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(RESEARCH ARTICLE)

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Coastal erosion investigation using electrical resistivity and remote sensing along the coastline of Bayelsa State, Nigeria

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Abstract

Coastal erosion is a serious issue in the coastal communities of Bayelsa State. The soil components and vegetative cover along the shoreline or close to the shoreline were studied using electrical resistivity and remote sensing. Data acquisition was done with resistivity meter and adoption of google earth. In the study area, some locations were made up of high resistivity values in the top soil while in other areas low resistivity values in the top soil meaning different soil compositions. Areas of high erosional activities like Sangana were of low resistivity in the top soil. It was noted that areas of high erosion were connected to sparse vegetative cover. It was recommended that continuous or time dependent study be always conducted in the area to know the trend of events in the area concerning coastal erosion.

Keywords: Electrical resistivity; Remote sensing; Resistivity meter; Time dependent study

1. Introduction

Coastal erosion in Bayelsa State is a serious issue of threat to the coastal communities for which little or no effort has been directed to it. It was also found out that research in this area was minimal. It was until recently that some studies were carried out. Coastal erosion along the shores of Bayelsa State is a serious one which is gradually eating up the coastal communities, if combative measures are not put in place. For example, communities like Sangana, etc are constantly eroding away in Brass Local Government Area while others like Koluama, Ekeni, Ezetu etc are eroding away in Southern Ijaw Local Government Area of Bayelsa State.

Coastal areas are often changing and susceptible to nature. Coastal area is a significant economic area in every nation of the world. The areas attract more attention because most of the human populations of the world are located in the coastal area mostly close to the shores (Ojanikele, 2025)

Erosion as a natural disaster leads to a tremendous threat mostly in highly populated areas (Ejikele et al 2015). Coastal areas are erosionally affected. The areas are in a dynamic nature due to the relationship between the ocean and land (Henry et al., 2013).

Suhendra et al (2023) did a coastal vulnerability assessment using electrical resistivity tomography in Indonesia and noted that claystone was more in the coastal area with resistivity of 16-200Ωm at a depth of 15-20m. The coastal area in their research location was made up of clay shale rocks (207-220Ωm) and depth of 2-14.8m. The clay shale rocks were not eroded or abraded with resistivity values greater than 250Ωm. This was due to the fact that clay shale has low porosity, consequently, was made up of a compact rock density.

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Muhammed Irhan et al (2021) examined the vulnerability of the West coast of Acer Besar Indonesia by means of four geological parameters which are geomorphological parameters, beach elevation, beach slope and shoreline changes. They were able to note differential impacts of coastal vulnerability. In terms of geomorphology, areas of serious vulnerability are in the sandy beaches which are of gentle slope whereas other areas of low vulnerability are of high elevation and cliff beaches.

Kamal (2024) made a review of published studies with regard to remote sensing and GIS techniques for assessing coastal changes which were published between 2012 and 2022 along different coasts world wide. The outcome showed that multisource and multisensory remote sensing datasets were used worldwide for monitoring coastline changes such, as medium-resolution imagery, SAR and optical high-resolution imagery, modern remote sensing techniques, GIS-based methods, spatial analysis and artificial intelligence. Conclusion was made that the coastal changes can be monitored by means of remote sensing.

Odubo et al., (2024), considered the issue of coastal erosion from the perspective of coastal wave actions such as swash and backwash. These wave actions have been known to be impacting on the shoreline. Conspicuously, the waves are the most disturbing factors along the shoreline.

Odubo et al., (2025) investigated erosional activities of Koluama II settlement in Bayelsa State from Digital Shoreline Analysis System and came up with outstanding figure of rate of erosion per annum. They made reasonable conclusions as regards future erosion in the study area. An estimation of the extent of land mass which would be eroded by 2040 was made.

This study is aimed at looking at the variables which might be leading to this problem such as soil types, characteristics, vegetative cover, human factor etc.

2. Materials and Method

2.1. Materials

2.1.1. Location and geological setting of the study area

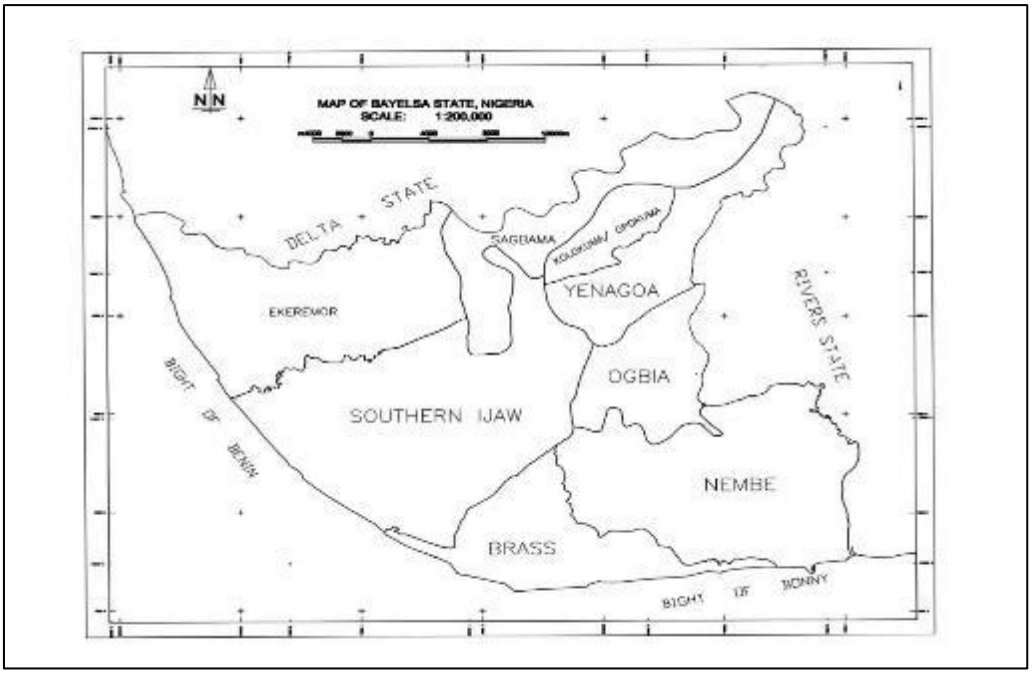

Figure 1 Map of Bayelsa State

The study area is located within the extreme southern part of Bayelsa State which is bounded by the Atlantic Ocean in the southern end , the region of fresh and saltwater interface and part of the fresh water in the further north. The vegetations are predominantly mangrove forest and fresh water swamp forest. It has numerous creeks, rivers, streams

etc which are discharging or connecting to the Atlantic Ocean.The seasonal flood water coming from the north is also discharging into the Atlantic Ocean through these creeks, rivers etc.

Three geologic formations constitute the Niger Delta Basin which are Benin, Agbada and Akata formations. Information derived from the subsurface pointed out this stratigraphic units. In terms of age, they advance from the youngest which is Benin formation to Agbada and Akata which is the oldest formation. A number of researchers have dived in to the study of the stratigraphy of the Niger Delta and camp up with tangible conclusion among them are Uko *et al*. (2002), Okiongbo and Soronnodi-Onoiniwu (2015).The study area falls within the Benin formation of the coastal plain sand.

2.2. Instrument and Accessories

A resistivity meter named Hero Jat was used which is a light weight equipment which can be easily carried around. The equipment is made in such a way that the battery is inbuilt. It has connections for two current electrodes and two potential electrodes.

2.3. Methods

Vertical electrical sounding was used in acquiring the data. In this method, Schlumberger configuration was utilized. In the Schlumberger configuration, the distance between current electrodes is divided by two (if AB is the distance between two current electrodes, AB is divided by 2 ie AB/2). The distance between potential electrodes is similarly halved (if MN is the distance between potential electrodes, then MN is divided by 2 ie MN/2). For each station, the AB/2 distance of each of the current electrodes was moving while the MN/2 distance of the potential electrodes was kept fixed until a particular distance of AB/2 was reached where signal could not get to the potential electrodes. It was then the potential electrodes would move a little bit as the current electrodes were moving until the spread of the intended distance was reached. The spread of the current electrodes was the determining factor of the depth of penetration of the current. It was resistance which was measured in the field. The resistance was converted to resistivity by means of a geometric factor. It is called a geometric factor because of the configuration of the field measurement procedures. Different arrays of field measurements have different geometric factors.

Ipi2win and ixid or interpex were used in analyzing and interpreting the data. The softwares are able to iteratively analyse the observed data until the residual between the observed model and the reference model is minimal. Analysis into different layer thicknesses and respective resistivities was done by the help of the software's.

The remote sensing data was extracted from various google earth images at the locations and comparative analysis was conducted to interpret the various results.

3. Results and Discussion

The results of the various vertical electrical soundings of the different locations are presented in the following figures and tables.

Table 1 Sangana 1

Resistivity	Thickness	Depth	Error
19.230	0.52890	0.52890	4.4924
233.81	1.4922	2.0211	
97.099	2.4731	4.4941	
6.5765	11.248	15.742	
2.6579			

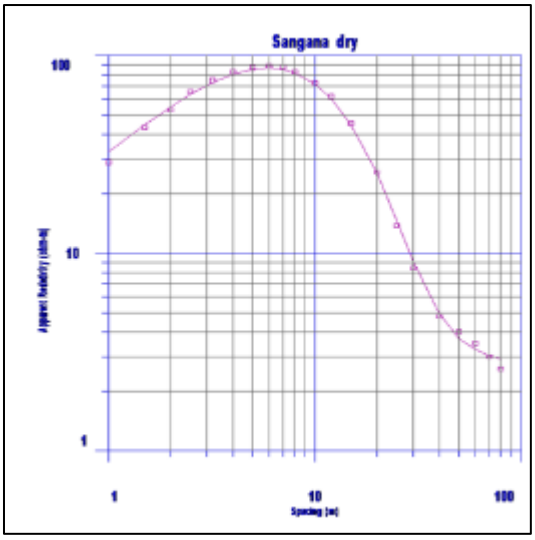

Figure 2 Sangana 1

Table 2 Sangana2

Resistivity	Thickness	Depth	Error
44.693	0.80414	0.80414	3.9613
75.877	1.7655	2.5697	
39.796	3.6831	6.2527	
5.6933	10.601	16.853	
11.382			

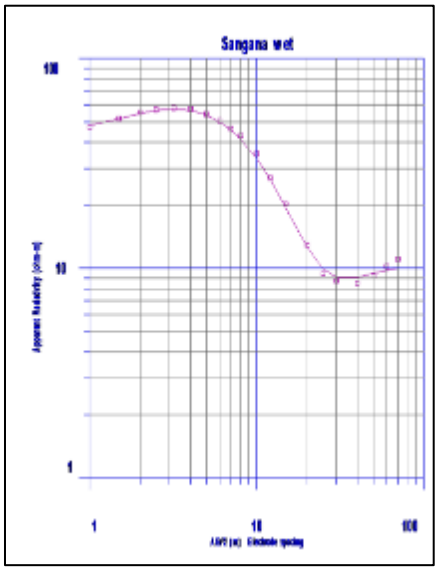

Figure 3 Sangana 2

Table 3 Okuru

Resistivity	Thickness	Depth	Error
53.091	0.78958	0.78958	4.6633
200.12	4.6300	5.4195	
116.48	3.8381	9.2576	
5.7787	22.882	32.139	
5.4413			

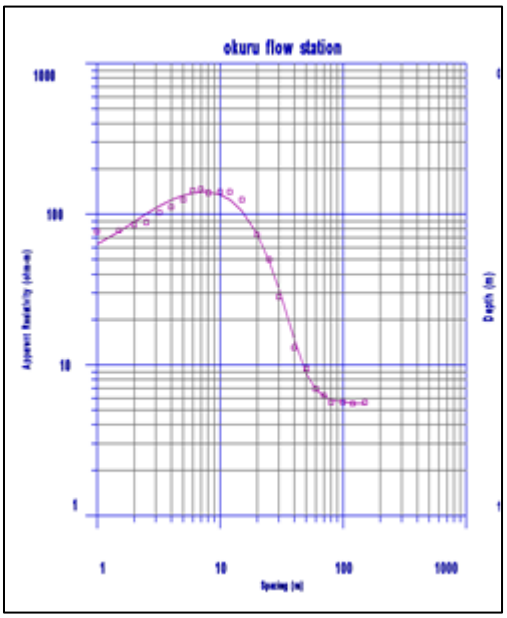

Figure 4 Okuru

Table 4 Brass 1

Resistivity	Thickness	Depth	Error
359.86	0.95252	0.95252	4.4461
106.23	6.2400	7.1926	
100.15	17.188	24.380	
28.497	48.408	72.788	
29.763			

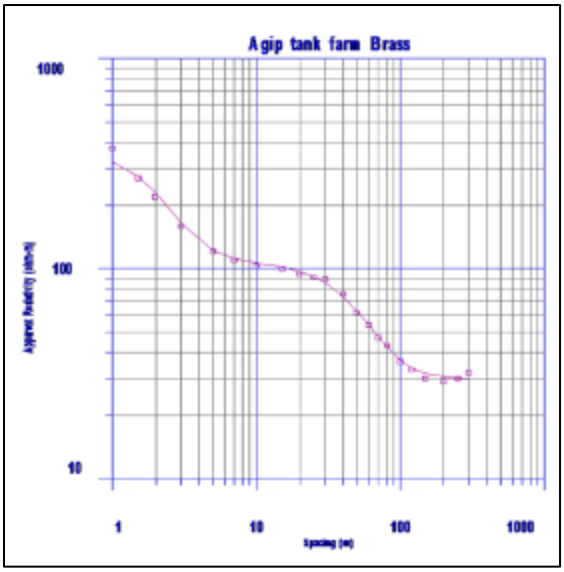

Figure 5 Brass 1

Table 5 Brass 2

Resistivity	Thickness	Depth	Error
254.44	2.0679	2.0679	3.1425
72.133	5.6105	7.6784	
11.557	19.886	27.564	
3.2416	53.345	80.909	
4.8464			

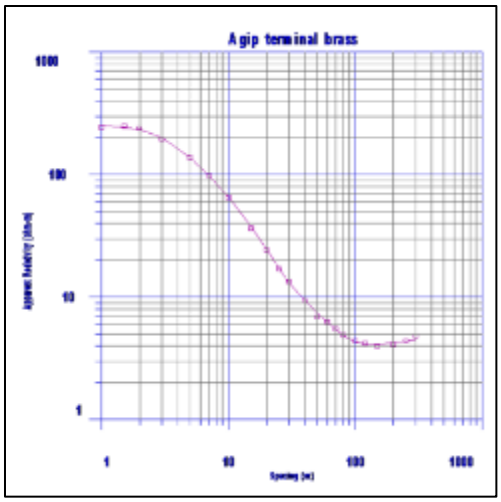

Figure 6 Brass 2

From the VES results of locations of Sangana and Okuru communities, the top soils are close to being similar because the variation of resistivities of the top soils of the two locations can be considered to be small. It is , therefore, considered that the two areas have similar top soils though negligible variations of resistivity values. The location of Okuru is very close to koluama community just like Sangana community.in essence, Sangana, Koluama and Okuru communities are having similar topsoils.

On the contrary, Brass is having a comparatively higher values of resistivity of the top soil. These higher values of the resistivity could mean a lot of soil properties such as presence of inorganic compounds, traces of hydrocarbon, compaction or stony material. This is where the importance of groundtruthing comes to play. At the time when this study was conducted there was no trace of crude oil or hydrocarbon or other inorganic materials at or close to the site of the survey. The results are, therefore, limited to the characteristics of the soil. The top soil of Brass (Twon) is a bit different from that of Sangana and koluama where the erosional activities are more serious.

The resistivity values of Figs1,2 and 3, the soil particles are of more finer sandy material and loose than those of Fig 4 and 5 which are of higher values of resistivity. The soil of Figs1,2,and 3 can be more eroded than those of Fig4 and 5.

Figure 7 Sangana

Figure 8 Okpoma

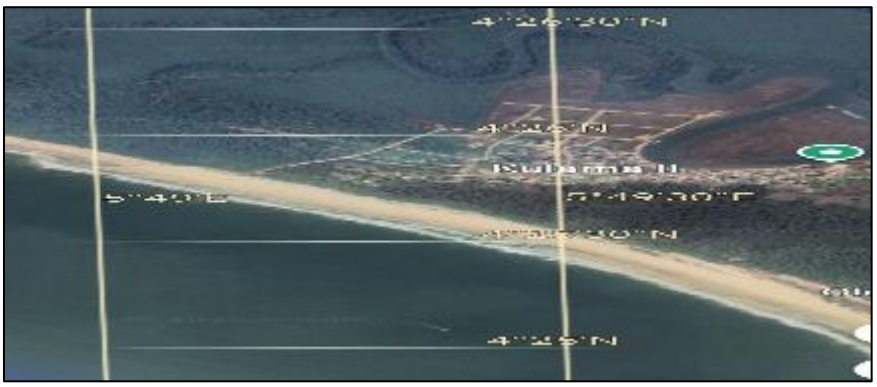

Figure 9 Koluama 2

Figure 10 Koluama 1

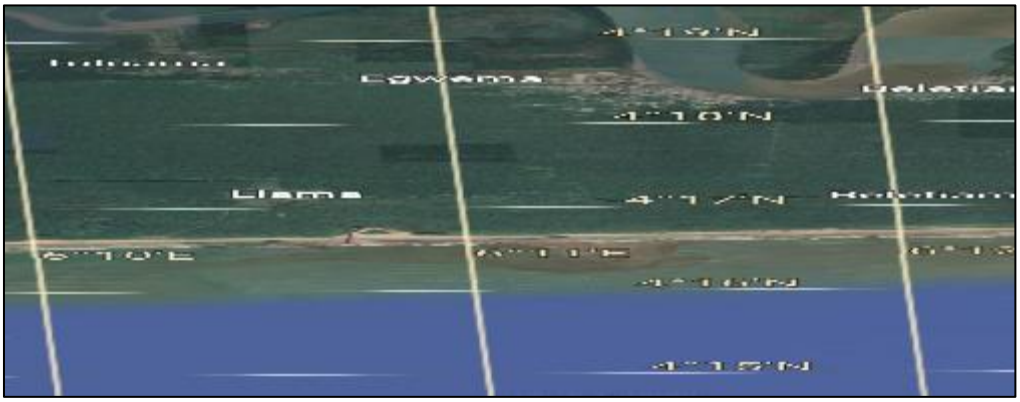

Figure 11 Egwema

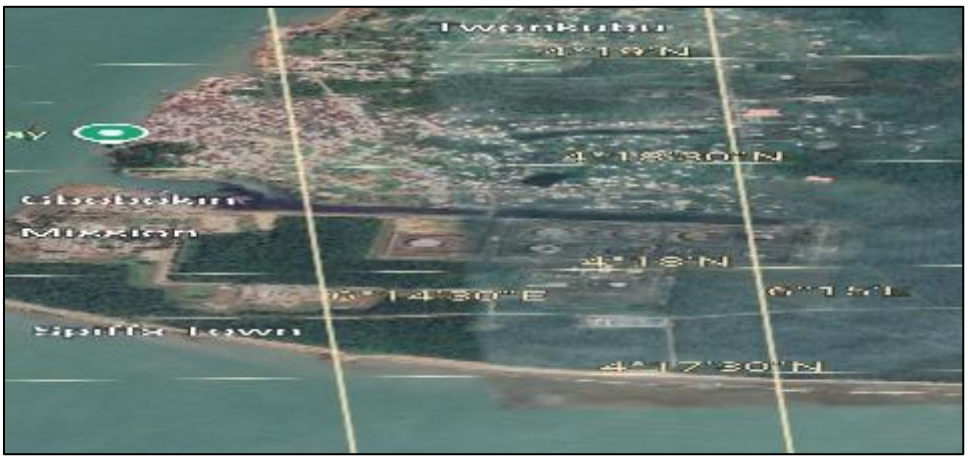

Figure 12 Twon Brass

The area of study is made up of mangrove forest. From Figs 7,8,9,10 and 12 along the shoreline, vegetative cover is sparse in areas such as koluama 2, koluama 1, Sangana, Brass Island and others. This sparse nature of vegetation is attributable to previous oil spill which occurred in the past particularly at koluama and Sangana area. It is , therefore, identified that erosion may persist due to lack of protection from vegetation as noted form the various figures. However, in Fig11, there is enough vegetative cover and the community (Egwema) is situated from some distance away from the shore not like other communities noted.

4. Conclusion

There are different values of resistivity in the topsoil of the various locations. There are higher values of resistivity in the topsoil in some locations and low values of resistivity in the topsoil in other locations. There are also areas of sparse vegetative cover, in fact, along the shoreline there are little vegetation to protect the shoreline.

Recommendation

Continuous study or time dependent study be always carried out in order to know the trend of events in the area concerning coastal erosion. The governments should also direct attention to this issue of coastal erosion and see how it can be resolved.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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