

A REVIEW OF OIL SPILL POLLUTION AND AIR QUALITY IN THE NIGER DELTA: CAUSES, EFFECTS AND CONTROL

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ABSTRACT

Oil spill is the term used to describe the leak of crude petroleum into the environment. Though, the natural seeped of crude oil into the environment is inevitable, the rate of anthropogenic leaching of oil into the ecosystem is alarming. It is released intentionally into the environment through bunkery, pipeline vandalism, pipeline sabotage, corrosion of crude oil pipeline, poor maintenance culture of oil facilities, leak from faulty equipment and sometime, from accidental discharge from tankers, vessels, and other logistic process. While the presence of crude oil on surface water, underground water and the terrestrial contaminates and pollutes them, the open combustion with the atmosphere has no economic, health and socio – economic value. The products of this now deadly mixture of chemical compound are feeds to climate change, acid rain and its associated effects on the ecosystem and many health defects in man. Because the impacts of oil spill remain many years after cleanup, the synergy of green innovations and the implementation of the millennium development goal alone will not do the trick, stakeholders should sit and review the fundamental cause of oil seep into the environment and close the gaps identified in this study in other to nip the cause of oil spill in the bud.

Keyword: Oil Spill, Climate Change, Sabotage, Acid Rain, Pipeline Vandalism, Faulty Equipment, Bunkery, Green Innovation.

INTRODUCTION

Oil spill may also be referred to as oil leak or seep. It is a process where crude oil or petroleum fractions are intentionally leached into the environment through mechanical means such as bunkering - a term used to describe the process involving oil theft which may include the diversion and smuggling of crude or petroleum product and its unauthorized shipping [1]; Sabotage – involves the process where oil pipeline is intentional destroyed in order to illegally access crude petroleum and order product in other to get government attention [1]; oil theft - when oil pipeline is engaged negatively and the content siphoned and diverted for economic gain [1, 2]; pipeline vandalism - the deliberate, mischievous, malicious, willful or ignorant destruction and

damage of pipelines carrying crude oil especially for personal gain and oil leak during transportation through pipeline as a result of equipment failure and logistics [2]. Crude oil is also released into the environment naturally at the bottom of the sediment through sediment break or fractures thus releasing a sticky, thick like tar – a dark fluid like substance with the same physical look as used “motor oil or engine oil”. According to [3], oil that is spilled or seeped into the ocean forms a large slick that spread and drift with winds and ocean currents. While crude oil and other petroleum fractions are leaked into the ecosystem in varying quantities from the refueling of ships and smaller boats, capsizing, or sinking big ship carrying crude, break of pressured crude oil pipelines, faulty drilling operations process, accident at oil well head or pipeline, engineering failure resulting

from the exploration and exploitation. The presence of this dreaded chemicals (crude oil – a fossil fuel formed beneath the earth crust submerged under pressure millions of years ago) in the environment alters the chemical constituent of the environment, thus leaving such composition harmful to man [4, 5]. According to [6], the presence of such substances in the environment contaminates the ecosystem and thus results to oil spill pollution [7]. The impact of oil spill pollution on the environment cannot be overemphasized. Oil spill if carelessly handled, may result to mold or massive fire and also, the deliberate combustion of crude oil associated compound such as natural gas, deposits gaseous compounds in the likes of NO_x, SO_x, CO_x, CO, CH₄, particulate matter, hydrocarbons (pentane, hexadecane, octacosane and the cyclohexane) ash, photochemical oxidants, H₂S, aromatics hydrocarbons (naphthalene, phenanthrene, benzene pyrene), the asphaltenes (phenols, fatty acids, ketones, esters, porphyrins) and the resins (pyridines, quinolines, carbazoles, sulfoxides and amides [8]. into the atmosphere alongside water vapour leading to complex environmental concern. Literature reveals that the presence of such gases in the atmosphere escalates the rise in the temperature of both the troposphere and earth surface resulting to the natural fluctuation of the climate [9,10, 11, 12, 13]; reducing the pH of condensed moisture in the atmosphere that falls visibly in separate drops in a process known as an acid rain [14, 15]. The reduction of soil pH as a fallout of acid rain, thus depleting soil nutrient [15, 16]. These gases also have significant effect on man and other hematological parameters [16, 17]. These health effects ranges from cancer, neurological, reproductive, and developmental effects. Deformities in children, lung damage and skin problems [17, 18, 19, 20, 21]. Previous study also reveal that oil spilled on the vegetation has significant impact on both the terrestrial and aquatic habitat. General survey reveals that oil spill reduces soil fertility, hence affecting crop yield. Oil spill is most common in the Niger Delta area of Nigeria. It has since been a menace that has practically reduced the people to a mere victim of unemployed, helpless, hopeless and most marginalized set of individuals. Their source of

livelihood has been destroyed by these environmental mess caused by oil spill [1], leaving the people and the region in extreme poverty. It should be noted that the Niger Delta region is still the most popular and biggest single most important wetland structure with the highest production of petroleum gases across the globe. Literature reveals that the basin till date is still the most referenced basin because of the massive deposits of crude oil [1]. While exploration and exploitation is still ongoing in the region, it is mostly covered by the rain forest and the occupation of majority of the people in the region is fishing and farming. The region also produces and supplies abundant food made available for trade and consumption all year round. This review is unique because this ecosystem is constantly exposed to the risk emanating from noise pollution, degradation of the ecosystem and acoustic discharge, fluid from drilling deliberately or unintentionally leached into the ecosystem, contamination resulting from the discharge from flaring crude oil associated gases, crude blowout, the dumping of crude petroleum related by-product. These environmental risk results to the degradation of the terrestrial community and, safety issues relating to the use of explosives; land pollution which may affects plants and may also contaminate ground and surface water and ecological biodiversity. Oil spills is the term used to describe the introduction of crude oil (petroleum) or oil distilled products such as gasoline, diesel fuels, jet fuels, kerosene, Stoddard solvent, hydraulic oils, lubricating oils into the environment or ecosystem and that can pollute the surface of the land, air, and water environments [22]. The aim of this review is to review the fundamental cause of oil spill in the Niger Delta region; the effects of the combustion of such spill; also, to proffer solution to this environmental menace and to establish a relationship between oil spill and air quality in a broad sense.

The Combustion of Oil Spill

The atmosphere is like a blanket of gases enveloping the earth. While it protects the earth from the excessive heat and radiation of the sun, it has a composition of about 78% of Nitrogen, 21% of Oxygen, 0.93% of Argon, 0.04% of Carbon

dioxide and a trace amount of neon, helium, methane, krypton and hydrogen, as well as water vapor. Literature reveals that the atmosphere interacts directly with the lithosphere, hydrosphere, biota, and society [23]. The interaction and synergy between these complex elements supporting the existence of human and other organism has since been affected by the combustion of fossil fuel [24, 25]. Crude oil is extremely a toxic substance, they are mainly hydrocarbons compound consisting of hydrogen and carbon molecule that undergoes complex chemical changes with flame to produce contaminant of major concern such as CO, CO₂, SO₂, NO_x, N₂O, volatile organic compounds (VOCs), and hydrocarbons (HCs). Products like the particulate matter with particles less than 10 microns (PM10), Fine particles less than 2 microns (PM2.5), and ammonia (NH₃) are also formed [26]. These atmospheric contaminants leached into the atmosphere are retained long enough in the atmosphere and moved to other region through transportation, dispersion, and deposition. The transport fate of these atmospheric vapors and scavengers has long existed. The life span of these pollutants in the atmosphere is determined by its reactivity - loss rate by reaction with hydroxyl radicals among others and the removal rate – the dry and wet deposition. Evidently, the environment may be preserved from these “environmental destroyers and climatic fluctuates” by limiting the combustion and amount of oil spill leached into the environment.

Implications of the Combustion of Crude Oil on Air Quality

No atmospheric condition is free from environmental contaminant. While it is impossible to have an ideal atmospheric condition due to complex human activities emanating from her extraordinary technological advancement, when the atmospheric composition contains tolerable amount of solid particle and other pollutants, it is referred to as good air quality. The atmospheric contaminant may become increase and exceeds tolerance limit due to the discharge of atmospheric waste, the pattern of the wind and atmospheric temperature [27]. The presences of atmospheric

pollutants lead to the following environmental concerns

1. Climate Change

The climate is wrongly interpreted for weather. While weather is a short time interface of existing meteorological components – temperature; direction and speed of wind; amount and type of precipitation; sunshine hours in the troposphere; thus, climate is the weather condition over a long period in the region. Climate change is a change in the structure of weather, and the associated deviation in the land and sea surfaces. It could also be seen as the long-term drift in the mean weather conditions of a region. Climate change used interchangeably with global warming, is a product of the complex human activities such as the combustion of fossil fuel which influences the heat output from the solar system thus, linking the atmosphere, ocean, and land. Such products released into the atmosphere are referred to as greenhouse gases [28]. Greenhouse gases such as water vapour, carbon dioxide and methane when released, mop up heat from the sun and emit some of it back to the earth, thus raising surface temperatures. This process is popularly called the greenhouse effect [28]. Greenhouse effects is a concept that describes the partnering of greenhouse gases with the ideal atmospheric constituent to serve as blanket of gases and allows a larger amount of the light rays from the Solar system to filter through the troposphere. It allows the temperature of the surface part of the earth and the air above it to increase, while a fraction of the heat radiates back toward outer space as infrared radiation. This radiation, unlike visible light, has the capacity to be absorbed by the greenhouse gases in the atmosphere, thus, increasing its temperature. The heated troposphere in turn radiates infrared radiation back toward Earth's surface [28, 29]. Although, literature reveals that greenhouse gases have positive influence on the existence of life itself [28, 29, 30], anthropogenic greenhouse effect has led to a more complex extreme weather conditions, excessive and compound rainfall or precipitation, leaving behind more water in the mangrove and the extreme north drier; sea level and other water bodies raised due to melting of polar ice and increased in ocean

temperatures - warmer water expands, which can contribute to sea level rise, the altering ecosystems and natural habitat by shifting the geographic ranges, seasonal activities, deviation of the rainfall an sunshine pattern, migration patterns, and abundance of land, freshwater, and marine species. General survey reveals that global warming could reposition the Earth's climates thus, permanently modifying the rainfall and drought pattern and this may possibly exert pressure on food production in certain regions [28, 29].

2. Acid Rain

Acid rain or deposition is the used to describe the process where the pH of a precipitate is less than 7 when measured on the pH scale or meter. Acid deposition can form because of the oxidation of CO_x, NO_x or SO_x gases that are released into the atmosphere. Acidic deposition takes place in two ways - wet and dry. Wet deposition is any form of water droplet falling freely from the atmosphere which removes acids from the atmosphere and places them on the earth surface. In the absence of rain drop, dry deposition of polluting particles and gases sticks to the ground through suspended particles. Acid rain has massive ecological effects, and this is visible in the Niger Delta region. It reduces the pH of streams, lakes, marshes thus, altering their chemical composition and become harmful to aquatic lives. Most times, it leads to eutrophication. It leached metal into the water bodies thereby, inducing metal toxicity [4]. The presence of acid rain affects soil nutrient and soil composition hence, affecting crop yield. It also leads to high and increased maintenance costs resulting from corrosion and the loss of detail on stone and metal statues, monuments, and tombstones. SO₂ and NO_x react in the atmosphere to form fine sulfate and nitrate particles that could pass through the nostril. Many scientific studies have shown a relationship between these particles and the effects on heart function, such as heart attacks resulting in death for people with increased heart disease risk, and effects on lung function, such as breathing difficulties for people with asthma [1, 4]. Acid rain could be prevented in the Niger Delta by having a check at the emission of oxides of Nitrogen and Sulphur.

3. Smog and soot

The Niger Delta atmosphere is most times, covered with smog and soot. Smog and soot are prevalent types of air pollution. Smog – ground level ozone, occurs when the bye products of the combusting fossil fuels combine with sunlight. Soot - particulate matter, is a combination of tiny particles of chemicals, soil, smoke, dust, or allergens - in the form of either gas or solids, find their ways into the atmosphere. Particulate matter (PM) pollution includes particles with diameters of 10 micrometers (µm) or smaller are called PM10, and also an extremely fine particle with diameters that are generally 2.5 micrometers (µm) and smaller and are called PM2.5. Particulate matter contains tiny liquid or solid droplets that can be inhaled and cause serious health effects [31]. Particles <10 µm in diameter (PM10) after inhalation can invade the lungs and even reach the bloodstream. Fine particles, PM2.5, pose a greater risk to health [32, 33]. This similar twin destroyer has massive health and environmental implication. While Smog irritates the eyes and throat and inflict damage to the lungs, especially those of children and people who engage in outdoor exercise. It is more complicated with those with asthma or allergies - can intensify their symptoms and trigger asthma attacks. The tiniest airborne particles in soot, whether gaseous or solid, are especially dangerous because they can penetrate the lungs and bloodstream and worsen bronchitis, lead to heart attacks, and even hasten death

Causes of Oil Spill

Oil seep into the Niger Delta environment is visible and quantifiable. The presence of these dreadful chemical compound in the ecosystem has implications on the health of the people, the standard of living, socio – economic activities, the economy, and the lifestyles of the people. Hence, the fundamental cause of these atmospheric anthropogenic imposed contaminant seeped into the Niger Delta environment is reviewed below:

1. Spill Resulting from Bunkery

Bunkering is defined by [34] as a legal process where a licensed operator provides fuel, water and lubricants for marine services or at request [35, 36]. According to [37], oil bunkering is

misinterpreted within the Nigerian context due to the political, economic and social controversies embedded in criminal practices. It could also be referred to as oil theft. It is a phrase employed to describe activities that involve oil theft. Oil theft occur when oil pipeline is engaged negatively and the content siphoned and diverted for economic gain. It may arise from pipeline vandalism, sabotage and from leak from faulty equipment. This process may include the diversion and smuggling of crude oil and its unauthorized shipping. It requires the culprit to forcefully established a link into an oil pipeline, and then to barges that are out of sight along tributaries - creeks with mangrove forest cover. Thus, transporting same to be sold at designated sale point, maybe internationally or to be refined locally. To access the oil, a small group of welders will puncture a pipeline at night, establishing a tapping point from which the group can operate. Routinely, oil bunkery occurs in the riverine areas and on dry land [38]. General survey does not only reveal that the process allows oil to leak into the environment but it also result to fire outbreak. More importantly in the Niger Delta, confrontations, violent and dispute in the region make the creek deserted with security and other traffic thus, encouraging bunkering. Routinely, spill occur at the Niger Delta waterway especially through bunkery because security operatives connive with them and spare them split seconds to operate hence, forcing bunkers to be impatient to keep a suitable position while transferring crude products. Apart from the massive environmental impacts of oil pollution due to collisions, unwanted spill and accidents, there is little or no support during bunkery which thus, results to the loss of lives due to explosion and fire outbreak [38, 39]. Oil theft or bunkering in Nigeria is due to corruption practices in government and other stakeholders, poor governance, poverty, unemployment, poor or weak institution.

2. Spill Resulting from Sabotage

Sabotage involves the process where oil pipeline is intentional vandalize in other to illegally access crude petroleum and other product in other to get government attention [40]. Sabotage of crude oil facilities is progressively highlighted in the Niger

Delta region and the implication of spill oil into the environment has led to abject poverty; environmental degradation of farmlands leading to soil infertility and poor yield; water pollution; fish kill; biodiversity loss and species extinction; unprecedented diseases affecting the health pattern of man. Sabotage is an attitude intended to negatively affect, disrupt, or subvert government activities, stakeholders and/or any organization for selfish intention by public assassination of effort, mortification, damage to property, destruction of working relationship, or the harming of citizens [41]. This worrisome display of the intentional vandalism of crude oil pipelines is aimed to disrupting the chain of supply of petroleum product for selfish interest by specific group intent for “black - market sales” either in small, locally or at the international market is unconstitutional and is thus, prohibited under the Nigerian law. Literature reveals that the region is now tagged an “An Ecologically Waste Land.” Additional oil spill and pollution and its environmental impact from such illegal oil refining process may be suicide for people of this region.

3. Oil Spill due to Faulty Equipment

Faulty equipment leads to equipment failure. Equipment failure is a term used to describe any activity where equipment lacks the capacity to complete its intended purpose or task. It may also mean that the equipment stopped working, is not performing as desired, or is not meeting target expectations. For oil facilities, faulty equipment occurs when substandard engineering equipment are engaged for production purpose and hence, may malfunction during production process. Literature reveals that faulty equipment occurs in the offshore rig equipment and in flow station and well head [42]. It further documented the 2010 Gulf of Mexico oil spill. The spill was reported to be partially due to the failure of a blowout preventer, a vital piece of equipment on rigs. Investigation on the cause of the spill reveal that the failed equipment was operating at low capacity, thus initiating a host of complex activities that led to mechanical fault that saw oil leached into the environment. Investigation further revealed that the blowout preventer - a stack of valves that seal the well if a leak begins, did not

function correctly. If the equipment had worked as intended, it would have prevented further leaks by closing steel rams over the top of the well, sealing it effectively [42]. General survey and interview reveal that oil facilities supervised by the Nigeria National Petroleum Corporation show similar defect due to poor maintenance culture and corruption and is a medium of frequent oil spill in the region. Equipment failure leads to loss of asset availability, deviation from standard procedure, not meeting the quality and expected target quantity, loss of time, labor and money, and loss of integrated system. It can be prevented or reduced through proper maintenance management, inspection, timely finding of problems, rectification of problems, and repair. General survey reveals that faulty equipment are refurbished and reintegrated into the system by contractors and other parties involved in order to make profit.

4. Vandalism as a Source of Oil Spill

Crude oil pipelines are major channel for transporting crude or petroleum products from the point of exploitation and exploration to a point where they serve as utility. Crude oil pipeline vandalism could be seen as the deliberate, mischievous, malicious, willful, or ignorant destruction and damage of pipelines carrying crude especially for personal gain. It may also be used synonymous to the act of bunkering, which is the act of drilling into the pipelines with the intent to steal products. It can also be seen as a hostile attitude of disreputable and discreditable corrupt group or person with destructive motive of damaging pipeline carrying crude. Pipeline vandalism is popular in Nigeria and in the Niger Delta. General survey revealed that socio – economic challenges and the poverty level of the people in the region is thus responsible for the act and it is the direct product or result of unemployment, destruction of their source of living, anger, frustration, and marginalization.

5. Oil Spill due to Pipeline Corrosion

Corrosion is the term used to describe a naturally occurring chemical process of the destructive combination of a substance reacting with its biotic and the abiotic element of the environment [43, 44]. It is a natural potential hazard that either lead

to pipeline leaks or ruptures. Pipeline corrosion seep crude or petroleum products into the environment thereby contaminate the soil, groundwater, or surface water. Corrosion occurs in oil facilities and installation belonging to multinationals across the Niger Delta since they are made of materials which at their combination with oxygen and moisture. Corroding pipeline carrying crude petroleum is a massive concern in the production process in the petroleum sector, chemical and mechanical engineers, and chemists. Fluid flowing from oil and gas pipelines also has a combination of chemicals including CO₂, H₂S, organic acids, bacteria, sand, and water. The CO₂ dissolves in the presence of water to form an acidic oxide which reacts with the crude oil pipeline. Literature reveals that the chemical properties of the surrounding environment of a buried pipeline are not adequately understood due to the variations in the oxygen content, moisture content, and chemical composition of the soil and the pipe length. Also, the moisture content and oxygen content of the soil also vary with time; the coating quality varies along the length of a pipeline; the coatings sometimes become disbanded from the pipe surface, allowing contact with groundwater and the physical variations in soil characteristics and placement affect the distribution of cathodic - protection current [45].

6. Oil Spill due to Accident from Tankers Carrying Petroleum Products

Oil leak into the environment resulting from the accidental discharge crude petroleum/oil from tankers is popular among the Niger Delta region of Nigeria. Crude oil is drilled at a particular location, and it is then transported from the point where it is explored to a point where it is sold and/or processed to other finished products. In the Niger Delta territory, crude oil logistic is key and big and this process has left significant trace of oil on territorial waters which in turn has impacted the ecosystem negatively. Report from this study reveal that the Niger Delta has spill of oil on coastal and vegetative land through the accidental discharge of oil content by tankers. The spill was as results of the bad and poor road network with a near “unmotorable pothole”, super emitters tankers coupled with poor operational loading procedure and logistic plan. While in an attempt to address these shortcomings, stakeholders in the oil business should putting their head together to review the cause and to proffer solutions to oil spill

in the region, these issues or problem should be strongly reviewed.

Possible Solution to Oil Spill

The major environmental challenge posed by the open combustion of oil spill is climate change, acidic deposition, the acidification of land and water bodies, health implications in human and the death of other organism both in the aquatic and terrestrial habitat. it occurs when greenhouse gases are leached and trapped in the atmosphere, leading to greenhouse effect. This effect forms a blanket of gases like layer around the earth's atmosphere that absorbed solar energy in the form of heat, thus making the earth atmosphere warmer. Increases in temperature will accelerate the decomposition of reservoir species such as peroxyacetyl nitrate (PAN). These species are chemically stable and allow NO_x to be transported over long distances but decompose to reactive forms at higher temperatures. Increasing temperatures will result in increasing humidity [46, 47]. Water vapor is a greenhouse gas and a source of hydroxyl radical (OH)[·]. increases in the atmospheric abundance of (OH)[·] can result in net production or destruction of O₃ depending on ambient NO_x levels. These dreaded atmospheric pollutants are acidic in nature. They chemically combine with water droplet during rain drop to produce an acidic deposition. This process is the foundation for many other environmental crises such as eutrophication, the acidification of the water bodies and land among others. To get rid of this defiance, those in the positions to make laws need to engage in green innovation and such agenda be communicated through the grassroots through simple and complex enlightenment programs. Green innovation is a term that is used to describe all the aspects of radical and creative changes in technology as it relates to green products and processes, energy saving, pollution management, waste recycling, product design and environmental management. While the world focuses and depends on green innovation to address and resolve complex environmental crises, stakeholders may/should review the fundamental cause of environmental concern such as oil spill. The major source of oil spill in Africa and Nigeria are sabotage of oil facilities, vandalism of crude oil pipelines, oil theft, poor maintenance culture of oil facilities, corrosion of oil pipeline and the accidental discharge of tankers carry crude during logistic process. These listed concern above is

induced by poverty, marginalization, poor governance and interference among others. While government and other stakeholder seek the synergy of the millennium development goal and the green innovation, issues concerning the welfare of the people especially those of the Niger Deltan should be reviewed and prioritized. The mindset of the people should be changed by improving their per capital income, providing them with basic amenities, restore their hope by restoring their source of livelihood, initiate an all-inclusive dialogue and implement the finding, create institution that checkmate corrupt environmental practice, transparency in governance and to practice true democracy.

CONCLUSION

The effects of oil spill in the Niger Delta environment is an ongoing tragedy. It has zero environmental benefit to man. The impact of spill on the environment may be irreversible, it may persist in the environment many years after cleanup and may be self-destructive. Every one of us regardless our colour and race has a role to play to consciously engage in processes that limits activities that may leak crude petroleum into the environment. Positive attitude toward reducing oil seep into the environment may curb the emission of greenhouse gas and pollution. Still, decision makers, companies, leaders, and activists across the country and around the world staunchly believe that this is the time to act to save planet earth. Bearing in mind that the emissions we release today may not only impact us long into the future but may led to automated self-destruction.

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