals, particularly lead and chromium, were concerning. The lead levels in the water samples exceeded WHO standards, posing potential health risks. Moreover, the presence of coliform bacteria at levels surpassing WHO recommendations further underscores the need for urgent intervention to safeguard public health.

In summary, the findings from this research underscore the critical need for comprehensive soil and water management strategies in Umuagu village. Mitigating the erosion problem will require soil stabilisation efforts, and addressing the water quality issues will necessitate measures to reduce heavy metal contamination and microbial pollution.

REFERENCES

1. Abdulfatai1, I. A., Okunlola, I. A., Akande, W. G., Momoh, L. O. and Ibrahim, K. O. (2014). Review of Gully Erosion in Nigeria: Causes, Impacts and Possible Solution. Journal of Geosciences and Geomatics, 7(3), 125-129.
2. Arua, I., (1986). Paleoenvironment of Eocene deposits in the Afikpo syncline, southern Nigeria. J. Afr. Earth Sci. 5, 279⁻284.
3. Ekwenye, O.C., Nichols, G., Mode, A.W., (2015). Sedimentary petrology and provenance interpretation of the sandstone lithofacies of the Paleogene strata, south-eastern Nigeria. J. Afr. Earth Sci. 109, 239⁻262.
4. Ekwenye, O.C., Nichols, G.J., Collinson, M., Nwajide, C.S., Obi, G.C., (2014). A paleogeographic model for the sandstone members of the Imo Shale, southeastern Nigeria. J. Afr. Earth Sci. 96, 190⁻211.
5. Emeh, C., & Igwe, O. (2018). Effect of environmental pollution on susceptibility of sesquioxide-rich soils to water erosion. Geology, Ecology, and Landscapes,2,115–126.
6. Emeh,C. O., & Igwe, O. (2017). Variations in soils derived from an erodible sandstone formation and factors con-trolling their susceptibility to erosion and landslide. Journal of the Geological Society of India,90(3), 362–370.
7. Igwe, C. A. (2012). Gully erosion in southeastern Nigeria: Role of soil properties and environmental factors in Tech Research on Soil Erosion, G. Danilo, Ed. 1-22.
8. Igwe, O., & Egbueri, J. C. (2018). The characteristics and the erodibility potentials of soils from different

geologic for-mations in Anambra State, Southeastern Nigeria. Journal of the Geological Society of India,92(4), 471–478.

9. Madu, F. M., Okoyeh, E. I., Okolo, C. M, Aseh, P, Elomba, U. F. (2022a). Irrigation Water Quality Assessment and Hydrochemical Facie of Oguta Lake, Southeastern Nigeria. European Journal of Environment and Earth Sciences. 3(1):1–6
10. Madu, F. M., Okoyeh, E. I., Okolo, C.M., Chibuzor, S. N., Boma, K., Onyebum, T. E., and Okpara, A. O. (2022b). Physicochemical and Microbial Assessment of Oguta Lake, Southeastern Nigeria. International Journal of Innovative Science and Research Technology, 7(11); 2051 - 2061
11. Madueke, C. O., Okore, I. K., Maduekeh, E. C., Onunwa, A. O., Okafor, M. J., Nnabuihe, E. C., & Nwosu, T. V. (2021a). Characterization and land evaluation of three tropical rainforest soils derived from the coastal plain sands of southeastern Nigeria. Agro-Science, 20(2), 25-36.
12. Maduekea, C. O., Okorea, I. K., Maduekehb, E. C., Onunwaa, A. O., Johnbosco, M., Okafora, E. C. N., & Nwosua, T. V. (2021b). Comparative assessment of tropical rainforest soils formed from different geologic formations in southeastern Nigeria. Environment & Ecosystem Science (EES), 5(1), 47-57.
13. Nwajide, C.S., (1980). Eocene tidal sedimentation in the Anambra Basin, southern Nigeria. J. Sediment. Geol. 25, 189–207.
14. Nwajide, C.S., (2006). Anambra Basin of Nigeria: synoptic basin analysis as a basis for evaluating its hydrocarbon prospectivity. In: Okogbue, C.O. (Ed.), Hydrocarbon Potentials of the Anambra Basin: Geology, Geochemistry and Geohistory Perspectives. Proceedings of the 1st Seminar Organized by Petroleum Technology Development Fund Chair in Geology. University of Nigeria, Nsukka, pp. 1–46.
15. Nwajide, C.S., (2013). Geology of Nigeria's Sedimentary Basins. CSS Bookshops Ltd, Lagos,
16. Nwajide, C.S., Reijers, T.J.A., (1996). Sequence architecture in outcrops: examples from the Anambra Basin, Nigeria. NAPE (Nig. Assoc. Pet. Expl.) Bull. 11 (1), 23–32.
17. Obidimma, C. E., & 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, 2(10), 286- 291.
18. Okolo C. M., Onuorah I. D., and Madu F. M. (2023). Seasonal Variation in Physicochemical Properties of Water in Onitsha Metropolis, Southeastern, Nigeria. Asian Journal of Environment & Ecology, 22(4); 39 - 5
19. Okoyeh, E. I., Akpan, A. E., Egboka, B. C. E., & Okeke, H. I. (2014). An assessment of the influences of surface and subsurface water level dynamics in the development of Gullies in Anambra State, Southeastern Nigeria. Earth Interactions,18,1–24.
20. Osuji, G.E., Eshett, E.T., Oti, N.N., & Ibeawuchi, I.I. (2002). Land Use Practices and the Predisposition of Selected Watersheds in Imo State to Erosion in: Proceedings of the 36th Annual Conference of the Agricultural Society of Nigeria held at Federal University of Technology, Owerri, Nigeria. p. 565.
21. Reyment, R.A., (1965). Aspects of the Geology of Nigeria: the Stratigraphy of the Cretaceous and Cenozoic Deposits. Ibadan University Press, Ibadan, p. 145.
22. Short K.C, and Stauble A.J. (1967). Outline of Geology of Niger Delta. Am Assoc Pet Geol Bull. 1967;51
23. Simpson, A., (1955). The Nigerian coalfield. The geology of parts of Onitsha, Owerri and Benue provinces. Geol. Surv. Nig. Bull. 24, 85