Journals Pub

International Journal of
Geological and Geotechnical Engineering

ISSN: 2581-5598
Volume 10, Issue 2, 2024
July-December
DOI (Journal): 10.37628/IJGGE

https://journalspub.com/journal/ijgge/

Research IJGGE

Groundwater Exploitation in the Base Complex of Ado-Ekiti: Sustainability Issues and Future Directions

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Abstract

Water is an essential and irreplaceable resource necessary for sustaining life, and in a diverse and populous country like Nigeria, the sustainable management of groundwater resources is of critical importance. This paper explores the current groundwater utilization practices in Ado-Ekiti, a rapidly growing urban area, and presents strategies aimed at ensuring the long-term sustainability of these vital resources. The study analyzes several key factors affecting groundwater resources, including geological formations, water quality, community involvement, existing regulatory frameworks, the role of technological advancements, economic considerations, and potential challenges to sustainable management. A comprehensive approach was employed, incorporating the use of remote sensing technologies and Geographic Information System (GIS) techniques to optimize groundwater management practices in Ado-Ekiti, which is located in the southwestern part of Nigeria. The region's challenging hard rock terrain complicates groundwater exploration, making innovative methods essential. To address this, Landsat satellite imagery was utilized to assess land use patterns, land cover changes, and to identify geological features indicative of potential groundwater sources. The study suggests adopting a range of sustainable practices, such as rainwater harvesting, managed aquifer recharge, improved well construction techniques, and the deployment of advanced groundwater monitoring systems. These practices are coupled with an emphasis on maintaining high water quality standards to ensure a continuous and reliable supply of clean water for the community. Ultimately, the study underscores the importance of a holistic and integrated approach to groundwater management, combining technology, community participation, and regulatory measures to safeguard the future availability of groundwater in Ado-Ekiti.

Keywords: Groundwater sustainability, Ado-Ekiti, rainwater harvesting, water quality, sustainable management

INTRODUCTION

As the most populous country in Africa, Nigeria's varied landscape includes arid northern regions, lush forests, and a coastal belt. The issue of over-extracting groundwater has become a topic of global concern. Groundwater plays a significant role in Nigeria's economic growth, environmental health, and public well-being. It is a key source of drinking water, particularly in rural areas where other water sources may be scarce, and supports agriculture, industrial processes, and ecosystems. With the country's ongoing urbanization and rapid population growth, the demand for sustainable groundwater management is becoming more pressing. Factors such as the composition of the subsoil, geological formations, and availability of water resources are crucial in determining the potential for groundwater

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Received Date: August 02, 2024
Accepted Date: October 22, 2024
Published Date: October 30, 2024

Citation: Oluwadare Joshua Oyebode. Groundwater Exploitation in the Base Complex of Ado-Ekiti: Sustainability Issues and Future Directions. International Journal of Geological and Geotechnical Engineering. 2024; 10(2): 21–27p.

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extraction [1–3]. To accurately assess groundwater resources, a systematic and well-structured methodology is necessary. This paper evaluates various approaches for assessing groundwater potential, aiming to identify practical techniques for sustainable management. Groundwater is an integral part of the water cycle, involving the continuous movement of water between oceans, the atmosphere, and land surfaces. In Ado-Ekiti, a city in Ekiti State, groundwater is a primary source of drinking water. However, increased population growth and urban development are placing pressure on this critical resource, making sustainable management practices necessary to maintain a reliable water supply and protect the environment. This study provides a comprehensive analysis of sustainable groundwater practices in Ado-Ekiti [4–7].

LITERATURE REVIEW

Geological and geographical factors play a critical role in determining the sustainability of groundwater use in Ado-Ekiti. Understanding these aspects is essential for effective groundwater management. The following geological and geographical elements affect groundwater use in the region:

Geological Factors

- *Subsoil characteristics:* The geological map of Ado-Ekiti (Figure 1) illustrates how the subsoil composition influences groundwater availability. Permeable materials like sand and gravel allow water to be stored underground more effectively. For proper water resource management, understanding the distribution and characteristics of these materials is vital [8].
- *Rock formations:* Different types of rock formations in Ado-Ekiti, such as Precambrian basement rocks, exhibit various levels of permeability. While some rocks may serve as aquifers, storing and transmitting water, others may act as barriers, thus affecting groundwater movement and availability [9].
- *Lithological composition:* The type of subsurface material affects groundwater flow and storage. Sedimentary rocks, for example, may have porous areas that contain significant amounts of groundwater, whereas igneous and metamorphic rocks are usually less permeable. Analyzing the lithology is essential to identify groundwater-rich zones [10].
- *Faults and fractures:* Geological faults and fractures can either facilitate or restrict groundwater flow. Their location and orientation need to be well understood to implement sustainable groundwater management strategies effectively [11].

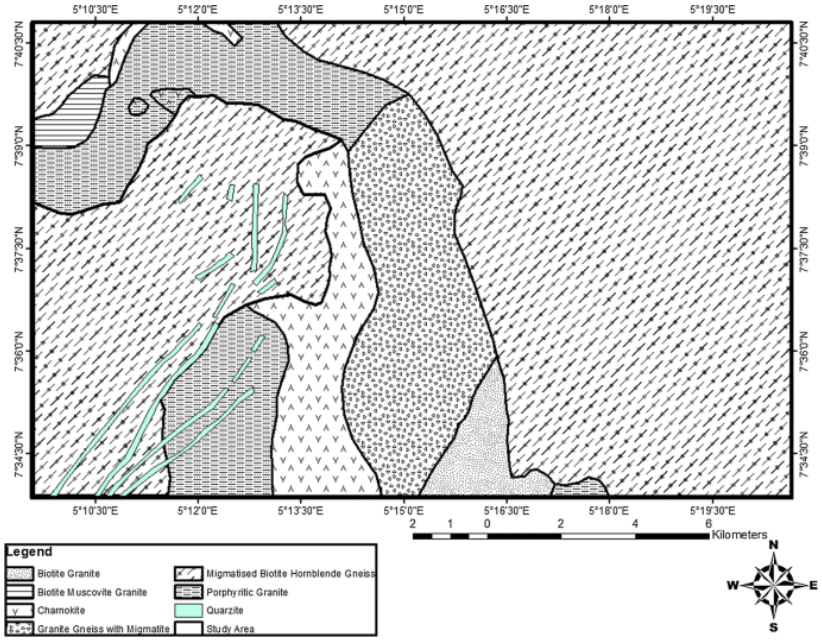

Figure 1. Geological map of Ado-Ekiti.

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Geographical Factors Influencing Groundwater in Ado-Ekiti

Topography

The physical landscape of Ado-Ekiti plays a crucial role in groundwater movement and replenishment. Higher elevations can act as zones for aquifer recharge, where rainwater seeps into the ground. In contrast, lower areas may serve as discharge zones, where groundwater appears as springs or contributes to streams [12].

Climate

The region's rainfall patterns significantly affect groundwater availability, as sufficient precipitation is needed to replenish underground water reserves. The intensity and timing of rainfall should be considered to evaluate the long-term sustainability of groundwater use [13].

Surface Water Interaction

Rivers, lakes, and streams in the area can influence groundwater levels and quality. The interaction between these surface water bodies, and underground aquifers is vital for managing the region's water resources [14].

Land Use and Vegetation

The type of land cover, such as forested areas versus urban zones, impacts groundwater recharge rates. Natural vegetation enhances water infiltration, while urbanization often reduces recharge and introduces pollutants.

Proximity to Coastal Areas

For regions near the coast, seawater intrusion can compromise groundwater quality, necessitating careful management of groundwater resources in these areas.

In Ado-Ekiti, understanding these factors is essential for sustainable groundwater management. Thorough geological surveys, hydrogeological studies, and continuous monitoring of water quality and levels are necessary to make informed management decisions. This is particularly important considering the region's population growth and associated environmental pressures.

The Geological Foundation of Ekiti State University

Ekiti State University is situated in southwestern Nigeria on Precambrian basement rock formations. The university depends on a combination of groundwater, surface water, and rainfall for its water supply. In tropical regions, natural weathering processes create surface layers with varying porosity, which can form reliable aquifers if they have suitable thickness and characteristics.

Beneath these surface materials, the basement rock may contain fractures and fault lines resulting from previous tectonic activity. Identifying these structures is crucial for locating groundwater zones in such a geological setting. The primary water sources in this environment are the weathered zones and the fractures within the rock, as the basement rocks themselves lack significant porosity. Groundwater is typically found in unconfined conditions near the surface and in semi-confined conditions in deeper fractures.

Previous Research on Sustainable Groundwater Use in Ado-Ekiti

Past studies have provided insights into the hydrogeological conditions, water quality, and groundwater availability in the region. Key themes include:

Hydrogeological Characteristics

Research has identified various types of aquifers and their distribution, aiding in the identification of areas with sustainable groundwater potential.

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Water Quality Assessments

Evaluations of groundwater quality, including parameters like pH and conductivity, are essential for ensuring water safety.

Recharge Mechanisms

Studies have examined how factors such as rainfall and land use affect groundwater recharge, which is critical for maintaining adequate water levels.

Over-Extraction and Declining Water Tables

Excessive groundwater extraction in some areas has led to decreasing water tables, impacting both water availability and environmental health.

Hydrogeological Mapping

Maps produced by these studies serve as valuable tools for planning sustainable groundwater use.

Community Involvement

Engaging local communities in groundwater management is crucial for sustainable practices.

Urbanization and Pollution

The impact of urban growth on groundwater resources, including land use changes and pollution risks, has been studied.

Climate Change Impacts

Research has considered the potential effects of climate change on groundwater recharge and availability.

Innovative Techniques

New technologies for groundwater management, such as aquifer recharge and water modeling, have been explored.

Sustainable Groundwater Management Practices in Ado-Ekiti

To ensure sustainable water use in Ado-Ekiti, the following practices should be implemented:

Groundwater Monitoring

Regular monitoring of water levels and quality is essential for early problem detection and informed decision-making.

Rainwater Harvesting

Encouraging the use of rainwater for nondrinking purposes reduces the strain on groundwater.

Efficient Irrigation

Using water-efficient agricultural practices helps minimize reliance on groundwater.

Pollution Prevention

Measures should be taken to prevent groundwater contamination from industrial and agricultural activities.

Community Engagement

Involving local communities in conservation efforts increases awareness and promotes sustainable practices.

Government Regulations

Clear policies and enforcement mechanisms are needed to regulate groundwater use.

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Technological Innovations

Real-time monitoring and advanced water management tools can improve groundwater management.

Economic Considerations

Cost-effectiveness and the economic benefits of sustainable practices should be considered in management decisions.

Educational Programs

Educating the public on groundwater issues fosters responsible use.

Protection of Recharge Areas

Preventing harmful land-use changes in recharge zones helps maintain groundwater levels.

Research Methodology for Groundwater Study in Ado-Ekiti

The study utilized remote sensing and GIS techniques to optimize groundwater development. Landsat satellite images were used for land use mapping, while the Shuttle Radar Topographic Mission provided data on drainage, slopes, and geomorphology. Thematic maps were created and integrated using GIS software to produce a groundwater potential map validated against existing data.

Legal and Policy Considerations for Groundwater Management

Nigeria's Land Use Act of 1978 governs land and mineral resource ownership but lacks clear guidelines for groundwater management. To protect groundwater, it should be given similar legal status as other valuable resources like gold. Licensing for well ownership should be implemented with added responsibilities, such as data sharing and professional standards for well drilling.

Recommendations for Improved Water Management

Nigeria should upgrade its water resource data management, collaborate with federal and state water agencies, and complete comprehensive hydrogeological mapping. Proper management of surface water will alleviate pressure on groundwater resources. Strengthening institutions and enforcing regulations will enhance resource utilization and help achieve sustainable water management.

CONCLUSIONS

Ado-Ekiti's dependency on groundwater requires sustainable management strategies, such as rainwater harvesting, better well construction practices, and community involvement. By addressing existing challenges and implementing effective practices, the region can ensure long-term water security and environmental protection.

Recommendation

1. Comprehensive Hydrogeological Studies: Conduct detailed hydrogeological studies to understand the aquifers, groundwater flow patterns, and recharge sources in the Ado-Ekiti area. These studies will help identify sustainable yield and suitable well locations.
2. Regular Monitoring and Data Collection: Establish a groundwater monitoring network to collect data on water levels, quality, and aquifer behavior. Regular data collection is essential for informed decision-making.
3. Well Spacing and Location: Implement guidelines for well placement, ensuring that wells are spaced appropriately to avoid interference and the creation of cones of depression. Avoid drilling wells in low-lying areas to prevent contamination.
4. Water Quality Protection: Implement strict regulations and monitoring to protect groundwater quality. Prevent the discharge of pollutants, chemicals, and waste into areas near wells or recharge zones.

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5. Community Awareness and Education: Educate the community about the importance of sustainable groundwater management and the need for conservation. Encourage responsible water use practices.
6. Water Conservation Measures: Implement water conservation programs that promote efficient use of groundwater, especially in agriculture and domestic settings.
7. Legislation and Regulation: Develop and enforce local groundwater management regulations and standards to control drilling, well construction, and abstraction. Include penalties for violations.
8. Licensing and Permitting: Introduce a permitting system for well construction and groundwater abstraction, ensuring that only licensed drillers can operate in the area.
9. Diversify Water Sources: Encourage the use of alternative water sources, such as rainwater harvesting, surface water reservoirs, and treated wastewater for non-potable purposes, reducing the reliance on groundwater.
10. Emergency Response Plan: Develop a contingency plan to address groundwater emergencies, such as well failures, contamination incidents, or droughts.
11. Collaboration and Stakeholder Engagement: Collaborate with local communities, government agencies, NGOs, and academic institutions to promote sustainable groundwater management and share expertise.
12. Research and Innovation: Support research initiatives focused on groundwater management, aquifer recharge, and innovative technologies for water treatment and conservation.
13. Regular Maintenance and Rehabilitation: Ensure that existing wells are properly maintained and rehabilitated as needed to prevent losses in well efficiency and quality.

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