

Isolation and Identification of Bacteria in Soil Samples in the Sub-Saharan Region of Sokoto, Nigeria

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Abstract

This study investigates the isolation and identification of bacterial species in soil samples from the Gwadabawa region of Sokoto, Nigeria, focusing on their potential roles in hydrocarbon exploration and degradation. Soil samples were collected, prepared, and analyzed using microbiological methods, including serial dilution, Gram staining, and biochemical assays. The identified bacterial species include *Enterococcus faecalis*, *Proteus mirabilis*, *Bacillus pumilus*, *Bacillus anthracis*, and *Kingella kingae*. Among these, *Enterococcus faecalis* and *Proteus mirabilis* were the most prevalent, accounting for 29% and 28% of the isolates, respectively. These bacteria exhibit characteristics indicating hydrocarbon-rich subsurface conditions, making them valuable for exploration efforts. Factors such as soil pH and texture influence microbial activity, favoring the growth of certain bacteria. This study highlights the potential of indigenous microbial species in hydrocarbon exploration and suggests biostimulation and bioaugmentation as strategies to optimize microbial applications in exploration and bioremediation processes.

Keywords: Hydrocarbon Exploration, Microbial Diversity, Bioremediation, Soil Bacteria, *Enterococcus faecalis*

INTRODUCTION

Soil is a fundamental component of ecosystems, playing a pivotal role as a reservoir for microbial communities that drive essential processes such as nutrient cycling, plant growth, and pollutant degradation. In sub-Saharan Africa, where agriculture and natural resource management underpin economic sustainability, the study of soil microbial diversity is of critical importance. Among these microbial communities are bacteria capable of performing vital ecological functions, including bioremediation; the natural breakdown of environmental contaminants such as hydrocarbons (Mekonnen *et al.*, 2024).

Petroleum hydrocarbons serve as indispensable energy sources but often contribute to widespread soil contamination, particularly in regions with significant industrial activities (César *et al.*, 2024). Sokoto State in Nigeria exemplifies this challenge, as increasing hydrocarbon contamination poses a growing environmental and public health concern. The degradation of hydrocarbons is predominantly facilitated by microbial communities whose effectiveness depends on the physicochemical properties of the soil (Pandolfo *et al.*, 2023).

In recent years, microbial prospecting has gained prominence as a critical tool for both oil exploration and environmental remediation (Lirette *et al.*, 2024). Identifying and characterizing bacterial species capable of metabolizing petroleum hydrocarbons not only advances our understanding of microbial mechanisms in pollution mitigation but also offers practical solutions to environmental challenges. This study focuses on isolating and identifying bacterial species from soil samples collected in Gwadabawa, Sokoto State. The research aims to elucidate the roles these bacteria play in degrading petroleum hydrocarbons, contributing to both scientific knowledge and potential bioremediation strategies.

MATERIALS AND METHODS

Soil samples were collected from the top layer (0–15 cm depth) at various locations in Gwadabawa Local Government Area. Each sample was labeled, placed in pre-sterilized polythene bags, and transported to the Microbiological Laboratory at Usmanu Danfodio

University. Various culture media were prepared according to manufacturer instructions and sterilized via autoclaving.

The analysis involved serial dilution and the pour plate method for bacterial culturing followed by incubation. The cultured bacteria underwent macroscopic and microscopic characterization through Gram staining. Biochemical tests such as Simmon's Citrate, Indole, Methyl Red, Oxidase, Catalase, Urease, and Glucose Utilization tests were performed to identify the bacterial isolates.

RESULTS AND DISCUSSION

Table 1: Frequency of Occurrence of Bacterial Isolates in Gwadabawa

Identified isolate	Frequency of occurrence	Percentage of Frequency of occurrence (%)
<i>Bacillus arthracis</i>	1	14
<i>Enterococcus faecalis</i>	2	29
<i>Proteus mirabilis</i>	2	28
<i>Bacillus pumilus</i>	1	14
<i>Kingella kingae</i>	1	14

The data highlights that *Enterococcus faecalis* and *Proteus mirabilis* were the most frequently occurring isolates, each representing 29% and 28% of the total isolates respectively. These bacteria were dominant among the isolates indicating their relatively higher prevalence.

The bacterial isolates identified play significant roles in hydrocarbon degradation. Hydrocarbon degradation is a critical process in contaminated environments where bacteria act as primary agents for breaking down hydrocarbons into less harmful compounds.

Enterococcus faecalis and *Proteus mirabilis* have been reported in previous studies to exhibit potential for hydrocarbon degradation. For instance, *Enterococcus faecalis* is a facultative anaerobe capable of surviving under low-oxygen conditions often found in hydrocarbon-polluted soils. It contributes to the initial breakdown of hydrocarbons particularly in environments where aerobic bacteria are less active (Castañeda Chávez *et al.*, 2024).

Similarly, *Proteus mirabilis* is a versatile bacterium often associated with contaminated environments; it can utilize hydrocarbons as a carbon source contributing to their breakdown through enzymatic processes (Ghosal *et al.*, 2016).

The presence of *Bacillus anthracis* and *Bacillus pumilus* is significant as *Bacillus* species are well-documented hydrocarbon degraders. These bacteria produce extracellular enzymes such as lipases, proteases, and oxygenases facilitating the breakdown of hydrocarbon chains into simpler less toxic compounds (Khaliq, 2023).

The detection of *Kingella kingae* is less common in hydrocarbon degradation studies; however, as a facultative anaerobe it may participate in hydrocarbon breakdown under oxygen-limited conditions.

Limitations and Future Directions

While this study provides valuable insights into the microbial community's potential for hydrocarbon degradation it also acknowledges certain limitations. The relatively low diversity of bacterial isolates may restrict the overall effectiveness of bioremediation strategies. Future research should focus on expanding microbial analyses in hydrocarbon-prospective regions to identify additional bioindicator species. Regular assessments of soil conditions such as pH and organic matter content—are essential to correlate these factors with microbial activity.

Societal Relevance and Policy Recommendations

The implications of this research extend beyond scientific inquiry; they hold significant relevance for local communities facing environmental challenges due to hydrocarbon contamination. Implementing bioremediation strategies informed by microbial diversity can enhance soil health and support sustainable agricultural practices. Policymakers should consider integrating microbial studies with traditional exploration techniques to develop comprehensive site assessments that address both environmental protection and resource management.

CONCLUSION

The bacterial isolates identified in Gwadabawa have the potential to contribute to hydrocarbon degradation particularly *Enterococcus faecalis*, *Proteus mirabilis*, and *Bacillus* species. These findings suggest that the microbial community in the region is well-adapted to conditions favorable for hydrocarbon breakdown. However the low diversity of other isolates underscores the need for further investigation to enhance microbial activity for efficient hydrocarbon remediation in the area.

Recommendations

Detailed microbial analyses in hydrocarbon-prospective regions should be conducted to identify bioindicator species while regular assessment of soil conditions such as pH and organic matter is essential to correlate these factors with microbial activity. Combining microbial studies with traditional exploration techniques can provide comprehensive site assessments; investing in research and development on microbial-hydrocarbon interactions will enhance exploration methodologies.

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