

ASSESSMENT OF PHYSICOCHEMICAL PARAMETERS IN CRUDE OIL CONTAMINATED WATER SAMPLES OF THREE COMMUNITIES OF IKPOKPO, ATANBA, AND OKPELE-AMA OF GBARAMATU KINGDOM, ALONG THE ESCRAVOS RIVER IN WARRI SOUTH WEST LOCAL GOVERNMENT AREA OF DELTA STATE, NIGERIA

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ABSTRACT: Background: Water plays a significant role in maintaining the human health and welfare. Due to increase in industrialization, urbanization and various human activities has increase the pollution of surface water and ground water (WHO, 1997). The aim of this study was to carry out the physicochemical analysis of crude oil contaminated water samples obtained from the crude oil contaminated sites of the three communities of Ikpokpo, Atanba and Okpele-ama of Gbaramatu Kingdom of Warri South West L.G.A of Delta State, Nigeria and determine its effects on the aforementioned communities and also to compare the results obtained with other sources of normal drinking water. Results: WHO maximum permissible limits for all the parameters are being presented in Table 1. The results of all the physicochemical parameters analysed using different analytical methods can be summarised as follows: From Table 3, pH of water has mean of 6.8, standard deviation of ± 0.147 and the range value is from 6.0 to 7.0. Also, from table 5, the mean is 5.7 and range value is from 5.2 to 6.1, with standard deviation of ± 0.354 respectively. Decrease or increase in pH values of water below or above the WHO permissible limits can result in a serious health related complications such as vomiting, cholera, diarrhoea, kidney and liver diseases, stomach cramps and nausea upon consumption. In table 3, the average value is 1.39NTU, the standard deviation is ± 0.103 NTU and the range is from 1.21NTU to 1.5NTU. The range of the results in Table 5 is from 27NTU to 40NTU and the mean or average value is 31NTU with standard deviation ± 3.488 NTU. Increased turbidity level in water is not desirable and can lead to some health related issues such as gastrointestinal diseases e.g. perianal abscesses, colitis. More so, from table 3, the mean value of temperature is 28.3°C and the range is from 28°C to 28.7°C with standard deviation of $\pm 0.248^{\circ}\text{C}$. Furthermore, the results in table 5, has the standard deviation of $\pm 1.472^{\circ}\text{C}$, the mean value is 32°C with ranges from 30°C to 34°C respectively. The average value of electrical conductivity from Table 3 is $187\mu\text{s/cm}$ and the range is from $180\mu\text{s/cm}$ - $193\mu\text{s/cm}$ with standard deviation of $\pm 5.269\mu\text{s/cm}$, meanwhile, in Table 5, the standard deviation is $\pm 3889.3\mu\text{s/cm}$, average value of electrical conductivity is $24197.2\mu\text{s/cm}$ and the range is from 16871 to 27300 $\mu\text{s/cm}$. These values are higher than the maximum permissible limits of electrical conductivity in water. The range of TSS values in Table 3 is from 17mg/L to 23mg/L and the mean value is 20.3mg/L with standard deviation of ± 2.160 mg/L. Upon comparison with the values of TSS from table 5, with mean 35.8mg/L, while the range is from 31mg/L to 40mg/L and standard deviation of ± 1033.9 mg/L, which were all above the ranges of WHO TSS limit in normal drinking water. This can serve as a growth medium for bacteria and other microorganisms. TDS in Table 3 has the mean value of 118mg/L, the range values from 110mg/L-125mg/L and the standard deviation is ± 5.138 . Also from table 5, the mean value of 17796.7mg/L and the ranges from 16400mg/L to 19500mg/L with standard deviation of ± 2.898 mg/L. High content of TDS values produces an unwanted taste and diluted colour in water, indicating that the water is mineralised as such; upon consumption of the water with high TDS limits, can result in health related complications like kidney and heart diseases. Conclusion: On the basis of findings, it was

concluded that the crude oil contaminated water samples collected from the crude oil contaminated sites of the three communities aforesaid were all above the permissible limits (WHO, 1997). Meanwhile, the normal drinking water samples obtained within Kano Metropolis, used in benchmarking were consistent with WHO standards.

KEYWORDS: physicochemical analysis, water quality, who, crude oil, contamination

INTRODUCTION

Water plays a significant role in maintaining the human health and welfare. It is necessary for industry, agriculture and human existence. The healthy water ecosystem is depended on the physicochemical and biological characteristics (DeZuane, 1997). Due to increase in industrialization, urbanization, agriculture activity and various human activities has increase the pollution of surface water and ground water (WHO, 1997). Water is the most widely circulated and abundant substances found in nature. In total, there is 1400 million billion litres of water, but most of this water is not used for drinking purpose, because 97% is sea water and only 3% is fresh water, out of which 2% is lided in the polar ice caps and glaciers, only 1% water is available for portable use (WHO, 2006). Clean drinking water is now recognised as a fundamental right of human beings. Around 780 million people do not have access to clean and safe water and around 2.5 billion people do not have proper sanitation. As a result, around 6–8 million people die each year due to water related diseases and disasters. Therefore, water quality control is a top-priority policy agenda in many parts of the world. In the today world, the water use in household supplies is commonly defined as domestic water. This water is processed to be safely consumed as drinking water and other purposes. Water quality and suitability for use are determined by its taste, odour, colour, and concentration of organic and inorganic matters (WHO, 2004). Contaminants in the water can affect the water quality and consequently the human health. The potential sources of water contamination are geological conditions, hydrocarbons spills, industrial and agricultural activities, and water treatment plants. These contaminants are further categorized as microorganisms, in organics, organics, radionuclides, and disinfectants (DeZuane, 1997). Hydrocarbon (HC) group of compounds consist of hydrogen and carbon in their structure. As petrochemical industries are flourishing worldwide, Hydrocarbon contamination has become one of the major environmental problems faced globally (Nwilo and Badejo, 2001). Petroleum exploration and production in the Nigeria's Niger Delta region and export of oil and gas resources by the petroleum sector has substantially improved the nation's economy over the past five decades (Hyne and Norman, 2001). However, activities associated with petroleum exploration, development and production operations have local detrimental and significant impacts on the

atmosphere, soils and sediments, surface and groundwater, marine environment, biologically diversity and sustainability of terrestrial ecosystems in the Niger Delta (Nwilo and Badejo, 2001). Discharges of petroleum hydrocarbon and petroleum-derived waste streams have caused environmental pollution, adverse human health effects, detrimental impact on regional economy, socio-economic problems and degradation of host communities in the 9 oil-producing states in the Niger Delta region. Although there are other potential anthropogenic sources of pollution, some of the major environmental consequences such as air pollution, global climate change and oil spills in the Niger Delta may be regional or global in scale (Diaz and Eduardo, 2008). Apart from other anthropogenic emission sources, atmospheric pollution in the region is associated with emissions from flaring and venting of petroleum associated natural gas by petroleum industries (Nwilo and Badejo, 2001). Atmospheric contaminants from anthropogenic activities can be categorized into (i) gaseous pollutants, (ii) persistent organic pollutants, (iii) particulate matter and (iv) trace elements and/or heavy metals (Nwilo and Badejo, 2001). Release of petroleum hydrocarbons into the environment, whether accidentally or due to anthropogenic activities, is a major cause of controlled water and soil pollution and may also contribute to regional atmospheric pollution (Nwilo *et al.*, 2001).

Oil Spills: An oil spill is the release of a liquid petroleum hydrocarbon into the environment, especially marine areas, due to human activity, and is a form of pollution. The term is usually applied to marine oil spills, where oil is released into the ocean or coastal waters, but spills may also occur on land. Oil spills may be due to releases of crude oil from tankers, offshore platforms, drilling rigs and wells, as well as spills of refined petroleum products (such as gasoline, diesel) and their by-products, heavier fuels used by large ships such as bunker fuel, or the spill of any oily refuse or waste oil (Gundlach, 1987).

Oil spill and the Niger Delta (Southern Part of Nigeria):

The South region are the principal oil-rich region comprising the states of Akwa Ibom, Bayelsa, Cross River, Delta, Edo and Rivers, while the three remaining oil-rich states are from South West (Ondo) and South East (Abia and Imo) – all can lightly be referred to as the Niger Delta region, even though the core Niger Delta states are Bayelsa, Delta and Rivers. Since the advent of oil and its exploration in the Niger Delta, the region has been neglected in Nigeria's schemes of development compared to its economic contribution. Or put more clearly, the Nigerian government has over the years focussed on oil (exploration) without much consideration for the

(development of the) Niger Delta, which is the source of the oil. The region's once green vegetation and adoring blue waters were turned black from the oil exploration activities of the black gold leaving the people unemployed as a result of the destruction of the economic activities in farming and fishing, as well as reduced means of food production and with increased health risk. From an historical perspective, the United Nations Development Programme (*UNDP; 2006*) says that, before the Second World War, a delicate balance existed between the human populations of the Niger Delta and its fragile ecosystem. The exploitation of natural resources did not go beyond the search for medicinal herbs, fuel, game, fish, and construction materials.' The situation is different today as ambitious economic aspiration has destroyed the region's heritage and pillar of livelihood. The Niger Delta region stretches over an approximate 70,000 square kilometres with more than 50 ethnic groupings. The oil companies' operations extend beyond 60% of the land mass so close to the communities with variable impacts on the homes, farmlands and water sources of these people (*UNDP; 2006*). The socio-economic livelihoods of the inhabitants are disrupted by the pollutants from the operations of these oil companies with their main economic sources of fishing and agriculture negatively impacted. Oil spillage is a common occurrence in the Niger Delta and is caused by poor infrastructure maintenance, human error, and intentional vandalism or theft of oil resulting in spills or leaks during processing and transportation. Over the years from 1976 to 1996, spill incidents in total of 4,835 were recorded with 1.897 million barrels of oil lost as pollution to the environment (*Orimoogunje, Oluwagbenga and Ajibolas, 2013*). *UNDP (2006)* estimates that between 1976 and 2001, an approximate 6,800 spills totalling 3 million barrels of oil were recorded in the Niger Delta region. This can be attributed to increased oil production and the lack of enforced regulatory control regarding environmental relations. The estimated barrels of crude oil spilled annually in the Niger Delta over surface and ground waters as well as vegetation and air is 240,000 (*Orimoogunje, Oluwagbenga and Ajibola, 2013*). The health effects of these pollution activities include contamination and poisoning of water, food and the environment resulting in ill health and death (*World Health Organization (WHO, 2003)*). *Oteh and Okpo (2012)* gave account of oil spills in the Niger Delta in the past fifty years at an average 1.5 million tons, fifty times more than the volume of oil recorded in 1989 in Exxon Valdez oil spill in Alaska, with corrosion accounting for 50% of the spills, 28% due to sabotage, and 22% to oil production drills and operations. The severity of these frequent and collectively massive spills is only amplified by other environmental problems in the region like seasonal floods and a limited land space which does not allow for human resettlement thus constraining development (*UNDP, 2006*). This is also more critical in the case of

a serious spill as people are not able to relocate to another nearby place for development due to the shortage of land. While economic gains exist in the exploration of oil in the Niger Delta, the losses due to hazards appear to exceed the benefits for the residents of the region and oil workers who are both at risk due to exposure and are directly affected from the negative impact of oil spills in the region, which are evident in the damages done to the region's ecosystem (*UNDP, 2006*). These impacts include soil contamination, affecting terrestrial lives (*Akpomuvie, 2011*). The oil spills kill plants, organisms and animals and in the process, the food chains are disrupted while aquatic productivity is also decreased. Otaigbe and Adesina (*2005*)'s medical case report aptly emphasized the risk of oil exposure to human health. Oil spill accounts for the major source of pollution in the Niger Delta with threats to human and the ecosystem, with the damages evident on streams and farmlands greatly affecting the livelihood of the people. As Osuji (*2004*) explains, environmental pollution as a continuous act in the region creates the impact over the long-term, having not been tracked and assessed as the incident occurs. Thus today, the Niger Delta region is devoid of its pre-oil era with the telling negative impacts of oil operations evident in its life expectancy which used to be close to 70 years but now below 40 years; once a net food exporter but now imports about 80% of its food, with dilapidated infrastructure and visible signs of being sickly on its populace (Ecumenical Council for Corporate Responsibility (ECCR, *2010*). According to Osuji, (*2004*), an oil spill as a form of pollution is a product of human activities which occur in the form of a release of a liquid petroleum hydrocarbon into the environment, occurring over both lands and marine. The inorganic chemicals hold a greater portion as contaminants in drinking water in comparison to organic chemicals. Parts of inorganics are in mineral form of heavy metals. Heavy metals tend to accumulate in human organs and nervous system and interfere with their normal functions (*Goyer, 2001*). In recent years, heavy metals such as lead (Pb), arsenic (As), magnesium (Mg), nickel (Ni), copper (Cu), and zinc (Zn) have received significant attention due to causing serious health problems. Moreover, the cardiovascular diseases, kidney-related problems, neurocognitive diseases, and cancer are related to the traces of metals such as cadmium (Cd) and chromium (Cr) as reported in epidemiological studies. The Lead (Pb) is known to delay the physical and mental growth in infants, while Arsenic (As), Selenium (Sn) and mercury (Hg) can cause serious poisoning with skin pathology and cancer and further damage to kidney and liver, respectively (*Goyer, 2001*). Oil spill accounts for the major source of pollution in the Niger Delta with threats to human and the ecosystem, with the damages evident on streams and farmlands greatly affecting the livelihood of the people (ECCR, *2010*). The World Health Organization estimated that up to 80 % of all sicknesses and diseases in the world are

caused by inadequate sanitation, polluted water or unavailability of water (*WHO 1997*). A review of 28 studies carried out by the World Bank gives the evidence that incidence of certain water borne, water washed, and water based and water sanitation associated diseases are related to the quality and quantity of water and sanitation available to users (*WHO, 2004*). A number of scientific procedures and tools have been developed to assess the water contaminants. These procedures include the analysis of different parameters such as pH, turbidity, conductivity, total suspended solids (TSS), total dissolved solids (TDS) and heavy metals (*Abebe, 1986*). These parameters can affect the drinking water quality, if their values are in higher concentrations than the safe limits set by the World Health Organization (WHO) and other regulatory bodies. These parameters can affect the drinking water quality, if their values are in higher concentrations than the safe limits set by the World Health Organization (WHO) and other regulatory bodies. Therefore, the investigation of the drinking water quality by researchers and governmental departments has been performed regularly throughout the world (*Nollet, 2000*).

Effect of water quality for residence health: Diseases related to contamination of drinking-water constitute a major burden on human health (*WHO, 2004*). Interventions to improve the quality of drinking-water provide significant benefits to health. Improving access to safe drinking-water can result in tangible benefits to health. Every effort should be made to achieve a drinking-water quality as safe as practicable (*WHO, 2006*). The great majority of evident water-related health problems are the result of microbial (bacteriological, viral, protozoan or other biological) contamination. Excessive amount of physical, chemical and biological parameters accumulated in drinking water sources, leads to affect human health (*Fawell, 1993*). As discussed above, all the crude oil contaminated water sources obtained from six different locations of crude oil contaminated sites of Ikpokpo, Okpele-ama and Atanba Communities of Gbaramatu kingdom of Warri South West L.G.A of Delta State, Nigeria, were above the WHO guideline standards (*WHO, 2004*). Therefore, the present study has found out that the crude oil contaminated water sources were not suitable and safe for consumption and can have significant health impacts on residents of the affected communities within the Niger Delta Region. Furthermore, oil spill model systems may be used by industry and government to assist in planning and emergency decision making of critical importance for the skill of the oil spill model prediction is the adequate description of the wind and current fields. There is a worldwide oil spill modeling (WOSM) program (*Pezeshki, 2000*). Tracking the scope of an oil spill may also involve verifying that hydrocarbons collected during an ongoing spill are derived from the active spill or some other source. This can involve

sophisticated analytical chemistry focused on finger printing an oil source based on the complex mixture of substances present (*Pezeshki, 2000*). Largely, these will be various hydrocarbons, among the most useful being polyaromatic hydrocarbons (*Pezeshki, 2000*). In addition, both oxygen and nitrogen heterocyclic hydrocarbons, such as parent and alkyl homologues of carbazole, quinoline, and pyridine, are present in many crude oils. As a result, these compounds have great potential to supplement the existing suite of hydrocarbons targets to fine-tune source tracking of petroleum spills. Such analysis can also be used to follow weathering and degradation of crude spills (*Pezeshki, 2000*).

Justification: Reports on the extent of the oil spills vary.

The Department of Petroleum Resources estimated 1.89 million barrels of petroleum were spilled into the Niger Delta between 1976 and 1996 out of a total of 2.4 million barrels spilled in 4,835 incidents. (Approximately 220 thousand cubic metres). A UNDP report states that there have been a total of 6,817 oil spills between 1976 and 2001, which account for a loss of three million barrels of oil, of which more than 70% was not recovered. 69% of these spills occurred off-shore, a quarter was in swamps and 6% spilled on land (*UNDP, 2006*). Recently, several oil spills have been reported in press in August and September 2016. All of these spills have had a devastating impact on the water, agriculture, environments and general well-being of the local communities in Delta State (*NOSDRA, 2016*).

MATERIALS AND METHODS

Site location: Crude oil spills have been reported in the press in August and September 2016. All of these spills have had a devastating impact on the drinking water, agriculture, environments and general well-being of the local communities. In Delta State, Ten Ijaw communities along the Escravos River in Warri South West Local Government Area of Delta State have been affected by a crude oil spill from a Nigerian National Petroleum Corporation (NNPC) facility. The spill occurred on August 17th 2016, and journalists in the area were told that it was traced to a crude oil trunk line from the Pipelines and Products Marketing Company (PPMC), the products marketing and distribution subsidiary of the NNPC. The communities that were affected were the Tebujor/**Okpele-Ama**, **Ikpokpo**, Okerenkoko-Gbene, Opuedebubor, Opuede, Opuendezion, **Atanba**, Oto-Gbene, Meke-Ama Communities in Gbaramatu Kingdom, along the Escravosriver in Warri South West Local Government Area of the state.

Sourcing for crude oil contaminated water: Samples of untreated water were collected from three different locations of crude oil polluted areas of Ikpokpo, Okpele-ama and Atanba communities, in Gbaramatu Kingdom on 12th of April, 2019, along the Escravos River in Warri South West local Government Area of Delta State, Niger Delta Region of Federal Republic of Nigeria, using ten 5 litres chemically clean amber glass bottles and properly covered with Teflon-lined lids in such a way as to completely protect all the water samples from any external contamination. Another sample of normal drinking water were collected in two locations of Sharada Industrial area and Jambulo residential area of Gwale L.G.A of Kano State, Nigeria which was used as medium for comparison as a bench mark to see whether both sources were within the WHO standards. All the bottles containing the untreated produced water samples were properly labelled for identification and transferred to the laboratory, in ice boxes, for laboratory analyses targeted at detecting the physicochemical parameters and quantifying the concentrations of heavy metals in the samples (*Musliu and Salawudeen, 2012*).

Chemicals and Reagents: All chemicals and reagents to be used for this research project are of analytical grades.

Sterilization of Glass wares and other working equipments: Materials which included conical flasks, funnels and test tubes were sterilized in a hot air oven at 160°C for about 1 hour. All pipettes and other heat-resistant glassware's were wrapped in Aluminum foil to protect the items from recontamination during handling and storage before sterilization was done at 160°C for 1hr in the hot air oven. Water was used to wash all the equipment's, detergents were used where necessary and 70% ethyl alcohol which is bactericidal was used to swab the top of the working bench in the laboratory where the inoculations were done.

Laboratory Analyses: Physicochemical Analysis of the normal water and the crude oil contaminated water: The pH, Temperature, Electrical conductivity, Total suspended solids, Turbidity and Total dissolved solids were all determined using standard laboratory techniques to ascertain whether the parameters are within the WHO permissible limits or exceeded the level for normal drinking water. These parameters were all determined using standard methods of Nollert (2000), Apha (1994) and Sawyer (1995).

- i. **pH:**-The PH is the activity of Hydrogen ions in the water and expressed by negative logarithm to the base 10 of the H⁺ ion activity in moles/L. pH is measure with help of portable pH meter

on site of sample collection. The pH meter is the first calibrated by using buffer solution having pH 4.7 and 9.2. $\text{pH} = -\log \text{H}^+$; or $\text{H}^+ = (10)^{-\text{pH}}$.

- ii. **Temperature:** - Temperature is measure with help of Digital thermometer on site of sample collection. It is very important parameter because of this parameter the changes occur in the water.
- iii. **Electrical conductivity (EC):**- Pure water is not a good conductor of electric current rather's a good insulator. Increase in ions concentration enhances the electrical conductivity of water. Generally, the amount of dissolved solids in water determines the electrical conductivity. Electrical conductivity (EC) actually measures the ionic process of a solution that enables it to transmit current (Nollet, 2000).
- iv. **Turbidity:** - Determine turbidity as soon as possible after the sample is taken. Gently agitate all samples before examination to ensure a representative measurement. Sample preservation is not practical, begin analysis promptly. Refrigerate or cool to 4°C, to minimize microbiological decomposition of solids, if storage is required. For best results, measure turbidity immediately without altering the original sample conditions such as temperature or pH. Turbidity is measure with the help of Digital turbidity meter. This calibrated with the help of standard NTU (Nollet, 2000).
- v. **Total Dissolve Solids (TDS):**- Total dissolve solid are those which are present in water after filtering water through 1 micro meter pores (Apha, 1995). The procedure is carried out by heating i the sample at 1030 C in the oven till drying of evaporated dish (Sawyer, 1994). **TDS (mg/ l) = {(Wf – Wi) x 1000 x 1000} / Volume of sample**
Where, Wi- Initial weight of evaporated dish. Wf- Final weight of evaporated dish.
- vi. **Total Suspended Solids (TSS):**- Total suspended solids are those solids which are retained by the filter of 1 micro meter pores, and they are, therefore, also called as non-filterable solids (Apha, 1995). Their quantity can be determined by passing a known volume of water sample through a glass fibre filter apparatus and weighing the dry residue left (Sawyer, 1994).

T. S. S. (mg /l) = Mass of the residue/ Volume of sample filtered.

RESULTS

Table 1: WHO permissible limits of physicochemical parameters of Normal drinking water quality.

S/N	PHYSICOCHEMICAL PARAMETERS	WHO PERMISSIBLE LIMITS
1	pH	6.5-8.5
2	Temperature (°C)	28-30
3	Electrical Conductivity (µs/cm)	400min-1000max
4	Turbidity (NTU)	5
5	Total Suspended Solids -TSS (mg/L)	25
6	Total Dissolved Solids –TDS (mg/L)	400

KEY: WHO: - World Health Organization, **S/N:** - Serial Number.

Table 2: Physicochemical analysis of the normal drinking water samples collected from six different locations of Sharada Phase 1 Industrial Layout and Jambulo Residential Quarters of Gwale L.G.A of Kano State, Nigeria.

<i>Physicochemical Parameters and their Si-Units</i>							
S/N	Normal Drinking Water Samples	PH	Temperature (°C)	Electrical Conductivity (µs/cm)	Turbidity (NTU)	TSS (mg/L)	TDS (mg/L)
1	SHD-1	6.7	28.1	184	1.37	19	115
2	SHD-2	6.8	28.3	186	1.43	20	119
3	SHD-3	7.0	28.0	193	1.50	23	125
4	JMB-4	6.6	28.4	180	1.21	17	110
5	JMB-5	6.9	28.2	191	1.47	22	121
6	JMB-6	6.7	28.7	185	1.38	21	118

KEY: SHD & JMB: - Normal Water sample collected from Sharada Industrial area and Jambulo Residential area of Gwale LGA, Kano State, Nigeria. (**N**-serial number, from 1-6).

S/N: - Serial Number, **mg/L:** - Milligram per litre.

Table3: Mean, Standard deviation and range values of the normal drinking water samples collected from six different locations of Sharada Phase 1 Industrial Layout and Jambulo Residential Quarters of Gwale L.G.A of Kano State, Nigeria.

Physicochemical Parameters	pH	Temperature (°C)	Electrical conductivity (µs/cm)	Turbidity (NTU)	TSS (mg/L)	TDS (mg/L)
Mean	6.8	28.3	187	1.39	20.3	118
±	±	±	±	±	±	±
Standard Deviations	0.147	0.248	5.269	0.103	2.160	5.138
Range values	6-7	28.0-28.7	180-193	1.21-1.50	17-23	110-125

Physicochemical Parameters and their Units.							
S/ N	Crude oil Contaminated Water Samples	pH	Temp (°C)	Electrical Conductivity (µs/cm)	Turbidity (NTU)	TSS (mg/L)	TDS (mg/L)
	ND-1	5.7	34	27300	27	31	16400
2	ND-2	6.0	33	24002	29	35	18020
3	ND-3	5.2	30	16871	32	40	19500
4	ND-4	6.1	31	27603	35	37	18100
5	ND-5	5.9	32	24403	33	33	17420
6	ND-6	5.4	31	25004	30	39	17340

Table 4: Physicochemical analysis of the crude oil contaminated water samples collected from six different crude oil contaminated sites of Ikpokpo, Okpele-ama, and Atanba in Gmaramatu Kingdom, along the Escravos River in Warri South West L.G.A of Delta State, Nigeria.

KEY: ND_n: - Crude oil contaminated water samples obtained from Niger Delta, (n-serial numbering from 1-6).S/N: - Serial Number, mg/L: - Milligram per litre. TSS: - Total Suspended

Physicochemical Parameters	pH	Temperature (°C)	Electrical Conductivity (µs/cm)	Turbidity (NTU)	TSS (mg/L)	TDS (mg/L)
Mean						
±	5.7	32	24197.2	31	35.8	17796.7
	±	±	±	±	±	±
Standard Deviations	0.354	1.472	3889.3	3.488	1033.9	2.898
Range Values	5.2-6.1	30-34	16871-27300	27-35	31-40	16400-19500

Solids.

TDS: - Total Dissolved Solids.

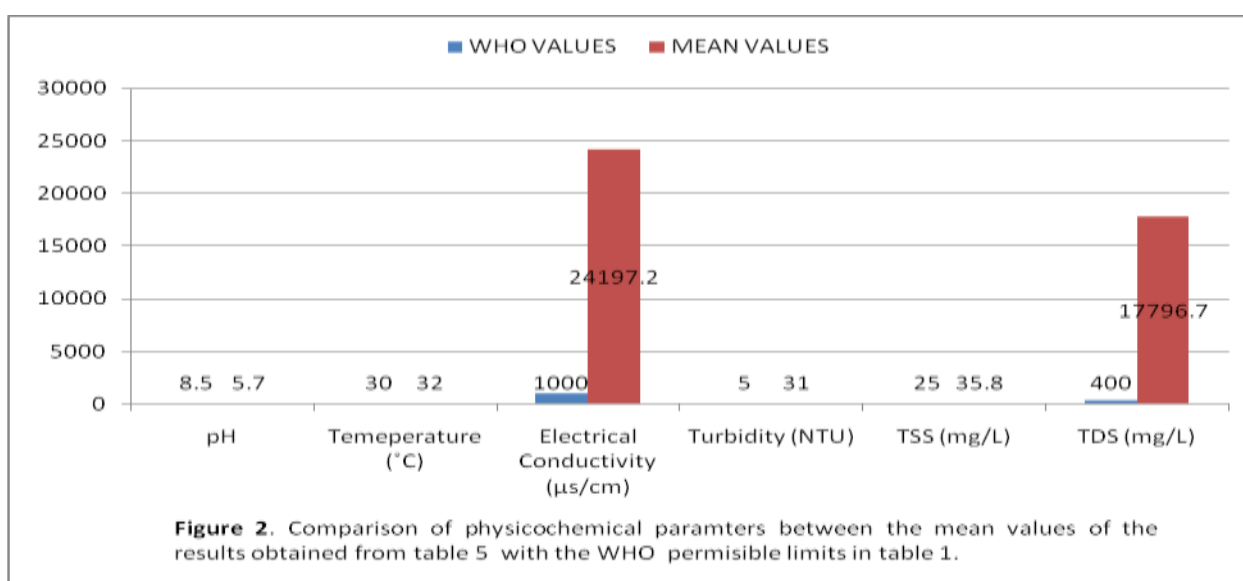
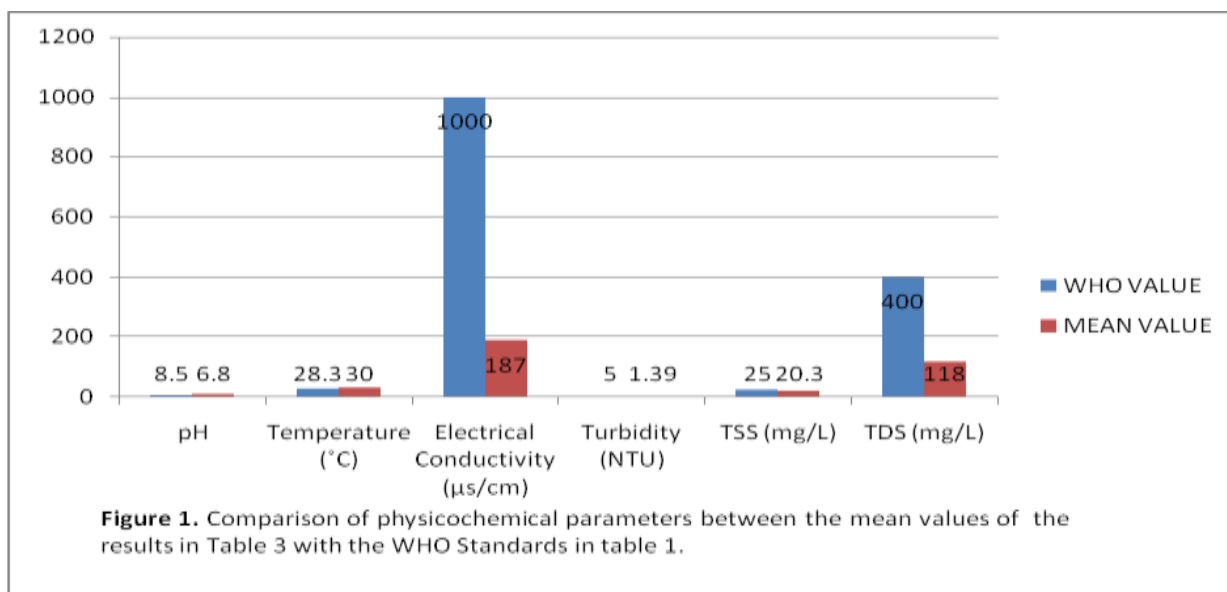


Figure 3. Aerial view of Escravos River being floated with oil spills across the communities of Gbaramatu kingdom of Warri South L.G.A of Delta State, Nigeria. Source: (NOSDRA, 2016).



Figure 4. Images of crude oil contaminated sites of some of the affected communities of Atanba, Ikpokpo and Okpele-ama of Gbaramatu Kingdom of Warri South West L.G.A of Delta State, Nigeria. Source: (NOSDRA, 2016).



Figure4. Aerial views of crude oil contaminated sites of some of the affected communities of Atanba, Ikpokpo and Okpele-ama of Gbaramatu Kingdom of Warri South West L.G.A of Delta State, Nigeria. Source: (NOSDRA, 2016).

DISCUSSION

The world health organisation (WHO) maximum permissible limits recommended in 1997, for all the physicochemical parameters of normal drinking water were shown in table 1. In this table, a detailed description of all the permissible values of all the physicochemical parameters has been outlined by WHO (1997). The maximum permissible values for all the parameters are as follows:- pH (6.5-8.5), Temperature (28-30°C), Electrical conductivity ($400_{\min}$ - $1000_{\max}$ $\mu\text{S}/\text{cm}$), Turbidity (5NTU), Total suspended solids-TSS (25mg/L), and Total Dissolved Solids- TDS (400mg/L) respectively. These WHO standards are used as indicators through which quality of normal drinking water can be ascertained in order to determine whether the water is acceptable for consumption or not. The results of all the physicochemical analysis that were carried out can be described in details below:-

pH of water: pH is a vital parameter in evaluating the acid-base balance of water. It serves as an indicator of acid-alkaline condition of water station. The maximum permissible limit of pH of water recommended by WHO is from 6.0 to 8.5. In Table 3, the mean or average value of pH of water is 6.8, the range value is from 6.0 to 7.0 and the standard deviation is ± 0.147 from the overall results obtained in Table 2, of the normal water samples obtained from both Sharada Industrial area and Jambulo residential area of Gwale LGA of Kano state, Nigeria. These values obtained are within the normal range of WHO pH permissible limits for normal drinking water. The overall results indicate that the pH of the water sources obtained from the aforementioned areas of Kano metropolis are within the desirable and suitable ranges of WHO standards. Also, from table 5, the mean or average value of pH is 5.7, range value is from 5.2 to 6.1 and the standard deviation is ± 0.354 of the overall results obtained in Table 4, of the crude oil contaminated water sources obtained from six different locations of crude oil contaminated sites of Ikpokpo, Okpele-ama and Atanba Communities of Gbaramatu kingdom of Warri South west LGA of Delta State, Nigeria. These values are below or lower than the WHO pH permissible limits and thus, indicating a slight shift of pH into acidic phase. This may be due to infiltration of organic particles in the water. Hence, the water is not recommended for human consumption. Basically, pH of Water is determined by the amount of dissolved carbon dioxide (CO_2) which forms carbonic acid in water. It is an integral parameter that plays a vital role in evaluating the quality of drinking water. Decrease or increase in pH values of water below or above the WHO permissible limits can result in a serious health related complications such as vomiting, cholera, diarrhoea, kidney and liver diseases, stomach cramps and nausea e.t.c. upon consumption. Also

leakage of acidic water into the river can directly harm the aquatic animals by lowering the sodium and oxygen activities within their systems.

Turbidity: - Turbidity is the cloudiness of water caused by a variety of particles and is one of the important parameters in water analysis. It is a measure of light emitting properties of water and is used to indicate the quality of waste discharge with respect to colloidal matter. The maximum permissible limits of turbidity in water recommended by W.H.O in 1997, is 5NTU (NTU-Nephelometric Turbidity Unit). From table 3, the mean or average value is 1.39NTU, the range is from 1.21NTU to 1.5NTU and the standard deviation is ± 0.103 NTU respectively of the overall results obtained in Table 2, of the normal water sources obtained from six different locations of both Sharada Industrial area and Jambulo Residential area of Kano State, Nigeria. These values are within the range of WHO permissible limits of turbidity in drinking water. The ranges of the results obtained in Table 5 is from 27NTU -40NTU and the mean value is 31NTU with standard deviation of ± 3.488 , of the crude oil contaminated water sources obtained from six different locations of crude oil contaminated sites of Ikpokpo, Okpele-ama and Atanba communities of Gbaramatu kingdom of Warri South West L.G.A of Delta State, Nigeria (in table 4). These values are above or higher than the W.H.O permissible ranges of turbidity in normal drinking water. Increased turbidity level in water is not desirable and can lead to some health related issues such as gastrointestinal diseases e.g. perianal abscesses, colitis and tissues.

Temperature: - Water temperature is critical because it is an important quality in environment parameters. W.H.O maximum permissible limits of temperature in normal drinking water from table 1 are 28-30°C. Results in Table 3, has the mean average value of 28.3°C and the range is from 28.0°C to 28.7°C with standard deviation of ± 0.248 °C, from overall results in table 2, of the normal drinking water sources obtained from six different locations of both Sharada industrial area and Jambulo Residential area of Gwale L.G.A of Kano State, Nigeria. These values of temperature are within the normal range of W.H.O (1997) standards. Also, from the results obtained in Table 5, the mean or average value is 32°C and the range is from 30°C to 34°C with standard deviation of ± 1.472 respectively of crude oil contaminated water sources obtained from six different locations of crude oil contaminated sites of Ikpokpo, Okpele-ama and Atanba communities of Gbaramatu kingdom of Warri South West L.G.A of Delta State, Nigeria. These values are below the range of WHO standards for normal drinking water. This may be due to the effect of crude oil particles present in the contaminated water. The increase in temperature

of water could lead to odour. Temperature is very important and its one of the important parameters of physiochemical analysis of water. It helps to regulate the maximum dissolved oxygen concentration of the water, and influences the rate of chemical and biological reactions.

Electrical Conductivity: - Electrical Conductivity is the ability of any medium to carry an electric current. The presence of dissolved solids such as calcium, chloride, magnesium etc. in water sample carries the electric current through the water. It is measured in $\mu\text{S}/\text{cm}$ or S/m (Micro Siemens per centimetre or Siemens per meter). Result obtained from Table 1 shows that the maximum permissible limits of electrical conductivity in water is from 400_{min} to 1000_{max} $\mu\text{S}/\text{cm}$ that is being recommended by WHO in 1997. The average value from Table 3 is $187\mu\text{S}/\text{cm}$ and the range is from $180\mu\text{S}/\text{cm}$ - $193\mu\text{S}/\text{cm}$ with standard deviation of $\pm 5.269\mu\text{S}/\text{cm}$ from the results of the parameters in table 2, of the normal drinking water sources obtained from Sharada Industrial area and Jambulo Residential area of Gwale L.G.A of Kano State, Nigeria. These values are within the WHO permissible ranges. Furthermore, from the results in Table 5, the standard deviation is $\pm 3889.3\mu\text{S}/\text{cm}$, the average value is $24197.2\mu\text{S}/\text{cm}$ and the range is from $16871\mu\text{S}/\text{cm}$ to $27300\mu\text{S}/\text{cm}$ respectively from results (table 4) of the crude oil contaminated water sources obtained from six different locations of crude oil contaminated sites of Ikpokpo, Okpele-ama and Atanba communities of Gbaramatu kingdom of Warri South West L.G.A of Delta State, Nigeria. These values are higher than the maximum permissible limits recommended by WHO (1997). The increase in value of electrical conductivity above W.H.O standards may be due to high minerals content in the crude oil contaminated water samples obtained from the Niger Delta region of the Southern part of Nigeria. Conductivity does not have a direct impact on human health. High conductivity may lead to covering the aesthetics value of the water by giving mineral state to the water.

Total Suspended Solids of Water: - Total Suspended Solids-(TSS) is the dry weight of suspended particles that are not dissolved in a sample of water that can be trapped by a filter analysed using a filtration apparatus. It is one of the parameter that is used to assess the quality of any type of water which can be used for drinking. It is measured in milligram/litre (mg/L). The maximum recommended limit set by WHO is $25\text{mg}/\text{L}$ which is shown in Table 1. Meanwhile, the standard deviation is ± 2.160 , the range values is from $17\text{mg}/\text{L}$ to $23\text{mg}/\text{L}$ and the mean or average value is $20.3\text{mg}/\text{L}$ (from table 3) respectively, of the normal drinking water sources obtained from both Sharada Industrial area and Jambulo Residential area of Gwale

L.G.A of Kano State, Nigeria. These values are within the range of W.H.O permissible limits of TSS in normal drinking water. More so, from the results obtained in Table 5, the mean or average value is 35.8mg/L, while the range is from 31mg/L to 40mg/L of and the standard deviation is ± 1033.9 mg/L from the results obtained in table 4 of the crude oil contaminated water sources obtained from six different locations of crude oil contaminated sites of Ikpokpo, Okpele-ama and Atanba communities of Gbaramatu kingdom of Warri South West L.G.A of Delta State, Nigeria. These values are above or higher than the ranges of WHO standards. Thus, the need for suitable measures to remediate the water for human consumption. Increase in total suspended solids-(TSS) of water increases with increase in temperature. This is because suspended particles absorb more heat from solar radiation than water molecules. The increase in total suspended solids value in water can serve as a growth medium for bacteria and other microorganisms if not being properly remediated to the level of WHO standards.

Total dissolved solids: - Total dissolved solids-(TDS) are inorganic matters and small amount of organic matters, which are present as solution in water. Water has the ability to dissolve a variety of inorganic and some organic minerals or salts such as sodium, magnesium, calcium, potassium, bicarbonate, chlorides and sulphates. Total dissolved solids of water are measured in milligram per litre (mg/L). The maximum permissible limits of total dissolved solids in water recommended by WHO (1997), is 400mg/L in Table 1. Results obtained in Table 3, has the mean or average value of 118mg/L and the range is from 110mg/L -125mg/L, with standard deviation of ± 5.138 mg/L, of the normal drinking water sources obtained from both Sharada Industrial area and Jambulo Residential area of Gwale L.G.A of Kano State, Nigeria in table 2. These values are within the range of WHO standards. Also results from table 5, the standard deviation is found to be ± 2.898 , the mean value of 17796.7mg/L and the range is from 16400mg/L to 19500mg/L respectively, crude oil contaminated water sources obtained from six different locations of crude oil contaminated sites of Ikpokpo, Okpele-ama and Atanba communities of Gbaramatu kingdom of Warri South West L.G.A of Delta State, Nigeria. While upon comparison, the values obtained from Table 3 are above or higher than the maximum limits recommended by WHO for TDS in drinking water. High content of TDS values produces an unwanted taste and diluted colour in water thus, indicates that the water is mineralised as such; there is urgent need for treatment to minimal acceptable limits of W.H.O standards. If these values are not checked, upon consumption of the water with high TDS limits, can result in health related complications such as kidney and heart diseases etc.

Effect of water quality on affected communities of the Niger Delta Region health: - Diseases

related to contamination of drinking-water constitute a major burden on human health. Interventions to improve the quality of drinking-water provide significant benefits to health (WHO, 2006). Water is essential to sustain life, and a satisfactory (adequate, safe and accessible) supply must be available to all (WHO, 2004). Improving access to safe drinking-water can result in tangible benefits to health. Every effort should be made to achieve a drinking-water quality as safe as practicable. The great majority of evident water-related health problems are the result of microbial (bacteriological, viral, protozoan or other biological) contamination. Excessive amount of physical, chemical and biological parameters accumulated in drinking water sources, leads to affect human health. As discussed in the results, all the crude oil contaminated water sources obtained from six different locations of crude oil contaminated sites of Ikpokpo, Okpele-ama and Atanba Communities of Gbaramatu kingdom of Warri South west LGA of Delta State, Nigeria are above the WHO guideline standards (WHO, 2004). Therefore, the present study has found out that the crude oil contaminated water sources are not suitable and safe for consumption and can have significant health impacts on residents of the affected communities within the Niger Delta region, hence there is an urgent need for the Federal Government of Nigeria to drive appropriate means remediate the contaminated water to the level of WHO guideline standards for normal drinking water (WHO, 1997).

CONCLUSION

On the basis of findings, it was concluded that all the physicochemical parameters of the crude oil contaminated water samples collected from the crude oil contaminated sites of the three communities of Ikpokpo, Atanba and Okpele-ama of Gbaramatu Kingdom of Warri South West L.G.A of Delta State, Nigeria were all above the World Health Organization permissible limits for normal drinking water (WHO, 1997). Meanwhile, in all the Physicochemical parameters of the normal drinking water samples obtained from both Sharada Industrial area and Jambulo residential areas of Gwale L.G.A of Kano State, used in benchmarking were consistent with World Health Organization standard for drinking water (WHO, 1997). The samples were analyzed for intended water quality parameters following internationally recognized and well established analytical techniques. Therefore, the present study has found out that the crude oil contaminated water sources are not suitable and safe for consumption and can have significant health impacts on residents of the affected communities within the Niger Delta region, hence there is an urgent need for the Federal Government of Nigeria to drive appropriate means

remediate the contaminated water to the level of WHO guideline standards for normal drinking water.

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