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# Seismic-Based Environmental Effects of Petroleum Exploration Activities in Parts of Tropical Forest Areas of Nigeria

**Madu Anthony Joseph Chinenyeze*, Ugwu Richard Ekene*, Agbo Christian Chukwudi*, Emmanuel Uzoechi****

*Department of Geology, College of Physical and Applied Sciences, Michael Okpara University of Agriculture Umudike, Abia State, Nigeria, **United Geophysical Nig. Limited

**Abstract:** ***Exploration activities generate a number of environmental impacts, positive and negative impacts. Provision of jobs for the community and other professionals, increase in commercial activities within the environment, engagement of youths in useful ventures, and award of contracts are the positive impacts of exploration activities within the site areas. Negative impacts also exist. They include waste generation, pollution, degradation of the environment and the associated effects on wildlife. Remedial actions are necessary in order to mitigate the challenges posed by the negative impacts. Pre-existing camp sites can be re-used in order to conserve the vegetation and associated wildlife; proper waste management, judicious and adequately directed use of chemicals, sealing of leakages and the compliance to shot-hole drilling procedures are the urgent measures that must be adopted in order to ensure a friendly and sustained Niger Delta and general tropical forest environment in Nigeria.***

**Keywords:** Environmental impacts, line-cutting, shallow drilling, mud-pits, blowouts, explosives, formation of craters

## 1. Introduction

The exploration and exploitation of petroleum resources as a prominent source of revenue has continued to grow at an increasing trend worldwide, not only in Africa, or in Nigeria, nevertheless, it has accompanying environmental consequences. Some basic environmental impacts of petroleum exploration activities which are depicted in Geophysical field activities and its closely related support services considered significant in this study. They comprise both field-based impacts, and office-based impacts that naturally spread out of office. The areas of direct waste generation and environmental degradation consequences are so prominent and conspicuous that standard procedures for environmental friendliness in the various operations are inevitable. Positive and negative impacts are contacted on the dry-land and on swamp terrains, and communities in hydrocarbon laden areas of the tropical forests of Nigeria. The positive impacts include provision of jobs for the community and other professionals, increase in commercial activities within the environment, engagement of youths in useful ventures, and award of contracts to both elders and youth leaders within the prospect areas. The negative impacts comprised the degrading of agricultural soils, deforestation, tree felling, mangrove felling, reduction of mangrove swamp forests heritage during line cutting, and bush clearing for camp setups, depletion of associated wild-lives/monkeys, and soil pollution from spillage of engine oil, diesel, PMS, and crude oils from vandalized wells or pipelines, where seismic lines serve as illegal accesses.

The enlarged spectrum of positive aspects consists of availability of jobs, increase of commercial activities in the host communities with small scale businesses, mini-markets, minor-contracts supplies to youth leaders, women leaders, some medium-level contracts to elders and spokesmen, thus, improving the economic well-being of the entire host communities. The compartment of the significant environmental degradation or challenges kicks-off the negative impacts which vary from one level of oil exploration to another. The early exploration stream starting from seismic survey line cutting which leaves lines' widths and cleared camp sites open, particularly in mangrove swamp terrains. The latter are re-planted or re-vegetated with seedlings from mangrove nurseries. A study by Salau[1] and Adeyemo[2] about the impact of oil and gas exploration and exploitation on agriculture showed sister-activities as having direct relationship between gas flaring and productivity-decline in agriculture as shown on Table-1 below.

**Table 1:** Relationship between Gas flaring and productivity-decline in Agriculture

| Distance of Farmland from Flare site | Percentage Loss in Yield of Crops |
|---|---|
| 200 meters | 100 percent |
| 600 meters | 45 percent |
| 1 Kilometer | 10 percent |

Source: Salau, 1993:19-22, Adeyemo, 2002:69

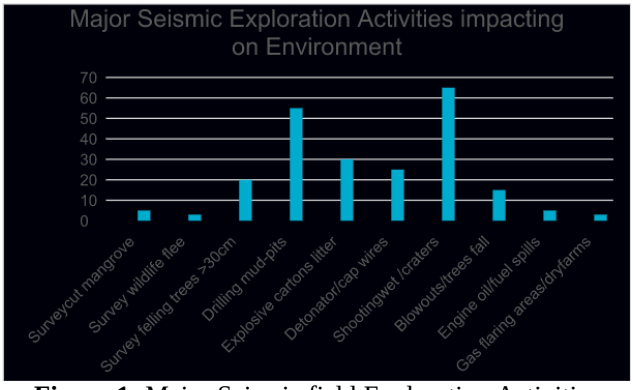


**Figure 1:** Major Seismic field Exploration Activities impacting on Environment

Other major sources of environmental impacts of seismic exploration activities consist of the following,

1. Materials and Energy
2. Waste Management
3. Use of Chemicals
4. Spills
5. Produced water (discharge from shot hole drilling) and
6. Shooting of explosives (dynamite)

There are procedures and standards and regulations put in-place in order to comply with International Management System as guideline for prevention and control of pollution and degradation of the environment. Nevertheless, some exploration activities inadvertently impact the immediate environment in such areas as lines cutting, bush clearing for camp sites and cutting of economic trees/cash crops by surveyors during line cutting. Geological hazards due to the instability of soil and rock masses, landscape degradation, and the extensive destruction of vegetation for access by seismic crew have been reported.[3, 4] The drilling of shallow holes for dynamite shooting for recording of seismic signals impacts on community farmlands. The impact is at varying degrees, ranging from degrading of farmlands, in which the near-surface of the ground is devalued with scattering of drillers' mud-pits along the seismic lines (for 2D operations) or source lines (for 3D or 4D operations), see Table-2. Water pits during special drilling of boreholes for drillers' water supply constitutes another level of drilling impact in large scale farmlands in the near-Savannah to Sahel NE Nigeria's Upper Benue Trough to Chad Basin where extensive large scale farming is common. Thus, landowners and communities are affected stakeholders.

In the tropical forest areas there is natural re-vegetation after line cutting and shooting activities, but in the mangrove forest swamps, the mangrove plants do not re-grow naturally. Hence it triggered off mangrove re-plantation projects sponsored by oil companies like Shell Petroleum Development Company, through engagement of Consultants / Contractors having nurtured mangrove Nurseries.

## 2. Objective

Though seismic industry puts in effort to manage its environmental impacts there are yet latent areas that require a lot of actions in order that petroleum exploration activities will not be seen as hostile or unfriendly to the tropical forest environment of Nigeria.

## 3. Methodology

The consequences of various aspects of exploration activities are evaluated to measure the significance level of the impact on the environment. The repetitive activities are monitored and evaluated for adequate attention to control Indicator-areas of environmental protection signatures.

## 4. Results Evaluation and Discussion

Use of Pre-existing camp sites

In the effort to restrain the magnitude of devastation of the tropical forest areas in the Niger Delta during line cutting and camp clearing the idea of re-use of Camp facilities previously occupied by other Department was adopted. Besides, camp facilities used by a road construction company or a drilling company

**Table 2:** Activities of Petroleum Exploration and Occurrences of Impact to the Environment

| No. | Exploration/Seismic Activities | Aspect of Environmental Impact | Consequences | Frequency per yr-project, (#/1000km) |
|---|---|---|---|---|
| 1 | Survey line cutting/clearing | Reduction thickness of mangrove forests | No natural regrowth, Open land space | 4 |
| 2 | Survey line cutting/clearing | Fleeing of wildlife e.g monkeys, antelopes, elephants | No refuge or change of habitat for wildlife, extinction | 2? |
| 3 | Survey line cutting/clearing | Felling of trees | Reduction of forest reserve (>30cm girth) | 20 |
| 4 | Drilling shot holes for explosives | Mud-pits for mixing bentonite/mud | Pits scattered all over bush | 55 |
| 5 | Pre-loading of explosives | Litter of dynamite cartons | Hazardous cartons in homes | 30 |
| 6 | Shooting dynamite on Source lines | Litter of detonator/cap wires | Youths picking cap wires for hats/ kids' caps | 25 |
| 7 | Shooting shallow shot holes, wet/flooded areas | Source lines/bush have craters / traps | Blowouts and craters on source lines | 65 |
| 8 | Shooting shallow shot holes | Air-blast due to untamped shot hole | Falling of dead wood or rotten trees | 15 |
| 9 | Base and Field mechanic workshops | Minor and major spills of engine oil / fuel | Soil contamination | 5 |
| 10 | Gas flaring at well sites (Sister-Petroleum Activity) | Drying of farm land | Black rain water/ carbonic acid in rains, low pH (i.e. acidic) | 5 |

IAGC Standard was published on tolerance limit for tree girth less than 30cm permitted for felling or cutting, whereas trees especially economic trees of higher girth than 30cm were not permitted for felling.

The procedure of re-use of pre-existing Camp sites was adopted in order to conserve the forest vegetation, and associated wildlife. This also allows the contemporary foliage sedimentation in the recent Niger delta. Several kilograms of cut-vegetation, grasses or foliation which will

sediment to fossilized petroleum source rocks in the next dozen of million yrs.

For purposes of compliance to "Best Practice" on environmental protection in the Niger Delta, the understated guidelines were stipulated for implementation at execution of projects.

Line cutting:

- Maintain maximum of 1m line width
- Not to cut down trees in excess of 30cm girth
- Re-plant trees on seismic lines where natural re-growth is not considered sufficient (e.g replanting of mangrove trees).

The volume of waste generation in the petroleum exploration takes a massive tonnage that every aspect required a review to work out effective ways of waste control or management. The chain of waste generation in petroleum exploration in the Niger Delta environment is complicated, but essentially starts from the planning stage, to office-based waste materials, paper wastes, and computer/IT-materials.

Management of Waste Generation

The population of workforce in the various sections of the petroleum exploration activities provoked commensurate or rather tremendous amount of food/kitchen wastes generated. Extremely high level of skilled planning was required to stock up food storage that would last for months in the camp, or in the marine vessel, sailing from one location to another. Control of food stuff and effectiveness of storage facilities affect the amount of perishable or biodegradable items, which constitutes high tonnage that are buried in wastes pits.

Reduction of wastage by controlled usage of materials, and enforcement of environmentally responsible disposal of wastes. Sewage pits for human wastes is a source of concern in the environmental management package in the area. Evacuation is managed in the swamp due to shallow water table, and contracted to third parties and evacuated to Local Government Approved sites in the dry land area. In effect, the grey water or sewage water is contained in sewage barges which are treated and certified environmentally friendly before disposal to approved sites.

Use of Chemicals

Different types of chemicals are used in the seismic operations, comprising paints for survey markings and building/refurbishing of camps, acids for fleet of vehicles' batteries. Another significant chemical used is the dynamite explosive, [2, 4, 6-Trinitro-Toluene (TNT)][5], Safety precautions are put in-place by the government as mandatory guidelines and the operating companies adopt procedures of operation, violation to which results in both fatal accidents and damage to the environment. Example of such damages incurred in the latter is the formation of craters during "blowouts" of explosive shots in wet or soft lands when the dynamite explosive was not buried to the stipulated drill depth/shot depth. In such cases also the blasting sound releases strong energy that shakes down rotten woods in the tropical forest terrain. Sometimes, undetonated explosives (due to misfire or "cap-only") are left to rot or decompose over time. The cumulative environmental effect if occurrence was in a large-scale, resulted in the recommendation for use of "Bio-degradable explosives". On the use of clay mineral based bentonite for flushing or drilling, water-based bentonite can be adopted.

Spills

Occurrence of spills had sometimes arisen from mechanic workshops where engine oils and fuels can spill in the course of refills, discharges, or evacuation and fuel transfers. High values of oil and grease has been reported in the study area and are far above the recommended limits[6] of between 0.01 and 0.1 mg $l^{-1}$ [7, 8] . Oil spillages are observed at well heads due to vandalization of facilities in obscure prospects. The vandals would want to hide under the cover of population of exploration workers, and presence of fleet of water crafts. Other spills include hazardous chemical substances, though controlled by compliance to safe storage and good operational control procedures.

Studies in oil spill have shown that physical, chemical and biological processes that depend on oil properties such as hydrodynamics, meteorological and environmental conditions govern the transport and fate of spilled oil in water bodies[9, 10]. It should be targeted to prevent spillages of all hazardous chemical substances by safe storage and compliance to good operational control procedures.

In addition, these goals will be achieved by implementing an HSE management system and through the realization of the following activities:

Shot hole drilling

Sometimes the array of mud-pits especially during single deep hole (SDH) programs constitutes significant environmental hazards. Remedial efforts are made after geophysical data acquisition to backfill or cover the mud-pits after shot hole flushing and prevent ground surface or soil degradation, besides the hazardous exposure to wildlife entrapment. In the course of single deep hole drilling, experiments were conducted to determine the depth to the water table or thickness of weathered layer, vadose zone. This derived information served as important guide for planning and programming shot hole drilling so as not to encroach into the aquifers. Thus, the integrity of the aquifer are not threatened.

Shot hole planning is also carried out according to operational procedure to ensure that shot holes were drilled at a minimum safe distance of 100m from structures and 200m from well heads also following EGASPIN standard.

Explosives

In the use of dynamite or explosive energy source, there were occurrences of decay of dynamite sticks due to long exposure to changing weather conditions, age of the explosive resulting to expiry status. The field practice adopts perforation of the life-stick so as to facilitate decay of dynamite sticks. There were occurrences of degradation of the environment with littering of detonator or cap wires. The formation of craters in wet areas and soft soils where shot hole depths are shallow, to the violation of specifications of the program issue. Operational procedures are worked in recent times to ensure that the craters are re-filled or backfilled at the completion of recording activity. The target to refill all craters formed at the explosion of dynamite of shallow pattern holes, is followed up to closeout of such environmental actions. Additional support can be described as the introduction of water-based explosives to avoid the Nitro-Glycerine based type when the opportunity to adopt water based products come onboard.

## 5. Conclusion

The various petroleum exploration activities have positive impacts on the local communities, as well as negative impacts on tropical forest environment. The critical areas involving felling of big trees, drilling of shallow shot holes and concomitant charge-loading without tamping resulting in blowouts and crater formations, have been flagged for monitoring and operational compliance by exploration companies, as violators should be punished by the law. Impacts on the environment have been assessed and operational procedures worked out for compliance to ensure minimal negative impact to the host environment. Legislative guidelines of government should also be followed by all stakeholders, exploration companies and monitoring agencies alike.

## References

[1] Salau, A.J. (1993). Environmental Crisis and Development in Nigeria. Inaugural Lecture, No.13University of Port Harcourt, Choba, Nigeria.
[2] Adeyemo, A.M. (2002). The Oil Industry Extra-Ministerial Institutions and Sustainable Agricultural Development: A Case Study of Okrika L.G.A. of Rivers State, in Nigeria. Journal of Oil and politics,
[3] Adekoya, J.A. (1995). Negative Environmental Impact of Mineral Exploitation in Nigeria. In Impact of Human Activities on the West African Savanna. Proceedings of the Regional Training Workshop Held at the Federal University of Technology, Akure, Nigeria, pp: 314. 2(1).
[4] Chikwendu, C.C. (1998). Oil production and environmental pollution in Nigeria's coastal area: integrated environmental and Living resources management in the Gulf of Guinea. In Chidi Ibe, A.; Oteng-yeboals, A.A.; Zabi, S.G. & Afolabi, A. (Eds), Proceedings of the Regional Symposium on the Gulf of Guinea Large Marine Ecosystem. pp: 195-206.
[5] Madu, A.J.C., Eze, C.L., Otuokere.I.E. (2016). Investigation of the Possible Impact of Seismic Explosive Energy Sources on the Turbidity of Groundwater in Sagbama, Niger Delta, Nigeria. Int. J. Chem. Mater. Environ. Res. Vol. 3, No. 4: pg. 91-96
[6] Triphati, B.D., Sinkandar, M, Shukia, S.C. (1991). Physico-Chemical Characterization of City Sewage Discharged into River Ganga at Veranasi, India. Environmental Int'l 17.
[7] Chapman, C., 1992. Water Quality Assessments. In Chapman. D. (Ed) A Guide to the use of Biostar Sediments and Water in Environmental Monitoring. Chapman & Hall, London Melbourne Midress, pp: 66 - 104.
[8] Mc Neely, R.N., V.P. Neimanis and L. Dwyer, 1979. A Guide to Water Quality Parameters, Water Quality Sourcebook.
[9] Twumasi, Y. and Merem E. (2006). GIS and Remote Sensing Applications in the Assessment of Change within a Coastal Environment in the Niger Delta Region of Nigeria. Int'l Journal of Environmental Research & Public Health, 3(1):98-106.
[10] Nwilo, P.C. and Badejo, O.T. (2008). Oil Dispersion and Trajectories on Nigerian Open Sea. The Conference Proceedings of the International Conference on the Nigeria State, Oil Industry and the Niger Delta, pp: 164 - 192