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Review Article

Assessment of Petroleum Exploration Activities and their Environmental Impacts on Soil, Water, and Livelihoods in the Niger Delta Region, Southern Nigeria

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Abstract

This paper synthesizes empirical evidence on the environmental and socioeconomic impacts of petroleum exploration and production in the Niger Delta, Southern Nigeria, focusing on soils, surface and groundwater, and local livelihoods. A review of field-based studies, environmental assessments and community surveys reveals pervasive hydrocarbon contamination (TPH, PAHs), elevated heavy-metal concentrations, and widespread degradation of mangrove and farmland soils. Contaminants migrate into surface waters and shallow aquifers, impairing drinking-water quality and fisheries. Empirical studies also document reduced agricultural yields, loss of fish catches, health complaints, and livelihood erosion—effects compounded by weak monitoring, delayed spill response and chronic seepage from aging pipelines. Remediation efforts (engineered excavation, bioremediation, phytoremediation) show variable success; cost, ecological sensitivity (mangroves) and governance deficits limit large-scale recovery. The synthesis concludes that meaningful restoration requires coordinated long-term remediation, rigorous monitoring, community engagement and strengthened regulatory enforcement. Priority actions include hotspot remediation, alternative livelihood support, and establishing transparent contaminant and health-monitoring systems.

Keywords: Engineered excavation, Bioremediation, Phytoremediation, health-monitoring systems.

BACKGROUND INFORMATION

The Niger Delta of southern Nigeria is one of the world's most petroleum-rich coastal deltas. Since the discovery of commercial oil in the 1950s, petroleum exploration and production have driven Nigeria's economy contributing large shares of export earnings, government revenue, and foreign exchange [11]. Exploration and production activities in the region include seismic surveying, drilling (onshore and offshore), construction of flowlines and access roads, installation of production platforms and wellheads, storage and loading facilities, and associated transportation (pipelines, barges, tankers). Upstream operations are often accompanied by downstream and midstream infrastructure, and by services and industrial activities that expand human settlement and economic activity around oil facilities [4].

While oil and gas operations have generated economic benefits at the national level, they have also produced a complex suite of environmental pressures at local and regional scales. Routine operational discharges, accidental oil spills, bush burning and gas flaring, produced water disposal, pipeline leakages, and poor waste management have led to contamination of soils and surface and groundwater bodies. Seismic operations and heavy equipment movement cause soil compaction and erosion; vegetation clearance and mangrove destruction alter hydrology and reduce ecosystem resilience; and chronic ambient air pollution (from flaring and fugitive emissions) affects human and ecological health [14].

These environmental changes directly undermine the primary livelihoods of many Niger Delta communities, which historically relied on artisanal fishing, small-scale farming, mangrove harvesting, and related activities. Contaminated soils reduce crop yields and food quality; oil in rivers and creeks kills fish and reduces fish catch; pipeline rights-of-way and booms disrupt access to fishing grounds and farmlands. Socioeconomic consequences include loss of income, food insecurity, increased poverty, migration, conflicts over scarce resources, and deterioration of public health (skin and respiratory conditions, potential long-term contamination of drinking water sources) [6].

Several institutional and governance factors compound the environmental problem: overlapping land and resource tenure, weak enforcement of environmental regulation, limited capacity of regulatory agencies, inadequate spill response and remediation, sometimes poor corporate environmental management, and insufficient inclusion of affected communities in decision-making and benefit sharing. There are also gaps in baseline environmental data, long-term monitoring, and independent scientific assessment making it difficult to quantify cumulative impacts and to design effective mitigation and restoration programs. Socially, perceived and real inequities in how oil revenue and compensation are distributed have produced grievances and social unrest in parts of the region [5].

This study therefore seeks to assess petroleum exploration activities in the Niger Delta and to quantify and qualify their environmental impacts on soil, water, and community livelihoods, with a view to informing policy, remediation priorities, and sustainable livelihood interventions.

Statement of the problem

Despite decades of oil and gas activity, many parts of the Niger Delta continue to suffer visible and systemic environmental degradation that undermines ecological functions and human wellbeing. The main elements of the problem are:

Recurrent oil spills, surface hydrocarbon deposits, and disposal of drilling and production wastes have altered soil physical and chemical properties reducing permeability, nutrient availability, and biological activity thereby impairing crop productivity and agroecological resilience.

Oil slicks, produced water discharges, and accidental leaks pollute rivers, creeks, and groundwater aquifers used for drinking, cooking, and irrigation. The contamination increases treatment costs, poses health risks, and reduces the availability of safe water for domestic and livelihood uses.

Oil in aquatic environments causes direct mortality of fishes and benthic organisms, reduces reproductive success, and degrades nursery habitats (mangroves, estuaries). This has led to reduced fish catches and income losses for artisanal fishers.

Loss of livelihoods, decreased food security, increased unemployment, and health issues (dermal, respiratory, and possibly longer-term chronic conditions) disproportionately affect vulnerable households. These outcomes contribute to poverty traps and social tensions.

There are gaps in regular environmental monitoring, slow or inadequate clean-up and restoration efforts after spills, poor enforcement of environmental regulations, and limited community participation in decision-making. Compounding this is inadequate baseline data and inconsistent impact assessment practices—making it difficult to measure cumulative and long-term effects.

While there are numerous case studies and reports of localized impacts, few comprehensive assessments synthesize the spatial extent of contamination, compare contamination levels with environmental standards, quantify livelihood losses, and propose prioritized, evidence-based remediation and livelihood restoration strategies.

Therefore, the problem is both environmental and socio-economic: petroleum exploration activities have demonstrable negative impacts on soils, water, and livelihoods in the Niger Delta, and current institutional, technical, and social responses are insufficiently effective to halt, remediate, or reverse these impacts at scale.

Jurisdiction of the study

This study is geographically and administratively situated in the Niger Delta region of southern Nigeria. For clarity and operational scope, the jurisdiction will cover the core Niger Delta states and selected coastal/adjoining areas where petroleum exploration and production activities are concentrated. The study area will include, but is not strictly limited to, the following states: Abia, Akwa Ibom, Bayelsa, Cross River, Delta, Edo, Imo, Ondo, and Rivers. Within these states the research will focus on representative local government areas (LGAs), riverine communities, and coastal zones that host petroleum exploration infrastructure (onshore and near shore pads, flowlines, terminals, and associated service facilities). The study will consider sites affected by documented oil spills, areas with active exploration and production operations, and nearby control (less-impacted) sites for comparative analysis. Administratively, the jurisdictional frame includes community, LGA, state, and federal levels recognizing the roles of the Nigerian Federal Government (including the Department of Petroleum Resources and relevant regulatory agencies), state environmental ministries, local government authorities and the oil companies operating within the region.

Aim of the study

To assess the environmental impacts of petroleum exploration activities on soil quality, water resources, and community livelihoods in the Niger Delta region of southern Nigeria, and to propose evidence-based mitigation, remediation and livelihood restoration strategies.

Objectives

1. To map and describe the types, spatial distribution, and intensity of petroleum exploration and production activities in the selected study areas of the Niger Delta.
2. To quantify contaminant concentrations (e.g., total petroleum hydrocarbons, PAHs, selected heavy metals) in soils and in surface and groundwater at impacted and control sites, and to compare these concentrations with national and international environmental standards.
3. To evaluate the effects of petroleum contamination on agricultural productivity and fishery yields by documenting crop performance, soil fertility indicators, and catch data from affected and less-impacted communities.
4. To assess the adequacy and effectiveness of current mitigation, spill-response, and remediation measures practiced by oil companies, regulatory agencies, and local communities, including timelines and outcomes of past remediation efforts.
5. To identify socio-economic, institutional, and technical barriers to effective environmental management and propose a prioritized set of policy, technical, and community-based interventions for pollution prevention, ecosystem restoration, and sustainable livelihood recovery.

Research questions

1. What are the current types, frequencies, and spatial distribution of petroleum exploration and production activities in the selected parts of the Niger Delta?
2. What are the levels and patterns of hydrocarbon and associated contaminant (e.g., heavy metals, total petroleum hydrocarbons, polycyclic aromatic hydrocarbons) concentrations in soils and surface/groundwater at impacted sites compared with control sites and established environmental standards?
3. How have petroleum exploration activities affected agricultural productivity, fishery yields, and other core livelihood assets (e.g., access to clean water, grazing grounds, mangrove resources) among affected communities?
4. How effective are existing mitigation, spill-response, and remediation practices (by oil companies, regulators, and communities) in reducing environmental contamination and restoring ecosystem services?
5. What institutional, socio-economic, and technical factors constrain effective environmental
6. management and sustainable livelihood recovery in the Niger Delta, and what locally-appropriate interventions would improve resilience and restoration outcomes?

EMPIRICAL REVIEW

Widespread hydrocarbon contamination of soils

Empirical field surveys consistently find elevated Total Petroleum Hydrocarbons (TPH) and PAHs in soils at spill sites and near pipelines; oiling often leads to surface crusts or tar residues that reduce soil porosity and fertility [3].

Heavy-metal accumulation in soils and sediments

Multiple studies report elevated Pb, Cd, Cr, Ni, Zn in sediments and soils adjacent to production facilities and illegal refining sites, with concentrations sometimes exceeding guideline values for agricultural soils 9% [5].

Surface-water contamination and ecology impacts

Grab-sampling of creeks and estuaries reveal hydrocarbon and metal contamination, reduced dissolved oxygen, and degraded aquatic habitats; these changes are linked to fish kill events and lower biodiversity in impacted channels.[4]

Shallow groundwater vulnerability

Studies that sampled domestic wells show hydrocarbons and, in some cases, heavy metals in shallow aquifers near spill sites; plume migration and seasonal flooding increase exposure pathways for communities relying on hand-dug wells [6].

Loss of mangrove functionality and reduced fisheries productivity

Empirical observations show oil-affected mangroves with reduced regeneration, root dieback, and declining benthic invertebrate populations, resulting in lower nursery function and declines in fish catches reported by fishers [12].

Soil biological impairment and reduced agricultural outputs

Field and laboratory assays indicate reduced microbial activity, nutrient cycling disruption, and lower crop yields on oil-contaminated farmland; some locations exhibit persistent productivity losses despite partial natural attenuation [15].

Chronic and episodic contamination from pipeline leaks and illegal refining

Empirical incident records and environmental sampling show that both acute large spills and chronic seepage from poorly maintained pipelines (plus artisanal refining) create long-term contamination hotspots requiring different remediation approaches [7].

Human-health signals and community-reported symptoms

Cross-sectional household surveys and clinic report frequently document skin disorders, gastrointestinal complaints and respiratory symptoms in impacted communities; however, long-term epidemiological causal attribution is limited by baseline data gaps [2].

Remediation outcomes are mixed: Engineered removal vs. bioremediation

Excavation and off-site treatment yield rapid contaminant reductions but are costly and disruptive; bioremediation and phytoremediation are cheaper but slower and less effective for weathered tars in anoxic mangrove soils. Empirical monitoring shows partial recovery where remediation was sustained [1].

Governance, monitoring and institutional shortfalls amplify impacts

Empirical analyses of incident response timelines, regulatory enforcement records and community interviews show delayed responses, inadequate baseline monitoring and poor transparency — factors that magnify environmental damage and reduce remediation effectiveness [1].

Summarized Methodology

Stage	Activity	Expected Output
1	Define objectives	Clear study purpose and scope
2	Delineate study area	Sampling map and site categories
3	Design data collection	Field & lab protocol
4	Conduct field sampling	Representative samples
5	Laboratory analysis	Contaminant data
6	Socio-economic survey	Livelihood and perception data
7	GIS mapping	Hotspot distribution maps
8	Data analysis	Statistical relationships
9	Impact evaluation	Severity ranking
10	Recommendations	Actionable policy and remediation plan

CASE STUDIES

Three detailed case studies — Assessment of petroleum exploration activities and their environmental impacts on soil, water and livelihoods in the Niger Delta, Nigeria

Case Study 1 — Ogoniland (including Ogale, Gokana area): chronic contamination and the UNEP assessment

Background

Ogoniland (Rivers State) is one of the most studied areas in the Niger Delta because of long-term, repeated oil pollution from pipeline leaks, operational discharges and artisanal refining. In 2011 the United Nations Environment Programme (UNEP) published a comprehensive environmental assessment of Ogoniland after wide concern about contamination of creeks, mangroves, surface water and groundwater [1]. The UNEP study collected thousands of samples from soils, surface waters, sediments and groundwater and documented high concentrations of hydrocarbons and toxic compounds in many locations.

METHODS

UNEP combined field surveys, >4,000 chemical analyses (soil, sediment, surface and groundwater samples), geospatial mapping, interviews and review of local health and socio-economic conditions. They mapped contaminant plumes and identified hotspots where total petroleum hydrocarbons (TPH), benzene and other polycyclic aromatic hydrocarbons (PAHs) exceeded safe screening levels [1].

Findings — soil & water

- ✓ Soils: surface and subsurface soils in many locations had TPH and PAH contamination well above guideline values; sediments and mangrove soils were heavily polluted and showed poor capacity to recover naturally.
- ✓ Groundwater & surface water: groundwater used for drinking in several communities was contaminated with hydrocarbons (including benzene) at levels posing human health risks; creeks and ponds showed widespread hydrocarbon contamination often persisting for years.

Findings — livelihoods & health

- ✓ Fisheries and agriculture were severely affected: fishing declines due to mortality and contamination of fish; farmland productivity reduced where oil smothered vegetation or altered soil properties [13]. The report linked environmental contamination with loss of income, food insecurity and increased health risks from contaminated water and seafood.

Remediation

UNEP recommended a long-term, large-scale remediation and restoration programme (including refinery waste removal, soil remediation, phytoremediation and groundwater treatment), immediate provision of safe water, health monitoring and capacity building [1]. The Ogoniland assessment has become a benchmark for policy and litigation and underpins plans for clean-up and community remediation funds.

Case Study 2 — Bodo (Rivers State): discrete large spills and destruction of traditional fisheries/farming

Background

Bodo (Bodo West, Rivers State) experienced two major oil spills in 2008 (and a subsequent spill reported later) from pipelines operated by Shell's former Nigerian subsidiary. These spills released large volumes of crude oil into mangrove creeks and intertidal areas that local communities depend on for fishing and agriculture. Bodo became the focus of litigation, detailed academic studies and community surveys documenting immediate and long-term impacts on livelihoods and ecosystems [3].

Methods

Researchers used a mixed approach: field sampling of sediments and water, household questionnaires and income surveys, repeat ecological surveys of mangroves and fisheries, remote sensing/landcover change analyses, and socioeconomic impact assessments. Some studies compared pre- and post-spill catch and income data.

Findings: soil & water

- ✓ Mangrove sediments and intertidal soils showed thick oil coatings and elevated hydrocarbon concentrations that persisted for years. Oil residues reduced oxygen exchange in sediments, altered microbial communities and impeded natural breakdown in anoxic mangrove soils.
- ✓ Surface water and shallow tidal creeks showed contamination that reduced water quality for fishing and subsistence use; analyses showed changes in benthic communities and fish mortality in affected reaches [1].

Findings — livelihoods & socio-economic impacts

- ✓ Fishing — the principal livelihood for many households — collapsed in many local areas after the spills. Studies document drastic declines in fish catches and related incomes, loss of processing/trading jobs, and knock-on effects on food security.
- ✓ Farming — where oil reached agricultural plots, crop failure and reduced soil fertility were reported. The spills therefore affected both income and subsistence food supplies.

Remediation

Bodo became prominent in litigation and advocacy: compensation cases, settlement processes, and calls for proper clean-up. The case highlighted how single large spills can cause concentrated, long-lasting harm to mangroves and livelihoods and how remediation, compensation and ecosystem restoration must be integrated [1].

Case Study 3 — Gas flaring and diffuse long-term impacts on soils, vegetation and livelihoods (e.g., Ogbia/Imiringi and other host communities)

Background

Besides oil spills, gas flaring is a chronic industrial practice in the Niger Delta that produces high heat, acidifying gases and soot over long periods. Numerous studies document how chronic gas flaring affects soils, vegetation, air and water quality, with consequences for crop yields and community health. Examples include community studies in Ogba/Immuring and regional reviews synthesizing many local studies [2].

Methods

Common methods include radial soil sampling at varying distances from flare sites (e.g., 200 m to 800 m), laboratory analyses of soil pH, organic matter, heavy metals and nutrient status; vegetation surveys (species richness, canopy damage), air quality monitoring where available, and socio-economic questionnaires on crop yields and health. Some studies combine remote sensing to detect vegetation stress [1].

Findings: soil & water

- ✓ Soil degradation: repeated exposure to heat and acid deposition reduces soil organic matter, alters pH, increases salinity in surface layers, and in some studies increases certain heavy metals in topsoils — all factors that reduce fertility.
- ✓ Vegetation: impaired growth, leaf scorch and reduced crop yields near flare sites; declines in species diversity in heavily exposed areas.
- ✓ Water: acid rain and increased particulate deposition can change the chemistry of surface waters and reduce suitability for irrigation or consumption in some micro-catchments [8].

Findings — livelihoods & health

- ✓ Reduced agricultural productivity near flare sites reduces household food production and income. Chronic exposure is also associated with respiratory and other health complaints in communities. The cumulative economic losses from lost crop yields and health costs are sizable.

Policy

Gas flaring reduction, capture and utilization, buffer planting, soil restoration measures and health interventions are recommended. The studies show that chronic, low-intensity industrial stressors (like flaring) produce spatially diffuse but persistent livelihood and ecosystem declines that require different remediation strategies than those used for acute spills [12].

Recommendations

1. **Establish a permanent, independent environmental monitoring network.**
   Fund and equip local, independent laboratories and community monitoring stations to regularly sample soil, water and air and publish open data to increase transparency and early detection of spills.
2. **Scale up scientifically guided remediation using best-practice techniques.**
   Prioritize UNEP-recommended remediation for the worst hotspots (e.g., engineered bioremediation, excavation/removal where necessary, sediment capping), with independent technical oversight and public reporting.
3. **Strengthen regulatory enforcement and penalties.**
   Enforce pipeline integrity standards, mandatory reporting of spills, and substantial penalties for negligence; tie enforcement outcomes to national oil licensing and permit renewals.
4. **Ban routine gas flaring and reduce fugitive emissions.**
   Accelerate implementation of existing flare-out commitments and invest in gas capture/utilization to reduce local air pollution and greenhouse gas emissions.
5. **Implement community-led compensation and livelihood restoration programs.**
   Develop transparent, timely compensation mechanisms and invest in livelihood diversification (aquaculture, agroforestry, small-scale processing) tailored by participatory assessments using SLF principles.
6. **Mandate biodiversity and ecosystem-service restoration (mangrove & wetland rehabilitation).**
   Prioritize mangrove restoration in heavily impacted estuaries to rebuild nursery habitats, stabilize sediments and improve fisheries recovery.
7. **Create a scientifically governed remediation fund with strong anti-corruption safeguards.**
   Ensure that funds for cleanup (national and company contributions) are managed transparently, with independent audits and community oversight panels to avoid misallocation. Recent investigations highlight governance risks that must be addressed.
8. **Strengthen emergency spill response capacity.**
   Invest in rapid-response teams, local equipment depots, and community training in containment and reporting to reduce the scale of damage from spills.
9. **Support local laboratory and technical capacity building.**
   Train and accredit regional labs to perform TPH, PAH, and heavy-metal analyses and develop standard operating procedures (SOPs) and QA/QC to ensure reliable data.
10. **Institutionalize long-term health surveillance.**
    Establish community health monitoring to track chronic conditions (respiratory, dermal, potential cancer markers) and link findings to remediation priorities and compensation claims.
11. **Promote transparency, community participation and rights to information.**
    Require oil companies and regulators to publish environmental monitoring results, remediation plans, and contracts; create accessible community forums for grievances and participatory decision-making.
12. **Invest in research and monitoring of cumulative and climate-linked impacts.**
    Support longitudinal research on cumulative contamination, interactions with sea-level rise and rainfall changes, and adaptive livelihood strategies—ensuring evidence feeds back into policy.

CONCLUSION

The Niger Delta exemplifies a complex intersection of resource wealth and local vulnerability. Empirical literature and on-the-ground assessments demonstrate that decades of petroleum exploration and production have left persistent contamination in soils, sediments and waterbodies, damaged fisheries and agricultural systems, and eroded the livelihoods and health of many coastal and riverine communities. Scientific assessments (notably UNEP’s Ogoniland report) and subsequent studies report contamination levels far exceeding safe thresholds in multiple locations, while governance and remediation efforts have been variably effective and, in some cases, hampered by poor oversight and mismanagement [7].

Addressing this problem requires integrated, evidence-based action: rigorous monitoring and transparent data, technically sound and independently overseen remediation, strengthened regulation and enforcement, meaningful community participation and compensation, and investment in livelihood recovery and public health surveillance. The recommended combination of technical remediation, institutional reform, and socio-economic interventions—guided by DPSIR and Sustainable Livelihoods thinking—offers a pathway to reduce environmental harm and rebuild resilient local economies. Without such integrated approaches, contamination and its human consequences are likely to persist, undermining both ecological integrity and social justice in the Niger Delta.

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