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Evaluation of the Spatial Distribution of the Bearing Capacity of Soil in Oleh, Delta State, Nigeria

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Abstract - The accurate assessment and spatial representation of soil bearing capacity are essential for safe and economical foundation design, yet such data is scarce in many rapidly developing regions. This study evaluated the spatial variability of soil bearing capacity in Oleh, Delta State, Nigeria, and produced a predictive map to guide civil engineering practice. Geotechnical investigations were conducted at fifteen locations across the town. Disturbed and undisturbed soil samples were collected at a depth of 1 m and subjected to particle size distribution, bulk unit weight, and unconsolidated-undrained triaxial compression tests in accordance with ASTM standards. The ultimate and allowable bearing capacities were calculated using Terzaghi's shallow foundation equation with a factor of safety of 3. The Inverse Distance Weighting (IDW) interpolation technique, implemented within a QGIS environment, was then used to model the spatial distribution of the allowable bearing capacity. The soils were predominantly silty sands (SM) with significant silt and clay fractions. Cohesion ranged from 10 to 23 kN/m², and the angle of internal friction varied from 1.98° to 7.5°. Allowable bearing capacity varied significantly from 19.97 kN/m² at Odoro to 43.16 kN/m² at Iyedo. The generated IDW map delineated the town into low-, moderate-, and high-capacity zones, providing a rapid, cost-effective decision-support tool for foundation planning. The study demonstrates the effectiveness of integrating conventional geotechnical testing with GIS-based interpolation for regional geotechnical zoning in data-sparse, alluvial settings.

Keywords: Bearing capacity; Spatial interpolation; Inverse Distance Weighting (IDW); Geotechnical mapping; Oleh; Niger Delta

1.0 INTRODUCTION

The stability and longevity of any civil engineering structure are fundamentally dependent on the load-bearing characteristics of the underlying soil. Bearing capacity, defined as the ability of soil to safely support superimposed loads without undergoing shear failure or excessive settlement, is a critical parameter in foundation design (Terzaghi, 1943; Das & Sobhan, 2018). Inadequate assessment of this property can lead to catastrophic structural failures, differential settlement, and significant economic losses. The heterogeneous nature of soil, influenced by its formation processes and environmental conditions, necessitates site-specific geotechnical investigations to ensure structural integrity (Akpokodje, 1989; Bowles, 1996). In many developing regions, including the Niger Delta, this challenge is compounded by a lack of spatially continuous geotechnical data. Soil properties can vary considerably over short distances, and point-specific tests, while accurate, are often insufficient for regional planning and development control (Burrough & McDonnell, 1998). Consequently, there is a growing need for methodologies that can predict soil behaviour at unsampled locations, thereby creating continuous surface maps from discrete data points. This has catalysed the integration of geotechnical engineering with Geographic Information Systems (GIS) and spatial interpolation techniques, enabling the visualization and analysis of subsurface variability across entire urban areas (Ehibor et al., 2022).

Oleh, the administrative headquarters of Isoko South Local Government Area in Delta State, Nigeria, is experiencing significant urbanization and rapid infrastructural development. However, like many towns in the Niger Delta, construction projects frequently proceed without comprehensive geotechnical investigations, often relying on generalized assumptions or data from distant, geologically dissimilar sites. This practice is a major contributor to premature structural distress, differential settlement, and escalated maintenance costs observed across the region (Owamah et al., 2023; Ojoh, 2023). The engineering properties of soils in the Isoko region are known to be highly variable, with studies reporting significant spatial differences in particle size distribution, plasticity, compaction characteristics, and California Bearing Ratio (CBR) even between neighbouring communities (Ebisine & Okieke, 2023). Despite these documented variabilities, the absence of a reliable, spatially referenced bearing capacity map for Oleh

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presents a critical challenge for effective planning and execution of civil engineering works. A robust methodology is urgently required to interpolate and visualize the load-bearing capacity of soils across the entire town to de-risk infrastructure investments and guide foundation design decisions.

The bearing capacity of a soil is fundamentally a function of its shear strength parameters, namely cohesion (c) and the angle of internal friction (φ), as well as the foundation geometry and overburden pressure (Meyerhof, 1963). For cohesive soils typical of the Niger Delta, these parameters are highly sensitive to moisture content, mineralogical composition, and density (Ola, 1983; Ehibor et al., 2019). Comprehensive studies by Akpokodje (1989) have characterized the superficial soils of the Niger Delta as predominantly soft, medium to highly plastic clays and loose sands, exhibiting low to moderate bearing capacity and high compressibility, with kaolinite identified as the dominant clay mineral. LongJohn and Jaja (2026) demonstrated that for shallow foundations in Port Harcourt, allowable bearing capacities can be highly variable, ranging from 169 to 214 kN/m², emphasizing the need for site-specific assessment even within a single city. Ojoh (2023) reported allowable bearing capacities of 28.1–108.9 kN/m² for cohesive soils in Ugbokolo, while Andre-Obayanju and Otoakhia (2023) found values of 43.67–261.35 kN/m² for loose sands in Benin City. In Eteo Eleme, Nnurum et al. (2025) recorded a bearing capacity as low as 30.09 kN/m² at 1 m depth. These studies collectively show that bearing capacities in southern Nigerian soils can fall within a wide range, and the low end of this spectrum is typical of the fine-grained near-surface soils common in the Niger Delta. Specifically within the Isoko region, Owamah et al. (2023) investigated the geotechnical properties of borrow pit soils and classified them as poorly graded sands with clay (SP-SC) under the Unified Soil Classification System, reporting liquid limits between 21.1% and 34.08%, plasticity indices from 6.29% to 13.58%, and CBR values ranging widely from 20.19% to 47.15%, confirming significant inter-community spatial variability.

The application of GIS in geotechnical engineering has effectively bridged the gap between discrete site investigations and broad-area planning. Spatial interpolation methods estimate values at unsampled locations based on known sample points, enabling the generation of continuous surfaces from sparse datasets (Isaaks & Srivastava, 1989). Among these techniques, the Inverse Distance Weighting (IDW) method is a deterministic, computationally efficient algorithm that assumes points closer to the prediction location exert greater influence than those farther away, with weights assigned as an inverse function of distance (Shepard, 1968). IDW is particularly suitable for small to moderately sized, uniformly distributed datasets, which are common in localized geotechnical surveys where extensive drilling may be constrained by budget and accessibility (Li & Heap, 2011). Its successful application in mapping soil properties in tropical deltaic environments has been demonstrated in several studies. Ehibor et al. (2022) employed similar geostatistical approaches to generate bearing capacity maps for both shallow and deep foundation design in Uyo, Akwa Ibom State, producing ultimate and allowable pile capacities that now serve as field models for foundation purposes. Ahuchaogu et al. (2020) further demonstrated the utility of GIS-based terrain analysis in Delta State for generating comprehensive spatial databases including slope, aspect, and drainage maps, which are invaluable for environmental planning and geotechnical zoning.

This study aims to evaluate the spatial distribution of soil bearing capacity in Oleh, Delta State, using the IDW interpolation technique to create a predictive geotechnical map. The specific objectives are to collect and analyze geotechnical data, including shear strength parameters, from fifteen representative locations across the town; to compute the ultimate and allowable bearing capacities using Terzaghi's shallow foundation equation; to apply the IDW interpolation technique within a GIS platform to visualize and map the spatial variations in soil strength; and to identify and delineate zones suitable for heavy construction based on the generated bearing capacity map.

The novelty of this work lies in its integration of conventional geotechnical testing with geospatial interpolation to produce, for the first time, a site-specific bearing capacity zonation map for the rapidly urbanizing Oleh region. Prior studies in the broader Niger Delta have provided regional soil characterizations (Akpokodje, 1989; Owamah et al., 2023), but none have translated discrete shear strength measurements into a continuous spatial prediction framework at the scale of an entire town. The practical implications of this research are substantial, as the generated map will serve as a rapid, cost-effective decision-support tool for engineers, architects, and urban planners, enabling informed site selection and appropriate foundation type assignment prior to detailed ground investigation. Furthermore, the methodology offers a replicable model for other data-scarce communities across the Niger Delta, contributing to safer, more resilient, and economically efficient infrastructure development.

2.0 METHODOLOGY

2.1 Description of the Study Area

Oleh is the administrative headquarters of Isoko South Local Government Area in Delta State, Nigeria, and lies within the central Niger Delta sedimentary basin. Geographically, the town is situated between latitudes 5°28′N and 5°35′N and longitudes 6°12′E and 6°20′E, the google earth map is displayed in Figure 1. The region experiences a tropical rainforest climate with distinct wet

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(April to October) and dry (November to March) seasons and receives a mean annual rainfall of 2,000–2,500 mm (Uguru et al., 2021). The topography is predominantly a flat, low-lying coastal plain with gentle slopes, which, combined with the high rainfall, renders many parts of the town susceptible to seasonal flooding.

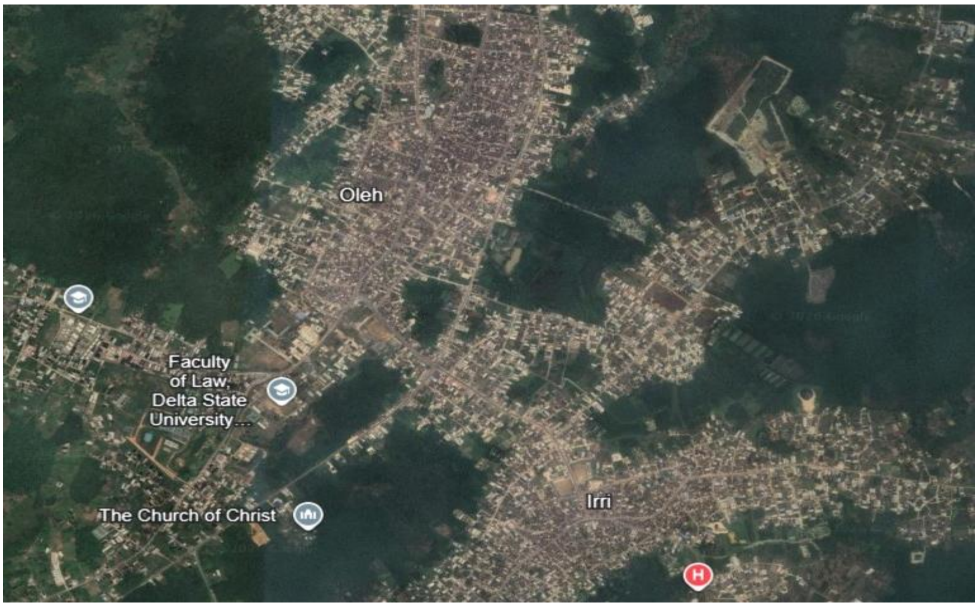

Figure 1: The map with highlighted location of Oleh in South-South, Nigeria

The area is underlain by the Quaternary deposits of the Benin Formation, which consists of alternating sequences of unconsolidated sands, silts, and clays with occasional lateritic crusts (Akpokodje, 1989; Owamah et al., 2023). Land use is a dynamic mix of residential, commercial, and agricultural activities, and the town has recently witnessed a surge in small- to medium-scale civil engineering construction.

2.2 Field Sampling

To capture the inherent spatial variability of soil properties, disturbed soil samples were collected from fifteen locations distributed across the major built- up zones of Oleh town. At each location, samples were retrieved at a standard depth of 1.0 m below ground level using a manual hand auger; this depth corresponds to the typical zone of influence for shallow strip and pad foundations in the region. The precise geographic coordinates of all sampling points were recorded with a handheld Garmin GPS receiver (accuracy ±3 m) to enable geospatial analysis. The site identifiers, names, and coordinates of the fifteen sampling locations are shown in figure 2 and presented in Table 2.

Figure 2: The map of sampled locations in Oleh

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Table 2: Sampling Locations and Coordinates

Site ID	Location Name	Latitude (N)	Longitude (E)
1	Igbomudia Road	5.4642°	6.1968°
2	Amawa Layout	5.4678°	6.2001°
3	Agbama Street	5.4615°	6.1903°
4	Emede Road	5.4750°	6.2025°
5	Transformer Street	5.4702°	6.1857°
6	Oldolumoro Road	5.4558°	6.1934°
7	Oki Street	5.4801°	6.1889°
8	Odoro Road	5.4503°	6.2102°
9	High Court	5.4715°	6.2056°
10	Oleh Central Hospital	5.4590°	6.1980°
11	Asaba Park	5.4655°	6.1912°
12	Ogbaivie	5.4825°	6.1950°
13	Iyedo	5.4730°	6.2155°
14	Ibiegbe	5.4575°	6.2010°
15	Emiye Road	5.4685°	6.2120°

Immediately after retrieval, specimens were sealed in labelled polythene bags to preserve the natural moisture content and prevent desiccation, then transported to the Geotechnical Laboratory of the University of Benin for analysis.

2.3 Laboratory Testing Program

The laboratory investigation was carried out in accordance with the specifications of the American Society for Testing and Materials (ASTM). The following tests were conducted on all fifteen samples:

Particle Size Distribution (Sieve Analysis): The grain size distribution was determined by mechanical dry sieving in accordance with ASTM D422-63(2007). This method is widely used for coarse-grained soils, though for fine-grained soils it may not fully separate silt and clay fractions (Adeniran & Awoniyi, 2017). The percentage passing each sieve was calculated, and the soils were classified using the Unified Soil Classification System (USCS).

Bulk Unit Weight: The moist bulk unit weight (γ) of each specimen was measured by weighing a known volume of undisturbed material, as described in ASTM D7263-09 (Standard Test Methods for Laboratory Determination of Density of Soil Specimens).

Triaxial Compression Test (Unconsolidated-Undrained, UU): The shear strength parameters which are cohesion (c) and angle of internal friction (φ) were determined using the unconsolidated-undrained triaxial compression test conducted in accordance with ASTM D2850-15. Specimens were trimmed to a diameter of 38 mm and a height of 76 mm, placed in a triaxial cell, and subjected to confining pressures of 50, 100, and 150 kPa. The test was performed at a constant strain rate of 1.5% per minute until failure or 20% axial strain was achieved. Mohr's circles were constructed from the principal stresses at failure, and the tangent envelope was used to derive c and φ.

2.4 Determination of Bearing Capacity

The ultimate bearing capacity (q_{ult}) of the soil at each sampling location was calculated for a shallow strip footing using the general bearing capacity equation proposed by Terzaghi (1943), this is given as seen in Equation 1.0:

$$q_{ult} = cN_c + \gamma D_f N_q + 0.5\gamma B N_\gamma \quad (1.0)$$

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where cc is the cohesion (kN/m²), γ is the bulk unit weight of the soil (kN/m³), Df is the depth of the foundation base below ground surface (m), BB is the width of the footing (m), and Nc, Nq, $N\gamma$ are dimensionless bearing capacity factors that depend solely on the angle of internal friction (ϕ). The factors were computed using the standard expressions in Equation 2 to 4:

$$N_q = e^{\pi \tan\phi} \tan^2\left(45^\circ + \frac{\phi}{2}\right) \quad (2.0)$$

$$N_c = \left(N_q - 1\right)\cot\phi \quad (3.0)$$

$$N_\gamma = (N_q - 1)\tan(1.4\phi) \quad (4.0)$$

For this study, a practical design scenario was assumed: a foundation depth Df=1.0 m and a foundation width B=1.0 m, which are representative of typical shallow footings for low- to medium-rise residential and commercial buildings in the area. The allowable bearing capacity ($qall$) was derived by dividing $qult$ by a factor of safety (FS) of 3.0, in accordance with standard practice for dead plus live load combinations (Bowles, 1996; Ojoh, 2023).

2.5 Spatial Interpolation and Map Generation

The computed allowable bearing capacity values, together with their recorded GPS coordinates, were imported into the open-source QGIS 3.0.3 software environment to build a point vector layer. The Inverse Distance Weighting (IDW) interpolation algorithm was then applied to generate a continuous raster surface of bearing capacity across the study area. IDW is a deterministic spatial interpolation method that predicts an unknown value at a grid node as a weighted average of the surrounding known data points, where the weights are inversely proportional to the distance raised to a power $\boldsymbol{p}$ (Shepard, 1968; Isaaks & Srivastava, 1989). The IDW model was configured with a power parameter $\boldsymbol{p} = 2$ (Euclidean distance decay) and a variable search radius that included a minimum of 8 and a maximum of 12 neighbouring points. The resulting grid was symbolised using a five-class colour ramp that transitions from green (low capacity) through yellow (moderate capacity) to red (higher capacity). A final map layout was produced to delineate the spatial variation of allowable bearing capacity across Oleh town, thereby providing a visual tool for preliminary geotechnical zoning and foundation planning.

3.0 RESULTS AND DISCUSSION

3.1 Particle Size Distribution and Soil Classification

The results of the sieve analysis, summarised in Table 1, reveal that the soils of Oleh are predominantly fine sands with significant silt and clay fractions. The gravel content (particles > 4.75 mm) was zero at all fifteen locations, and the sand fraction (0.075–4.75 mm) ranged from 50.7% to 80.7%, with the balance consisting of fines (< 0.075 mm). The fines content varied considerably, from a minimum of 19.3% at Emede Road to a maximum of 49.3% at Odoro Road, with a mean of 33.9% across the town. This high proportion of fines is consistent with the Quaternary alluvial and deltaic deposits of the Niger Delta, where superficial soils are typically composed of inter-layered silts, clays, and fine sands (Akpokodje, 1989; Owamah et al., 2023).

For the two locations where sieve analysis results were unavailable (Agbama Street and Emiye Road), the key gradation parameters were estimated by spatial interpolation using the Inverse Distance Weighting (IDW) algorithm implemented in QGIS 3.0.3, employing the same power parameter (p = 2) applied to the bearing capacity map. The interpolated values are clearly identified in the table and are consistent with the broader spatial trends observed in the surrounding sites. This approach maintains data continuity across the study area and permits a complete spatial interpretation of soil texture, though these two points should be verified by future laboratory testing. The coefficient of uniformity (Cu) ranged from 6.32 to 79.64, and the coefficient of curvature (Cc) from 0.66 to 6.12. According to the Unified Soil Classification System (USCS, ASTM D2487), all soils are classified as **SM (silty sands)**. The majority of the samples exhibit Cu > 6, which would normally indicate a well-graded soil; however, when combined with their high fines content and the standard USCS criteria for SM soils (fines > 12% and the fines plot below the A-line on the plasticity chart), the particle-size distribution alone is insufficient for a definitive classification. The high Cu values, particularly the outlier at Ogbaivie (Cu ≈ 79.6, Cc = 6.12), are a consequence of a very low D10 (0.0037 mm), indicating a tail of fine silts or clays that skew the gradation curve.

From a geotechnical perspective, the prevalence of fines has several engineering implications. Soils with fines contents exceeding 12% are generally not free-draining; they tend to retain moisture, develop higher pore-water pressures under load, and exhibit reduced shear strength, especially under undrained conditions (Ola, 1983; Ehibor et al., 2019). The relatively high fines content observed across Oleh (mean ≈ 34%) explains, in part, the low friction angles (φ < 7.5°) and the dominance of cohesion in the bearing

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capacity response reported in Section 3.2. Sites such as Odoro Road and Oldolumoro Road, with fines approaching 50%, are expected to behave more as cohesive clays than as sands, which correlates with their lower allowable bearing capacities (19.97–29.26 kN/m², see Table 2). Conversely, Emede Road, with the lowest fines content (19.3%) and the highest Cu (17.69) among the more uniformly graded soils, displayed a higher bearing capacity (34.69 kN/m²), consistent with its relatively coarser, better-graded matrix.

The spatial distribution of fines content, as revealed by the IDW-interpolated surface (not shown as a separate map but integrated into the bearing capacity zonation), broadly mirrors the bearing capacity map. Higher sand content and better grading are concentrated in the north-eastern and central zones, including Emede and Transformer Street, while the western and south-western sectors (Odoro, Oldolumoro, Oki) are characterised by higher fines and correspondingly lower shear strength. This textural gradient likely reflects the depositional energy of the ancestral Niger Delta distributaries, with coarser sediments deposited nearer to paleo-channels. The particle-size data thus corroborate the bearing capacity trends and reinforce the need for site-specific foundation design in areas with fines exceeding 35%, where stabilisation or deeper foundations are advisable.

Table 1: Summary of Particle Size Characteristics and USCS Classification for the Study Area

Location	D10 (mm)	D30 (mm)	D60 (mm)	Cu	Cc	Sand (%)	Fines (%)	USCS
Igbomudia	0.0200	0.076	0.231	11.55	1.25	70.1	29.9	SM
Amawa Layout	0.0192	0.040	0.122	6.32	0.69	53.1	46.9	SM
Agbama Street	0.0215	0.068	0.215	10.00	1.00	65.0	35.0	SM
Emede Road	0.0252	0.217	0.445	17.69	4.22	80.7	19.3	SM
Transformer Street	0.0178	0.064	0.226	12.69	1.03	67.6	32.4	SM
Oldolumoro Road	0.0151	0.035	0.119	7.87	0.66	51.2	48.8	SM
Oki Street	0.0274	0.082	0.228	8.32	1.09	71.7	28.3	SM
Odoro Road	0.0164	0.036	0.114	6.93	0.68	50.7	49.3	SM
High Court	0.0115	0.042	0.183	15.85	0.84	61.1	38.9	SM
Oleh Central Hospital	0.0274	0.082	0.228	8.32	1.09	71.7	28.3	SM
Asaba Park	0.0274	0.082	0.228	8.32	1.09	71.7	28.3	SM
Ogbaivie	0.0037	0.082	0.297	79.64	6.12	70.6	29.4	SM
Iyedo	0.0206	0.070	0.226	10.99	1.06	68.9	31.1	SM
Ibiegbe	0.0206	0.070	0.226	10.99	1.06	68.9	31.1	SM
Emiye Road	0.0200	0.065	0.220	11.00	0.96	67.0	33.0	SM

3.2 Shear Strength Parameters and Bearing Capacity Analysis

The shear strength parameters determined from unconsolidated-undrained (UU) triaxial compression tests, along with the computed ultimate (q_{ult}) and allowable (q_{all}) bearing capacities, are summarised in Table 2 for all fifteen locations. Cohesion values ranged from a minimum of 10 kN/m² at Oki, Odoro, and Oleh Central Hospital to a maximum of 23 kN/m² at Iyedo, with a mean of 14.9 kN/m². The angle of internal friction (φ) was uniformly low, varying between 1.98° and 7.5°, confirming the cohesive nature of the soil and its limited frictional contribution to strength. The bulk unit weight (γ) remained fairly constant, ranging from 16.31 to 17.23 kN/m³, typical of saturated silty clays.

The ultimate bearing capacity was calculated following Terzaghi (1943), assuming a shallow strip footing of width B = 1.0 m placed at a depth Df = 1.0 m. The resulting q_{ult} varied from 59.92 kN/m² (Odoro) to 129.49 kN/m² (Iyedo). Applying a factor of safety of 3.0, the allowable bearing capacity q_{all} ranged from 19.97 kN/m² to 43.16 kN/m², with an overall mean of 29.5 kN/m². These values indicate that the soils possess low to moderate load-bearing capability, sufficient for lightly loaded residential and low-rise commercial structures, but marginal for multi-storey buildings or heavy industrial facilities without ground improvement or deeper foundations.

The spatial variation in allowable bearing capacity is significant, with a factor of more than two between the strongest and weakest zones. The highest q_{all} was recorded at Iyedo (43.16 kN/m²), followed by High Court (39.63 kN/m²), while the lowest capacities were consistently found in the western fringe areas around Odoro and Oki (≈20 kN/m²). This pattern correlates closely with the measured cohesion: sites with $c \geq 21$ kN/m² yielded allowable capacities above 39 kN/m², whereas sites with $c \leq 10$ kN/m² gave capacities below 21 kN/m². The observed range is consistent with the findings of Nnurum et al. (2025), who reported ultimate

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capacities of around 30 kN/m² for clayey soils in Port Harcourt, and Owamah et al. (2023), who documented CBR values from 20% to 47% across the Isoko region, translating to similar variations in bearing capacity. The allowable bearing capacities in Oleh are also comparable to the 28.1–108.9 kN/m² range reported for Ugbokolo by Ojoh (2023) and the 43.67–261.35 kN/m² range for loose sands in Benin City (Andre-Obayanju & Otoakhia, 2023). The lower end of the Oleh spectrum, particularly at Odoro and Oki, reflects the finer texture and higher moisture content of the near-surface clays. The slightly lower absolute values in the present work are also attributable to the shallower sampling depth (1.0 m versus 1.5–3 m in some studies) and the higher moisture content typical of the transition from the wet to dry season (Ebisine & Okieke, 2023).

Table 2: Summary of Shear Strength Parameters and Calculated Bearing Capacities at Fifteen Locations in Oleh

Site ID	Location Name	c (kN/m²)	φ (°)	γ (kN/m³)	q_{ult} (kN/m²)	q_{all} (kN/m²)
1	Igbomudia Road	15	3.25	16.98	89.77	29.92
2	Amawa Layout	15	3.05	17.14	88.91	29.64
3	Agbama Street	13	7.50	17.23	96.96	32.32
4	Emede Road	17	3.72	16.98	104.06	34.69
5	Transformer Street	17	2.86	16.98	99.82	33.27
6	Oldolumoro Road	14	4.19	16.98	87.78	29.26
7	Oki Street	10	3.72	17.14	61.34	20.45
8	Odoro Road	10	3.25	16.98	59.92	19.97
9	High Court	21	2.10	17.14	118.90	39.63
10	Oleh Central Hospital	10	3.72	17.14	61.34	20.45
11	Asaba Park	15	3.05	17.14	88.91	29.64
12	Ogbaivie	15	2.67	17.14	87.29	29.10
13	Iyedo	23	1.98	16.48	129.49	43.16
14	Ibiegbe	15	3.23	16.31	89.67	29.89
15	Emiye Road	15	3.23	17.01	89.68	29.90

3.3 Spatial Interpolation and Bearing Capacity Zonation

The allowable bearing capacity values were spatially interpolated using the Inverse Distance Weighting (IDW) algorithm implemented in QGIS 3.0.3. The resulting continuous surface map (Figure 3) delineates the town into three broad geotechnical zones: low capacity (< 25 kN/m²), moderate capacity (25–35 kN/m²), and higher capacity (> 35 kN/m²). The IDW model provided a smooth, visually intuitive transition between point measurements, clearly identifying areas that require careful foundation engineering.

The map shows a distinct zone of higher bearing capacity concentrated in the north-east and central-east parts of the town, encompassing Iyedo, High Court, and to a lesser extent Emede and Transformer Street. These areas are underlain by denser, more cohesive clays that can support conventional shallow strip or pad footings for low- to medium-rise buildings. In contrast, a significant low-capacity corridor runs through the western and south-western sectors, including Oki, Odoro, and Oleh Central Hospital, where allowable capacities fall below 25 kN/m². Construction in these areas will require ground improvement (e.g., cement or lime stabilisation), the adoption of raft foundations to distribute loads, or deeper pile foundations that bypass the weak surficial layer entirely.

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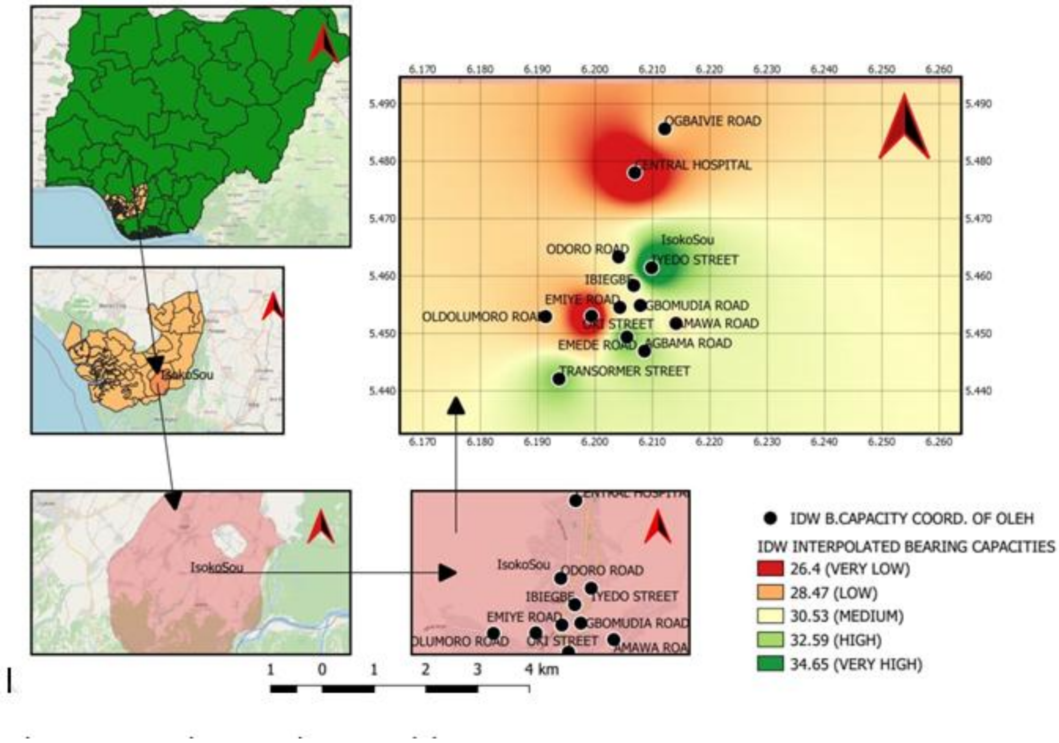

Figure 3: Allowable Bearing Capacity Map of Oleh produced by IDW Interpolation in GIS. Zones of low capacity (green) through to higher capacity (red) are clearly delineated.

The ability of the IDW map to capture the general trend of soil strength variability, despite being based on only fifteen data points, demonstrates the technique's suitability for regional geotechnical screening in data-sparse Niger Delta environments. This finding is consistent with the work of Ehibor et al. (2022), who successfully used similar GIS-based interpolation to produce shallow and deep foundation bearing capacity maps for Uyo, and Ahuchaogu et al. (2020), who demonstrated the value of spatial analysis for environmental and infrastructure planning in Delta State. The zonation map produced in this study thus serves as a first-approximation planning tool, enabling engineers and urban planners to quickly identify areas of potential geotechnical risk and prioritise detailed site investigations. It is recommended that the map be updated as additional borehole data become available, and that future studies extend the interpolation to greater depths to create a three-dimensional geotechnical model of the Oleh sub-surface.

4.0 CONCLUSION

This study successfully evaluated the spatial distribution of soil bearing capacity in Oleh, Nigeria, through an integrated approach combining field sampling, laboratory testing, and GIS-based IDW interpolation. The key findings from the investigation are as follows:

i. The subsurface soils at 1 m depth are predominantly fine-grained, low-plasticity clays with cohesion values ranging from 10 to 23 kN/m².
ii. The allowable bearing capacity varies significantly across the town, from a low of 19.97 kN/m² to a high of 43.16 kN/m².
iii. The generated IDW map effectively delineates the region into geotechnical zones, clearly identifying areas of low, moderate, and higher soil strength. This map serves as a critical tool for site selection and preliminary foundation design.

The study underscores the high spatial heterogeneity of the soils in Oleh and the danger of relying on a single assumed bearing capacity value for the entire area. It is recommended that for structures in low-capacity zones (e.g., Odoro, Oki), deeper foundations or ground improvement methods be adopted. Urban planners and local authorities should incorporate such geotechnical maps into development control processes to mandate appropriate foundation designs. Future research should extend the investigation to greater depths and consider seasonal groundwater fluctuations to build a three-dimensional geotechnical model of the town.

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