Original Research Article

Assessment of Geotechnical Investigation Techniques for Evaluating Planning and Parametric Mapping in the Niger Delta Sub-region of Nigeria

ABSTRACT

Aim The goal of this study was to generate geological engineering parameters that could be used for Development planning and control purposes.

Study Design: The study was designed to use the various parameter values to produce iso-contour maps using Surfer II computer software.

Place and Duration of Study: The research was conducted at Borokiri Sadfill around the Borokiri axis of Port Harcourt (the eastern Niger Delta) between February and June 2020.

Methodology: This involved a combination of field sampling and laboratory analysis. The fieldwork included boring, particle analysis, and in-situ testing, while the laboratory analysis included oedometer and triaxial tests. The in-situ results were integrated with laboratory analysis to obtain a comprehensive understanding of the geological conditions.

Results: The results show that the clays in the study area had high cohesion, ranging from 38 kPa to 90 kPa. The friction angles ranged from 4 to 5, and the settlement values ranged between 18 mm and 84 mm. The strength parameter is a critical factor for understanding the stability of the soil, and the results obtained indicate that the soil in the study area is relatively stable. The data obtained from the study was processed using Surfer II computer software to produce iso-contour maps. These maps are useful for reconnaissance studies as they provide a regional view of the area, which is excellent for development planning.

Conclusion: The study generated essential engineering parameters that can be used for development planning and control purposes in Borokiri Sadfill. The methodology used in the research, which involved a combination of field sampling and laboratory analysis, provides a comprehensive understanding of the geological conditions in the area. The iso-contour maps generated from the data are useful tools for development planning and control.

Keywords: Geological engineering mapping, bearing capacity, settlement, development planning.

Introduction

The Niger Delta is a vast geographical area covering approximately 36,260 square kilometers, which constitutes about 4% of Nigeria's landmass [1][14]. The area faces several environmental and geological challenges, including uneven subsoil settlement, abundant organic and highly compressible clays, poor drainage systems, erosion, and flooding. These challenges are complex and interconnected with other problems in the area such as environmental sustainability, poverty, climate change, portable water availability, and infrastructural development, among others [4] [1] [13] [12].

Unfortunately, little has been done by various bodies to address these problems due to their complexity and enormous cost. Individual and organizational efforts have not yielded the required results as their actions were mainly based on isolated cases geared toward personal estate development [3]. Therefore, there is a need to evolve faster ways of assessing the subsoil competence in the Niger Delta, especially at the shallow foundation level, to guide development planning and control The Global Competitive Index 2017-2018 listed underdeveloped infrastructure as the most problematic factor for doing business in Nigeria [19].

Recently, there has been a new focus on applying geologic knowledge and skills to a broad range of engineering, environmental, and socio-economic issues, requiring integrated earth-science knowledge. This concept emphasizes interactions and linkages rather than components and trends, providing a new paradigm shift toward an integrated and holistic approach to solving geological and environmental problems [6].

Engineering geology is the application of geological sciences in engineering practice to ensure that the geologic factors affecting the location, design, construction, operation, and maintenance of engineering works are recognized and adequately provided for [1][7].The International Association of Engineering Geology and the Environment defines engineering geology as the science diverted to the investigation, study, and solution of engineering and environmental problems, which may arise as a result of the interaction of geology and the works or activities of man, as well as the prediction and development of measures for the prevention or remediation of geological hazards [18] [16][11].

A detailed engineering and geological mapping of the superficial soils of the Niger Delta becomes necessary to gain proper understanding of the environmental and geological problems in the area [18][15]. Mapping is essential in synthesizing field data in engineering geology and subsurface geotechnical investigation [4][2][10][8]. With the application of Geographic Information Systems (GIS), Geological engineering mapping for environmental management and planning has become more common [6][10]. GIS has become a handy tool in the preparation of more accurate and detailed maps for engineering and geoscience planning literature on the subject [8][7].

The aim of this study was to prepare a set of geological engineering parametric maps to guide decision-making in environmental developmental planning, control, and management. This study involved a detailed investigation conducted in accordance with approved scientific standards. It is essential to embrace an integrated and holistic approach in solving environmental and geological problems in the Niger Delta to ensure sustainable development.

1.1 Study Location

The research was conducted in the Borokiri area of Port Harcourt, which is located in the southeastern region of Rivers State and within the southern Niger Delta region of Nigeria. Borokiri is situated between latitudes 14.43.1N and 14.46.8N of the equator and longitudes 7.15.9E and 7.17.3E of the Meridian [7]. The area is characterized by mangrove tidal flats along the shoreline of the Bonny River, which is one of the many rivers that crisscross the Niger Delta and ultimately flow into the Atlantic Ocean. The Niger Delta region is known for its varied morphological units, including meander belts, coastal plains, freshwater swamp deposits, and mangrove swamps. Borokiri experiences two distinct seasons, a rainy season from April to October and a dry season from November to March, with an annual mean rainfall of approximately 4000 mm [2][5]..

The Niger Delta is characterized by an intricate network of rivers that flow into the Atlantic Ocean, featuring diverse morphological units such as meander belts, coastal plains, freshwater swamp deposits, and mangrove swamps. The area has two distinct seasons, namely the rainy season from April to October, and the dry season from November to March. The region experiences a very high average annual rainfall of approximately 4000 mm, as reported by various sources such as references [11][1] [18].

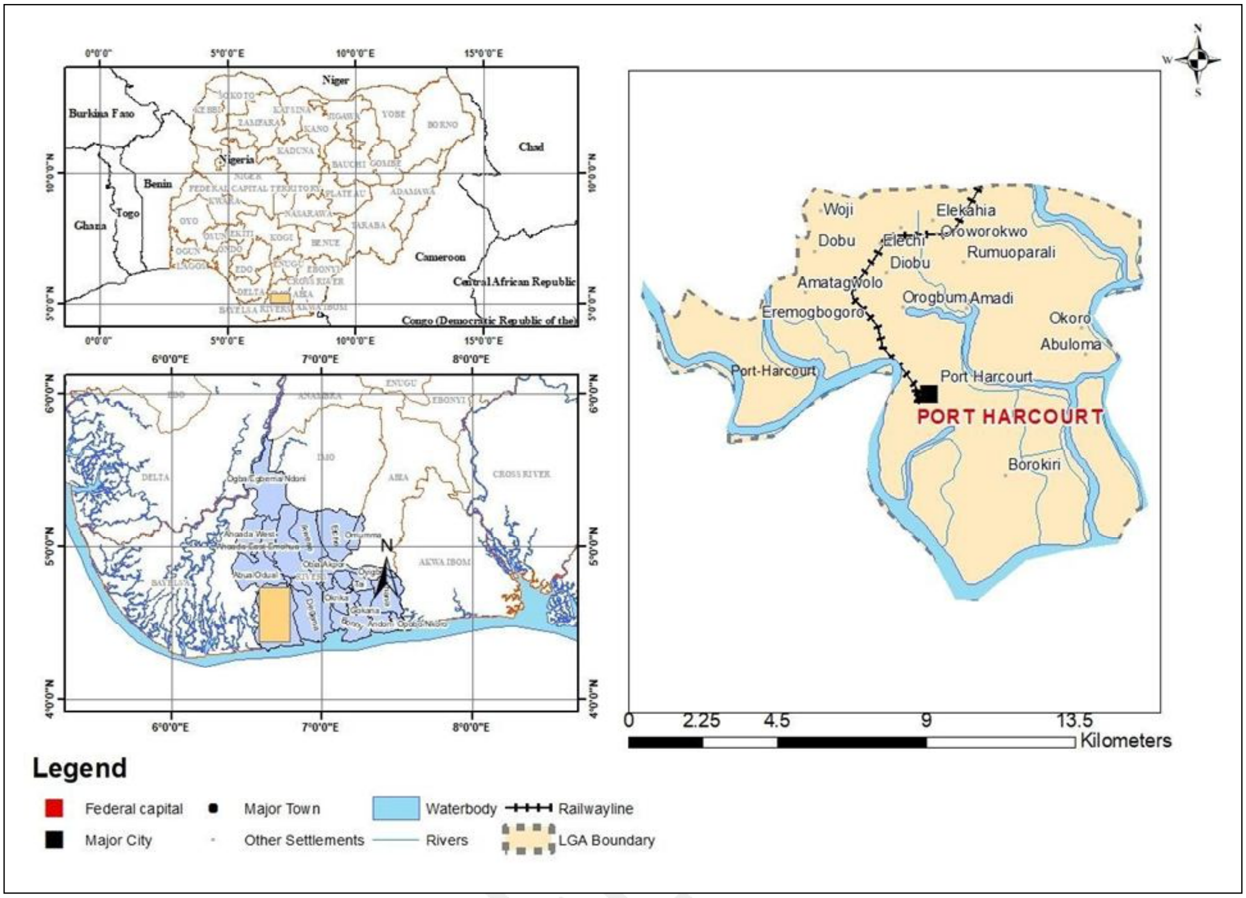

Figure 1: Location Map of the Study Area

2.0 Materials and Methods

This study involved a comprehensive investigation of soil properties in the study area, utilizing both field and laboratory analysis methods. The field analysis was carried out by drilling boreholes using a shell and hand auger rig, soil samples were obtained at regular intervals of 0.75 m and when a change in soil type was noticed. These samples were then transported to the laboratory for further analysis.

Undisturbed, cohesive soil samples were collected using a conventional open-tube sampler that was 100 mm in diameter and 450 mm in length. The study area was divided into a grid, and a total of 18 sample locations were selected to represent each grid. The locations were recorded using Meller GPS for accuracy. The collected samples were classified based on their appearance and characteristics during the field analysis process [1].

Laboratory Tests

In this study, a combination of field and laboratory analysis was employed to investigate the soil properties of the study area. The laboratory analysis involved conducting a series of classification tests on disturbed samples according to the British Standard (BS 1377 of 1990). These tests included determining the natural grain size distribution, moisture content, unit weight, and soil consistencies (Atterberg limits). The purpose of these tests was to validate and enhance the field identification and classification of the samples.

In addition, relatively undisturbed samples were analyzed to determine their design and strength parameters, such as consolidation and compressibility. Undrained triaxial tests were conducted to determine the undrained cohesion (Cu) and the angle of internal friction (θ).To establish the sample locations, Meller GPS was used to record the 18 selected sample locations representing different grids in the study area. Boreholes were drilled using a shell and hand auger rig up to 30 meters, but the study was limited to a depth of 7 meters. Samples were collected at regular intervals, with both disturbed and undisturbed samples collected for laboratory analysis.

The results of the laboratory analysis were used to confirm and improve the field identification and classification of the samples. The integration of in-situ and laboratory results in this study provided a comprehensive understanding of the soil properties in the study area.

3. Results

This section presents and discusses the test results and their application in engineering geological Parametric Mapping of the locations.

3.1 Subsurface Lithology Characteristics

The following are the findings of laboratory testing, in-situ penetrating, and drilling that were used to determine the soil isratigraphy:

- Dark Organic Peaty Clay (DOPC)
- Dark Grayish Silty Clay (DGMC)
- Dark Grayish Sandy Clay (DGSC)

Table 1. Characteristics of the various Lithological Types

S/N	Soil Type	Depth (m)	Engineering Geological Characteristics
1	Dark Organic Peaty Clay (DOPC)	0.0-1.0	• Dark brown in colour • High Organic content • Fair to poor compaction characteristics • Medium to high compressibility • Ability to swell and shrink • Sensitive to water • Poor drainage characteristics • Belongs to CL group in the USCS classification
2	Dark Grayish Silty Clay (DGMC)	1.0-5.0	• Dark and grayish in colour • Some Organic matter • Poor to fair compaction characteristics • Highly compressible • Swelling and expansion abilities • Low hydraulic conductivity • Impervious and difficult to drain water • Belongs to OH group
3	Dark Grayish Sandy Clay (DGSC)	5.0-13.0	• Dark clay with fine sand • Fair to good compaction characteristics • Limited compressibility • Poor drainage characteristics • Fairly stable as fill material • Belongs to SC.

3.2 Grainsize Analysis

Table 2 displays the results of the analysis of gradation patterns. It is worth noting that there are no significant differences in the various properties within the same major oil group. Therefore, the ranges and averages of values from different boreholes were used instead of typical values.

In all the locations studied, the organic clay passed through the 4.75mm sieve with a percentage of 90% and above, while for the other soil types, the percentage ranged between 80-95%. The 2mm sieve retained between 0-18% of the soil types across all locations.

Table 2: Representative Grain Size Distribution Pattern

S/N	Soil Type	% Passing Sieve Sizes				
		Symbol	**>4.75**	**4.75m**	**75µ**	**2µ**
1.	Dark Organic Peaty Clay	OH	90-98	80-95	65-76	5-9
2.	Dark Grayish Silty Clay	SC	80-95	61-65	45	12-15
3.	Dark Grayish Sandy Clay	CH	70-96	50-55	26	10-18

3.3 Consistency Indices of the Soils

The study included the determination of Atterberg limits, liquid limit (LL) and plasticity index (PI), as well as the natural moisture contents (wn). The Atterberg limits were determined in accordance with the standard test methods ASTM D423 and AASHTO T89, and the results were tabulated in Table 3. The data indicated high values for both the liquid limit and plasticity index, ranging from 34% to 40% for LL and 7 to 25% for PI. These results are consistent with the area's meteorological conditions and proximity to the sea, where high water content is expected. Moisture content varied between 20 and 70% in the study area.

Table 3: Consistency of Sub-soils in the Area

S/N	Soil Type	Symbol	Liquid Limit (%)	Plasticity Index (%)	Moisture Content
1.	Dark organic Peaty Clay	OL	35.0-38.2	7.4-8.2	20.3-22.5
2.	Dark Grayish Silty Clay	OH	34.0-35.8	8.2	20.3
3.	Dark Grayish Sand Clay	CH	34.0-40.0	10-12	24.8-32.6

3.4 Drainage Condition / Permeability

In the studied region, water is normally present at modest depths, ranging from submerged at high tide to 0.30 meters below the surface of the earth at low tide. This demonstrates the region's shallow soils' high permeability. The permeability values are adequate, according to the Coefficient of Permeability (K) values acquired during consolidation tests on the top 1.50 to 3.00 meters of soil. Table 4 lists these values along with how they affect drainage and consolidation.

3.5 Consolidation Tests

To determine the consolidation characteristics of the soil samples, Terzaghi's one-dimensional consolidation (oedometer) tests were conducted on relatively undisturbed samples. The results of the tests, which are presented in Table 4, provide two important parameters, namely the co-efficient of volume compressibility (Mv) and the co-efficient of consolidation (Cv), which were determined over a range of pressures between 50 and 40 kPa for the samples. These parameters are critical for understanding how the soil will behave under loading conditions, particularly in terms of settlement and stability.

Detail result shows that the coefficient of compressibility (M_v) for the organic soft clay (OL) is between 1.12 x 10^{-} m^2/MN and 1.40 x 10^{-} m^2/MN. The dark greyish silty clay (OH) below had values between 0.98 m^2/MN and 1.25m^2/MN.

Table 4: Consolidation and Drainage Characteristics of the Various Soil Layer

Soil/Strata Type	Depth Range (m)	Co-efficient Compression (Mv(m^2/Mv)	Co-efficient Consolidation Cv(m^2/yr)	Co-efficient Permeability (k)m/s	Remarks
Dark organic Peaty Clay (OL)	0.00	1.20	1.32-1.60	1.5 x 10^{-5}	Highly Compressible
	1.00	1.40		2.30 x 10^{-7}	Moderately Impermeable
Dark Greyish silty clay	1.00	0.98	1.27-1.45	2.50 x 10^{-4}	Moderately Impermeable

(OH)	5.00	1.27		3.5×10^{-8}	Moderately Compressible
Dark Grayish Sand Clay (CH)	5.00	1.07	1.19-1.45	2.65×10^{-4}	Moderately Compressible
	13.00	1.26		3.00×10^{-6}	Highly Impermeable

3.6 Bearing Capacity of the Sub soils

The Terzaghi formula for computing the bearing capacity of soils based in laboratory results was used in computing the bearing capacity of the sub soils at various sample points. This is given for rectangular footing as;

$$Qu = CN_c\ (I+O.3B/L) + YD_fN_qRw_1 + 0.5YBN_q\ (I-0.2B/L)\ Rw_2 \qquad 1$$

Where;

Qu = ultimate bearing capacity

C = undrained cohesion of the soil

B = width of footing

L = Length of footing

Y = Unit weight of soil

D_f = Dept. of footing

Q = Angle of friction as O for undrained condition of soil.

Rw_1 = reduction factor for water table above the base level of foundation

$= 0.5\ (1 + Dw_1/D_f$

Rw_2 = reduction factor for water table below the base level of foundation

$= 0.5\ (1 + Dw_2/B)$

Value of various strength Characteristics are presented in table 5.

Table 5: Strength Characteristics of the Various Soil Layers

S/N	Soil Type	Symbol	U-U Tri-axial Test	
			$\Theta_u(^0)$	C_u(kPa)
1.	Dark organic Peaty Clay	OL	4	41.4 - 48.5
2.	Dark greyish silty clay	OH	4	56.6 - 65.6
3.	Dark Greyish Sand Clay	CH	4	73.0 – 80

Settlement Computations

The likely settlement as a result of vertical loading was computed considering subsurface lithology and the likely land improvement method. Settlement prediction was made for a foundation depth of 2.5m.

The settlement of each layer was computed using skepton and Bieranar [9] which gives Oedometer settlement as;

$$S = M_v \,.\, d_v \,.\, H \qquad 2$$

Where;

Mv = Coefficient of Volume Compressibility

H = Thickness of compressible layer

d_v = average effective vertical stress imposed m the particular layer form wet foundation pressure (q_n)

Table 6: Analyzed Geotechnical Data

Easting	Northing	Liquid Limit (%)	Cohesion (kPa)	Angle of Friction (θ^0)	Bearing Capacity KN/m^2	Settlement (mm)	T90 (Yrs)
278533.2	524913.2	33.6	62.3	5	189.94	82	7.42
278563.9	524870.1	32.1	68.4	6	162.35	80	4.27
278563.7	524805.5	35.8	56	4	191.67	69	2.8
278564	524900.8	26	64.4	4	135.27	352	3.69
278594.7	524863.8	24.5	75	6	155.27	168	3.65
278625.4	524820.7	29.2	79	6	201.08	70	5.69

278533.4	524993	24	80	4	172.87	332	3.92
278625.8	524952.8	26.5	64	4	175.32	172	4.81
278656.4	524863.6	31	67	6	156.81	148	4.33
278687.1	524829.8	24.5	78	4	198.1	63	4.81
278687.1	524829.8	29.8	62	6	169.07	84	5.1
278748.8	524860.3	25	58	4	202.37	96	3.86
278687.4	524943.4	37.2	43.2	6	185.62	97	4.72
278625.9	524980.5	25	59	4	172.72	128	5.06
278687.6	525023.3	29	46	6		217	4.48
278656.9	525054.1	26	53	4			
278687.7	525051	38	43.5	5			
278626	525038.9	35.8	46.3	6			

4.1 Geological Engineering Parametric Mapping

A thorough technique is required to produce iso-contour maps for variables including liquid limits (LL), cohesion, friction angles, and bearing capacity settlements. Through methodical field stacking of a region at various sizes, a full collection of engineering and geological data is collected using this method. The gathered data should subsequently be kept in a designated data bank for simple usage and access [7]. The iso-contour maps may then be produced using GIS-based mapping techniques, providing a better knowledge of the site's geotechnical characteristics and assisting in decision-making [10].

The Procedures include;

- Geotechnical characterization of the superficial layers within the depth of interest based on parameters selected.
- Generation of a spatial base map using Google earth with geo-referenced sample location points and the parameter values were transferred to each location point.
- The geotechnical parameters obtained during field and laboratory analysis maintained in Spreadsheet Excel 2013 noting their reference co-ordinates.
- Using a GIS technology tool Surfer II, the basic information is translated into digital topographic database which generates a new file of worksheet. The file is gridded and then plotted to create the contours.

- In the final map, parametric values, which now feature classes, are represented by shaded color codes.
- Using a GIS technology tool **Surfer II, the** basic information is translated into digital topographic database which generates a new file or worksheet. The file is gridded and then plotted to create the contours.
- In the final map, parametric values, which now feature classes, are represented by shaded color codes.

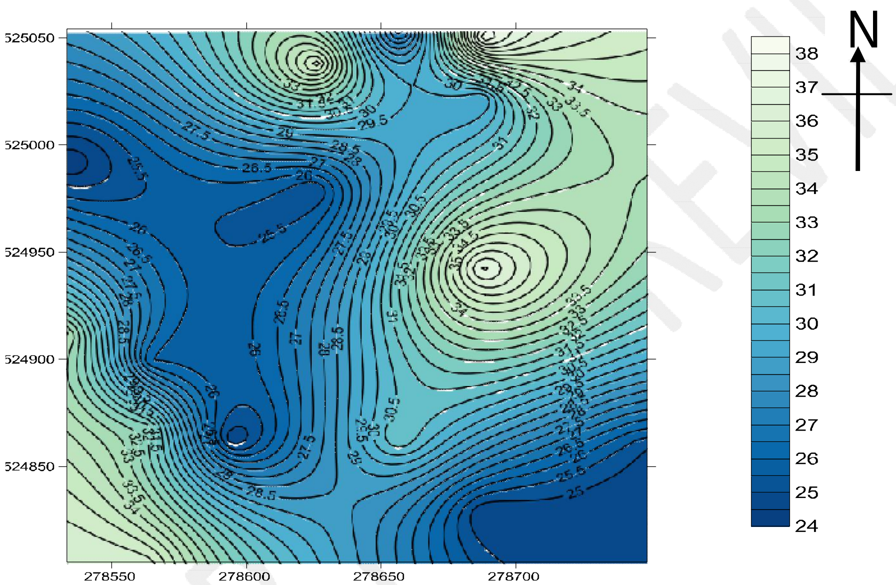

Figure 2: Liquid Limit

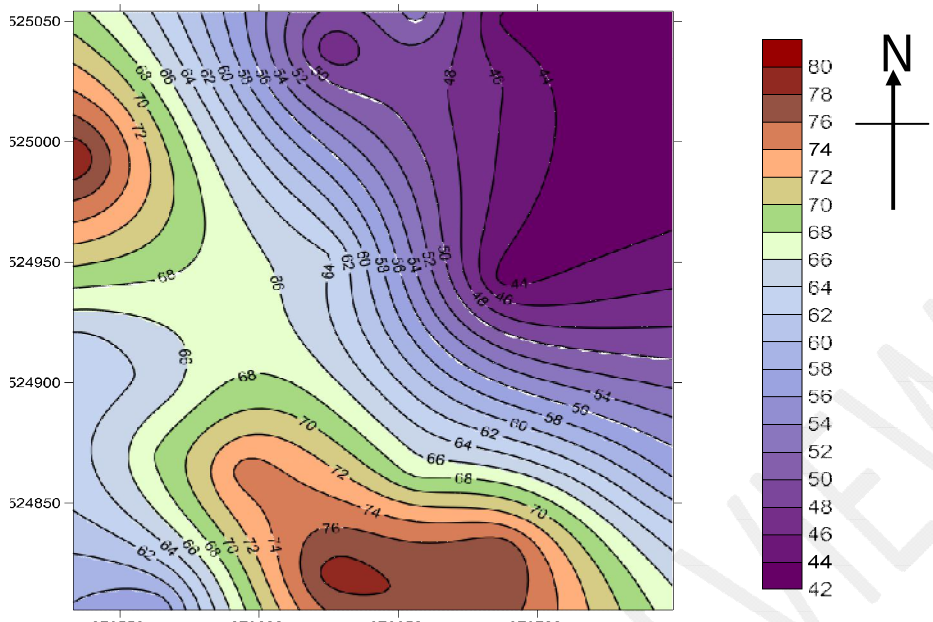

Figure 3:Cohension

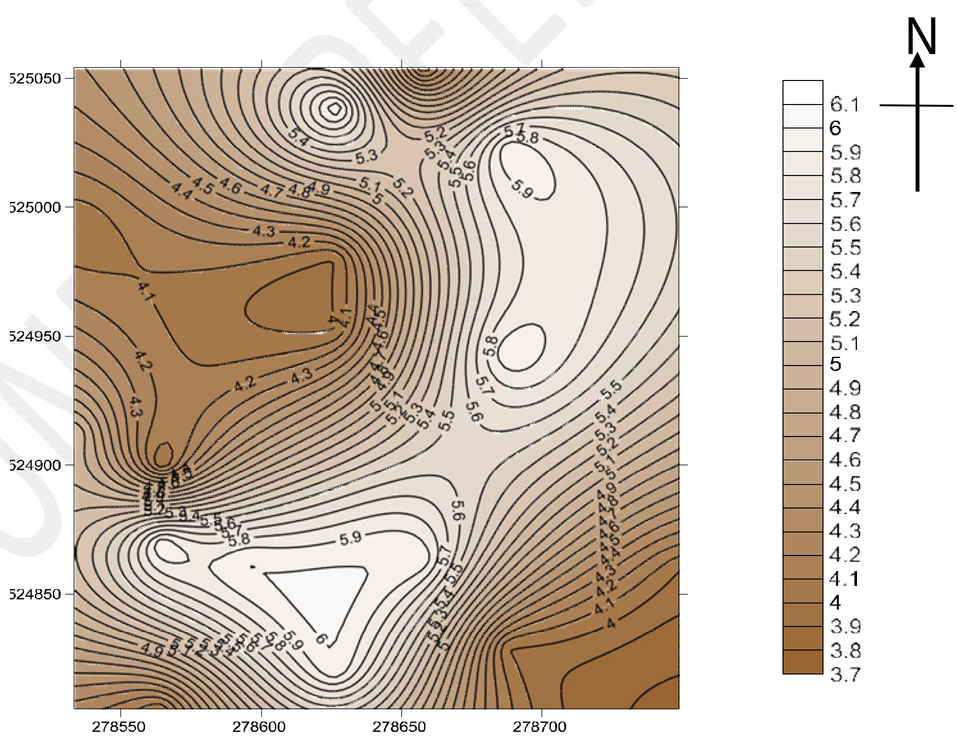

Figure 4: Angle of Internal friction

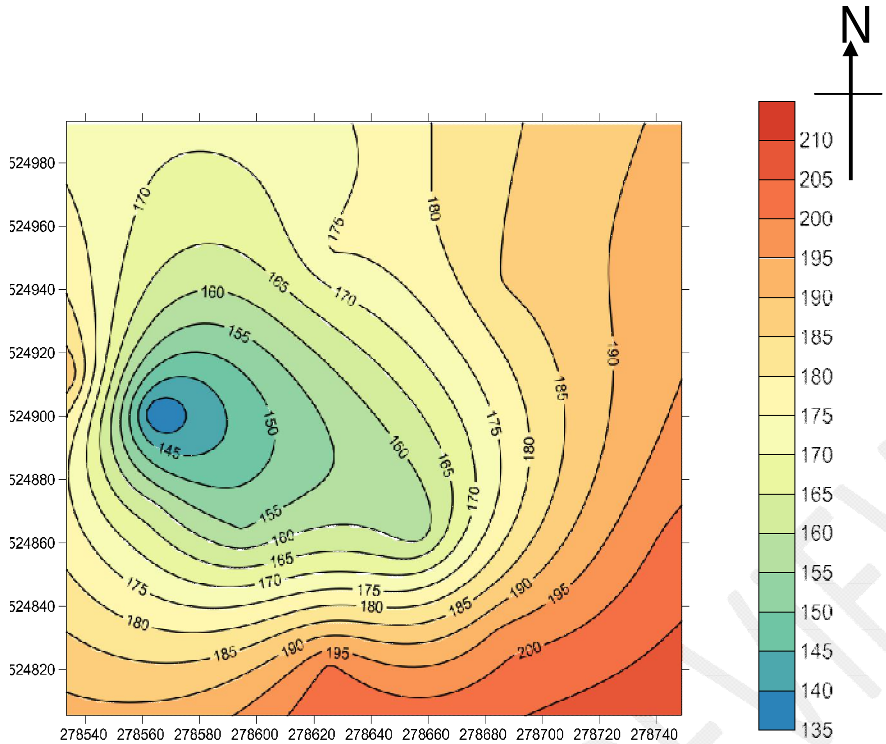

Figure 5: Bearing capacity

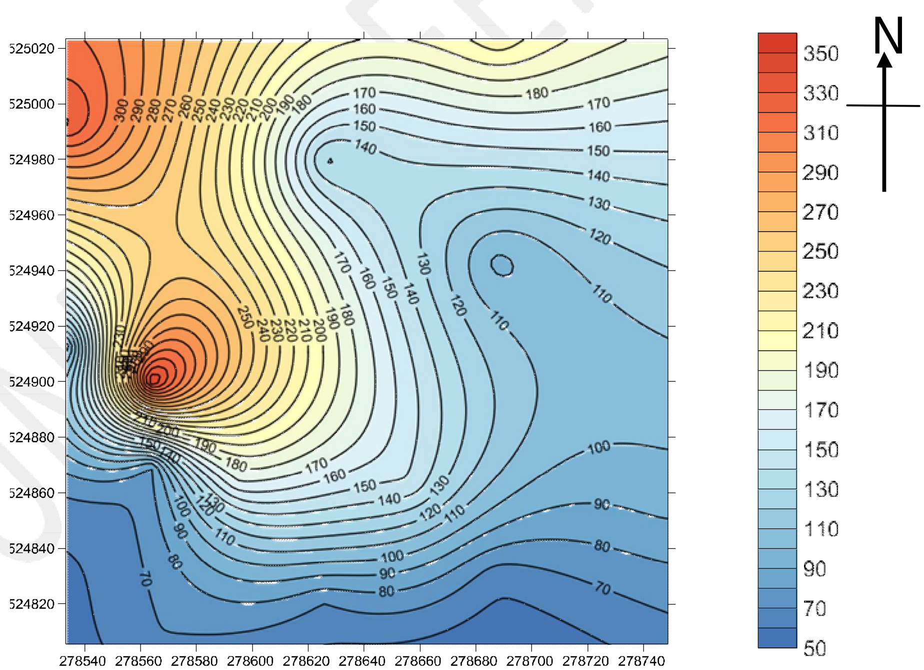

Figure 6: Settlement

5. Discussion

The research was focused on the assessment of the geological engineering parameters such as the soil consistency, moisture content, Atterberg limits, and permeability. The results obtained from the investigation showed that the area is characterized by clayey soils of varying consistencies [2].

The stratigraphic layers encountered during the shallow foundation level investigation were delineated as clays of various consistencies. The range of the consistency values, such as the liquid limit (LL) and plastic limit (PL), is a good indication of the likely behavior of the clayey soils in the presence of excess water [1[. The high moisture content of the clays, ranging from 20.3% to 32.6%, is similar to previous studies conducted in the region. This high moisture content could be attributed to the heavy rainfall and proximity to the coast. During the rainy season, the clay absorbs water and swells, while in the dry season with less rainfall, the clays shrink and crack. This constant swelling and shrinking of the clays is a result of the hydro-metrological changes, which are also responsible for some of the geotechnical problems in the region [3][14]

The Atterberg limits, which are essential parameters for determining the plasticity and compressibility of soils, were also determined. The results showed high values of liquid limit (LL) and plasticity index (PI), ranging from 34% to 40% for LL and 7% to 25% for PI. These values indicate the high plasticity and compressibility of the clayey soils, which could result in excessive settlements of foundations.

Permeability tests were also conducted on the soil samples, and the results indicated that the soils have appropriate permeability values. This information is useful for drainage and consolidation planning in the area.

In order to produce iso-contour maps for liquid limits, cohesion, friction angles, and bearing capacity settlements, a comprehensive approach was used. This involved acquiring a complete set of engineering and geological data, systematically layering the area in different scales, collecting the comprehensive information in a data bank, and using GIS-based mapping techniques. This approach provides a detailed and accurate representation of the geological and geotechnical characteristics of the area, which is essential for effective planning and management of engineering projects in the region [15].

Overall, the geotechnical investigation techniques used in this study provide valuable information on the geological and geotechnical properties of the soils in the Niger Delta Sub-region of Nigeria [18]. This information is essential for effective planning, design, and construction of engineering projects in the area, particularly in relation to foundation design, drainage, and consolidation. The comprehensive approach used in producing iso-contour maps provides a detailed and accurate representation of the geological and geotechnical characteristics of the area, which is essential for effective planning and management of engineering projects in the region [6].

Conclusion

In conclusion, this research has shown the importance of comprehensive geotechnical investigations in the Niger Delta sub-region of Nigeria. The use of geotechnical mapping techniques, such as the production of iso-contour maps, can aid in the understanding of the behavior of the soil and its potential impact on engineering projects. However, it is essential to note that these maps should not replace detailed studies, which are necessary for specific projects.

Additionally, the study highlights the difficulty of accurately characterizing subsurface conditions. Even the most thorough investigation program can only provide limited information, and unexpected conditions may still arise during construction. The adoption of the observation method becomes the most cost-effective approach in such situations, as it allows for adjustments to be made during construction to ensure the project's success.

Finally, it is important to note that the hydro-meteorological changes in the Niger Delta region, particularly during the rainy season, have a significant impact on the behavior of the soil. This study emphasizes the need for continued monitoring and evaluation of the soil properties to ensure the safety and success of engineering projects in the region.

REFERENCES

1. Abam, T.K.S. (2019). Settlement Prediction in lateritic soils. Comparing plate load, CPT and Oedometric methods of computation, Proceedings of the 3rd Internatinal Conf. of the Nigerian Asso for Engineering Geology of the Environment (2): 51-57
2. Akpoborie, I. A., & Ovuru, B. O. (2021). Subsurface Geotechnical Investigation of Selected Sites in Delta State, Nigeria. Journal of Multidisciplinary Engineering Science and Technology, 8(1), 66-75.
3. Barati, M., Amini, A., & Carranza, E. J. M. (2019). Fusion of lineament factor (Lf) map analysis and multifractal technique for massive sulfide copper exploration: The Sahlabad area, East Iran. Ore Geology Reviews, 114, 103071. https://doi.org/10.1016/j.oregeorev.2019.103071
4. Cai, M., Zou, D., & Huang, H. (2019). Laboratory and numerical studies of anisotropic damage and permeability evolution of sandstone. International Journal of Rock Mechanics and Mining Sciences, 116, 106-117.
5. Cetin, H., & Yilmaz, I. (2020). The use of unmanned aerial vehicles (UAVs) for rockfall hazard assessment in transportation infrastructure. Bulletin of Engineering Geology and the Environment, 79(3), 1545-1556.
6. Edet, A. E., & Obia, A. J. (2021). Geotechnical Properties of Lateritic Soil in the Niger Delta Region of Nigeria. International Journal of Scientific Research in Engineering and Management, 5(5), 22-30.
7. Fidelis, A.A, Teme, S.C and Ebiegberi, O. (2018). Geotechnical considerations for the design and Construction of foundation in a marshy stream channel of Iwochang-Ibeno Eastern Niger Delta, Nigeria, Journal of Civil, construction and Environmental Engineering, 3(6): 154-170
8. Haddad, M., & Shahriar, K. (2021). Stability analysis of earth slopes reinforced with geogrid. International Journal of Geosynthetics and Ground Engineering, 7(1), 1-12.
9. Iyakwari, S. O., & Odewande, A. A. (2020). Geotechnical Evaluation of Lateritic Soils in Ughelli, Niger Delta Area, Nigeria. Nigerian Journal of Technology, 39(3), 778-785.
10. Jafari, M. K., Carranza, E. J. M., & Pour, A. B. (2020). Neuro-Fuzzy-AHP (NFAHP) Technique for Copper Exploration Using Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) and Geological Datasets in the Sahlabad Mining Area, East Iran. Remote Sensing, 12(12), 1991. https://doi.org/10.3390/rs12121991
11. Morison T, Esonanjor E.E. Geotechnical Assessment of Subsoil Integrity for Foundation Design in Owerri, Nigeria, Journal of Applied Geology and Geophysics. 2022; 1(10):9-14
12. Obia, A. J., & Edet, A. E. (2021). Geotechnical Properties of Sand Deposits in the Niger Delta Region of Nigeria. Journal of Multidisciplinary Engineering Science and Technology, 8(3), 153-161.
13. Ogedengbe, O. O., & Ojo, J. S. (2020). Geotechnical Investigation of Some Sites in Ijebu-North Local Government Area of Ogun State, Southwestern Nigeria. International Journal of Scientific Research in Engineering and Management, 4(11), 31-43.

14. Ojoh, K. A., Edet, A. E., Oyekanmi, A. A., & Ebeniro, J. O. (2020). Permeability estimation from Stoneley waves in carbonate reservoirs. Journal of Petroleum Science and Engineering, 190, 107006. https://doi.org/10.1016/j.petrol.2020.107006

15. Okon, A. E., & Oviasogie, P. O. (2019). Geotechnical Investigation of Lateritic Soils in Ekpoma, Edo State, Nigeria. International Journal of Scientific Research in Engineering and Management, 4(10), 15-26.

16. Oni, G. A., & Owolabi, R. O. (2020). Geotechnical Investigation of Lateritic Soil for Highway Construction in Ogun State, Nigeria. Nigerian Journal of Technology, 39(1), 236-243.

17. Teme, S.C, Etu, D., Morrison , T. and Folade, I. (2022). Application of Engineering Geology and Geotechnics in design of the Foundation for a 3 star hotel in the coastal zone of the Niger Delta, Nigeria, 3rd IAEG Africa Regional congress and 7thNAEGE annual international conference, Lagos

18. Umoren, I. U., & Ekerong, I. O. (2019). Geotechnical Investigation of the Subsurface Soil Conditions in Parts of Calabar, Cross River State, Nigeria. International Journal of Engineering and Advanced Technology, 8(6), 116-123.

19. World Economic Forum. (2017). The global competitiveness report, 2016-2017, Palgrave. http://www3.weforum.org/docs/GCR2017-2018/05FullReport/TheGlobalCompetitivenessReport2017%E2%80%932018.pdf