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Petroleum Exploration, Exploitation, Spill and Diffusion of Crude Oil in Niger Delta Marine Environment: A Review

Aprioku, P.S, Akpa, J.G., Ademiluyi, F.T. , and Ehirim, E.O.
peter.aprioku@ust.edu.ng, akpa.jackson@ust.edu.ng, ademiluyi.taiwo@ust.edu.ng, and ehirim.emmanuel@ust.edu.ng Department of Chemical/Petrochemical Engineering. Corresponding Author: peter.aprioku@ust.edu.ng

ABSTRACT
This paper reviews and gives a concise extent of work done on exploration, exploitation, physic-chemical parameter of sea water before and after spill, physic-chemical properties of crude oil, other properties and crude oil and marine water and diffusion of crude oil in the marine Niger Delta. The physic-chemical parameters reviewed in this paper have been recorded. The exploration, exploitation, and incidents of crude oil spills in the Niger Delta have persisted for many decades. This comprehensive review has highlighted both global and regional causes of these activities, as well as significant oil spill events. It is important to recognize that the impacts of oil spills extend beyond surface facilities, as crude oil infiltrates surrounding water bodies and even the ground. Finally, the paper describes existing gaps and future research directions in the diffusion of crude oil in water and provides platforms for new conceptual framework for further research.

KEYWORDS: *Spill, Crude Oil, Exploitation and Exploration, Diffusion of Crude Oil, Marine Environment.*

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I. INTRODUCTION

Various oil spills have been recorded in several regions of the world. Diligent investigations have revealed that approximately 75% of these spills were caused by groundings, collisions, and contacts, while around 8% were attributed to oil transfer operations (Kasai, 2002; USCG, 2007) as shown in Figures 1

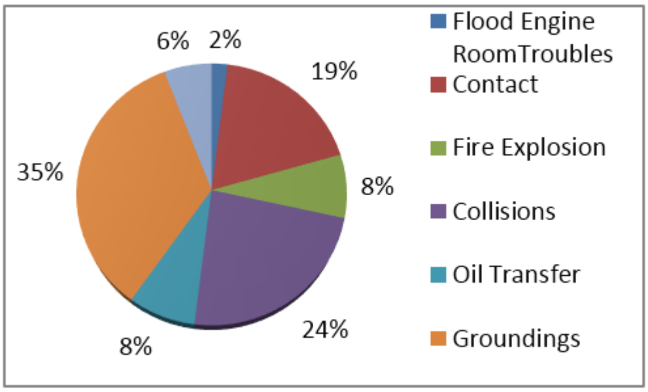

Figure 1: Pie graph showing Causes of Oil Spills in the Marine Environment (Ben-David et al., 2005; Alonso-Alvarez et al., 2007).

This paper presents an exhaustive outline of critical oil spill that represent a serious danger to marine environments. The emphasis is on remarkable episodes in three areas: Shetland (85,000 metric tons), off the bank of Spain (70,000 metric tons), and in the Bedouin Bay (816,000 metric tons) (Kasai, 2002; USCG, 2007). These spills negatively affect ecologically delicate seaside regions, which are essential for supporting weak enterprises like marine culture offices in Shetland (Albert et al., 2018; Nwilo et al., 2007) and power stations, as exemplified by the Bay Conflict oil slick (Hosny and Dhari, 2002).

A few key variables show the potential natural harm brought about by oil slicks or spill and the ensuing scattering of oil in water. These elements incorporate the structure of the oil, neighborhood saltiness, water profundity, normal ocean temperatures, season, wave energy, winning breeze and ebb and flow headings, the immaculateness of the climate, sorts of marine territories in touch with the oil, and, critically, the speed and viability of tidy up endeavors (Bautista and Rahman, 2016). Late exploration on the beach front and marine results of the 1991 Inlet War, examined during the 1992 Mt Mitchell Journey, has given bits of knowledge into these elements.

Taking into account the disturbing recurrence of oil slicks in both inland waters and vast oceans, directing exhaustive examinations becomes basic to figure out the destiny of petrol and its results in the climate. This understanding is significant for precisely evaluating the natural impacts of oil slicks. Indeed, even after tidy up tasks, water-solvent parts of unrefined petroleum diffuse into the water and may persevere, presenting progressing risks to the climate and possibly collecting poisons in the pecking order, consequently imperiling human wellbeing (NRC, 2003; Allan et al., 2012). Unpredictable parts of unrefined petroleum begin dissipating following a spillage, helped by wind and flows, with the pace of vanishing corresponding to their fume pressure. These cycles can go on for a really long time, prompting the expulsion of roughly 30-half of the all out hydrocarbons (Almeda et al., 2013; Jonas et al., 2014). The general pace of smooth vanishing is impacted by the contending cycles of dispersion and dissipation.

The essential point of this paper is to give subjective data on the dispersion of raw petroleum in marine conditions of the Niger Delta. We assess existing strategic bits of knowledge concerning the portrayal and dissemination of seawater and raw petroleum in the Niger Delta climate and direct a careful survey of the dispersion of unrefined petroleum in marine conditions of the Niger Delta.

This review is based on extensive analysis and builds upon recent studies to achieve the following objectives.

1. Characterization of Sea Water in Niger Delta,
2. Study of Salinity, Dissolved Oxygen, pH and Surface Water Temperature in Nkoro River in Niger Delta Area of Nigeria
3. Characterization of Crude Oil in the Niger Delta
4. Diffusion of Crude Oil in Marine Environment
5. Crude Oil Spill Dispersal in Niger Delta marine environment
6. Laboratory Assessment on Rate of Diffusion of Spilled Oil in Marine Environment

The various results obtained from the above analysis were synthesized to describe existing gaps and future research directions in the diffusion of crude oil in the Niger Delta marine environment

II. MATERIALS AND METHODS

The current study made use of Google Scholar as a valuable tool to compile noteworthy academic papers on crude oil exploration, exploitation, spills, and the spread of crude oil in the marine ecosystems of the Niger Delta from 2000 to 2022. Google Scholar proved to be a highly effective search engine, granting access to a wide array of scholarly literature and research findings. This research covered diverse subjects, with careful selection of papers that addressed various aspects.

These viewpoints incorporated the authentic foundation of oil investigation and double-dealing in Nigeria, late examinations on unrefined petroleum spills and the variables adding to the scattering of unrefined petroleum in the marine climate of the Niger Delta. Also, the review analyzed the attributes of seawater properties in the Niger Delta, like saltiness, broke up oxygen, pH, and surface water temperature. Exceptional consideration was given to examinations carried out on the Nkoro Waterway, which is situated in the Niger Delta district of Nigeria.

Besides, the examination zeroed in on portraying unrefined petroleum in the Niger Delta, concentrating on the dispersion examples of unrefined petroleum in the marine climate, leading research center evaluations on the pace of oil dissemination in marine conditions, and investigating the central standards of mass exchange. By extensively analyzing these regions, this study distinguished existing examination holes, consequently laying the foundation for future bearings in academic examinations.

III. RESULTS AND DISCUSSIONS

The summary of review of research findings from previous studies are discussed below

3.1 History of Oil Exploration and Exploitation in Nigeria

The shoreline of Nigeria along the Atlantic Sea extends for around 853 kilometers, spreading over between scope 4°10' to 6°20' N and longitude 2°45' to 8°35' E. This beachfront locale covers an area of around 28,000 square kilometers and is joined by a mainland rack that reaches out for 46,300 kilometers. It is described by a dominatingly low-lying landscape, with rises not surpassing 3.0 meters above ocean level. The region involves assorted environments, including new water swamps, mangrove swamps, lagoonal squashes, flowing channels, ocean-side edges, and shoals (Zaixing, 2018).

Geomorphologically, the Nigerian coast can be arranged into four unmistakable units: the Boundary Tidal pond intricate, the Mud coast, the Arcuate Niger Delta, and the Strand Coast (Adeaga, 2014). The essential vegetation in this locale comprises of mangrove woodlands, saline bog timberlands, and rainforests (Dada et al., 2020). The seaside region encounters heat and humidity, with a blustery season from April to November and a dry season from December to Spring.

Nigeria stands firm on a critical footing as one of the world's biggest exporters of oil, filling in as a significant provider to Western Europe. In 2002, it was positioned as the fifth-biggest provider of unrefined petroleum to the US (EIA, 2003). In spite of the significance of Nigeria's oil industry, there is restricted information about the effects of oil slicks along the coastlines of networks in the Niger Delta. Significant oil slicks have prompted broad contamination of marine coastlines, bringing about extreme natural harm to local networks. Since the revelation of oil in Nigeria during the 1950s, the nation has confronted unfavorable natural results related with oil improvement. The development of the oil business, combined with populace development and lacking ecological guidelines, has caused critical natural corruption, especially in the Niger Delta district, which fills in as the core of the nation's oil industry. Oil slicks represent a significant danger to the Nigerian climate, with the possibility to obliterate whole biological systems, particularly in the Niger Delta district (Immanuel & Zak 2016). Numerous people group in the space experience the ill effects of the negative effects of oil slicks, prompting progressively testing everyday environments (Oyem, 2001).

The adverse consequences of oil slicks stretch out to marine life, which becomes defiled and presents dangers to human wellbeing through the utilization of debased fish. Oil slicks likewise bring about the obliteration of farmlands, contamination of ground and drinking water sources, and misfortunes in fishing exercises along the seaside waters.

The scattering of raw petroleum spills in the beach front waters is affected by a few variables, including wind float flows, wind waves, normal surface flows, tides, ocean depths geography, and oil thickness. Moreover, oil slicks go through different cycles like dissipation, emulsification, disintegration, photochemical oxidation, and biodegradation. Factors influencing the dispersal of oil slicks in the beachfront waters incorporate shift in weather conditions, flowing flows, waves, longshore flows, and spreading.

3.1.1 Marine Environment

The marine realm encompasses a vast expanse, incorporating the oceans, seas, bays, estuaries, and other substantial bodies of water. It encompasses the intersection between these water bodies and the atmosphere, as well as the coastal areas extending from the mean high-water mark. This dynamic environment plays a pivotal role in supporting life on our planet. With oceans alone covering approximately 71% of Earth's surface, they not only provide sustenance in the form of food but also offer a plethora of employment opportunities.

Due to the immense importance of the marine environment, any type of pollution or oil spill that occurs in these waters can have dire consequences for both living organisms and human livelihoods (Mitchell, 2006). Acknowledging the significance of this ecosystem, the present investigation centers on examining the effects of crude oil diffusion specifically within this distinctive setting.

3.2 Recent past Works Crude Oil Spill and Agents of Crude Oil Spill Dispersal along the Nigeria Niger Delta marine environment

The broad Nigerian shoreline is lined by the huge Atlantic Sea, extending for roughly 853 kilometers between scope 4°10' to 6°20' N and longitude 2°45' to 8°35' E. Traversing an area of around 28,000 square kilometers, this beach front district is transcendently portrayed by low-lying territory, with heights not outperforming 3.0 meters above ocean level. It envelops different territories, for example, new water swamps, mangrove swamps, lagoonal crushes, flowing channels, ocean side edges, and shoals (Zaixing, 2018). Geomorphologically, the Nigerian coast can be ordered into four unmistakable units: the Obstruction Tidal pond perplexing, the Mud coast, the Arcuate Niger delta, and the Strand coast (Adeaga, 2014). Vegetation in the space comprises principally of mangrove timberlands, harsh marsh woods, and rainforests (Dada et al., 2020). The waterfront environment is tropical, described by a stormy season from April to November and a dry season from December to Spring.

Nigeria stands firm on a huge footing as a significant worldwide exporter of oil, providing Western Europe and positioning as the fifth-biggest unrefined petroleum provider to the US in 2002 (EIA, 2003). Be that as it may, the comprehension of the effect of oil slicks on the coastlines of networks in the Niger Delta, a basic district for the nation's oil industry, stays restricted. Various significant oil slicks have prompted broad contamination of marine coastlines, bringing about critical environmental harm in neighboring networks. Nigeria has been wrestling with antagonistic ecological outcomes related to oil advancement since the 1950s. The extension of the oil business, combined with populace development and an absence of ecological guidelines, has inflicted any kind of damage, especially in the Niger Delta locale. The commonness of oil slicks represents a huge danger to Nigeria's current circumstance, equipped for crushing whole environments while possibly not really made due, particularly in the Niger Delta locale (Immanuel Ness, 2016). Networks in space get through the deteriorating impacts of oil slicks, prompting progressively deplorable day-to-day environments (Oyem, 2001).

The inconvenient effect of oil slicks stretches out to marine life, which becomes tainted, presenting dangers to human well-being through the utilization of contaminated fish. Oil slicks have additionally brought about the obliteration of farmland, contamination of ground and drinking water, and mishaps in fishing exercises inside the beachfront waters.

Different elements impact the scattering of unrefined petroleum spills in our beachfront waters, including wind float flows, wind waves, normal surface flows, tides, ocean depth geography, and oil thickness. Oil slicks go through cycles like dissipation, emulsification, disintegration, photochemical oxidation, and biodegradation. Factors that influence the dispersal of oil slicks in our waterfront waters incorporate shifts in weather conditions, flowing flows, waves, longshore flows, and spreading.

3.3 Recent Past Works on Characterization of Sea Water in Niger Delta.

Ocean water, usually alluded to as salt water, is the fluid arrangement present in oceans and seas. On a worldwide scale, seawater in Earth's seas has a typical salt substance of roughly 3.5% (35 g/L or 599 mM). This intends that for each kilogram (generally identical to one liter by volume) of seawater, it contains around 35 grams (1.2 oz) of disintegrated salts, principally involving sodium (Na+) and chloride (Cl-) particles. At the outer layer of the sea, seawater has a typical thickness of 1.025 kg/L. In contrast with new water and unadulterated water (which has a thickness of 1.0 kg/L at 4 °C or 39 °F), seawater is denser because of the expanded mass which is brought about by the presence of the dissolved salts corresponding to its volume. With higher salt fixation, the edge of freezing over of seawater diminishes. Under ordinary saltiness levels, seawater freezes at roughly - 2 °C (28 °F) (Chester and Roy, 2012). The least recorded temperature of fluid seawater was - 2.6 °C (27.3 °F) in 2010, identified inside a stream underneath an Antarctic icy mass.

The pH level of seawater as a rule goes from 7.5 to 8.4. Be that as it may, there is no generally settled reference pH scale explicitly customized for seawater, and varieties of up to 0.14 units can be seen between estimations in view of various reference scales (Chester and Roy, 2012). Past investigations on the qualities of seawater have for the most part centered around different properties, including saltiness, thermophysical ascribes (thickness, pH, and warm conductivity), compound creation, and microbial structure.

A study was conducted in a coastal region of Port Harcourt, Niger Delta, Nigeria, in 2012 by Moses et al. This research was to identify the hydrogeochemical processes influencing groundwater chemistry. The major geological units of the study area are sand, silt, and shale of the Oligocene–Pleistocene of Benin Formation. For the purpose of their study, a total of 18 groundwater samples were measured for major ions. Findings from this showed that areas underlined by high electrical conductivity values indicate areas with poor groundwater quality. Results from hydrogeochemical facies analysis plotted in the Piper diagram showed a trend of Na^{+}> K^{+} > Mg^{2+} > Ca^{2+} > Cl^{-} > SO_4^{2-} > HCO_3^{-}. Further findings from the hydrogeochemical analysis revealed that groundwater is of the same origin, deductions from the Chadba plot revealed that saline water intrusion influenced hydrochemical composition of groundwater it was reflected by Na–Cl type waters. Results from Gibbs plot revealed that precipitation is the major hydrochemical process that influences groundwater, and saltwater intrusion may also be connected to anthropogenic impacts; such as sewage disposal from septic tanks. In summary, the abstraction of groundwater in the area should be reduced, septic tanks should be built far from where boreholes are sunk. They concluded from their study that the government should ensure water purification plants are installed while drilling boreholes, to further reduce the current level of salinity in groundwater (Oshineye, 2000, Oldenburg and Fowler, 2006, Nwilo and Badejo, 2005). Moreover, good hygiene and good sanitary habits should be inculcated by the inhabitants of the study area.

In 2021, Taiwo et al., conducted a research. In their work, Oilfield brines from nine producer wells in the Miocene reservoirs (2,472.25–3,532.48 m.b.s.l.), offshore Niger Delta, were investigated along with two seawater samples to understand their hydrogeochemical characteristics in relation to the host rock mineralogy. Chemical analysis revealed that the waters are slightly alkaline and can be generally classified as saline water of the Na–Cl type based on their total dissolved solids (TDS). On the basis of bicarbonate, chloride, and sulfate ions, they are shown to be of connate origin. The relative abundance of major ions is in the following order: Na > Ca > Mg > K and Cl > HCO3 > SO4. Saturation indices (SI) of selected mineral phases calculated using PHREEQC indicate that the dissolution of iron oxide and carbonate minerals may contribute major ions in the formation of water. The preponderance of alkali elements suggests the presence of feldspars, which could have resulted from sediments through which the water flows. An inverse relationship is observed between the resistivity of formation water and its TDS, which could be used to calculate resistivity values of formation waters in the area if the TDS contributions are known. Chemical data suggest that the formation waters were derived from seawater, dominantly altered by reverse ion-exchange processes and subsequently by water-rock interactions. Multivariate statistical analyses (correlation and factor analysis) indicate multiple sources of enrichment of ions in the formation waters.

In 2015, Dienye and Woke investigated the physico-chemical parameters of the upper and lower reach of the New Calabar River across five stations in relation to season from December 2013 to May 2014.The result showed that the water was slightly acidic across months with pH range of 6.18 to7.08 and across Stations. Relatively high Dissolved Oxygen levels were observed during the study with higher value at the upstream sampled stations than downstream sampled stations. There was no significant variation in Temperature and BOD across Stations and season. Further results revealed that there were variation in salinity values, lowest salinity was recorded in station 5 (5.93 mg/l) and lowest in station 2 (1.08 mg/l) while the highest salinity in December (6.01).Dissolved Oxygen decreased across Stations (6.45 to 4.49 mg/l) but showed variation across season.

3.4 Study of Salinity, Dissolved Oxygen, pH and Surface Water Temperature in Nkoro River in the Niger Delta Area of Nigeria

An extensive examination was done on the Nkoro Stream, arranged in Waterways State inside the Niger Delta locale of Nigeria. The essential point of the review was to look at numerous elements, including saltiness, disintegrated oxygen levels, pH, and surface water temperature inside the stream. Information assortment spread over a one-year time frame, from January to December 2008 (Abowei, 2009). The review zeroed in on understanding what changes in these ecological circumstances meant for estuarine fish species. This exploration extends how we might interpret these life forms as well as empowers the evaluation of the expected effect of human exercises on estuarine fish populaces.

To gauge disintegrated oxygen and temperature, a Broke up Oxygen meter (OxyGuard Helpful MK II) was utilized. Likewise, a pH meter (Hanna Instrument model No. H1 8915 ATC) was utilized to decide pH levels, while saltiness was estimated utilizing a salinometer (model: New S-100). The tests of these instruments were lowered in the stream, and the relating readings were recorded. The estimations were led from a kayak along the Nkontoru - Occupation Ama segment, which structures part of the Nkoro waterway framework.

The recorded qualities for the boundaries are as per the following: Saltiness went from 5% in September to 17% in February. Dissolved oxygen values shifted from 6 mg/l in January, April, July, and October to 10 mg/l in September. pH values went from 6.1 in August to 8.5 in November, while temperature values went from 24 °C in July to 32 °C in Spring.

Additionally, saltiness values went from 12.8±0.30% at Station 4 to 13.3±0.10% at Station 3. Broken down oxygen values went from 3.2±0.1 mg/l at Station 3 to 7.3±0.16 mg/l at Station 1. pH values differed from

7.3±0.17 at Station 1 to 7.7±0.14 at Station 3, while temperature values went from 27.3±0.24 °C at Station 1 to 33.7±0.21 °C at Station 3. There were no massive contrasts seen in saltiness and pH between the stations, however tremendous contrasts were recognized in broke up oxygen and temperature ($P < 0.05$).

The relationship lattice examination uncovered critical relationship among the factors at various stations. The likenesses in the relationship among the ecological factors demonstrate that the water at the stations probably began from a similar source, specifically the Atlantic Sea through the Bonny Stream (Schobert, 2013, Ozekhome, 2001, Oyem, 2001).

Positive affiliations were noticed, proposing useful comparability. The variety in the strength of the connection between water factors in the lower Bonny Stream of the Niger Delta was ascribed to contrasts in microhabitats within the review environment for the current work (Niger Delta Petroleum Resources, 2011, Meredith, 2000).

3. 5 Recent Past Works on Characterization of Crude Oil in the Niger Delta

A study conducted by Ofodile et al. in 2018 aimed to examine the properties of crude oil extracted from the Afiesere Oil Field in the Afiesere community, Ethiope Local Government Area of Delta State, Nigeria. This oil field is located within OML 30 of the NPDC FIELD, covering an area of 1,095 square kilometers. Its discovery dates back to the period between 1961 and 1966. The main objective of the study was to characterize the crude oil and assess its suitability for transportation, storage, and refining purposes.

To carry out the analysis, a representative sample of the crude oil was obtained from the Research & Development Division of the Nigerian National Petroleum Corporation (NNPC). The analysis took place at the Water/Oil Laboratory of the Eleme Petrochemicals Company Limited in Rivers State and the Laser Engineering Laboratory in Port Harcourt. Modified ASTM/IP methods were utilized to evaluate the physical, elemental, and compositional properties of the crude oil. The analysis encompassed various parameters, including color/appearance, density, specific gravity, API gravity, moisture content, gum content, cloud point, pour point, flash point, kinematic and dynamic viscosities, Reid vapor pressure, metallic constituents (vanadium and nickel), as well as elemental and compositional hydrocarbons using GC-FID.

Table 1: Physical and chemical characteristics of crude oil.

S/NO.	Parameter	Unit	Result
1	Appearance/colour	-	Dark brownish liquid
2	Density@15°C	g/cm^3	0.944
3	Specific gravity@60F	-	0.945
4	API gravity	°	18.2
5	Reid vapour pressure	kPa	7
6	Kinematic viscosity	cSt	80.4
7	Dynamic viscosity	-	75.9
8	Moisture	ppm	3175
9	Gum content	mg/100 ml	71,000
10	Cloud point	°C	-2
11	Pour point	°C	-10
12	Flash point	°C	95

The results obtained for the crude oil from the Afiesere Oil Field are as follows: density (0.9440 g/cm3), specific gravity (0.9450), API gravity (18.2°), vapor pressure (7 kPa), kinematic viscosity (80.4 cSt), moisture content (3175 ppm), gum content (71,000 ppm), cloud point (-2°C), pour point (-10°C), flash point (95°C), vanadium (0.05 ppm), nickel (0.39 ppm), N_2 (0.11%), O_2 (<0.5%), S_2 (1.25%), aliphatic hydrocarbons (0.032-2.804%), and heavier hydrocarbons (0.210-1.737%). These findings provide valuable insights for predicting the transportation, storage, and refining processes associated with the analyzed crude oil.

The specific gravity and API gravity values play a crucial role in classifying crude oil as either light or heavy. Generally, specific gravity values range from approximately 0.80 to 0.88 for light crude oils, 0.94 to 0.98 for heavy oils, and 1.00 to 1.03 for bitumen. While API gravity value for Light oil is > 31.1, Medium oil falls between 22.3 and 31.1, Heavy oil falls between 10 and 22.3, and for Extra Heavy oil < 10.0 (heavier than water). Based on the results, the crude oil from the Afiesere Oil Field falls into the category of heavy oil. Additionally, Ofodile et al. (2018) have also determined the metallic, elemental, chemical, and physical compositions of other crude oils in the Niger Delta region.

Adedosu and Sonibare in 2005, applied Infrared spectroscopy in characterizing crude oils from Niger Delta in terms of their source and thermal maturity. The samples were characterized based on the peak intensities of the aliphatic and the carboxyl/carbonyl groups relative to the aromatics. Using this method, the oils classified mainly as oil derived from type 1 kerogen contrary to type II/III already reported for Niger delta oil. The Vitrinite Reflectance (VR) values obtained from the VR equivalent grid ranged from 0.5 to 0.7%, indicating that the oils are of low maturity. The estimated VR determined from the IR spectra correlate favourably with available values in the literature. The results of this study showed that Infrared spectroscopy might not be a good tool for oil source characterization but can be useful in determining oil maturity (CIA, 2005).

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Two crude oils from Rivers and Delta States, Niger Delta Nigeria, samples A and F respectively, and their binary mixtures at different compositions, samples B, C, D, and E, were geochemically characterized using bulk properties and aliphatic hydrocarbon distributions by Mark et al., 2018. Results of density and API gravity, which classified samples A, B, C, D as light oils and samples E, F as medium oils, were observed to increase and decrease with increase in the composition of oil sample F respectively. The composition of the saturates, from 68.00 to 71.10%, suggest high maturity of the oil samples which did not show a relationship to the compositional mix of the two Niger Delta crude oils (Chokor, 2008).

Bimodal distribution of n-alkanes in samples A and B with a slight prominence of the short chain suggest marine source with significant terrestrial input, while the prominence of the long chain n-alkanes in sample F, which suggest a terrestrial source, progressively increased in samples C, D, and E. Pr/Ph ratios from 2.37 to 2.70 suggest source rocks deposited in an oxic environment (Chukuezi, 2006).

. Ratios of Pr/nC_{17}, from 0.94 to 1.20, and Ph/nC_{18}, from 0.39 to 0.53, suggest shale source rocks with terrestrial higher plant input. From these results, the geochemical characteristics of the individual Niger Delta crude oils were exhibited by their binary mixtures. However, density, API gravity, n-alkane distribution, Pr/nC_{17} and Ph/nC_{18} ratios were expressed relative to the compositional mix of the two Niger Delta crude oils (Dublin and Abiol-Oloke, 2009, Demirdöven et al., 2004, Civil Liberties Organization, 2002).

Chikwe and Onojake in 2018, obtained Crude oil from different locations in the Niger Delta area of Nigeria and analyzed them by Infrared Absorption Spectrometric technique using Nicolet IS5 Fourier Transform spectrometer to identify the functional groups and compounds in the samples (Celestine, 2003)

. The sampling sites were at four locations in the Niger Delta area of Nigeria namely Usan, Ogbele, Abo and kokori oil fields. Condensate samples were obtained at Ogbele gas plant. Results obtained revealed that the amount of surface active components in the crude was in following trend, sample E > sample A > sample C > sample D > sample B, while the level of biodegradability follows the trend; sample E > sample B > sample A > sample C > sample D. Results show that Sample E has the highest amount of surface active components as well as the highest level of biodegradability (Barth et al., 2004)

. Sample B has the least amount of surface active components, while sample D has the least level of biodegradability. The presence of functional groups such as amines, sulfates, isocyanates, hydroxyl, halo compounds, thiols and nitro compounds in the crude increases the surface active properties of the crude due to their polarity and hydrophilicity, which influences the interfacial tension of the crude and the oil recovery efficiency (Arinze, 2016)

. The level of crude biodegradability is dependent on the amount of aliphatic saturates in the crude, the concentration of acidic components as well as sulphur and nitrogen compounds in the crude. Infrared spectroscopy identifies the functional group in crude samples, this is necessary in knowing the amount of the surface active components and the level of biodegradability of crude oil.

3.6 Recent Past Works on Diffusion of Crude Oil in Marine Environment

The effects of oil contamination on the climate and environment are vigorously affected by the capacity of raw petroleum parts to break up in seawater (Akpofure et al., 2000). Broad examination has uncovered that the disintegrated part of oil, instead of the emulsified or adsorbed portions, represents a huge risk to marine life because of its high poisonousness. This broke up division can be handily devoured by creatures at the lower levels of the well-established pecking order, at last gathering and packing in life forms higher up the trophic levels (Zhendi et al., 2003).

Albeit the dissemination of different kinds of raw petroleum in seawater is for the most part confined, with a greatest solvency of 30mg/l at 22°C, the monstrous volume of seawater outperforms the amount of oil in most oil slicks. Subsequently, significant amounts of oil can in any case disintegrate (Wenger et al., 2002, Villar et al., 2012, Shcherbakov et al., 2012).

Non-hydrocarbons with higher extremity and low atomic weight hydrocarbons present in raw petroleum can promptly break up in seawater. The dispersion pace of these various parts inside an oil spill is impacted by many-sided communications between the oil's organization (counting the general overflow of parts, explicit gravity, consistency) and the physicochemical properties of the general climate (e.g., ocean state, saltiness, temperature, pH). The dissemination cycle starts upon contact between the oil and water, yet long haul impacts likewise become possibly the most important factor, for example, the debasement of the first oil constituents through Phyto and biodegradation, prompting the arrangement of progressively polar mixtures (ANEEJ, 2004).

A portion of these mixtures show higher dissolvability in seawater contrasted with the parent hydrocarbons (Zhendi et al., 2003).

The spreading of oil builds the contact region between the smooth and seawater, possibly bringing about an expanded dissemination of water-dissolvable parts (Adeyemo, 2002). Be that as it may, under unambiguous circumstances, the deficiency of exceptionally dissolvable and unstable sweet-smelling hydrocarbons from an oil spill through disintegration in seawater might be negligible contrasted with misfortunes through dissipation. Over the long haul, the disintegration rate might additionally diminish as the oil loses its lighter and more dissolvable parts because of vanishing (Speight, 2007), as outlined in examinations in Figure 2.

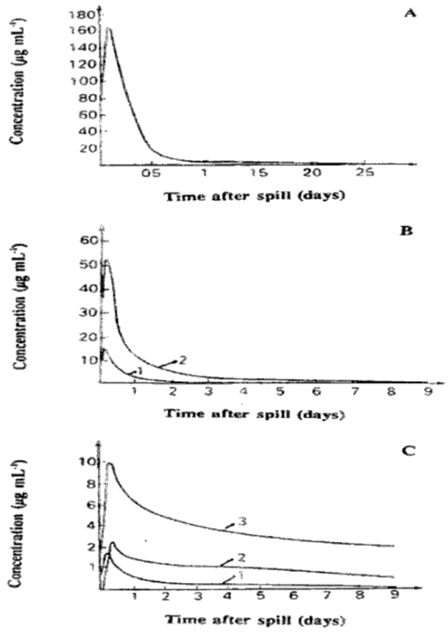

Fig. 2: Gathering of deteriorated sweet-smelling parts in a water segment got from a wave tank investigate as a component of persevering through time: (A) toluene; B) ethylbenzene; 1, 4-dimethylbenzene; (C) I n-propylbenzene; rnethylnaphthalenes; c.2-naphthalenes.

Any preliminary examination of crude petrol deterioration in water should contemplate something like three factors: engineered components, natural factors and exploratory components. (Source: Speight, 2007)

3.7 Recent Past Works on Laboratory
Assessment on Rate of Diffusion of Spilled Oil in Marine Environment

Water bodies are a source of ecosystem services such as water supply, production, recreation, and aesthetics (Akaegbobi, 1999)

. In 2008, two major oil spills took place in Bodo creek. A major challenge with the assessment and monitoring of an environment is the lack of baseline data. However, Bodo Creek has been studied extensively. Nkeeh et al., reviewed pre-spill, post-spill, and post-clean-up studies on physicochemical parameters in Bodo Creek. Their study revealed that the difference in the levels of the physicochemical parameters including pH, salinity, dissolved oxygen (DO), biochemical oxygen demand (BOD), and temperature in Bodo Creek, before and after the oil spill was not statistically significant ($P > 0.05$); other physicochemical parameters examined in their study are alkalinity, total hardness, chemical oxygen demand (COD) and total dissolved solids (TDS). The study also revealed that pH and temperature were higher in the post-cleanup study, while DO and conductivity were higher in the pre-cleanup study (Hoeiland, et al., 2001, Hargate, 2006, Farooq et al., 2013).

BOD was significantly higher in the post-spill study than the pre-spill study, indicating a high level of pollution as a result of the oil spill. Their review also shows that there are higher pH and temperature levels in post-clean-up studies than the pre-cleanup studies. Pre-clean-up DO and conductivity were higher than the levels in the post-clean-up study (Alaibe, 2008).

In 2017, a research center evaluation was led by Mmecha and partners to investigate the pace of oil dispersion in the marine climate. The focal point of the review was to acquire experiences into the spreading conduct of unrefined oil inside marine silt utilizing physicochemical boundaries. To accomplish this goal, the analysts assembled tests of raw petroleum and silt from five Nearby Government Regions in Bayelsa State, situated in the Niger Delta locale of Nigeria. The research facility investigation occurred among Spring and November 2017.

To reenact the dispersion cycle, the scientists used exceptionally planned cylindrical reactors, where they set the silt tests. Accordingly, three unmistakable sorts of raw petroleum tests were brought into the silt. Defiled dregs tests were recovered from the cylindrical reactor at a profundity of 15 meters like clockwork. These examples were exposed to examination utilizing Gas Chromatograph-Fire Ionization Locator (GC-FID) to gauge the centralizations of **Total** Hydrocarbon (TPH), Complete Hydrocarbon Content (THC), Poly Fragrant Hydrocarbon (PAH), Benzene Toluene Ethylene Xylene (BTEX), as well as other metallic components.

Out of the 22 boundaries dissected from the field tests, the scientists zeroed in on four parts of the unrefined petrol tests (TPH, THC, PAH, and BTEX) to explore the attributes of raw petroleum dissemination in marine silt. They utilized different displaying apparatuses for transport processes, including Investigation of Change (ANOVA) and Dramatic Smoothing conditions (Aigbedion et al., 2007)

The essential target of the review was to look at what petrol parts and interchangeable cations meant for the stream elements inside the dregs. The discoveries affirmed that spilled rough petrol diminishes as it diffuses into the marine residue. The ANOVA examination yielded the accompanying connections for TPH: YR AR = - 13.92x + 7171, with a connection coefficient (r) of 0.9920; YR BR = - 18.72x + 4038, with a connection coefficient (r) of 0.9494; YR CR = - 219.50x + 6165, with a connection coefficient (r) of 0.9796. Comparable conditions were determined for THC, PAH, and BTEX. Thus, these discoveries consider the forecast of the profundity of raw petroleum dissemination in case of an underground crisis (Aloja and Ekeh, 2002).

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3.8 Fundamental of Mass Transfer

In the context of a system comprised of components with varying concentrations at different points, there exists an inherent tendency for mass to move in order to minimize concentration differences within the system. This natural phenomenon, where a constituent migrates from an area of higher concentration to an area of lower concentration, is commonly referred to as mass transfer (Energy Information Administration, 2003).

When this mass transfer is solely driven by the movement of molecules, without any convection occurring within the system, it is known as molecular diffusion. Mass transfer is a prevalent occurrence in our daily lives. For instance, when a sugar cube is added to a cup of tea, it gradually dissolves and spreads evenly throughout the water. Ponds lose water through evaporation, leading to an increase in the humidity of the surrounding air. The laws governing mass transfer help us understand the relationship between the flux of a diffusing substance and the concentration gradient that propels the mass transfer process.

To explain the role of components within a mixture, here are some commonly used relationships and definitions.

3.8 Equation Governing Mass Transfer through Diffusion

In order to study the movement of crude oil in receiving sea waters, a model based on an established transport equation was employed. The solved model was then utilized to predict the concentration of crude oil, as determined through experimental analysis. The well-known equation governing the transportation of pollutants (Chawla and Singh, 2014; Patil and Chore, 2014) is expressed as $\frac{\partial C}{\partial t} = \frac{k}{\rho C_k}\frac{\partial^2 C}{\partial x^2} - v\frac{\partial C}{\partial x}$ (1)

Where

C =Concentration of crude oil (mg/l)
k = Conductivity of crude oil in water (J/s.m.K)
C_p= Specific heat capacity of crude oil in water (J/kg. K)

$\dot{\rho}$ = Density of crude oil in water (g/l)
v = Velocity of crude oil in water (m/s)
t = Time of crude oil transport
x = Distance along the direction of transport (m)

Letting $\frac{k}{P\, C_P} = D$ (diffusivity of crude oil in water (m^2/s). Then equation (1) reduces to

$$\frac{\partial C}{\partial t} = D\frac{\partial^2 C}{\partial x^2} - v\frac{\partial C}{\partial x} \quad (2)$$

Assuming steady state transport, where differential change in concentration over time is
Constant, equation (2) reduces to:

$$D\frac{d^2C}{dx^2} - v\frac{dC}{dx} = 0 \quad (3)$$

But for decreasing concentration of crude oil with increase in distance of transport, concentration gradient, $\frac{dC}{dx}$ is negative, thus, equation (3) can be re-written as:

$$D\frac{d^2C}{dx^2} + v\frac{dC}{dx} = 0 \quad (4)$$

The solution to equation (4) can be used to obtain the rate of diffusion.

3.9 General Limitation of Past Works

The accompanying areas frame ebb and flow research holes and likely bearings for future examination:

Describing Marine Salt Water in the Niger Delta: Distributed writing tending to the portrayal of marine salt water in different districts of the Niger Delta is scant. It is fundamental for address this information hole through ensuing examination tries.

Explicit Portrayal of Raw Petroleum Tests in the Niger Delta: In spite of broad information on the properties of light and weighty unrefined petroleum tests, research endeavors have principally centered around mixes as opposed to explicit areas inside the Niger Delta (Dada et al., 2020). There is a critical requirement for committed exploration to describe raw petroleum tests from unmistakable regions inside the Niger Delta.

Creating Exact Trial Arrangements for Concentrating on Oil Corruption in Marine Conditions: Concentrating on the destiny of oil debasement in the marine climate has represented a constant test because of the requirement for trial arrangements that successfully recreate ecological circumstances while giving practical estimations of these cycles adrift (Alexandra Gas and Oil Connections, 2006). Despite the fact that research center reproductions have yielded important experiences into the misfortune and corruption of spilled oil, further observational examinations are important to improve how we might interpret raw petroleum dissemination and its effect in marine conditions.

Directing a Definite Lab Concentrate on Raw petroleum Dissemination in Salt Water Marine Conditions: While a few examinations have researched the dissemination of raw petroleum in salt water marine conditions, a more thorough lab study is pivotal to decide the diffusivity of raw petroleum in salt water and the relating amount of oil included. Such a review would add to a more profound comprehension of dissemination elements and work with the extension of information in this examination space.

IV. Conclusion:

The exploration, exploitation, and incidents of crude oil spills in the Niger Delta have persisted for many decades. This comprehensive review has highlighted both global and regional causes of these activities, as well as significant oil spill events. It is important to recognize that the impacts of oil spills extend beyond surface facilities, as crude oil infiltrates surrounding water bodies and even the ground.

The discussions presented in this study have shed light on existing gaps and limitations in understanding the diffusion of crude oil in water and other mediums. These insights serve as the foundation for developing new conceptual frameworks and guiding future research directions aimed at bridging these gaps and overcoming limitations in the field.

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Figure Table
Figure 1: Pie graph showing Causes of Oil Spills in the Marine Environment (Ben-David et al., 2005; Alonso-Alvarez et al., 2007).

Fig. 2: Gathering of deteriorated sweet-smelling parts in a water segment got from a wave tank investigate as a component of persevering through time: (A) toluene; B) ethylbenzene; 1, 4-dimethylbenzene; (C) I n-propylbenzene; rnethylnaphthalenes; c.2-naphthalenes.

Any preliminary examination of crude petrol deterioration in water should contemplate something like three factors: engineered components, natural factors and exploratory components. (Source: Speight, 2007)

Table 1: Physical and chemical characteristics of crude oil.