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Geo-Environmental Assessment: Evidence from Geotechnical and Chemical Insight for Irrigation Purpose, Nigeria

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ABSTRACT

Aim of Study: Climate change constitute a serious challenge to food security globally. Its impact on food production has been alarming and this study aim to address the severe environmental problem linked to soil and weather variability condition.

Methodology: Selected exploratory pits within the study area for Geotechnical and chemical assessment were bored to elucidate the area for irrigation design that will serve the plantation. This study was done by getting ditch cutting samples at defined coordinates of the area. This facilitated better and deeper insight into the soil composition of the area.

Findings: The facies consisted of silty-sandy soil with some clayey-sandy soil and the area was thus noted more for its non-plastic property using Atterbergs test. Compaction analysis revealed maximum dry density that varied between 1263.0 kg/m^3-1627.2$kg/m^3$and Optimum moisture content that varied between 11.1% to 15.0. Compression Index used in determining the settlement potential of the fine-grained clay/silt material of the study area recorded 6.2 x 10^{-4} of P3 sample to 8.6 x 10^{-4} in P5 sample. Coefficient of volume compressibility (mv) varied 6.1 x 10^{-4} to 8.6 x 10^{-4}.More importantly, Sulphate, Nitrate, Bicarbonate and Chloride have respectively shown a good area to enhance sugarcane plantation.

Conclusions: The area is tectonically stable as no tremor has been reported with underground water potential that can supplement the water need for irrigation of the proposed plantation. Chemical analysis of the soil has revealed its good for sugarcane plantation. Thus, study concluded that the soil of the study area is suitable for such purpose with Pad and Strip foundational footing recommendation.

Keywords: Lithological Facies, Oedometer Test, Casagrande, Atterbergs Limit and Intake.

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1. INTRODUCTION

The Environmental evaluation of the study area for Agricultural research was done with selected pits to pinpoint the most suitable point for Intake and Pumping station of a proposed irrigation system using

Geotechnical Engineering and chemical evidence. This elucidated the best position for their emplacement. This exploration and investigation involved four stages of procedure.

These stages are:

(1) Preliminary investigation using published information and other existing data;

(2) Detailed field work and climatic variation assessment of the area in question;

(3) Excavation to provide confirmation of the structural emplacement including the lithological details of the area and its geotechnical evaluation.

(4) Location of most suitable Intake and pumping station point for irrigation purpose in the investigated area

Sugarcane being the raw material will need be cultivated using the designed Intake and Pumping station along the river in that area. It is a significant industrial crop that is used to produce bioenergy, sugar, and other products. The Saccharum hybrid is the variety of sugarcane that is currently planted in many nations to produce white sugar. This variety of sugarcane is gaining popularity all over the world because of its large leaves, moderate tillering, generally upright stalks, excellent cane production, high sucrose content, and comparatively soft skin. In essence, the irrigation of this sugarcane will necessitate the design and construction of Intake and Pumping station from the direct abstraction of adjacent river. Lateritic soil stabilized with sugarcane straw ash as advanced (Amu et al 2011) is also a veritable tool to consolidate the lateritic soil.

1.2 Geoscientific Assessment of the Area

The study area is largely overlain by sedimentary rocks deposited in fluvial condition with massive emplacement of the Nupe ie Bida basins deposit in the area. Publication by previous workers has revealed conglomerates, sandstone and claystone facies (Fig.1). Conglomeratic sandstone and medium-coarse-grained sandstone subfacies make up the braided channel facies, which are widely distributed. Their unidirectional flow pattern and lack of marine biogenic feature indicators suggest their fluvial origin. Other researchers have regularly examined and written on the stratigraphy, mineral resources, and paleoenvironmental evolution of the sediments in the northwest of the northern Bida Basin and the southern Bida Basin, including Lafiagi (Adeleye, 1972). The weather variations in the area is similar to that of Ilorin metropolis as advanced by (Ibrahim et al 2004) so the need for adequate irrigable water arrangement that will drive the proposed sugarcane plantation in the area. The stratigraphy and sedimentation of Upper Cretaceous succession of the (Adeleye, 1972) Bida Basin have been documented in the central parts of the basin around Bida with four our mappable stratigraphic unites were recognized. The study area is largely a sedimentary terrain with aquiferous underground water (Ibrahim et al 2024) potential similar in Akerebiata area, North-Central Nigeria.

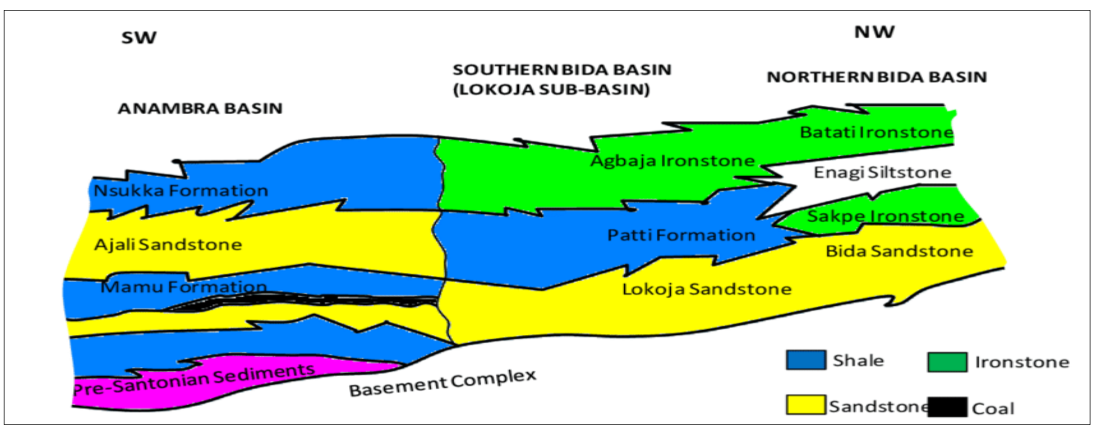

Fig. 1: Stratigraphic emplacement of the sediments in Bida Basin.

1.3 *Environmental Variability of Lafiagi*

In Lafiagi, the dry season is hot all year round and partially cloudy, while the wet season is unpleasant and overcast. The average annual temperature fluctuates between 65°F and 98°F; it is rarely lower or higher than 58°F or 103°F. During the 2.8-month hot season, which runs from February 1 to April 24, the average daily high temperature rises beyond 96°F. April is often the hottest month in Lafiagi, with highs of 97°F and lows of 77°F. The average daily maximum temperature during the 3.5-month cool season, which runs from June 28 to October 11, is less than 88°F.With an average low temperature of 66°F and high temperature of 93°F, December is the coldest month of the year in Lafiagi. Over the course of the year, Lafiagi's average percentage of cloud cover varies significantly with the season. In Lafiagi, the clearer season lasts for 3.4 months, starting around November 8 and ending around February 18. December is the clearest month of the year in Lafiagi, with 55% of the sky being clear, mainly clear, or partly overcast on average (Fig. 1.2). The weather (Ibrahim et al 2024) right now is unpredictable with lots of uncertainty.

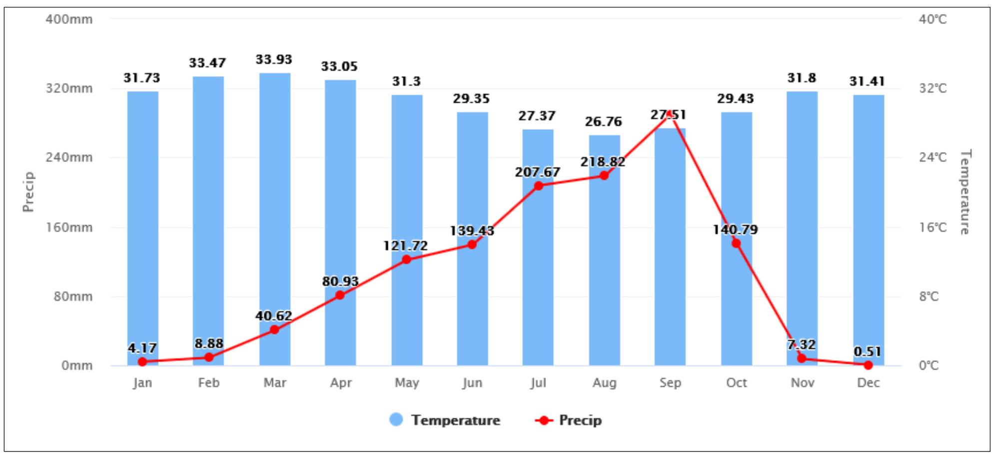

Fig. 2: The chart shows the mean monthly temperature and precipitation of Lafiagi in recent years

December is the clearest month of the year at Lafiagi, with 55% of the sky being clear or partially overcast on average. May is the cloudiest month of the year in Lafiagi, with 81% of the sky being overcast or mostly cloudy on average. Climate change variability is currently altering most of the weather pattern in the area including the variability of rainfall, sunshine, humidity, cloudiness and temperature pattern. It is worthy of note that climate change currently ravaging the global community has made it extremely hard to pinpoint the exact climatic weather for the nearest future with lots of uncertainty heralding the weather condition of Lafiagi and in the global arena (Jangir et al 2020, Olanrewaju and Negedu 2015 and Shahid et al 2018).

1.4 *Field work and Methodology of Study*

Field work entailed excavation of the pit for sample collection and Geotechnical assessment at defined coordinates and dimension along the proposed study area for the construction of Intake and Pumping station of the sugarcane plantation. This was followed by getting the soil samples of each profile in thick walled zip-lock bags for further laboratory inferences of the area. Additionally, the samples were air-dried and then chemically digested using a solution of hydrofluoric and nitric acids for geochemical analysis in accordance with the International Atomic Energy Agency's protocol (IAEA-TECDOC.1996). Ultra pure NHO3 and HF were used to digest a 0.2g sample in a Teflon digestion bomb. After being placed on a quartz sample carrier, an aliquot of the digestate was dried under an infrared lamp. Using a black scientific infrared spectrophotometer M500, the infrared analysis was performed. The KBr preparation procedure was used. The profiles created for a proper exemplification of the area in issue were used to log the pits in the area.

Fig. 3: Field work and bagged samples for laboratory assessment

In essence, 13-15 samples that represented the total lithological profiles f the area and sections were penciled down for Geotechnical assessment while 9 lithological pit profiles that represented all accessible and partially accessible points of the area were taken to the Geotechnical and Geochemical laboratories for further study on salient Cation and Anion content of the soil in the area that will enhance the sugarcane plantation in the area.

Table 2.2: *Excavated pits, lithological facies and their dimensional analyses*

S/N	Pit sample codes	Coordinates X	Coordinate Y	Pit length (m)	Pit depth (m)	Pit width (m)	Lithological Inference
1	**P1-LASLAF**	755,567.86	992,969.10	3.5	2.8	1.5	**Gravelly Sandy soil**
2	**P2-LASLAF**	755,585.35	992,959.40	3.1	2.6	1.5	**Gravelly sandy soil**
3	**P3-LASLAF**	755,568.20	992,949.11	4.1	4.2	1.6	**Clayey Sandy soil**
4	**P4-LASLAF**	755,550.71	992,958.81	3.9	4.1	1.5	**Clayey Sandy soil**
5	**P5-LASLAF**	755,585.69	992,939.40	3.13	2.8	1.8	**Gravelly Sandy soil**
6	**P6-LASLAF**	755,551.05	992,938.81	2.9	2.7	3.2	**Silty Sandy soil**
7	**P7-LASLAF**	753,416.23	990,643.28	3.2	2.7	3.6	**Silty Sandy soil**
8	**P8-LASLAF**	753,555.16	990,499.41	3.1	3.2	3.5	**Gravelly Sandy soil**

2. RESULTS AND DISCUSSIONS

The results obtained from the analyses carried out on the collected samples of the area are hereby displayed for further interpretation.

2.1 Soil Classification by USC System

Field observation of all ditch cuttings and laboratory inference seved as the guide for the lithological identification of all samples (Tables 5 to 8). This indicate that fine and medium-grained loose sandy soil predominates among the overburden or regolith, components inside the proposed sugarcane plantation site. The large percentages of sand fraction or extremely fine and coarse sand fraction, in comparison to the low fraction of silt and clay in the majority of the P1S1–P2S3 samples that were tested demonstrates this. Additionally, the findings showed that the liquid limit is greater than 39% and that over 50% of the soil sample is less than 0.075mm (No. 200 sieve). The soil is therefore categorized as MH/OH, which suggests clayey-sandy soils, in accordance with the Unified Soil Classification System (USCS).

The MH soils i.e. inorganic silty sandy soils were found mainly within the pumping station and Intake axis, while the OH i.e. organic clay soils seem to be more pronounced within the intake area and partly pumping station area. Further analysis from the Atterbergs limit of the 14 studied samples has revealed a similar result that shows that from P1S1 to P2S3 there is no single plastic limit of the soil nor plasticity index was recorded and this clearly shows that the fine grained mud, silt and clay fraction of the samples are absent or in the smallest quantity in the studied samples. More puzzling within a shorter distance of less than 200 meters pits 3 to pit 5 all recorded appreciable varied amount of fine grained clay and silt fractions in the ditch cuttings. This has classified them to be named silty or clayey sandy soil.

2.2 Atterbergs Limit Test

The test was carried out on selected samples (P1LAF-P3LAF) of the area to establish the level of plasticity of the evaluated soil. P1-LAF gave a liquid limit of 20.8%, Plastic Limit of 9.6% with a Plasticity Index of 11.2%. P2-LAF and P3-LAF gave a liquid limit of 34.7% and 29.3%, Plastic limit of 11.6% and 15.1% with Plasticity Index of 23.1% and 14.2% respectively. In essence, these soil samples (P1-P3) can be categorized as Plastic soil that will need be treated for the purpose of the design of an Intake and Pumping station in the area.

Fig. 4:Atterbergs limit curve for P2-LASLAF

P4 and P5 samples have displayed a non-plastic character with moisture content of 11.8, 17.9, 25.0 and 31.3 at the first, second, third and forth blows. The samples are said to be totally non-plastic (NP) and with a liquid limit (LL) of 18%. The ductility of the sample is caused by no presence of either silt or clay in the sample to warrant a good Plastic limit upon addition of water at different blows (Umoren et al., 2016) advanced a similar result at Nkari Dam-site.

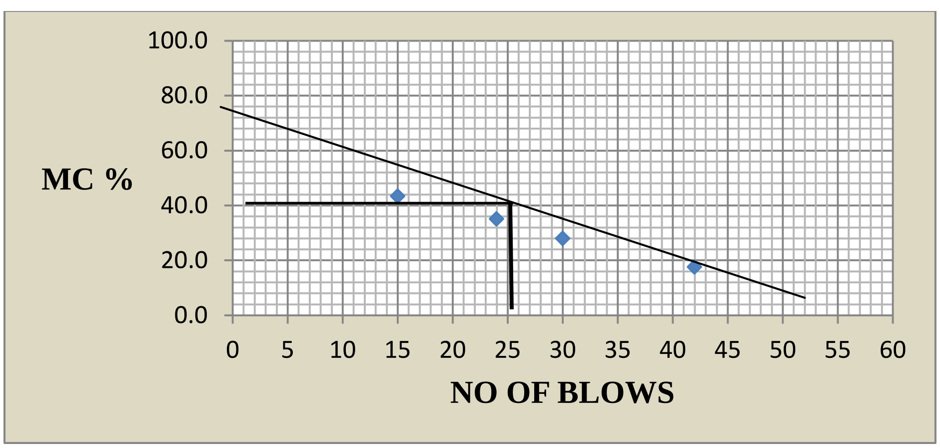

Fig. 4: Atterbergs limit curve for P4-LASLAF

2.3 *Compaction Test*

The swelling property of the soil at the maximum condition of water addition ie moisture content and maximum dry density was measured to examine the level of stability of such soil to excessive rainfall condition in the area, then the stability and suitability of the area for Intake and Pumping station design. As water is added, the thickness of the diffuse ion layer increases, causing the clay minerals to swell. Identification of high volume change soils is necessary because to the possible risks to foundation construction on these soils. The percentage of swell under a 6.9KN/m2 (1Psi) surcharge of a laterally confined specimen compacted at optimum moisture content (OMC) to maximum dry density (MDD) in a standard compaction test is an empirical index used to identify these soils. The results are calculated in tabular form (Tables 2.3 to 2.6) and (Figs. 5-8).

Table 2.3: *Sample P1-LAF moisture content at different dry density*

Moisture %	7.14	9.52	11.76	12.73	15.69
Dry Density	1549.68	1594.27	1624.45	1558.59	1491.52

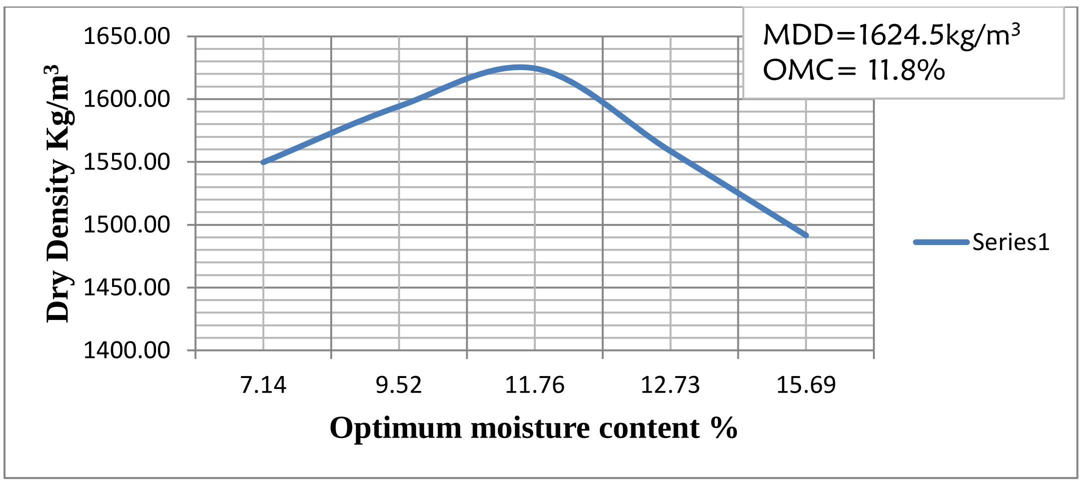

Fig. 5: Graph of Dry Density against Optimum moisture content of sample P1-LAF

Table 2.4: *Sample P2-LAF moisture content at different dry density*

Moisture %	7.50	11.90	13.33	15.00	19.15
Dry Density	1411.28	1487.62	1504.29	1556.10	1448.17

The study carried out by [4] on sugarcane straw ash has revealed the increase in Optimum moisture content which varied to the result obtained in this study and was traced to the additional water held within the flocculent soil structure due to excess water absorbed as a result of the porous property of sugarcane straw ash.

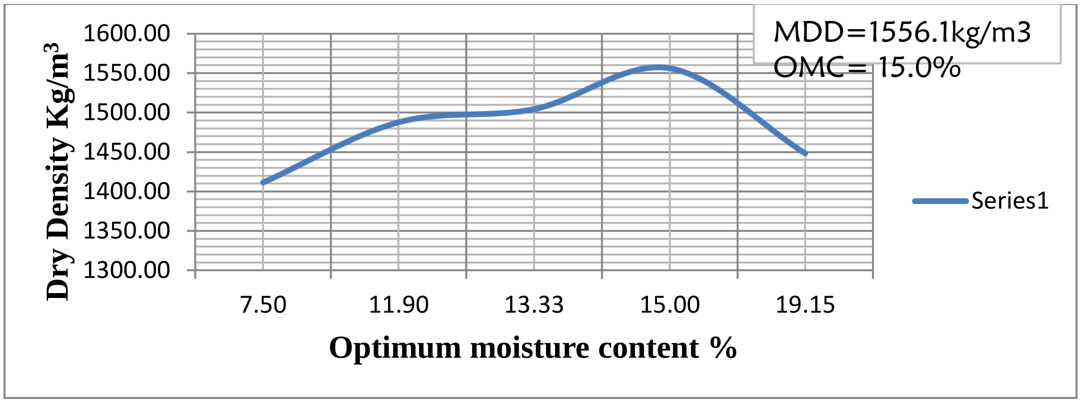

Fig. 6: Graph of Dry Density against Optimum moisture content of sample P2-LAF

Table 2.5: *Sample P3-LAF moisture content at different dry density*

Moisture %	8.33	8.17	10.00	11.11	16.22
Dry Density	1540.67	1560.00	1603.15	1627.16	1511.80

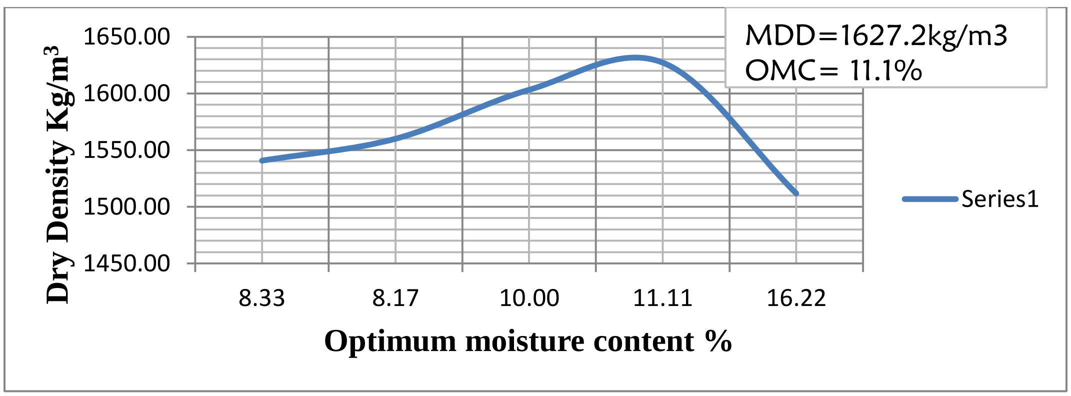

Fig. 7: Graph of Dry Density against Optimum moisture content of sample P3-LAF

Table 2.6: *Sample P4-LAF moisture content at different dry density*

Moisture %	7.17	10.60	12.90	13.04	17.65
Dry Density	1134.12	1249.06	1263.00	1218.23	1140.12

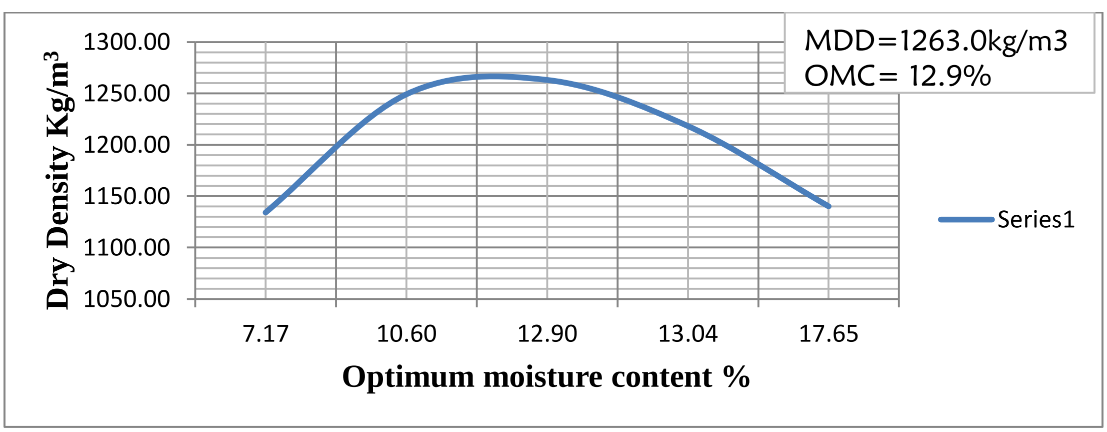

Fig. 8: Graph of Dry Density against Optimum moisture content of sample P2-LAF

2.4 *Consolidation (Oedometertest)*

Coefficient of consolidation for the samples of the area were estimated from the time-settlement curve using graphical method. In essence, Casagrande logarithm of time fitting method was adopted with Cv determined by estimating the time at 50% consolidation. The laboratory procedure, computation, estimation and plotting are hereby enclosed for your perusal across the investigated samples of pits P1 toP7. The summary of the finding is hereby (Table 2.9) attached.

Table 2.7: *Sample P1 height at differential time of load application*

time (min)	d (mm)
0.1	1.499
0.25	1.652
0.5	2.304
1	2.981
2	3.284
4	4.161
8	4.575
15	4.954
30	5.351
60	5.554
120	5.667
240	5.838
480	6.032
960	6.227
1200	6.638
1320	6.724

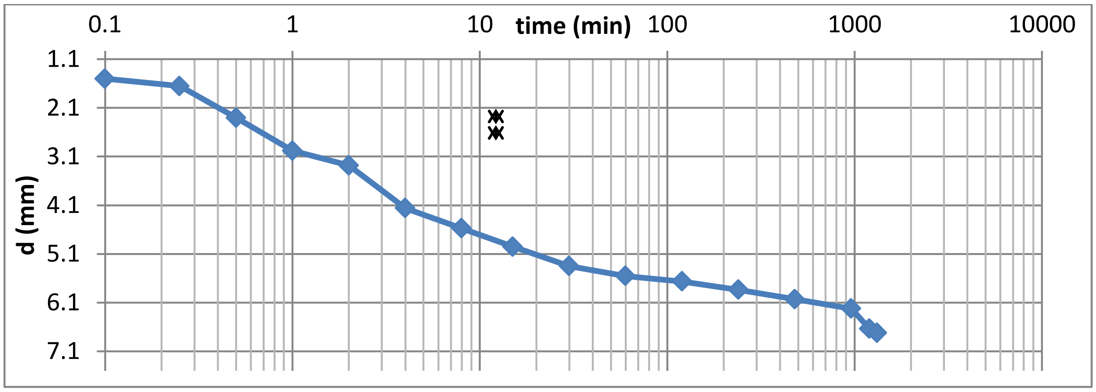

Fig. 9:Casagrande settlement curve at various time intervals of P1 sample

Table 2.8: *Measured consolidation pressure in sample P1*

Consolidation pressure (kPa)	Change in height of specimen*, H (mm)	Height of specimen (2H=2H1-H=18.8-H) (mm)	Equivalent height of voids, (=2H - 2Ho) =2H - 7.277 (mm)	Void ratio, e=(2H - 2Ho)/2Ho
0	0	18.800	11.090	1.439
20	0.763	18.037	10.327	1.340
40	1.435	17.365	9.655	1.252
80	1.646	17.154	9.444	1.225
160	2.075	16.725	9.015	1.169

320	2.256	16.544	8.834	1.146
480	2.957	15.843	8.133	1.055
640	4.356	14.444	6.734	0.874
1280	6.395	12.405	4.695	0.609

Table 2.9: *Summary of Oedmeter test results obtained in the study area*

Locations	aV	Cc	mV	Findings
P1	**8.1 x 10^{-4}**	**7.7 x 10^{-4}**	**7.4 x 10^{-4}**	Investigated samples for the area has shown almost same deformation pattern that responded to the applied loads same way, thus, good for Intake, PS and even BWS respectively.
P2	**8.6 x 10^{-4}**	**6.3 x 10^{-4}**	**6.3 x 10^{-4}**	
P3	**9.4 x 10^{-4}**	**6.2 x 10^{-4}**	**6.1 x 10^{-4}**	
P4	**8.5 x 10^{-4}**	**6.7 x 10^{-4}**	**7.4 x 10^{-4}**	
P5	**8.8 x 10^{-4}**	**8.6 x 10^{-4}**	**8.6 x 10^{-4}**	
P7	**8.3 x 10^{-4}**	**7.3 x 10^{-4}**	**7.9 x 10^{-4}**	

av is Coefficient of Compressibility

Cc is Compression Index

mv is Coefficient of volume compressibility

PS is Pumping station

BWS is Bulk Water Supply

Table 2.10: Sample P2 height at differential time of load application

time (min)	d (mm)
0.1	1.488
0.25	1.602
0.5	1.954
1	2.434
2	2.634
4	2.902
8	3.125
15	3.304
30	3.501
60	3.704
120	3.994
240	4.006
480	4.139
960	4.231
1200	4.398
1320	4.454
1440	4.767

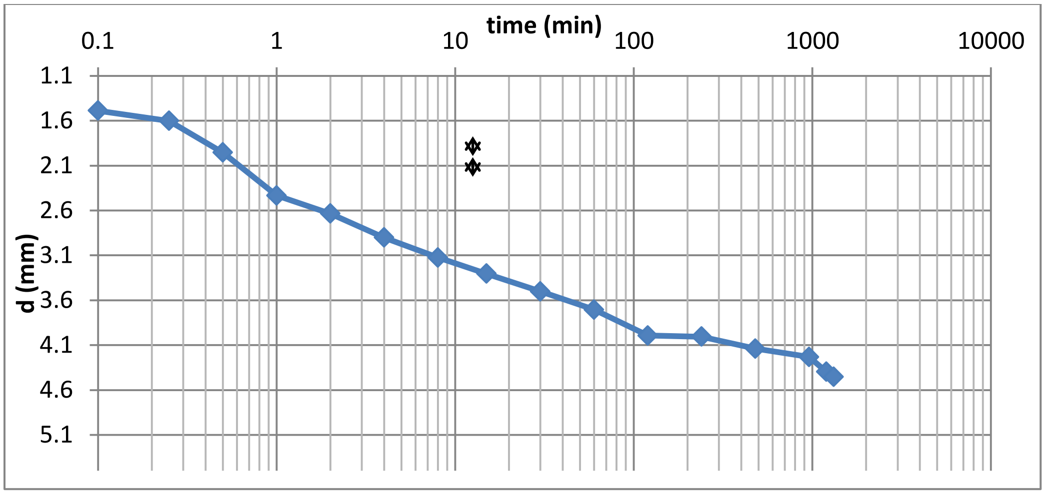

Fig. 10: Casagrande settlement curve at various time intervals of P2 sample

The Oedometer test was repeated for all the 7 enumerated samples of the area with summary of findings tabulated (Table 2.9). More importantly, the results obtained has vividly shown that the area will be suitable for the purpose of Intake, Pumping station and even bulk water supply because the differential loads applied to the soil samples responded favorably.

Table 2.11: *Measured consolidation pressure in sample P2*

Consolidation pressure (kPa)	Change in height of specimen*, H (mm)	Height of specimen (2H=2H1-H=18.8-H) (mm)	Equivalent height of voids, (=2H – 2Ho) =2H – 7.277 (mm)	Void ratio, e=(2H – 2Ho)/2Ho
0	0	18.800	12.101	1.806
20	0.689	18.111	11.412	1.704
40	1.679	17.121	10.422	1.556
80	1.988	16.812	10.113	1.510
160	2.275	16.525	9.826	1.467
320	2.498	16.302	9.603	1.434
480	3.008	15.792	9.093	1.357
640	4.768	14.032	7.333	1.095
1280	5.657	13.143	6.444	0.962

The consolidation and compressibility properties of four chosen undisturbed soil samples were determined using a comparable dimensional consolidation test. According to the test results, the soil samples under investigation showed low to medium compressibility properties.

2.5 Permeability Test

Permeability immediately influences the amount of water that will fill the vacant spaces and, eventually, decide the strength of the soil in question since it regulates the strength and deformation of soils. As a result, an in-situ permeability test was carried out with recorded values at different time intervals (Table 2.12). The test's results, which range from 1.01 x 10-4 to 9.26 x 10-6 m/s, indicate that the sand medium's capacity to permit percolated subsurface water and infiltrated rainwater to flow through is minimal and should support the design of the intake and pumping stations for the irrigation scheme of the study area (Umoren et al., 2016) had the values of permeability varying according to various environmental factors.

Table 2.12: *Permeability of investigated soil samples of the area*

Test sample/location	Time taken (s)	Permeability (m/s)	Suitability for Intake and PS
P1	180	1.23 x 10	Permeability result has shown the area is good for Intake and Pumping station for the proposed sugarcane plantation
P2	393	5.65 x 10	
P3	240	9.26 x 10	
P4	135	1.65 x 10	
P5	205	2.44 x 10	
P6	22	2.27 x 10	
P7	142	1.08 x 10	
P8	-	-	
P9	-	-	

2.6 Sieve Analysis

The Sieve analysis of the study samples was done and this has revealed a wide gradational difference across the study samples. Selected samples of the study area were subjected to this assessment to reveal their soil fraction composition in the area. TP1 S3 that originated from P1-LAF has shown more sand fraction of 68% than the silt and clay fraction that recorded 28% and 4% respectively. The evaluated sample has shown a good one for pumping station design and construction.

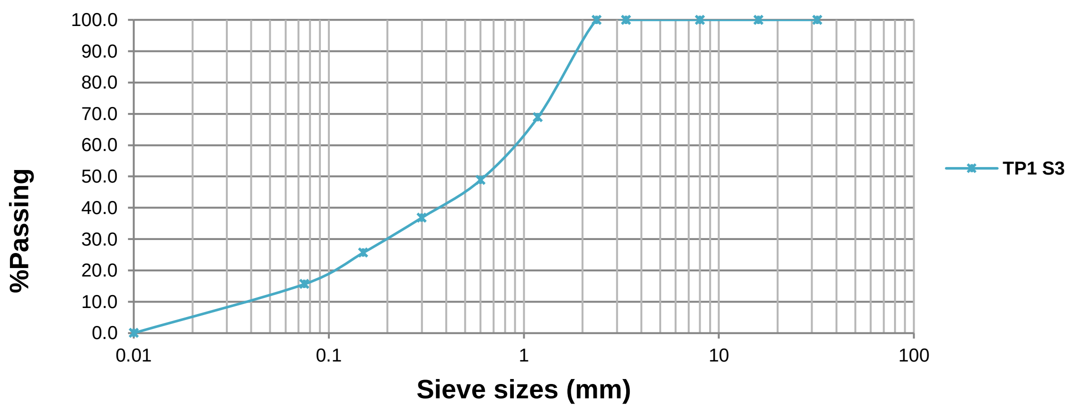

Fig. 11: Sieve analysis result of sample TP1 in the study area

Studied samples of TP7, 8 and 9 were selected for the sieve analysis in the area. Findings from these grain size analysis has shown largest amount of sand fraction in varying proportion than the silt and clay fraction.

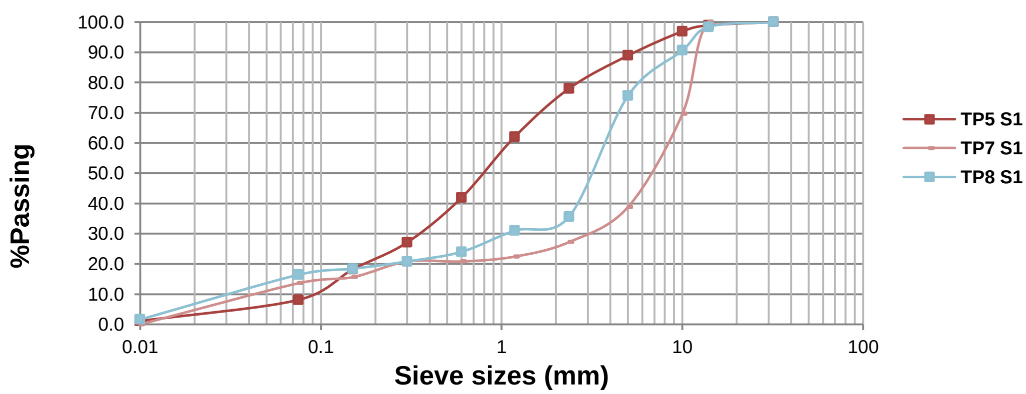

Fig. 12: Sieve analysis result of sample TP5,6 and 7 in the study area

With a significant percentage of coarse-grained sand in its matrix and nearly identical engineering properties of extremely low fine materials of silt and clay, the gradational curves were sparsely connected. The samples' fine and medium-grained sand components are ideal for pumping station lithological facies because they will improve the area's strip, pad, or circular footing design. The clay fraction that ranges from 1-3% across all investigated samples is commonly unstable and mostly not desirable for the Intake or Pumping station of an Irrigation work.

A well-graded coarse to fine-grained sand with a little quantity of clay or silt in the matrix was found in the examined samples from pits 5, 6, 7, and 8. The grains' sub-angularity, which causes them to interlock, will make them appropriate for the pumping station and intake as they have also demonstrated increased shear strength. The soil sample composition from the gradational curve of the collected samples (S1) from these trenches showed that the soil sample composition is graded, with a low fraction of fine silt in its matrix and nearly the same engineering quality of coarse-fine sand material.(Akinrinmade et al 2013) suggested the importance of sieve analysis of soil before the Engineering design of a project like dams and other structures to have basic understanding for the correct foundational footing emplacement.

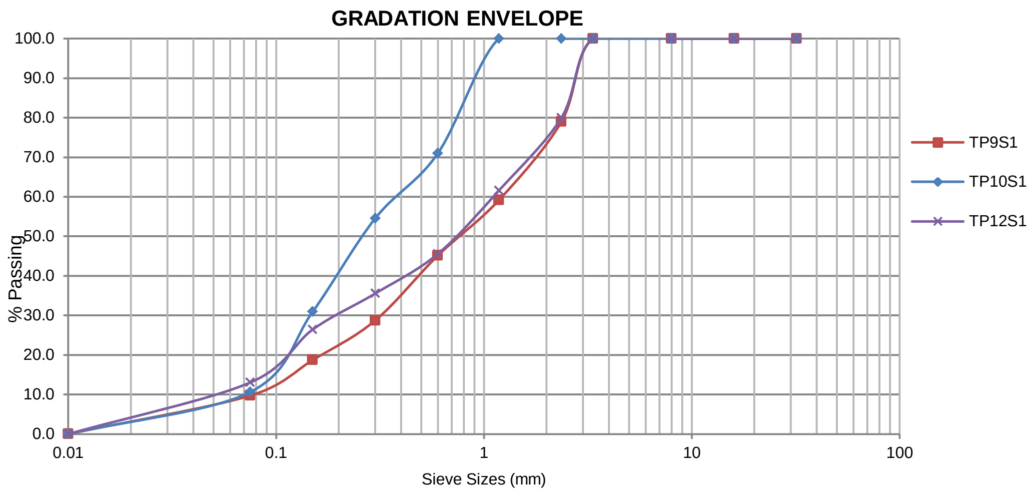

Fig. 13: Sieve analysis result of sample TP9, 10 and 11 in the study area

2.7 Anion Analysis Test Result

The anion test result has shown the area of investigation has a moderate to high anion concentration that will enable the pipelines that will carry the bulk water supply from pumping station to all irrigation rooms to last longer. Quality of soil is the significant characteristics that determine crop procurement and its suitability which in turn affects the yield of the plantation per hectare of cultivation and constitute the Geochemical assessment of the area. Good soil is the one which is suitable for all varieties of plants to grow on it. It is also an indicator of a good environment. To understand the soil health and to conserve it is always better to subject that particular soil for soil testing for its chemical analysis in the area. Selected soil samples were thus subjected to salient Anion and Cation tests with the following results obtained from the analysis. Physico-chemical assessment of soil is crucial to agricultural farm cultivation especially sugarcane plantation depending on (Olaniran, 2002) prevailing climatic variables.

2.8 Sulphate Analysis of the Study Area

Laboratory study that entailed sulphate analysis was conducted on selected exploratory pit samples (Pits 1-9) of the area and the results has shown a variation in the sulphate composition of the soil in the area for sugarcane plantation.

Table 2.13: *Sulphate concentration in the selected samples*

Sample	Absorbence	Conc (mg/L)	Conc(Cmol/Kg)
P1-LAFLAS	2.1214, 2.1199, 2.1176	4.9326, 4.9289, 4.9231	0.0103, 0.0103, 0.0103
P2-LAFLAS	0.5360, 0.5364, 0.5298	0.9760, 0.9770, 0.9606	0.0020, 0.0020, 0.0020
P3-LAFLAS	4.5360, 4.7222, 4.3974	10.9586, 11.4233, 10.6127	0.0228, 0.0238, 0.0221
P4-LAFLAS	4.5457, 4.8776, 4.4142	10.9828, 11.8111, 10.6546	0.0228, 0.0246, 0.0222
P5-LAFLAS	4.2681, 4.6709, 4.6683	10.2900, 11.2952, 11.2813	0.0214, 0.0235, 0.0235
P6-LAFLAS	4.2982, 4.3687, 4.7587	10.3651, 10.5411, 11.5143	0.0216, 0.0220, 0.0240
P7-LAFLAS	4.4525, 4.0874, 4.4969	10.7502, 9.8390, 10.8610	0.0224, 0.0205, 0.0226
P8-LAFLAS	4.7525, 4.0864, 4.4969	10.6592, 9.8490, 10.8610	0.0028, 0.0215, 0.0226
P9-LAFLAS	3.6203, 3.7022, 3.6897	8.6733, 8.8777, 8.8465	0.0181, 0.0185, 0.0184

The pit 2 recorded the lowest sulphate level concentration across the three titre values of 0.9760, 0.9770, 0.9606 mg/L. The highest sulphate level was recorded from pit 4 with the 3 titre values of 10.9828, 11.8111, 10.6546 mg/L. (Table 2.13). This is a wide variance that is anticipated to have significant effects on the soil quality of the area because of the close proximity. The available data from the laboratory for the area has revealed that further investigation ie Agricultural research will be needed to further pinpoint the essence of this wide variations and how it can be remedied for the sugarcane plantation.

2.9 Nitrate Analysis of the Area

Commercial sugarcane commonly have lower uptake and storage of nitrate than related giant grass and grain crop species. To provide insight into nitrate use and the regulatory mechanisms involved, nitrate storage and uptake of ammonium and nitrate were assessed in closely examined in two experimental comparisons of the collected soil samples of LASUCO area. The results collected from the laboratory has revealed that P1 and P6 are having 1.4 mg/L respectively and the lowest in the series of all titter values obtained. Their equivalents is 0.002258065 Cmol/Kg. The highest value computed from P4 and P5 with 2.1mg/L respectively. Their equivalent was 0.003387097 Cmol/kg.(Table 2.14).

Table 2.14: *Nitrate concentration in the selected samples*

Sample code	Titre Value	Titre Value	Nitrates 1 (mg)	Nitrates 2 (mg)	Nitrates 1 (mg/L)	Nitrates 2 (mg/L)	Nitrates 1 (Cmol/Kg)	Nitrates 2 (Cmol/Kg)
P1-LAFLAS	0.4	0.4	0.14	0.14	1.4	1.4	0.002258065	0.002258065
P2-LAFLAS	0.5	0.5	0.175	0.175	1.75	1.75	0.002822581	0.002822581
P3-LAFLAS	0.5	0.5	0.175	0.175	1.75	1.75	0.002822581	0.002822581
P4-LAFLAS	0.6	0.6	0.21	0.21	2.1	2.1	0.003387097	0.003387097
P5-LAFLAS	0.6	0.6	0.21	0.21	2.1	2.1	0.003387097	0.003387097
P6-LAFLAS	0.4	0.4	0.14	0.14	1.4	1.4	0.002258065	0.002258065
P7-LAFLAS	0.5	0.5	0.175	0.175	1.75	1.75	0.002822581	0.002822581
P8-LAFLAS	0.5	0.5	0.175	0.175	1.75	1.75	0.002822581	0.002822581
P9-LAFLAS	0.5	0.5	0.175	0.175	1.75	1.75	0.002822581	0.002822581

2.10 Bicarbonate Result of Collected Samples

P1 recorded 0.236 cmol/kg, while the concentration of P2 sample is 0.34cmol/kg. P4 recorded the highest of 0.976 cmol/kg while the lowest one is P5 with 0.116cmol/kg (Table 2.15). As of right now, no HCO_3-transporter has been identified in higher plants, such as sugarcane. However, increased root production of organic acids, particularly malate, succinate and citrate, coincides with HCO_3-induced suppression of root growth. According to [5], this implies that extra HCO_3- reaches the root and is broken down by CA and PEP, resulting in higher quantities of organic acid. Nevertheless, CA has the ability to convert CO_2 that diffuses from the soil's atmosphere into the root into HCO_3^-.Releasing bicarbonate into the soil rhizosphere helps maintain the cation-anion balance of the plant. When nitrate is the primary source of nitrogen for plants, it has been suggested that increased HCO_3- outflow from the roots, particularly in situations of high nitrate uptake, contributes to the distinctive alkalinization of the rhizosphere. The total K+ and NO_3-uptake as well as the HCO_3-eflux have actually been found to be electrical in maize, sugarcane, and tomatoes. P4 recorded the highest amount of bicarbonate in the series with 0.976 cmol/kg with the lowest being 0.116 cmol/kg of P5 sample (Table 2.15).

Table 2.15: *Bicarbonate concentration in the selected samples*

S/N	Sample code	Bicarbonate(Cmol/kg)
1	P1-LAFLAS	0.236
2	P2-LAFLAS	0.347
3	P3-LAFLAS	0.368
4	P4-LAFLAS	0.976
5	P5-LAFLAS	0.116
6	P6-LAFLAS	0.476
7	P7-LAFLAS	0.308
8	P9-LAFLAS	0.764

2.11 Chloride analysis of collected samples

The concentration of chloride (Cl^-) in the soil depends on many factors: (i) the underlying parent bedrock material (ii) depositions of airborne Cl^- (iii) depositions through irrigation water, (iv) inputs via fertilization and other human activities, (v) contributions from basin brines or saline springs or (vi) pumping-induced saltwater intrusion (Table 2.16) (Keniya et al 2024**)** advanced the Soil Physico-chemical Properties in Sugarcane Cultivation Areas of Navsari District just as (Al-Ghanim et al 2016**)** studied the trace metals in tissues of Wallagoattu (lanchi) from the Indus River.

Table 2.16: *Chloride concentration in the selected samples*

Sample code	Titre Value(T.V)	Titre Value(T.V)	Chloride 1 (mg/l)	Chloride 2 (mg/l)	Chloride 1 (Cmol/Kg)	Chloride 2 (Cmol/Kg)
P1-LAFLAS	0.9	1	90	100	0.25	0.27
P2-LAFLAS	0.5	0.6	50	60	0.13	0.16
P3-LAFLAS	0.6	0.7	60	70	0.16	0.19
P4-LAFLAS	0.9	1	90	100	0.25	0.27
P5-LAFLAS	0.7	0.8	70	80	0.19	0.22
P6-LAFLAS	0.6	0.7	60	70	0.16	0.19
P7-LAFLAS	1.6	1.7	160	170	0.44	0.47
P8-LAFLAS	1.2	1.3	120	130	0.33	0.36

2.12 Seismicity of the area

The investigated area is quite tectonically stable with no earthquake history nor any tremor recorded in the area. It is worthy of note that the thick pile of sedimentary rocks of the area hardly favour such condition of landslide or soil creep as commonly dictated by tectonically unstable regions of the world. Lafiagi and indeed the study location can be said to be tectonically stable and the earth materials of silty/clayey sandy soil are also suitable for the purpose of sugarcane plantation that will serve as raw materials for the proposed sugar refinery. Foundations and seismic activity of agricultural areas is commonly inevitable (Buchanan et al 2011**)** as proposed for the site evaluation exercise of an area prior to cultivation and harvesting.

2.13 Groundwater monitoring of the area

Excavated pits allowed proper monitoring of the groundwater condition of the area. The area being a sedimentary terrain is very good in production of groundwater as all samples collected from the pit areas were soaked with underground water within the first 1 hour of sampling of some pits in the area. The static water level of any 50 meters deep borehole could be as low as 3-5 meters with the potential of getting an artesian well in that area that may contribute immensely towards the enhancement of the irrigation potential of the proposed farmland. The groundwater potential of the area especially around the upland of the area is a known veritable alternative source of irrigable water that will be highly needed during the peak of dry season. There is a great need to comb the area for all the fractural network that will contribute to the production of this groundwater in that area as it will provide an additional water security of the proposed sugarcane plantation (Buchanan et al 2021) had a similar aquiferous groundwater seepages in Akerebiata sedimentary area.

2.14 Slope stability

Slope condition are gentle as such stable with no steep slopes that can erode the land area to form deep gullies and eventual loss of soil and its nutrients. The slope stability of the area will go a long way to have a bumper harvest of sugarcane irrigation as the irrigable water will travel faster across the sugarcane plantation parts most especially the commonly developed numerous stems down to the roots in the soil. The removal of soil during harvest and inappropriate irrigation techniques, which can cause erosion, are two ways that sugarcane production can exacerbate soil loss. When sugarcane is planted on hillsides or slopes, erosion is particularly important since it speeds up water runoff. The impacts of cultivating near steep slopes have been convincingly demonstrated by the characterization and classification of soils in steep-sided hills and sharp-crowned ridges. It is generally advised against planting sugarcane in regions with slopes higher than 8%. Future crop yields may decline as a result of the removal of organic and nutrient-rich material caused by increased erosion. It can also result in sediments and other pollutants being washed into aquatic habitats, which can result in a wide range of environmental issues, including eutrophication and acidification.

3. CONCLUSIONS

Assessment of the area for the purpose of design and Construction of Intake and Pumping station that will serve a sugarcane plantation has been concluded with Geochemical evidences revealing silty and clayey sandy soil in the area which was noted for its non-plastic and plastic soil nature using Atterbergs limit test. Maximum dry density (MDD) that varied between 1263.0 kg/m^3-1627.2 $kg/m^3$was recorded and Optimum moisture content that varied between 11.1% to 15.0% has shown good void spaces for water retention in the area. Permeability test has revealed a value that ranges from 1.01×10^{-4} to 9.26×10^{-6}m/s, thus the ability of the medium to allow infiltrated rain water pass through is low. Oedometer test has revealed that the coefficient of compressibility (aV) varied between 8.1×10^{-4} of P1 to 9.4×10^{-4} of P3.Compression Index used in determining the settlement potential of the fine-grained clay/silt material of the area recorded 6.2×10^{-4} of P3 to 8.6×10^{-4} in P5. Coefficient of volume compressibility (mv) varied between 6.1×10^{-4} of P3 sample to $8.6 \times 10^{-4}$of P5 sample.

More importantly, Geochemical assessment of the area using the Sulphate, Nitrate, Bicarbonate and Chloride contents of collected soil samples have respectively shown a good area free of contamination to enhance sugarcane plantation for the proposed refinery. Historical review of the tectonic condition in the area is quite good and stable with no tremors ie small earth shock waves has never been experienced in the area. The area is known for good underground water potential that can supplement the water need of the river for irrigation of the proposed plantation. Most especially, during the peak of dry season which is currently more prolonged than the rainy season as currently been traced to climate change ravaging the global community.

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