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A Cursory Review of the Consequences of Human Activities and Land-Use Changes in the Niger Delta

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Abstract: This study discusses the manifestation and consequences of human activities on the Niger Delta ecosystem. The Niger Delta is resource-rich and abundantly blessed with expanse of agricultural/aquatic resources and vast reserves of petroleum hydrocarbon. The delta has played prominent roles in the global economic activities, ranging from slave trade, palm oil business and now hydrocarbon export, spanning more than a century ago. The brunt of human activities resulting from the exploitation of Niger Delta resources, affects the ecosystem. The study was carried out using a mixed scale approach involving literature search, land-use/land cover change detection using Landsat® satellite imageries and sampling and analysis of soils from four representative locations. The magnitude and severity of such effects are contingent not only on natural variables, but also the exploitative activities of man. This study has analysed the interplay of several variables resulting from anthropogenic activities. Information contained in this study is valuable towards understanding and sustainable management of the fragile Niger Delta ecosystem.

Keywords: Deforestation, ecosystem management, land degradation, soil health, sustainable development

INTRODUCTION

The Niger Delta is a geologic phenomenon formed in the area where the River Niger exits into the Atlantic Ocean. Like any geologic delta, it is triangular in shape and straddles from the town called Aboh in Delta State at the extreme, to the mouth of Imo River (Rivers State) to the east and mouth of Benin River (in Delta State) to the west. The Niger Delta was formed from fluvo-marine deposits during the upper Cretaceous; occasioned by low-lying topography and meandering of the resultant distributaries of the River Niger (Short and Stäuble, 1965). As the deposition of the fluvo-marine sediments continued, there was a corresponding decrease in the slope gradient of the Niger River bed. This, coupled with reduced stream velocity, accentuated tidal activity at the mouth of the River Niger distributaries, which also resulted in the formation of Barrier Islands along the Atlantic Ocean coastline. The climate of the Niger Delta is characterized by two seasons (wet and dry), high precipitations and high relative humidity all year round. The wet season lasts from March through October, with shorter dry season in-between. Annual rainfall ranges from 4,000 mm along the coast to 2500 mm at the northern extreme of the delta, with showers being experienced even during the dry season (Brandolini and Hamadina, 2008). Relative humidity across the delta fluctuates above 90% for most of the year, while annual mean temperature approximates 28oC. The cloud is overcast for most of the year, with mean annual sunshine period of about 1,500 h (www.gaisma.com).

The Niger Delta is resource-rich and abundantly blessed with expanse of agricultural/aquatic resources and vast reserves of petroleum hydrocarbon (Irikana, 2011). All of Nigeria's more than 600 oilfields are in the Niger Delta (60% onshore), with a proven oil reserve of over 35 billion barrels and production rate of 2.5 million barrels a day (Egberongbe *et al*., 2006). Over time, the Niger Delta has played important roles in the global economy (through slave trade, palm oil trade and now fossil fuels export) and documented human economic activities in the Niger Delta dates back to more than a century (Enemugwem, 2009). At the lowest levels of society, inhabitants of Niger Delta eke out their living by subsistent harvesting of natural resources (fishes, forest products, backyard farms, etc.). At higher levels, resource-exploitation takes the form of profiteering and range from profitable plantation farming to petroleum hydrocarbon exploitation. The effects of human activities on the ecosystem often manifest as land-use changes. Some of the changes are either beneficial (positive) or adverse (negative): Positive changes are seen as improvements, while negative changes, in contrast, are considered retrogressive in nature. Beneficial or positive changes may be tangible in

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the case of physical development such as roads, housing, urban centres, etc., or intangible such as human capital development. A plethora of adverse changes has resulted from human interactions with the Niger Delta ecosystem. Land-use/land cover changes due to deforestation are rampant in sub-Saharan Africa and the main reason is 'slash and burn' agriculture. However, it appears that the major drivers of land-use changes in the Niger Delta are urban expansion and infrastructural development, accentuated by revenues derivable from petroleum hydrocarbon exploitation and exploitation.

Land-use changes such as conversion of forests to farmlands in slash-and-burn agriculture alters environmental quality (McAlister *et al*., 1999) and results in losses of carbon; e.g., about 320 tonnes of C was released annually at a deforestation rate of 154,000 km^2/year in Africa (Kotto-Same *et al*., 1997). In Nigeria, land-use/land-cover changes account for 40% of CO2 emissions, which is even higher than that contributed by gas flaring (30%) associated with oil production (Federal Ministry of Environment, 2003). Since land-use changes are rampant, coupled with the fact that gas flaring occurs only in the Niger Delta, it can be safely assumed that Nigeria's CO_2 emissions mostly comes from the Niger Delta.

The objectives of this review are to highlight land use changes resulting from human activities in the Niger Delta, as well as their manifestation and consequences. The review is biased towards terrestrial ecosystems (including the built-up areas) rather than the aquatic ecosystem of the Niger Delta. Information contained in this study was gleaned from scientific sources, as well as the authors' original research study.

MATERIALS AND METHODS

The study was carried out using a mixed scale approach involving literature search for secondary data on human activities with ecological significance, change detection using Landsat® satellite imageries and sampling and analysis of soils from four representative locations within the terrestrial ecosystem around Port Harcourt and environs (Fig. 1). For the change detection, two imageries representing two epochs (1985 and 2005) spanning 20 years were compared analysed using the supervised method of change detection as described by Twumasi and Merem (2006). The study area was chosen because it harbours contrasting land-use types resulting from human perturbation in the Niger Delta region of Nigeria.

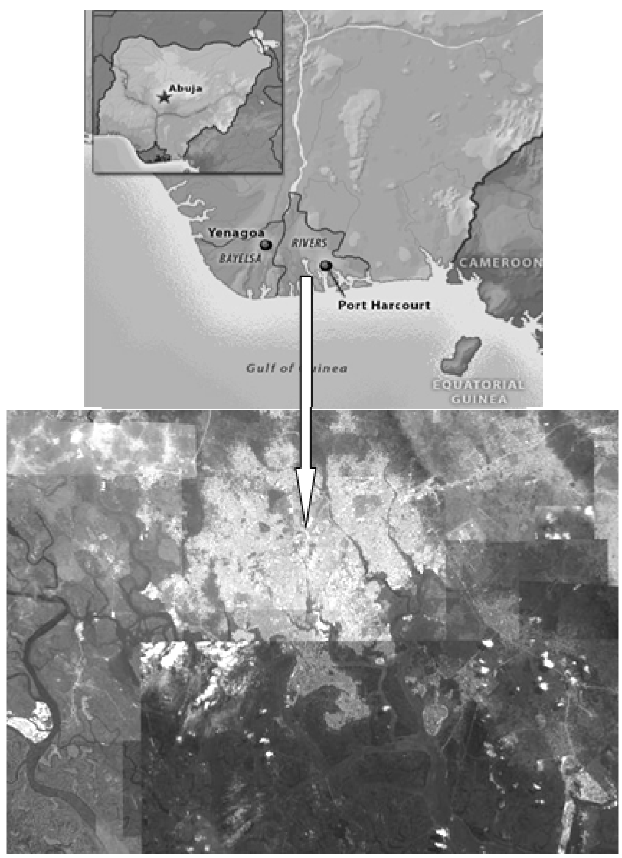

Fig. 1: Location of the study area

For soil bacilli quantification, soils were collected at three depths at each of four sites and subjected to laboratory analysis following methods described by Baker *et al*. (2000). The four sites for soil bacilli quantification were selected (within the upland coastal plain sands section of the study area) to represent contrasting land-uses, with varying degree and complexity of human perturbations thus:

- Onne axis harbours the Oil and Gas Free Zone, which is a hub for industrial activities (especially oil and gas) in the Niger Delta and presently rapidly urbanising
- Nkpolu axis representing a rapidly expanding human settlement, characterised by infrastructural construction activities
- Choba axis is a peri-urban environment, with influx of diverse persons, mostly young persons, as it harbours the University of Port Harcourt and a university hospital
- Ndele axis, a typical rural setting characterised by rural livelihood activities like farming

Primary data derived from soil sampling and analysis were statistically analysed (SAS, 2001) and both evaluated in the light of secondary information obtained from literature search. Where necessary, ground-truthing of information was carried out to provide clarity and context and panoramic views were obtained.

RESULTS AND DISCUSSION

A brief sketch of natural ecosystems of the Niger Delta: Barrier islands/strand coast/beach ridges: The coastal barrier islands support freshwater vegetation, even though they are directly in contact with the Atlantic Ocean and rimmed by mangrove swamp, making them freshwater 'islands' within saline ecosystems. Nevertheless, the barrier islands are liable to saline water intrusion, which renders them delicate and sensitive to perturbation. The soils of the beach ridges are generally sandy, formed due to the action of waves on sediments deposited at the mouths of rivers and estuaries. The soils often have low organic matter content, low inherent fertility and are prone to erosion, except in back swamps where the soils may be loamy and relatively more fertile. The vegetation is relatively less diverse and consists of a few species that could grow on infertile sandy soils. The strand coasts render ecological services critical to the sustenance of biodiversity such as providing nesting/breeding sites for marine wildlife.

Mangrove swamp: The Niger Delta is said to harbour the third largest expanse of mangrove forest in the world covering almost 20,000 km2. The mangrove ecosystem is very unique in the sense that, it is characterised by saline tidal waters and highly adapted plant species. The mangrove soils consist of unconsolidated materials, with fibrous detrital materials at various stages of decomposition. The soil (commonly called Chikoko) are often alkaline in its natural saturated state, however, when drained, e.g., due to dredging, they become strongly acidic due to the oxidation of pyritic compounds contained in the soil.

The mangrove renders ecological services that include the stabilization of the swamp system (by trapping of silt) and provision of valuable habitats for the spawning and survival of organisms such as fishes, shrimps, periwinkles, cockles, crabs, etc. The destruction of the mangrove ecosystem results, amongst others, in the loss of the fragile mangrove plants, exacerbation of coastal erosion and worsening of flooding episodes. Since mangrove plants have extremely slow growth rates, it takes decades before the mangrove ecosystem recovers from destruction, if at all it does. The destruction of the mangrove vegetation renders the mangrove swamp vulnerable to colonization by prolific and fast-growing invasive non-native species such Nipa palms, that are incapable of performing the ecological functions of the native mangrove plant species.

Lowland rainforest: The Niger Delta being a humid environment also harbours the lowland rainforest that generally remains dry for most of the year. In its original state, the lowland rainforest is characterized by distinctively layered canopy structure, but when disturbed the canopy layering become blurred. At present, there is only near-primary forest as all forest within human reach has been affected by the activities of man. The near-primary forest may have a structure of primary forest that is three layers: the emergent layer with very tall trees, below which is the canopy layer that is often closed, thereby reducing the amount of light reaching the forest floor; and below the canopy layer exists the lowest layer, made of lianas, creepers, etc. When the primary forest is disturbed, it turns to a secondary forest, which is characterized by the presence of economic trees such as oil palm trees and a rather open canopy. In most parts of the Niger Delta, the near-primary forest often occurs in patches adjoined by the more disturbed secondary forest. Contiguous to the secondary forest are often found fallow lands, homesteads, farmlands, or even roads.

Freshwater swamp forest: The swamp forest is perhaps the only ecosystem in the Niger Delta that is most influenced by changes in hydrology. The hydrology of the Niger Delta, at present, is influenced by three factors: rainfall, tidal movement and opening of Kainji dam

Table 1: Land use/land cover changes in the study area (1985-2005)

	1985		2005		Change*	
Land cover types	Km^2	%	Km^2	%	Km^2	%
Built-up	383.22	10.54	582.33	16.01	199.11	51.960
Sparse vegetation	476.79	13.11	678.51	18.65	201.72	42.310
Forest	842.61	23.17	650.22	17.88	-192.39	-22.830
Freshwater swamp	365.60	10.05	373.11	10.26	7.51	2.054
Mangrove	1,167.15	32.09	1,034.03	28.43	-133.12	-11.410
Fallow re-growth	401.79	11.05	318.97	8.77	-82.82	-20.610
Totals	3,637.17	100.00	3,637.17	100.00	–	–

*: '-' sign indicates a decline in quantity

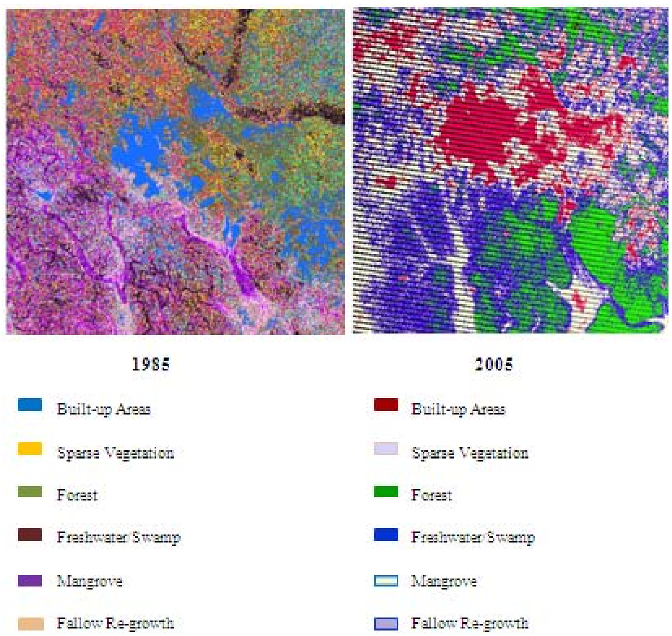

Fig. 2: Satellite imageries showing expansion of built-up areas around port harcourt and environs (1985 and 2005)

sluices during high water levels (Abam, 1998). Based on hydrological variations, the swamp forest can be further subdivided into three zones. These include flood forest, which remains flooded from October through December and dominated by swamp-tolerant plant species; the eastern and western delta flanks, which is characterized by non-swamp plant species; and back swamps interspersed by old creek levees that are often flooded and not under the influence of tides, but always waterlogged and relatively stable all year round.

Manifestation and consequences of human activities: Deforestation, urbanization and land-use changes: Deforestation is a rampant phenomenon in sub-Saharan Africa (including Nigeria) and the main reason for deforestation is slash and burn agriculture. However, in the Niger Delta, deforestation in recent years is usually to pave way for oil and gas activities, infrastructure development, plantation agriculture and/or urbanisation. In addition, activities such as land-reclamation/sand-filling alter land-use and land cover compositions in the Niger Delta, but records of such activities are hard to come by. However, with the help of remotely-sensed satellite imageries, it is possible to quantify land-use/land cover changes and several workers have employed this technique to discuss changes in the Niger Delta.

Satellite imageries have been used to detect changes in land-use around Port Harcourt and its environs (Fig. 2), over the period 1985 to 2005 and the results are shown in Table 1. The total spatial coverage of the study area equalled 3,637.168 km^2 and consisted of built-up area, as well as Mangrove and freshwater ecosystems. The freshwater types can further be disintegrated to: Forest, Sparse Vegetation, Fallow re-growth and Freshwater swamp. It is noteworthy that even though the Built-up Area was observed across both freshwater and mangrove ecosystems, they were disproportionately concentrated in the freshwater ecosystem (Fig. 2).

In the year 1985, with the exception of mangrove ecosystem, the Forest occupied the largest (23.17%) expanse of land within the study area, followed by Sparse Vegetation (13.11%) and Fallow re-growth (11.05%),

Plate 1: A typical vandalized oil well where crude oil is stolen for illegal 'efining'

while Built-up (10.54%) and Freshwater swamp (10.05%) occupied the least. By the year 2005, the Forest constituted 17.88% of the land cover types, representing a decline of 22.83%. In contrast, the Built-up area expanded by 51.96% and constituted 16.01% of the land use/land cover types. Similarly, the coverage of Sparse Vegetation increased by 42.31%, while Fallow Regrowth declined by 20.61% in 2005, as compared to 1985 (Table 1).

The data presented in Table 1 and the imageries shown in Fig. 2 suggest rapid land-use/land cover changes resulting from vegetation clearance to pave way for expansion of built-up areas (such as houses/offices, roads, industries and schools, etc.). In rural settings, forest disturbance also occurs, albeit at frightening levels and most of the primary forests (closed canopies) have disappeared, while the proportion of disturbed forests (with open canopies) has expanded as a result of human activities such as illegal timber logging, which is a rampant practice in forested areas of the Niger Delta, including forest reserves (Hamadina *et al*., 2007).

Pollution resulting from oil spillages: Oil exploration and productions activities have been going on in Niger Delta for more than half a century. Presently, more than 1,500 oil wells have been drilled in more than 600 oil fields and over 7,000 km of pipelines and flow lines laid across the Niger Delta (excluding the deep offshore). Oil spillages usually trail oil exploration and production activities, some of which could be inadvertent spillages, which have occurred severally in the Niger Delta. Over the years, however, locals learnt to sabotage oil installations to collect oil-spill compensations from oil companies, which give higher returns than subsistence livelihoods, but this accentuated the contamination of the Niger Delta ecosystems (CEHRD, 2008). During the late 1990s, leading to the peak of militancy around the mid 2000s, pipeline sabotage transformed into large scale thievery of petroleum substances, often accompanied by serious discharges of crude oil and related materials into the terrestrial ecosystem (Plate 1). For instance, in Bodo

Plate 2: The local 'refining' process of stolen crude oil in the Niger Delta

West, an oilfield in the Niger Delta, eight incidences of oil spills were recorded during the period Nov. 1979 and Dec. 2008: five of the spills led to the discharge of >6000 barrels, while three of them that occurred on Dec. 1999, Aug. /Sept. 2003 and Aug. 2008, were not quantified (Doyle, 2002; Umechuruba, 2005; CEHRD, 2008).

Interestingly, while the spills that occurred before 1999, in Bodo West, were said to be due to either equipment failure or maintenance error on the part of the oil companies, those that occurred after 1999 were all due to impairments on a 24" trunk-line conveying crude petroleum for export at coastal town of Bonny (Doyle, 2002; CEHRD, 2008). It is believed that many spills have occurred unreported in the Niger Delta, as a result of unscrupulous vandalism of pipelines, which CEHRD (2008) referred to a "criminal oil economy". This 'criminal oil economy' also involves the erection of 'illegal refineries' where stolen crude oil is 'refined' using metal drums and heat and refined by simple distillation using metal drums as condensation device (Plate 2). The crude oil being 'refined' in these 'illegal refineries' are criminally sourced from damaged well-heads, pipelines and flow-lines, that are mostly operated by international oil companies (CEHRD, 2008). The stealing of crude from facilities results in serious contaminations from crude oil spillages as these unscrupulous elements are untrained and ill-equipped to manipulate oil facilities in an environmentally safe manner.

Coupled with accidental discharges in the course of oil industry operations, spillages from aging/poorly maintained facilities, as well as criminal activities have contributed immensely to human-induced impacts in the Niger Delta (Doyle, 2002; CEHRD, 2008). The impacts of oil spills include damage to ecosystems, destruction of fish farms/ponds, fishing nets and, threat to food security amongst the indigenes. In the mangrove ecosystems spillages lead to death of economically important organisms such as mud-skippers, periwinkles, oysters, cockles, etc. that constitute livelihood sources to the local folks.

Soil health effects due to land-use/land-cover changes: The effects of land use changes on the terrestrial ecosystem of Niger Delta are seldom documented. However, the outcome of a study using the abundance of bacilli in the top 30 cm of soils, as an index of soil health, under contrasting land-use/land cover types across different sites show the total bacilli count in the surface 0-10 cm layer were significantly (p<0.001) higher in than the bottom layers (Fig. 3, 4 and 5). In terms of sites of sampling, Choba axis, had higher bacilli count, followed by Ndele and Nkpolu axis, while the Onne-axis had the least (p<0.001). The different land-use types had significant (p<0.001) effects on total bacilli count, but the pattern of effects differed with location. For instance, while the total bacilli count (in 0-10 cm soil layer) tended to increase with land-use change from Forest to Sparse vegetation or Fallow re-growth. However, the Built-up land-use type had contrasting effects in different locations: decline in total bacilli count in the case of Nkpolu and Choba, while at Ndele and Onne, the reverse was the case (Fig. 3).

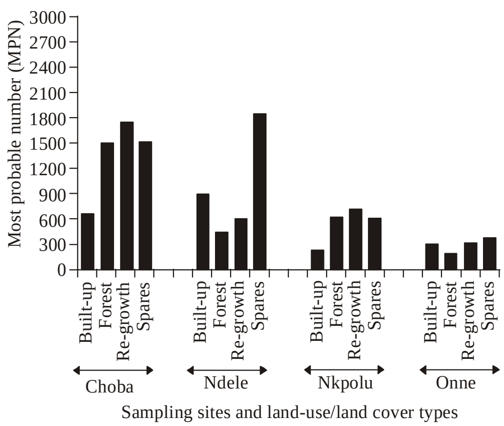

Fig. 3: Total bacilli count in 0-10 cm soil layer under different land-use/land cover types

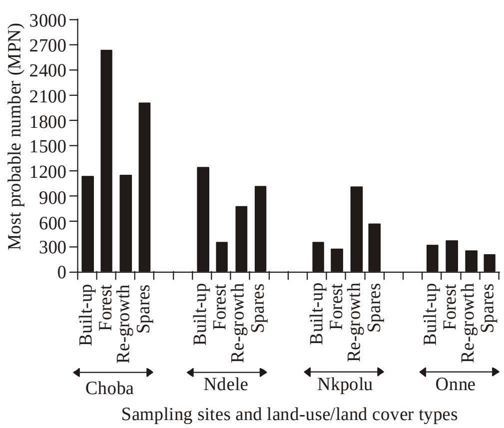

Fig. 4: Total bacilli count in 10-20 cm soil layer under different land-use/land cover types

In the 10-20 cm layer, the effects of the different land-uses on total bacilli counts were significant and the pattern differences is similar to that of the upper 0-10 cm

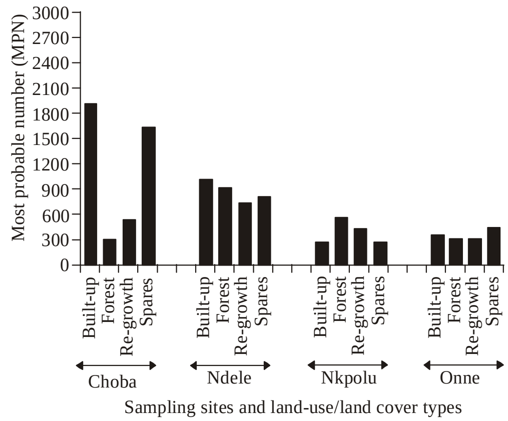

Fig. 5: Total bacilli count in 20-30 cm soil layer under different land-use/land cover types

layer (Fig. 4), except that Built-up land-use had higher counts than forest, while Forest regrowth and Sparse vegetation resulted in decreases in comparison with Forest in Onne (p<0.001). The magnitude of changes in bacilli count is comparatively higher in Choba and Ndele, as compared to Nkpolu and Onne. At the subsurface 20-30 cm soil layer, the total bacilli count varied significantly (p<0.001) with land-uses and across locations, but the differences were disproportionate: greater in Choba and Ndele, as compared to Nkpolu or Onne (Fig. 5).

Ecosystem degradation resulting from dredging: Another human activity with deleterious effects in the Niger Delta is dredging. Dredging is done for several reasons, but principally, the main reasons for dredging are to expand creeks/rivers to facilitate passage of sea vessels; or to create slots for accessing/installing oil/gas facilities. Dredging destroys habitats/spawning grounds of certain fishes, including shell fishes that grow on muddy tidal flats of the mangrove zone (Irikana, 2011). Also, dredging creates artificial sandbars that favours the growth of mangrove-degrading Nypa palm (Nypa fruticans) seedlings (Irikana, 2011) and it causes acidification of mangrove soils (Ohimain *et al*., 2004, 2010). According to Ohimain *et al*. (2010), The acid-sulphate mangrove soils of the Niger Delta easily acidifies to form sulphuric acid when exposed to the air, as is the case with dredge spoils; and the sulphuric acid so formed is washed into the surrounding environment resulting in the death of mangrove vegetation. The resultant acidified ecosystem hinders the establishment of the salt-loving mangrove vegetation and favours the proliferation of the opportunistic Nypa palms that are incapable of rendering the ecological services of the original mangrove vegetation (Rhizophora spp).

Wildlife poaching and 'bush meat' trade: The practice of killing wildlife for human consumption predates recent history, but in recent time wildlife carcasses, referred to as 'bush meat', have become delicacies and money-making merchandise in most of Sub-Saharan Africa including the Niger Delta (Okiwelu *et al*., 2009). The trade in 'bush meat' is a thriving business and transactions not only occur in remote locations, but also along highways and even within large cities; e.g., a bush meat market has been thriving in Omagwa village in the Niger Delta (Okiwelu *et al*., 2009). Wildlife losses due to 'bush meat' trade/consumption are exacerbated by high population density, fast growing population and pressure on resources to satisfy human needs (Harcourt et al., 2001). Such pressure has resulted in destruction of local biodiversity-friendly sites such as 'shrine groves' to pave way for infrastructural development needs in urbanising localities (Hamadina *et al*., 2007).

Infrastructural development is often associated with construction works, sometimes large-scale, that attract workers/speculators in search of greener pastures, resulting in influx of relatively huge population into often sleepy rural communities. However mild it may be, the effects of human influx on wildlife may include nuisance, habitat loss/fragmentation, loss of refuge sites ('sacred'/'evil' forests) and increased demand for 'bush meat'. Wildlife harvesting for the bush meat is intensifying at a rate that casts doubt on the ability of the fragmented Niger Delta ecosystem to sustain it (Okiwelu *et al*., 2009).

Atmospheric pollution form discharge of compounds: The Niger delta is subject to environmentally polluting discharges of gaseous, liquid and solid wastes mostly linked to hydrocarbon production, but also other activities. Atmospheric discharges of gaseous products of hydrocarbon processing, including gas flaring, as well as aerosol particles of unburned fuel often return back as 'fall out' (by gravity) or 'wash out' (by the rain) to the soil and vegetation.

About 2.5 billion cubic feet of petroleum gas (equivalent to >45 million tons of CO_2) is lost daily due to gas flaring. Increasing concentrations of internal-combustion engines (e.g., motor-vehicles and generators), bush burning and the activities of industrial sector have also increased air emissions (especially CO_2) over the years (Federal Ministry of Environment, 2003). However, despite the fact that increase in atmospheric CO_2 affects vegetative growth of plants and despite decades of gas flaring, no comprehensive empirical evaluation of ambient CO_2 effects has been reported for the terrestrial ecosystems of Niger Delta.

Forest degradation and wildlife losses: The major human-induced degradation of forests being reported are those that occur in relation to the conversion of natural habitats to agricultural uses; and non-sustainable harvesting of forest products (such as exploiting mangroves for fuelwood). Other forest-degrading activities include discharge of industrial wastes (for instance, the use of unlined waste pits to dispose of drilling wastes), timber logging, etc. The aforementioned, coupled with oil and gas exploration/exploitation activities, occur in the Niger Delta; and they result in direct threats to the sustenance of biodiversity and wildlife habitat.

Generally, it is difficult to quantify biodiversity losses due to human activities as there is a dearth of data in this regard (Mckee et al., 2003), but the experiences of local hunters in the Niger Delta suggest significant losses. On the Wilberforce Island in the Niger Delta, experienced hunters revealed that elephants (Loxodonta africana), African buffalo (Syncerus caffa) and pygmy hippos (Hexaprotodon liberiensis), used to visit the area up to 1970s (Hamadina et al., 2007). Nevertheless, records of wildlife extinctions in the Niger Delta are scarce and most published researches relied on local hunters as primary source of information (Powell, 1997; Hamadina et al., 2007). Biodiversity losses are worsened by consumption of wildlife carcasses as 'bush meat' by humans.

Inappropriate waste handling and disposal: Waste is any solid, liquid or gaseous substances that are either residues or by-products of a process, having no immediate value and may or may not be degradable, hazardous or non-hazardous. In the Niger Delta, wastes are generated from several sources: industry, households, hospitals, farms, markets, parks, etc. The rates of waste generation are often faster than handling capacities, leading to heaps of wastes seen across the major cities in the Niger Delta. The compositions of such wastes heaps around the Niger Delta cities are often not known, but often include industrial and medical wastes, even though household wastes are predominated by organic materials, plastics, papers, etc. (Ayotamuno and Gobo, 2004). The manner of disposal of wastes in the Niger Delta calls for concern as they constitute nuisance to aesthetics and also pose health risk to inhabitants of cities like the 'garden city' of Port Harcourt, where wastes are dumped without segregation.

CONCLUSION

The Niger Delta ecosystem has borne the brunt of human activities resulting from the exploitation of its natural resources. Some of the effects on the ecosystem are contingent on natural variables, but also the density of human inhabitation and the activities of man. This study has discussed the responses of the Niger Delta ecosystem to the impacts of anthropogenic activities. Information contained in this study is valuable towards understanding the dynamics of the fragile Niger Delta, a resource-bearing ecosystem of global reckoning.

REFERENCES

Abam, T.K.S., 1998. Impact of dams on the hydrology of the Niger Delta. Bul. Engr. Geol. Env., 57(3): 239-251.

Ayotamuno, J.M. and A.E. Gobo, 2004. Municipal solid waste management in Port Harcourt, Nigeria: Obstacles and prospects. Man. Env. Qual., 15(4): 389-398.

Baker, F.J., R.E. Silverton and C.J. Pallister, 2000. Introduction to Medical Laboratory Technology. 7th Edn.,.

Brandolini, G.V. and M.K. Hamadina, 2008. Nigeria Environmental Profile. Final Report prepared for EC Delegation to Nigeria on behalf of Agrifor Consult, Belgium.

CEHRD, 2008. Persistent oil spillage at Bodo Creek; unprecedented impacts on ecosystem stability, biodiversity and food security of Ogoni communities. Centre for Environment, Human Rights and Development (CEHRD), Nigeria.

Doyle, J., 2002. Riding the Dragon: Royal Dutch Shell and the Fossil Fire. Annex A: A Royal Dutch Shell Sampler-a Chronology of Selected Environmental and public Safety Incidents, 1947-2002. Environmental Health Fund. Jarboe Printing, Inc., Washington, DC, USA.

Egberongbe, F.O.A., P.C. Nwilo and O.T. Badejo, 2006. Oil Spill Disaster Monitoring Along Nigerian Coastline. Promoting Land Administration and Good Governance 5th FIG Regional Conference Accra, Ghana, March 8-11, 2006.

Enemugwem, J.H., 2009. The Development of the Niger Delta of Nigeria, 1900-1966. J. Sust. Dev. Afr., 10(4): 162-178.

Federal Ministry of Environment, 2003. Nigeria's First National Communication Under the United Nations Framework Convention on Climate Change. The Ministry of Environment of the Federal Republic of Nigeria, Abuja Nigeria. pp: 132.

Hamadina, M.K., D. Otobotekere and D.I. Anyanwu, 2007. Impact assessment and biodiversity considerations in Nigeria: A case study of Niger Delta university campus project on wildlife in Nun River Forest Reserve. Man. Env. Qual., 18(2): 179-197.

Harcourt, A.H., S.A. Parks and R. Woodroffe, 2001. Human density as an influence on species area relationship: Double jeopardy for small African reserves? Biodivers. Conserv., 10: 1011-1026.

Irikana, G.J., 2011. Mangrove resources utilization in Nigeria: An analysis of the andoni mangrove resources crisis. Sacha J. Env. Stud., 1(1): 49- 63

Kotto-Same, J., P.Woomer, A. Moukam and L. Zapfack. 1997. Carbon Dynamics in Slash-And-BurnAgriculture and Land Use Alternatives of the Humid Forest Zone in Cameroon. Agr., Ecosys. Environ., 65(3):245-256.

McAlister, J.J., B.J. Smith and B. Sanchez, 1999. Forest clearance: Impact of landuse change on fertility status of soils from the São Francisco area of Niterói, Brazil. Land Degrad. Dev., 9(5): 425-440.

Mckee, J.K., P. Sciulli, C.D. Fooce and T.A. Waite, 2003. Forecasting global biodiversity threats associated with human population growth. Biol. Cons., 115: 161-164.

Ohimain, E.I., W. Andriesse and M.E.F. van Mensvoort, 2004. Environmental impacts of abandoned dredged soils and sediments available options for their handling, restoration and rehabilitation. J. Soils Sed., 4(1): 59-65.

Ohimain, E.I., J.F. Bamidele and O.O. Omisore, 2010. The impacts of micro-topographic changes on mangrove in the lower reaches of Benin River, Niger Delta. Env. Res. J., 4(1): 167-172.

Okiwelu, S.N., N. Ewurum and M.A.E. Noutcha, 2009. Wildlife Harvesting and Bushmeat Trade In Rivers State, Nigeria: -I- Species Composition, Seasonal Abundance and Cost. Sci. Afr., 8(2): 1-8.

Powell, C.B., 1997. Discoveries and priorities for mammals in freshwater forests of the Niger delta. Oryx, 31(2): 83-85.

Short, K.C. and A.J. Stäuble, 1965. Outline of geology of Niger Delta. Am. Assoc. Petr. Geol. Bull., 51: 761-779.

SAS., 2001. Statistical Analytical System. SAS Institute, Cary, North Carolina, USA.

Twumasi, Y.A. and E.C. Merem, 2006. GIS and remote sensing applications in the assessment of change within a coastal environment in the Niger Delta region of Nigeria. Int. J. Env. Res. Pub. Health, 3(1): 98-106.

Umechuruba, C.I., 2005. Health impact assessment of mangrove vegetation in an oil spilled site at the bodo west field in rivers state. Nig. J. Appl. Sci. Environ. Mgt., 9(1): 69-73.