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Comparative Biodegradation of Water-Based and Oil-Based Drilling Fluids by Freshwater Bacterial Species

Ozoude, T. O[1], Amachree, E.U.[2], Alozieuwa. U. B[3]. EZE, V. C[4].

[1]Department of Microbiology, Veritas University, Abuja, Nigeria.

[2]Evangel Laboratory and Services, Port Harcourt, Nigeria.

[3] Department of Biochemistry, Veritas University, Abuja, Nigeria.

[4] Department of Microbiology, Michael Okpara University of Agriculture Umudike, Abia State, Nigeria.

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Abstract

The petroleum-based drilling fluids constitute major environmental pollutants due to their persistence and toxic effects on aquatic ecosystems. This study monitored the biodegradation potential of freshwater bacterial species on oil-based drilling fluid (OBDF) and water-based drilling fluid (WBDF), with the aim of determining their degradability and the microbial species involved in the process. The findings revealed that indigenous bacterial genera including *Micrococcus*, *Pseudomonas*, *Bacillus*, *Corynebacterium*, and *Proteus* were actively involved in the degradation of the drilling fluids, demonstrating their capacity to utilize hydrocarbon compounds as sources of carbon and energy. Marked reductions in Biological Oxygen Demand (BOD) and Chemical Oxygen Demand [COD] were observed throughout the biodegradation period, indicating progressive microbial degradation of organic pollutants present in the drilling fluids. COD ranged from 79.40 - 193.10 mg/L for OBDF and 78.10 - 298.60 mg/L for WBDF, while BOD from 16.10 - 65.70 mg/L and 11.70 - 68.60 mg/L for the OBDF and WBDF respectively. The study further revealed that WBDF showed a higher biodegradation percentage [79.90%] when compared to 60.00% recorded for OBDF after 20 days. Although WBDF showed the highest biodegradation percentage, the difference among treatments was not statistically significant at [$p \leq 0.05$]. These findings show the ecological importance of indigenous freshwater bacteria in the natural remediation of drilling fluid contamination.

Keywords: Biodegradation, drilling fluids, bacteria, freshwater, COD, BOD.

Corresponding author, email: ozoudet@veritas.edu.ng

Introduction

Varieties of drilling waste products are produced by petroleum sector operations. The geotechnological parameters of the drilling process, the kind of rock drilled, together with the kind and constituents of drilling mud all have a major influence on the chemical makeup of drilling wastes and their toxic effect.[1] Aquatic and terrestrial life forms are endangered by the accidental and intentional release of petroleum and similar products into the environment. The consequences of this kind of release include the mortality of plants and animals living in contaminated areas, deforestation, contamination of drinking water sources, and a decrease in animal and plant reproduction as a result of the disturbance of the food chain.[2]

Drilling fluids and discarded drilling mud come frequently into contact with bacteria and other organisms that infect the mud during drilling operations. Most often, this biological contamination is unintentional. In some drilling fluid, only robust bacteria that can adjust to the environment will survive. In this way, the organisms are predetermined by the spent mud habitat. Indigenous species are able to degrade the harsh compounds in the drilling fluid (such as linear alpha olefins, internal olefins, esters, or paraffins) into simpler and less toxic chemicals before they are actually used.[3]

The methods of degradation of natural materials to simpler chemicals such as CO_2, H_2O, NH_3 by microbes (majorly, bacteria species that use oxygen) is called biodegradation. This is caused by the activity of bacterial and fungal enzymes and can be referred to as the mineralization of organic matter under aerobic conditions to yield CO_2 and H_2O [Gutiérrez-Rial *et al.*, 2025[4]]. This process bring about increase in the biomass of microorganisms [Gutiérrez-Rial *et al.*, 2025[4]]. The ability of a harmful chemical to biodegrade is a crucial characteristic because, while highly persistent substances can retain their poisonous effects in a long term, high rates of biodegradation will quickly diminish concentration and, consequently, the toxic effect. There are different degrees of degradable substances, from the easily biodegradable substances such as acids, carbohydrates, alcohols with low molecular weight, to intractable substances with several years of biological half -life like DDT and dioxins.[5]

Many microorganisms such as fungus, bacteria are involved in the biodegradation process while research on the roles of algae and protozoa are few.[6] Microorganisms play crucial part in the recycling of energy from complex and heavy chemicals back into simpler and lighter ones, which are the building blocks of life. Although it was once believed that drilling fluids and their additives possessed low susceptibility to microorganism attack due to their complex nature and sophisticated organic structure, it is evident that they are ideal environments for a variety of microorganisms.[7] Drilling fluids are constantly exposed to large numbers and kinds of microorganisms.

Once significant quantities of oil have been removed from the environment using a variety of physiochemical techniques, the degradation process by microorganisms helps remove oil spills from the surrounding area. This is made possible by the enzyme systems found in them (microorganisms) which degrade and use various hydrocarbons as sources of carbon and energy.[8] The material is changed by microorganisms using enzymatic or metabolic mechanisms. It is based on the growth and co-metabolism processes. The only source of carbon and energy during the growth of a microbe, is an organic contamination which leads to full degradation (mineralization) of an organic pollutant by microbes. The metabolism of an organic substance in the presence of a growth substrate, which serves as the main source of carbon and energy, is known as co-metabolism.[9] Although there are wide variations in biodegradation pathways, carbon dioxide is typically the end result of the degradation.[10] The use of wastes by microbes is primarily due to their natural capacities to degrade materials which is as a result of the diverse metabolic activities of bacteria and fungi, originating from their significance in the cycling of nutrients in nature. Considering the total microbes found in an environment, there exists those capable of using hydrocarbons due to the presence of hydrocarbons in the environment regardless of been contaminated or not.[11] A number of factors determine the use of contaminants as substrate by microbes or their co-metabolizing them, including genetic potential and specific influences such as availability of nitrogen, pH, temperature, and sources of phosphorus; these factors are determinants of the extent and rate of degradation.[12] Petroleum exploration, development, and production have negative and severe local effects on the atmosphere, soils and sediments, surface and ground water, marine environment, and biological diversity, and the long-term health of terrestrial ecosystems. Environmental conditions in the sea and other aquatic ecosystems differ from place to place, therefore, more research on the biodegradation of drilling fluids in various aquatic habitats by microbial species are needed. Thus, this study is aimed at comparing the biodegradation of drilling fluids [OBDF and WBDF] by bacteria in freshwater habitat.

Materials and Methods

Sample collection

Using a sterile container which was rinsed before collecting the water sample, water sample was collected from the Nwaniba river, Akwa Ibom State. This was immediately taken to the laboratory for analysis.[13]

Isolation of drilling fluids utilizing bacteria

The bacteria that utilizes drilling fluids were isolated from the water sample on Mineral Salt Medium (MSM) in duplicate employing the vapour-phase method. The MSM which served as the sole source of carbon for the bacteria, was prepared by the method of Nwainyi *et al.*, (2014) [14]. After the period of incubation, the bacterial colonies were enumerated and then, were sub-cultured onto freshly prepared nutrient agar plates by streaking. Distinct colonies were aseptically transferred aseptically to agar slants, labelled properly and were stored in nutrient agar slants, as stock cultures for preservation and identification [15, 16].

Identification of bacteria isolates

Microscopic examination, [gram staining], biochemical tests and cultural morphology were the basis for the identification of the bacterial isolates. A classical method of Bergey's Manual of Determinative Bacteriology [1974], 8th edition was referenced for the identification of bacteria.[17]

2.4. Biodegradability Set up

One thousand milliliters of freshwater sample was dispensed in three of 1500 mL Erlenmeyer flask. Ten [10 mL], [1%] of each drilling fluid was dispensed into each of the freshwater sample in the Erlenmeyer flasks [giving a volume of 1010 mL for each flask] while the chemical was not introduced into the third of flask. This flask served as the control. The flasks were incubated at room temperature [28 - 30 ^{o}C] and 150 rpm in a rotary shaker for 20 days. The controlled shaking ensured adequate aeration and mixing of the medium, facilitating microbial activity and substrate degradation. At day 0 and at 5-day intervals for a period of 20 days, samples were taken from the experimental test flasks to determine the pH, TDS, DO, BOD, COD, Total heterotrophic bacteria, and total drilling fluid utilizing bacteria.[18]

Physicochemical analysis of the Freshwater sample

Hydrogen ion concentration

The effluents were collected in clean glass bottles. Using the pH meter, the pH of the samples were measured in the laboratory, using pH meter. The pH meter was first calibrated using standard buffer solutions of pH 7, 4 and 10, in order. This was done by pouring small amount of the buffer pH 7 into a clean beaker and a magnetic stirrer bar dropped into it and beaker placed on the magnetic stirrer to get a homogeneous mixture. The pH meter electrode immersed into the beaker thereby immersing the tip in the buffer solution and magnetic stirrer started. The meter was adjusted to read the pH value of the buffer. The electrode at each time was removed, washed with distilled water and dried with soft tissue. The process was repeated for pH 4 and 10. The pH of the samples was analyzed following the procedure above after calibration of the meter, and the results of the meter for each sample were recorded.[19]

Dissolved Oxygen

DO is the amount of oxygen in the sample. The titrimetric method of Wrinkler [1888][20] was used in measuring DO. Water samples were collected carefully in airtight glass bottles to prevent atmospheric oxygen contamination. Manganous sulphate solution and alkaline iodide-azide reagent were then added to the sample. This results in the formation of a white precipitate of manganous hydroxide. In the presence of dissolved oxygen, the manganous hydroxide is oxidized to a brown manganic hydroxide precipitate. After thorough mixing, concentrated sulfuric acid was added to dissolve the precipitate, liberating iodine, equivalent to the amount of dissolved oxygen

Total Dissolved Solid (TDS)

The procedures described by APHA (1998)[21] was used to determine Total Dissolved Solid. Well-mixed water samples were filtered through a standard glass fibre, filtered to remove suspended particles and other insoluble materials. Then, measured volume of the filtrates were each transferred into a clean, pre-weighed evaporating dish. The samples were evaporated to dryness on a steam bath and then dried in an oven at 105 ^{o}C until a constant weight was obtained. After drying, the dish was cooled in a desiccator to prevent moisture absorption and then reweighed. The increase in weight of the dish represented the number of dissolved solids present in the water samples. The concentration of total dissolved solids was calculated using the formula:

$$TDS\ (mg/L) = (A-B) \times 1000 / Volume\ of\ sample\ (mL)$$

Where:

A = final weight of dish plus dried residue (mg)

B= initial weight of empty dish (mg)

Biochemical Oxygen Demand, 5 - day method (BOD_5)

Standard method described by Winkler [1988][20] was employed. Water samples were collected in airtight BOD bottles to prevent the introduction of atmospheric oxygen., after which the initial dissolved oxygen [DO_1] concentration of the samples were determined. Manganese sulphate solution and alkaline iodide-azide reagent were added to each water sample while concentrated sulfuric acid was then added to dissolve the precipitate and release iodine equivalent to the amount of dissolved oxygen. The liberated iodine was titrated with standard sodium thiosulfate solution using starch indicator until the blue coloration disappeared. Another set of sealed BOD bottles containing the water samples were incubated in the dark at 20 °C for five days to prevent photosynthetic oxygen production. After incubation, the final dissolved oxygen (DO_5) concentration was determined.

The BOD_5 value was calculated as the difference between the initial and final dissolved oxygen concentrations:

$$BOD_5\ [mg/L] = DO_1 - DO_5$$

Where:

DO_1 = initial dissolved oxygen concentration [mg/L]

DO_5 = dissolved oxygen concentration after 5 days of incubation [mg/L]

Chemical Oxygen Demand [COD]

The COD measures the oxygen equivalent of the organic matter content of a samp le which is capable of oxidation in the presence of a strong chemical oxidant.[22] The dichromate reflux titrimetric method of Schmitz [2017] [23] was used to determine the COD. A measured volume of each water sample was transferred into a reflux flask, then, a known excess quantity of standard potassium dichromate [$K_2Cr_2O_7$] solution was added as the oxidizing agent. After this, concentrated sulfuric acid containing silver sulphate catalyst was then carefully introduced to create a strongly acidic environment and enhance oxidation of organic compounds while mercuric sulphate was also added where necessary to eliminate chloride interference. The reaction mixture was refluxed by heating for approximately two hours, during which oxidizable substances in the samples were chemically converted to carbon dioxide and water. After cooling, the excess unreduced potassium dichromate remaining in the solution was titrated with standardized ferrous ammonium sulphate [FAS] solution using ferroin indicator. A colour change from blue-green to reddish-

brown indicated the endpoint of the reaction. The COD value was calculated from the difference between the volume of FAS used for the blank and that used for the sample:

COD [mg/L] = [A−B] ×M×8000/V

Where, A = volume of FAS used for blank [mL]

B = volume of FAS used for sample [mL]

M = molarity of FAS solution

V = volume of water sample [mL]

Monitoring Biodegradation using the percentage ratio of BOD to COD

The BOD of each biodegradation set up was monitored at 0, 5, 10, 15 and 20 days.[21] At day 0 the COD was determined while the final biodegradation potential also referred to as the percentage of carbon in the material that is potentially mineralized was calculated from the percentage of the ratio of BOD [for day 0, 5, 10, 15, 20] to COD at a day 0.[24,25] . [COD at day 0- as a standard baseline which provides the reference point for BOD/COD biodegradation assessment] COD at day 0 The percentage of carbon that can be mineralized in the test compounds that was actually mineralized was derived from the formula

P ÷ I × 100 = M

100 - M = N

Where:

P = Percentage of carbon that can be degraded in the compound

I = Percentage of carbon that can be degraded in the test compound at day 0

N = Percentage of carbon in the test compound that was actually degraded

Statistical analysis of data

The Statistical Package for Social Sciences [SPSS] was employed for descriptive statistics to calculate percentages and standard error of mean of the data while ANOVA was used to analyze the results of the ultimate biodegradation of the drilling fluids in order to determine if there is significant difference in their biodegradation at [p≤0.05].

Results

The result of petroleum product utilizing bacteria count showed bacterial species count which ranged from 2.3 x 10^4 to 1.5 x 10^4 and 5.0 x 10^4 to 3.5 x 10^4 for OBDF and WBDF respectively (**Table 1**).

The cultural characteristics and biochemical reactions of the isolates revealed that the drilling fluid utilizing

Table 1: Petroleum product utilizing bacterial count (CFU/mL)

Sample code	Day 0	Day 5	Day 10	Day 15	Day 20
Control	2.3 ×10^4	2.0 ×10^4	1.7 ×10^4	1.6 ×10^4	1.3 ×10^4
OBDF	2.3 ×10^4	2.8 ×10^4	2.5 ×10^4	1.5 × 10^4	1.5 ×10^4
WBDF	5.0 ×10^4	6.5 ×10^4	8.2 x10^4	4.5 × 10^4	3.0 ×10^3

Table 2: Cultural: characteristics of the bacteria isolates

S/N	Shape	Elevation	Transparency	Colour	Margin	Isolate code
1	Circular	Convex	Opaque	Light yellow	Smooth	ISO 1
2	Circular	Flat	Opaque	Greenish-white	Rough	ISO 2
3	.Circular	Flat	Opaque	Cream	Rough	ISO 3
4	Circular	Convex	Transparent	Cream	Smooth	ISO 4
5	Circular	Convex	Opaque	Cream	Smooth	ISO 5

Table 3: Grams reaction, morphology and biochemical identification of bacterial isolates

	Isolate 1	Isolate 2	Isolate 3	Isolate 4	Isolate 5
Grams reaction	+	-	+	+	-
Shape	Cocci	Rod	Rod	Rod	Rod
Catalase	+	+	+	+	+
Oxidase	+	+	-		-
Indole	-	-	-	-	-
VP	-	-	+	-	-
MR	-	-	-	+	+
Citrate	-	+	+	+	-
Urease	-	-	+	-	+
Probable Bacteria	*Micrococcus* sp	*Pseudomonas* sp	*Bacillus* sp	*Corynebacterium* sp	*Proteus* sp

Table 4: pH of the chemicals in Fresh water during the period of biodegradation

SAMPLE [Duplicate]	DAY 0	DAY 5	DAY 10	DAY 15	DAY 20	Standard Error of mean [SEM]
Control	7.89	7.64	7.64	7.61	7.12	0.13
OBDF	7.72	7.80	7.68	7.21	6.98	0.16
WBDF	7.35	7.42	6.98	5.04	5.00	0.55

Standard Error of Mean is a measurement that indicates how accurate my estimate of the sample mean could be as compared to the population mean. It indicates the precision of the mean.

bacteria were *Micrococcus* spp, *Pseudomonas* spp, *Bacillus* spp. *Corynebacterium* spp and *Proteus* spp.

For the physicochemical parameters, a decrease was observed in all the parameters by Day 20. The pH shifted from 7.72 to 6.98 and 7.35 to 5.00 (for water samples having OBDF and WBDF respectively) over the 20 days reaction time, indicating a slight shift from neutral to slightly acidic media. However, there were no significant changes in the control (**Table 4**) The result of the dissolved oxygen (DO) showed a slight shift from 7.52 mg/L to 6.82 mg/L and 7.45 to 6.38 mg/L for OBDF and WBDF respectively. This is an indication that the oxygen consumption of the microorganisms was rapid and this could cause stress in the water leading to suffocation and death of the organisms (**Table 5**)

Table 6 showed the TDS variation patterns of the culture reactions during the 20 days biodegradation process of the drilling fluids. The TDS increased for day 5 and decreased dramatically by day 10 of the reactions, with the highest TDS reduction from 71.00 mg/L to 5.00 mg/L and 69.00 mg/L to 5.00 mg/L recorded during the biodegradation of WBDF and OBDF water samples. The BOD measures the amount of oxygen available for microbial consumption. A gradual decrease was observed in the BOD of the reaction mixture from 65.70 mg/L to 16.10 mg/L] and 68.60 mg/L to 11.70 mg/L for OBDF and WBDF respectively [Table 7]. Also, a reduction was observed in COD. The values changed from 193.10 mg/L to 79.40 mg/L and 298.60 mg/L to 78.10 mg/L for the chemicals OBDF and WBDF respectively [Table 8]. The percentage carbon mineralized in each chemical during the period of biodegradation ranged from 23.40 % to 5.80 % and 30.7 % to 12.20 % for WBDF and OBDF respectively (**Table 9)**. The result of the percentage biodegradation potential of the chemical for Day 20 was observed to be 79.90 % and 60.00 % for WBDF and OBDF respectively (**Figure 1**).

Table 5: Dissolved Oxygen (mg/L) of the chemicals in Fresh water during the period of biodegradation

Sample [duplicate]	Day 0	Day 5	Day 10	Day 15	Day 20	Standard Error of mean [SEM]
Control	7.10	7.02	6.89	6.73	6.35	0.14
OBDF	7.52	7.40	7.28	6.89	6.82	0.19
WBDF	7.45	7.21	7.08	6.50	6.38	0.21

Standard Error of Mean is a measurement that indicates how accurate my estimate of the sample mean could be as compared to the population mean. It indicates the precision of the mean.

Table 6: Total Dissolved Solids (mg/L) of the chemicals in Fresh water during the period of biodegradation

Sample [duplicate]	Day 0	Day 5	Day 10	Day 15	Day 20	Standard Error of mean [SEM]
Control	10.00	58.00	62.00	55.00	70.00	10.55
OBDF	71.00	89.00	71.00	50.00	5.00	14.44
WBDF	69.00	78.00	52.00	35.00	5.00	12.99

Standard Error of Mean is a measurement that indicates how accurate my estimate of the sample mean could be as compared to the population mean. It indicates the precision of the mean.

Table 7: Biochemical Oxygen Demand (mg/L) of the chemicals in Fresh water during the period of biodegradation

Sample [duplicate]	Day 0	Day 5	Day 10	Day 15	Day 20	Standard Error of mean [SEM]
Control	45.60	37.80	30.20	23.80	19.90	4.66
OBDF	65.70	35.30	30.10	19.80	16.10	8.78
WBDF	68.60	39.20	23.60	17.20	11.70	10.23

Standard Error of Mean is a measurement that indicates how accurate my estimate of the sample mean could be as compared to the population mean. It indicates the precision of the mean.

Table 8: Chemical Oxygen Demand (mg/L) of the chemicals in Fresh water during the period of biodegradation

Sample [duplicate]	Day 0	Day 5	Day 10	Day 15	Day 20	Standard Error of mean [SEM]
Control	176.90	100.00	73.40	50.20	42.00	24.29
OBDF	193.10	142.40	100.90	98.20	79.40	20.36
WBDF	298.60	210.20	155.70	92.50	78.10	40.46

Standard Error of Mean is a measurement that indicates how accurate my estimate of the sample mean could be as compared to the population mean. It indicates the precision of the mean.

Table 9: Percentage (%) carbon in the chemicals that is mineralizable in Fresh water

Sample (duplicate)	Day 0	Day 5	Day 10	Day 15	Day 20	Standard Error of mean [SEM]
Control	25.80	21.40	18.20	17.20	14.70	1.91
OBDF	30.70	18.30	15.60	14.10	12.20	3.29
WBDF	23.40	17.20	13.10	7.90	5.80	3.18

Standard Error of Mean is a measurement that indicates how accurate my estimate of the sample mean could be as compared to the population mean. It indicates the precision of the mean.

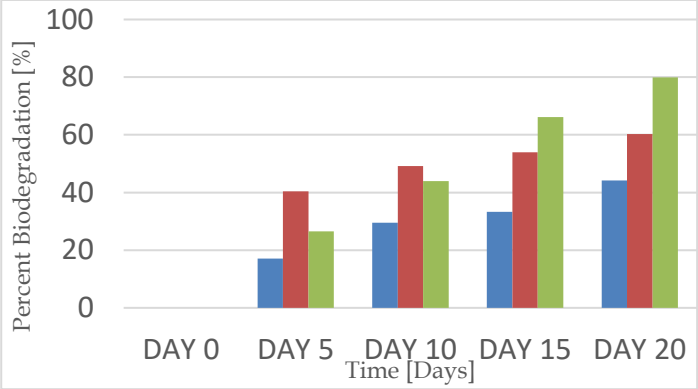

Figure 1: Percentage (%) ultimate biodegradation of the chemicals in the Fresh water

Discussion

Bacterial species utilizing the petroleum products include, *Micrococcus* sp, *Pseudomonas* sp, *Bacillus* sp, *Corynebacterium* sp, and *Proteus* sp. This is in agreement with the works of [18;26] which reported similar species of bacteria utilizing petroleum products. There was no molecular characterization to confirm these isolates.

The result of petroleum product utilizing bacteria count revealed more bacterial species count which ranged from 2.3 x 10^4 CFU/mL to 1.5 x 10^4 CFU/ mL and 5.0 x 10^4 CFU/mL to 3.0 x 10^3 for OBDF and WBDF respectively. Drilling fluid utilizing bacterial count showed an increase in day 5 and 10 of incubation for WBDF and increase in day 5 of incubation period for OBDF then a decrease in the count was observed throughout the remaining incubation periods for the two cultures. The increase in microbial population observed within day 5 to 10 may be due to the fact that some species were utilizing the chemical and converting it into materials that other populations make use of, for growth and metabolism. As this nutrient depletes, a decrease in microbial population was observed. The gradual decrease in bacterial number is linked to the release of toxic substances by the chemicals that kill the microbial species in the culture medium.[27] The increase and decrease in the bacterial population is in agreement with the findings of [18, 27]

pH of the water samples containing chemicals showed a shift from close to alkaline to acidic pH. The pH shifted from 7.72 to 6.98 and 7.35 to 5.00 (for water samples having OBDF and WBDF respectively) over the 20 days period, showing a slight shift from neutral to slightly acidic media though, there were no significant changes in the control.

The pH changed slightly from above neutral/near alkaline to acidic. This may be explained by the main alcohol being oxidized to produce acidic metabolites. The pH affects the bacterial development and metabolic activity of species that break down hydrocarbons. The majority of bacteria that break down hydrocarbons work best at neutral pH levels between 6.50 and 7.50. Some studies [28, 29, 30] also noticed a similar pattern, with the pH of the inoculation medium falling from 7.00 - 4.20 within 7 days as a result of a high quantity of acidic metabolites created when *Gordonia sihwaniensis* species broke down hexadecane. According to Koloti *et al.*, 2024], [31] the decrease in pH as petroleum hydrocarbons biodegrade, could potentially be caused by the presence of acid emulsifiers. A change in pH during the biodegradation process can also have effect on the nutrients and hydrocarbons availability and also the kinetics of adsorption-desorption that are essential for improved biodegradation.[32] Therefore, the carbon dioxide trapped at the time of complete breakdown of the petroleum substrates could be the cause of this pH fall in the cultures.

The TDS increased by day 5 and decreased dramatically by day 10 while the highest reduction in TDS from 71.00 mg/L to 5.00 mg/L and 69.00 mg/L to 5.00 mg/L were recorded for biodegradation of WBDF and OBDF water samples. TDS measures conductible and non-conductible dissolved compounds in water. The quick consumption of dissolved hydrocarbons and ionic minerals in the mixture during the microbial cell growth, may be the cause of the drastic reduction in TDS from day 10. The actual quantity of nutrients needed to preserve and/or increase the efficiency of biodegradation of treatment systems can be found by using TDS to track the amount of nutrients consumed in biological wastewater treatment systems.

Hanson *et al.*, (2019) [33] observed that the breakdown of nonylphenol ethoxylate and alkyl surfactants in shale gas wastewater was limited by high TDS levels. This suggests that the ability of the biological wastewater treatment system to remove COD effectively is threatened when the TDS dosing rate reaches a certain threshold. The result of the dissolved oxygen (DO) showed slight shift from 7.52 mg/L to 6.82 mg/L and 7.45 to 6.38 mg/L for OBDF and WBDF respectively. This is an indication that the oxygen consumption of the microorganisms was rapid and this could cause stress in the water leading to suffocation and death of the organisms. This suggests that the biodegradation process is working more efficiently. Among other things, it has been noted that DO directly correlates with the biodegradation of petroleum hydrocarbons.[31]

The BOD measures the amount of oxygen available for microbial consumption. A gradual decrease was observed in the BOD of the reaction mixture from 65.70 mg/L to 16.10 mg/L and 68.60 mg/L to 11.70 mg/L for OBDF and WBDF respectively.

The high BOD value [65.70 to 16.10 mg/L, 68.60 to 11.70 mg/L] for OBDF and WBDF, respectively observed led to the death of microbial species resulting from the contamination or pollution of the water habitat, a low BOD is an indicator of good quality while high BOD indicates polluted water [34]. The results of Nrior and Wosa, [2016] and Koloti et *al*., [2024[[18,31] are consistent with this decrease in BOD values. There was a reduction observed in COD from Day 0 to Day 20. The COD decreased from 193.10 mg/L to 79.40 mg/L and 298.60 mg/L to 78.10 mg/L for the chemicals OBDF and WBDF respectively. Due to the abundance of vital resources, including oxygen, nitrates, phosphates, and cations, the microbial species demonstrated significant cell proliferation and metabolic activity on day five of biodegradation in the culture media. This finding concurs with the conclusions of [18;31]

The proportion of carbon that can be mineralized in the chemicals ranged from 30.70% to 12.20% for OBDF and from 23.40% to 5.80% for WBDF. This suggests that the chemicals in question are biodegradable. However, the ultimate biodegradation of the chemicals revealed that WBDF had a biodegradation potential of 79.90 percent, while OBDF had a biodegradation potential of 60.00 percent. The statistical analysis by ANOVA showed that there is no significance difference in the biodegradation of both fluids at [p≤0.05]

Conclusion

The present study compared the biodegradation of drilling fluids; OBDF and WBDF by bacterial species from fresh water habitat, using the ratio of BOD to COD. The bacterial species degrading the drilling fluids were identified to include; *Micrococcus, Pseudomonas*, *Bacillus, Corynebacterium*, and *Proteus* species. Though, there was no molecular identification to confirm the species. Although, WBDF had the highest biodegradation percentage, the difference among treatments was not statistically significant

Authors Contributions

Author OTO and AEU designed the research work and carried it out while Author OTO wrote the first draft of the manuscript. Author AUB assisted in literature searches and statistical analysis while Author EVC reviewed the manuscript. All the authors read and approved the final manuscript.

Competing Interests

There were no competing interest among the authors.

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