# The Geology, Hydrogeology and Water Resources Properties of Uke and its Environs of Idemili Area of Southeastern Nigeria

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## ABSTRACT

This study investigates the geological and hydrogeological characteristics of Uke and its surrounding areas, located within the Idemili Local Government Area. The region is geographically situated between latitudes 06°03’N and 06°07’N, and longitudes 06°52’E and 06°58’E. The primary objectives of this research include delineating geological boundaries and assessing the hydro geochemistry of the Uke area. A comprehensive geological mapping effort was conducted to create a geologic map and establish a stratigraphic framework for the region. Field observations of exposed outcrops revealed two main lithologic units: the Nanka Formation and the Ogwashi-Asaba Formation. The delineation of these boundaries is crucial for understanding the subsurface geology. The area is characterized by a variety of streams, including Mmiri John, Ezigbo, and Obiaja, along with a major river. The drainage pattern in this region is dendritic, trending primarily in a northeast-southwest direction. Hydrochemical analysis of water samples indicated the presence of slightly acidic conditions, with pH values ranging from 5.4 to 6.17. The groundwater quality is affected by the leaching of $Fe3+$ and exhibits high levels of dissolved oxygen, measured between 5.6 and 10.2 mg/L. Surface water samples displayed varying total dissolved solids (TDS) concentrations, with higher values ranging from 16.7 to 34.18 mg/L and lower values between 8.6 and 10.4 mg/L. Notably, heavy metal analysis revealed little to no presence of heavy metals in the samples. One of the most critical issues identified in this study is the fecal contamination of groundwater, which poses significant health risks to local communities. Generally, the streams in the area are not considered potable for drinking without treatment, although they can be safely used for agricultural purposes such as irrigation. In conclusion, the findings from this study underscore the importance of sustainable water management practices and highlight the need for further research to address groundwater quality issues and potential contamination sources in the Uke area and its surroundings. The results serve as a foundation for informed decision-making in managing the region’s water resources effectively.

**KeyWords** – Hydrogeological, Hydrochemical, Boundaries, Dissolved Oxygen, Risk, Contamination, Treatment.

## INTRODUCTION

### Background Study

Uke and its environs are in Idemili South and idemili north Local Government Area of Anambra state, Nigeria. The population of the area is dense about 206,000 (NPC, 2006; Mac-millan, 2006; Oformata, 2002). Towns that made up of the study area includes; Ojoto,Nnobi, Umuoji, Uke and Alor, Ideani, Uruagu, Nnobi, These towns are part of the Anambra Basin, a significant geological and hydrogeological area known for its sedimentary formations and groundwater potential. This project aims to provide an in-depth analysis of the geology and hydrogeology of these towns, highlighting the lithological characteristics, groundwater resources, and the implications for local development. The towns under study are situated within the Anambra Basin, which is a major sedimentary basin in Nigeria. The geological formations in this region span from the Late Cretaceous to the Tertiary period, comprising a variety of sedimentary rocks, including sandstones, shales,

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and lignites. The geological features of these towns play a crucial role in determining the availability and quality of groundwater, which is essential for both domestic and agricultural use. The geology of Ojoto is dominated by the Nsukka Formation, which includes shales, sandstones, and coal seams. This formation is typical of the Maastrichtian age and is characterized by fluvial-deltaic deposits.

**Scope of Study**

The research involved: Review of literature on the geology and sedimentology of the region Study of the topographic and geologic maps of the area to acquire first-hand information about the area. Reconnaissance survey of the Ojoto and environs, followed by detailed field work to gather information pertaining to the geomorphology, stratigraphic succession, and textural aspects of the rocks, sedimentary structures and drainage of the area. Assessment of the hydrogeology of the region, focusing on the distribution, flow, and quality of groundwater resources, Identification of primary aquifers, their recharge mechanisms, and the sustainability of groundwater resources. Examination of groundwater quality, including potential sources of contamination and the impact of geological formations on water chemistry. Evaluation of the environmental implications of the region's geology, including soil erosion, land degradation, and resource management. Analysis of geotechnical challenges associated with infrastructure development, particularly in areas with significant geological constraints such as expansive clays or erodible soils.

**Location and Accessibility of the Study Area**

The study area is situated within latitudes N 06°01 N and N 06° 08 N and longitudes E06°52’E and 07°00’E .The area is situated in Anambra State, southeastern Nigeria and is bordered to the north by Umuoji, to the west by the Iyiowa Forest and to the east by the erosion-ravaged Agulu–Oko–Ekwulo-bia–Nanka areas. It is about 15 km southeast of Onitsha. The study area, comprising Ojoto, Umuoji, Uke, Alor, Nnobi, Ideani, and Uruagu, is strategically located within Anambra State and is accessible via a network of major highways and local roads.

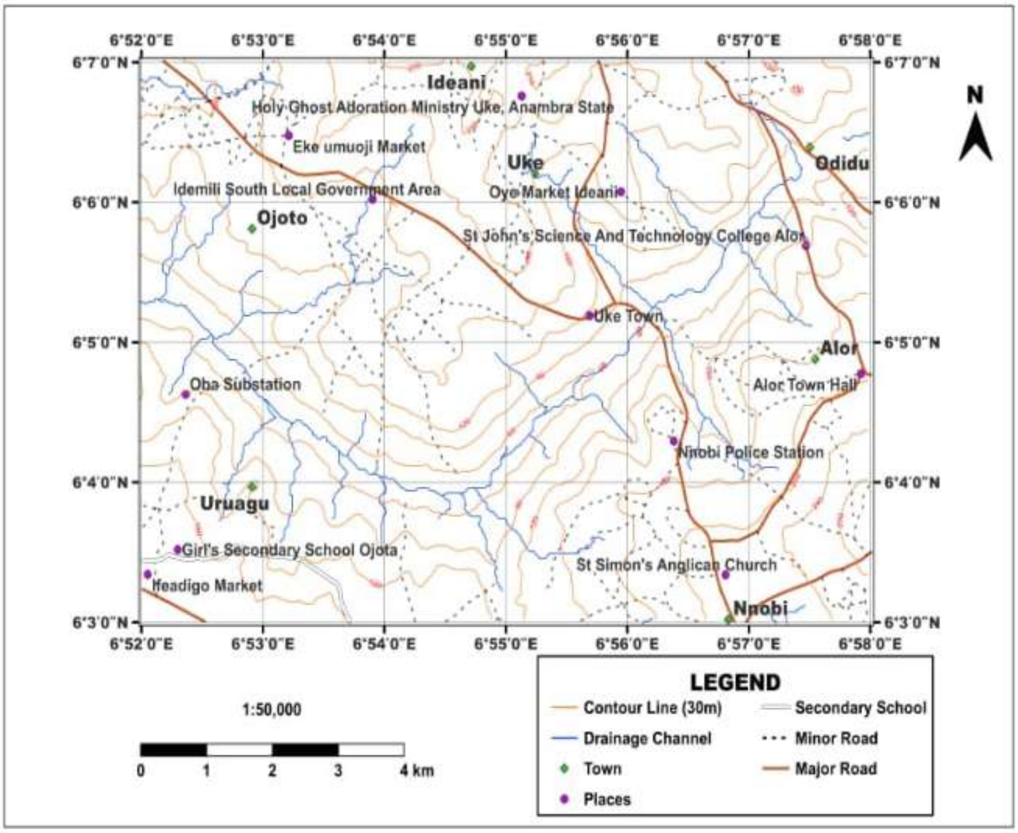


**Fig.1.: Location map of the study area**

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### Topography and Drainage of the Study Area

The area falls within the Niger Delta basin and the topography of the study area is characterized by a combination of low hills, undulating plains, and valleys. The area lies within the Anambra Basin, a region known for its relatively gentle terrain that gradually slopes from the uplands in the east to the lowlands in the west.the study area is resting on top of gentle dipping parts of the Awka–Orlu Ridge.

### Vegetation of the Study Area

The vegetation of the study area is a mix of primary and secondary tropical rainforest, farmlands, plantations, and riparian vegetation. Human activities such as deforestation, agriculture, and urbanization have significantly altered the natural landscape, leading to habitat loss and reduced biodiversity. Conservation efforts, including reforestation, sustainable agriculture, and the establishment of protected areas, are essential for preserving the region's ecological balance and ensuring the continued provision of ecosystem services.

## LITERATURE REVIEW

### Nsugbe Formation

This is the third lateral equivalence within the Ameki Group. It has been hardly documented and was suggested to be a possible lithostratigraphic unit of Formation rank distinct from the contagious Nanka Formation with which it has a rather unclear boundary. The thickness of the Formation is yet unknown but it is not expected to differ substantially from that of the Nanka Formation. It lithologically consists of flat-bedded, occasionally wave ripple-laminated, and burrowed, clayey medium grained sandstone (Nwajide, 2013).

### Nanka Formation

They have been identified as the loose sand facies of the Ameki Group (Nwajide, 1979,1980). Its boundaries with the adjacent units are transitional and have had to be arbitrarily placed. The lithology of the Formation is overwhelmingly loose, poorly cemented, flaser bedded, fine to medium sand, with a few mudrock breaks. (Nwajide, 2013).

### Imo Formation

The Imo Formation is situated above the Mamu Formation and below the Enugu Formation. It is a significant component of the geological sequence in southeastern Nigeria and is part of the southeastern extension of the Niger Delta. It extends across the southeastern Nigeria region, encompassing parts of Imo State and neighboring areas. The Imo Formation was deposited in a coastal plain to deltaic environment, with characteristics influenced by both riverine and marine processes. Key depositional settings include: Coastal Plain, Delta Front.

### Geology and Hydrogeology of the Area

The study area is underlain by two main Formations; the Eocene Nanka Sands and the Quaternary Ogwashi-Asaba Formation. (Nwajide, 2013; Reyment, 1965). In the study area it is a sequence of poorly consolidated, poorly sorted, friable, medium to coarse sands of Eocene age. The Formation contains thin band of claystone, siltstone and shale. The units have good porosity and permeability. The sandstone unit is aquiferous (Nwajide, 1979). Overlying the Nanka Sands is the Ogwashi-Asaba Formation. This consists of altercation of lignites and clays. The Formation is aquiferous with good porosity and permeability. The aquifers in the area range in depth from 134m to 237m. Water levels occur at shallow depths in the plains and valley courses while the water levels occur at greater depths in the highland areas (Okpoko, 2017).

Groundwater recharge in the study area is by infiltration from rainfall and surface runoff. The cost of exploitation of deep aquifer is high amongst the inhabitants in the area with the attendant risk of drilling abortive boreholes because most times professionals are not involved during exploitation. The streams that

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made up the drainage system in the study area comprised Mmiri Ezigbo Odida and Obiaja stream. Hydraulic connectivity exists between the surface water systems and the groundwater systems. Through the phases of hydrogeologic cycle the groundwater system is recharged from infiltration of part of overland flow into the soil (Fetter, 2001; Heath, 1983).The drainage pattern of the basin is dentritic with individual streams flowing from sandy highlands to shaly lowlands. Meteorological, topographical and geological factors contribute to the amount of their flow and discharge.

## MATERIALS AND METHODS

### Desktop Study

This process requires a thorough evaluation of the area, its geologic structure, accessibility, Formation and possible problems which could be encountered during the fieldwork. At this stage, the past work of some of authors in the given location is to be studied for better understanding and preparations.

### Field Work Study

During the field work, outcrops are sited, observed and the position is marked using Global positioning system (GPS). This is followed by detailed logging of the outcrop taking note the rock type (lateral extent, gross thickness, bed thickness) textural features (color, grain size, and sorting of grains, clay content, cementation/ compaction if present), sedimentary structures (nature of bedding, internal structure), tectonic structure (fracturing, joints, faults, folds), and biogenic structures.

This constitutes the central part of this work. And also water bodies surface as streams, springs and rivers were also studied to determine the color of the water and also the direction of flow, the flow velocity of the various water bodies found were also carefully calculated, boreholes dug in the area were also recorded and samples of water collected for analysis and also information regarding to the depth and lithologs of the boreholes were collected and studied. Photographs of outcrops and the sedimentary structures encountered were also taken with proper scale.

### Laboratory Method and Map Production.

The geologic map of the study area with the accurate interpretation and illustration was produced and all comprehensive and exhaustive geologic report of the study area written with full explanatory note. Samples of water collected from several surface and subsurface water bodies were analyzed in the laboratory and Samples of sand size grains from the different units were collected and subjected to sieve analysis using the standard American Ro-tap sieve method to determine the engineering properties of the rocks and soil samples collected in the field. Such properties include grading, sorting, plastic limit, liquid limit and plasticity index of the samples collected.

The data obtained from these analyses was used to identify the stratigraphic succession and interpret environment of deposition of the rocks in the study area, and most importantly an insight in the water quality of the area.

## RESULTS AND DISCUSSIONS

### Geological Field Mapping

During the course of our field mapping, various locations were visited, studied and mapped. The mapped locations include; VES locations, Water bodies, Excavation site and Gully erosion sites. Observations of these locations were made and its characteristics were defined and put together to obtain the geologic map of the study area.

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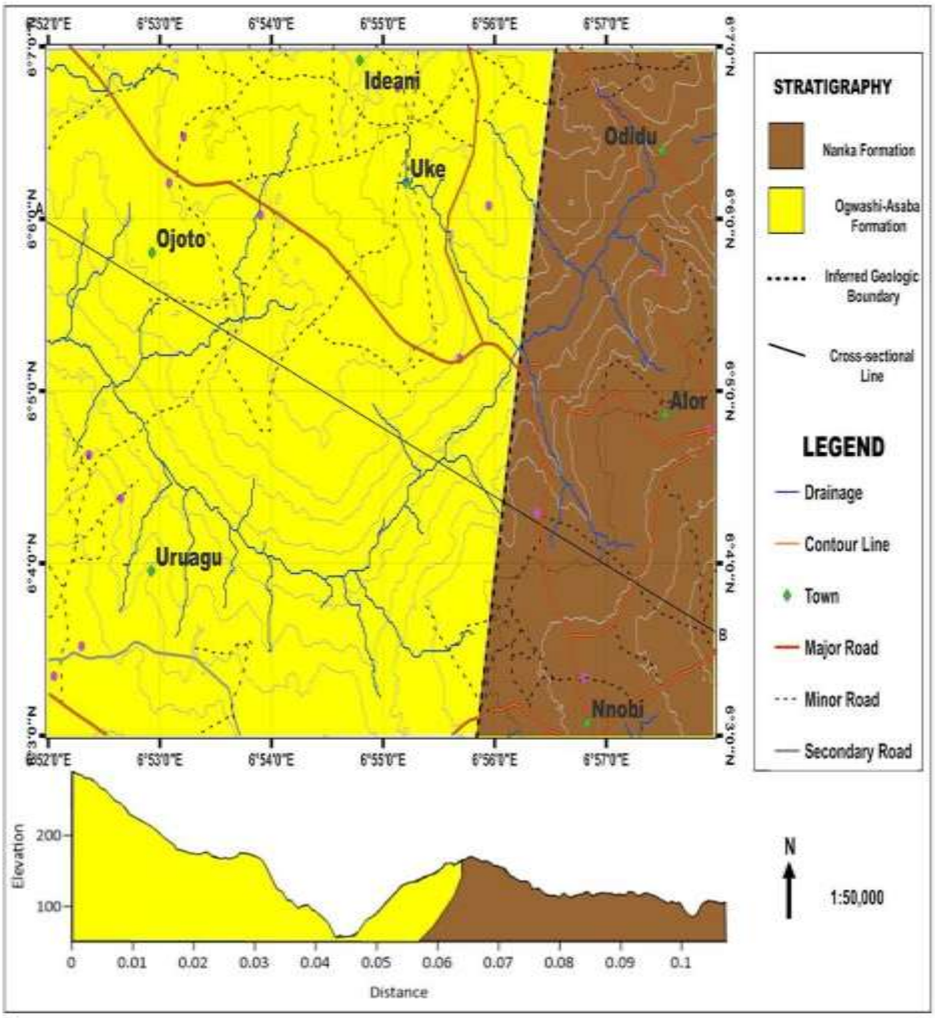
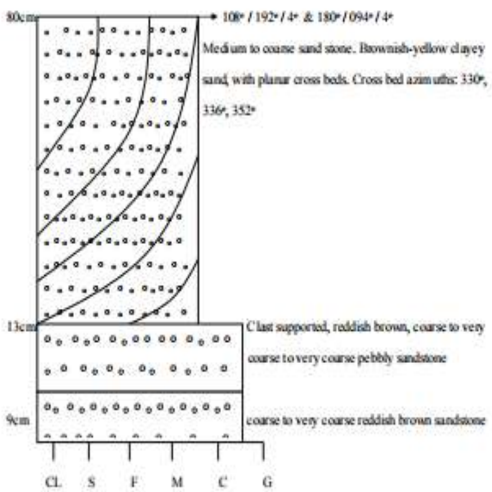
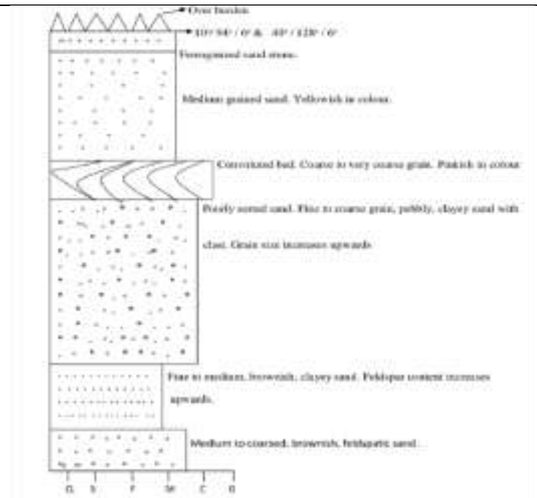



Fig 4.1. - A geological and cross-sectional map of the area

**Outcrop Description and Litho Logs of Outcrops**




**Log 1 – Log of Outcrop 1**




**Log of Outcrop 2**

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**Borehole log**

**Table showing the borehole log data of Nnobi-Nnewi Road, Nnobi**

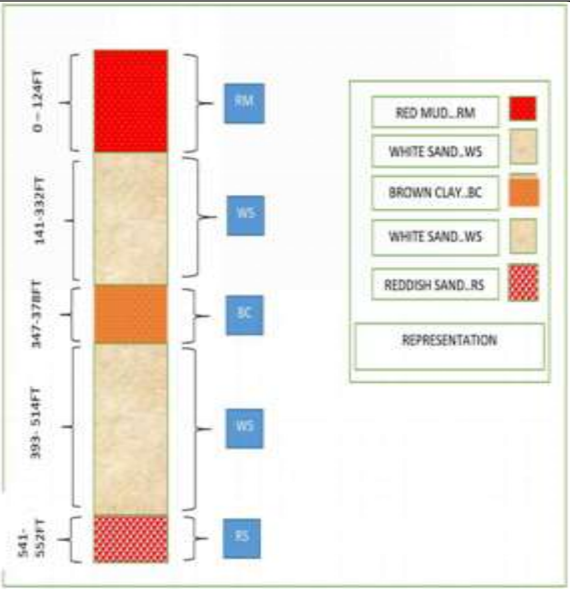


**Fig 4.4. Borehole log of Nnobi umuru**

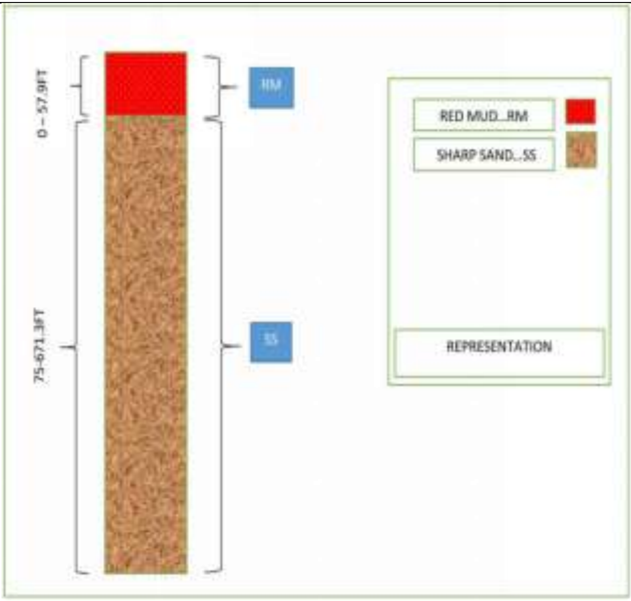


**Fig 4.5. Borehole log of Abor village, Ojoto**

**Table 4.1. Results of Water Analysis**

| **Sample number** | **Surface water 1** | **Surface water 2** | **Surface water 3** | **Under ground water 4** | **Under ground water 5** | **Under ground water 6** | **Under ground water 7** | **Under ground Water8** |
|---|---|---|---|---|---|---|---|---|
| Water component | | | | | | | | |
| $Fe^{3+}$ | 0.25 | 0.36 | 0.44 | 0.03 | 0.01 | 0.08 | 0.6 | 004 |
| $Ca^{2+}$ | 1.4 | 8.0 | 1.6 | 5.8 | 7.2 | 4.8 | 1.0 | 0.4 |
| $Mg^{2+}$ | 8.6 | 7.08 | 2.43 | 5.35 | 2.4 | 0.98 | 1.0 | 0.6 |
| $Na^{+}$ | 0.1 | 0.4 | 0.3 | 0.1 | 2.2 | 3.2 | 3.4 | 2.2 |
| $K^{+}$ | 9.0 | 6.0 | 1.8 | 0.09 | 0.02 | 4.6 | 8.6 | 4.2 |
| $Cl^{-}$ | 5.6 | 1.00 | 0.02 | 0.06 | 0.04 | 0.08 | 0.001 | 0.006 |
| $HCo_3$ | 0.88 | 0.04 | 0.05 | 0.02 | 0.75 | 0.6 | 0.48 | 0.12 |
| $Co^{2}$ | 140 | 100 | 75 | 15 | 11 | 11.5 | 16.2 | 10.2 |
| $So^{2-}$ | 3 | 5 | 2 | 3 | 1 | 2.2 | 3.2 | 1.1 |

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| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| $Sio_2$ | 0.02 | 0.06 | 0.03 | 0.007 | 0.001 | 1.0 | 0.006 | 2.4 |
| $No_2^-$ | 1.20 | 3.00 | 1.70 | 2.2 | 3.1 | 2.6 | 4.6 | 3.8 |
| $No_3^-$ | 0.1 | 1.0 | 2.2 | 5.30 | 13.20 | 7.50 | 5.8 | 4.6 |
| $NH_4^-$ | 0.88 | 7.04 | 1.76 | 3.4 | 2.4 | 6.16 | 8.6 | 5.2 |
| $Po_4$ | 0.03 | 0.1 | 0.08 | 0.026 | 0.05 | 0.04 | 0.006 | 0.008 |
| Dissolved oxygen | 20 | 20 | 24 | 8 | 5.6 | 7.4 | 8.6 | 7.4 |
| TDS | 34.18 | 16.76 | 28.16 | 10.2 | 8.6 | 10.4 | 10.2 | 8.7 |
| TSS | 4 | 6 | 8.5 | 1.2 | 1.8 | 2.2 | 8.8 | 10.0 |
| Conductivity (ms/cm) | 34 | 28 | 41 | 12 | 12 | 14 | 16.5 | 12.6 |
| Temperature (ºC) | 27 | 28 | 26 | 22 | 24 | 20 | 24 | 26.5 |
| $_p$h (Acidity/ Alkalinity) | 5.9 | 6.17 | 6.3 | 5.6 | 5.8 | 5.85 | 5.4 | 58 |
| Turbidity (FTU) | 30 | 28.6 | 24.6 | 1 | 3 | 5 | 2 | 6 |
| Colour (pt/co) | 12 | 10 | 8 | Nil | Nil | 0.001 | Nil | Nil |
| Total Hardness (mg/l) | 13 | 18 | 27 | 36 | 41 | 33 | 30 | 44 |
| Lead | Nil | Nil | 0.001 | Nil | Nil | Nil | Nil | Nil |
| Cadmium | 0.001 | 0.001 | Nil | Nil | Nil | 0.002 | 0.005 | 0.006 |
| Zinc | 0.005 | 0.008 | 0.006 | 1.0 | Nil | 0.006 | Nil | 0.001 |
| Nickel | 0.008 | 0.004 | Nil | Nil | 0.001 | Nil | Nil | Nil |
| Cobalt | 0.001 | 0.001 | 0.5 | Nil | Nil | Nil | Nil | 0.005 |

**Table 4.2. BIOLOGICAL TEST OR E-COLI TEST**

| | |
|---|---|
| Surface water (1) | + v |
| Surface water (2) | + v |

| | |
|---|---|
| Surface water (3) | -v |
| Underground water (1) | Nil |
| Underground water (2) | Nil |
| Underground water (3) | Nil |
| Underground water (4) | Nil |
| Underground water (5) | Nil |

## CONCLUSION AND RECOMMENDATION

There is need to regularly monitor groundwater levels, quality, and recharge rates within the Formation to guide sustainable extraction practices. Promote the use of water-efficient technologies and methods in agriculture and urban development to alleviate the strain on groundwater reserves. Applying advanced geological and geophysical techniques to gain a deeper understanding of the Formation's reservoir properties, such as porosity, permeability, and fluid dynamics. Design foundations that take into account the specific characteristics of the Nanka and Ogwashi Formations to improve stability and reduce the risk of settlement or structural failure. Establish long-term groundwater and environmental monitoring initiatives to observe changes in water quality and levels, especially in regions affected by mining and hydrocarbon extraction. Develop and enforce regulations that address contamination risks from coal seams and industrial processes, ensuring the protection of groundwater resources.

Involve local communities in discussions about water resource management and environmental sustainability, fostering stewardship and raising awareness. Provide stakeholders with training and tools on sustainable practices for groundwater use, resource extraction, and ecosystem conservation. Encourage collaboration between government bodies, private sector players, and local communities to develop a unified approach to managing water, hydrocarbons, and land use. Adopt an ecosystem-based management strategy that accounts for the interconnected nature of groundwater, surface water, and ecosystems, ensuring a holistic and sustainable approach to resource management.

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