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## **Bioremediation: A Strategic and Sustainable Technique for the Remediation of the Hydrocarbon Polluted Environment of the Niger Delta.**

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### **Abstract**

*Human activities are severely impacting negatively on the environment globally. In trying to encourage development and at the same time conserve the environment, the United Nations Development Program (UNDP) established development framework known as sustainable development goals (SDGs). This frame work seeks to integrate three key pillars of development together so that development will be addressed wholistically. The three pillars are social development, economic development and environmental protection. The SDGs is made up of 17 goals with separate targets that sum up to 169 targets. This framework is expected to be adopted by all nations including local, States, Federal Governments and Agencies. A critical review of the 17 goals indicates that they need a clean environment for them to be achieved. In the Niger Delta the environment is severely polluted with petroleum hydrocarbon that it will require remediation for the SGDs to be achieved. With wide spread distribution of hydrocarbon degrading microbes in the region couple with the effectiveness, efficiency, low cost, environmental friendliness and public acceptability, bioremediation stand out as strategic and sustainable remediation technique that can be adopted and integrated into SDGs process in order to achieved the desired goals in the Niger Delta region of Nigeria.*

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**Keywords:** Sustainable development, strategic, Bioremediation, technique and goals.

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### **Introduction**

The National Oil Spill Detection and Response Agency (NOSDRA) in Nigeria estimated that the crude oil spilled into the Niger Delta environment between 1976 and 1996 was more than 2.4 million barrels (The Guardian, 2010). Greater proportion of about 1.82 million (77%) of the total spill was not recovered. The crude oil was spilled offshore, in swamps and on land (Agbogidi and Eruator, 2007). Some of the spills were caused by oil pipeline sabotage but the majority of oil spills were due to poor maintenance and monitoring by the oil companies (Aljazeera, 2012). As a result, Petroleum-contamination of both terrestrial and marine environments has been wide spread and persistent in the Niger Delta.

As world leaders gathered and made another declaration of commitment to Sustainable Development Goals (SDGs), there is need for the Nigerian Government both State, Federal and donor agencies to integrate bioremediation as a strategic sustainable technique among other measures for the achievement of the development goals in the Niger Delta. This is very vital considering the strategic importance of a wholesome environment in the reduction of poverty and attainment of healthy life and good standard of living.

In the Niger Delta region of Nigeria, petroleum hydrocarbon pollution has been wide spread and persistent. This has made microorganisms including bacteria and fungi in the aquatic and terrestrial environment to be resilient and adjust to the polluted environment by utilizing the hydrocarbon as carbon and energy source, hence making bioremediation feasible and attractive option to clean the environment of the Niger Delta. A lot of researches have been carried which indicate that the Niger Delta polluted environment is rich in hydrocarbon degrading microbes which make bioremediation a suitable technique to remediate the environment. For instance, (Mansi *et al* (2017a) isolated hydrocarbon degrading bacteria in crude oil polluted soil in the Niger Delta. (Mansi *et al*, (2017b) also isolated hydrocarbon degrading bacteria from municipal drainage bio sludge in the Niger Delta. Bioremediation has proven successful in the remediation of crude spill as revealed by results of project and researches carried out in the region and in other countries. Abu and Dike (2006) reported successful bioremediation of crude oil impacted wetland sediment in the Niger Delta. (Iheoma *et al*, 2013) also reported 99% removal of hydrocarbon from crude polluted site using bioremediation technique in the Niger Delta. Shell Petroleum Development Company implemented bioremediation of crude oil impacted site at Bomu in Ogoni land in Rivers State. The remediation was completed in December 2011 where Initial TPH of impacted soil ranged from 10,000 mg/kg to 122,950mg/kg and about 96% reduction of soil TPH was achieved during the project closed out (SPDC, 2011). Bioremediation of the open water Mega Borg spill off the Texas coast in June 1990 which involved application of seed culture produced by the Alpha Corporation was declared effective by the Texas General Land Office. Bio treatment with the Alpha culture was also used on a spillage from the Apex Barges after an accident at Galveston Bay in Texas in July 1990. Here also the Texas General Land Office reported that the bioremediation was effective.

A critical critical of the Seventeen goals of the Sustainable Development Goals (SDGs) reveals that more than Ten (10) of the goals are environmentally related as their achievement will depend greatly on clean, friendly and wholesome environment. For instance, in the Niger Delta where majority of rural dwellers are either farmers or fishermen, many have been robbed of their means of livelihood and impoverished as a result of soil and marine pollution cause by frequent and wide spread oil spills. For sustainable development to be achieve in the Niger Delta therefore, the polluted environment need to be restored for the people to return to commercial farming and fishing, have access to clean and potable water, good standard of living and live a healthy life. This paper is therefore focus on bringing to the fore the need to integrate bioremediation as a strategic and sustainable technique for the cleanup of the polluted environment in order to achieve sustainable development goals in the Niger Delta.

### **Incidences of Oil Spill in Nigeria, Environmental and Health Impacts of Crude Oil Pollution**

Thousands of tons of oil have been released into the surrounding land and water in the Niger Delta region. For instance in 1989, about 1,680,000 gallons of oil was released into the surrounding water at Idoho from an oil production facility on water. The oil spill at Azuzuama community in Southern-Ijaw Area of Bayelsa State where an Agip oil pipeline exploded and killed about twelve workers on oil pipeline maintenance (Premium Times, 2015) and the Ikarama oil spill in Yenagoa Local Government Area of Bayelsa State are cases still fresh in mind (Daily post, 2015).

The Niger Delta of Nigeria which is the most endowed delta in the world with respect to mineral and human resources (Oyinloye and Olamiju, 2013), has witnessed several oil spills but most of the oil spills were not reported or under reported. In 2013, a newspaper report has it that about 420 to 630 million gallons of crude oil have been released in to the land and

water bodies in the Niger Delta zone of Nigeria since the drilling of crude oil started in Oloibiri in 1958 (This day newspaper, 5 February, 2013). Department of Petroleum Resources (DPR), confirmed that between 1976 and 1996 approximately equivalent of 18,900 million cubic meters of petroleum hydrocarbon oil were spilled in about 4,647 incidents recorded in the South South geopolitical zone of Nigeria. Many of the oil released incidences are not reported in the literature (Oyinloye and Olamiju, 2013). Independent assessment estimated about 15 million barrels of crude oil has been released in to this deltaic zone.

When there is an oil spill on water, spreading immediately takes place. The gaseous and liquid components evaporate. Some get dissolved in water and even oxidize, while some undergo bacterial changes and eventually sink to the bottom by gravitational action. The soil is then contaminated with a gross effect upon the terrestrial life. As the evaporation of the volatile lower molecular weight components affect aerial life, so the dissolution of the less volatile components with the resulting emulsified water, affects aquatic life (Akpofure *et al*, 2000).

The harmful effects of oil spill on the environment are many. Oil kills plants and animals in the estuarine zone. Oil settles on beaches and kills organisms that live there. It also settles on ocean floor and kills benthic (bottom-dwelling) organisms such as crabs. Oil poisons algae, disrupts major food chains and decreases the yield of edible crustaceans. It also coats birds, impairing their flight or reducing the insulative property of their feathers, thus making the birds more vulnerable to cold. The Ogoni community is exposed to petroleum hydrocarbons in outdoor air and drinking water, sometimes at elevated concentrations. They are also exposed through dermal contacts from contaminated soil, sediments and surface water (UNEP, 2011). This report is an evident of the health risk the people of the Niger Delta are expose to as a result of oil pollution.

Crude oil pollution also endangers fish hatcheries in coastal waters and as well contaminates the flesh of commercially valuable fish. In the Nigerian coastal environment a large areas of the mangrove ecosystem have been destroyed. The mangrove was once a source of both fuel woods for the indigenous people and a habitat for the area's biodiversity but is now unable to survive the oil toxicity of its habitat. Oil spills in the Niger Delta have been a regular occurrence, and the resultant degradation of the surrounding environment has caused significant tension between the people living in the region and the multinational oil companies operating there. It is only in the past decade that environmental groups, the Federal Government, and the foreign oil companies operating in the Niger Delta began to take steps to mitigate the impacts. Large areas of the mangrove ecosystem have also been destroyed. The mangrove forest was in the past a major source of wood for the indigenous people. In some places it is no longer in a healthy state to sustain this use (Nwilo and Badejo 2005). The Idoho oil spill traveled all the way from Akwa Ibom state to Lagos state dispersing oil through the coastal states, up to the Lagos coast. This culminated in the presence of sheen of oil on the coastal areas of Cross river state, Akwa Ibom state, Rivers state, Bayelsa state, Delta state, Ondo state and Lagos state. In many villages near oil installations, even when there has been no recent spill, an oily sheen can be seen on the water, which in fresh water areas is usually the same water that the people living there use for drinking and washing. In April 1997, samples taken from water used for drinking and washing by local villagers were analyzed in the U.S. A sample from Luawii, in Ogoni, where there had been no oil production for four years, had 18 ppm of hydrocarbons in the water, 360 times the level allowed in drinking water in the European Union (E.U.). A sample from Ukpeleide, Ikwerre, contained 34 ppm, 680 times the E.U. standard. Following the major Texaco spill of 1980, it was reported that 180 people died

in one community as a result of the pollution. On several occasions, people interviewed by Human Rights Watch said that spills in their area had made people who drank the water sick, especially children. Oil spillage has a lot of deleterious effects on the environment and human health as a result of its toxicity to almost all forms of living organisms. There is also the risk of causing or contributing to Climate Change when spill is allowed to remain in the environment for a long time unattended to. Crude oil kills fish quickly at a concentration of 4000 parts per million (ppm) i.e. 0.4%. (Prasad, M.S 1987). Crude oil and its related products causes birth defects in humans. ([www.lockslaw.com](http://www.lockslaw.com) 2010-05-04). Benzene, a volatile organic compound present in crude oil and gasoline is known to cause leukemia in humans. (Jerome et al, 2016). The compound is also known to lower the white blood cells count in humans, which would leave people exposed to it more susceptible to infections. (Hussein, *et al* (2016).). Studies have linked benzene exposure in the mere parts per billion (ppb) range to terminal leukemia and other blood human system disease within 5 to 15 years of exposure.

### **The Significance of a Wholesome Environment in the Achievement of the Sustainable Development Goals (SDGs)**

The sustainable Development Goals are made up of Seventeen (17) universal goals and one Hundred and Sixty nine targets which United Nations member countries are expected to adopt as frame work to develop their policies for the next Fifteen (15) years starting from this year 2016. A critical look at these goals shows that a lot depend on a wholesome environment for them to be achieved. For instance



**Plate 1:** Crude oil floating on River water in the Niger Delta





**Plate 2:** Swamp vegetation in the Niger Delta destroyed by oil spill.

**Goal 1:** End poverty in all its form everywhere. The impact of oil spillage to environment are numerous and enormous. These include impact on soil quality, crop production, water quality, fishing activities, air quality, land use, land coverage and ecosystem damage. All these are been experience in the Niger Delta. As good as this goal may seem, it will be a mere wish when the environment for economic activities is ash and unfavourable. Oil pollution has made the environment in the Niger Delta ash and unfavourable for economic activities such as farming and fishing which is the main source of livelihood and revenue earning for the majority of the people. Therefore achieving the goal of ending poverty in all its form everywhere will be a mirage in the Niger Delta if the polluted environment is not properly remediated.

**Goal 2:** End hunger, achieve food security and improve nutrition, and promote sustainable agriculture. Ending hunger and achieving food security is closely tied to farmable and fishable environment and this cannot be achieved in significantly polluted environment as it is in the Niger Delta. Any crops in areas directly impacted by oil spills will be damaged, and root crops, such as cassava, will become unusable. When farming recommences, plants generally show signs of stress and yields are reportedly lower than in non-impacted areas (UNEP, 2011). This report by UNEP reflect the food insecurity risk the Niger Deltans are exposed to if the Environment is not urgently remediated.

**Goal 3:** Ensure healthy lives and promote wellbeing for all at all ages. Healthy lives and good wellbeing can only be achieved in clean and wholesome environment but not in environment where the waters, fishes and soil is severely polluted with crude oil as in the Niger Delta. Crude oil kills fish quickly at a concentration of 4000 parts per million (ppm) i.e. 0.4%. (Prasad, M.S 1987). Crude oil and its related products causes birth defects in humans. ([www.lockslaw.com](http://www.lockslaw.com) 2010-05-04).

**Goal 4:** Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all. Poor people cannot afford to send their children to good schools. So the people of the Niger Delta cannot be equitably educated when the environment continue to remain severely polluted.

**Goal 5:** Achieve gender equality and empower all women and girls. Women are worst affected by the effect of environmental pollution in the Niger Delta where more than 90% of women dwelling in the rural areas are farmers. Therefore you can imagine how many women are out of farm work due to severe environmental pollution.

**Goal 6:** Ensure availability and sustainable management of water and sanitation for all. Ground and surface waters in the Niger Delta are significantly polluted hence this goal can only be achieved when the heavily polluted environment of the Niger Delta is properly remediated, which bioremediation offer a cheaper, effective and eco-friendly means of clean up. The UNEP report on the Ogoni land shows that well waters, rivers and creek waters have been severely polluted and therefore make the people of the Niger vulnerable to cancer as a result of hydrocarbon pollution.

**Goal 8:** Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all. The people of the Niger Delta may not be included in the sustainable economic growth quest of the Nigeria Government as per SDGs if the environment of the zone is not remediated. Fish tend to leave polluted areas in search of cleaner water, and fishermen must therefore also move to less contaminated areas in search of fish.(UNEP, 2011).This report is a proof that means of livelihood of the average Niger Delta fisherman has been negatively impacted by the menace of oil pollution and something need to be done

**Goal 11:** Make cities and human settlements inclusive, safe, resilient and sustainable. The severely polluted environment of the Niger Delta cannot provide safe, resilient and sustainable settlements if it remains unpremeditated. See plate 3 showing a Niger Delta resident standing in severely polluted surface water in the river. How can be people be safe in degraded environment like this.



**Plate3**

**Goal 12:** Ensure sustainable consumption and production patterns. Sustainable production pattern is inconceivable in ash and hostile environment as in the severely polluted

Niger Delta environment. In a devastated environment like the Niger Delta region, how can sustainable and productive patterns be ensured when farmlands have been destroyed by oil spills, river water severely polluted and fishes destroyed and the few survivors have ran away for safety. This goal can only be achieved by sustainable remediation of the environment.

**Goal 13:** Take urgent action to combat climate change and its impacts. If this is to be true in the Niger Delta then the Polluted environment must be remediated as urgently as stated as oil spill also has the risk of causing or contributing to Climate Change when spill is allowed to remain in the environment for a long time unattended to, due to volatilization of greenhouse gases.

**Goal 14:** Conserve and sustainably use the oceans, seas and marine resources for sustainable development. Water surfaces coated with crude oil as commonly seen in the Niger Delta cannot be said to conserve and therefore cannot be sustainably use. The UNEP investigation found that the surface water throughout the creeks contains hydrocarbons. Floating layers of oil vary from thick black oil to thin sheets. The highest reading of dissolved hydrocarbon in the water column, of 7,420 µg/l. In situation like this how can marine resources be conserved?

**Goal 15:** Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss. If this must be true in the Niger Delta then the environment must be remediated.

**Goal 16:** Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all level. Oil spills in the Niger Delta have been a regular occurrence, and the resultant degradation of the surrounding environment has caused significant tension between the people living in the region and the multinational oil companies operating there. Therefore to promote peaceful and inclusive society for sustainable development in the Niger Delta, the polluted environment of the zone must be effectively and efficiently remediated.

### **Bioremediation a Strategic and Sustainable Technique to Achieve Wholesome Environment in the Niger Delta**

Bioremediation has been globally acknowledged as an effective, efficient, economical and ecofriendly environmental remediation technology. Apart from been cheap and environmentally friendly, the technique also has high public acceptability. With the wide spread distribution of microorganism with the capability to degrade petroleum hydrocarbon in the Niger Delta, bioremediation stand out either alone or in conjunction with other remediation technique as a viable and strategic technique for remediating the severely polluted environment of the Niger Delta. The strategies of bioremediation are simple, just simple tools are required. Cheaper and provides opportunity for the native people to participate and earn income. Some of the strategies of bioremediation include.

#### **In-situ bioremediation**

**I Bioventing:** Bioventing is the most common in situ treatment and involves supplying air through wells to contaminated soil to stimulate the indigenous bacteria. Bioventing employs low air flow rates and provides only the amount of oxygen necessary for the biodegradation while minimizing volatilization and the release of contaminants to the atmosphere. It works for simple hydrocarbons and can be used where the contamination is deep under the surface.



**II Biosparging:** Biosparging involves the injection of air and microbial nutrient under pressure below the water table to increase groundwater oxygen concentrations and enhance the rate of biological degradation of contaminants by naturally occurring bacteria. Biosparging increases the mixing in the saturated zone and thereby increases the contact between soil and groundwater. The ease and low cost of installing small diameter air injection points allows considerable flexibility in the design and construction of the system.

**III Biostimulation:** Some microorganisms are present in the contaminated site, but for effective remediation, growth of microorganism should be stimulated. Biostimulation is the process of adding nutrient, electron acceptor and oxygen to stimulate existing bacteria involve in bioremediation. This is the process of optimizing the environmental condition of the remediation site. Additives are usually added to the subsurface through injection wells.

**IV Bioaugmentation:** It is the addition of a group of indigenous microbial strain or genetically engineered microbes to treat polluted soil. It is effective where native microorganisms are not identified in the soil or do not have the metabolic capability to perform the remediation process.

### **Ex-situ bioremediation**

These techniques involve the excavation or removal of contaminated soil from the ground. These strategies include.

**I Land farming:** Land farming is a method in which contaminated soil is spread over a prepared bed along with some fertilizers and occasionally rotated. It is a simple technique in which contaminated soil is excavated and spread over a prepared bed and periodically tilled until pollutants are degrade. The goal is to stimulate indigenous biodegradative microorganisms and facilitate their aerobic degradation of contaminants.

**II Compost:** Composting is a process of piling contaminated soil and organic substances such as manure or agricultural wastes. The added organic material supports the development of a rich microbial population and elevates temperature of the pile. Stimulation of microbial growth by added nutrients.

**III Biopile:** Biopile is a hybrid of land farming and composted piles typically used for treatment of surface contamination with petroleum hydrocarbons. It is refined version of land farming that tends to control physical losses of the contaminants by leaching and volatilization. Biopile provide a favorable environment for indigenous aerobic and anaerobic microorganisms.

**IV Bioreactors:** Slurry reactors or aqueous reactors are used for ex-situ treatment of contaminated soil and water pumped up from a contaminated plume. Bioremediation in reactors involves the processing of contaminated solid material (soil, sediment, sludge) or water through an engineered contaminated system.

### **Conclusion**

The goals of the SDGs are very laudable and futuristic but the achievement of these laudable goals depends greatly on a wholesome environment. In the Niger Delta region of Nigeria where the environment is severely polluted with petroleum hydrocarbon as a result of frequent oil spillage, these goals will be very far from realization if the polluted environment is not remediated. You cannot end poverty in an area where people means of lively hood and revenue earning is severely destroyed. Healthy lives and well-being cannot also be achieved in area where the only source of drinking water is significantly polluted; rivers and ponds fishes are contaminated. Bioremediation is very amenable in the environment of the Niger Delta. It is cheap, effective, efficient ecofriendly, requires just inexpensive equipment, has high public acceptability and therefore it is a strategic and sustainable technique for the achievement of the Sustainable Development Goals in the Niger Delta region of Nigeria if integrated in to the implementation framework of the SDGs.



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