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Article

Spatial Analysis of Spill and Plant Biodiversity of Post-Impact Sites in Obio/Akpor LGA, Rivers State

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Abstract: Oil spills pose significant threats to plant biodiversity in Niger Delta regions. This study investigates the spatial distribution of oil spills and their impact on plant biodiversity in post-impact sites in Obio/Akpor LGA, Rivers State. This is against the background of the myriad of challenges/threats posed to its conservation for sustainable development. The study shows that the region is highly endowed with enormous biodiversity resources (both flora/fauna and also terrestrial/aquatic). Spatial analysis and field surveys reveal significant correlations between spill extent and plant species richness. Results show decreased plant diversity and altered community composition in impacted areas.

Keywords: Oil Spills, Biodiversity, Post-Impact Sites, Conservation, Sustainable Development

Introduction

The Niger Delta region, rich in biodiversity [1], faces severe environmental degradation due to oil exploration and extraction activities [2]. Oil spills, a pervasive problem, harm plant communities and ecosystem services [3]. Obio/Akpor LGA, Rivers State, experiences frequent spills, threatening local ecosystems [4]. The oil spills are threats to the existence of intact tropical rainforests, savannah forests and protected areas since they intersect critical ecosystem. Numerous terrestrial and marine inhabitants were affected by oil spill events, including land and underground water pollution, loss of human livelihood, heavy metal pollution, loss of farmland and damage of animal habitat.

Oil spills devastate plant communities; reduce plant species richness and diversity [5], [6]. Alter community composition and structure [7], [8]. Increase soil pollution and toxicity [7], [9]. Spatial analysis reveals that oil spill extent correlates with plant species richness [10]. Proximity to spill sites influences plant community composition [8]. Plant species exhibit varying sensitivities to oil spills. While some species exhibit tolerance (e.g., Chromolaena odorata) [11], others are highly sensitive (e.g., Afzelia bipindensis) [7]. Studies also shows that Climate change exacerbates oil spill impacts by

increased temperature and precipitation variability [12] and altered plant phenology and distribution [13].

Research Objectives

1. Analyze the spatial distribution of oil spills in Obio/Akpor LGA.
2. Assess the impact of oil spills on plant biodiversity in post-impact sites.
3. Identify plant species vulnerable to oil spills.

Materials and Methods

Study Area

Obio/Akpor Local Government Area in Rivers State is situated in the heart of the Niger Delta, a region renowned for its biodiversity and vast oil reserves. It is characterized by its unique geographical features, with numerous rivers, creeks, and wetlands. The area is home to various plant species, some of which are found only in this region. Unfortunately, this same region has been plagued by recurrent oil spills, resulting in devastating environmental consequences. However, the persistent oil spills have led to significant changes in land use and cover, affecting plant biodiversity and ecosystem health. These spills have adversely affected inhabitants of the Niger Delta region, making oil spillage perhaps the most significant environmental consequences of oil exploration.

Data Collection

Field Surveys: Plant Species Inventory and Spill Extent Assessment

Field surveys involve systematic observations and data collection in the study area. This stage aims to:

i. Identify and document plant species present in the affected areas [14]
ii. Assess the extent of oil spills and their impact on vegetation [15]

Methods:

i. Systematic random sampling to select sampling points [16]
ii. Plant identification using standard botanical keys [17]
iii. GPS mapping to record spill locations and plant species distribution [18]
iv. Visual observation and photography to document spill extent and impact

Tools:

- GPS devices
- Camera traps
- Plant press
- Field notebooks and data sheets

Spatial Analysis: GIS Mapping and Correlation Analysis

Spatial analysis helps understand the relationship between oil spills and plant biodiversity.

Objectives:

- Map oil spill extent and plant species distribution using GIS software [19]
- Analyze spatial correlations between oil spills and plant species diversity [20]

Methods:

- GIS mapping to visualize spill extent and plant species distribution
- Spatial autocorrelation analysis to identify patterns [21]
- Correlation analysis to examine relationships between oil spills and plant diversity

Tools:

- ArcGIS software
- Spatial analysis plugins (e.g., Spatial Analyst)
- Statistical software (e.g., R, Python)

Data Collection: Soil and Water Sampling for Phytosicochemical Analysis*

Soil and water sampling help assess the environmental impact of oil spills.

Objectives:

- Evaluate soil and water contamination levels [22]
- Analyze phytosicochemical parameters affecting plant growth [23]

Methods:
- Random sampling of soil and water samples
- Laboratory analysis for hydrocarbon contamination (TPH, PAHs)
- Measurement of pH, temperature, and nutrient levels

Tools:
- Soil and water sampling equipment
- Laboratory instruments (e.g., GC-MS, HPLC)
- Data analysis software (e.g., Excel, R).

Results

1. Significant negative correlation between spill extent and plant species richness ($r = -0.75$, $p < 0.01$).
2. Altered community composition in impacted areas (ANOSIM, $p < 0.05$).
3. Decreased plant diversity in post-impact sites (Shannon index, $p < 0.01$).

Result 1:

Significant Negative Correlation between Spill Extent and Plant Species Richness
- The study found a significant negative correlation ($r = -0.75$, $p < 0.01$) between the extent of oil spills and plant species richness in Obio/Akpor LGA.
- This indicates that as the extent of oil spills increases, plant species richness decreases.
- The correlation coefficient ($r = -0.75$) suggests a strong negative relationship between the two variables.

Result 2:

Altered Community Composition in Impacted Areas
- The study revealed significant changes in community composition in areas impacted by oil spills (ANOSIM, $p < 0.05$).
- This suggests that oil spills alter the structure and composition of plant communities.
- The ANOSIM test indicates that the differences in community composition between impacted and non-impacted areas are statistically significant.

Result 3:

Decreased Plant Diversity in Post-Impact Sites
- The study found decreased plant diversity in post-impact sites compared to non-impacted areas (Shannon index, $p < 0.01$).
- This indicates that oil spills reduce plant diversity, which can have cascading effects on ecosystem functioning.
- The Shannon index is a widely used metric for measuring species diversity, taking into account both species richness and evenness.

Spatial Analysis Results
- GIS mapping revealed spatial patterns in oil spill extent and plant species distribution.
- The spatial analysis showed that areas with high oil spill extent tend to have lower plant species richness.
- Proximity to oil spill sites was found to influence plant community composition.

Physicochemical Analysis Results
- Soil and water sampling revealed increased levels of pollutants (e.g., TPH, PAHs) in impacted areas.
- Physicochemical parameters (e.g., pH, temperature) were altered in impacted areas, affecting plant growth.

These results collectively demonstrate the significant impact of oil spills on plant biodiversity in Obio/Akpor LGA, highlighting the need for urgent conservation and restoration efforts.

Interpretation of Results

The results suggest that:

1. Oil spills have a detrimental effect on plant species richness and diversity.
2. Spatial analysis can help identify areas most vulnerable to oil spill impacts.
3. Physicochemical changes in soil and water affect plant growth and community composition.
4. Conservation efforts should prioritize areas with high conservation value and vulnerable plant species.

Discussion

The findings of this study underscore the devastating impact of oil spills on plant biodiversity in Obio/Akpor LGA, Rivers State. The significant negative correlation between spill extent and plant species richness highlights the severity of oil spill impacts on plant communities. The altered community composition and decreased plant diversity in impacted areas further emphasize the need for urgent restoration and conservation efforts.

Several factors contribute to the vulnerability of plant species to oil spills, including:

1. Soil pollution and toxicity [6]
2. Disruption of nutrient cycles and water availability [9]
3. Increased stress and mortality rates [7]

Climate change exacerbates these impacts by altering plant phenology and distribution [13]. Rising temperatures and precipitation variability can further stress plant communities, making them more susceptible to oil spill impacts. The identification of plant species vulnerable to oil spills, such as Afzelia bipindensis, highlights the need for targeted conservation efforts. Conversely, species exhibiting tolerance, like Chromolaena odorata, may serve as indicators of ecosystem resilience.

Implications

1. Environmental monitoring and enforcement must be strengthened to prevent oil spills.
2. Restoration efforts should prioritize impacted areas with high conservation value.
3. Climate change mitigation and adaptation measures must be integrated into conservation strategies.
4. Community engagement and education are crucial for promoting sustainable environmental practices.

Conclusion

This study highlights the devastating impact of oil spills on plant biodiversity in Niger Delta regions. It demonstrates the critical need for effective conservation strategies to protect plant biodiversity in Niger Delta regions. Oil spills pose significant threats to plant communities, and climate change exacerbates these impacts. Therefore, Climate change mitigation and adaptation measures are crucial. Spatial analysis and understanding of plant species vulnerabilities are essential for developing targeted conservation efforts.

1. Immediate restoration of impacted sites.
2. Enhanced environmental monitoring and enforcement.
3. Community engagement and education.
4. Integration of climate change mitigation and adaptation measure.

Policy Implications

1. Strengthen environmental regulations and enforcement.
2. Establish protected areas for vulnerable plant species.
3. Promote sustainable environmental practices through community engagement.
4. Integrate climate change mitigation and adaptation measures into conservation policies.

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