

EFFECT OF DRILLING MUD ON DRILLING PROCESS PIPES, WORKERS AND THE ENVIRONMENT OF NEMBE CREEK IN BAYELSA STATE

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Abstract: This study is carried out with primary, secondary and laboratory analysis to identify effect of drilling mud on drilling process pipes, workers and the environment - severity- on-drilling pipes, personnel, the environment as well as major areas of exposure to drilling fluids. Passive and active inductive reasoning and observation was carried out to assess drilling fluid effect on rig workers as well as a laboratory analysis on both physio-chemical properties of soil and produced water sample to determine drilling fluid effect on drilling process pipe lines on the Nembe creek trunk line. Reliable suggestions from this paper will reduce the gap as for seen from other authors such as Wisan Hussain (2021) effect and hazards of drilling fluid on well drilling workers and administrative processes adopted in Iraq field. Also, Augusta Ayotamuno (2024), effect of oil-based drilling mud on physiochemical properties on water quality. Results obtained gave determining factors of the present for future research on effect of drilling operations around Nembe, Santa braba to new Calabar River of Bayelsa state. Gaps such as exposure time, handling procedures as well as management of all activities in synergy as a team with goal zero on operations. According to the result obtained from primary data, there is compromise to standards in areas of exposure time due to the yell for more money from overtime as well as Organization business profit; Drilling companies undermining the effect of heavy metal physiochemical properties forming low specific activities sludges and scales on pipes thereby increasing effect of corrosion on pipes resulting to cracks and leak. Personnel using not fit for purpose tools as well as lack of replacement of PPE as at when due. Secondary and laboratory assessment met standards in physiochemical parameters of pH (6.8), heavy metal concentration of soil sample, produced water (TDS)1049.4mg, heavy metal concentration in produced water of lead, zinc, copper and barium; all fell below standard in control area range of Federal ministry of Environment. Also, the study as a gap observed from other authors is that personnel lack awareness of hazardous nature of physiochemical properties of chemicals as well as danger of exposure level. The study therefore suggests more strict measures to compliances on standard, training of personnel on treatment of the fluid adequately before reinjection and the government developing frameworks on complete adherence and monitoring or face litigative fines for defaults.

Key words: Drilling, Drilling Mud, Physio- chemical properties, Laboratory, Corrosion, Aspect and Impact

INTRODUCTION

Liquid drilling fluid referred to as drilling mud are used to provide hydrostatic pressure which will prevent formation fluid from entering into wellbore, keep drill bit cool, suspend drill cuttings and carry drill cuttings from borehole to the surface thus are selected to avoid formation damage and limit corrosion. Various types of mud include water based, oil based, synthetic based and gas-based mud. On this journal concentration is going to be oil-based mud (OBM). During drilling, returning mud can contain natural gases or other flammable materials that has the risk of a fire or an explosion if they ignite. Also during drilling naturally occurring radioactive materials (NORM) flows with oil, gas and water mixture and accumulates in scale, sludge and scrapings. The accumulation can vary from one facility to another depending on geological formation, operational and other factors. Low specific activity sludges and scale is a radioactive deposit inside pipes and other production equipment which consist of calcium carbonate and barium sulphate and co-precipitated radium. These are salts dissolved in reservoir in a mixture of formation water and injected seawater. Other

radionuclides such as lead-210 and Polonium-210 are also found in pipelines scrapings as well as sludge accumulating in tank bottom. Mixing of seawater which is rich in sulphate and formation water which is rich in brine increases scaling tendency in processing or drilling pipes.

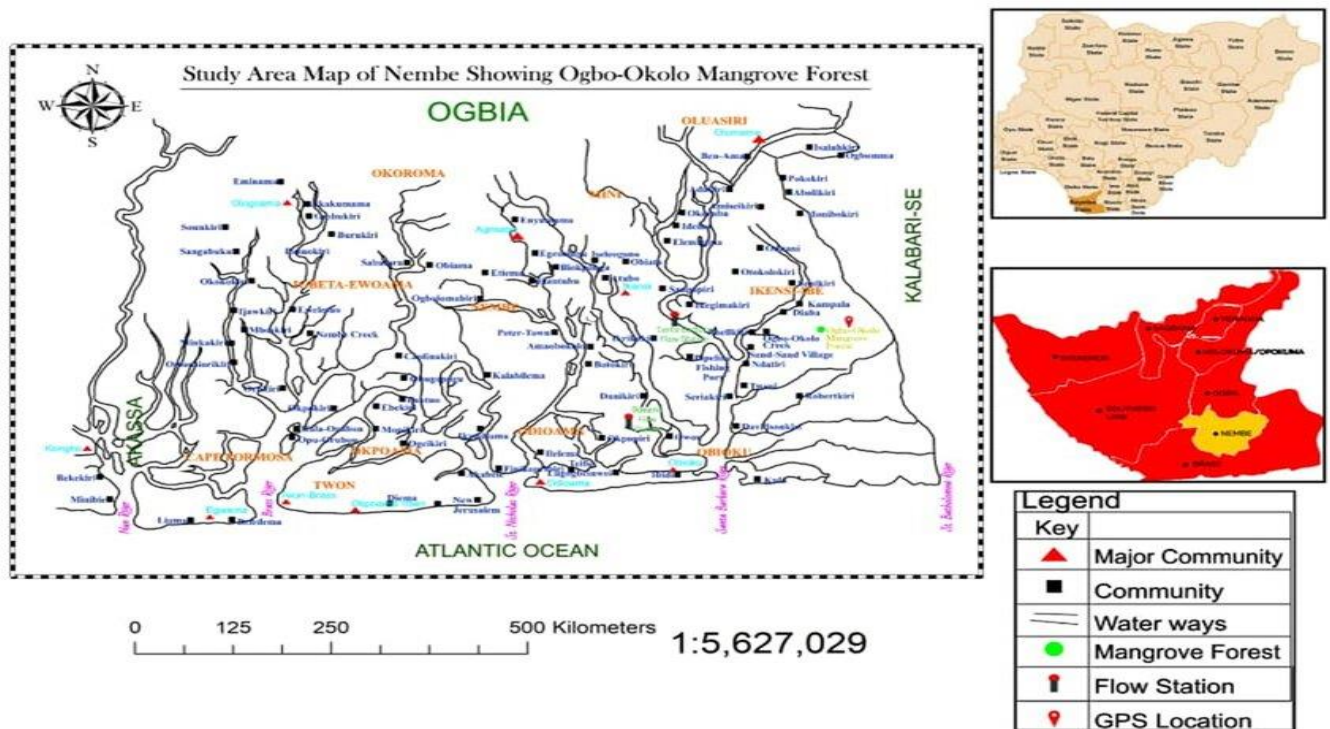
Exposures to low specific activity sludges and scales are generally to be low but are source of ionizing radiation which needed to be avoided either by inhalation or ingestion as the materials contain alpha particle emitters, which may cause considerable health problems when they enter the body. In oil and gas production LSA sludges and scales can be typically found in the production well, well heads, safety valves, separators, crude pipelines and crude oil tanks. Handling measures should be well defined in procedures, supervision, monitoring and reduced exposure time to avert health problem. Information on the degree of contamination, and the levels of xenobiotic compounds present

in surface water samples can help to identify potential risks to human and environmental health (Feng et al., 2019). A comprehensive analysis of the physicochemical properties and xenobiotic levels in water exposed to oil-based drilling mud is necessary to assess the potential risks to human and environmental health and develop effective strategies to minimize the impact of oil and gas drilling mud effect on processing pipes, human and the environment (Feng et al., 2019).

There is little misunderstanding between drilling fluid and drilling mud thus been used interchangeably in the industry, although they perform the same functions but, on this journal, a little light is thrown on their distinctive characteristics in order to make more informed decisions regarding which fluid be used for any given environment. Drilling Mud is a form of drilling fluid which effectively runs with water, oil or synthetic – based fluid with different enhancement such as clays, polymers and weighting agents like bentonite that helps to maintain the right temperature, lubricate drill bit, stabilizes formation pressure and makes wellbore firm. While drill fluid touches every area in drilling process that can be either air, water, foam or any mixture of fluids, solids and chemicals in drilling operations. It has a wide range of physiochemical properties, for example water – based drilling fluids contain a combination of oil, synthetic – base fluids and emulsifiers as well as additives like organophilic clays, surfactants and rheology modifiers thus overcomes conventional water limitations.

Specifically, drilling fluids are formulated to facilitate specific drilling requirements or environmental conditions, but drilling mud serve other critical categories of needs such as lubrication, cooling and avoidance of formation damage.

STUDY AREA



Nembe creek Trunkline field is a Miocene deltaic sandstone-shale area with accumulated oil association and unassociated gas on a depth range of 7,000 to 12,000ft. The oils gravities is between 16- and 41-degrees API with heavy oils coming from shallow reservoirs. The area by 1977 has about 30 wells of increase recoverable oil reserves of 645 million bbl. Per day with water ways and mangrove forestation. Oil operation encompasses drilling of wells, production and flow line pipes replacement as well as enhance oil recovery.

CORROSION:

Corrosion is the deterioration of materials by chemical interaction with their environment, for example moisture and metals. A natural process that the metal is attempting to revert to the chemically combined state in which it is almost invariably found in the earth crust. Corrosion is some times referred to as the degradation of plastics, concrete and wood, but generally refers to metals. Rusting of ordinary steel is the most common form of corrosion.

Consequences of corrosion are many, varying from effects on the safe, reliable and efficient operation of equipment or structures are more serious than simple loss of a mass of metal. Major harmful effects of corrosion include: structural failure or breakdown of equipment; failure of vessels and pipes allowing escape of their contents and possible harm to people, plant, equipment and the environment; mechanical damage to valves, pumps etc.

Various control measures are available although full life-cycle must be considered as corrosion may occur at any stage. Material selection, fabrication, shape and cost are all significant. Its control may be able to reduce risk to a quantifiable and appropriate low level where the consequences of failure are serious.

Control measures to be considered includes:

Corrosion allowance – metal added to the design thickness against general corrosion loss for many purposes whilst the process of depleting the corrosion allowance must be monitored and recorded.

Coatings – the choice of coating is related to its intended function, which includes coating for visual decorative appearance, temporary coating for transport or storage, using wax, grease or water repellent and long-term corrosion protection, using organic, inorganic or metal coating systems.

Cathodic and anodic protection – This is the control of metal potentials to reduce the corrosion rate. The principle of cathodic protection involves the connecting of an external anode to the metal to be protected and the passing of an electrical current so that all areas of the metal surface become cathodic and therefore do not corrode.

Inhibitors – They are substances added in small concentrations to reduce the corrosion rate. Liquid phase or vapour phase varieties are used in close systems such as central heating, power boilers, sealed packaging.

Quality control – Confusion of materials must be avoided, especially if repairs are to be carried out in a planned maintenance schedule. Also, where resistance to corrosion depends on correctly applied welding technology, it should be carried out to appropriately designed and qualified welding procedures.

Corrosion awareness – when corrosion reaches a critical level, it can lead to an expensive or catastrophic situation. Knowledge of corrosion control is important to have understanding of the application, effect and benefit of a corrosion control programme and their work may impact upon its efficiency.



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Method of Assessment:

Primary data assessment was conducted through subjective induction passive and active reasoning on Areas of drilling fluid exposures, Hazardous components of drilling mud (MSDS) and Physical observation of personnel of drilling operation.

Fluid Exposure areas:

1. Shale shaker house.
- 2- Drilling floor.
- 3- Mud pit system.
- 4- Sack room.
- 5- Laundry services.

Affected workers are:

1. Floor derrick men: They are exposed to drilling fluids either by inhaling aerosols and vapors /mist or by skin contact. Through making pipe connection during tripping activities from the drill neck, collect cores and cutting samples, carrying out general housekeeping, mixing and adding fluid, collecting samples, and monitoring of pumps.

2. Mud Engineer: Mud Engineers may periodically check the mud by measuring its viscosity, density and other properties.
3. Laboratory attendance: During drilling samples are collected many times each day from pit and flow lines for test to know the benefit meeting standards of operation. The potential contact is by skin and inhalation
4. Motor men: Workers here are responsible for all motors, generators and general maintainers.

Passive and Active reasoning includes observation and interviews on the workers which are as follows:

Workers	OBSERVATIONS	INTERVIEWS- ROOT CAUSE
Floor derrick men	Dermatitis – skin inflammation, itching, & swelling,	On interviews response indicate presence of aromatics
Mud Engineers	Skin & Eye irritation	On interviews response indicate presence of paraffins
Laboratory Attendance	Coughing and headache	On interviews response indicate presence of alpha olefins in drilling fluid
Motor Men	Skin inflammation and scaling	On interviews response indicate presence of esters in drilling fluids

Passive reasoning shows that all work men suffer from all health hazards that affects not only hands and arms but extends to all parts of the body. The health effect is determined by the hazardous components of drilling fluids and their physiochemical properties additives which personnel are exposed to. Irritant effect can result from non- corrosive substances and preparations either immediate or prolonged contact repeatedly to skin which results to inflammation or can result to cancer. Adequate physical observation of drillers and other rig workers show cases the health effect of Dermatitis and Eyes irritation. Other health hazards include headache, nausea and cough which affects the physical look of personnel growing lean. Some medical records indicate symptoms of asthma due to inhalation of aromatic physiochemical properties of drilling fluid.

Also, prolonged exposure can lead to neurotoxicity, that has the potentials of dizziness and fatigue as well as severe health issues such as cancer or damage to immune system or cardiac arrest / difficulty in breathing.



Dermatitis of the hands



Physical manual handling of drilling fluids.

Physiochemical properties of hazardous chemical.

Understanding the physical and chemical properties of a chemical will help handlers to undertake tasks with adequate precautions to achieve safe handling. Physiochemical properties includes ignitability, explosiveness, reactivity, toxicity, flammability, asphyxiation and irritability. Danger of exposure includes tissue damage, reproductive changes such as developing embryo, mutagenicity, this is a damage to genetic cell, carcinogenicity, and uncontrolled row of tissues, allergic reactions and physiological changes thus a physiochemical and hydrocarbon analysis is needed.

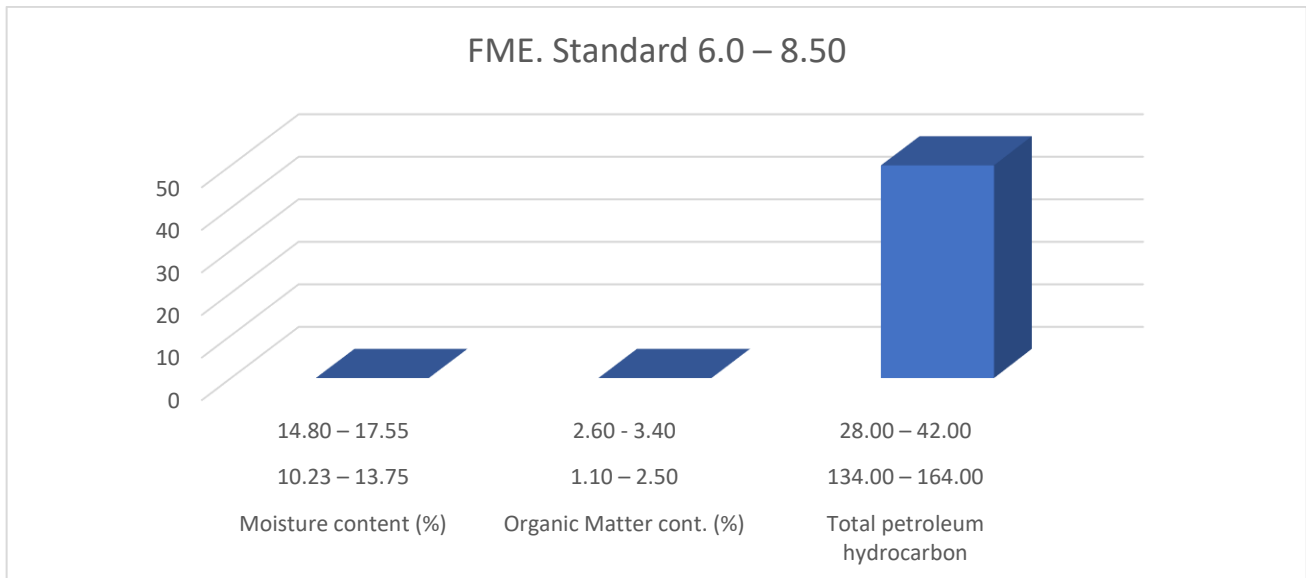
Physiochemical and hydrocarbon analysis was carried out to attest the effect of drilling fluid on pipes and the environment of Nembe creek trunk line. This was done by analyzing soil samples, heavy metal concentration in soil and physiochemical parameters, heavy metal concentration and total hydrocarbon content on produced water of Nembe creek trunk line through Santa Braba to new Calabar River.

Physiochemical and hydrocarbon parameters of soil samples: Soil samples was collected from study area and analysed for physiochemical parameters, total petroleum hydrocarbons (TPH) and heavy metal concentrations to assess effect of physiochemical properties of drilling mud on process pipes, drilling workers and the environment. Corresponding values obtained are tabulated as follows:

Physiochemical and hydrocarbon parameters of soil sample:

Parameter	Drilling fluid areas	Control area from drill fluid	FME. Standard
pH	4.50 – 5.80	6.00 – 6.80	6.0 – 8.50

Moisture content (%)	10.23 – 13.75	14.80 – 17.55	NA
Organic Matter cont. (%)	1.10 – 2.50	2.60 - 3.40	NA
Total petroleum hydrocarbon	134.00 – 164.00	28.00 – 42.00	50.000

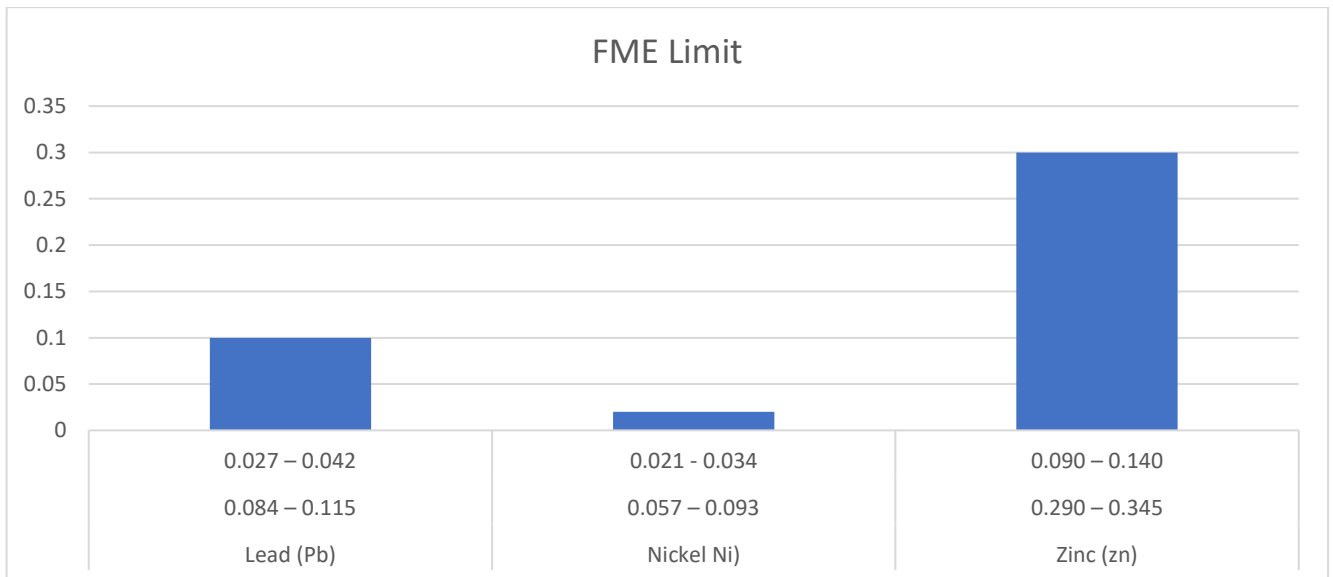


DISCUSSION

Result and discussion: Drilling fluid work area result shows pH value range of 4.50 – 5.80 indicating higher acidity compared to control area of 6.00 – 6.80. The values fall below FME recommended level of 6.0 – 8.50 signifying that drilling fluid effect has lowered the soils buffering capacity, thus reducing suitability for agriculture. Similarly, moisture content result of soil is 10.23 – 13.75% lower than control area of 14.80 – 17.55% which is attributed to hydrophobic nature of petroleum hydrocarbon ability to reduce soil water retention. The organic matter content in drilling mud area is 1.10 – 2.50% lower than control area 2.60 – 3.40%. This indicates interference of drilling fluid effect on microbial activity and deposition which is vital for soil fertility of the environment. Most alarming is total petroleum hydrocarbon concentration ranging from 134.00 – 164.00 mg/kg significantly exceeding FME Limit of 50.00 mg/kg. Indicating severe hydrocarbon effect posing long term risks to human health, ground water integrity and crop development.

Heavy metal concentrations in soil samples

Heavy metal	Fluid storage area	Control Area	FME Limit
Lead (Pb)	0.084 – 0.115	0.027 – 0.042	0.1
Nickel (Ni)	0.057 – 0.093	0.021 - 0.034	0.02
Zinc (Zn)	0.290 – 0.345	0.090 – 0.140	0.3



Discussion: Concentration level of heavy metals in soil samples as analyzed on lead, Nickel and Zinc on fluid area and controlled area determines that Pb and Zn concentrations are 0.084 – 0.115 and 0.290 – 0.345 mg/kg respectively while FME limits are 0.1 for Pb and 0.3 mg/kg for Zn. They are noticeably higher than the control area and more critically Nickel level in fluid area ranged from 0.057 – 0.093 mg/kg which exceeds FME standard of 0.02 mg/kg. Also control site had Nickel 0.021 – 0.034 mg/kg. Indicating high contamination which is quite toxic to plant life, microorganisms and other bioaccumulates. Thus, the environment soil quality potential is indicating long term effect of degradation.

Physiochemical parameters of produced water:

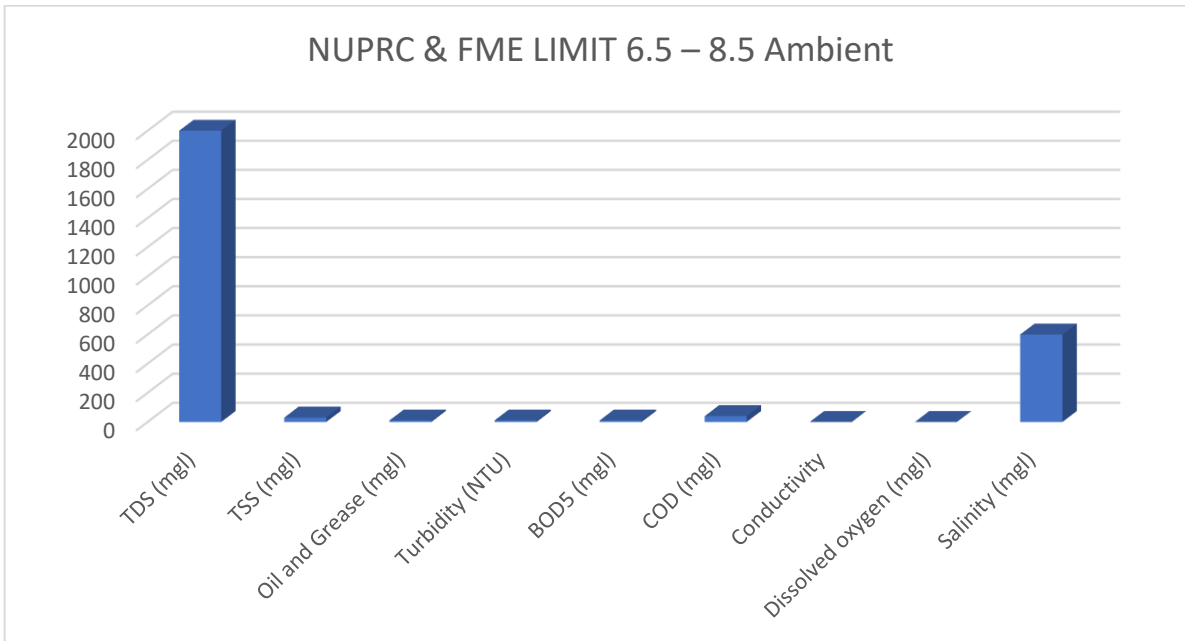
Physiochemical analysis of aqueous effluent samples were collected from Nembe creek trunk line to evaluate the environmental impact of oil drilling activities to assess the quality of effluent released into the environment and compare results with established environmental standards. The analysis is focused on a broad range of water quality indicators that are critical to ecosystem, health and regulatory compliance. These includes pH, temperature, total dissolved solids (TDS), total suspended solids (TSS, mg/l), Oil and Grease (mg/l), turbidity (NTU), Biochemical oxygen demand over five days (BOD5, mg/l), Chemical, oxygen demand (COD, mg/l), electrical conductivity (uS/cm), dissolved oxygen (DO, mg/l) and salinity (mg/l).

Selection of these parameters was guided by their environmental relevance, particularly in oil producing areas where effluent discharges can significantly affect surface and ground water quality. Monitoring such parameters provides insight into the chemical composition of the produced water, the extent of treatment, and the potential for ecological damage if not properly managed. DO and pH levels influence aquatic life sustainability, while turbidity and TSS are indicators of particulate pollutants. BOD5 and COD are determinants of organic pollutant loads of water.

Physiochemical Analysis of Nembe creek trunkline produced water

Parameter	Inlet water	Outlet water	NUPRC & FME LIMIT
pH	7.10 – 8.40	6.70 – 8.20	6.5 – 8.5
Temperature	37.00 – 44.00	39.00 – 48.00	Ambient
TDS (mg/l)	874.5 – 1166.0	805.6 – 1049.4	2000
TSS (mg/l)	26.00 – 28.00	16.00 - 1600	30
Oil and Grease (mg/l)	0.466 – 0.601	0.437 – 1.353	10
Turbidity (NTU)	260.00 – 280.00	300.00 – 350.00	10

BOD5 (mg/l)	5.95 – 6.30	6.03 – 6.15	10
COD (mg/l)	11.04 – 14.98	9.60 – 11.52	40
Conductivity	1650 - 2200	1520 - 1980	NA
Dissolved oxygen (mg/l)	4.50 – 4.70	4.40 – 4.60	NA
Salinity (mg/l)	76.57 – 83.66	41.83 – 83.66	600



Results from the table above represent concentration measures from both the inlet (untreated effluent) and outlet (treated effluent) points of water treatment system. The data were compared against regulatory limits of the Nigerian upstream petroleum regulatory commission (NUPRC) and Federal Ministry of Environment (FMEEnv) to determine compliance status. The result data on the table represent treatment process addressing severe physiochemical contaminants to produced water in the Nembe creek trunk line area. TDS, TSS, pH, BOD5, COD, Oil and grease, conductivity, DO and salinity fall within permissible limit of both NUPRC and FMEEnv. Which suggests that the treatment system in place is largely successful in minimizing harmful discharges into environment. Also temperature and turbidity values on the table exceed the recommended regulatory limit, temperature result will negatively affect aquatic ecosystem while the turbidity indicates that fine particles remain in the treated effluent which can reduce light penetration in water bodies, disrupt photosynthesis and hinder aquatic life.

Result data from treatment of produced water implies that specific upgrades is needed targeting to thermal regulation and solid particle removal. General water quality needed continuous monitoring with adequate remediation strategies to maintain and improve environmental compliance and sustainability.

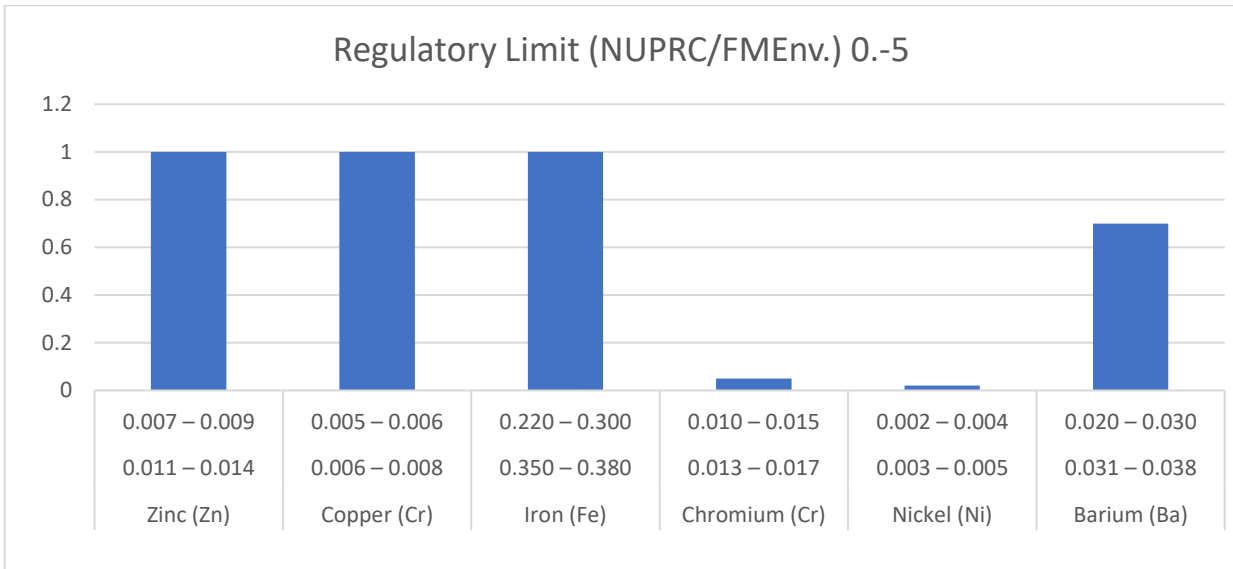
Heavy Metal Concentration:

Among the most persistent and toxic pollutants found in oilfield effluent are lead (Pb), Zinc (Zn), Copper (Cu), Iron (Fe), Chromium (Cr), Nickel (Ni) and Barium (Ba) analyzed in the aqueous samples from Nembe creek Trunkline to assess and evaluate level of compliance to regulatory guidelines.

Heavy Metal concentration in produced water of Nembe creek Trunkline

Heavy Metal	Inlet concentration (mg/l)	Outlet concentration (mg/l)	Regulatory Limit (NUPRC/FMEEnv.)
Lead (Pb)	0.006 – 0.010	0.004 – 0.007	0.5

Zinc (Zn)	0.011 – 0.014	0.007 – 0.009	1.0
Copper (Cr)	0.006 – 0.008	0.005 – 0.006	1.0
Iron (Fe)	0.350 – 0.380	0.220 – 0.300	1.0
Chromium (Cr)	0.013 – 0.017	0.010 – 0.015	0.05
Nickel (Ni)	0.003 – 0.005	0.002 – 0.004	0.02
Barium (Ba)	0.031 – 0.038	0.020 – 0.030	0.7



Discussion: On the table, all analyzed heavy metals in both inlet and outlet samples fall well below maximum allowable limits standard of NUPRC and FMEnv. This proves the effectiveness treatment of removing heavy metals from the processed produced water. Lead and Chromium, which are known for toxicity even at low concentrations, were detected in very minimal amounts and remained below thresholds. Also, trace metals like Zinc, Copper and Iron were within permissible levels suggesting that their presence is likely due to natural geochemical interactions rather than anthropogenic contamination. The effectiveness reduction in concentrations from inlet to outlet samples further underscores the efficacy of the treatment system.

Despite the compliance level, it remains very important to adhered to continuous monitoring and improvement, as bioaccumulation of heavy metals in aquatic organisms and sediments can pose long – term ecological and human health hazard. Consistent tracking will ensure early detection of any spike in metal concentrations and allow timely intervention.

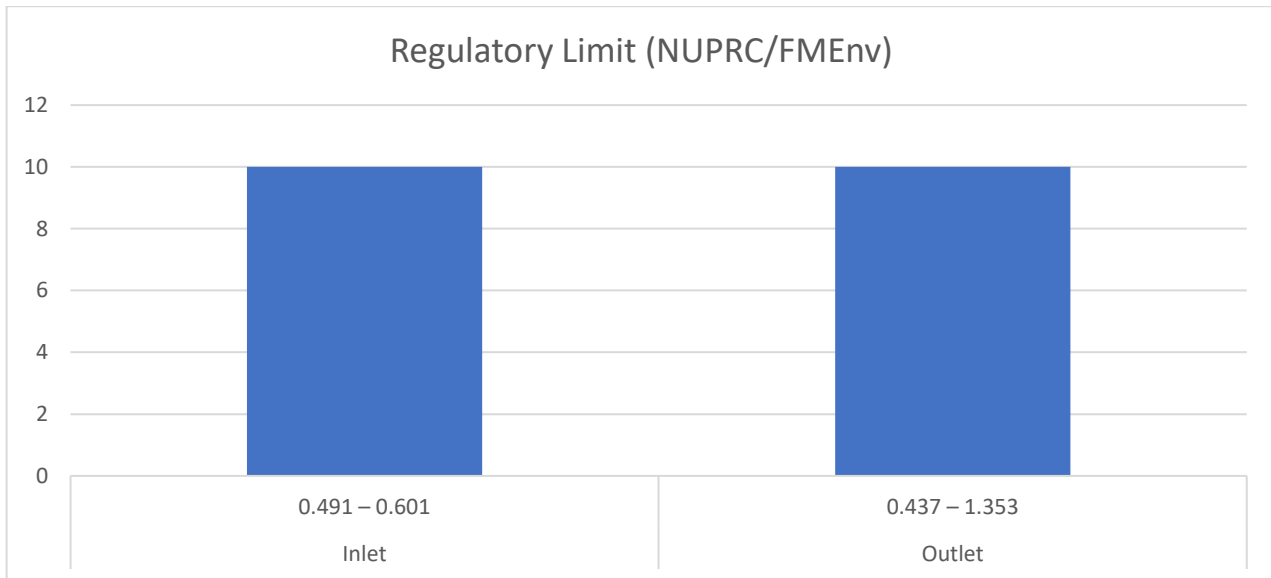
Petroleum Hydrocarbon levels:

Total Hydrocarbon Content (THC) analysis was carried out on the Nembe creek trunkline. THC serves as an essential indicator of hydrocarbon pollution and is critical in determining the extent of oil contamination in discharged water. Elevated hydrocarbon levels in effluents can pose significant risks to aquatic life by reducing oxygen level thus introducing toxic compounds into food chain of the ecosystem organisms.

Analysis of THC was carried out on samples from both inlet and outlet of the produced water treatment system. Results acquired were compared against regulatory standards of Nigerian Upstream Petroleum Regulatory Commission (NUPRC) and the Federal Ministry of Environment (FMEnv), both stipulate that the acceptable limit for THC in discharged effluent should not exceed 10 mg/l.

Total Hydrocarbon Content (THC) in Produced Water:

Sample Point	THC Concentration (mg/l)	Regulatory Limit (NUPRC/FMEnv)
Inlet	0.491 – 0.601	10.0
Outlet	0.437 – 1.353	10.0



Discussion:

Results from the analysis clearly indicated from both inlet and outlet THC concentrations of Nembe creek trunkline are significantly below regulatory limit of 10.0 mg/l. this reflects efficient and effective hydrocarbon separation and treatment procedures carried out. The outlet values, though slightly varied but still fall within range of permissible limits which indicate a safe discharge of hydrocarbon effluent discharge procedure and system.

Although, the performance of hydrocarbon removal is commendable, it is crucial to sustain this result through continuous improvement in operations and adherence to scheduled maintenance culture. Also, more regulatory monitoring should be done.

Summarily, laboratory assessment of soil and produced water samples of Nembe creek Trunkline revealed clear signs of contamination, as reflected in reduced pH Values indicating acidity, lower moisture content and organic matter content as well as Total petroleum hydrocarbon levels exceeding regulatory limits. This finding shows likelihood of impairment of soil fertility, structure and capacity to support plant and microbial growth.

Heavy metal concentrations in soil, particularly nickel was also found to exceed acceptable environmental thresholds, indicating further toxic impact of drilling fluid and crude oil activities in the environment while in contrast, lead and zinc remains within permissible limits.

Water sample analysis demonstrated that the produced water treatment system is generally efficient and effective in removing contaminants, including heavy metals and hydrocarbons. Most measured parameters such as pH, TDS, BOD, COD, oil and grease as well as THC were within allowable standard limits set by NUPRC and FMEnv. However, elevated turbidity and outlet temperatures suggest the need for improvements in filtration and cooling mechanisms to meet compliance.

CONCLUSION AND RECOMMENDATION:

According to the result obtained from primary data, there is compromise to standards in areas of exposure time due to the yell for more money from overtime as well as Organization business profit; Drilling companies undermining the effect of heavy metal physiochemical properties forming low specific activities sludges and scales on pipes thereby increasing effect of corrosion on pipes resulting to cracks and leak. Personnel using not fit for purpose tools as well as lack of replacement of PPE as at when due. Secondary and laboratory assessment met standards in physiochemical

parameters of pH (6.8), heavy metal concentration of soil sample, produced water (TDS)1049.4mg, heavy metal concentration in produced water of lead, zinc, copper and barium; all fell below standard in control area range of Federal ministry of Environment. Also, the study as a gap observed from other authors is that personnel lack awareness of hazardous nature of physiochemical properties of chemicals as well as danger of exposure level. For these reasons the following recommendations are suggested:

RECOMMENDATION

1. Drillers and other craftsmen in drilling companies should be given adequate training on drilling fluid physiochemical properties effect always as a program.
2. Department of oil production and resources (DPR) should develop more frame work on exposure limits mostly on the aromatic Alkenes and emphasize awareness to workers.
3. Education should be a requirement for chemical handling employees in drilling – for those cable of reading and writing to understand information on MSDS of fluids.
4. Inspections should not only focus on safety – critical plant and equipment, but should also include safety – related plant and equipment.
5. A clear framework should be established to define roles and responsibilities which failed to clearly identify those individuals' responsible for maintenance of safety – related plant and equipment.
6. Ministry of industries should ensure that measurable acceptance criteria are established for external corrosion of gratings, bolts, cable trays and valves rather than relying upon subjective decisions made by inspectors

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