

# IMPACT OF OILFIELD WASTEWATERS FROM SOKU SWAMP RIG ON THE POPULATION AND DIVERSITY MICROBES OF SOKU RIVER IN NIGER DELTA

## Abstract

Oilfield wastewater contains poisonous and dangerous compounds that harm microorganisms and the quality of the water. An ongoing environmental concern in the Niger Delta is the rapid deterioration of water quality brought on by oilfield wastewater discharged from Nigerian oil industry operations. For a period of two months, biweekly studies were conducted to evaluate the microbiological effects of oilfield effluent from the Soku swamp oil rig on the Soku River in Rivers State in the Niger Delta. A total heterotrophic bacterial count, a hydrocarbon-utilizing bacterial count, a total fungal count, a hydrocarbon-using fungal count, and a microflora count were all determined using water samples obtained from upstream, downstream, drilling points, Deck drainage, and a control point. Total heterotrophic bacteria (THB) counts ranged from 0.2 to 2.4 (log<sub>10</sub>cfu/ml), total fungal (TF) count ranged from 0.1 to 0.95 (log<sub>10</sub>cfu/ml), while the total hydrocarbon utilizing bacterial (THUB) count ranged from 0.01 to 0.25 (log<sub>10</sub>cfu/ml), and the total hydrocarbon utilizing fungal (THUF) count ranged from 0.01 to 0.85 (log<sub>10</sub>cfu/ml). A statistical study revealed no appreciable difference in THB between the sampling stations and the controls. *Streptococcus* spp., *Bacillus* spp., *Pediococcus* spp., *Kurthia*, *Staphylococcus*, and *Micrococcus* spp. were among the bacteria species isolated for the study. *Aspergillus flavus*, *Penicillium adamatzii*, *Rhizopus oligosporus*, and *Penicillium* spp. were among the fungi that were isolated. The study's bacterial and fungal counts showed how oilfield effluent affected aquatic microorganisms. The abundance of microorganisms that use hydrocarbons demonstrated that the water body under study had active native hydrocarbon utilizers that can be used in the bioremediation process.

**Keywords:** Oilfield wastewater, drilling point, deck drainage, hydrocarbon utilizing bacteria and fungi

## INTRODUCTION

Oilfield wastewater, sometimes referred to as produced water, is the formation and injection water made when removing crude oil and natural gas from onshore and offshore wells (Neff et al., 2011a). The nature of the production water can vary from intense brine of saltwater to almost pure freshwater, and it is a complex mixture of dissolved and particulate organic and inorganic components. The most frequent types of organic molecules in generated fluids are monocyclic aromatic hydrocarbons and water soluble low molecular weight organic acids. Large amounts of oil field waste water are produced during offshore drilling for oil and gas, and these waste waters are often released into the aquatic environment after being treated in some way. After being separated from the oil drawn from the reservoir, the wastewater from the oilfield is released into the sea (Jerry et al., 2006). Oilfield wastewater, which is water generated alongside oil and gas but separated for disposal, can retain up to 50mgL<sup>-1</sup> of distinct phase oil as tiny droplets and can also contain up to 35mgL<sup>-1</sup> of dissolved hydrocarbons (Koons et al., 1979). More dangerous than crude oil itself may be the various inorganic components that are dissolved in formation water (Wardley-Smith, 1979). The release of hazardous substances and the buildup of these

contaminants in these aquatic ecosystems endanger the ecological health of many river systems (Pruell et al., 1990).

According to Ibiebele and Oteri (1985), the formation waters from Nigerian oilfields contain between 3,000 and 9000 mgL<sup>-1</sup> of chloride ions, and regular discharge of these wastewaters into freshwater environments might seriously harm aquatic and agricultural resources. Oilfield formation water has gained notoriety as a significant pollution of Nigeria's aquatic environment in recent years (Ibiebele, 1985; Garbado et al., 2011). Before being released into the aquatic or terrestrial environment, oilfield formation water is treated in some way to lessen its impact (Garbado et al., 2011).

The type of hydrocarbon product being produced, the geological characteristics of the formation from which the water is originating, the production history of the reservoir, and the operational conditions under which it originates are just a few of the many factors that can affect the characteristics of produced water (Fakhru'l-Razi et al., 2009). Although the major constituents of generated water are comparable throughout oil production facilities (Fakhru'l-Razi et al., 2009), the composition of this fluid is thought to be highly variable (Durrell et al., 2006) and constituent concentrations can vary between sources by orders of magnitude. According to Fakhru'l-Razi et al. (2009), the constituents of produced water include solids like formation solids, corrosion and scale materials, bacteria, waxes, and asphaltenes, as well as dissolved gases and heavy metals and radioactive materials. It also contains production chemicals, which are typically synthetic additives. Depending on their solubility and structural characteristics, hydrocarbons, which make up the majority of oil molecules, may be present in generated water as distributed droplets or dissolved in the water phase (OGP, 2005). Carboxylic acids are often found in the dissolved phase, whereas aliphatic hydrocarbons are typically found in the dispersion phase. Depending on their molecular weight and structural complexity, aromatic compounds can exist in either or both phases. Lower molecular weight compounds tend to be substantially more water soluble and are therefore more frequently found in the water (dissolved) phase (OGP, 2005). Large amounts of produced water are produced during the production stage of conventional oil wells. According to Neff et al. (2011)a, there are approximately 1.1 m<sup>3</sup> of waste generated for every m<sup>3</sup> of oil produced globally, making this the largest waste stream linked with the production process (Arctic Monitoring and Assessment Programme (AMAP), 2010). Before being released into the ocean as trash or reinjected into a sub-sea formation for disposal, produced water is often treated to eliminate the dispersed crude oil content (i.e., droplets of crude oil, typically ranging in size

from 1 to 10  $\mu\text{m}$ ) (Ekins et al., 2007; Yeung et al., 2015). The maximum oil-in-water concentration limits, which typically range between 14 mg/L and 39 mg/L, are one of the parameters of permissible water quality that are required for discharged waters under most jurisdictions' environmental rules (OGP, 2005). Small dispersed oil particles, micro-emulsions, dissolved elements, and organic compounds are frequently still present in treated generated water, indicating that current treatment technologies are not completely effective (Fakhru'l-Razi et al., 2009). Water-soluble low molecular weight organic acids (mainly mono- and di-carboxylic acids) and monocyclic aromatic hydrocarbons (MAHs), such as benzene, ethyl benzene, toluene, and xylenes, are the most prevalent organic compounds in most treated produced waters (Neff et al., 2011a). Based on their chemical properties, the MAHs, related heterocyclic aromatic compounds, polycyclic aromatic hydrocarbons (PAHs), and occasionally one or more metals including iron, lead, mercury, and zinc are expected to contribute the most to the ecological danger in marine environments (OGP, 2005). Oilfield wastewater contains poisonous and dangerous compounds that harm microorganisms and the quality of the water. Bunkering and illegal crude oil refining are two oil-related operations that have a detrimental environmental impact on the environment and pose a serious threat to the entire Niger Delta ecology, making the entire ecosystem unsustainable (Solomon et al., 2017). As a result, this study examined the abundance and diversity of microorganisms in the Soku River in Rivers State as a result of oilfield wastewater from the Soku swamp oil rig.

## **MATERIALS AND METHODS**

### **Description of study Area**

Soku is a community in Akuku- Toru Local Government area, Rivers State. It is located in a coastal swamp zone around 40km South West and known to be part of the Niger Delta oil producing community. Its geographical coordinates are Latitude  $4.683,4^{\circ} 41. 0''$  North and Longitude  $4.683, 6^{\circ} 41. 0''$  East. The oilfield site is known as OML 23, where all the oil production processes are carried out and oilfield wastewater is discharged.

### **Collection of Samples**

Samples of oilfield wastewater were taken at the onshore Soku flow station (OML, 23), which is part of the Akuku-Toru local government area (AKULGA) in Rivers State, Nigeria. The samples of oilfield wastewater were collected in sanitized glass bottles, labeled properly right away, and

kept in an ice-filled cooler. However, the upstream and downstream were measured from a location 500 meters to the left and right of the drilling point, respectively. The drilling point sample was taken from the oil rig's drilling point, while the deck drainage sample was taken from the drilling point's deck. Contrarily, the Control sample was taken from a location 2 km upstream of the drilling site. The collected and appropriately labeled oilfield wastewater samples were immediately transported to the laboratory for analysis within 24 hours for processing and analyses.

### **Media Preparation**

For the total heterotrophic bacterial count, nutrient agar was used; for the total fungal count, potato dextrose agar; and for the isolation of the total hydrocarbon-using bacteria and fungi, mineral salt agar medium prepared in accordance with Mills et al(1978) 's modified minimal salts medium (MSM) composition was used.  $MgSO_4 \cdot 7H_2O$  (0.42g), KCl (0.29g),  $KH_2PO_4$  (0.83g),  $Na_2HPO_4$  (1.25g),  $NaNO_3$  (0.42), and agar (20g) are the components of the minimal salts medium (MSM), which is made up of them in a liter of distilled water. After being properly combined, the mixture was autoclaved at 15 pressure for 15 minutes at 121 °C, then allowed to cool to 45 °C. The medium was created by mixing sterile MSM that had been chilled to 45°C in an aseptic environment with 1% (v/v) crude oil that had been sterilized using Millipore filter paper with a 0.22 m pore size (Obire, 1988). After properly combining, the MSM and crude oil were aseptically poured into sterile Petri dishes to set.

### **Microbiological Analysis of the Oilfield Wastewater**

#### **Determination of Total Heterotrophic Bacterial (THB) Count of Oilfield Wastewater**

The nutritional agar and spread plate method, as reported by Prescott et al., was used to count the total heterotrophic bacteria (THB) (2005). In triplicate, an aliquot (0.1 ml) of each serially diluted sample was inoculated onto three separate sterile nutrient agar plates using dilution ratios of  $10^{-4}$  for oilfield effluent and  $10^{-5}$  for the other river water samples. The plates were incubated for 24 hours at 37°C in an upside-down posture. Only counts of 30 to 300 were recorded when colonies on the plates were counted after incubation. For oilfield wastewater or river water, the average values of replicate plates were determined and expressed as colony forming units (cfu/ml) (Obire and Wemedo, 1996).

#### **Determination of Total Fungi Count of Samples of Oilfield Wastewater**

The spread plate method was also used to count all the fungus present in the samples. To prevent bacterial growth, 0.1 ml of streptomycin solution was added to an aliquot (0.1 ml) of each sample's serial dilution (10<sup>-2</sup>) before plating it onto a separate Potato dextrose agar plate. The distinct colonies that formed on the plates were counted as the viable counts (CFU) of fungi in the oilfield wastewater after being cultured at 28°C for 5-7 days (Obire and Wemedo, 1996).

### **Hydrocarbon Utilizing Bacterial Count (HUB) of Samples**

Oilfield wastewater samples were used to calculate the total number of hydrocarbon-using bacteria by inoculating 0.1ml of the serially diluted samples (10<sup>-3</sup>) onto mineral salt agar. Utilizing sterile filter paper discs impregnated with filter sterilized crude oil as the sole carbon source in the mineral salt agar, the Vapor Phase Transfer technique was used (Obire and Wemedo, 1996). The sterile filter papers were aseptically placed within the inoculated Petri dishes' inner cover and allowed to incubate for five days at room temperature. The number of developing colonies was counted, and the average of duplicate colonies was computed as colony forming units per milliliter (cfu/ml).

### **Hydrocarbon Utilizing fungal Count (HUF) of Samples**

Oilfield wastewater was tested for total hydrocarbon utilizing fungal count by inoculating 0.1ml of the serially diluted samples (10<sup>-1</sup>) on mineral salt agar. To prevent bacterial development, streptomycin (0.1 ml) will be added to the mineral salt medium (Obire and Wemedo, 1996). Utilizing sterile filter paper discs soaked in filter sterilized crude oil, the only carbon source in the mineral salt agar, the Vapor Phase Transfer technique was used. The sterile filter papers were aseptically placed within the inoculated Petri dishes' inner cover and allowed to incubate for five days at room temperature. The number of colonies that form was counted, and the average of duplicate colonies was used to compute the colony forming units per milliliter (cfu/ml) of water sample.

### **Characterization and Identification of Bacterial and Fungal Isolates from Samples**

The isolates from the investigation were inspected, and their morphological, cultural, and microscopic properties were noted. Gram staining, motility, catalase, oxidase, citrate utilization, sugar fermentation, hydrogen sulphide generation, indole production, methyl red, and the Voges Proskauer test were among the morphological and biochemical tests performed using the isolates. Using Bergey's manual of determinative bacteriology, the isolates' morphological and biochemical properties were compared to those of recognized Taxa (1994). Pure fungal cultures were examined

under a compound microscope while still on plates and after being wet mounted in lactophenol on slides for the presumed identification of fungi isolates. Vegetative hyphae and reproductive structures were observed, and they were documented and matched to the established identification key of Barnett and Hunter (1972) and Malloch (1997).

### **Statistical Analysis**

To ascertain whether there is a statistically significant difference between different concentrations of oil field wastewater and length of incubation, statistical analysis was also carried out using Duncan Multiple Range test and Analysis of variance.

### **Results**

The results of Total Heterotrophic Bacteria Count (THB) ranged from 0.02 Log<sub>10</sub>cfu/ml to 2.4 Log<sub>10</sub>cfu/ml. The highest count was recorded in the Downstream (2.4 Log<sub>10</sub>cfu/ml), while the lowest was observed in the Deck Drainage (0.2 Log<sub>10</sub>cfu/ml). The total fungal counts (TFC) ranged from 0.05 Log<sub>10</sub>cfu/ml to 0.95 Log<sub>10</sub>cfu/ml. The highest count was recorded in the Control (0.95cfu/ml), while the Lowest was observed in the Downstream. The Total Hydrocarbon Utilizing Bacteria (HUB) count ranged from 0.01 Log<sub>10</sub>cfu/ml to 0.25 Log<sub>10</sub>cfu/ml. The highest count was observed in the Deck Drainage (0.25 Log<sub>10</sub>cfu/ml), while the lowest was recorded in Upstream, Downstream and Control (0.01 Log<sub>10</sub>cfu/ml). The total Hydrocarbon Utilizing Fungi (HUF) counts ranged from 0.015 Log<sub>10</sub>cfu/ml to 0.85 Log<sub>10</sub>cfu/ml. The highest was recorded in the Deck Drainage, while the lowest was recorded in the Upstream. The microbiological counts obtained in the various sampling points in Log<sub>10</sub>cfu/ml are as shown in Fig 1.

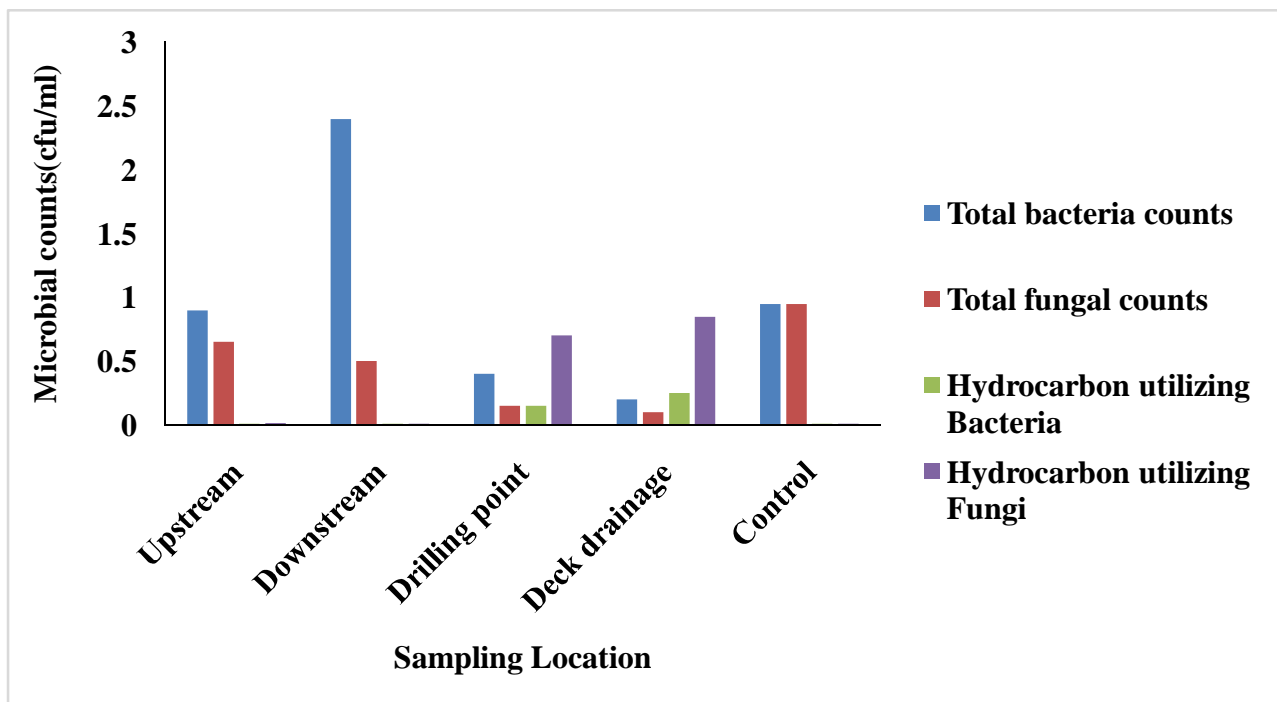


Fig 1: Microbial Counts of Soku

The predominant bacteria are of the genera; *Bacillus*, *Streptococcus*, *Kurthia*, *Staphylococcus*, *Micrococcus* and *Pediococcus* and fungi genera; *Rhizopus*, *Penicillium*, *Aspergillus* that were isolated from the oilfield wastewater from Soku are as shown in Table 1 and Table 2 respectively.

Table 1: Bacteria isolated from the Oilfield Wastewater from Soku

Isolates code	Organism
DD S11	<i>Streptococcus</i> spp
S12	<i>Bacillus</i> spp
S13	<i>Pediococcus</i> spp
S14	<i>Micrococcus</i> spp

S15	<i>Bacillus</i> spp
S16	<i>Bacillus</i> spp
<b>Hydrocarbon Utilizing Bacteria</b>	
HSU1	<i>Kurthia</i> spp
HSU2	<i>Bacillus</i> spp
HSDD	<i>Staphylococcus</i> spp
HSDP	<i>Pediococcus</i> spp
HSC1	<i>Staphylococcus</i> spp
HSC2	<i>Staphylococcus</i> spp

**Keys; DDS- deck drainage Soku, HSU1,2- Hydrocarbon utilizing bacteria upstream 1&2, HSDD; Hydrocarbon bacteria deck drainage, HSDP-Hydrocarbon bacteria drilling point, HSC1 &2- Hydrocarbon bacteria control 1&2**

**Table 2: Fungi Isolated from Oilfield Wastewater from Soku**

Isolates code	Organism
SK7	<i>Rhizopus oligosporus</i>
SK10	<i>Penicillium adamatzii</i>
SK4	<i>Aspergillus flavus</i>
SK15	<i>Penicillium</i> spp

**Keys; SK- Soku**

## DISCUSSION

The microbial population and variety of bacteria and fungus in Soku oilfield wastewater were revealed by the current investigation. According to Atlas (1981) and Leahy and Colwell (1990), populations of naturally occurring hydrocarbon-degrading microorganisms affect the pace of petroleum hydrocarbon biodegradation in nature. Microbial populations have a role in the degradation of hydrocarbon contaminations. According to Leahy and Colwell (1990), hydrocarbon biodegradation is influenced by the makeup of the microbial population and how it adapts to the presence of hydrocarbons. Throughout the several research months, the oilfield wastewater had greater heterotrophic bacteria counts than other samples. The results showed that the downstream had a higher heterotrophic bacteria count than the control, which was followed by the deck drainage, which had the lowest count. This is likely because less oilfield wastewater was dumped there than in the deck drainage. The control point had the highest fungus count, which was followed by the upstream and downstream regions, respectively. This may be due to the downstream experiencing fewer activity. The high hydrocarbon utilizing bacteria and fungi count was obtained in the Deck drainage, followed by the Drilling point, the least count was obtained in the Upstream, Downstream and Control, this high hydrocarbon utilizing bacteria and fungi count found in the Deck Drainage can be attributed to more hydrocarbon content being deposited there since it is close to the Drilling point and drains the wastewater. The high hydrocarbon utilizing bacteria and fungi found in this study concurs with a research carried out by Aleruchi and Obire (2019) also reported hydrocarbon utilizing bacteria and fungi count in oilfield wastewater which can be attributed to inorganic and organic constituent found in the oilfield wastewater that serves as nutrient for bacteria and fungi growth. Continuous release of treated oilfield wastewater will negatively damage the aquatic ecosystem's ability to operate, which will have an impact on agricultural and aquatic resources with significant economic value (Obire, and Amusan, 2003). The isolated Bacteria (*Streptococcus*, *Bacillus*, *Kurthia*, *Staphylococcus*, *Micrococcus* and *Pediococcus*) and Fungi (*Rhizopus oligosporus*, *Penicillium adamatzii*, *Aspergillus flavus*) were hydrocarbon utilizing bacteria and fungi which indicated that the oilfield waste water contained high hydrocarbon contents. Similar organisms were also isolated by Aleruchi and Obire (2019) indicating high hydrocarbon content contained in the oilfield waste water that is been discharged into Soku.

## CONCLUSION AND RECOMMENDATION

The environment that has been contaminated by hydrocarbons is degraded in part by the microbial population of microorganisms that use hydrocarbons. The presence of these microorganisms in the waste water may be due to their ongoing exposure to the hydrocarbon (oily) waste water components, which may have given rise to their capacity to use and thrive in the presence of the hydrocarbons. The large population of hydrocarbon consumers at the sampling stations shows that the hydrocarbon consumers have multiplied in the contaminated area as a result of adapting to the level of hydrocarbons in the environment. The research also showed that the utilizers made up the vast majority of the species recovered as total heterotrophic bacteria and total fungus. The reaction of these microorganisms in the oil-contaminated environment demonstrates that the isolated bacteria and fungus could use the oil as an energy and carbon source, which serves as food for their growth and may thus be helpful in the bioremediation of polluted sites.

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