OIL SPILL: AN OVERVIEW IMPACT ON OUR ECOSYSTEM AND CLIMATE CHANGE

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Abstract
Oil spill is a disaster to our ecosystem and climate which needs to be addressed. However, the global trade between countries on oil is steadily on the rise, but with little or no effort to preserve or mitigate the anthropogenic activity impacts on our ecosystem and climate. While oil is been transported or mined, large quantities are leaked into the environment uncheck, because most countries view it as a non-appreciable effect. Oil induced into the eco-environment can cause a disastrous effect quickly, such as loss of habitat, loss of lives, DNA damage, and cardiac dysfunction. Nations like China and African countries lack the interest to mitigate these effects. There is a need to implement a global policy to govern the unfriendly exploitation and transportation of oil.
Keywords: Oil spill, Ecosystem, Climate change, Hazard, Marine, Terrestrial

INTRODUCTION

Oil spills a consequence of man's anthropogenic activities is one of the major contributors to disturbances in the ecosystem. The terrestrial and atmospheric ecosystem receives an increasing amount of oil spill yearly (Ali et al., 2020) and marine ecosystem oil spill is also becoming an event of concern. Oil spill has become the most pollutant in the marine (MI News Network inmarine insight, 2021), and depending on the quantities of oil spilt, the impact can last for over 20 years. Oil spilt on marine can affect the aquatic life in various ways which can be long- or short-term effect in the same way, if the event occurs on terrestrial, it can pose many adverse risks which can range from land degradation, agricultural land loss, health issues and eventually may affect the food chain. However, when this disaster event occurs, techniques are employed to minimize the impact on the environment. Some of these techniques include using oil booms, sorbents, skimmers dispersants and in-situ burning, however, in-situ burning (igniting the floating oil on water surface) is the most frequently used cleanup method because of its ability to remove 98% of oil spill (MI News Network inmarine insight,2021). Despite eliminating the oil spill from marine surface at a high level of confidence, the toxic fume released from this activity impact significantly climate change and aquatic life.

The transportation mechanism to which oil reaches end-use consumption involves risk and vulnerability. An oil spill can be accidentally induced into the environment in many ways like offshore platform, tankers, drilling rigs and wells or by an explosion. In some regions and countries, oil spill is treated with limited interest or non-appreciable effect environment, therefore a large quantity of oil leak into the environment become undictated.

It is necessary to analyze the impact of these activities which will evince the extent and degree to which it destabilizes our ecosystem and climate. This study exercises the following objectives to accomplish its research:

- It examines the general impact of oil spill disaster event on our ecosystem
- It examines the role of oil spill disaster event to climate change

Scope of the Study

The scope of this study examines the interrelation between oil spills on climate change. Impact of petroleum oil spill on ecosystem taking into consideration its effect on biodiversities (plant and animal including man) such as influence on the food chain, health and forced migration, using a review of published works for analysis.

Oil and Behavioural Characteristics

Petroleum oil consists of a mixture of hydrogen and carbon existing predominantly. It is the formation of the remains of the plants and animals usually found below the ocean floor or grounds. When an oil spill occurs it can persist on land or water over some time. This persistent nature of the non-aqueous behaviour is due to its physical and chemical properties (Table 1). However, it can exhibit a dynamic behaviour depending on the eco habitat it is spilt and the influence of ecosystem characteristics. Oil spill on marine can be influenced by wave, temperature or current causing it to spread over large even to the coastal areas within a short time especially if it has a reduced viscosity. In terrestrial habitat, oil spilt on a soil surface can persevere over a long time thus transporting itself down to the groundwater as a result of its density. Oil consist of a mixture of hydrocarbon gases with a higher percentage of methane. When oil rests on a surface after a spill incident over a time, some of its gases can be trapped into the atmosphere through the evaporation process which constitutes to air pollution or climate change.

Table 1: Main characteristics of oil

MAIN OIL CHARACTERISTICS RELEVANT TO TRANSPORTATION	OIL SPILL ENVIRONMENT	TRANSPORTATION OF THE SPILLED OIL
Lighter (less dense) than water	Aqueous (e.g., marine)	Spilled oil will accumulate on top of water surface if the oil in the underwater spills (such as the one from offshore drilling) will move upward and settle on the surface of the water. Then, it may disperse over large areas in the marine environment due to the various water currents and waves.
	Land or Subsurface	Spilled oil can reach groundwater bodies, in which case it will form a sheen on top of groundwater and will move at lower speeds.
Mixture of volatile compounds (e.g., hydrocarbons)	Aqueous (e.g., marine)	Spilled oil starts evaporating when in contact with air (when it reaches the top of the water), and so the air above the spill becomes polluted with various volatile oil components. Depending on their concentration, such air pollutants may travel by the wind and aerosols.
	Land or Subsurface	Volatilization is accentuated on land surfaces and in shallow subsurface depths, because spilled oil must be in contact with air in order for the volatilization to occur. Once evaporated, the volatile gaseous compounds usually travel upward through soil pores and, depending on the concentration, may reach the surface and accumulate in any existing structure (e.g., homes).

Source: Environmental Pollution Centers

Mixture of compounds with different water solubility	Aqueous (e.g., marine)	Although oil accumulates on top of the water (as non-aqueous phase liquid), some oil compounds may dissolve (to some extent) in the water. If dissolved, such compounds integrate into the sea life.
	Land or Subsurface	
Formation of oil slicks or sheens on water	Aqueous (e.g., marine)	Because oil and water are not miscible, oil slicks form whenever oil is spilled into the water. These slicks persist in the environment for a long time.
	Land or Subsurface	The oil carried by rainwater in particulate matter forms may persist in the subsurface environments, including the top of groundwater, for decades.
Oil has a physical state (liquid) and biodegradable components	Aqueous (e.g., marine)	Some natural attenuation processes may reduce the amount of oil. This is due to a combination of evaporation, dissolution, and biodegradation of oil spill. In sea or river environments such natural attenuation processes are faster than those in subsurface environments, on land or in groundwater.
	Land or Subsurface	
Oil composition involving the presence of individual components with environmental persistence and bio accumulative potential (e.g., PAHs)	Aqueous (e.g., marine)	Some oil components may persist in the environment for longer periods of time, accumulating in sediments, sea life, and wildlife.

Environmental implication on Different Ecosystem

An ecosystem consists of biotic (plant and animal) and non-abiotic (water, atmosphere and soil) interacting with each other. Once, oil is discharged into the environment, it poses certain hazardous risks to the organisms such as climatic hazard- polluting the air through emissions of harmful substances into the atmosphere or chemical hazards- having the potential to harm the health and life of the organisms for example the decrease in dissolved oxygen and damage to marine birds (toxicity by ingestion and reduction in the floatability by impregnation of feathers) and reduction in light transmission (affecting photosynthetic activity) (Huz et al., 2011).

Myriads of research asserted that the persistence of oil spill impact can be long or short term. The Gulf of Mexico oil spill in 2010 had documented a short term effect of death and injury rates of species of Whales, Dolphins, oysters, Sea turtles, Sharks and Tuna (Beyer et al., 2017) and increased diseased rate among species (Beyer et al.,2015, Adams,2015). However, the long term effect can last for six years possessing the ability tobio-accumulateorbio-concentrate in a food chain (Adesipo et al., 2020).

Marine Ecosystem

A marine environment consists of a complex system of interacting biodiversity. The adaptive nature of these species is dependent on **t**he physical characteristics of marine habitat. These characteristics such as salinity, temperature, intensity of light are altered when oil spill occurs within the marine environment. The vulnerability of the existing species to the oil spill is dependent on certain factors such as the biological units and depths (Chang et al., 2014). For example, bird species and marine mammals must frequently navigate through the water-air interface to breathe (Peterson et al., 2003). Nevertheless, even the less vulnerable species may eventually be exposed as a result of changes in the environment such as diffusing the non-aqueous liquid over a large surface or even the seafloor.

Marine mammals are incapable of detecting oil slick therefore consumes contaminated food, marine tar residuals and having physical contact with oil which adhere to their sensitive body parts, eyes and skin (Loughlin, 2013). Most juvenile marine animal are more susceptible to oil spill hazard. For example, the young sea turtle tend to indiscriminately swallow tar balls which has come contact with oil (Zhang et al., 2019)

Terrestrial Ecosystem

The consequences of oil spill on land are of complex behaviour and dynamics. Oil spill on terrestrial can affect animals (including man), plant, soil and groundwater. Elucidation of the processes, vulnerabilitiesand impacts of human dimension of oil spill noted that oil spill effect can be classified into different ways- effect of the oil spill causing human harm outright (inhalation of aromatic hydrocarbon and other vaporous compound, direct effect on ecological processes causing human health impact (example consumption of seafood with bio accumulated oil toxins),loss of major subsistence or export industries (through loss of fisheries), economic stressor that can alter intermediary processes (psychological effect of community decline), (Webler and Lord, 2010).

The devastationof oil spill on land includes; first- air pollution (integration with air resulting in inhaling of polluted air by organisms), inhaling the volatilised elements of hydrocarbon from an oil spill can affect the respiratory system, liver and increase cancer risk (Laffon et al.,2016). Second- prolonged oil on soil can transport through infiltration to contaminate groundwater. These pollutants are then trapped at the vadose zone and vertically migrate to the aquifer through the leaching effect (Xue Bai et al., 2019). Consuming this water poses serious health issues. Myriads of health-related research affirmed the long-term effect of consuming this contaminated water to include severe DNA degradation, impaired cellular immunity, cancer (Aguilera et al., 2010, Rogers et al., 2002). Third, the destruction of agricultural land which in turn, renders the land infertile thus, reduces food productivity practice and impose forced migration because some

farmers lands are destroyed and this forces them to move to other geographic location to settle and engage in other practices.

Contribution of Oil Spill to Climate Change

The role of oil spill has drawn little attention over the years. This is because the evidence of oil spill impact on climate change may not widely be visible or directly evident. Nevertheless, oil spill contribution to climate change can occur via anthropogenic activities or chemical processes. Discussed below are the practices and processes through which oil spill can degrade our climate constituting to climate change:

Clean up method

When oil incidence occurs especially in the marine environment, due to its high toxicity effect, clean up practice is exercised. Oil clean up can be carried out with over ten technique show ever, In-situ burning method is the most frequently used. According to MI News Network in Marine insight (2021), in-situ burning method effectively removes about 98% of an oil spill and is the most effective in comparison with other clean up method. Notwithstanding, when this techniques is employed, it produces a break in the bonds of hydrocarbon producing CO2 compound (eq1), this CO2 gets trapped in the atmosphere which drives climate change.

$CH4 + 2O2 \rightarrow CO2 + 2H2O + heatenergy$ (1)

Some countries especially in Asia and Africa show less interest and action when oil is spilled. However, less attention has been paid on the role of oil exploration industries as contributors to climate change. The indiscriminate activities, accidental or purposeful discharge of oil into the environment destroys the terrestrial and aquatic plants such as the mangroves and neglected oil on land tends to volatise and oxidise.

Destruction of Mangroves

Mangroves provide shelter to many biodiversity including aquatic and terrestrial plants and animals. Many animals (Brittle stars, Sea anemones, Sea urchins) and plants (Lilies, Vines, and Ferns) make a home on mangrove. Mangroves shrubs possess the ability to thrive on harsh environment like salty, hot and muddy conditions unlike most plants. Despite its ability to survive harsh environment, Hydrocarbon Oil is highly toxic to mangroves thus, oil spilled by the exploration industry into the environment pose a serious threat to them. Most marine oil exploration occur in environmentally sensitive areas either at the inland basin or offshore on continental shelves which is a habitat of many organisms (Kvenolden and Cooper, 2003) mangroves. During exploration activity oil penetrates the habitat destroying many mangroves.

Mangroves provides many ecological benefits to our ecosystem and human. They can help to weather the impact of climate change by trapping massive amount of greenhouse gases (GHG) such as carbon, storing them in their soils. According to Global Mangrove Alliance, annually, mangroves traps over 6 billion of carbon however, about 30% of mangroves have been lost and 1 in 50of the survival mangroves are indiscriminately deforested(Polidoro et al., 2010) and many are destroyed by oil spill.. Forest accounts for 30% solution to climate change through carbon sequestration and, has more capacity to sink more carbon already stored from the atmosphere. Destruction of mangrove by oil industries, has drastically reduced carbon sequestration thus raising the storage of carbon in the atmosphere in turn, driving climate change. With this accelerating rate of loss, mangrove will functionally disappear in less than 100 years(Duke et al., 2007). For example, in Niger Delta region Nigeria, oil spill accounts for 73% destruction in vegetation (Mohammadi, liu and Xie, 2016) of which about 50% is mangroves. A patch of mangroves can absolve times carbon more than a patch of forest, therefore, every destruction in a patch of mangrove is a 10 times increase in carbon in the atmosphere which will result to a 10 times increase in temperature riseasa consequence of decrease in carbon sequestration and a disruption in the equilibrium of carbon cycle.

Evaporization and Oxidation Processes

Most oil spill incidence on land are mostly neglected especially in developing countries. This oil tends to volatilise and oxidise with time. Numerous studies have focused more on the aspect of CO2 contribution to climate change via in-situ burning after oil spill event neglecting the evaporation and oxidation of methane. Oil exposure on land are susceptible to volatilisation. Hydrocarbon oil contains series of organic compounds constituting various gases including methane which is emitted when oil spill event oil and not cleaned up. The impact of methane emission especially via oil spill should not be underestimated.

According to global warming potential (GWP), methane as a GHG is over 80 times more potent than CO2 thus implying the ability to cause a fast rise in temperature than carbon (IV) oxide. Trapping of methane in the atmosphere last only a decade. A rise in temperature as a result of the methane in the atmosphere drives climate change. Thus, the implication of this is its double whammy effect whammy on climate. Itplays a significant role towards degradation of our climate pointing to the fact that the atmosphere is oxidising in nature which oxidises organic molecules contained within over time. With this effect, it oxidises the carbon in methane to CO2 which is trapped in the atmosphere for another more decades (Gillenwater, 2010).Uncontrolled emission of gases by human activities has caused degradation to the ecosystem which has changed the climatic statistical properties. Scientists believed that this steady increase in gases especially methane is highly detrimental to the climate.

Conclusion

Oil spill is one of the sources of emission of heat trapping gases like CH4 and CO2especially when the oil is light and long exposed yet, even the trapping of methane into the atmosphere has drawn little or no attention despite its potential effect. The toxicity effect of oil on our ecosystem and climate can be direct or indirect, on a long or short term scale. Irrespective of time scale, it still has a significant impact which should be of much concern. The implication of oil spill impact on our ecosystem should not be the only point of interest to the oil industries or public but its influence on our climate should not be overlooked. The literature of this research has recognised the need for further study on the impact of oil spill on climate either direct or indirect. Although in-situ burning cleans oil spill at 98%, there is need for continuous research for an alternative method that significantly minimises the effect on our climate while maintaining about 99% level of clean-up. Global policies should be seriously implemented on oil spill, words and policies should be turned into action. Investigation by an international body should be effectively implemented. This will put to an end or minimise the non-appreciable behaviour especially in Asia and Africa as a result of neglect and necessary disciplinary action or penalty to be given such as a large amount of fine because this irresponsible behaviour does not only have influence limited within their environment but spans across the globe. This will significantly decrease the rate of oil spill into the environment and hasten the clean-up of an oil spill to reduce the rate of gases trapped in the atmosphere.

REFERENCES

[1] Adams, A. 2015, "Summary of information concerning the ecological and economic impacts of the bpdeepwater horizon oil spill disaster", *Natural Resource Defense Council,* .

[2] Adesipo, A.A., Freese, D. &Nwadinigwe, A.O. 2020, "Prospects of in-situ remediation of crude oil contaminated lands in Nigeria", *Scientific African*, vol. 8, pp. e00403.

[3] Aguilera, F., Méndez, J., Pásaro, E. &Laffon, B. 2010, "Review on the effects of exposure to spilled oils on human health", *Journal of Applied Toxicology: An International Journal*, vol. 30, no. 4, pp. 291-301.

[4] Bai, X., Song, K., Liu, J., Mohamed, A.K., Mou, C. & Liu, D. 2019, "Health risk assessment of groundwater contaminated by oil pollutants based on numerical modeling", *International journal of environmental research and public health*, vol. 16, no. 18, pp. 3245.

[5] Barry Stevens (June 01, 2017)Greenhouse Gas levels are higher than the past 800,000 Years [online]. Available: https://oilprice.com/Latest-Energy-News/World-News/Greenhouse-Gas-Levels-Are-Higher-Than-The-Past-800000-Years.html

[6] Beyer, J., Trannum, H.C., Bakke, T., Hodson, P.V. & Collier, T.K. 2016, "Environmental effects of the Deepwater Horizon oil spill: a review", *Marine pollution bulletin,* vol. 110, no. 1, pp. 28-51.

[7] Chang, S.E., Stone, J., Demes, K. &Piscitelli, M. 2014, "Consequences of oil spills: a review and framework for informing planning", *Ecology and Society,* vol. 19, no. 2.

[8] De la Huz, R., Lastra, M., Junoy, J., Castellanos, C. &Vieitez, J. 2005, "Biological impacts of oil pollution and cleaning in the intertidal zone of exposed sandy beaches: preliminary study of the "Prestige" oil spill", *Estuarine, Coastal and Shelf Science*, vol. 65, no. 1-2, pp. 19-29.

[9] Duke, N. C., Meynecke, J., Dittmann, S., Ellison, A. M., Anger, K., Berger, U., Field, C. D. (2007). A world without mangroves? *Science, 317*(5834), 41-42.

[10]Environmental Pollution Centers (no date) Environmental Effects of Oil Spill [online] Available: https://www.environmentalpollutioncenters.org/oil-spill/effects

[11] Laffon, B., Pásaro, E. &Valdiglesias, V. 2016, "Effects of exposure to oil spills on human health: Updated review", *Journal of Toxicology and Environmental Health, Part B,* vol. 19, no. 3-4, pp. 105-128.

[12] Global Mangrove Alliance (no date) New study shows mangrove forests soils hold more than 6.4 billion tons of carbon globally [online] Available: https://www.mangrovealliance.org/news/new-study-shows-mangrove-forests-soils-hold-more-than-6-4-billion-tons-of-carbon-globally/

[13] MI News Network (January 15, 2021) 10 Methods for Oil Spill Cleanup at Sea [online]. Available:https://www.marineinsight.com/environment/10-methods-for-oil-spill-cleanup-at-sea/

[14] Mohamadi, B., Liu, F., &Xie, Z. (2016). Oil spill influence on vegetation in Nigeria and its determinants. *Polish Journal of Environmental Studies, 25*(6)

[15] Peterson, C.H., Rice, S.D., Short, J.W., Esler, D., Bodkin, J.L., Ballachey, B.E. & Irons, D.B. 2003, "Long-term ecosystem response to the Exxon Valdez oil spill", *Science (New York, N.Y.)*, vol. 302, no. 5653, pp. 2082-2086.

[16] Polidoro, B. A., Carpenter, K. E., Collins, L., Duke, N. C., Ellison, A. M., Ellison, J. C., . . . Koedam, N. E. (2010). The loss of species: Mangrove extinction risk and geographic areas of global concern. *PloS One, 5*(4), e10095.

[17] Rogers, V.V., Wickstrom, M., Liber, K. & MacKinnon, M.D. 2002, "Acute and subchronic mammalian toxicity of naphthenic acids from oil sands tailings", *Toxicological Sciences,* vol. 66, no. 2, pp. 347-355