Comparative Assessment of Surface Water Quality in Olugbobiri and Ogboinbiri Creeks, Bayelsa State, Nigeria

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Abstract
The comparative assessment of surface water quality in Olugbobiri and Ogboinbiri creek is studied, as to relate the impact of oil spill due artisanal refining in Olugbobiri creek and that observed in Ogboinbiri creek occasioned by pipeline vandalisation. Water samples were collected from five sample stations each along Olugbobiri and Ogboinbiri creek in June 2018 (Wet Season) and December 2018 (Dry Season. There were minimal differences in the values of physicochemical variables recorded in Olugbobiri and Ogboibiri Creeks, with ANOVA showing significant spatial differences only for DO, turbidity, and nitrate. However, significant seasonal variations were observed for pH, temperature, conductivity, TDS, salinity, turbidity, DO, nitrate, sulphate, calcium, zinc and iron; and significant interaction between station and season for DO and nitrate. All the parameters were within the acceptable limits for potable water except iron and PAH. The high concentration of iron may be as a result of the natural the concentrations of PAH was largely from petroleum-related activities in the area. It is concluded that water from the Olugboiri and Ogboinbiri creeks are not suitable for drinking.

Keywords: *Surface Water Quality; Artisanal Refinery; Olugbobiri Creek; Ogboinbiri Creek; Bayelsa State; Nigeria.*

Introduction

The deplorable condition of water quality in rivers and creeks in some areas in Niger Delta is a major source of concern due to high prevalence of artisanal refining activities and pipeline vandalization. River Nun Tributary where Olugbobiri community lies and Ogboinbiri community which lies in the distributary is one of the Niger Delta prolific reserves of oil and gas and the hot bed of oil and gas exploration and development activities in Nigeria (Onuoha, 2008). Due to the extensive volume of hydrocarbon development, there is high potential for release of crude oil and its products, leading to pollution of water bodies. This can be through incidents, and accidents such as oil well blowouts, oil tankers sinking, pipeline vandalization and artisanal refining of crude oil pollutes water bodies as reported by Kadafa, (2012). The people of Olugbobiri and Ogboinbiri are predominantly fisher folks, also engaged in farming along creeks; cultivating maize, rice, cassava and sugar cane according (Alagoa, 1999).

There are also critical imperatives for water use in rural communities where surface water bodies provide the sources of potable water (RPI, 1985). The Niger Delta comprises a complex network of rivers with an intercalation of creeks; water from these sources support a variety of

uses (NEDECO, 1961). Daka *et al*. (2014) assessed surface and groundwater quality in some oil field communities in the Niger Delta. They reported that measured physicochemical variables of surface water and groundwater from the study area showed water quality values that were generally within the Nigerian standards for drinking water, apart from turbidity, iron and chromium in both surface and groundwater. However, their sampling locations were not associated with artisanal refining activities. In this paper, we present a comparative assessment of some water quality variables of Olugbobiri and Ogboinbiri creeks which harbour artisanal refineries in different intensities.

Materials and Methods

Study Site

The study sites comprised of Olugbobiri and Ogboinbiri creeks in Bayelsa State of Nigeria. The creeks are tidal in nature drained by river Nun water, and located on the southern part of Niger Delta on the tributary and distributary of River Nun (Fig 1). The creeks have input of Artisanal refinery products and pipeline vandalised products, with more into the Olugbobiri creek compared to the Ogboinbiri creek. Five sample stations were established in each creek. The sample stations and their co-ordinates are: Ogboinbiri Creek - Stn 1: $4^0$78'28'N, $5^0$93'48'E; Stn 2: $4^0$78'69'N, $5^0$94'85'E; Stn 3: $4^0$79'37'N, $5^0$95'55'E, Stn 4: $4^0$80'90'N, $5^0$95'82'E; Stn 5 $4^0$83'08'N,$5^0$97'59'E. Olugbobiri Creek - Stn 1: $4^0$54'81'N, $5^0$91'06'E; Stn 2: $4^0$58'44'N, $5^0$92'31'E; Stn 3: $4^0$61'51'N $5^0$93'89'E; Stn 4: $4^0$62'41'N $5^0$95'78'E; Stn $54^0$64'93'N $5^0$98'59'E.

Water Sampling and Laboratory Analyses

Water samples were collected from the five samples stations in each creek in July 2018 (Wet Season) and December 2018 (Dry Season) in appropriate containers. Samples for heavy metal analyses were acidified with nitric acid. All water samples were preserved in ice-cooled boxes for transportation to the laboratory, and transferred to the refrigerator until analyses.

Water temperature pH, Conductivity, Salinity, and Total Dissolved Solids were measured *in situ* with Extech. EC 500 meter, while DO was measured with Extech DO 700; for Turbidity lamotte 300 WiTri-meter was used. Alkalinity, Chloride, Sulphate, Phosphate, Total hardness, Calcium and Magnesium were determined by standard methods (APHA 1985). Heavy metals were determined by Atomic Absorption Spectrophotometry using a GBC Avante, while total petroleum hydrocarbons (TPH) and polycyclic aromatic hydrocarbons (PAH) were determined by gas chromatography using HP 5890 Series II. .

Statistical Analysis

Two-way analysis of variance (ANOVA) was performed for each parameter to determine significant differences between stations and season. The analyses were performed using Minitab R14.

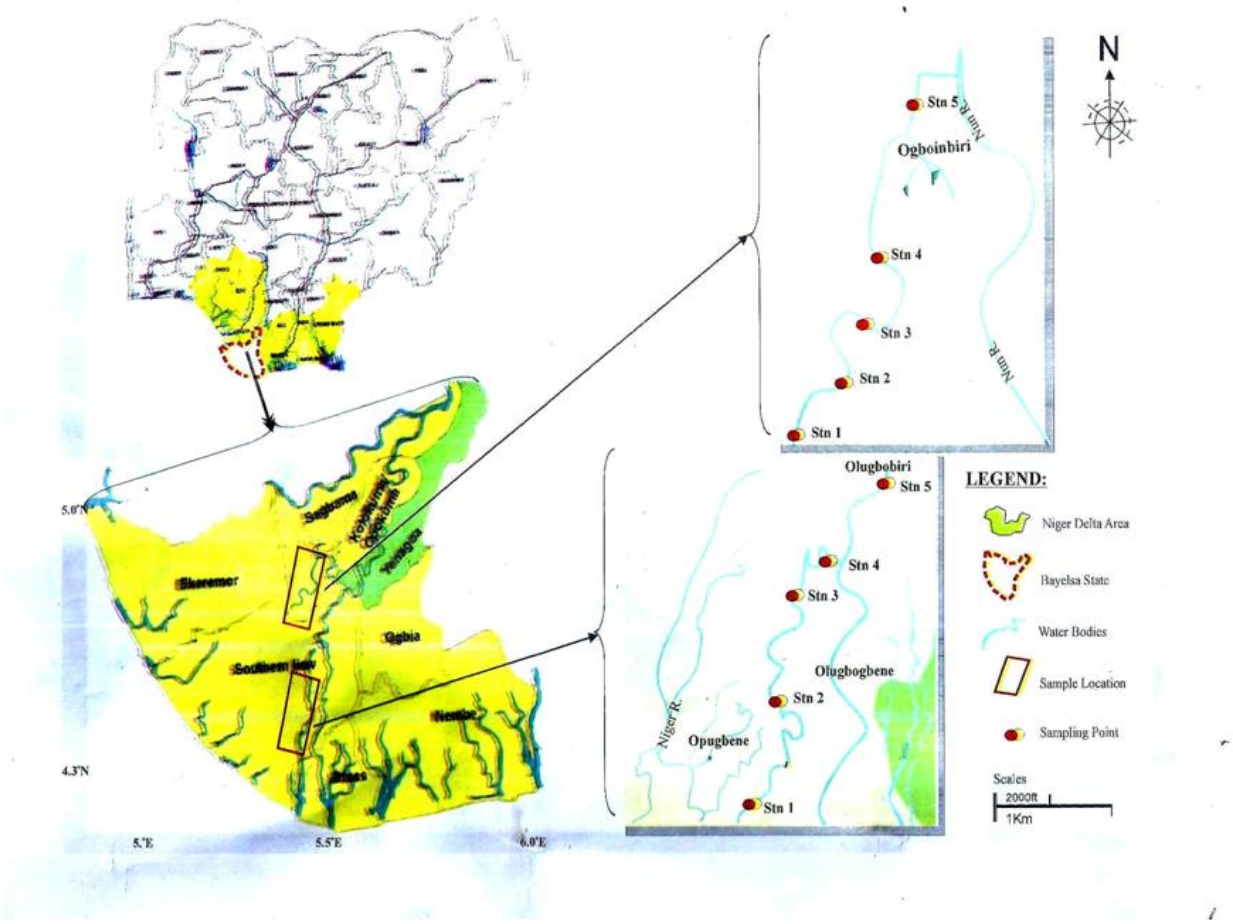

Fig 1: Map of Study Area Showing Sampling Sites in Olugbiri and Ogboinbiri Creeks

Results and Discussion

Figure 2 is a presentation of the mean values of some physicochemical parameters of water. Mean surface water temperature range from 28.16 ^{o}C at Ogboinbiri in the Wet Season to 30.4 ^{o}C at Olugbobiri in the Dry season (Fig 2A), while pH ranged from 7.22 in wet season to 7.94 in the dry season (Fig 2B). The range of values for other parameters were: salinity, 0.052 to 0.062 PSU (Fig 2C); Conductivity96.7 to 144.92 □S/cm (Fig 2D); TDS, 70.74 to 99.84 mg/L (Fig 2E); Turbidity, 13.6 to 30.08 NTU (Fig 2F); DO, 4.3 to 7.56 mg/L (Fig 2G); chloride, 1.1 to 2.0 mg/L (Fig 2H); Sulphate, 2.26 to 4.04 mg/L (Fig 2I); Alkalinity, 4.88 to 6.24 mg/L (Fig 2K),; Total Hardness, 9.4 to 11.24 (Fig 2L); Calcium 1.88 to 3.84 mg/L (Fig 2M); Magnesium, 0.51 to 1.6 mg/L. Levels of all physicochemical parameters measured are consistent with previously reported data in Rivers of the Niger Delta (Akpan *et al.* 2002; Daka and Chinedu-Agunobi, 2013). The values fall within the range considered adequate for aquatic life (McNeely *et al.* 1979; Chapman 1996).

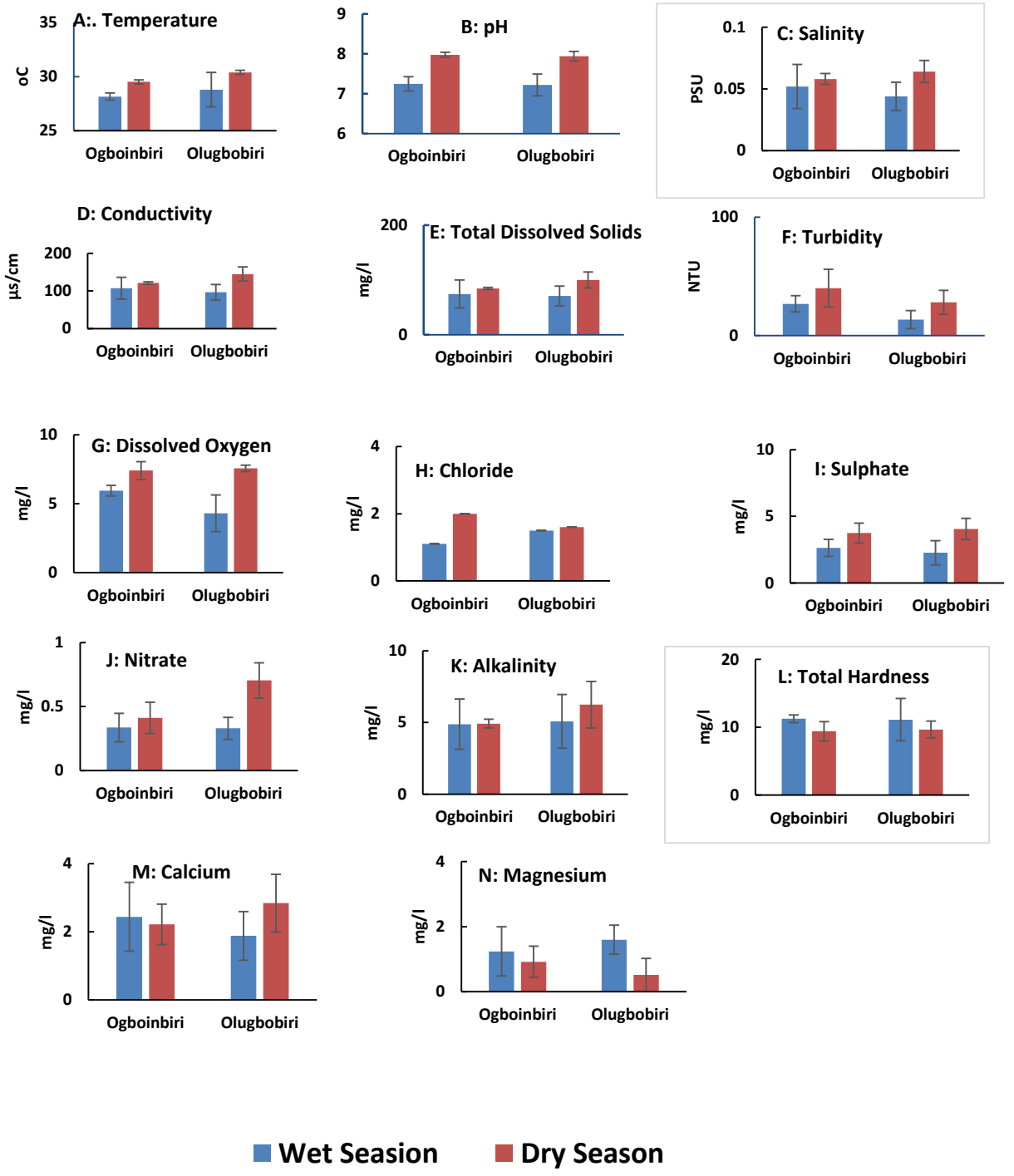

Fig 2: Mean (± SD) of some Physicochemical Variables of Water in Olugbori and Ogboinbiri Creeks

There were minimal differences in the values of physicochemical variables recorded in Olugbobiri and Ogboibiri Creeks, with ANOVA showing significant spatial differences only for DO, turbidity, and nitrate (Table 1). However, significant seasonal variations were observed for pH, temperature, conductivity, TDS, salinity, turbidity, DO, nitrate, sulphate, calcium, zinc and iron; and significant interaction between station and season for DO and nitrate. The

significant seasonal variations observed for most parameter was a result of the dilution effects of precipitation and run-off during the Wet Season.

Table 1: Summary of Two-way Analysis of Variance (ANOVA) Water Quality Variables. Significant differences are highlighted.

Parameter	Station		Season		Interaction	
	F	p-Value	F	p-Value	F	p-Value
pH	0.12	0.730	67.34	<0.001	0	0.973
Temperature	0.01	0.915	45.49	<0.001	9.46	0.007
Conductivity	0.51	0.487	11.95	<0.005	3.67	0.073
Salinity	0.04	0.851	6.15	0.025	1.78	0.201
TDS	0.61	0.448	6.48	0.022	1.53	0.234
Turbidity	6.84	0.019	8.38	0.011	0.02	0.878
DO	4.64	0.005	47.18	<0.001	6.86	0.019
Chloride	0.01	0.914	1.59	0.226	0.11	0.747
Nitrate	7.54	0.014	18.67	<0.005	8.19	0.011
Sulphate	0.01	0.933	17.26	<0.005	0.89	0.358
Alkalinity	1.24	0.282	0.77	0.392	0.67	0.424
Total Hardness	0.01	0.933	4.00	0.063	0.05	0.821
Ca	0.01	0.935	1.05	0.32	2.68	0.121
Mg	0.01	0.938	7.77	0.013	2.29	0.15
TPH	1.91	0.186	3.43	0.083	1.45	0.247
PAH	2.54	0.131	2.24	0.154	0.11	0.74
Zinc	0.01	0.912	5.40	0.034	0.68	0.422
Copper	3.17	0.094	0.06	0.811	2.57	0.129
Iron	0.25	0.627	6.79	0.019	6.14	0.025

The mean concentrations of total petroleum hydrocarbons (TPH) were generally higher in Olugbobiri Creek than Ogboinbiri Creek, with wet season values being higher than dry season (Fig 3). However, there was no significant difference between the two creeks and between seasons (Table 1). Similarly, no significant difference was observed in the mean concentrations' of polycyclic aromatic hydrocarbons (PAH). Amongst the heavy metals determined the order of occurrence was iron > copper > zinc (Fig 4) while, cadmium, lead and nickel were below detection limits. The values obtained are similar results recorded by Eremasi *et al.* (2015) and Aghoghovwia *et al*. (2018) in River Nun and its tributary. Although there was no significant difference in the concentration of iron between the two creeks, there was significant difference between seasons and interaction between season and creek. So, while there was significance seasonal variation in Ogboinbiri creek, which was not the case in Olugbobiri creek.

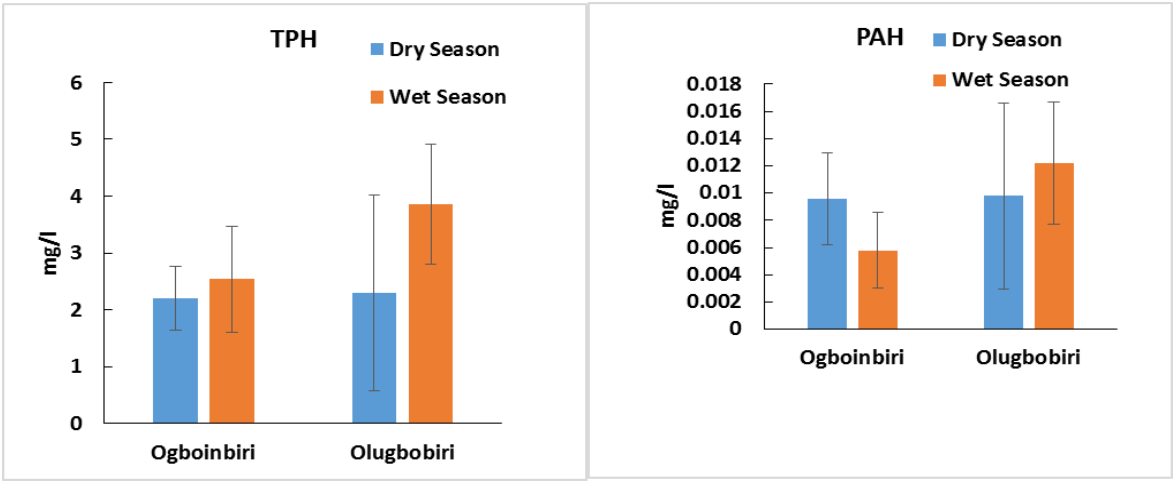

Fig 3: Mean (± SD) Concentrations of Total Petroleum Hydrocarbons (TPH) and Polycyclic Aromatic Hydrocarbons (PAH) in Olugbori and Ogboinbiri Creeks

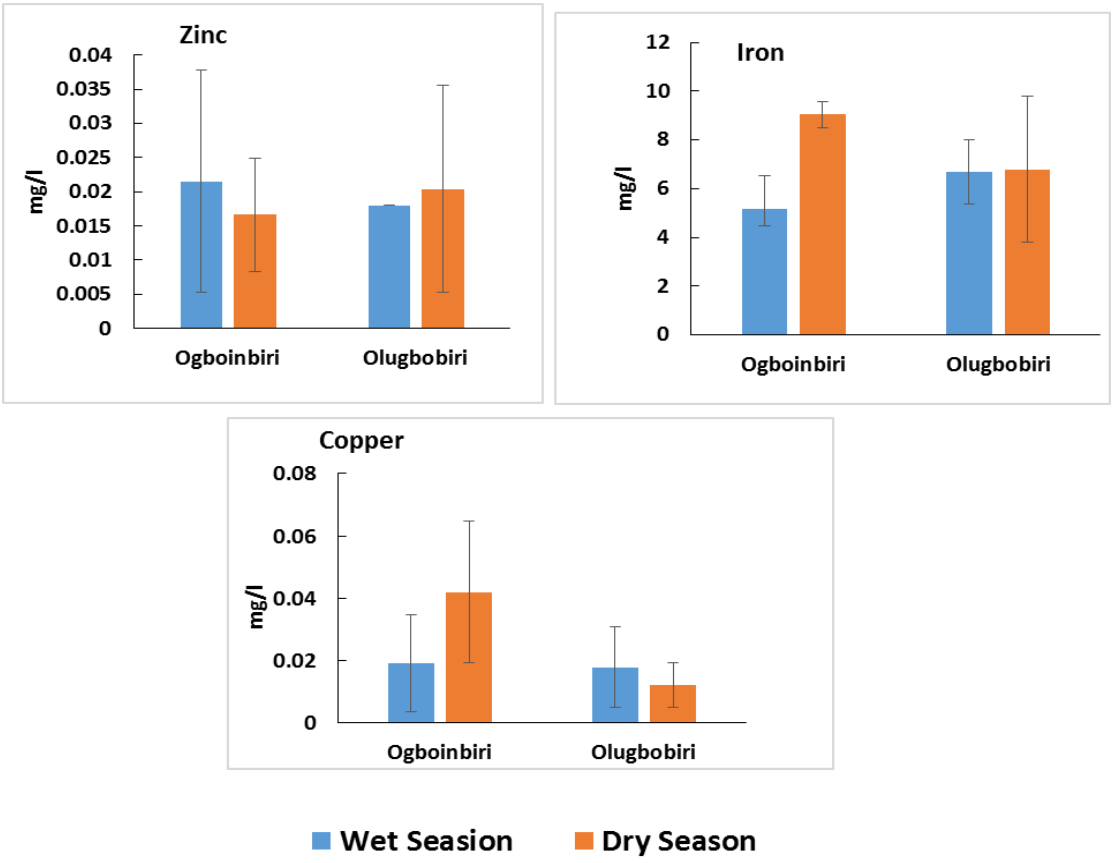

Fig 4: Mean (± SD) Concentrations of Some Heavy Metals in Olugbori and Ogboinbiri Creeks

A comparison of the water quality variables with national standards for potable water (NIS, 2015) is presented in Table 2. All the parameters were within the acceptable limits for potable water except iron and PAH. The high concentration of iron may be as a result of the natural concentrations in rock/soil formations in the area. However, the concentrations of PAH was largely from petroleum-related activities in the area.

Table 2: Mean water quality variables and comparison with National Standards (NIS) for potable water. Exceedances of NIS limits are highlighted.

		Ogboinbiri		Olugbobiri		
		Wet Season	**Dry Season**	**Wet Season**	**Dry Season**	**NIS 2015**
pH		7.248	7.976	7.22	7.942	6.5-8.5
Temp.	(°C)	28.16	29.52	27.06	30.7	
Conductivity	(µS/cm)	1077.52	121.34	96.7	144.92	1000
Salinity	psu	0.052	0.058	0.044	0.064	
TDS	(mg/l)	74.26	84.34	70.74	99.84	500
Turb.	(NTU)	26.92	40.08	13.6	28.26	
DO	(mg/l)	5.94	7.4	4.3	7.56	
Chloride	(mg/l)	1.1	2	1.5	1.6	
Nitrate	(mg/l)	0.336	0.412	0.33	0.704	50
Sulphate	(mg/l)	2.62	3.74	2.26	4.04	100
Phosphate	(mg/l)	<0.05	<0.05	<0.05	<0.05	
Alkalinity	(mg/l)	4.88	4.92	5.08	6.24	
T. Hard.	(mg/l)	11.24	9.4	11.12	9.66	150
Ca	(mg/l)	2.44	2.22	1.88	2.84	
Mg	(mg/l)	1.24	0.92	1.6	0.52	
TPH	(mg/l)	2.536	2.2038	3.858	2.2954	
PAH	(mg/l)	0.0058	0.0096	0.0122	0.0098	0.007
Zn	(mg/l)	0.0166	0.0215	0.0204	0.018	3
Cu	(mg/l)	0.042	0.0192	0.012	0.0178	1
Cd	(mg/l)	<0.001	<0.001	<0.001	<0.001	0.003
Pb	(mg/l)	<0.001	<0.001	<0.001	<0.001	0.01
Ni	(mg/l)	<0.001	<0.001	<0.001	<0.001	0.02
V	(mg/l)	<0.001	<0.001	<0.001	<0.001	
Fe	(mg/l)	9.0366	5.1836	6.7834	6.6858	0.3

Conclusion

There were no significant differences for most of the water quality parameters between Olugbobiri and Ogboinbiri Creeks. Some water quality variables measured in the Olugbori and Ogboinbiri creeks are within the NIS limits for portable water. However, iron and PAH (a potential carcinogen) were higher than their respective limits, making water from these rivers unsuitable for drinking.

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