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ARTICLE

Assessing the Impacts of Cemetery on Soil and Groundwater around the St. Peter Anglican Church's Cemetery, Ikere-Ekiti, Southwestern Nigeria

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ABSTRACT

This study evaluated the effects of St. Peter Anglican Church's Cemetery, Ikere-Ekiti, Southwestern Nigeria, on surrounding soils and groundwater using a Two-Dimensional (2-D) Electrical Resistivity Tomography (ERT), measured physical characteristics of selected 25 wells' water and a standardized sanitary survey checklist of the wells. Wells' locations were captured employing an eTrex 12 Channel Global Positioning System (GPS). Subsequently, in-situ parameters (temperature (℃), electric conductivity (EC (µS/cm)) and pH) were measured using a multiparameter portable meter (model Testr-35). Sanitary inspection revealed substantial variation in protective infrastructures. Thirteen of the twenty-five wells lacked cement bases, only one well (Well 25) was fenced, and a few wells near the cemetery exhibited marshy surroundings and inadequate covering, resulting in risk scores ranging from 20% to 50%. Measured in-situ parameters revealed that the pH ranged from 6.49–7.21, EC from 88–687 µS/cm, and Total Dissolved Solids (TDS) from 44–343 mg/L. All physical parameters had values within the approved World Health Organization (WHO) standard for drinking water. The result of the ERT revealed that the leachate from the cemetery has accumulated within stations 15 and 19 (distances 75–95 m) to a depth of about 2.5 to 25 m around the South-Western part of Traverse 1. Traces of the leachates were observed around stations 7 to 9 within a depth range of 0–7.5 m along the North-Eastern part of Traverse 2. Overall, the results showed that the quality of groundwater is suitable for domestic use, as most wells have good infrastructure built up that prevented percolation of leachates.

Keywords: Cemetery; Electrical Resistivity Tomography; Sanitary Inspection; Physical Parameters; Leachates

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1. Introduction

The continuity and sustainability of life, as well as the ecosystem, depend to a greater extent on clean and safe water. Both surface water and groundwater can be used for domestic, industrial and agricultural activities. However, in Nigeria, most communities depend on groundwater, given the fact that it is stored naturally below the surface and is often less affected by seasonal changes and pollution compared to surface water. Unfortunately, the quality of groundwater that satisfies specific purposes is not always guaranteed [1–3].

Groundwater contamination poses a significant challenge, particularly in developing countries where over four million people consume polluted groundwater [4,5]. Major sources of such contamination include seepage from septic tanks, open dumps, industrial effluents, agricultural waste and poor land management [6–10]. In recent years, in many cities in Nigeria, groundwater has been stressed by urbanization pressure and population growth [11].

Among the many sources (anthropogenic and natural) of soil and groundwater contamination, cemeteries have become a quiet but growing environmental concern. Burial and cremation constitute the two most common legal methods of disposing of the human body after death. Burial grounds are essential for human societies, yet they can serve as potential sources of groundwater pollution if they are not properly located or managed. When human bodies decompose, necroleachates (contaminants) are released into the surrounding soil and groundwater. The necroleachates carry heavy metals, pathogens and chemicals from embalming, which can spread into the soil and groundwater, posing serious health challenges to humans [12,13]. Research revealed that groundwater located close to cemeteries sometimes contains elevated levels of nitrates, chlorides and microbial indicators such as total and fecal coliforms, all of which can pose serious health risks to humanity in the environment [14,15].

In Nigeria, environmental impact assessments or hydrogeological investigations are rarely conducted before the siting of many cemeteries, which are usually located close to residential areas. The St. Peter Anglican Church's Cemetery in Ikere-Ekiti, Southwestern Nigeria, is surrounded by built-up areas, some with a distance of less than 10 m from it. The occurrence of groundwater at Ikere-Ekiti is erratic in view of the varied Basement complex that characterizes the area [16,17]. Groundwater occurs in the weathered overburden and/or fractured layers of the bedrock. Soil permeability and the composition of clay minerals affect how easily leachate moves through the ground. Sandy soils are more easily permeated compared to clayey soils. Most of the wells in the vicinity of the St. Peter Anglican Church's Cemetery are shallow and possibly vulnerable to contamination. Contaminants can easily travel through sandy soils or fractures to reach the water table [18]. Residents of the study area depend on hand-dug wells and boreholes for their daily water needs, warranting investigating the surrounding wells' water quality status employing measurement of in-situ parameters and sanitary survey indicators.

Previous investigations in southern Nigeria have reported that cemetery leachates can significantly affect nearby wells, depending on the burial density, soil type, and depth to groundwater [9,12]. The St. Peter Anglican Church's Cemetery in Ikere-Ekiti is located close to built-up areas and residents in the area have been using the shallow wells' water for domestic activities without adequate assessment of its safety. The health risk arises because of the possible contamination by decomposition of human bodies, which may infiltrate the subsurface and contaminate shallow aquifers [15,19,20].

Furthermore, the geology of the study area, which is characterized by weathered and fractured basement rocks, makes the aquifer system mostly susceptible to infiltration of contaminants from surface and near-surface sources. During the rainy season, these leachates can migrate faster through the soil into groundwater, increasing the possibility of elevated concentrations of nitrates, electrical conductivity (EC), total dissolved solids (TDS), and microbial pathogens in nearby wells [18,21,22]

Although there has been previous research on cemetery-related groundwater contamination in many parts of Nigeria, little or no scientific documentation exists for Ikere-Ekiti. This study, therefore, examines the impact of cemetry on soil and groundwater in the basement terrain of the St. Peter Anglican Church's Cemetery, Ikere-Ekiti, Southwestern Nigeria, with a view to elucidating the quality status of the wells' water and determining the extent of its effects on the surrounding soils.

2. Location of Study

The study area is the St. Peter Anglican Church's Cemetery, located in Ikere-Ekiti, Ekiti State, Southwestern

Nigeria (**Figure 1**). Ikere-Ekiti is situated in the southern part of Ekiti State, lying between latitudes 7°29′ and 7°31′ N and longitudes 5°12′ and 5°14′ E, covering a total area of 346.5 km^2 [23,24]. The town is one of the largest urban settlements in Ekiti State and serves as a gateway town to Ondo State. The St. Peter Anglican Church's Cemetery is situated on the outskirts of the town, enclosed by residential areas, small-scale farms and school buildings. The cemetery is off the Ikere–Ise tarred road with other adjoining untarred roads (**Figure 1**).

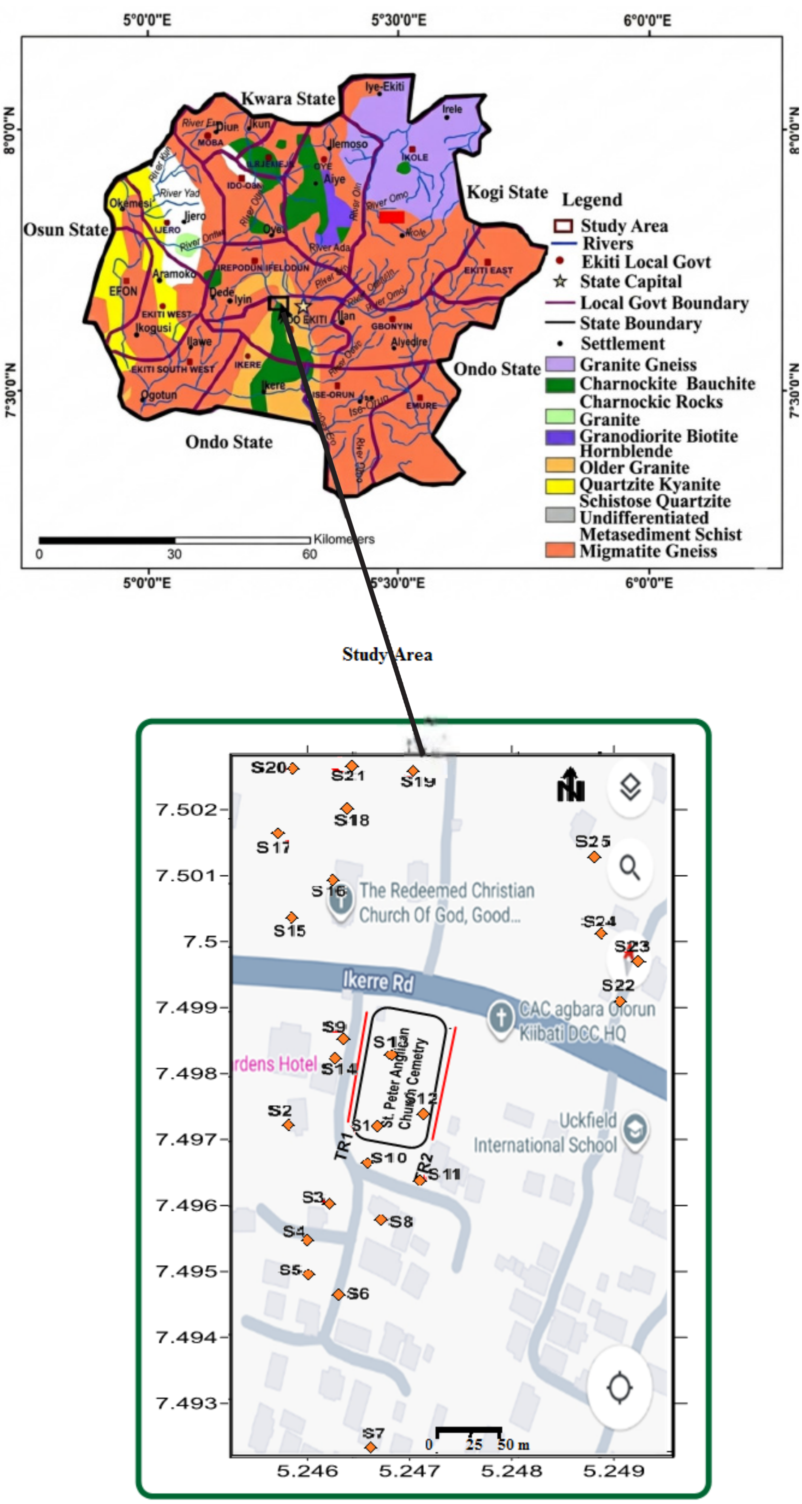

Figure 1. Location Map.

Ikere-Ekiti is within the tropical rainforest climatic zone of Nigeria, having two main seasons: the wet season (April to October) and the dry season (November to March). The average annual rainfall ranges from 1,200 mm to 1,500 mm, while the mean annual temperature is about 27 °C [9]. During the rainy season, permeation is high, enhancing groundwater recharge. In addition, there is a corresponding increase in the infiltration of contaminants from the surface runoff and necroleachates from cemeteries into the subsurface aquifer.

The topography of Ikere-Ekiti is undulating, with gentle slopes that promote surface runoff into low-lying areas. Drainage is mainly controlled by several seasonal streams and small tributaries that flow into the Ose River [25]. Poor drainage and shallow groundwater levels around the cemetery may increase the risk of leachate percolation into the aquifer system.

3. Materials and Methods

The methodology entails capturing the geographical coordinates of each well using a 12 Channel Geographical Position System (GPS). Also, the in-situ parameters and sanitary survey characteristics were taken and recorded at each well's location. Thereafter, the subsurface geophysical parameters were measured employing ABEM Terrameter SAS 300C.

The in-situ parameters, including Temp (°C), pH, EC (µS/cm) and TDS (mg/L) of water from each of the shallow wells were measured using a multiparameter portable meter (model Testr-35). The procedure was repeated until all twenty-five selected wells scattered over the study area were covered.

Employing the sanitary survey standard of WHO and Heinrich et al. [26,27], sanitary survey observations were made in-situ and recorded accordingly. Some of the sanitary observations include if the distance of the well is <10 m to the latrine, whether the well is covered, if different ropes and buckets are used for fetching the water, whether the well is lined, whether the apron is cracked or damaged, whether the water is colored, has an odor, etc. The overall assessment of the risk profile of each well is observed by directly computing the frequency of occurrence of risk questions as appropriate. The aggregate risk score was graded as very high (90 to 100%), high (60 to 80%), intermediate (40 to 50%), and low (0 to 30%), in line with Mushi et al.'s [28] research on sanitary inspection of wells using risk-of-contamination scores.

The electrical resistivity imaging geophysical approach was deployed to investigate the influence of leachate from the cemetery on the loose formations within the study area. Two traverses (TR1 and TR2) (**Figure 1**) were established at NE–SW (northeast–southwest) direction on either side of the Cemetery. The traverse length was 105 m with an inter-station spacing of 5 m and five movements. The data gathered from the physical parameters and the geophysical surveys were processed and presented using tables. The volume of water in each well was estimated using $\pi r^2 h$, where $\pi = 3.14$, r = radius (m) of well, and h(m) = water column (well depth − water level). From the obtained volumes of water, the groundwater potential of the area was produced using Surfer 11.0 software [29].

4. Results and Discussion

Table 1 documents sanitary inspections of 25 wells around St. Peter Anglican Church's Cemetery, Ikere-Ekiti, Southwestern Nigeria. Most of the wells close to the cemetery showed good maintenance with cemented bases, covers, and lining (preventing infiltration of leachates into the wells), though some lacked proper covering or cementation. Wells S1, S9, S12, S13, and S14, which are close to the cemetery, have risk scores that ranged from 30–40%, with S13 having the highest score of 40%. These risk scores do not pose a threat to human health, but caution must be taken to ensure proper sanitation around the wells at all times, as they reflect the highest risk scores. The water in all the wells was colorless and odorless, revealing preliminary evidence of no obvious contamination. The wells behind St. Peter Anglican Church and along Araromi-Ise Road demonstrated consistently superior conditions, all featured cemented bases, proper lining, and adequate covering. However, one of the wells close to the cemetery was on marshy ground, while a few others have no cement bases, potentially compromising water quality requirements. The observations suggest varying sanitation standards across locations, with newer or better-maintained areas showing improved infrastructure. This data is crucial for assessing groundwater safety and identifying wells requiring remediation to prevent waterborne diseases in the community. Though a sanitary survey is not a conclusive measurement of the quality status of water but a pointer to the need to take caution if the risk scores are high. It is necessary for well owners to obey sanitary rules to avoid anthropogenic contamination of the water in wells.

Table 1. Data Obtained from Sanitary Survey of Wells in the Study Area.

Code	Location	Easting (GPS)	Northing (GPS)	Elev (m)	Covered Well	Distance to Latrine > 10 m	Near Animal Breeding	Damage Apron
1	Opp. Cemetry	5.249839	7.497117	360	Yes	Yes	No	No
2	Opp. Cemetry	5.245318	7.497253	360	Yes	Yes	No	No
3	Opp. Cemetry	5.24569	7.495999	350	Yes	Yes	No	No
4	Opp. Cemetry	5.245552	7.495606	350	Yes	Yes	No	No
5	Opp. Cemetry	5.245494	7.495038	350	Yes	Yes	No	No
6	Opp. Cemetry	5.245774	7.494779	360	Yes	Yes	No	No
7	Opp. Cemetry	5.246236	7.492268	360	No	Yes	No	No
8	Opp. Cemetry	5.246287	7.495783	360	Yes	Yes	No	No
9	Opp. Cemetry	5.2458	7.4986	360	Yes	Yes	No	No
10	Opp. Cemetry	5.246095	7.496633	360	Yes	Yes	No	No
11	Opp. Cemetry	5.246765	7.849642	360	Yes	Yes	No	No
12	Opp. Cemetry	5.246442	7.497667	360	Yes	Yes	No	No
13	Opp. Cemetry	5.246112	7.49853	360	Yes	Yes	No	No
14	Opp. Cemetry	5.245837	7.498358	360	Yes	Yes	No	No
15	Behind Redeem	5.245278	7.500556	380	Yes	Yes	No	No
16	Behind Redeem	5.245556	7.501111	370	Yes	Yes	No	No
17	Behind Redeem	5.245278	7.501667	370	Yes	Yes	No	No
18	Behind Redeem	5.245833	7.502222	370	Yes	Yes	No	No
19	Behind Redeem	5.24667	7.502778	370	Yes	Yes	No	No
20	Behind Redeem	5.245278	7.502778	380	Yes	Yes	No	No
21	Behind Redeem	5.245826	7.50284	370	Yes	Yes	No	No
22	Araromi Street	5.249585	7.499417	380	Yes	Yes	No	No
23	Araromi Street	5.249373	7.499832	380	Yes	Yes	No	No
24	Araromi Street	5.249024	7.500232	380	Yes	Yes	No	No
25	Araromi Street	5.24895	7.501434	380	Yes	Yes	No	No

Code	Well Lined	Rope/Bucket	Marshy Area	Fenced	Odorless/Colorless	Cement Base	Total Risk (%)
1	Yes	Yes	No	No	Yes	No	30
2	Yes	Yes	No	No	Yes	Yes	20
3	Yes	Yes	Yes	No	Yes	Yes	30
4	Yes	Yes	No	No	Yes	Yes	20
5	Yes	Yes	No	No	Yes	Yes	20
6	Yes	Yes	No	No	Yes	No	30
7	No	Yes	No	No	Yes	No	50
8	Yes	Yes	No	No	Yes	Yes	20
9	Yes	Yes	No	No	Yes	No	30
10	Yes	Yes	No	No	Yes	Yes	20
11	No	Yes	No	No	Yes	Yes	20
12	No	Yes	No	No	Yes	Yes	30
13	No	Yes	No	No	Yes	No	40
14	No	Yes	No	No	Yes	No	30
15	No	Yes	No	No	Yes	No	30
16	Yes	Yes	No	No	Yes	No	30
17	Yes	Yes	No	No	Yes	Yes	20
18	Yes	Yes	No	No	Yes	Yes	20
19	Yes	Yes	No	No	Yes	Yes	20
20	Yes	Yes	No	No	Yes	Yes	20
21	Yes	Yes	No	No	Yes	Yes	20
22	Yes	Yes	No	No	Yes	Yes	20
23	Yes	Yes	No	No	Yes	Yes	20
24	Yes	Yes	No	No	Yes	Yes	20
25	Yes	Yes	Yes	Yes	Yes	No	30

A critical observation of the result segregates the study area into 3 major segments (the immediate vicinity of the cemetery—wells 1–14, the opposite side of the cemetery—wells 15–21, and Araromi Street, almost adjacent to the cemetery—wells 22–25. The wells' locations were measured using the Geographical Positioning System (GPS), which revealed elevations that ranged from 350 m to 380 m, with the wells near the cemetery lying more in the lowlands, 350–360 m, while the area behind the St. Peter Anglican Church and Araromi Street lies on a higher elevation of 370 to 380 m.

Table 1 further shows that virtually water from all the wells is being fetched using buckets and ropes, which are capable of introducing contaminants to the groundwater. The risk assessment shows great variation between locations. Wells on the opposite side of the cemetery had the highest vulnerability to contamination, with total risk percentages ranging from 20% to 50%. The most critical profiled well was Well 7, with 50% risk, which lacked covering, lining, and a cement base—all crucial lacking features that highly facilitate the infiltration of pathogens. On the other hand, wells 2, 4, 5, 8, and 10 received the lowest risk rating of 20% due to comprehensive protection features such as appropriate covering, lining, and cemented bases. Marshy conditions were prevalent at well 3 (30% risk), showing environmental conditions contributing to the potential for contamination. Wells behind St. Peter Anglican Church showed better sanitary conditions: the risk percentages were constant between 20% and 30%. Eight wells (17–24) obtained the optimal rating of 20% risk, proving that the protection infrastructures are homogeneously applied. Thus, wells' water can be prevented from contamination if sanitary rules are obeyed. Wells 15 and 16 obtained a risk score of 30% each due to the lack of cement bases, proving infrastructural deficiencies even in the better-maintained area as a probable source through which contaminants can be introduced into wells. All wells in this locality had adequate separation from latrines (>10 m) and were not near any animal breeding facilities, minimizing the risks of fecal contamination. Araromi Street's wells (wells 22–25) showed similar sanitary profiles as those behind the St. Peter Anglican Church, with three wells having 20% risk. Well 25 recorded 30% risk and was the only well in the entire study area with fencing infrastructure, yet without a cement base—an interesting paradox indicating the need for protective measures to safeguard our wells from being infected by pollutants. All wells across all locations maintained proper latrine distances and reported no animal breeding proximity, indicating community awareness of basic sanitation principles. However, the universal absence of fencing, except well 25, and inconsistent application of cement base (13 out of 25 wells did not have this feature), are systemic vulnerabilities that require intervention to ensure sustainable water quality protection.

4.1. Physical Parameters of Wells' Water and Structural Features of the Wells

The physical parameters and structural features of shallow wells in the study area (**Tables 2** and **3**) show significant variation in both water quality and structural values. The pH varies from 6.49 to 7.21, indicating slightly acidic to near-neutral water, although most samples fall approximately at 6.6. The temperatures are relatively stable and vary from 25.7 to 28.6 °C, indicating shallow groundwater controlled by ambient climatic conditions. The electrical conductivity (EC μS/cm) shows a large variation, from a value as low as 88 μS/cm to as high as 687 μS/cm, reflecting changes in dissolved ion content. Correspondingly, total dissolved solids ranged between 44 and 343 mg/L, falling within the acceptable limits for potable groundwater; however, the moderately elevated values from some of the wells' water imply a localized mineral enrichment or anthropogenic influence. In this study, the TDS (mg/L) and EC (μS/cm) are positively correlated with a correlation factor $r = 0.91$ (**Figure 2**). The high positive correlation signifies that the ions contributing to EC (μS/cm) are similar to the ones making up TDS (mg/L) [30].

The EC (μS/cm) is a measure of how the water can conduct electricity, whereas TDS (mg/L) measures the total solids that are dissolved in the water, including salts, minerals, and any other substances.

In the structural aspect of the wells, the water levels varied largely from 0.11 m to 8.19 m, indicating varying conditions of topography and abstraction of groundwater. Well depths vary between 2.7 and 13.38 m, reflecting shallow, unconfined aquifers characteristic of wells in the area. The computed saturated height of water (water column) above the base of each well ranged from 0.53 to 5.18 m, reflecting variations in depth and water level. The radii of wells are fairly uniform, varying between 0.78 m and 0.97 m, suggesting similar methods of construction for wells within the area. Computed well's water volume πr^2h varies between 1.32 and 12.89 m^3, reflecting variations in the storage capacity of groundwater within these wells.

The summary of the physical parameters of shallow groundwater in the study area (**Table 3**) indicates a high degree of spatial variability in both water quality and structural features of the wells. However, all physical parameters have values within the approved standard for drinking water [26]. The results generally reflect the impact of local geology, conditions of recharge, and construction methods on the nature of water wells in the area.

Table 2. Physical Parameters of Shallow Wells' Water in the Study Area.

Code	pH	Temp (°C)	EC (µs/cm)	TDS (mg/L)	Water Level (m)	Depth (m)	Water Column (m)	Radius of Well (m)	Volume (∏r^2h) (m^3)
1	7.19	26.9	496	120	8.19	13.38	5.18	0.89	12.89
2	7.21	26.8	301	119	4.28	4.81	0.53	0.89	1.32
3	6.64	26.1	269	126	0.11	4.2	4.09	0.90	10.41
4	6.56	26.3	239	119	3.24	5.66	1.92	0.89	4.78
5	6.59	26.8	263	132	5.15	8.85	3.7	0.89	9.21
6	6.58	26.2	226	112	5.33	8.28	2.95	0.90	7.51
7	6.6	27.3	270	135	2.5	3.85	1.35	0.90	3.44
8	6.62	27.6	305	152	3.11	5.44	2.33	0.93	6.33
9	6.51	28.6	286	143	0.42	3.11	2.69	0.92	7.15
10	6.65	27.2	307	154	0.91	2.7	1.79	0.93	4.86
11	6.59	28.2	236	114	3.42	5.7	2.28	0.93	6.2
12	6.6	27	377	190	2.13	3.7	1.57	0.96	4.55
13	6.49	27	170	85	1.95	3.25	1.3	0.97	3.84
14	6.65	28	100	50	2.55	4	1.45	0.90	3.69
15	6.62	25.7	281	151	5.2	7.58	2.38	0.93	6.47
16	6.52	28.5	88	44	2.2	4.8	2.6	0.90	6.62
17	6.6	28	145	73	5.14	6.7	1.56	0.94	4.33
18	6.57	27.5	141	70	1.31	3.53	2.22	0.90	5.65
19	6.59	28	151	76	1.28	4.15	2.87	0.87	6.82
20	6.54	27.8	145	72	2.68	4.53	1.85	0.82	3.91
21	6.54	27.1	185	92	2.76	6.9	4.14	0.80	8.32
22	6.62	27.1	687	343	2.1	5.3	3.2	0.78	6.11
23	6.5	27	196	98	3.21	6.03	2.82	0.83	6.1
24	6.57	27	410	205	3.8	6.29	2.49	0.82	5.26
25	6.65	27.7	245	123	1.43	5.4	3.97	0.80	7.98

Table 3. Summary of Physical Parameters of Shallow Groundwater in the Study Area.

Parameters	Min	Max	Mean	St.Dev	Ambrose-Agabi et al. [15]
pH	6.49	7.21	6.632	0.177	6.5–8.5
Temp (°C)	25.7	28.6	27.256	0.742	-
EC (µS/cm)	88	687	260.76	130.594	1,000 µS/cm
TDS (mg/L)	44	343	123.92	60.475	500 mg/L
Water Level (m)	0.11	8.19	2.976	1.832	-
Depth (m)	2.7	13.38	5.5256	2.290	-
Water Column (m)	0.53	5.18	2.5292	1.078	-
Radius (m)	0.78	0.97	0.852	0.052	-
Volume (m^3)	1.32	12.89	6.15	2.434	-

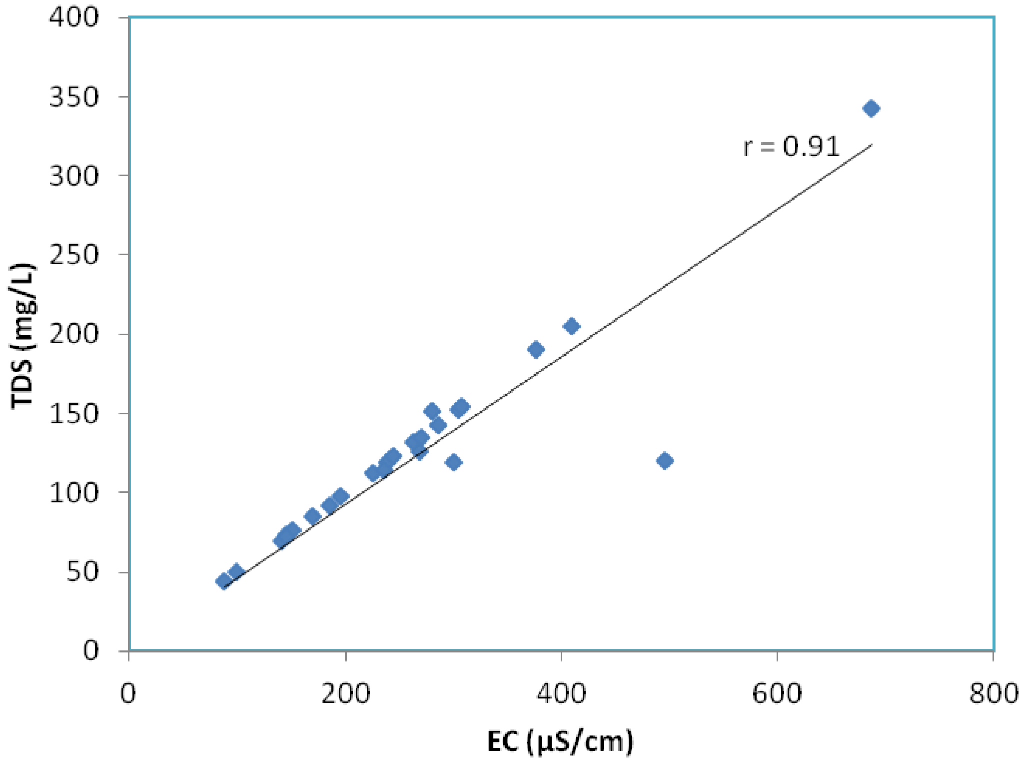

Figure 2. Graph of EC (µS/cm) vs. TDS (mg/L).

4.2. Pseudo-Resistivity Sections

Results of the pseudo-resistivity sections for traverses 1 and 2 are presented in **Figures 3** and **4**, respectively. **Figure 3** revealed varying geologic formations, including topsoil, weathered formation, partly weathered zone and fresh basement with resistivity values (Ω·m) ranging from 23–101, 102–458, 459–1534 and 1,534 to infinity; with depth range of 0–2.5 m, 5–25 m, 7–25 m and 5 m to infinity respectively. The leachate resistivity values ranged from 0 to 25 Ω·m. The result has revealed that the leachate of the cemetery has accumulated within stations 5 and 8 (distances 25–40 m) to a depth of about 0 to 8 m with a deeply bluish colouration around the North-Eastern part of Traverse 1. Also, traces of the leachate can be found around stations 11 to 19 within a depth range of 2–15 m around the southwestern part of Traverse 1 (**Figure 3**). **Figure 4** revealed varying geologic formations along traverse 2 which includes topsoil, weathered formation, partly weathered zone, fractured zone and fresh basement with resistivity values in Ω·m ranging from 18–113, 114–488, 489–1,334, 17.5–88.6 and 1,335 to infinity; with depth range of 0–2.5 m, 5–25 m, 7–25 m, 0–7.5 m and 5 m to infinity respectively. The leachate resistivity values range from 0 to 17 Ω·m. The result has revealed that the leachate from the cemetery has accumulated within stations 15 and 19 (distances 75–95 m) to a depth of about 2.5 to 25 m with a deeply bluish colouration around the South-Western part of Traverse 2. Also, traces of the leachate can be found around stations 7 to 9 within a depth range of 0–7.5 m around the North-Eastern part of Traverse 2. The study area slopes from traverse 1 down to traverse 2. Traverse 2 is very close to a river channel. The study revealed that the fresh basement outcropped around traverse two with fractures highly pronounced within the bedrock. A little part of the leachate from the cemetery has accumulated around the southwestern part of Traverse 1, while the major accumulation was found within the North-Eastern part of the study area to a depth of about 25 m within the fractured zone at distances of 75 to 95 m before further migration into the river channel.

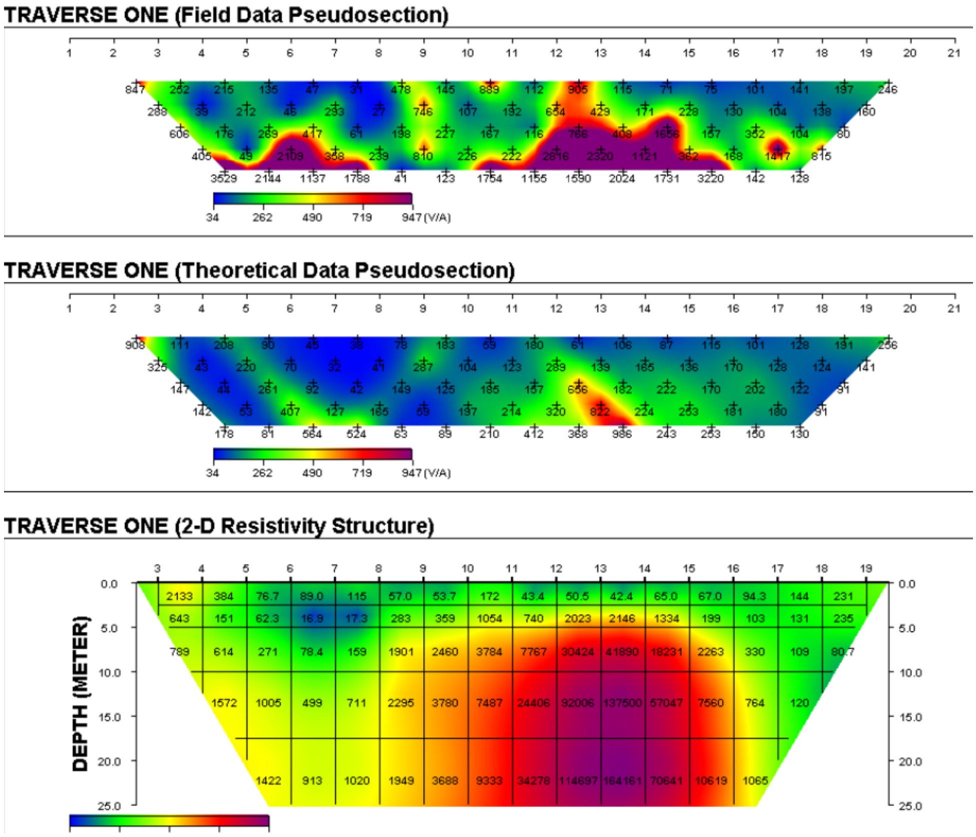

Figure 3. 2D-Pseudoresistivity Structure along Traverse 1.

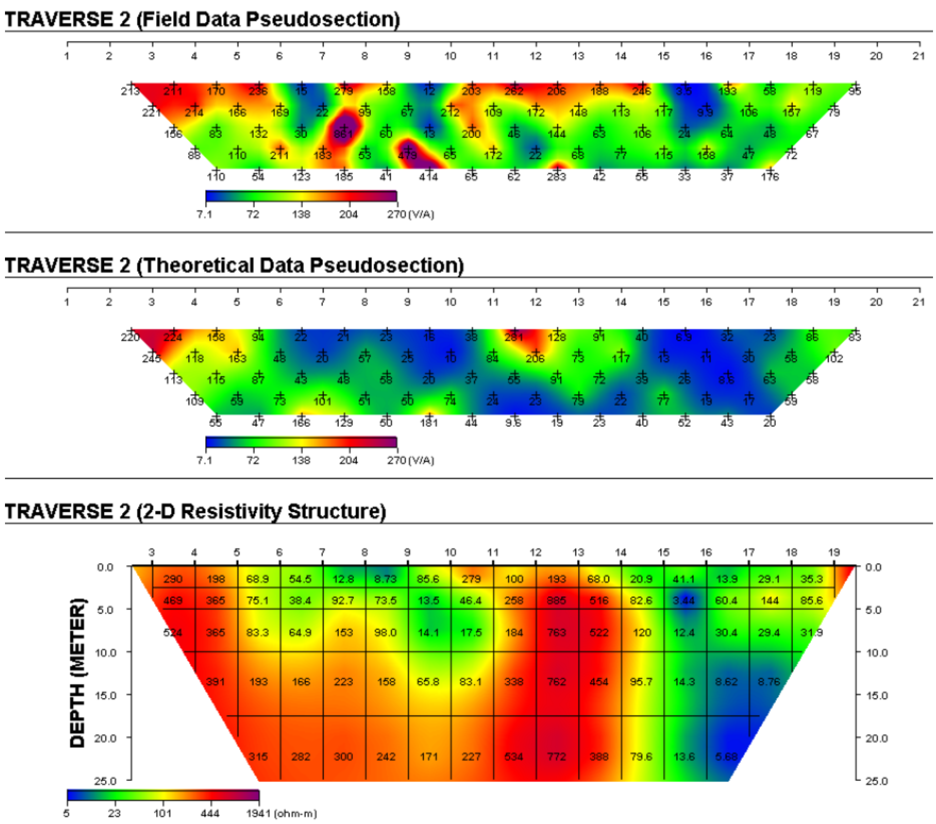

Figure 4. 2D-Pseudoresistivity Structure along Traverse 2.

4.3. Groundwater Potential of the Study Area

The volumetric groundwater potential of the study area was determined by examining the volume of water present in 25 hand-dug wells within the study area. The produced groundwater potential map was categorized into Low, medium and high with volume ranges of 1.5–4.5, 4.6–8.0 and 8.1 to 11.5 m^3, respectively, as revealed in **Figures 5** and **6**. The high groundwater potential exists within the North-Eastern and the South-Western part of the study area, the medium potential can be observed around the North central, South central, and the Eastern part of the study area; while the low potential can be seen in the Southern, Western and part of the North-Western part of the study area. However, the volumetric assessment revealed low groundwater potential that may require additional water sources, especially deep boreholes to sustain the water needs for domestic activities.

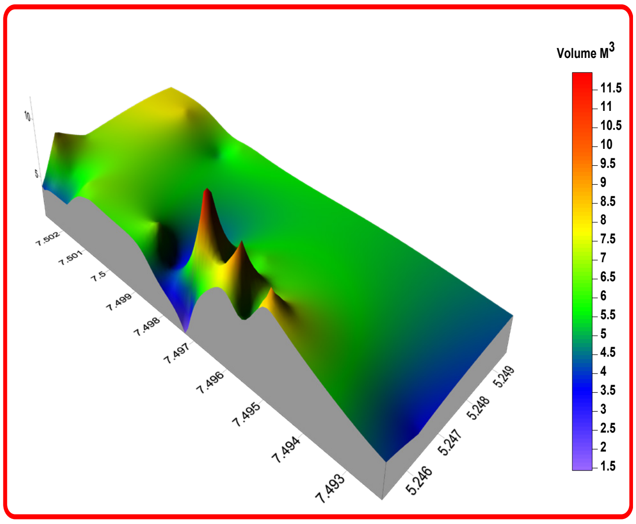

Figure 5. 3D-Groundwater Volumetric Potential Map of the Study Area.

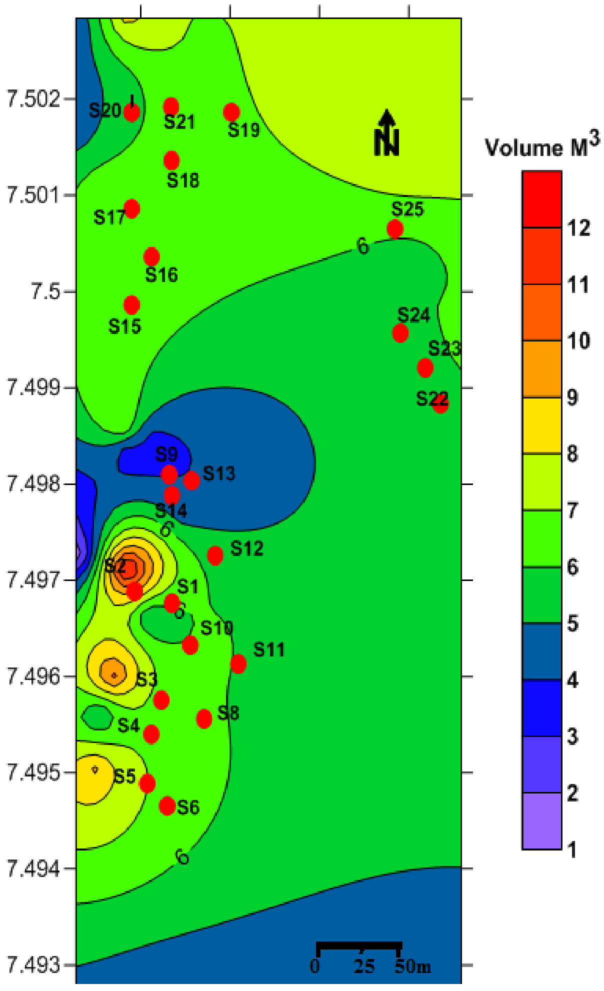

Figure 6. 2D-Potential Map of the Study Area.

5. Conclusion

This work showed that the majority of wells are within the sanitary survey regulations, except for a very few, especially those that are on marshy ground, and a few others that are neither covered nor lined. The measured physical parameters revealed that the water is suitable for consumption as they are all within the approved WHO standard for drinking water. The EC (μS/cm) and the TDS (mg/L) values are strongly positively correlated, signifying that they are derived from similar ions. The other measured parameters, depth and radius of the wells, revealed that the wells are shallow groundwater. Geophysical evaluation showed that part of the soil in the study area has been affected by leachates from the cemetery, especially in the northeastern part. Volumetric estimation of water in the wells revealed that available water may not sustain the community's water needs, especially during the dry season when the shallow wells might have dried up. Deep-seated boreholes may be needed to ameliorate water problems during that period. The study showed that the shallow groundwater in the area has not been adversely affected by the St. Peter Anglican Church's Cemetery because of the observed sanitary rules in most wells. The study concludes that consistent well protection, structural reinforcement, and community-based sanitation awareness are essential for ensuring long-term groundwater safety and sustainability in Ikere-Ekiti.

Author Contributions

Conceptualization, A.O.T. and O.O.A.; methodology, C.A.A., A.O.T. and O.O.A.; software, C.A.A. and A.O.T.; validation, A.O.T., O.O.A. and C.A.A.; formal analysis, A.O.T.; investigation, C.A.A.; resources, A.O.T., O.O.A. and C.A.A.; data curation, A.O.T. and O.O.A.; writing—original draft preparation, A.O.T.; writing—review and editing, A.O.T., C.A.A. and O.O.A.; visualization, O.O.A.; supervision, A.O.T.; project administration, A.O.T. and O.O.A.; funding acquisition, A.O.T., O.O.A. and C.A.A. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest

The authors declare no conflict of interest.

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