

Interpretation Of Leachate Contaminant Along the Department of Student Affair, University of Port Harcourt.

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-----ABSTRACT-----

Leachate contamination from improper waste disposal poses serious environmental and health risks, particularly in urban academic settings like the University of Port Harcourt, Nigeria. Leachate, a toxic liquid formed from decomposing waste and rainwater infiltration, contains harmful pollutants such as heavy metals, ammonia, and nitrates. If left unchecked, it can contaminate soil and shallow groundwater sources essential for domestic and institutional use. This study investigates leachate contamination around the Department of Student Affairs using Electrical Resistivity Tomography (ERT), a non-invasive geophysical method that identifies subsurface anomalies based on electrical resistivity variations. Data were collected along several 2D resistivity profiles using the Wenner array with 7-meter electrode spacing. Processed with RES2DINV software, the results revealed low resistivity zones ($<100\Omega\cdot m$) at depths of 0–8.93 meters—indicative of leachate plumes. These low-resistivity zones were located near active waste disposal areas, suggesting ongoing contamination and possible lateral spread, especially during the rainy season. The findings raise concerns about groundwater vulnerability and the need for urgent mitigation. The study demonstrates ERT's effectiveness in detecting subsurface contamination and recommends proper waste management strategies, including engineered landfills, leachate containment, and regular monitoring. It supports sustainable campus development and highlights the role of geophysics in environmental protection.

Keywords: Contaminants, Leachate, Niger Delta, Conductive, Geophysical, Techniques.

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I. Introduction

Leachate, a highly conductive liquid formed during the decomposition of organic and inorganic waste, is a major environmental concern due to its potential to contaminate soil and groundwater resources. In academic institutions like the University of Port Harcourt, located in the Niger Delta region of Nigeria, high waste generation from student activities, coupled with inadequate waste management practices, exacerbates the risk of leachate infiltration. The Department of Student Affairs, a central hub for student activities on the Choba Campus, generates significant quantities of solid waste, including food waste, plastics, and paper, which, if improperly managed, contribute to leachate production.

Electrical Resistivity Tomography (ERT) is a non-invasive geophysical technique that measures subsurface electrical resistivity to map geological and environmental features. By injecting a controlled electrical current into the ground and measuring the resulting potential differences, ERT produces high-resolution 2D or 3D images of subsurface resistivity variations. Low-resistivity zones ($<100\Omega m$) are often associated with conductive contaminants like leachate, which contains high concentrations of ions, heavy metals, and organic compounds. The ERT method has been widely applied in environmental studies to delineate leachate plumes, assess landfill integrity, and monitor groundwater contamination.

In the Niger Delta, where shallow groundwater aquifers are critical for domestic water supply, leachate contamination poses significant risks to public health and environmental sustainability. Previous studies in the Port Harcourt region have demonstrated the utility of geophysical methods, including ERT, Vertical Electrical Sounding (VES), and Self-Potential (SP) techniques, in detecting subsurface contamination. However, there is a paucity of site-specific studies focusing on high-risk areas like the Department of Student Affairs, necessitating targeted investigations to assess the extent of leachate contamination and its potential impact on groundwater resources.

The Department of Student Affairs at the University of Port Harcourt is a high-traffic area with significant waste generation due to student activities, including food vending, administrative operations, and social events. Improper waste disposal practices, such as open dumping, have led to concerns about leachate

percolation into the subsurface, potentially contaminating shallow groundwater aquifers. The lack of comprehensive data on the spatial distribution and depth of leachate plumes in this area hinders the development of effective waste management and groundwater protection strategies. Traditional methods, such as borehole sampling, are invasive, costly, and limited in spatial coverage, making non-invasive geophysical techniques like ERT critical for mapping subsurface contamination. This study addresses the need for a detailed assessment of leachate contamination around the Department of Student Affairs using ERT to provide actionable insights for environmental management.

The primary aim of this study is to interpret the distribution and extent of leachate contaminants around the Department of Student Affairs, University of Port Harcourt, using the Electrical Resistivity Tomography (ERT) method. This study provides a site-specific assessment of leachate contamination around the Department of Student Affairs, contributing to the limited body of knowledge on environmental pollution within the University of Port Harcourt. By employing ERT, the research demonstrates the applicability of non-invasive geophysical techniques in environmental monitoring, offering a cost-effective and efficient alternative to traditional methods.

The findings will inform university authorities, environmental managers, and policymakers about the extent of leachate contamination and its potential risks to groundwater quality, facilitating the development of targeted waste management and remediation strategies. Additionally, the study serves as a reference for researchers investigating similar environmental challenges in tropical sedimentary environments, particularly in the Niger Delta region. The study focuses on the area surrounding the Department of Student Affairs, University of Port Harcourt, Choba Campus as seen in Figure 1 below. It employs ERT to map subsurface leachate plumes and assess their potential impact on groundwater resources. The research includes field data collection, processing, and interpretation, with recommendations for environmental management. Due to resource constraints, detailed physicochemical analysis of groundwater samples was not conducted, limiting the study to resistivity-based interpretations, the study was conducted during the dry season (assumed for August 2025), and seasonal changes in rainfall may influence leachate migration patterns and the availability of high-resolution ERT equipment and the number of electrodes used may restrict the depth of investigation.

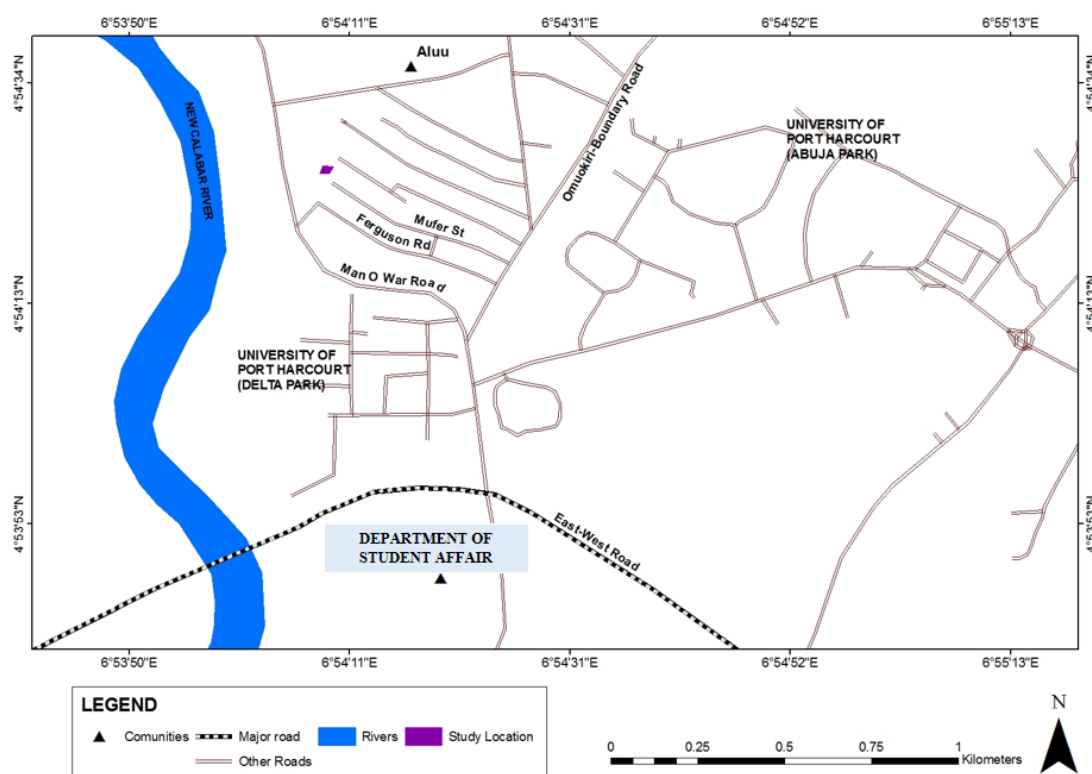


Figure 1: Location Map of the Study Area (Department of Student Affairs, University of Port Harcourt)

II. Literature Review

Leachate contamination has become a major global environmental concern, particularly in developing countries where solid waste management systems are often poorly regulated, underfunded, and technologically inadequate. In many cases, waste is disposed of in unlined landfills or open dumps lacking proper containment structures such as impermeable liners, leachate collection systems, or engineered covers. This allows leachate to migrate freely into surrounding soils and groundwater systems, leading to long-term ecological degradation and serious public health risks. In Nigeria, where groundwater serves as the primary source of potable water for over 60% of the population, the threat posed by leachate infiltration is particularly acute. Many urban and peri-urban communities rely on shallow aquifers for drinking water, irrigation, and domestic use. The intrusion of leachate into these aquifers can result in chronic exposure to toxic substances, leading to adverse health outcomes such as gastrointestinal infections, kidney damage, neurological disorders, and cancer. Moreover, the contamination of soil and water bodies disrupts ecosystems, reduces agricultural productivity, and undermines efforts toward sustainable development. Therefore, addressing leachate contamination requires a multidisciplinary approach involving proper landfill engineering, continuous environmental monitoring, public awareness, and the adoption of geophysical and hydrochemical techniques to detect and prevent subsurface pollution. Effective waste management policies, enforcement of environmental regulations, and investment in modern landfill technologies are essential to mitigate the risks posed by leachate and protect public health and environmental integrity in Nigeria and beyond.

Several studies have investigated leachate contamination in the Port Harcourt region, particularly around the University of Port Harcourt. Nwankwo and Udo (2025) employed high-resolution real-time resistivity techniques to study groundwater contamination around the Choba Campus, identifying low-resistivity zones ($<50\Omega\text{m}$) associated with leachate plumes. Emujakporue (2025) used the Self-Potential (SP) method to investigate contaminants in a dumpsite near the university, noting high conductivity in shallow subsurface layers. Alam et al. (2024) highlighted the application of ERT in geoenvironmental studies, demonstrating its ability to map contaminant plumes in sedimentary environments. These studies confirm the prevalence of leachate contamination in the region but lack specificity to high-risk areas like the Department of Student Affairs.

The study area is located around the Department of Student Affairs, University of Port Harcourt, Choba Campus, situated in the Obio/Akpor Local Government Area, Rivers State, Nigeria. The University of Port Harcourt is a public research university positioned along the East-West Road, Choba, Port Harcourt, with geographic coordinates approximately 4.9071°N , 6.9170°E . The Choba Campus, also referred to as the University Park, is one of the main campuses alongside the Abuja Campus (University Park) and Delta Campus. The Department of Student Affairs is a central hub for student activities, including administrative services, food vending, and social events, and is located within the Choba Park area, in proximity to key landmarks such as the UniPort Counselling Centre, Ofirima Roundabout, Convocation Arena, and University Stadium.

The Choba Campus is situated in a tropical sedimentary environment within the Niger Delta Basin, characterized by flat terrain and a mix of sandy and clayey soils. The area experiences a tropical monsoon climate with significant rainfall, which contributes to leachate generation from waste disposal sites. The Department of Student Affairs is surrounded by student hostels (e.g., Amino Kano and Nelson Mandela blocks), academic buildings, and waste disposal points, making it a high-risk area for leachate contamination due to intense human activity and waste generation.

ERT is a geophysical technique that measures subsurface electrical resistivity by injecting current through electrodes and recording potential differences. The method produces 2D or 3D tomograms that reveal subsurface features based on resistivity contrasts. In environmental studies, ERT is used to detect leachate plumes, map groundwater flow paths, and monitor landfill integrity. Low-resistivity zones ($<100\ \Omega\cdot\text{m}$) are indicative of conductive contaminants, while high-resistivity zones ($>500\ \Omega\cdot\text{m}$) represent dry or uncontaminated materials like sand or rock. The Wenner array, used in this study, is particularly effective for detecting vertical resistivity variations, making it suitable for shallow contamination studies.

III. Methodology

Field Procedures and Equipment Used

1. Site Reconnaissance and Preparation

Prior to data acquisition, a preliminary reconnaissance was conducted around the Department of Student Affairs, University of Port Harcourt, to evaluate the suitability of the area for ERT investigation. Survey lines were aligned to intersect suspected zones of leachate infiltration, with consideration for terrain topography and surface obstructions. Minimal vegetation clearing was performed to maintain environmental integrity.

2. Electrode Layout – Wenner Array Configuration

I employed Wenner array configuration due to its high signal-to-noise ratio, ease of deployment, and sensitivity to vertical resistivity variations—making it suitable for detecting leachate plumes, which typically affect the shallow subsurface.

Electrode spacing (a): 7 meters

Profile lengths: 140 meters

Line orientation: parallel to the waste disposal gradient

Each electrode was inserted vertically into the ground using steel rods and connected to the multi-core cable linked to the resistivity meter.

3. Data Acquisition

Data were acquired using a multi-electrode resistivity meter system capable of automated switching. The Wenner array involves four electrodes at a time: two outer electrodes for current injection (C1 and C2) and two inner electrodes for potential measurement (P1 and P2), with equal electrode spacing (7m) between all four.

The system automatically cycled through all possible electrode combinations for the Wenner array configuration along the profile. Apparent resistivity values were measured, and raw data were stored digitally.

4. Post-survey Activities

After data collection:

- i. All electrodes and cables were removed.
- ii. Electrode holes were refilled to restore the site.
- iii. Final site observations were documented to assist in interpretation.

clear geoelectrical signature of leachate impact zones, aiding in environmental assessment and waste management planning.

The following materials and equipment were employed during the field investigation to ensure successful acquisition, processing, and interpretation of subsurface resistivity data related to leachate contamination:

1. Resistivity Meter System: Model (ABEM Terrameter SAS 1000/4000)
2. Electrode Cable
3. Four Pairs of Stainless Steel Electrodes
4. Marking Pegs
5. Electrode Connectors
6. Global Positioning System (GPS) Device
7. Measuring Tape.
8. Hammers
9. Recording sheets and Pen

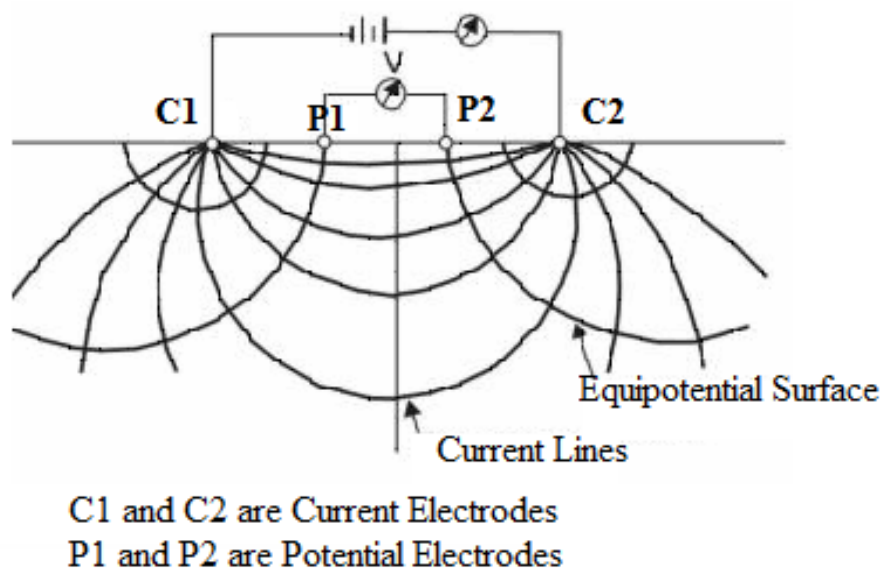


Figure 2: Wenner Array Configuration for ERT Survey

Data Processing and Analysis

ERT data were processed using RES2DINV software, which employs an iterative inversion algorithm to minimize noise and produce 2D resistivity tomograms. The inversion process used a robust data constraint to handle subsurface heterogeneity.

The tomograms were interpreted to delineate the spatial distribution, depth, and lateral extent of leachate plumes. Cross-sections were correlated with geological data to validate findings.

Quality Control Measures

To ensure data reliability, the following measures were implemented:

Electrode Contact: Electrodes were tested for proper grounding to minimize contact resistance.

Repeat Measurements: Multiple readings were taken at each electrode position to reduce noise.

Calibration: The resistivity meter was calibrated before each survey.

Field Conditions: Surveys were conducted during dry weather to avoid interference from surface moisture.

Precautions Taken

While conducting the Electrical Resistivity Tomography (ERT) survey, several precautions were taken to ensure data accuracy, safety, and minimal environmental disturbance. These precautions span site preparation, instrumentation, data acquisition, and post-survey procedures. Below is a detailed list of key precautions:

1. Site and Environmental Considerations
2. Safety Precautions
3. Equipment Handling
4. Data Quality Assurance

IV. Results

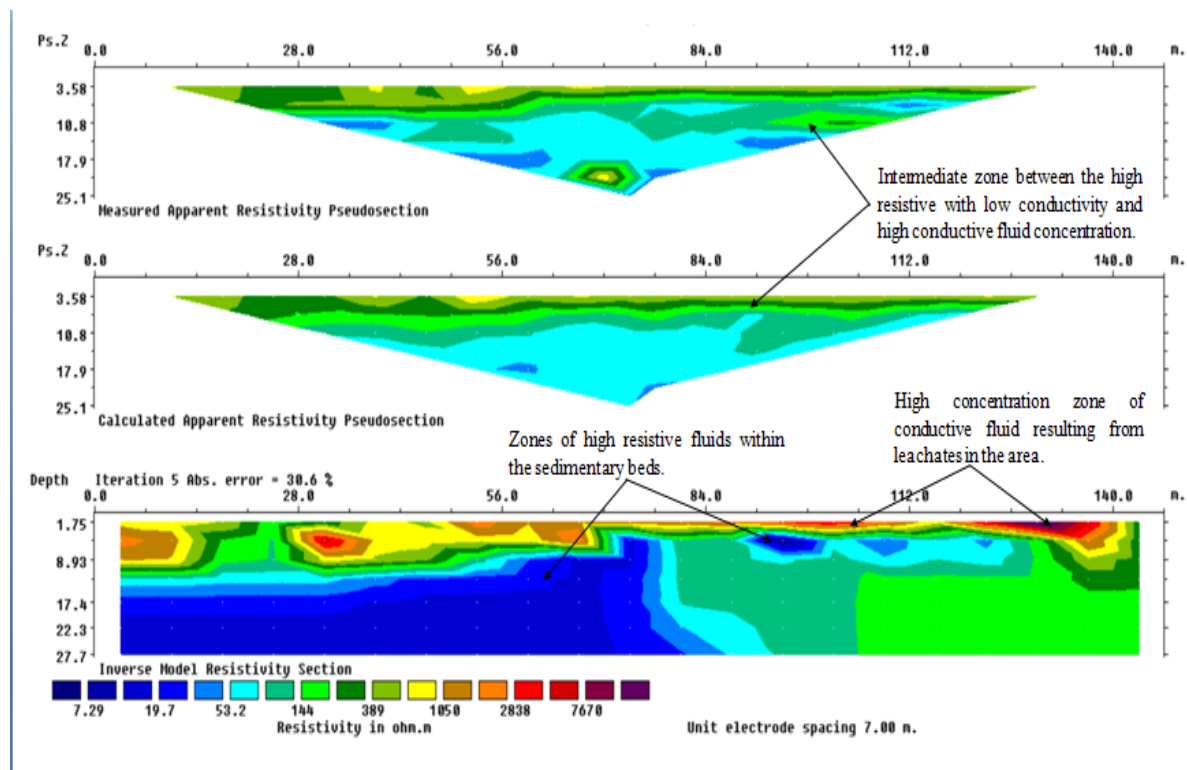


Figure 2: A Pseudosection of contaminant fluid concentration within the sediments at Student Affairs, Choba, Uniport.

Interpretation of Leachate Plume Distribution

The referenced figure is a resistivity tomogram, a sophisticated software-generated model designed to interpret subsurface electrical resistivity and fluid migration patterns within the sedimentary layers of the Earth's crust. This tomogram is complemented by a geophysical cross-section that highlights the presence of conductive leachate contaminants at shallow depths ranging from 0 to 8.93 meters in the investigated area. Such models are critical for understanding subsurface characteristics, particularly in the context of groundwater exploration and contamination assessment.

The study area is a dump site that was geophysically surveyed using a resistivity meter configured in a Wenner array. This survey technique is widely used in geophysical investigations due to its effectiveness in mapping subsurface layers, identifying fluid interactions within sediments, and evaluating their influence on groundwater potential, especially for aquifer prospecting. The Wenner array configuration provides high-resolution data, enabling a detailed visualization of subsurface structures and the detection of variations in electrical resistivity caused by different materials and fluids.

The accompanying geophysical section in the tomogram suggests an optimal depth for targeting an aquifer for groundwater prospecting. The tomogram itself is presented as an inverted pyramid, offering a two-dimensional (2D) representation of the subsurface. It employs a color-coded system to differentiate material properties: blue zones represent areas of high resistivity, typically associated with less conductive materials, while red or purple zones indicate highly conductive regions. The high-conductivity zones are likely linked to leachate-contaminated areas, where pollutants from the dump site have infiltrated the subsurface. These conductive zones pose a potential threat to aquifer vulnerability, particularly as depth increases, as they may indicate the presence of contaminants that could compromise groundwater quality.

In contrast, the blue zones, characterized by high resistivity, are interpreted as freshwater prospects, suggesting the presence of clean, uncontaminated groundwater. According to the tomogram, the potential for accessing freshwater increases with depth, indicating that the contaminants have not yet percolated to deeper subsurface layers. This finding is significant, as it suggests that the dump site's leachate has been confined to shallower depths, leaving deeper layers relatively unaffected.

The hydrogeophysical investigation further supports the suitability of the study area for groundwater prospecting. The data indicate that the optimal aquifer depth for exploration lies at shallow levels, where freshwater prospects are viable and less impacted by surface contaminants. This makes the area promising for groundwater development, provided that appropriate measures are taken to monitor and mitigate the potential spread of contaminants to deeper levels over time.

Thus, the resistivity tomogram and its accompanying geophysical section provide a comprehensive understanding of the subsurface conditions at the dump site. The clear distinction between high-resistivity freshwater zones and conductive, leachate-contaminated zones enables informed decision-making for groundwater prospecting. The study confirms that the area remains suitable for accessing clean groundwater at shallow depths, offering valuable insights for environmental management and resource exploration in the region.

Table 1: Summary of Resistivity Values and Corresponding Subsurface Features

Here's a structured table summarizing the resistivity values from the psuedosection image and the corresponding subsurface features:

Resistivity Range (Ωm)	Subsurface Features/ Interpretation
< 20 Ωm (Dark Blue – Light Blue)	Highly conductive zones → leachate-contaminated fluids, high concentration of pollutants within sediments.
20 – 55 Ωm (Cyan – Green)	Intermediate zones → transition between resistive and conductive layers, possible mixing of leachate with groundwater.
55 – 125 Ωm (Yellow – Light Orange)	Moderately resistive zones → less contaminated groundwater, possibly weakly mineralized water or fine-grained sediments.
125 – 620 Ωm (Orange – Red)	High resistivity zones → relatively clean groundwater, sandy sediments with fresh water, or unsaturated zones.
620 Ωm (Dark Red – Purple)	Very high resistive zones → compacted sedimentary beds, dry sands, or zones of high resistive fluids isolated from contamination.

Depth and Extent of Contamination

The leachate plume was confined to shallow depths (0-27.7meters), with the most pronounced contamination occurring within 0-8.93 meters of the surface. The lateral extent varied by profile, with the largest plume observed near an open dumpsite adjacent to the Department of Student Affairs. The limited vertical penetration suggests that clay layers' act as aquitards, protecting deeper aquifers but trapping contaminants in shallow zones.

The proximity of the leachate plume to shallow groundwater aquifers (0.8.93 meters) indicates a high risk of contamination. Although physicochemical analysis was not conducted, the low resistivity values suggest elevated concentrations of contaminants such as heavy metals (e.g., lead, cadmium), nitrates, and organic

compounds, which could exceed World Health Organization (WHO) guidelines for potable water. This poses a significant threat to water supply points used by students and staff, particularly in nearby hostels.

Table 2: Comparison of Resistivity Data with Regional Studies
Comparison table – This study vs Typical regional resistivity results

Resistivity range ($\Omega \cdot m$)	This study (Choba, UNIPORT) — interpretation	Typical regional ranges ($\Omega \cdot m$)	Typical regional interpretation	Agreement / notes
< 20	Highly conductive zones — interpreted as leachate-contaminated fluids / high pollutant concentration (dark–light blue).	~5–30	Strongly saline or polluted pore-fluids, saturated clay/organic-rich layers, active leachate plumes.	Good agreement. Values match typical signatures for heavy contamination or saline groundwater.
20 – 55	Intermediate conductive → transition between conductive plume and cleaner units (cyan → pale green).	~20–100	Brackish groundwater, mixed leachate/groundwater zones, saturated fine sediments.	Moderate agreement. Range overlaps typical brackish / mixed zones reported regionally.
55 – 125	Moderately resistive → less contaminated water; fine-grained or slightly coarser sediments (green → yellow).	~50–300	Fresh to slightly mineralized groundwater in sandy/silty aquifers; reduced contamination.	Consistent. Many regional studies report fresh aquifer resistivities in this band.
125 – 620	High resistivity → relatively clean groundwater, coarse sand, or unsaturated sediments (yellow→orange/red).	~200–1000	Unsaturated zones, coarse sand/gravel with fresh water, low clay content, or deeper resistive horizons.	Consistent directionally. Exact cutoffs vary with lithology and pore-water chemistry.
> 620	Very high resistivity → compacted beds, dry sands, or isolated high-resistivity fluids (dark red/purple).	> 1000 (often)	Bedrock, dry/unsaturated sediments, or massive resistive layers (fresh, coarse, low porosity).	Broadly consistent. Very high values usually indicate rock or very dry/coarse units; thresholds depend on local geology.

V. Conclusion

This study successfully mapped the distribution and extent of leachate contaminants around the Department of Student Affairs, University of Port Harcourt, using the Electrical Resistivity Tomography (ERT) method. The results confirmed the presence of a laterally extensive leachate plume at shallow depths (0-8.93 meters), primarily near waste disposal sites, with low resistivity values ($>100 \Omega \cdot m$) indicating high ionic content. The ERT method proved effective in delineating subsurface contamination in the sedimentary geology of the Niger Delta, offering high-resolution 2D tomograms for environmental monitoring. The findings highlight the vulnerability of shallow groundwater aquifers to leachate contamination, underscoring the need for improved waste management practices to protect public health and environmental sustainability.

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Appendix

Table 1: ERT Survey Parameters

a=7m				
S/NO.	Mid-point of four electrodes (m)	Geometric FactorK (K)	Resistance (Ω)	Apparent Resistivity(ρ_a)
1	10.5	43.98	14.9443	657.250314
2	17.5	43.98	11.1185	488.99163
3	24.5	43.98	6.0953	268.071294
4	31.5	43.98	6.9712	306.593376
5	38.5	43.98	16.2315	713.86137
6	45.5	43.98	7.8595	345.66081
7	52.5	43.98	19.3241	849.873918
8	59.5	43.98	11.6345	511.68531
9	66.5	43.98	15.7124	691.031352
10	73.5	43.98	13.4034	589.481532
11	80.5	43.98	10.7967	474.838866
12	87.5	43.98	12.9953	571.533294
13	94.5	43.98	12.4039	545.523522
14	101.5	43.98	13.6216	599.077968
15	108.5	43.98	14.1936	624.234528
16	115.5	43.98	10.7474	472.670652
17	122.5	43.98	13.9487	613.463826
18	129.5	43.98	13.0826	575.372748
a=14m				
S/NO.	Mid-point of four electrodes (m)	Geometric FactorK (K)	Resistance (Ω)	Apparent Resistivity(ρ_a)
19	21	87.96	3.8723	340.607508
20	28	87.96	4.6162	406.040952
21	35	87.96	4.6429	408.389484
22	42	87.96	5.0563	444.752148
23	49	87.96	4.6225	406.5951
24	56	87.96	3.6591	321.854436
25	63	87.96	1.3466	118.446936
26	70	87.96	1.2711	111.805956
27	77	87.96	0.9669	85.048524
28	84	87.96	0.7925	69.7083
29	91	87.96	0.9862	86.746152
30	98	87.96	1.1805	103.83678
31	105	87.96	0.8259	72.646164
32	112	87.96	0.4424	38.913504
33	119	87.96	0.6614	58.176744
a=21m				

S/NO.	Mid-point of four electrodes (m)	Geometric FactorK (K)	Resistance (Ω)	Apparent Resistivity(ρ_a)
34	31.5	131.95	0.3208	42.32956
35	38.5	131.95	0.2992	39.47944
36	45.5	131.95	0.6596	87.03422
37	52.5	131.95	0.6741	88.947495
38	59.5	131.95	0.5675	74.881625
39	66.5	131.95	0.4264	56.26348
40	73.5	131.95	0.6652	87.77314
41	80.5	131.95	0.7539	99.477105
42	87.5	131.95	0.8908	117.54106
43	94.5	131.95	1.2093	159.567135
44	101.5	131.95	1.9429	256.365655
45	108.5	131.95	1.7579	231.954905
a=28m				
S/NO.	Mid-point of four electrodes (m)	Geometric FactorK (K)	Resistance (Ω)	Apparent Resistivity(ρ_a)
42	42	175.93	0.4974	87.507582
43	49	175.93	0.5062	89.055766
44	56	175.93	0.5427	95.477211
45	63	175.93	0.3636	63.968148
46	70	175.93	0.3664	64.460752
47	77	175.93	0.5005	88.052965
48	84	175.93	0.4177	73.485961
49	91	175.93	0.2248	39.549064
50	98	175.93	0.207	36.41751
a=35m				
S/NO.	Mid-point of four electrodes (m)	Geometric FactorK (K)	Resistance (Ω)	Apparent Resistivity(ρ_a)
51	52.5	219.91	0.1745	38.374295
52	59.5	219.91	0.1868	41.079188
53	66.5	219.91	0.3196	70.283236
54	73.5	219.91	0.337	74.10967
55	80.5	219.91	0.3231	71.052921
56	87.5	219.91	0.3649	80.245159
a=42m				
S/NO.	Mid-point of four electrodes (m)	Geometric FactorK (K)	Resistance (Ω)	Apparent Resistivity(ρ_a)
57	63	263.89	0.2619	69.112791
58	70	263.89	3.3246	877.328694

59	77	263.89	0.1473	38.870997
a=49m				
S/NO.	Mid-point of four electrodes (m)	Geometric FactorK (K)	Resistance (Ω)	Apparent Resistivity(ρ_a)
60	73.5	307.88	0.1458	44.888904