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Research Paper

Surface and Ground Water Quality Determination in Orashi and Sombreiro River Basin using Weighted Arithmetic Water Quality Index

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ABSTRACT: *This study was primarily initiated to ascertain the status of water sources available to residents of communities along Orashi and Sombreiro rivers in the Niger Delta. The essence was to define the water quality and its health implication using standard methods. This study however adopted the weighted arithmetic water quality index, using certain available parameters in evaluation of the status of the water sources. Therefore, this study, made use of pH, Conductivity, Total dissolved solids, Turbidity, lead, Total Hardness, Chromium, and Total Coliform Count. The result of the study revealed that water quality index report for the both basins and sample locations in both seasons showed that the water quality was unsuitable for human consumption as it reported only for Sombreiro River Basin wet season ground water in 2 of the locations which are Obuama and Ebocha sample locations as having good water. The study also showed that water quality in Orashi and Sombreiro River basins according to weighted arithmetic water quality index shows that water in the study area is poor, bad and unsuitable for drinking. In the light of the study findings it was recommended that the activities of companies involved in exploration and exploitation of hydrocarbon in the Niger Delta should be monitored to ensure that they adhere to international best practices. These agencies should act more to protect water resources (surface and groundwater inclusive) from pollution and that other source of water that are healthy and good should be made available to the people to forestall the outbreak of water borne diseases.*

KEYWORDS: Water quality, Water qualityindex, River Basin, determination, Ground, Surface

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I. INTRODUCTION

Water is vital without which life will simply cease to exist. Water supports all forms of life and affects health, lifestyle, and economic well-being of man. This resource is vital in all forms of life and plays a critical role in the promotion of public health and the socio-economic development of human communities (Toure, Wenbiao& Keita, 2007). It is constantly in motion, passing from one state to another and from one location to another. The most significant reserves of water sources from human point of use are the surface water and groundwater. Surface water consists of water that flows through the land in the form of streams, springs and rivers. It collects to form ponds, lakes and seas. Unlike surface water, groundwater is situated in aquifers underground and relates to surface water across percolation, wells and sources (Toure, Wenbiao and Keita, 2007).

Although more than three quarter of the Earth's surface is made up of water, only 2.8 percent of the Earth's water is available for human consumption (Iskandar, 2010). Despite the huge quantity of water on the earth planet (almost 15,000 million cubic km) most of it contains salt, hence not idle for human usage (Asthana & Asthana, 2005). In other words, about 97% of the planet's water occurs as salt water in the oceans. Of the remaining 3%, two-thirds occur as snow and ice in polar and mountainous regions, and only about 1% of the global water as freshwater (Ibrahim, 2011). Much of the world's freshwaters are stored as surface and groundwater.

Much of the waters on the earth's surface and groundwater represent deposits which have accumulated over a long period. Underground water deposits receive their waters from surface waters which percolate down the upper strata of soil and rocks. Though soils possess an efficient biological machinery which effectively degrade impurities present in the water, a number of materials resistant to degradation passes through the upper layer of the soil and contaminate the groundwater. Salts of chromium, cadmium, mercury, lead among others may be present in groundwater in concentrations sufficient to cause harm on a living system (Asthana & Asthana, 2005).The world has seen the increase in freshwater consumption. It is estimated that freshwater consumption increased by six fold between 1900 and 1995 more than twice the rate of population growth, thus, many parts of the world are facing water scarcity problem (United Nations Environmental Programme, UNEP, 2002).

According to the World Health Organization (WHO) about 786 million people in the world do not have access to safe drinking water. This is roughly one in ten of the 7.4 billion world's population. At present, approximately one-third of the world's population inhabits areas with moderate to high water stress. More than 300 million people in Africa live in a water-scarce environment. It is estimated that eighteen African countries will experience water stress by 2025. This is so as the amount of freshwater available for each person in the continent has reduced to about one-quarter of what it was in 1950 (Sokpuwu, 2017).

There has been significant impairment of rivers with pollutants, rendering the water unsuitable for beneficial purposes (Igwe, Chukwudi, Ifenatuorah, Fagbeja&Okeke, 2017). Human activities on the river beds have been reported to create an environmental burden of considerable magnitude which effects are felt on the quantity and quality of water resources over a wide range of space and time scales (Adedeji, Idowu, Usman &Sogbesan, 2019). Water is typically referred to as polluted when it is impaired by anthropogenic contaminants. Due to these contaminants it either does not support human use or undergoes a marked shift in its ability to support its biotic communities. Water pollution is the leading worldwide cause of death and diseases (West, 2006). It accounted for the deaths of 1.8 million people in 2015 (Kelland, 2017). According to Global Oceanic Environmental Survey (GOES) water pollution is a major environmental challenge that presents a danger for the existence of life on earth in the next decades.Although water pollution is universal, it is more pronounced in some countries. India and China tops countries with high levels of water pollution.

In 2007 about half a billion Chinese had no access to potable drinking water. The arid and semi-arid regions in the north of the country as well as many cities suffered from serious water shortage. Seventy-eight per cent of rivers which flowed through Chinese cities could not be used for potable supplies, and 50 per cent of the groundwater in their cities was found to be polluted (State of Environment Report, People's Republic of China, 1996).

According to Rapu (2003), over 15% of rural dwellers depend on polluted river waters for their domestic needs in South Africa. In Sudan, about 70% of persons in Sudan accessed their water supply from surface waters, which in most cases are polluted by agricultural chemicals and industrial effluents (Khalil, 2005). According to Shuaib (2007) about 40% of Nigerians depend on either polluted surface waters or wells for their domestic activities. The growing problem of contamination and pollution of water resources has necessitated the monitoring of water quality considering its impact on man and aquatic lives. It is against this background that the present study examines petroleum development and water quality in Orashi/Sombreiro River Basins.

II. MATERIALS AND METHODS

Water quality index (WQI) used in determining the quality of both surface and ground water-bodies was first developed by Horton in 1965, later an updated version was developed by Brown, McClelland, Deininger& Tozer, (1970). Since then its use for water quality determination have become a common practice although several other water quality indexes have been developed and as well used by different scholars and practitioners. Amidst the different water quality indexes developed and used, the weighted arithmetic water quality index has gained more prominence amongst scholars (Oni &Fasakin, 2016). This is owing to the ability of WQI to provide a number, simple enough for the public to understand, that states the overall water quality at a certain location and time using the measured values of selected water quality parameters. In most cases, it is used to determine the potability of surface water and groundwater.

This study however, adopted the use of the weighted arithmetic index method (WAWQIM) to determine the impact of petroleum exploration on surface and ground water quality in Orashi and Sombreiro River Basin in the Niger Delta, hence the method followed by Tiwari & Mishra, (1985), Das, Panigrahi& Panda (2012) and Oni &Fasakin (2016) have been employed for calculating the Water Quality Index (WQI). In this method the quality rating scale has been assigned to the parameter which is also weighed according to its relative importance in the overall water quality. Water Quality Index (WQI) is a dimensionless number that combines multiple water quality factors into a single number by normalizing values to subjective rating curve (Gorde and Jadhav, 2013).

It is determined with the equation: $WQI = \sum(Qi)Wi / \sum Wi$ ……………… (Equation 3.1)

Where Qi = Quality rating

Wi = Unit weight

Hence for this study the following parameters were chosen for this exercise, pH, Conductivity, Total dissolved solids, Turbidity, lead, Total Hardness, Chromium, and Total Coliform Count.

The Water Quality Index (WQI) ranges after Oni &Fasakin (2016) have been defined as;
Above 100 = Unsuitable for drinking
76-100 = Very Bad
51-75 = Poor
26-50 = Good
0-25 = Excellent

III. RESULTS AND DISCUSSION

Table 1: Water Quality Parameters used in the Present Study and their unit weight

Parameters	Standards (NSDWQ)	1/si	(Wi =K/si)
pH	8	0.12	0.0008
Conductivity	1000	0.001	0.000006
Total Dissolved Solids	500	0.002	0.00001
Turbidity	5	0.2	0.001
Total Hardness	150	0.007	0.00004
Lead	0.01	100	0.6
Chromium	0.05	20	0.12
Nickel	0.02	50	0.3
Total Coliform Count	10	0.1	0.0006
		∑(1/si) = 170.4	

**k = 1/∑(1/si) = 0.006

Table 2: Calculated Water Quality Index Values for Sombreiro River Basin Dry Season Surface Water.

Parameters	Standards (NSDWQ)	(Wi =K/si)	SP1	SP2	SP3	SP1	SP2	SP3
			Qi	Qi	Qi	Qiwi	Qiwi	Qiwi
pH	6.5-8	0.0008	272	256	213	0.20	0.12	0.17
Conductivity	1000	0.000006	141.1	115	125.01	0.0008	0.0069	0.00075
Total Dissolved Solids	500	0.00001	169.3	138.3	150	0.0017	0.0014	0.0015
Turbidity	5	0.001	2.28	2.68	0.72	0.0023	0.0027	0.0007
Total Hardness	150	0.00004	210.52	113.5	332.1	0.0084	0.045	0.133
Lead	0.01	0.6	25330	31740	21580	15198	19644	12948
Chromium	0.05	0.12	11650	5040	6458	1398	604.8	774.9
Nickel	0.02	0.3	24185	25120	18790	7255.5	7536	5637
Total Coliform Count	10	0.0006	170	20	90	0.042	0.012	0.054
		∑wi=170.4						
WQI = ∑qiwi/∑wi						**139.7**	**163.1**	**109.5**

*SP = Sample point

As revealed inTable 2, dry season surface water quality index (WQI) value for sample point 1 (Obuama) is 139.7 while the value for sample point 2 (Ahoada) is 163.1. The water quality index (WQI) value for sample point 3 (Ebocha) stood at 109.5. Dry season surface water quality index value for Sombreiro River basin is highest in sample point 2 (Ahoada). At this sample point, water quality index stood at 163.1. This is followed by sample point 1 which is located in Obuama. At this sample point, surface water quality index is 139.7. Sample point 3 located at Ebocha had the least water quality index value of 109.5. The values 139.7, 163.1 and 109.5 respectively from the water quality index report for Sombreiro river basin dry season surface water revealed that the water from all the sample locations are all unsuitable for drinking purposes.

Table 3: Calculated Water Quality Index values for Sombreiro River Basin Wet Season Surface Water.

Parameters	Standards (NSDWQ)	(Wi =K/si)	SP1	SP2	SP3	SP1	SP2	SP3
			Qi	Qi	Qi	Qiwi	Qiwi	Qiwi
pH	6.5-8	0.0008	52	126	141	0.0042	0.1008	0.113
Conductivity	1000	0.000006	85.3	99.2	750.4	0.0005	0.000056	0.0045
Total Dissolved Solids	500	0.00001	102.4	110.7	90	0.0010	0.0011	0.0009
Turbidity	5	0.001	0.26	0.42	0.24	0.00026	0.00042	0.00024
Total Hardness	150	0.00004	50.1	80.4	247.2	0.002	0.0032	0.0099
Lead	0.01	0.6	12587	15286	10074	7552.2	9171.6	6044.4
Chromium	0.05	0.12	3445.7	2319	4005.8	413.5	278.3	480.7
Nickel	0.02	0.3	10540	21641	10181.5	3162.2	6492.3	3054.5
Total Coliform Count	10	0.0006	240	190	160	0.144	0.114	0.096
		∑wi =170.4						
WQI =∑qiwi/∑wi						**65.3**	**59.3**	**56.2**

*****SP = Sample point

As revealed inTable 3, wet season surface water quality index (WQI) value for Sombreiro River basin at sample point 1 (Obuama) is 65.3 while the value for sample point 2 (Ahoada) is 59.3. The water quality index (WQI) value for sample point 3 (Ebocha) stood at 56.2. Wet season surface water quality index value for Sombreiro River basin is highest in sample point 1 (Obuama). At this sample point, water quality index stood at 65.3. This is followed by sample point 2 which is located in Ahoada. At this sample point, surface water quality index is 59.3. Sample point 3 located at Ebocha had the least water quality index value of 56.2. The values 65.3, 69.3 and 56.2 respectively from the water quality index report for Sombreiro river basin wet season surface water revealed that the water from all the sample locations are all poor for drinking purposes.

Table 4: Calculated Water Quality Index values for Sombreiro River Basin Dry Season Ground Water

Parameters	Standards (NSDWQ)	(Wi =K/si)	SP1	SP2	SP3	SP1	SP2	SP3
			Qi	Qi	Qi	Qiwi	Qiwi	Qiwi
pH	6.5-8	0.0008	147	103	77	0.118	0.082	0.062
Conductivity	1000	0.000006	37.1	57.2	44.1	0.00022	0.00034	0.00026
Total Dissolved Solids	500	0.00001	44.5	68.9	52.9	0.00045	0.00069	0.00053
Turbidity	5	0.001	2.32	0.22	0.64	0.0023	0.00022	0.00064
Total Hardness	150	0.00004	160.3	157.1	153.6	0.0064	0.0063	0.0061
Lead	0.01	0.6	18532	36933	16924	11119,2	22159.8	10154.4
Chromium	0.05	0.12	6326.4	5040.2	4009.4	759.2	604.8	481.1
Nickel	0.02	0.3	10861	25121	22107.5	3258.3	7536.3	6632.3
Total Coliform Count	10	0.0006	40	60	20	0.024	0.036	0.012
		∑wi=170.4						
WQI =∑qiwi/∑wi						**88.8**	**177.8**	**101.3**

*****SP = Sample point

Table 4 showed that dry season groundwater quality index (WQI) value for Sombreiro River basin at sample point 1 (Obuama) stood at 88.8; the value for sample point 2 (Ahoada) is 177.8 while that of sample point 3 (Ebocha) stood at 101.3. Dry season groundwater quality index value for Sombreiro River basin is higher in sample point 2 (Ahoada). At this sample point, water quality index stood at 177.8. This is followed by sample point 2 which is located in Ebocha (101.3). The least water quality index value was obtained at sample point 1 which is located at Obuama. The values 88.8, 177.8 and 101. respectively from the water quality index report for Sombreiro river basin dry season ground water revealed that the water quality index for sample location 1 which is 88.3 is very bad while that of the two other locations are all poor for drinking purposes

Table 5: Calculated Water Quality Index values for Sombreiro River Basin Wet Season Ground Water.

Parameters	Standards (NSDWQ)	(Wi =K/si)	SP1	SP2	SP3	SP1	SP2	SP3
			Qi	Qi	Qi	Qiwi	Qiwi	Qiwi
pH	6.5-8	0.0008	89	48	53	0.07	0.038	0.042
Conductivity	1000	0.000006	42.0	48.4	53.4	0.0003	0.00029	0.00032
Total Dissolved Solids	500	0.00001	50.4	58.1	64.1	0.0005	0.00058	0.00064
Turbidity	5	0.001	2.2	1.8	0.18	0.0022	0.0018	0.00018
Total Hardness	150	0.00004	140.5	120.3	127.1	0.0056	0.0048	0.051
Lead	0.01	0.6	6135	11528	2485	3681	6916.8	1491
Chromium	0.05	0.12	4040.2	4050.8	2302.2	484.8	486.1	276.3
Nickel	0.02	0.3	5006	5601.5	10771	1501.8	1680.5	3231.3
Total Coliform Count	10	0.0006	170	140	140	0.102	0.084	0.084
		∑wi=170.4						
WQI = ∑qiwi/∑wi						**33.3**	**53.3**	**29.3**

*****SP = Sample point

Table 5 showed that wet season groundwater quality index (WQI) value for Sombreiro River basin at sample point 1 (Obuama) is 33.3; the value for sample point 2 (Ahoada) is 53.3 while that of sample point 3 (Ebocha) stood at 29.3. Wet season surface water quality index value for Sombreiro River basin is highest in sample point 2 (Ahoada). At this sample point, water quality index stood at 53.3. This is adjudged poor. This is followed by sample point 1 which is located in Obuama. At this sample point, surface water quality index is 33.3. Sample point 3 located at Ebocha had the least water quality index value of 29.3. The values 33.3, 53.3 and 29.3 respectively from the water quality index report for Sombreiro river basin wet season ground water revealed that apart from sample location 2 which value is 53.3 revealing that the water is poor the water from the other sample locations which are locations 1 and 3 are all good for drinking purposes.

Table 6: Calculated Water Quality Index values for Orashi River Basin Dry Season Surface Water.

Parameters	Standards (NSDWQ)	(Wi =K/si)	SP1	SP2	SP3	SP1	SP2	SP3
			Qi	Qi	Qi	Qiwi	Qiwi	Qiwi
pH	6.5-8	0.0008	352	208	185	0.282	0.116	0.148
Conductivity	1000	0.000006	131.1	172.8	87.4	0.00078	0.0010	0.00052
Total Dissolved Solids	500	0.00001	157.3	206.5	104.9	0.0016	0.0021	0.0010
Turbidity	5	0.001	3.12	0.28	2.32	0.0031	0.00028	0.0023
Total Hardness	150	0.00004	183.7	237.3	173.9	0.0073	0.0095	0.0696
Lead	0.01	0.6	48526	29822	30053	29115.6	17893.2	18031.8
Chromium	0.05	0.12	10503.8	13641.2	13018.2	1260.5	1636.9	1569.4
Nickel	0.02	0.3	34666	20512	37734.5	10399.8	6153.6	11320.4

Total Coliform Count	10	0.0006	70	90	140	0.042	0.054	0.084
		∑wi=170.4						
WQI=∑qiwi/∑wi						**239.3**	**150.7**	**181.5**

*****SP = Sample point

As revealed in table 6, dry season surface water quality index (WQI) value for Orashi River basin at sample point 1 (Mbiama) is 239.3; the value for sample point 2 (Old Sangana) is 150.7 while the water quality index (WQI) value for sample point 3 (Ndoni) stood at 181.5. Dry season surface water quality index value for Orashi River basin is highest in sample point 1 (Mbiama). At this sample point, water quality index stood at 239.3. This is unsuitable for drinking. This is followed by sample point 3 which is located in Ndoni. At this sample point, surface water quality index is 181.5. This is also unsuitable for drinking. Sample point 2 located at Old Sangana had the least water quality index value of 150.7. This is also unsuitable for drinking. The values 239.3, 150.7 and 181.5 respectively from the water quality index report for Orashi river basin dry season surface water revealed that the water from all the sample locations are all poor for drinking purposes.

Table 7: Calculated Water Quality Index Values for Orashi River Basin Wet Season Surface Water.

Parameters	**Standards (NSDWQ)**	**(Wi =K/si)**	**SP1**	**SP2**	**SP3**	**SP1**	**SP2**	**SP3**
			Qi	**Qi**	**Qi**	**Qiwi**	**Qiwi**	**Qiwi**
pH	6.5-8	0.0008	221	158	108	0.177	0.126	0.086
Conductivity	1000	0.000006	102.1	113.1	66.1	0.00061	0.00068	0.0039
Total Dissolved Solids	500	0.00001	122.5	135.7	79.3	0.0012	0.0014	0.0079
Turbidity	5	0.001	0.58	0.16	0.28	0.000058	0.000016	0.000028
Total Hardness	150	0.00004	140.1	180.3	133.6	0.0056	0.0072	0.0053
Lead	0.01	0.6	25838	11274	24643	15502.8	6764.4	14785.8
Chromium	0.05	0.12	6009.8	8285.4	10411	721.2	994.2	1249.3
Nickel	0.02	0.3	26346	11248	26502.5	3424.9	3374.4	7950.8
Total Coliform Count	10	0.0006	140	170	190	0.084	0.102	0.114
		∑wi=170.4						
WQI=∑qiwi/∑wi						**115.3**	**117.8**	**140.8**

*****SP = Sample point

As shown in table 7, wet season surface water quality index (WQI) value for Orashi River basin at sample point 1 which is located at Mbiama is 115.3; the value for sample point 2 which is located at Old Sangana is 117.8 while the value for sample point 3 which is located at Ndoni stood at 140.8. Wet season surface water quality index value for Orashi River basin is highest in sample point 3 (Ndoni). At this sample point, water quality index stood at 140.8. This is unsuitable for drinking. This is followed by sample point 2 which is located at Old Sangana. At this sample point, surface water quality index is 117.8. This is also unsuitable for drinking. Sample point 1 located at Mbiama had the least water quality index value of 115.3. This is also unsuitable for drinking. The values 115.3, 117.8 and 140.8 respectively from the water quality index report for Orashi river basin wet season surface water revealed that the water from all the sample locations are all poor for drinking purposes

Table 8: Calculated Water Quality Index values for Orashi River Basin Dry Season Ground Water.

Parameters	**Standards (NSDWQ)**	**(Wi =K/si)**	**SP1**	**SP2**	**SP3**	**SP1**	**SP2**	**SP3**
			Qi	**Qi**	**Qi**	**Qiwi**	**Qiwi**	**Qiwi**
pH	6.5-8	0.0008	187	89	61	0.149	0.071	0.049
Conductivity	1000	0.000006	98.1	72.3	23.1	0.00059	0.00043	0.00014

Total Dissolved Solids	500	0.00001	117.7	86.7	27.7	0.0012	0.00087	0.00028
Turbidity	5	0.001	2.42	0.36	4.2	0.0024	0.00036	0.0040
Total Hardness	150	0.00004	146.9	160.4	100.1	0.0065	0.0064	0.0040
Lead	0.01	0.6	34131	15341	20171	20478	9204.6	12102.6
Chromium	0.05	0.12	9222.6	2694.6	3690.4	1106.7	3232.5	442.8
Nickel	0.02	0.3	22418	30061	15579	6725.4	9018.3	4673.7
Total Coliform Count	10	0.0006	20	20	40	0.012	0.012	0.024
		∑wi=170.4						
WQI = ∑qiwi/∑wi						**166.1**	**108.8**	**101.1**

*SP = Sample point

Table 8 showed that dry season groundwater quality index (WQI) value for Orashi River basin at sample point 1 which is located at Mbiama is 166.1; the value for sample point 2 which is located at Old Sangana is 108.8 while the value for sample point 3 which is located at Ndoni stood at 101.1. Dry season surface water quality index value for Orashi River basin is highest in sample point 1 (Mbiama). The water quality is unsuitable for drinking. This is followed by sample point 2 which is located at Old Sangana. It is also unsuitable for drinking. Sample point 3 located at Mbiama had the least water quality index value of 115.3. This is also unsuitable for drinking. The values 166.1, 108.8 and 101.1 respectively from the water quality index report for Orashi river basin dry season ground water revealed that the water from all the sample locations are all poor for drinking purposes**.**

Table 9: Calculated Water Quality Index values for Orashi River Basin Wet Season Ground Water.

Parameters	**Standards (NSDWQ)**	**(Wi =K/si)**	**SP1**	**SP2**	**SP3**	**SP1**	**SP2**	**SP3**
			Qi	**Qi**	**Qi**	**Qiwi**	**Qiwi**	**Qiwi**
pH	6.5-8	0.0008	116	52	44	0.093	0.042	0.035
Conductivity	1000	0.000006	57.7	90.2	42.2	0.00035	0.00054	0.00025
Total Dissolved Solids	500	0.00001	69.3	108.3	50.6	0.00069	0.0011	0.00051
Turbidity	5	0.001	0.36	0.08	0.12	0.00036	0.00008	0.000012
Total Hardness	150	0.00004	93.5	126.8	73.7	0.0037	0.0051	0.0029
Lead	0.01	0.6	13485	2485	3679	8091	1491	2207.4
Chromium	0.05	0.12	6366.6	2302.2	2690.6	763.9	276.3	322.9
Nickel	0.02	0.3	15578.5	10771	6432.5	4673.6	3213.3	1929.8
Total Coliform Count	10	0.0006	120	140	140	0.072	0.084	0.084
		∑wi=170.4						
WQI=∑qiwi/∑wi						**79.4**	**29.2**	**26.2**

*****SP = Sample point

Table 9 showed that dry season groundwater quality index (WQI) value for Orashi River basin at sample point 1 which is located at Mbiama is 79.4; the value for sample point 2 which is located at Old Sangana is 29.2 while the value for sample point 3 which is located at Ndoni stood at 26.2. The values 79.4, 29.2 and 26.2 respectively from the water quality index report for Orashi river basin wet season groundwater revealed that the sample location water quality had a value of 79.4 which shows that it is poor while the water from the other two sample locations are all good for drinking purposes

IV. CONCLUSION AND RECOMMENDATIONS

Water quality in Orashi and Sombreiro River basins according to weighted arithmetic water quality index shows that water resource within the study area is poor, very bad and unsuitable for drinking. There is a deterioration of water quality in the Orashi and Sombreiro River basins. This applies to both surface and groundwater quality.The quality of surface and groundwater in Orashi and Sombreiro River basins are generally poor in wet season than in dry season. The physiochemical and microbiological analysis showed water quality to be better in wet season compared to the quality in dry season.

The value for most parameters is higher in dry season than in wet season. This applies to both surface and groundwater quality. In line with the above, the study therefore recommends thatthe activities of companies involved in exploration and exploitation of hydrocarbon in the Niger Delta should be monitored to ensure that they adhere to international best practices. These agencies should act more to protect water resources (surface and groundwater inclusive) from pollution.

More so it is important that other sources of water that are healthy and good should be made available to the people to forestall the outbreak of water borne diseases.

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