https://chemclassjournal.com/
ChemClass Journal Vol. 9 Issue 2 (2025); 507-520
e-ISSN:3092-8214 p-ISSN:3092-8206
DOI: https://doi.org/10.33003/chemclas-2025-0902/175

Impact of Oil spills on Drinking Water, Surface Water and Soil Quality in K-Dere and Kpor Communities, Ogoni, Nigeria

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Abstract

In order to bridge the gap in the scientific data on the potential exposure risk to hydrocarbon contaminated drinking, surface water, and soils, this study was conducted to evaluate the extent of pollution due to oil spills in two communities in Ogoni, Nigeria. Standard analytical methods were used in the measurements of physicochemical parameters of water (APHA), hydrocarbons (TPH: EPA 8015, PAHs: EPA 8270, BTEX: EPA 8260) and heavy metals concentrations (ASTM) in water and soil samples were employed for the study. Alteration of groundwater were indicated by a low mean pH of 6.4, objectionable odour, high turbidity in the range of 210 – 250 NTU and presence of heavy metals with mean concentrations (0.25 mg/L Cr, 0.08 mg/L As, 0.06 mg/L Pb and 0.01 mg/L Hg) exceeding NIS/WHO regulations. TPH (mg/L) were 767 (BHW1) < 1210 (BHW2) < 2430 (BHW3) and > 1030 (SW) in water while TPH (mg/kg) were 6541 (BHW1)> 6186 (BHW2) > 5127(BHW3) and NM (SW). The groundwater, surface water and soil samples showed high level of contaminations by organic and inorganic compounds. The results from laboratory analysis, exceeded benchmarks. Therefore, urgent, case-specific, effective intervention policies and practices are strongly recommended.

Keywords: Borehole water, groundwater, hydrocarbons, heavy metals, physiochemical, surface water.

Introduction

The need to monitor drinking water quality is driven by responsible and concerned legislation, public health risk awareness and protection, to meet the needs for the challenges, maximize and sustain the benefits for the environment.

Groundwater as used in this study, refers to fresh water drilled or pumped by means of borehole pumps for the purpose of drinking, washing, irrigation and all other human resident needs for freshwater. Drinking water has been effectively defined as all water either in its original state or after treatment, intended for drinking, cooking, food preparation (manufacture, processing, preservation or marketing of products or substances intended for human consumption) or other domestic purposes, regardless of its origin and whether it is supplied from a drinking water system, or a tanker, or taken from a private well [1]. A fairly 98% of the population of the study area depends on borehole water for consumption, bathing, washing, and other water needs. Borehole water (BHW) is generally assumed safest drinking water and widely consumed in K-Dere and her environs. However, prior to the 21st century, the indigenes of these communities solely depended on surface waters from streams, lakes, rivers and open dug wells for their livelihood. Sadly, still some residents do not have access to borehole water and resort to surface water majorly for bathing and washings.

The water in K-Dere community and her environs has been significantly contaminated with hydrocarbons following decades of oil exploration and intense mining activities in the community and Ogoni at large. In 2011, UNEP's field observations and scientific investigations found that oil contamination in Ogoniland is widely distributed and severely impacting all environmental media (air, soil, water and biota). Even without the presence of the oil industry in Ogoniland, oil spills continue to occur with more aggravating devastation. It is known that oil facilities belonging to the defunct and persona non grata, Shell Petroleum Development Company (SPDC), and other multinational oil companies are still running through the land. Occasionally, pipeline vandalism, bunkering, and commonly, equipment failure continues to cause oil spill and create both environmental and health havoc in the community and her environs. This is a pollution reality faced by the Ogoni people every day [2].

UNEPs' assessment team found high values of hydrocarbons exceeding DPR's intervention values both in groundwater and surface waters. The UNEP investigation found floating layers of oil varying from thick black oil to light sheens. The highest reading of dissolved hydrocarbon in the water column, of 7,420 µg/L, was detected at Ataba-Otokroma, at the border of Gokana and Andoni LGAs. Out of the 49 case assessments, UNEP observed hydrocarbons in soil at depths of at least 5 m. The soil texture in Ogoni does not contain significant clay layer capable of impeding infiltration of soluble hydrocarbons into groundwater. This was exemplified by the observation of the UNEP team (2011) at Nisisioken Ogale, in Eleme LGA, where an 8 cm layer of refined oil was observed floating on the groundwater which serves the community wells.

Toxic compounds in crude oil (e.g., BTEX, PAHs, Heavy metals, etc.) are transported into the water table and contaminate drinking water. These compounds are frequently reported in ground water in areas with oil spill [2]. Polycyclic aromatic hydrocarbons (PAHs) are a class of chemicals that occur naturally in coal, crude oil, and gasoline. They pose significant environmental and health risks, including potential for cancer, mutations, birth defects, and damage to aquatic life, while also persisting in the environment due to their low solubility and tendency to accumulate in sediments. Anthropogenically, they are introduced through burning coal, oil, gas, wood, garbage, and tobacco. In the atmosphere, PAHs can bind to or form small particles called soot. Naphthalene, the simplest, man-made PAH is often used to make other chemicals and mothballs. Cigarette smoke contains many PAHs [3]. Benzene, Toluene, Ethylbenzene and Xylene (BTEX) are volatile, naturally occurring compounds, monocyclic aromatic hydrocarbons found in crude oil and are grouped together due to similarities in properties and toxicity mechanisms. When crude oil is spilled into the environment, BTEX compounds may become attached to soil and rock particles from where they may be eroded by stormwater into surface water and percolated into groundwater. BTEX compounds are more persistent in groundwater than in air, therefore affecting water supplies for months or even years (ODHS, 1994). Several studies including [4] have found and reported significant levels of heavy metals in soils and groundwater of oil spilt sites in the Niger Delta.

Hence, routine drinking, surface water and soil quality monitoring such as drinking water quality surveillance as recommended by NIS [1] is necessary to help assess safe uses, treatment and remediation goals in line with international best practices. Sadly, there is little research available to determine the *status quo* of the environment in K-Dere and Kpor communities and its impact on the human population in the area. This study has been designed to bridge the gap of environmental data paucity in these communities. The study assessed the qualities of soil, groundwater and surface water commonly used for drinking, bathing, agricultural practices such as irrigation and livestock farming. The findings are expected to be useful for public awareness, environmental rights actions, decision and policy-making.

Materials and Methods

Sampling Procedure

A total of three (3) groundwater, 3 soil and 1 surface water samples were collected for this study at different locations within K-Dere and Kpor communities, Gokana LGA, Rivers State, Nigeria. The studied wells were chosen based on topography, streamline and flood path considerations. The borehole water and soil samples were collected at 4.6598°, 7.2966°; 4.6598°, 7.2772°; 4.6640°, 7.2775° while surface water was collected at 4.6610°, 7.2774° Latitudes. and Longitudes respectively.

Composite soil samples were collected using calibrated soil auger at a depth of 0.5 cm to 7.0 m, composite borehole water samples (BHW) were collected at a depth of 4.0 to 7.0 m while surface water (SW) was collected at different points at the surface level and made into a composite. All samplings were conducted within one month (July), 2023 and transported to the laboratory where they were preserved in accordance with standard sample preservation protocols.

The study was carried out in Kegbara Dere, frequently abbreviated and called K-Dere and Kpor communities. The sampled locations were done close to some major oil facilities and installations in Bomu oilfield in 1958. K-Dere and Kpor communities are located in Gokana LGA of Rivers State with a population of 233, 813 (Census 2016), a 2022 projected population of 336,300 and 1,986/km² Population Density inhabiting an area of 169.3 km² [5]. Gokana is the second largest local government area after Khana (421,300) out of the four LGAs that make up Ogoniland which has a 2022 projected population of 1,204,100 people. Oil activities crude oil exploration activities commenced in the area during the era of Shell D'iarchy, and later Shell but the first oil well (Bomu Well 1) in K. Dere was drilled in 1957 and produced in commercial quantities in 1958 at K-Dere (Bomu oilfield) [6].

Prior to several reported devastating oil exploitation activities, the area was filled with species diversity- natural bio-diversity and food chain. The natural habitat had been very crucial to improvements in local occupation (farming, fishing, hunting, herbalism, etc.), as well as the sustained supply of products and raw materials and added that the vast coast line with a network of intractable intertidal creeks and hundreds of hectares of mangrove swamp served as fishing grounds for the communities. The vast geographical land areas of the two communities are low-lying natural environment truncated by dendritic network of streams which serves as natural source irrigation for the fertile agricultural land, vegetation and the main repository of the genetic diversity – the forest.

K. Dere hosted about 40 oil & gas wells including Bomu wells Nos. 1, 2, 3, 4, 6, 7, 9,10,11, 16, 17, 19, 20, 21, 23, 24, 28, 31, 32, 34, 35, 36, 37, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, Bomu Unox 1, and Bani 1. Other assets located in the community are partially appraised wells, mega appraised gas reservoir being a gas field with associated oil,3 flow stations tied into a mega flow station, a giant manifold - a gateway gathering manifold housing the 24"/28" Bomu-Bonny Trans Niger pipeline,24''/28''Nkpoku-Bomu trunk lines risers and pig launchers; gas flare stand and pits, 24 dug burrow pits, perimeter linkage access roads, tank farm and manifold sites, helipads, base camps, 2 inshore Marine-base. Although oil production ceased in Ogoni in 1993 following the declaration of multinational oil operators as persona non grata, there are numerous pipelines (24"/28" Bomu-Bonny Trans-Niger pipeline) still carrying crude across the rivers and lands of K-Dere.

Description of study area

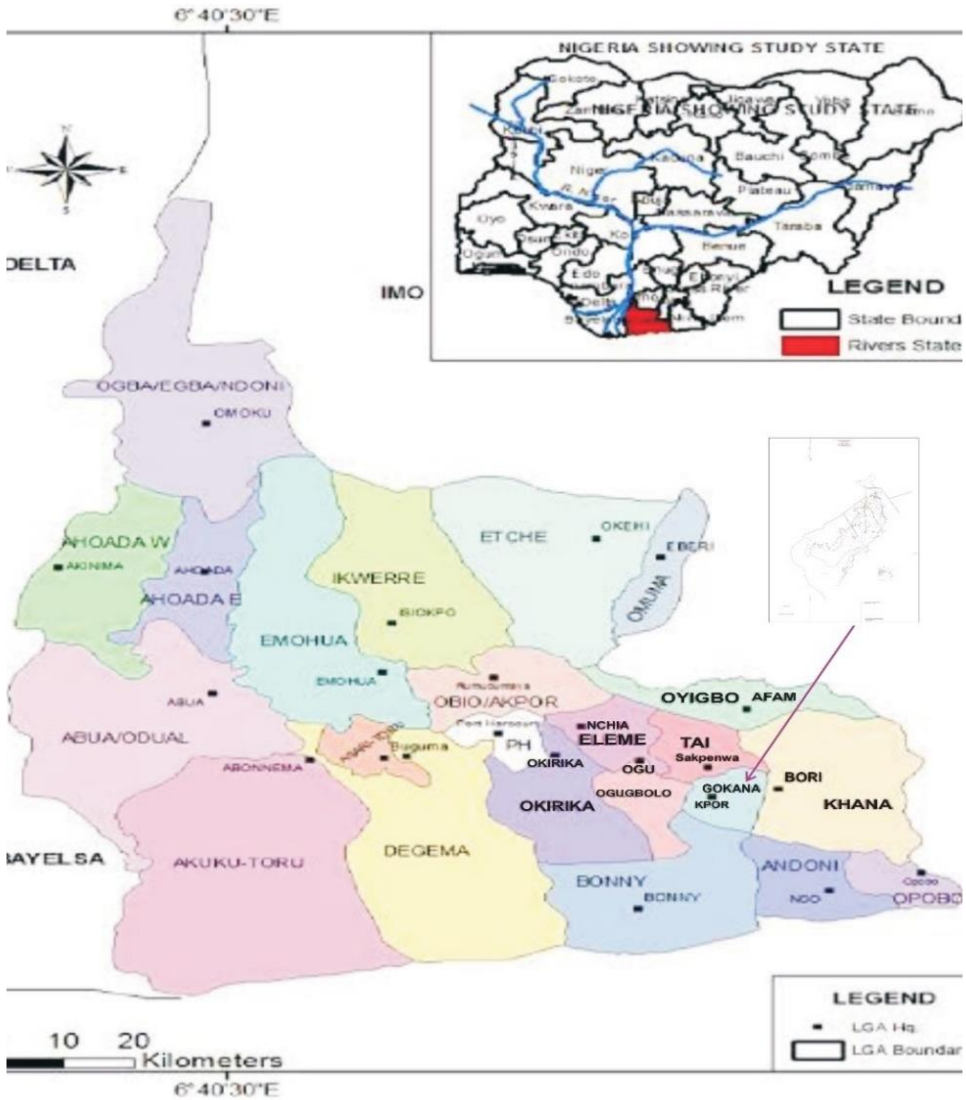

Figure 1: Map of study area showing sampling points and geographical distribution of Rivers State, Nigeria

Sample analytical methods

Different classes of hydrocarbons including: total petroleum hydrocarbons (TPH), four monocylic aromatic hydrocarbons: Benzene, Toluene, Ethylbenzene and Toluene (BTEX) and sixteen US EPA priority PAHs were assayed: naphthalene (Naph), anthracene (Ant), phenanthrene (Phen), acenaphthene (Ace), acenaphthylene (Acy), fluorene (Flu), fluoranthene (Flt), pyrene (Py), chrysene (Chr), benz(a)anthracene (BaA), benzo(a) pyrene (BaP), benzo(b)fluoranthene (B(b)F), benzo(k)fluoranthene (B(k)F), dibenzo(a,h) anthracene (DB(ah)A), benzo(g,h,i)perylene

(B(ghi)P), and indeno(1,2,3-c,d)pyrene (IP) were investigated in soil, groundwater and surface water using state- of-the-art gas chromatograph coupled to mass spectrometer (GC–MS) in accordance with standard US EPA analytical methodologies TPH (Method 8015), PAH (Method 8270), and BTEX (Method 8260)), heavy metals (APHA 4500-H), and unstable physicochemical parameters were determined in-situ using HANNA SeNsion16 multiparameter device in line with APHA (2012) and ASTM standard analytical guidelines.

Quality assurance and quality control

The sample containers (glass bottles) were prewashed to remove external contaminants before they were used. All the sample containers were labelled for proper sample identification and temperature controlled using ice pack stored in a plastic cooler and conveyed to Gilgal Environmental Services Limited Laboratory, Port Harcourt on the same sampling date for controlled preservation and analysis. The geographical location coordinate of each sample represented in UTM was dully recorded for easy referencing. Coordinates for both soil and water, date of sample collection were properly documented.

Surrogate compound (O – Terphenyl) was added to all groundwater and QC samples that were analyzed for BTEX, PAHs, and TPH compounds prior to laboratory analysis. Surrogate recovery data were used to evaluate the capability of the analytical methods to detect the target analytes in each sample and to assess bias and variability that may be due to matrix effects and gross laboratory processing errors.

Surrogate data in blanks and samples were used to identify general problems that may arise during sample analysis; surrogate data in groundwater samples were used to evaluate matrix interferences. A 70 to 130% recovery of surrogates was set as acceptable limit in this study and obtained recoveries were above 80%. High surrogate recoveries like those obtained in this study indicate that the target analytes will be detected, if present. Surrogate recoveries with the target acceptable range are an indication of suitability and accuracy in analytical method.

All analyses were carried out by trained analyst and certified laboratory according to highly standardized protocols.

Results and Discussion

Table 1: Some physicochemical parameters of borehole drinking water from K-Dere (Bomu Oilfield), and Kpor Communities, Ogoni, 2024

Water parameter	Groundwater			NIS/WHO (2007/2011) standard (MAL)*	Potential health impact
	BHW_1	BHW_2	BHW_3		
Temperature	-	-	-	Ambient	-
pH	6.0	6.3	6.8	6.5-8.5	-
Color, TUC	10.3	8.96	9.05	15	
Odour	Objectionable	Objectionable	Objectionable	Unobjectionable	-
Conductivity, µS/cm	320	250	120	1000	-
TDS, mg/L	170	120	60	500	-
DO, mg/L	4.4	4.5	5.5	-	
Turbidity, NTU	210	250	220	5	
Lead, mg/L	0.07	0.04	0.08	0.01	Cancer, interference with Vitamin D metabolism, affect mental development in infants, toxic to the central and peripheral nervous systems
Chromium, mg/L	0.24	0.19	0.31	0.05	Carcinogenic
Mercury, mg/L	0.01	<0.001	<0.001	0.001	Affects the kidney and central nervous system
Arsenic, mg/L	0.08	<0.001	0.07	0.01	Carcinogenic
Calcium, mg/L	15.23	20.11	26.8	-	Not of health concern

*Maximum Allowable Limits (MAL) represent concentrations of chemical and organic/inorganic contamination allowed in drinking water for which no adverse health effect is noticed.

Table 2: Contamination assessment of groundwater (borehole water) samples and soil sample from K-Dere and Kpor communities

	Borehole Water Quality			Surface Water Quality	[1]RfD_o/[2]MRLs/[3]MCLs (mg/kg/day)	RfC_i air (mg/m3)	CSF_o (mg/kg/day)	**CSF_i** (mg/kg/day)	Lifetime (mg/kg/yr)
Sample	BHW_1	BHW_2	BHW_3	SW_4					
BTEX		(mg/L)		BTEX					
Benzene	0.074	0.065	0.403	0.0304	[1]0.004[c] [3]0.005	0.03[c]	0.055[c]	2.7E-^{2} [c]	0.003
Toluene	0.020	0.048	0.018	0.016	[1] 0.08[a] ,0.2[b] 1	0.4 [b, c] 5.0[e]	-	-	-
Ethylbenzene	0.029	0.016	0.009	0.0127	[1] 0.1[a, b] [3]0.3[d]	1.0[a, b]	0.011[d]	0.0087[d]	0.7
m. p-Xylene	0.072	0.025	0.043	0.024	[1] 0.2 [a, b] [3]10	0.4	-	-	-
o-Xylene	0.047	0.070	0.035	0.031	[1] 0.2 [a, b] [3]10	0.1	-	-	-
Total	**0.24**	**0.22**	**0.51**	**0.11**					
		PAHs (mg/L)							
Naphthalene	0.04	0.04	0.04	0.03	[1]0.02[a, b]	0.003[a, b]	-	-	0.1
Acenaphthylene	0.01	<0.01	<0.01	0.02	-	-	-	-	-
Acenaphthene	0.23	0.05	0.16	0.22	[1]0.06[a, b]	-	-	-	-
Fluorene	0.03	0.12	0.12	0.18	0.04 [a, b]	-	-	-	-
Anthracene	0.06	0.04	0.02	0.08	[1]0.3[a , b,]	-	-	-	-
Phenanthrene	0.07	0.04	0.11	0.15	-	-	-	-	-
Fluoranthene	0.02	0.02	0.04	0.07	0.04[a , b]	-	-	-	-
Pyrene	0.02	0.07	0.02	0.08	0.03[a , b]	-	-	-	-
Benz (a) anthracene	0.02	0.02	0.06	0.04	- [a , b]	-	0.1[f]	-	-
Chrysene	0.04	0.14	0.13	0.04	- [a , b]	-	0.001[f]	-	
Benzo (b) fluoranthene	<0.01	<0.01	<0.01	<0.01	- [a , b]	-		-	-
Benzo (k) fluoranthene	<0.01	<0.01	0.02	0.02	- [a , b]	-	0.01[f]	-	-
Benzo (a) pyrene	<0.01	0.01	<0.01	<0.01	0.0003 [, b, f]	-	1.0[f] 1.7[g]	-	-
Dibenz(a,h) anthracene	<0.01	<0.01	<0.01	<0.01	- [a , b]	-	1.0[f]	-	-
Indeno(1,2,3-cd)pyrene	0.03	<0.01	<0.01	<0.01	- [a , b]	-	0.1[f]	-	-
Benzo (g,h,i) perylene	<0.01	<0.01	<0.01	<0.01	- [a , b]	-	-	-	-
Total	**0.57**	**0.55**	**0.72**	**0.93**					
		TPH, mg/L							
Water	767	1210	2430	1030					
Soil	6,541	6,186	5,127	*NM					

[a]US EPA (2018). Edition of the Drinking Water Standards and Health Advisories, [b]US EPA (1999). Human Health Benchmark, [c]US EPA (2000)

[d]OEHHA (2018), [g]OEHHA (2010), [e]US EPA (2005b), [f]US EPA (2023), *NM-not monitored, <0.01 Below method detection limit.

Physicochemical Alteration of Drinking Water Quality

Some parameters that have been recommended for drinking water monitoring were assessed in this study **(Table 1)** to determine the borehole water quality in which over 98% of combined population of K-Dere and Kpor are exposed to both directly or indirectly.

The pH of borehole water assessed ranged from 6.0 – 6.8 with a mean of 6.4. This result indicates weak acidity of drinking water in the studied locations. Acidity of unpolluted waters commonly arises from the presence of weak or strong acids (CH_3COOH or HCl), and/or certain inorganic salts (e.g., $CaCO_3$, NaCl, $MgSO_4$). Dissolved carbon dioxide can form weak carbonic acid [7]. Water with a pH value less than 7 may dissolve metals in water, causes speciation of the metals, and consequently increase the concentration of metals in water and result to deterioration of storage tanks or distribution systems. The observed color of the of the borehole water were all within [1] and [8] standards. Standard portable water is characteristic colorless and odorless. Color in drinking-water is usually due to the presence of colored organic matter (primarily humic and fulvic acids), presence of iron, iron compounds and other metals, natural impurities or as corrosion products and contamination of the water source with industrial effluents [8]. These are indications of the presence of hazards or contamination.

Odorous water is an indication of pollution. Odor in water can arise from presence of organic matter (humus), oil, or inorganic chemicals. In groundwater, leachates from waste, landfills, agricultural lands could infiltrate into ground water and impact undesirable odor to the water. Surface water exposed to surface runoffs can cause eutrophication and decays of organic matter and produce pungent odors. In an oil-producing community like K-Dere with widespread pollution, spilled oil is widely dispersed into the soils and transported into rivers and streams or infiltrated into the water table. Hydrocarbons and other contaminants present in the groundwater can be taken in by humans through the use of water for drinking and bathing. Although, there were no visible film of oil on the drinking water surface, organoleptic considerations (**Table 1)** have proven the presence of pollutants in the drinking water consumed in these locations. This observation supports the results obtained in this study for the presence of volatile organics such as BTEX in both ground and surface water.

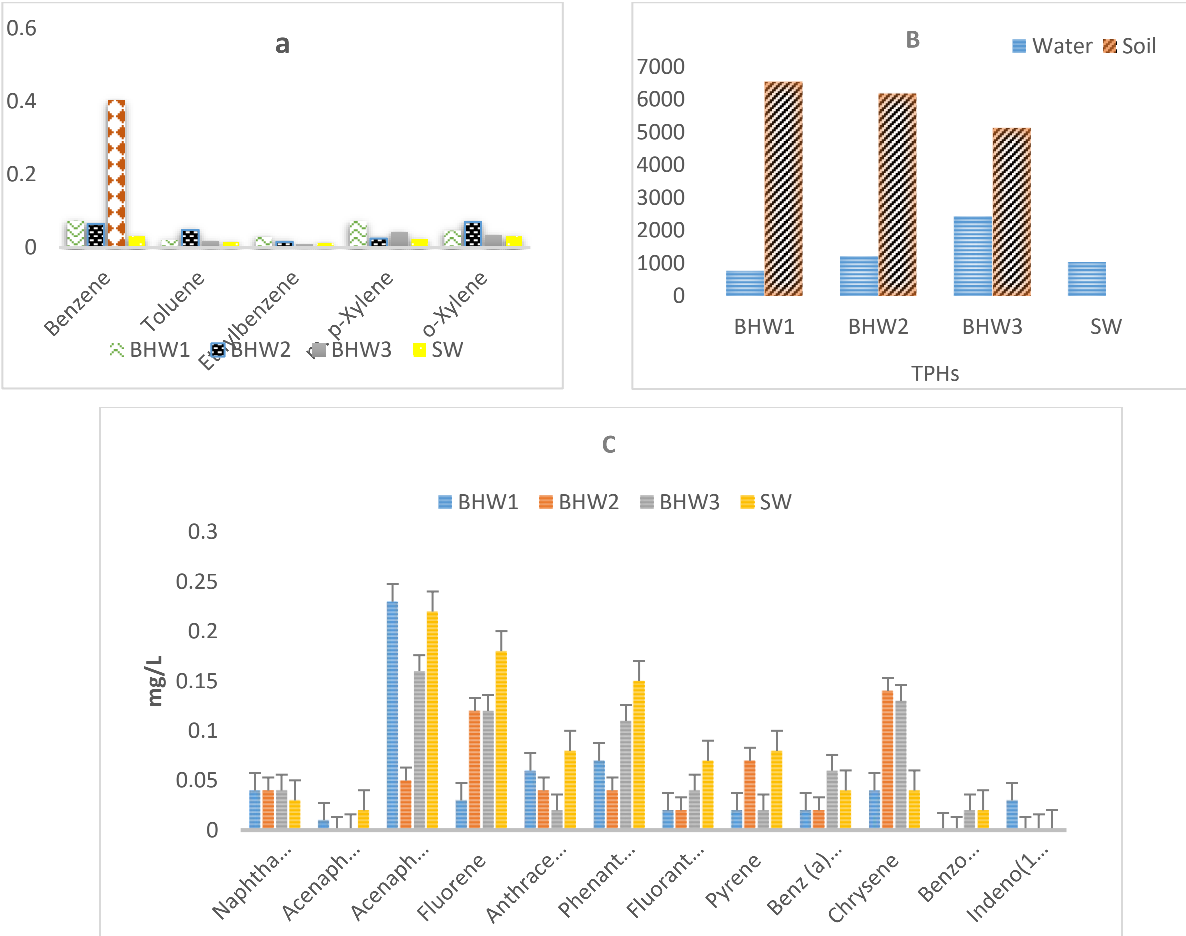

Figure 2: Concentrations of BTEX (a), TPH (b), and PAHs (c) in borehole waters and a surface water sampled from K-Dere and Kpor communities, Ogoni, Rivers state.

Dissolved solids scientifically assayed as total dissolved solids (TDS) in water come from both natural and anthropogenic sources. TDS and the electrical conducting capacity of water are related. Both the ionized and nonionized matter in water are quantified as TDS but only the ionized is reflected in the conductivity measurements [7]. Hence, it is a wrong approximation to link a direct proportionality between TDS and Conductivity. The TDS observed in borehole water from the study locations ranged from 60 – 170 mg/L and corresponding conductivity of 120 – 320 µS/cm. These were within the WHO/NIS maximum allowable limits of 500 mg/L and 1000 µS/cm respectively.

The dissolved oxygen (DO) levels (mg/L) found in borehole waters from the studied locations, were in the range of 4.4 – 5.5. DO refers to the amount of oxygen gas (O_2) that is dissolved in water which is essential for aquatic life. The amount of DO in water has no direct health implications, but it is an important indicator of overall water quality [7]. Low DO levels are an indication of pollution (organic and inorganic). The presence of contaminants in water may lower the DO levels due to oxidation reactions. In surface water and ponds, low levels of DO causes ecosystem imbalance and can cause death of aquatic biota.

High levels of turbidity that is defined by the objectionable odor and taste of the assayed borehole waters were found through nephelometric measurements in the range of 210 – 250 NTU well above the [1] MAL (5NTU) for drinking water. According to [7], the presence of clay particles, sewage solids, silt and sand washings, organic and biological sludge can make water turbid. These particles are less or insoluble in water. They are finely divided solids and are not filtrable by routine methods [7]. Although like odor and taste, turbidity may have no direct health effects, water that is highly turbid, is highly colored or that is aesthetically unacceptable can lead to the use of water from sources that are aesthetically more acceptable, but potentially less safe [8]. The health concern however may arise from the turbidity-causing materials [7]. Findings from similar research by [9] that investigated drinking water quality of 10 functional boreholes in Ebubu, Eleme LGA between June 2015 and August 2015 reported pH in the range of 4.17 – 4.75, mean EC of 177.69 ± 83.54 µS/cm and TDS of 106.50 ± 40.54mg/L. Results from this study agree with the MAL [1] and [8]. This low levels of TDS and EC could signal that any objectional taste may arise from dissolved but unionized petroleum hydrocarbons.

Heavy Metals and Macro-Mineral in Borehole Water

The concentrations of calcium were 15.23 – 26.8mg/L. Ca has no regulatory limit in drinking water. Ca has no health risk to human health as it is an essential and classified as a micromineral. It is however known to cause hardness of water and leads to wastages of soap during washings and scaling in metal piping systems. Results for heavy metal obtained by [9] ranged from Ca (4.10 – 10.77 mg/L) with a mean ±Std of 7.21 ± 3.03mg/L were all reported below the WHO maximum allowable limits (MAL).

The heavy metals assayed in borehole water sampled were Pb, Cr, As, and Hg. Lead (Pb) concentrations ranged from 0.04 – 0.08mg/L above the NIS/WHO regulatory limits of 0.01mg/L, Cr ranged from 0.19 – 0.31 above 0.05 mg/L, Hg ND – 0.01 above 0.001mg/L, Ni were ND – 0.01 not exceeding 0.01mg/L standard. Concentrations of these metals: Pb, Cr, As, and Hg were all above their respective [10] target values of 0.015, 0.001, 0.01 and 0.00005 mg/L respectively. Result from the study also shows that the DPR intervention values of these metals (Pb: 0 075, Cr: 0.03, As: 0.06 and Hg: 0.0003 mg/L) were exceeded in most drinking water samples studied. This is an indication of the extent and severity of environmental alteration impairing the natural functionality of soil for human, animal and plant life.

The heavy metals studied are known carcinogens and are common constituents of crude oil. Their concentrations in crude oil are a function of their abundance in the source rock. [11] has reported that some of the metals have their origin in the crude itself (e.g., Nickel); some are added during production (e.g., barium) and transportation; some metals migrate into the crude oil via corrosion products of pipelines and tanks (iron). In Ogoniland, [12] studied and reported varying levels of Ca, Cr, Cu, Fe, Mn, Zn, As and Hg ranging from 6.27, 390.37, 143.66, 12.81, 820.60, 820.78, 158.94, 3.16, 0.00mg/kg respectively in polluted agricultural soils.

Analysis of BTEX, PAHs and TPHS in Borehole Water

The levels of all the petroleum hydrocarbons in the borehole water and soils were determined as total petroleum hydrocarbon (TPH). The results obtained for borehole and surface water ranged from 767 – 2430 mg/L and 5127 – 6541mg/kg in soil respectively. These values exceeded [10] target and intervention values (50 and 5000 mg/kg respectively). BTEX ranged from 0.22 – 051mg/L with a mean of 0.32 mg/L in borehole drinking water while level in surface water was 0.11mg/L. PAHs ranged from 0.55 – 0.72 with a mean of 0.61 mg/L while surface water showed a concentration of 0.93 mg/L.

PAHs are classified based on number of the aromatic rings (2-, 3-, 4-, 5-, and 6-rings) and their molecular weights. PAHs having 2–3 rings with < 200 molecular weight as Light PAHs (LPAHs)) and Heavy PAHs (HPAHs) are those with more than 3 rings (>4 rings) and molecular weight > 200. High molecular weight PAHs (HPAHs) are less soluble in water, more lipophilic and have greater tendency for sorption to sediments, soils and are more bioavailable than low molecular weight PAHs that have less sorption-ability and high hydrophilicity and hence more solubility in water than HPAHs.

Conclusion

The findings from this study has provided scientific evidence of groundwater and surface water pollution and soil degradation of K-Dere and Kpor environment. This environmental degradation is attributed to the presence of noxious organic and inorganic substances from oil spill and related crude oil activities in the area. This condition has led to an alteration of groundwater, surface water and soils quality. This study has revealed low pH, cloudy water with high turbidity and objectionable taste above regulatory limits. The concentrations of Pb, Hg, Cr, and As were above their [7] MAL of 0.01,0.001, 0.05, and 0.01mg/L respectively.

Drinking and domestic water consumption presents deleterious health implications to the human population of study area. These conditions are expected to be aggravated in years to come with the reality of incessant oil spills, government insensitivity, persistent conflicts and deprivation of human rights by government and oil companies in the areas.

Further and regular water quality surveillance is recommended for independent researchers, governmental agencies, actors and regulators to generate more robust scientific data that depicts and establishes a comprehensive public health risk status and environmental degradation in the study areas. Urgent, case-specific effective intervention policies and practices are also strongly recommended.

Research Contributions

Acknowledgments: The authors would especially like to express their gratitude to all contributors of this work including Kobah Elabanabari, Evidence Epabari Enoch with special appreciation to Hart, A.I.

Conflicts of Interest: The authors declare no conflict of interest with a third party.

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