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Review Article
Impact of Human Activities on Biodiversity in Nigerian Aquatic Ecosystems

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Abstract
The human race has 850 million members when it entered the industrial age, sharing earth with life forms nearly as diverse as the planet has ever possessed. In the 20th Century, it became obvious that biological resources have limits and that we are exceeding those limits and thereby reducing biodiversity. Biodiversity is the term used to describe the total variety of living organisms (plants, animals, fungi and microbes) that exist on our planet. The biodiversity of Nigerian aquatic ecosystems is increasingly being destroyed or depleted by persistent threat of sediment pollution, organic pollution, eutrophication, acidification, heavy metals and organochlorines, thermal pollution, nuclear pollution, human introductions (voluntary or accidental) and oil pollution. This is the aftermath of intense human activities such as indiscriminate use of fertilizers and pesticides in agriculture, industrialization, urbanization, pressure due to rapid population growth; malutilization and mismanagement of natural aquatic resource; dam, road and bridge construction; irrigation; draining and filling of wetlands; petroleum exploration, exploitation and refining as well as the transportation, storage, marketing and use of petroleum products. The rapid decline in biodiversity of aquatic ecosystems in Nigeria could be reversed if there is sound engineering solutions based on ecological awareness. This should be determined on the basis of sound scientific evaluations of the existing resources and the carrying capacity of the ecosystem.

Key words: Human activities, biodiversity, aquatic ecosystems, eutrophication, gas flaring

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INTRODUCTION

The human race had 850 million members when it entered the industrial age, sharing earth with life forms nearly as diverse as the planet had ever possessed. In the 20th century, it became obvious that biological resources have limits and that we are exceeding those limits and thereby reducing biodiversity. This is therefore the time of extraordinary change in the relationship between people and the biological resources upon which their welfare depends. Each year, more people are added to the human population than ever before, species are becoming extinct at the fastest rate known in geological history and climate appears to be changing more rapidly than every day[1]. Human and industrial activities result in the discharge or various pollutants in to the aquatic environment, threatening the health of the population and damaging the quality of the environment by rendering water bodies unsuitable[2-3].

Biodiversity is the term used to describe the total variety of living organisms (plants, animals, fungi and microbes) that exist on our planet[4]. It is the totality of genes, species and ecosystems in a region[5]. The term is also used to describe the number, variety and variability of living organisms. A massive review of our current knowledge on the broad field of biological diversity commissioned by UNEP considers humans as an integral and critical important part of biodiversity. In the past, there was the tendency to treat human species as separate from the rest of nature[6]. In recent times, biodiversity had become easy targets for human over-exploitation due to burgeoning human populations and the quest for a "better life" through improvements in science and technology. Biodiversity, therefore, is being exploited at much faster rates than ever before with negative implications for sustainable human livelihood[7-8]. Biodiversity is facing a doctrine of crisis proportions which could ultimately lead to mass extinctions in the very near future[9].

The biodiversity of the Nigerian aquatic ecosystems is increasingly being destroyed or depleted by persistent threat of aquatic pollution resulting from intense human activities such as indiscriminate use of fertilizers and pesticides in agriculture; industrialization; urbanization; pressure due to rapid population growth; malutilization and mismanagement of natural aquatic resources; dam, road and bridge construction; irrigation; draining and filling of wetlands. The negative environmental and social impacts of these projects are becoming evident and cannot be ignored if we are to avoid the sorts of problems which they have brought in other parts of the World[10]. This study therefore, presents information on different types of human activities in Nigeria, their impacts on biodiversity in the Nigerian aquatic ecosystems, control and management of human activities to minimize damage on biodiversity.

DIVERSITY OF AQUATIC ECOSYSTEMS IN NIGERIA

The landmass of Nigeria is enclosed between latitudes 4°16'-13°52' N and longitudes 2°49'-14°32' E and being 1100 km on a North/West axis. The finite natural resource base shared by 158 million humans[11] and unknown number of plants and other animals is estimated as 923,700 km^2 of land[12-14]. Approximately 125,471 km^2 of Nigeria land mass is covered by the waters of the nations major rivers, lakes, ponds and pools[15]. This excludes the coastal region. Nigeria is a West African maritime State with a coastline that is about 853 km, long, stretching from the Western border with the Benin Republic to the Eastern border with the Cameroon Republic. The Nigerian coastal zone can be defined as the area which extends from the shelf break, inland to the limit of tidal influence[16]. This coastline is interrupted by a series of estuaries, which open into an extensive lagoon system in Lagos and Ondo States. In Lagos State, the creeks, floodplains, lagoons and rivers account for approximately 22% of the 790 km^2 land mass[17]. There are at least twenty-two estuaries from Benin River in Delta State coastal region to Cross River in Akwa Ibom State. Figure 1 and 2 show the aquatic ecosystems of Nigeria. The Nigerian coastal zone is generally low lying, resulting in extensive wetlands and mangrove swamps. Nigerian had the largest area of mangrove forest in Africa[18].

SPECIES DIVERSITY IN NIGERIAN AQUATIC ECOSYSTEMS

Nigerian aquatic ecosystems are characterized with diverse species of plants and animals. Unlike the terrestrial habitats, animals in the oceans are found at all depths, so that the total habitable space of a 4 km (average) deep ocean is 1,263,804 km^3. It is therefore reasonable to assume that Nigeria's aquatic flora and faunal biodiversity is higher than that of the terrestrial habitats[14].

The total fauna of the World is comprised of 25 phyla of which 24 phyla are invertebrates. The phylum chordata consists of the non-vertebrate and vertebrate chordates.

Invertebrate species diversity is much higher in the aquatic ecosystem than in the terrestrial ecosystem. The significance of greater protection to the aquatic ecosystems cannot be over-emphasized, since its diverse fauna is of great economic and social importance.

A summary of the faunal biodiversity of Nigeria aquatic ecosystems is shown in Table 1. There are at least 2570 faunal species.

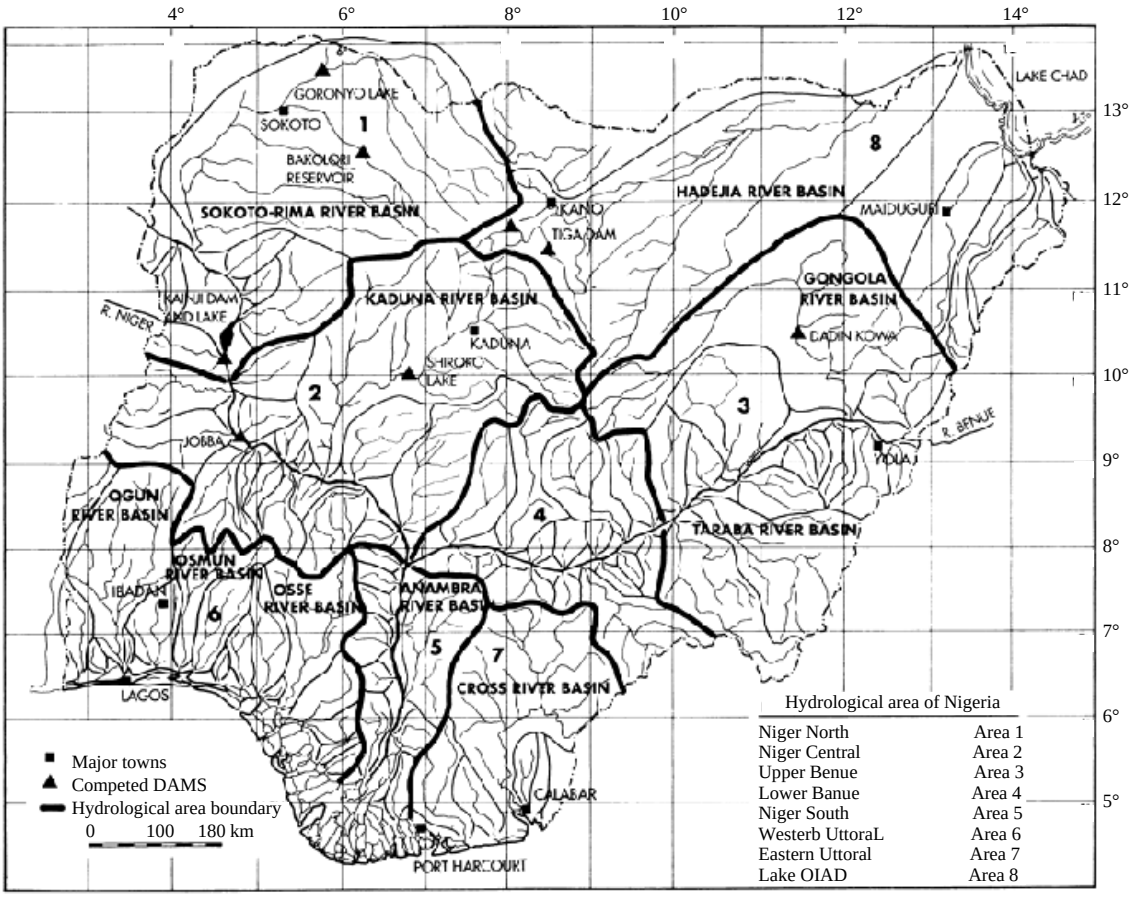

Fig. 1: Hydrology map of Nigeria[19]

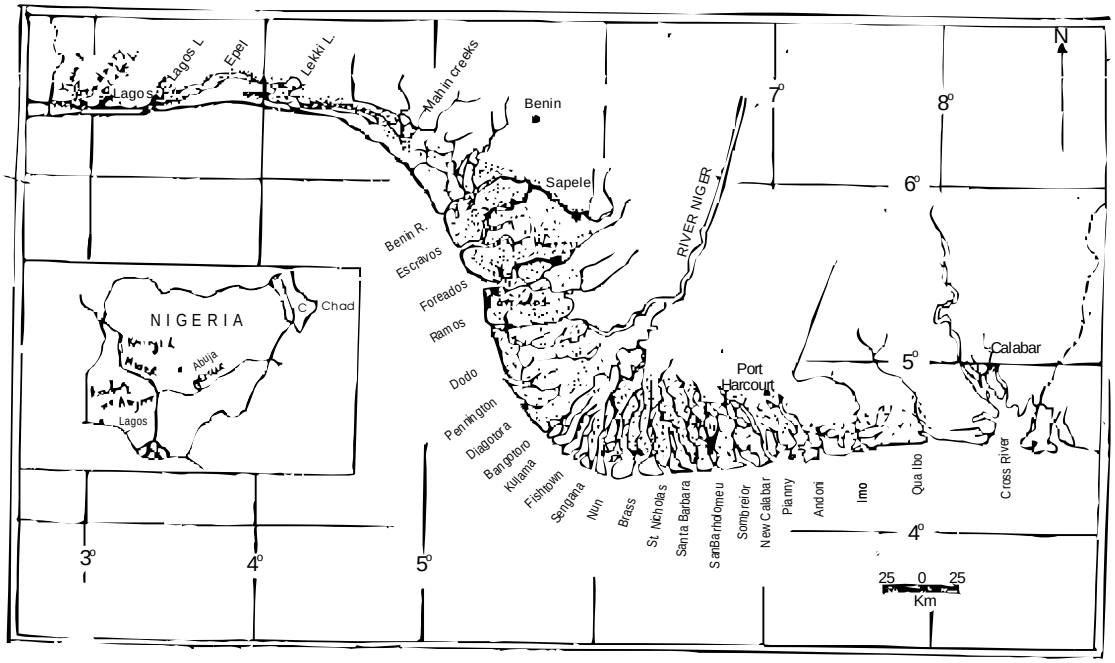

Fig. 2: Nigeria's coastal region. Inset-Nigeria[14]

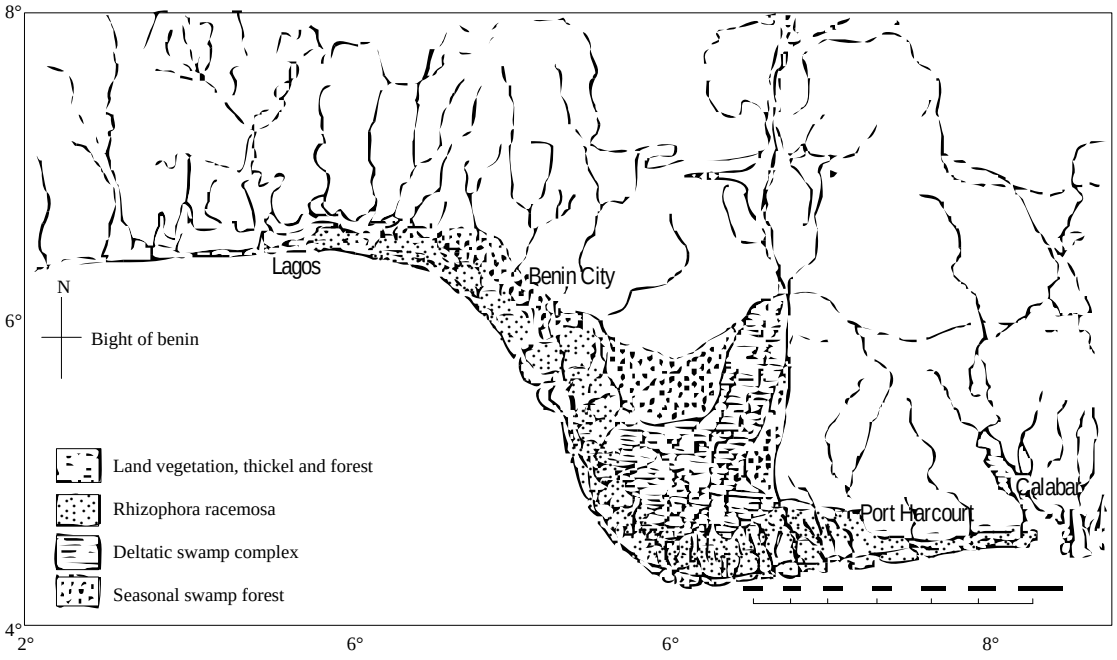

Fig. 3: Vegetation map of Nigerian coastal zone[16]

Table 1: Species diversity of Nigerian aquatic fauna (numbers represent the minimum)[14]

Phyla	Classes	No. of species
Protista	Mastigophora (103), Ciliophora (18), Rhizophora (196) and Sporozoa (18)	335
Cnidria	Anthozoa (1), Hydrozoa (3) and Scyphozoa (2)	6
Platyhelminthes	Cestodaria (12) and Trematoda (30)	42
Acanthocephala		6
Nematoda		15
Rotifera	Digononta (4) and Monogonota (193)	197
Annelida	Hirudinea (6) Oligochaeta (18) and Polychaeta (101)	125
Arthropoda	Arachnida (5) Crustacea (Branchiopoda (102), Branchiura (4), Cirripedia (4), Copepoda (92), Malacostraca (154), Ostracoda (91) and Insecta (280)	732
Mollusca	Amphineura (1), Cephalopoda (23), Gastropoda (120) and Bivalvia (101)	245
Echinodermata		3
Chaetognata		2
Chordata	Protochordata (3), Pisces (fishes) (824), Amphibia (28), Reptilia (13), Aves (73) and Mammalia (3)	944

Unidentified species account for approximately 8% of total

A vegetation map of the Nigerian coastal zone is presented in Fig. 3. Species compositions of vegetation in the mangrove forest are; climbers, grasses, sedges, herbs, shrubs and trees.

The species compositions of freshwater swamps in Nigeria are floating aquatics, submerged aquatic plants and fringe vegetation.

HUMAN ACTIVITIES RESULTING IN CONTAMINATION OF AQUATIC ECOSYSTEMS

Almost everything produced by man or resulting from his activities can bring about contamination and eventual pollution of our diverse ecosystems. Pollution is defined as the production and or introduction by man, directly or indirectly of substances or energy into the environment, resulting in deleterious effects or harm living resources, including human beings or interfere with amenities and other uses of the environment[20].

Human activities such as deforestation, channelization, filling and construction of canals, levees, dams, roads and bridges, agricultural, industrial and domestic activities, introduction of exotic species, over-exploitation of plant and animal species upset the hydrological regime, sediment characteristics and several biotic components. Upstream activities bring pollutants into mangrove swamps and estuaries.

Table 2 shows the types, sources and routes of entry into the aquatic environment of pollutants from human activities.

Table 2: Types sources and routes of entry of pollutants from human activities into the aquatic ecosystems[10]

Types of pollutants	Sources	Routes of entry
Oxygen-demanding wastes (organic pollutants)	Domestic sewage, human and animal wastes (such as wastes from canneries and woodpulp mills)	Thrown, dumped, or discharged into streams and rivers or into gutters, drains from where they may get washed by run-off into water bodies
Infectious disease agents	Domestic sewage, human and animal wastes	Washing, swimming, or working in paddy rice fields and on irrigated land
Plant nutrients such as nitrate, phosphates and others	Fertilized farm lands, ashes and detergent	Run-off from fertilized farmlands
Pesticides such as insecticides, herbicides, etc.	Organic and inorganic chemicals	Run-off from pesticides associated with farmlands
Industrial effluents which include DDT, dyes, mercury, cadmium, etc.	Textile factories; distilleries pulp and paper mills; fertilized plants; chemical and allied industry; food, beverages and tobacco industries, soap, detergents and confectionery industries	Human discharge
Eroded sediments	Deforestation and accelebrated soil erosion	Soil erosion, urban storm water runoffs and dredging activities
Other solid wastes	Metals, Plastics, artificial fibres etc	Dumping by human beings due to poor management of waste disposal
Petroleum products	Drill cuttings; drilling mud (fluids used to stimulate the production processes); accidental discharges of crude petroleum; refinery effluents which include oil and grease, phenol, cyanide, sulphide, suspended solids, chromium and biologically oxygen demanding organic matter	Petroleum, exploration, exploitation, refining, transportation, storage, marketing, use and ruptured oil pipelines

Table 3: Impacts of human activities on the biodiversity of some aquatic ecosystems in Nigeria

Aquatic ecosystems	Human activities and possible causes of impact on biodiversity	Associated impacts on biodiversity	Author(s)
Ikpoba River, Benin City, Edo State	Road and bridge construction and impoundment, resulting in sedimentation and siltation	Changes in water quality and the longitudinal distribution of species; reduction in the abundance and diversity of macro- benthic invertebrates	21-22
Tropical man-made lake (Moro dam), North of Ilorin Township, Kwara State	Leaching of fertilizers from farmlands, obnoxious fishing practices, sewage disposal, washing and bathing with detergents and soda soaps	High level of eutrophication resulting from increase in concentration of nitrate in the lake, lower species of plankton and fish death probably occurring from obnoxious fishing practices and poor water quality	23
Buguma Creek, Buguma, River State	Pedestrian bridge site, dumping and burning of domestic waste, continuous cutting of mangrove, sand dredging and sand filling, bathing and human settlement	Ecological modification of habitat, drastic reduction in taxa and abundance of species	24-25
Lower Cross River	Human settlement resulting in anthropogenic inputs, probably from upstream and run-off during wet season	Higher levels of magnesium, iron, lead, cadmium and nickel than WHO and SON maximum permitted levels for drinking water	26

IMPACT OF DISCHARGES FROM HUMAN ACTIVITIES ON AQUATIC BIODIVERSITY

The most important aquatic pollution forms resulting from pollutants due to human activities and which impact the biodiversity of aquatic ecosystems are; sediment pollution, organic pollution, eutrophication, acidification, heavy metals and organochlorines, thermal pollution, unclear pollution, human introductions (voluntary or accidental) and oil pollution.

The studies of impacts of human activities on biodiversity of aquatic ecosystems in the industrial sector (particularly oil companies in Nigeria) are not available in the scientific sector. Some available studies in the scientific sector are presented in Table 3.

ORGANIC POLLUTION

Organic pollutants such as domestic sewage, urban run-off, farm wastes and effluents from food processing industries, brewing industries, dairies, abattoirs, tanneries, textile and paper making factories have diverse adverse effects. These pollutants are biodegradable and are easily oxidized by making use of the dissolved oxygen in water. As dissolved oxygen drops, fish and other aquatic life are threatened or killed in the extreme case. Number of algae and bacteria is increased. Macrophytes are also adversely affected due to light reduction and solids rendering the bed of the river unstable for plants.

The faecal contamination of water can introduce a variety of pathogens into waterways. The surest confirmation of

Table 4: Some reports of outbreak of water related diseases in Nigerian[10]

Diseases	Places of outbreak	No. of lives affected	Newspapers
Cholera	Suleja Town, Niger State	More than 30 people died	Nigerian Standard, May 22, 1982
Typhoid fever	Plateau State	134 persons were affected and two died	The Guardian Monday 9, 1989
Hepatitis	Jos Adamawa State	More than 20 died, while about 500 others were hospitalized	Sunday Standard, June 26, 1989
Gastroenteritis	Kaura Namoda local government area of Sokoto	More than 90 died	Nigeria Herald, October 19, 1980

Table 5: Cases of water related diseases in Nigeria from 2002-2008[27]

Diseases	2002	2003	2004	2005	2006	2007	2008
Cholera	23,441	11,933	13,522	10,785	20,526	12,194	17,894
Dracunculiasis	2,588	1,234	2,206	153	36	1	NR
Hepatitis	9,451	8,894	7,104	13,609	6,419	5,239	NR
Typhoid	104,154	77,850	39,337	NR	NR	NR	NR

NR: No record of cases of disease

serious and widespread water pollution in Nigeria is, in fact, the level of incidence of water related diseases. The most serious of these are dysentery, cholera, typhoid, guinea worm infestation and bilharziasis.

Table 4 shows some news reports on water related diseases in Nigerian dailies, while Table 5 shows cases of water related diseases in Nigeria from 2002-2008.

EUTROPHICATION

Eutrophication will be defined as an increase in the rate of 'income' of nutrients[28]. The income of nutrients may be considered as artificial or cultural eutrophication if the increase is due to human activities, or natural eutrophication if the rate of increase is caused by a non-human process, such as forest fire. Only artificial eutrophication is considered under pollution.

The menace of water hyacinth in the Lagoons of Ogun, Lagos and Ondo state is to some extent, attributed to the unintended fertilization of aquatic ecosystems by run-off from fertilized farmlands. The process of eutrophication of aquatic ecosystems can be observed around the edges of water reservoirs throughout the country.

PESTICIDES

Pesticides such as insecticides and herbicides get washed into aquatic ecosystems where they may kill aquatic life or be absorbed by them and passed up the food chain until they become toxic to man. DDT for example is an insecticide, which was once widely used but the use of which had now been banned or severely restricted in many countries with Nigeria being a notable and unfortunate exception.

Agrochemicals such as Gammalin 20 (for spray of cocoa tree), Aldrin dust (for seed preservation) and DDT (for tsetse fly and simulium fly control), have been used from ignorance by some of our people, in fishing and hunting. This is a very dangerous habit, which could adversely affect biota of any kind of ecosystem, either directly or indirectly.

OIL POLLUTION

The discovery of oil in 1956 in Oloibiri, Bayelsa State, Nigeria and its exploitation two years later, marked the beginning of an important era in Nigeria. About a decade later, the significance of oil to the economic, social and political well being of Nigeria had become obvious. Presently, the nation depends solely on oil and efforts to shift the dependence from petroleum industry to other sectors of the economy have not been entirely successful[29].

The inextricable adverse effects of petroleum exploration, prospecting and marketing on plants, animals, man and his environment, has until very recently received no attention. These adverse effects are alarming in the Niger Delta where there is predominance of oil wells. Petroleum exploration, exploitation and refining as well as the transportation, storage, marketing and use of petroleum products have all created problems in various parts of the country.

The formation of a film of oil on water bodies effectively prevents natural aeration, leading to the death of organisms trapped below. Fish may also ingest spilled oil directly or indirectly, becoming unpalatable or even poisonous.

The oil spilled into the Nigerian environ between 1976-80 above is over 56 million gallon. "The number of registered oil spillages is increasing. Depending on the area, oil pollution could cause adverse impact on people (water quality), vegetation (smothering mangrove trees, crops, shore vegetation and fauna (fish, shellfish, soil fauna). This is demonstrated in several post impact studies on the recent or old spill sites. The 25 years old 'mystery spill' of trunkline in the Ejama-Ebubu caused during the civil war is a well-known-but not sufficiently studies yet-example"[6]. Table 6 shows the

Table 6: Physical presence of the oil industry in Nigeria[30]

Oil facilities	Area/number
Land area within which the networks of pipelines are located	31,000 km^2
Number of oil wells drilled	5,284
Number of flow stations	257
Length of main oil and gas pipelines in the region (flow lines between oil wells and flow stations not included)	7,000 km
Number of export terminals	10
Number of communities hosting oil/gas facilities	1,500

Table 7: Number of spills in the Niger Delta between 1979 and 2005[31]

Episodes	Years	States	Quantity spill in Barrels
Forcados terminal oil spills	1979	Delta	570,000
Funiwa No. 5 well blow out	1980	Rivers	400,000
Oyakama oil spillage	1980	Rivers	10,000
System 2C Warri, Kaduna pipeline rupture at Abudu	1983	Edo	18,000
Sohika oil spill	1983	Rivers	10,000
Idoho oil spill	1983	Akwa Ibom	40,000
Jones Creek oil spill	1998	Delta	21,000
Jesse oil spill	1998	Delta	10,000
Etiama oil spill	2000	Bayelsa	11,000
Ughelli oil spill	2005	Delta	10,000
Total	-	-	700,000

physical presence of the oil industry in Nigeria, while Table 7 shows the number of spills in the Niger Delta between 1979 and 2005.

Research findings based on information on fish and fisheries for freshwater oil spillage in the Niger Delta viz. the 1986 GENECO barge spillage (tidal New Calabar River) and several pipeline spillages: 1983 Utorogu and Ikata (both black water rivers/streams), 1985 Okoma (tidal Sombreiro black water river, stream and swamp) and 1983 Oshika (seasonal swamp) have shown that:

- No major species loss, but a 50% reduction in abundance of fish and an increase in diversity indices and abundance of prawns (Sombreiro and New Calabar Rivers)
- Loss of all species lacking accessory air breathing organs (Oshika and Okoma Swamps)
- Major loss of species without any obvious physiological patterns, Okoma Streams

Environmental impact research on effect of Oshika oil spill on aquatic biology showed that:

- After a year, oil-in-water values dropped to non-detectable limits (0.2 ppm), but oil-and-grease in sediments remained high. Many of the fluctuations observed in water quality parameters appeared to be due more to seasonal changes than to pollution
- Plankton and invertebrate studies generally showed high biomass and low-diversity communities during the dry season following the spill. Pollution related differences were clearly evident in March (7 months post-spill). In June/July, they showed evidence of recovery and normal aquatic vegetation was re-established
- The shrimp, Desmocaris in downstream areas free of visible oil, suffered heavy embryonic mortality for 2-3 months after the spill. In oiled areas, embryonic mortality was detected for up to 8 months after the spill. The mortality led to marked changes in population structure and reduced population sizes, at least to July (11 months post-spill). Fecundity was depressed after the spill, but after several months, it increased to levels above that of control site[32]

GAS FLARING

Global estimate indicates that the flaring of petroleum dissociated gas in the coastal area of Nigeria alone account for 28% of total gas flared in the world. Nigeria, like every coastal country has a coastal based economy through the onshore and offshore oil exploration and hence majority of industries and commerce are located along the area in proximity with ports and borders for effective transit of goods and services. These factors put so much pressure on the coastal biodiversity and reduce their suitability[11].

CONTROL AND MANAGEMENT OF HUMAN ACTIVITIES TO MINIMIZE DAMAGE ON BIODIVERSITY

Measures to curb the damage on biodiversity by human activities, which impact aquatic ecosystems in Nigeria, are the

most intricate and expensive and have attracted insignificant attention from both the public and government. Biodiversity of aquatic ecosystems in Nigeria is threatened by various human activities, which culminate in diverse forms of pollution. There is the urgent need for proper control and management of the various negative effects resulting from diverse cultural and social-economically important human activities in order to attain sustainable development.

There is an obvious need for an integrated approach to the control and management of human activities that impact biodiversity. This integrated approach should be an activity that will provide the framework for decision-making on how biodiversity can be conserved. The success of management depends on the level of awareness and co-operation of the public, decision-makers in government and managers. Control and management can further be enhanced by having national and regional coordination mechanisms. This is because marine waters and some of the marine living resources do not recognize national boundaries and therefore planning and management of marine resources and pollution prevention require a regional approach[33]. The regional approach has an additional approach in terms of the rational utilization of financial resources and manpower.

The key problems associated with human activities, with respect to biodiversity of aquatic ecosystem are related to inadequate planning for sustainable environmentally-sound, socio-economic development and the rational utilization of natural resources. These problems can only be overcome by adopting the following control and management options: Proper management of hydrological cycle, Environmental Impact Assessment (EIA), Environmental Auditing (EA), monitoring and research related to the sources, levels and effects of pollutants, legislation, technical methods of waste manage which include non waste (zero waste) option, waste minimization and waste treatment; multiagency projects; population control and environmental education.

CONCLUSION

The decline in biodiversity of aquatic ecosystems is largely caused by human activities and poses a serious threat to sustainable development. There is the need for urgent and decisive action to conserve and maintain genes, species and ecosystems.

Technological developments, coupled with the growing resource needs of rapid population growth, has increased the environmental hazards to biodiversity of all natural ecosystems.

The rapid decline in biodiversity of aquatic ecosystems in Nigeria could be reversed if there is sound engineering solutions based on ecological awareness. This should be determined on the basis of sound scientific evaluations of the existing resources and the carrying capacity of the ecosystem. In areas with rapid population growth, it may be necessary to invest in major carbon and nutrient-absorbing systems to avoid further degradation and to preserve the biological productivity of existing systems.

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