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POTENTIALIMPACTSOFNATURALGASPIPELINECONSTRUCTION AND OPERATION ON LAND/SOIL QUALITY IN SOUTH EASTERN NIGERIA

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ABSTRACT

The quest to make available, cheaper, cleaner, more efficient and more reliable sources of energy and feedstock for industrial and domestic uses, in Aba-Owerrinta axes of Abia State, Southeastern Nigeria in a developmental process cannot be over emphasized. This has necessitated the construction and installation of a 12" diameter natural gas pipeline with a l00 m wide right of way for a distance of 26 km by Shell Nigeria Gas (SNG). Though natural gas is a more environmental friendly fuel than other fossil fuels, the construction, installation and operation of the pipeline will invariably have impacts on the land/soil environment. Hence, the importance of an assessment of the envisaged impacts of the various stages of the gas project on the land/soil quality among other factors, against which the efficiency of the environmental management plan can be measured in the future. The identified soil types were classified as Inceptisols and Ultisols (Soil Taxonomy) and Fluvisols and Nitosols (WRB). The major potential impacts identified include loss of topsoil, modification of overland drainage pattern, accelerated erosion, land contamination and quality impairment through increased industrial activities and discharge of waste water and gaseous effluents and alteration in land use pattern. Mitigation measures suggested include, limiting of land clearing to required area, re-vegetation and proper disposal of wastes, among others.

INTRODUCTION

The challenges of ever increasing need for energy supply globally and locally, and the attendant consequences of exploitation of the energy resources such as crude oil and natural gas cannot be successfully addressed without due consideration for the environment (vegetation, land, soil, climate, hydrology, etc.). The absence of this inevitably leads to land/environmental degradation. Land degradation is more human induced than natural. It results in reduced capability of land to supply human needs. It is an insidious disease that threatens the quality of life of humans. Land/soil is very vulnerable, and once lost or damaged, it is extremely difficult and sometimes impossible to regenerate. Land degradation in any environment can be caused as a result of one or combination of deforestation/land clearing, poor land management, mining, urbanization, irrigation, fires etc. The effects of these can be seen in form of accelerated erosion, loss of organic matter, nutrient removal, salinization, alkalinisation, destruction of soil structure, etc. These invariably impact negatively on the quality of land to produce and environmental conservation.

Environmental impact assessment (EIA) is concerned with the systematic identification and evaluation of the potential impacts (effects), both beneficial and harmful, of proposed projects, plans, programmes or legislative actions relating to the physical, chemical, biological, cultural, and socio-economic components of the total environment (Canter, 1996; Wang *et al.*, 2006). According to World Resource Institute (1992), African land degradation is accounted for by water erosion (46 %), wind erosion (39 %), chemical degradation (12 %) and physical degradation 4%). Also, a United Nations Environment Programme (UNEP, 2011), report on environmental assessment of South eastern Nigeria, especially Ogoni land, showed that drinking water, air and agricultural soils in 10 communities contained over 900 times the permissible levels of hydrocarbon and heavy metals due to oil and gas exploitation and spillage. The report posited that recovery after extensive compliance with recommendations may take up to 30 years. Though natural gas is a more environmentally friendly fuel 'than other fossil fuels, the process of construction/installation and operation of a gas pipeline over a long distance will invariably have some environmental implications. It is also essential that environmental impact assessments are carried out before large scale enterprises are developed and that the development guidelines contained within them must be strictly adhered to. UNEP (2006), advocated that every economic project in the Niger Delta should be required to incorporate environmental provisions using tools such as environmental impact assessments, strategic environmental assessments and environmental policy integration. This study was carried to evaluate the potential impact of a 26 km by 100 m, 12" gas pipeline project, in the Niger Delta region of Southern Nigeria and suggested mitigation measures for efficient environmental management planning.

MATERIALS AND METHODS

Site description

The area of study traverses at least eight (8) autonomous communities, starting from Asa Umumgbede (Lat.5° 6' 47.7" N and long. 7° 19' 10.5" E) in Aba North Local Government Area (LGA) to Owerrinta (Lat.5° 18' 12.8" N and long. 70 17' 27.5" E) in Isiala Ngwa LGA in Abia State, South East, Nigeria. It covers a distance of about 26 km. The soils in the site are derived from coastal plain sands that are of quatemary Oligocene, Miocene and Pleistocene origin. They are generally characterised as very deep, well-drained soils, having loamy sand to sandy loam surfaces over sandy clay loam to sandy clay subsoil. The natural vegetation of the region is high rain forest. It is a region of high plant diversity but low abundance, in which case, several tree species are expected to be the dominant component of the vegetation. However, intensive farming activities for both subsistence and commercial purposes over a long period of time have drastically altered the floristic structure and composition of the natural vegetation. At present, oil palm fields and plantations, farmlands and agricultural mosaics characterize the vegetation.

Field work study

The field work entailed a rigid grid method of soil examination and identification, with the aid of Dutch soil auger. The soil types were examined and identified at the middle of the pipeline route and at 50 m away each to the left and right of the pipeline, along the 100 m wide tract and at intervals of 2 km along the route. This gives a total of 14 stations commencing from Owerrinta (Station 1), to Umuacha (Aba North, Station 14). The soils at the Industrial area (Ekeakpara) and at the point where the pipeline crosses the dual carriage way (Mkpaka) were also examined. This is to assess the effect of the land use types on the soils. At each station, the soil was probed to a depth of 0-120 cm for characterization and description of morphological properties. Modal profile pits were dug at the most representative station of the soil types identified. These were described according to the FAO (1986) guidelines and soil samples were collected for laboratory analysis.

Laboratory analysis

The soils' physical parameters (particle size, hydraulic conductivity, and moisture content) were determined using the methods described by Helmut, (1968). The chemical properties were determined using the methods described by Anderson and Ingram (1993), and Ministry of Agriculture, Fisheries and Food (1981). The soils were classified based on the guidelines of Soil Survey Staff (2010), FAO/IUSS (2006) and Moss (1975).

Impact assessment

The impact assessment approach adopted in this study is the inventory technique (Canter. 1996; Thomas, 2001). In this approach, an inventory of environmental resources is compiled by assembling existing data or conducting baseline monitoring with a presumption that the resources in the existing environment, or portions of it, will be lost as a result of the proposed project or activity: The assessment of the potential and associated environmental impacts of the project on the ecological variables (soil and land parameters) that are most likely to be affected by the project at various stages was made by scoring. This was based on the perceived level of severity or otherwise of the individual activity/operation of the project.

RESULTS AND DISCUSSION

Soil characterizalion and classification

The soils are generally well-drained, sandy loam/loamy sand on sandy clay loam to sandy clay (Table 1). The water content at saturation ranges from 9.7 — 15.9 % at 0-15 cm depth and 8.8 — 15.9 % at the 15-30 cm depths across the length of the proposed pipeline. The potential moisture storage of the soils are moderate. The soils have weak to moderate/medium sub-angular blocky structures and naturally have a ground cover that would control erosion. The susceptibility to water erosion in the area is moderate and if ground cover is maintained, the tendency for land degradation will be greatly reduced. The chemical properties of the soils (Table 2), indicate that the soils are generally acidic; conforming to the generally acidic nature of leached soils of this ecological zone (Ojanuga, 2006). The organic carbon, phosphate and exchangeable cations are generally low. The CEC values were low and are generally below the 4.0 cmol/kg critical level for arabic cropping, which further indicate the leached status of the soils characteristic of the area referred to as the 'acid sands' of southern Nigeria (Udoh and Sobulo, 1991; Ojanuga, 2006). The concentration of most of the heavy metals are low, with the exception of Fe which may imply that the chemistry of the soils as revealed by the red colouration and rhodic subgroup of the soil taxonomy are dominated by the oxides of iron (Fe).

The summary of the classification of the soil types in the study area is given in Table 3. The soils are formed on strongly leached sandstones which do not come down to mottled clays at lower depths. Three soil types were identified along the proposed pipeline (Soil Survey Staff, 2010). The soils at Owerrinta community (pro-

Table 1: Mean physical properties of the soils along the pipelines

S/no	Station/ Location	Particle size (g/kg)						Moisture content (%)				Hydraulic conductivity (cm/min)	
		Clay		Silt		Sand		Field actual		OMC Saturated			
		0-15cm	15-30cm	0-15cm	15-30cm	0-15cm	15-30cm	0-15cm	15-30cm	0-15cm	15-30cm	0-15cm	15-30cm
1	Owerrinta	103	78	80	128	817	793	6.1	7.6	9.78	9.67	2.2	3.5
2	Owerrinta	200	305	64	57	732	638	15.1	12.4	15.15	15.93	BL*	BL
3	Umuecha	192	230	82	85	730	685	10.6	11.6	13.37	13.71	BL	BL
4	Mkpuka	176	188	86	100	756	710	10.5	11.1	13.11	12.00	1.3	BL
5	Umunkwola	93	163	153	143	750	508	11.6	11.9	11.91	15.01	1.9	0.8
6	Umunkwola	132	157	97	101	756	755	10.11	10.65	12.67	12.15	2.3	BL
7	Umobasi	163	170	118	117	718	713	12.16	11.4	14.85	15.22	BL	BL
8	Amasa	68	105	125	135	805	760	10.32	11.47	13.21	14.02	3.3	2.4
9	Osisioma	72	100	145	155	783	745	8.14	8.54	11.73	12.85	1.677	0.65
10	Amavo	28	17	102	125	870	858	13.98	11.97	15.97	13.27	3.41	5.46
11	Ekeakpara	22	10	105	102	873	888	11.69	9.50	13.43	12.55	4.17	4.71
12	Ekeakpara	0	10	98	85	902	905	8.99	9.41	10.38	11.00	9.28	1.67
13	Ekeakpara	17	25	38	78	945	897	8.87	7.78	10.25	9.68	3.01	5.38
14	Umocha	50	47	83	102	867	852	13.13	12.57	14.25	14.74	3.22	4.17
15	Highway	178	149	123	175	700	681	11.97	8.65	13.29	11.44	BL	BL
16	(Mkpuka Industrial Area Ekpuka)	130	78	115	171	755	752	7.50	6.90	9.67	8.84	2.6	3.40
17	Control (Asokwa)	180	210	134	90	686	700	6.25	11.59	15.44	14.38	BL	BL

*BL-Below reliable determinative level. OMC-Optimum moisture content

Table 2: Mean chemical properties of the soils (15-30 cm depth) along the pipelines

Station/location	pH	THC	Oil & grease	TOC	PO_4^{2-}	SO_4^{2-}	Exchangeable cations				Exch Acidity	CEC	NO_3^-	Heavy Metals					
							Ca	Na	Mg	K				Fe	Cu	Pb	Ni	Zn	Mn
			(ppm)	(%)	(ppm)	(%)	(cmol/kg)						%	(mg/kg)					
1. Owerrinta	5.4	<0.05	69.4	0.36	0.57	0.005	0.27	0.53	0.27	0.01	3.7	4.18	0.001	2044	5.1	2.5	1.8	4.2	26.0
2.Owerrinta	4.4	<0.05	0.05	10.75	2.96	0.004	0.02	0.62	0.04	0.01	2.1	2.83	0.003	2361	4.3	2.5	2.9	1.1	10.5
3.Umuecha	4.4	<0.05	<0.05	0.81	2.21	0.003	0.02	0.71	0.04	0.01	2.3	3.03	0.003	2482	10.0	2.1	4.2	3.8	12.6
4.Mkpuka	4.6	<0.05	<0.05	0.74	0.09	0.006	0.02	0.77	0.09	0.04	1.7	2.65	0.006	2470	9.7	0.1	3.8	7.9	68.0
5.Umunkwola	5.1	<0.05	<0.05	1.29	0.64	0.005	0.32	1.49	0.92	0.24	0.8	3.69	0.006	2485	7.8	4.7	5.0	4.8	61.2
6.Umunkwola	4.5	<0.05	0.05	0.91	0.73	0.005	0.02	0.62	0.03	0.02	1.5	2.16	0.003	2353	6.4	1.7	3.8	3.3	70.1
7.Umobasi	4.5	<0.05	18.3	1.18	0.22	0.002	0.03	1.86	0.10	0.06	2.3	3.32	0.002	2458	5.5	1.1	5.4	4.4	78.6
8.Amasa	4.3	<0.05	<0.05	0.82	1.41	0.005	0.02	0.71	0.04	0.02	2.1	2.92	0.001	2481	6.9	4.2	5.2	4.3	64.3
9.Osisioma	4.3	<0.05	<0.05	0.77	1.07	0.003	0.02	0.58	0.04	0.03	2.1	2.80	0.001	2447	5.8	1.3	5.0	3.4	60.4
10.Amavo	4.3	<0.05	<0.05	0.63	0.56	0.002	0.02	0.77	0.03	0.03	2.1	3.0	0.003	2176	4.9	1.7	3.3	4.9	37.7
11.Ekeakpara	4.4	<0.05	<0.05	0.68	0.45	0.005	0.02	0.68	0.03	0.00	2.1	2.9	0.001	2399	56.9	4.2	3.8	4.6	33.2
12.Ekeakpara	4.3	<0.05	<0.05	0.63	0.81	0.005	0.02	0.10	0.04	0.15	1.9	3.2	0.003	2356	5.5	2.3	3.8	4.9	87.3
13.Ekeakpara	4.2	<0.05	<0.05	1.17	1.95	0.003	0.02	0.83	0.08	0.08	1.6	2.6	0.006	2243	2.8	0.9	2.1	3.3	29.9
14.Umocha	4.4	<0.05	<0.05	0.87	1.94	0.003	0.02	0.62	0.03	0.02	2.0	2.7	0.001	2411	24.9	0.8	4.2	5.6	50.2
15.Highway (Mkpuka)	4.6	218.0	326.0	0.97	0.62	0.005	0.12	1.32	0.29	0.20	1.0	2.8	0.003	2438	7.7	1.9	3.8	6.4	45.3
16.Industrial Area (Ekpuka)	4.5	<0.05	<0.05	0.80	2.13	0.008	0.06	0.62	0.05	0.03	1.4	2.2	0.005	2258	4.4	0.6	1.9	6.0	80.6
17.Control (Asokwa)	4.5	<0.05	<0.05	1.24	2.98	0.002	0.06	0.31	0.04	0.04	2.4	2.9	0.002	2431	5.5	2.5	5.0	4.7	68.7

Table 3: Classification and characteristics of the soils

Location	Profile No.	Soil Classification			Characteristics
		USDA	FAO/UNESCO	Local (Series)	
Owerrinta	OWT/SL/P1	Ustic Dystropepts	Dystric Fluvisol	Ngego	Have base saturation less than 50%; ustic moisture regime with weak diagnostic horizon, sandy loam and weak to medium sub-angular blocky.
Mkpuka	MPK/SL/P2	Typic Paleustults Fine-Loamy Siliceous Isohyperthermic	Rhodic Nitosol	Ahiara (Normal)	Isohyperthermic; ustic–udic moisture regime, base saturation less than 50%. Sandy clay loam; medium sub-angular blocky dark red subsoil.
Amavo	AMV/SL/P3	Typic Paleustults, Fine-Loamy siliceous Isohyperthermic	Umbric Nitosol	Kulfo (Normal)	Well drained sandy loam over sandy clay Isohyperthermic, ustic; dark to strong brown, medium sub-angular blocky.

file OWT/SL/P1) was somewhat young with evidence of alteration below 20 cm but there were no clear or well developed B horizons. In addition, features of recent depositions depicted by irregular distribution of organic carbon in the profile diagnostic for fluvial/ alluvial deposits were observed. Therefore, it was classified as Inceptisols (Soil Survey Staff, 2010) and Fluvisol (WRB, 2006). However, the soils at Mkpuka (MPK/SL/P2) and Amavo (AMV/SL/P3) are better developed with evidence of illuvial clay migration to the lower horizons. They were classified as Ultisols and Nitosol in the soil taxonomy and FAO/WRB classifications respectively. At the series level, the younger soil at Owerrinta was classified as Ngego, while the Mpuka and Amavo soils were Ahiara and Kulfo Series respectively (Moss, 1975).

Associated and potential environmental impacts

Table 4 depicts the scoring matrix of the associated and potential impacts of the activities of the pipeline project. According to Jay *et al.* (2007), this technique can be perceived as a worst-case prediction, and for certain types of resources it represents a reasonable approach for use in environmental impact studies. A useful approach for determining the environmental factors to be included in the matrix is the valued ecosystem components. Thomas (2001), explains that these can be drawn from the ecological context of the proposed project, and those aspects perceived by the public to be important. Aspects considered include the ecosys-

Table 4: Scoring of potential impacts of the activities of the pipeline project

Soil/Land Quality	CONSTRUCTION AND COMMISSIONING PHASE											OPERATIONS AND MAINTENANCE PHASE															
	Access	Site clearing	Wood Disposal	Environmental survey	Excavation	Spoil Disposal	Drainage	Equipment	Transport	Storage Facility	Labour	Site clearing	Excavation	Cut and Fill	Drainage alteration	Erosion control	equipment	Labour Force	Transport	Storage facilities	Waste disposal	Re-vegetation	Surveillance	Leaks	Manifold operation	Waste disposal	Vegetation control
Moisture availability	3	3	2	0	5	4	0	0	5	0	0	7	7	7	7	7	2	0	3	2	7	0	0	0	2	3	6
Nutrient availability	6	6	7	0	5	4	2	0	0	0	0	6	7	7	6	3	0	0	0	0	7	0	0	5	2	0	4
Resistance to Erosion	9	8	9	0	9	4	8	5	4	0	4	8	8	7	2	0	5	5	5	2	8	0	1	0	1	4	4
Soil toxicity	0	0	0	0	0	3	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	3	1
Workability of land	5	7	3	0	7	3	2	1	0	0	2	8	7	9	2	5	5	5	3	4	4	0	0	0	0	6	4
Wetness	5	8	4	0	4	3	5	3	0	0	3	8	4	8	2	6	3	2	0	1	6	0	0	0	0	3	3
Terrain/Topography	0	3	0	0	5	3	3	0	0	0	0	3	3	5	3	3	0	0	1	1	0	6	0	0	0	0	5
Soil structure	2	5	4	0	5	3	6	5	0	0	0	3	3	3	5	5	0	1	0	1	0	7	0	0	0	3	5
Soil depth	0	3	0	0	3	0	6	3	0	0	0	3	3	3	5	6	0	0	0	0	0	5	0	0	0	3	3

Matrix code for impact significance

0 – No impact; 1 – 3 Low level impact significance; 4 – 6 Medium level impact significance; 7 – 9 High level impact significance

tems that exist and their functional relationships; the carrying capacity of the bio-physical or social environment the resilience of the environment when exposed to various stresses; the weakest links in the systems; the sensitivity of the environment to stress and the level of biodiversity in the ecosystem. The major impacts envisaged in this project include loss of topsoil (organic matter), modification of overland drainage pattern, rapid erosion and alteration in land use pattern among others. Wide-ranging and usually destructive environmental changes have stemmed from oil and gas extraction, industrialization and urbanization in the Niger Delta area (UNEP, 2006). Oil spills and gas flares in particular have destroyed natural resources central to local livelihoods while alienation of people from their land and resources has led to the inefficient use of remaining resources and poor or inequitable land-use practices. (UNEP, 2006, 2011). The most serious human development problems relate to environmental sustainability, which is fundamental to peoples well-being and development.

The suggested mitigation measures against the impacts (Table 5) include limiting of land clearing to the required

Table 5: Mitigation measures/alternatives against the potential impacts

Environment component	Potential impact	Mitigation Method
Soil Fertility	Low Total Organic Carbon, low level of exchangeable bases, low Cation Exchange Capacity, low phosphorus and sulphate levels (reduced fertility and soil productivity)	▪ Maintenance of soil cover through mulching, application of organic fertilizers (farmyard manure, poultry droppings etc.) and inorganic fertilizers (NPK, 15-15-15, single supper phosphate, muriate of potash etc.) ▪ Keep soil disturbance and vegetation clearing to minimum required for operation and safety
Soil Structure	Destruction of soil aggregates and pores	▪ Minimal vehicular and equipment movement ▪ Re-vegetation, manual and/or chemical method of land clearing
Infiltration and Hydraulic Conductivity	Destruction of macro and micro pores; increased runoff and sedimentation from construction of pipeline etc.	▪ Use of light equipment for construction and installation ▪ Re-vegetation ▪ Install sediment traps or screens to control runoff and sedimentation
Bulk Density	Soil compaction and surface sealing	▪ Minimal vehicular equipment and labour traffic ▪ Re-vegetation
Land Capability and Land Suitability	Accelerated erosion due to vegetation removal, drainage alteration and soil compaction	▪ Re-vegetation ▪ Improved drainage network (e.g. grass water way) ▪ Corrosion protection
Drainage	Alteration of drainage patterns e.g. blocking water flow	Restore disturbed land along the right of way
Land use	Loss of farmland (contamination etc.)	Minimum offsite land use impact during construction

area, proper disposal of wastes, improvements of drainage network, minimal vehicular and labour traffic, etc. It is also suggested that re-vegetation should be carried out in such a way that the natural biodiversity of the area is maintained. UNEP (2011), suggested that biodiversity protection should be integrated into land use planning and forest management in relation to oil and gas exploration in the Niger Delta Basin. Project planning by local authorities, state and national ministries and agencies, development aid institutions and major private developers should incorporate steps to determine ways to maintain key sites, species and genes, and provisions for investments in research, assessment, and forestry, agriculture, fisheries and wildlife management.

Closure and post closure care

At closure there may be some negative effects on the soil environment, especially if the pipes are to be removed. This will trigger off the same impacts that may result at the installation, construction, and operation stages. However, if the pipes are not to be exhumed and appropriate mitigation measures applied, there is no likelihood of negative impacts on the soil environment, since the product of the operations is natural gas. This is on the premise that the source of the gas is either exhausted or sealed off properly.

CONCLUSION

While impact assessments are essential in any project and EIA may lead to the abandonment of certain proposals, its focus should be more strongly on the mitigation of any harmful environmental impacts likely to arise. It is pertinent that existing and proposed human activities on land/soil be related to its characteristics and qualities, and appropriate mitigation measures put in place against the envisaged impacts of such activities. This will invariably help to reduce the rate of land degradation and enhance rejuvenation of some already degraded ones. Thus, the quality of life will be enhanced for all.

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