Early Wet Season Quality Assessment Of Water Sources From Selected Cities In Rivers State, Nigeria.

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Abstract:
Incessant and uncontrolled disposal of solid waste in improvised and unprotected sanitary landfills, industrial activities which produce effluent and mining operations which produce minerals of heavy elements and spillage of crude oil, pose potential pollution hazards to ground water and surface water sources in Rivers State Nigeria. Water quality indices are useful tools for the overall assessment of water quality. Some previous studies (Onukwugha et al., 2019) have worked on (WQI) for boreholes located around waste disposal sites. Continuous sampling of surface and ground water sources was carried out around the selected cities/towns in Rivers State, Nigeria. The study which is a collaborative research between TETFUND and Federal Polytechnic Nekede was carried out during the early rainy seasons around March 2022. The water samples collected was tested for pH, phosphate, temperature, conductivity, nitrate, chloride, turbidity, hardness, BOD, DO, COD, TDS, Pb, Hg, Cd, Cu, Cr, Mn, E.Coli and Coliform. Thereafter, the test results obtained were used to compute the water quality index using Weighted Arithmetic Water Quality Index Method (WAWQI). The values of the water quality index as prescribed by the WAWQI method range as follows: from 0-25% is Excellent, 26-50% is good, 51-75 is poor, 76-100% is very poor and above 100% is unsuitable for drinking purpose. Field survey data of the study area was done, 31 water samples were collected, 20 were borehole samples while 11 were Surface (River) water samples. The WQI were computed in two stages; First was without heavy metals and second with heavy metals. Well distribution of water quality status were observed in the first stage and on the second stage, the middle range disappeared. The presence of heavy metals in our results in second stage made it possible. Therefore, we recommend that WQI should be computed considering only the parameters that were present in each sample based on heavy metals.

Keywords: *Groundwater, Surface-water, Water quality index, heavy metals, water status.*

1.0 INTRODUCTION

Water as a crucial resource for all social and economic development, is also essential in energy production and adaptation to climate change, but unfortunately various anthropogenic activities have put a strain on its quality. Predominantly, management of water resources has focused on surface water or ground water, as if they were separate entities. As development of land and water resources increases, it is superficial that development of either of these resources affects the quantity and quality of the other. Nearly all surface-water features (streams, lakes, reservoirs, wetlands, and estuaries) interact with ground water. Surface water commonly is hydraulically connected to ground water, but the interactions are difficult to observe and measure and commonly have been ignored in water-management considerations and policies.

Ceaseless and anarchic disposal of solid waste in improvised and unprotected sanitary landfills, industrial activities which produce effluent, and mining operations which produce minerals of heavy elements and spillage of crude oil, pose potential pollution hazards to ground water and surface water sources in Rivers State, Nigeria. Water resources quality and assessment is a very big problem in the selected pollution-prone cities in Rivers State, South-South, Nigeria. Waste producing activities that are ongoing and the absence of proper waste management system in these cities create a preponderance of pollution resulting from leachates and other effluents. Also, mineral mining operations produce heavy elements that are being discharged into water bodies. Surface and groundwater are major and treasured sources of water supply more especially to the people of Rivers State.

However, the notion that potable water was an inaccessible commodity in these cities has prompted the quest for better sources of potable water by the inhabitants. Most times the people of these areas spend a lot of money in trying to get these alternative sources of potable water which is hardly achieved. Going by these practices, the people will ever remain poor both financially and health wise because they spend more on water and still get substandard quality. Leaving the populace to their fate will go a long way in reducing their life expectancy.

Considering these factors, this study assessed the quality of water sources during the early wet season in the selected cities of Rivers State, South-South, Nigeria, with a view to ascertaining their suitability and otherwise recommend affordable source protection measures.

2.0 MATERIALS AND METHODS

Study Area

The study was carried out in Rivers State, Nigeria which is located at 4 4° 44'59.06"N, 6° 49' 39.58"E with its upland undulating to the hinterland and attains a maximum height of 30m above sea level at Okubie, to the southwest. Fourteen (14) of the twenty three (23) LGAs of the State are located on the upland with varying heights between 13m to 45m above sea level. These include Ogoni, lkwerre LGAs, Ahoada, Abual/Odual, Ogba/Ndoni /Egbema LGAs and Port Harcourt LGAs. The drier upland area of Rivers State covers about sixty one percent while riverine area, with a relief range of 2m to 5m, covers about thirty nine per cent of the State. The entire topography of the State is also characterized by a maze of effluents, rivers, lakes, creeks, lagoons and swamps crisscrossing the low lying plains in varying dimensions (Niger Delta Budget Monitoring Group, 2022).

Rainfall in Rivers State is seasonal, variable, and heavy. Generally, rain occurs, on the average, every month of the year, but with varying duration. The State is characterized by high rainfall, which decreases from South to North. Total annual rainfall decreases from about 4,700 mm on the coast to about 1,700 mm in extreme north of the State. It is 4,698 mm at Bonny along the coast and 1,862 mm at Degema. Rainfall is adequate for all year round crop production in the State. The duration of the wet season is not less than 330 days, of which a great number is rainy days (days with 250 mm or more of rain) (Niger Delta Budget Monitoring Group, 2022).

Current studies divulge that about 97% of water exists in an ocean that is unsafe for drinking and 3% is fresh water. Of the fresh water, 69% is held by glaciers and ice caps, wherein 30% is ground and 1% is locked up in lakes, rivers and swamps (Ocheri et al., 2014). That which follows as a consequence of the fore going analysis is a pointer to scarcity of safe drinking water which can be attributed partially to increase of world population. Other contributory factors include: expansion of industrial activities, incessant and uncontrolled disposal of solid and liquid waste, and discharge of chemical effluents into water sources. These factors when conjoined with environmental abjection obfuscate possible potential contaminant menace on ground water and surface water quality. This concern has attracted overwhelming attention in Nigeria, most especially in the South-East and South-South geopolitical zones.

Recent estimate relate that the high morbidity and mortality rate all over the globe are caused by paucity of good quality water (Akhavan et al, 2016). World Health Organization has put forward with convincing facts a minimum daily water consumption of 2.7-3.7 liter per capita per day (WHO, 1993).

Several researchers have previously computed water quality index in various locations and isolated sources (Onukwugha et al, 2019; Owamah, 2019; Chandra, et al., 2017 and Boah, et al, 2018). Most of the studies reveal that there has been a systemic reduction in the water quality of the areas studied.

2.1 DETERMINATION OF METALS

The metal content of the River water was determined by using atomic absorption spectrometry according to ASTM D 3557 , ASTM D 1691, ASTM D 1688, ASTM D 3559, ASTM D 858, D 1687 AND ASTM D 3223 (1996).

2.1.1 Sample pretreatment

Samples with suspended solids were filtered before aspiration.

2.1.2 Atomic Absorption Measurement

It was ensured that spectrometer, computer and printer are correctly installed.
The hollow cathode lamp was installed for the desired metal in the lamp turret.
It was ensured that the wavelengths, slit widths and maximum lamps current were correct as they are automatically selected. The metals were analyzed using atomic absorption spectrophotometer (GBC AVANTA Programmable) according to the following instrument conditions as shown in Table 1:

Table 1: Instrument for measuring heavy metal

Metal	Oxidant-Fuel	Background correction	Wavelength (nm)	Slith Width (nm)	Maximum lamp Current (mA)

Cd Zn	Air-Acetylene Air-Acetylene	Deuterium lamp Deuterium lamp	228.8 213.9	0.5 0.5	8 10
Cu Pb	Air-Acetylene Air-Acetylene	Deuterium lamp Deuterium lamp	324.8 217	0.5 0.5	5 15
Mn	Air-Accetylene	Deuterium lamp	279.5	0.2	15
Cr	Air-Acetylene	Deuterium lamp	357.9	0.5	10
Hg	Air-Acetylene	Deuterium Lamp	253.6	0.7	15

2.2 PHYSIC-CHEMICAL PARAMETER

2.2.1 pH AND TEMPERATURE (ASTM D1293, 1996).

The pH and temperature were determined in-situ electrometrically by using pH/Temperature meter (HACH EC10). The meter was calibrated with pH buffer of 4, 7 and 10 to correspond with the expected pH range of the sample by adjusting slope calibration controls. The pH value and temperature were displayed on the LCD of the meter using mode control.

2.2.2 DISSOLVED OXYGEN

Dissolved oxygen was determined in-situ electrometrically by using DO meter (HACH DO175). The DO meter was calibrated according to manufacturer's instruction, with a zero oxygen solution prepared by mixing 2gms of sodium sulphite in distilled water. The probe was immersed in the solution for 10minutes for polarization to take place. The slope control key was adjusted as the probe was placed 1cm above distilled water to read 100. The probe was immersed in sample and the dissolved oxygen value was displayed in mg/L.

2.2.3 Turbidity

The turbidity was determined by turbidimetric method (APHA 2130 B, 1995). Turbidity of the samples were determined using HACH turbidimeter (Model 2100). The instrument is standardized using turbidity standard reagents of 0.00NTU and 5.00NTU. The samples were introduced into the samples cuvette and then into the turbidimeter and the result is displayed on the digital readout display.

2.2.4 DETERMINATION OF CHEMICAL OXYGEN DEMAND (COD)

The chemical oxygen demand (COD) is a measure of the oxygen equivalent of the portion of the organic matter in a sample that is susceptible to oxidation by a strong chemical oxidant. The method was adapted from APHA 5220 D (1995).

2.2.4.1 Materials and Reagents

(a) HACH COD Reactor, (b) COD Digestion reagent vials, (c) DR/2010 spectrophotometer

2.2.4.2 Procedure

Digestion of samples

The COD reactor was turned on and preheated to 150°C. The caps of the COD Digestion Reagent Vials were removed. The vials were held at 45° angle. Two mililitres of the samples were pipetted into the vials respectively. The caps were replaced and inverted several times to mix the contents. The vials were placed in the preheated COD Reactor. A blank was prepared as explained above, except that distilled water was used to substitute the sample. The vials were heated for two hours.

Spectrometer measurement

The stored program number for chemical oxygen demand (COD) was entered according to the manufacturer's instruction, the wavelength dial rotated until the display shows **420nm**. The COD Vial Adapter was placed into the cell holder. The spectrometer was zeroed using the prepared blank. The sample vial was then placed into the adapter and the reading taken from the digital display in mg/L COD.

2.2.5 PHOSPHATE (APHA, 1998)

The effluent sample was pre-treated before the phosphate (total phosphate) was determined spectrophotometrically.
Ten milliliters of the sample was measured into a 10ml sample cell. The contents of one phos Ver 3 phosphate powder pillow (Hach reagent) was added and swirled to mix immediately. Thereafter, the spectrophotometer (Hach DR/2010) was dialed to wavelength of 890nm. After the waiting period of 2 minutes for complete reaction and colour development, the instrument was brought to zero reading with the blank, and the concentration of phosphate in the sample was read in mg/L PO_4^{3-}.

2.2.6 Conductivity/TDS measurement

Conductivity and total dissolved solid (TDS) was determined Electrometrically using Conductivity/TDS meter (HACH CO150). The meter is temperature compensated.
The probes were immersed in sample solutions and the conductivity values read off directly in micro-Siemen per cm (uS/cm) and TDS values in mg/L from the display. Samples which values exceeded the maximum meter value were diluted to fall within the range, and the dilution factor applied.

2.2.7 Ammonium (NH_4):
This is determined electrometrically using HACH IntelliCal ISENH3181. The probes are dipped into the water sample and the result displayed in mg/L in the result display unit.

2.2.8 Oxygen Retention Potential (ORP)
The oxygen retention potential is determined electrometrically using HACH HQ1100 and HQ11d portable pH/ORP meter. The probe was rinsed with deionized water and dried with lint-free cloth. The probe was put in the beaker containing the water sample. The result was taken when the reading was stable and is measured in milliVolt (mV).

2.3 BACTERIOLOGICAL ANALYSIS

2.3.1 Presumptive test
The Multiple tube fermentation technique/Most Probable Number (MPN) was employed to examine the water (American Public Health Association 1998). Inoculated into bottles of sterile double strength MacConkey broth with an inverted Durham's tube for gas collection and detection, a total of 105 ml water sample was taken from each water sample as one 50 ml, five 10 ml, and five 1 ml amounts. As a presumptive test for total coliform, they were cultured aerobically at 37°C for 18-24 hours. The number of bottles in which lactose fermentation with acid and gas production occurred was counted after incubation at 37°C. A change in the colour of MacConkey soup from purple to yellow indicated lactose fermentation and acid production, while the displacement of broth in the Durham's tube by bubbles indicated gas production (Feng et al.,2002). The MPN of coliforms in the 100 ml well water sample was calculated using McCrady's probability tables (Bartram and Balance,1996; Stevens et al., 2003).

2.3.2 Confirmatory test

A loopful of broth from the positive tubes in the presumptive test was transferred into increased coliform broth and incubated at 44.5°C for 24 hours in the confirmatory test for fecal coliform. After 24 hours, there was positive gas production in the tube. There was gas production in some of the tubes after incubation at 44.5°C, thus the number of positives was counted and compared to the MPN table. A loopful of broth from the positive tubes was streaked over MacConkey agar, and growth was seen after 18-24 hours of incubation at 35°C (Bartram and Balance,1996). Colony morphology, Gram stain, motility, and biochemical assays were used to further identify the isolates.

2.3.3 Identification of Isolates

Positive tubes of the presumptive and confirmatory test were sub-cultured on MacConkey agar for the enumeration of Escherichia coli and other enteric coliforms. All the inoculated media were incubated aerobically at 37°C for 24 h, after which the isolates were further characterized by a combination of colonial and morphological characteristics on solid media, Gram-stain as well as standard biochemical tests for oxidase production, motility, Triple Sugar Iron agar test, citrate utilization test, urease production, and indole test as described by Winn et al(2006).

2.3.4 Isolation of Salmonella typhi and Shigella

One ml of each water sample was inoculated into 5 ml of selenite F enrichment broth and incubated for 8 hours at 37°C. It was then inoculated onto Salmonella-Shigella agar and incubated at 35-37°C for 24-48 hours (Winn et al.,2006).

2.3.5 Isolation of Vibrio cholera

Inoculated one ml of each water sample into 5 ml of double-strength alkaline peptone water and incubated for 6-8 hours.
It was then inoculated onto thiosulfate citrate bile salt agar and incubated for another 24-48 hours at 37°C (Winn et al.,2006).

2.4 **The Weighted Arithmetic Water Quality Index Method**

Weighted arithmetic water quality index method classified the water quality according to the degree of purity by using the most commonly measured water quality variables as shown in Table 2. The method has been widely used by various scientists and the calculation of WQI was made by employing Equation 1 as follows:

$$WQI = \sum Q_i W_i / \sum W_i \quad \ldots\ldots\ldots \quad 1$$

The quality rating scale (Q_i) for each parameter is calculated by using Equation 2.

$$Q_i = 100\left(\frac{V_0 - V_i}{S_i - V_i}\right) \quad \ldots\ldots\ldots\ldots \quad 2$$

Where,
V_o is the observation value which the Estimated experimental Concentration results of the individual i^{th} parameter in the analyzed water.
V_i is the ideal value of the individual parameters permissible limit in the a purify or distilled water that is capable of giving a quality value of 100. For example V_i in Excepted element of pH is 7.0 and DO is 100%, FC is 0, BOD_5 is 0 ΔT^0C is 00c etc. (FLINN, 2018).
S_i is the recommended permissible limit or standard value of the i^{th} parameter in spring water or treated water.

The unit weight (W_i) for each water quality parameter is calculated using the following formula:

$$W_i = \frac{K}{S_i} \qquad \text{.........} \qquad 3$$

Where, K is proportionality constant and can also be computed using Equation 4.

$$K = \frac{1}{\sum \frac{1}{S_i}} \qquad \text{.........} \qquad 4$$

Table 2: Water Quality Rating as per Weighted Arithmetic Water Quality Index Method

WQI Value	Rating of Water Quality	Grading
0 – 25	Excellent water quality	A
26 – 50	Good water quality	B
51 – 75	Poor water quality	C
76 – 100	Very Poor water quality	D
Above 100	Unsuitable for drinking purpose	E

Source: (Armah et al, 2012)

2.4.2 Calculating WQI Using WAWQI Method

Weighted Arithmetic Water Quality Index can be achieved by adhering strictly to the following stages, according to (Eni et al, 2011).

Stage 1: Collect data of various physico- chemical water quality parameters.
Stage 2: Calculate Proportionality constant "K" value using formula equation 4.
Stage 3: Calculate quality rating for nth parameter (q_n). This is calculated using Formula of equation 2
Stage 4: Calculate unit weight for the nth parameters using equation 3.
Stage 5: Calculate Water Quality Index (WQI) using equation 1.

3.0 RESULTS AND DISCUSSION

The topography of the study area map as drawn with the aide of earth Google app is presented in Figure 1. Where the arrow head shows the point at which the sample was collected and the name of nearest bus stop name is written against the arrow head.

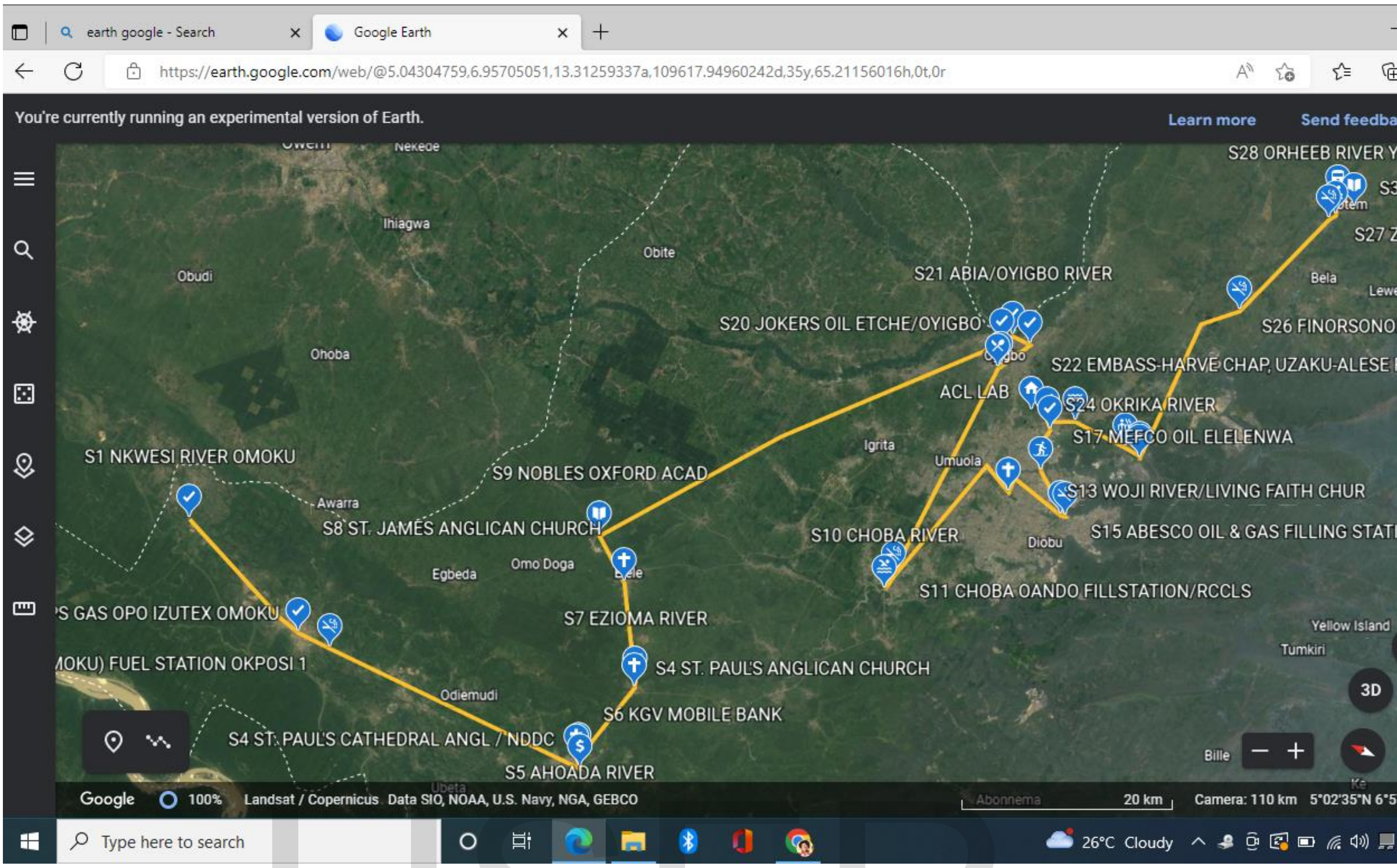

Figure 1: Study Area Map

The coordinate of the selected sample points were presented in Table 3 as shown below, with the name of the nearest bus stop at the collected point and the local government of the location against the number of the sample with their elevation GPRS.

Table 3: Field survey data of study area

SAMPLE NO.	NAME OF POINT	LGA	CORDINATE		ELEVATION
1	Nkwesi River	Ogba/Egbema/Ndoni	$5^0$27'53''N	$6^0$42'08''E	517m
2	LPG CHAPS Gas Opposite Izutex Musicals	Ogba/Egbema/Ndoni	$5^0$20'18''N	$6^0$39'10''E	518m
3	NNPC Fuel Station	Ogba/Egbema/Ndoni	$5^0$18'28''N	$6^0$39'07''E	518m
4	St Paul's Cathedral Anglica	Ahoada East	$5^0$04'32''N	$6^0$39'18''E	510m
5	Ahoada River	Ahoada East	$5^0$04'27''N	$6^0$39'26''E	507m
6	KGV Mobile Bank	Emohua	$5^0$04'09''N	$6^0$38'55''E	509m
7	Ezioma River	Emohua	$5^0$03'28''N	$6^0$44'15''E	516m
8	St James' Anglican Church	Emohua	$5^0$06'07''N	$6^0$48'38''E	530m
9	Madonna University	Ikwere	$5^0$08'17''N	$6^0$50'17''E	534m
10	River Choba	Obio/Akpor	$4^0$53'47''N	$6^0$53'57''E	503m
11	Choba Oando filling Station	Obio/Akpor	$4^0$53'38''N	$6^0$54'48''E	512m
12	Mater Misericordiae	Obio/Akpor	$4^0$50'05''N	$7^0$01'13''E	513m

	Catholic Church				
13	Living Faith Church River	Obio/Akpor	$4^0$49’01’’N	$7^0$02’54’’E	501m
14	PortHarcourt River Near Jasabi Gas(LPG)	PortHarcourt	$4^0$47’08’’N	$7^0$01’16’’E	502m
15	ABESCO Oil & Gas LTD filling Station	PortHarcourt	$4^0$46’53’’N	$7^0$01’19’’E	502m
16	Nans Opposite Amsure filling Station.	Obio/Akpor	$4^0$49’28’N	$7^0$05’02’’E	515m
17	Mefco Oil Elelenwa	PortHarcourt	$4^0$49’47’’N	$7^0$05’22’’E	515m
18	Morning Rose Hotel	Oyigbo	$4^0$53’10’’N	$7^0$06’58’’E	518m
19	De-Nero Gardens and Resort	Oyigbo	$4^0$53’16’’N	$7^0$08’49’’E	519m
20	Jokers Oil Etche	Etche	$4^0$53’36’’N	$7^0$08’05’’E	523m
21	Abia/Oyigbo River	Oyigbo	$4^0$53’14’’N	$7^0$08’38’’E	513m
22	Embass of Harvedias	Etche	$4^0$52’14’N	$7^0$08’36’’E	522m
23	Deeper life Bible Church	Okirika	$4^0$44’41’’N	$7^0$05’46’’E	501m
24	Okirika River	Okirika	$4^0$44’39’’N	$7^0$05’38’’E	499m
25	Refinery	Okirika	$4^0$45’33’’N	$7^0$05’51’’E	510m
26	Finorson Oil Opposite Deeper Life.	Tai	$4^0$43’09’’N	$7^0$14’46’’E	515m
27	Ziineyie Oil & Gas Kebara Yeghe	Gokana	$4^0$40’55’’N	$7^0$21’02’’E	520m
28	Orheeb River Yeghe	Gokana	$4^0$40’41’’N	$7^0$21’22’’E	580m
29	Kaani Bridge River	Khana	$4^0$40’55’’N	$7^0$22’09’’E	504m
30	Ken-saro Wiwa Polytechnic	Khana	$4^0$39’59’’N	$7^0$22’09’’E	518m
31	Akpaji Eleme River	Eleme	$4^0$48’28’N	$7^0$05’59’’E	501m

Table 4 shows the observed values of the parameters of the water sample characteristic in terms of physo-chemical and biological parameters with heavy metal and the source of water sample also indicated either river or borehole (BH).

Table 4: Observed experimental Parameter Values for tested water Samples

SAMPLE NO.	pH	Cond. (µ/cm)	Temp. (oC)	Turbidity (NTU)	DO (mg/l)	Redox Potential (mV)	TDS (mg/l)	PO_4^{3-} (mg/l)	NH4+ (mg/l)	BOD5 (mg/l)	COD (mg/l)	E-Coli (MPN/ 100ml)*10^2	SOURCE OF WATER
1	4.78	48	22	0	8.4	167	26	0.05	0.28	0.25	0.38	0.8	RIVER
2	3.6	292	24.5	5	8	206	161	0.28	0.38	0.13	0.19	3.5	BH
3	4.55	9	22	0	8	170	5	0.01	0.1	0.46	0.69	2.8	BH
4	4.11	60	24	2	8.5	181	33	0.07	0.18	0.21	0.31	0.4	BH
5	4.59	15	20	0	8.1	168	8	0.02	0.15	0.13	0.19	2.5	RIVER
6	4.19	28	26	0	7.7	181	15	0.02	0.22	0.42	0.63	1.1	BH
7	4.25	15	22	0	7.3	195	8	0.02	0.1	1	1.5	2.8	RIVER
8	3.82	311	22	3	7.2	252	171	0.25	0.43	1.17	1.75	0.8	BH
9	5.25	52	21	4	7.5	212	29	0.05	0.17	0.12	0.18	0.7	BH
10	5.6	4.93	22	10	6.4	197	2,712	0.36	0.56	1.33	2	3	RIVER
11	4.6	20	21	1	8.2	220	11	0.06	0.1	0.63	0.94	3.2	BH
12	3.67	243	22	1	9	255	134	0.25	0.55	0.13	0.19	2.6	BH
13	6.1	12,470	21	25	8.1	85	6,859	0.42	0.63	1.46	2.19	0	BH
14	6.49	23,100	23	65	3.5	16	12,705	0.32	0.7	1.88	2.81	3.6	RIVER
15	5.26	553	24	10	7.7	151	304	0.56	0.45	0.25	0.38	0	BH
16	3.83	69	21	0	8.5	251	38	0.08	0.34	0.33	0.5	0.7	BH
17	3.8	120	22	0	8.6	263	66	0.17	0.36	0.54	0.81	2	BH
18	3.95	56	21	2	7.9	195	31	0.04	0.24	0.13	0.19	2.7	BH
19	4	90	20	3	7.8	204	50	0.23	0.36	0.33	0.5	3.2	BH
20	3.39	183	20	3	8.3	222	101	0.19	0.35	0.21	0.31	2	BH
21	4.68	20	21	2	6	184	11	0.04	0.23	0.13	0.19	2.7	RIVER
22	3.49	233	22	1	8.5	228	128	0.07	0.25	0.25	0.38	3.4	BH
23	4.88	133	22	1	6.8	183	73	0.2	0.32	0.29	0.44	2.4	BH
24	6.47	31,700	27	78	4	130	17,435	0.35	0.75	1.5	2.25	1.6	RIVER
25	4.86	39	22	1	7	166	21	0.03	0.15	0.46	0.69	3.6	BH

26	5.26	61	23	2	7.2	176	34	0.07	0.25	0.79	1.19	1.7	BH
27	3.98	87	22	2	9.1	228	48	0.08	0.29	0.17	0.25	0.9	BH
28	3.55	40	22	0	7.2	223	22	0.15	0.34	0.54	0.81	1.3	RIVER
29	4.53	21	22	0	8	197	12	0.03	0.13	0.13	0.19	2.7	RIVER
30	3.99	14	23	0	9.8	211	8	0.02	0.1	0.25	0.38	1.8	BH
31	6.19	18,080	22.5	15	6.8	127	9,928	0.3	0.68	1.67	2.5	0.2	RIVER

The physo-chemical and biological bacteria parameter were also sources of their ideal limit state vi and standard si values which enable us compute for the relative weight 1/s and unit weight wi of each parameter as shown in Table 5.

Table 5: Unit Weight of Individual Parameters from the Permissible Standards and Ideal Limit State.

	pH	Conductivity (µs)	Temp (^{0}C)	Turbidity (NTU)	DO (mg/l)	Redox Potential (mV)	TDS mg/l	PO_4^{3-} (mg/l)	Ammonia NH4+ mg/l	BOD5 (mg/l)	COD (mg/l)	E-Coli (MPN/100ml)*10^2	
Standard Si	6.5	300	20	5	4	650	500	3	0.50	5	3.00	10	
Vi	7.5	0.05	6	0.1	100	300	50	0.1	0	0	0	0	$\sum$
Relative Weight 1/s	0.15	0.00	0.05	0.20	0.25	0.00	0.00	0.33	2.00	0.20	0.33	0.10	3.63
Unit Weight Wi	0.04	0.00	0.01	0.06	0.07	0.00	0.00	0.09	0.55	0.06	0.09	0.03	1.00

In the same vain the computation of the quality (Q-values) were done and tabulated in Table 6.

Table 6: Quality of the individual Parameters (Q-values) with no heavy metals

Qi	pH	Conductivity (µs)	Temp (^{0}C)	Turbidity (NTU)	DO (mg/l)	Redox Potential (mV)	TDS mg/l	PO_4^{3-} (mg/l)	Ammonia NH4+ mg/l	BOD5 (mg/l)	COD (mg/l)	E-Coli (MPN/100ml)*10^2
Q1	272.00	15.99	114.29	-2.04	95.42	-38.00	-5.33	-1.72	56.00	5.00	12.67	8.00
Q2	390.00	97.33	132.14	100.00	95.83	-26.86	24.67	6.21	76.00	2.60	6.33	35.00

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Q3	295.00	2.98	114.29	-2.04	95.83	-37.14	-10.00	-3.10	20.00	9.20	23.00	28.00
Q4	339.00	19.99	128.57	38.78	95.31	-34.00	-3.78	-1.03	36.00	4.20	10.33	4.00
Q5	291.00	4.98	100.00	-2.04	95.73	-37.71	-9.33	-2.76	30.00	2.60	6.33	25.00
Q6	331.00	9.32	142.86	-2.04	96.15	-34.00	-7.78	-2.76	44.00	8.40	21.00	11.00
Q7	325.00	4.98	114.29	-2.04	96.56	-30.00	-9.33	-2.76	20.00	20.00	50.00	28.00
Q8	368.00	103.67	114.29	59.18	96.67	-13.71	26.89	5.17	86.00	23.40	58.33	8.00
Q9	225.00	17.32	107.14	79.59	96.35	-25.14	-4.67	-1.72	34.00	2.40	6.00	7.00
Q10	190.00	1.63	114.29	202.04	97.50	-29.43	591.56	8.97	112.00	26.60	66.67	30.00
Q11	290.00	6.65	107.14	18.37	95.63	-22.86	-8.67	-1.38	20.00	12.60	31.33	32.00
Q12	383.00	81.00	114.29	18.37	94.79	-12.86	18.67	5.17	110.00	2.60	6.33	26.00
Q13	140.00	4157.34	107.14	508.16	95.73	-61.43	1513.11	11.03	126.00	29.20	73.00	0.00
Q14	101.00	7701.27	121.43	1324.49	100.52	-81.14	2812.22	7.59	140.00	37.60	93.67	36.00
Q15	224.00	184.35	128.57	202.04	96.15	-42.57	56.44	15.86	90.00	5.00	12.67	0.00
Q16	367.00	22.99	107.14	-2.04	95.31	-14.00	-2.67	-0.69	68.00	6.60	16.67	7.00
Q17	370.00	39.99	114.29	-2.04	95.21	-10.57	3.56	2.41	72.00	10.80	27.00	20.00
Q18	355.00	18.65	107.14	38.78	95.94	-30.00	-4.22	-2.07	48.00	2.60	6.33	27.00
Q19	350.00	29.99	100.00	59.18	96.04	-27.43	0.00	4.48	72.00	6.60	16.67	32.00
Q20	411.00	60.99	100.00	59.18	95.52	-22.29	11.33	3.10	70.00	4.20	10.33	20.00
Q21	282.00	6.65	107.14	38.78	97.92	-33.14	-8.67	-2.07	46.00	2.60	6.33	27.00
Q22	401.00	77.66	114.29	18.37	95.31	-20.57	17.33	-1.03	50.00	5.00	12.67	34.00
Q23	262.00	44.32	114.29	18.37	97.08	-33.43	5.11	3.45	64.00	5.80	14.67	24.00
Q24	103.00	10568.41	150.00	1589.80	100.00	-48.57	3863.33	8.62	150.00	30.00	75.00	16.00
Q25	264.00	12.99	114.29	18.37	96.88	-38.29	-6.44	-2.41	30.00	9.20	23.00	36.00
Q26	224.00	20.32	121.43	38.78	96.67	-35.43	-3.56	-1.03	50.00	15.80	39.67	17.00
Q27	352.00	28.99	114.29	38.78	94.69	-20.57	-0.44	-0.69	58.00	3.40	8.33	9.00
Q28	395.00	13.32	114.29	-2.04	96.67	-22.00	-6.22	1.72	68.00	10.80	27.00	13.00
Q29	297.00	6.98	114.29	-2.04	95.83	-29.43	-8.44	-2.41	26.00	2.60	6.33	27.00
Q30	351.00	4.65	121.43	-2.04	93.96	-25.43	-9.33	-2.76	20.00	5.00	12.67	18.00
Q31	131.00	6027.65	117.86	304.08	97.08	-49.43	2195.11	6.90	136.00	33.40	83.33	2.00

Final the water quality index WQI values for each parameter and the sum up of the individual values yield the wqi value for each samples as shown in Table 7. Which also indicate the status of the water quality and also the water source as borehole or river as the case maybe.

Table 7: Water Quality index for individual Parameters and water Sample status

WQIi	pH	Conductivity (µs)	Temp (^{0}C)	Turbidity (NTU)	DO (mg/l)	Redox Potential (mV)	TDS mg/l	PO_4^{3-} (mg/l)	Ammonia NH4+ mg/l	BOD5 (mg/l)	COD (mg/l)	E-Coli (MPN/100ml)*10^2	WQI	WATER QUALITY STATUS	SOURCE OF WATER
WQI1	11.53	0.01	1.57	-0.11	6.57	-0.02	0.00	-0.16	30.85	0.28	1.16	0.22	32.35	GOOD	RIVER
WQI2	16.53	0.09	1.82	5.51	6.60	-0.01	0.01	0.57	41.87	0.14	0.58	0.96	44.15	GOOD	BH
WQI3	12.50	0.00	1.57	-0.11	6.60	-0.02	-0.01	-0.28	11.02	0.51	2.11	0.77	14.12	EXCELLENT!	BH
WQI4	14.37	0.02	1.77	2.14	6.56	-0.01	0.00	-0.09	19.83	0.23	0.95	0.11	21.03	EXCELLENT!	BH
WQI5	12.33	0.21	4.24	-0.09	4.06	-1.60	-0.40	-0.12	1.27	0.11	0.27	1.06	2.20	EXCELLENT!	RIVER
WQI6	14.03	0.01	1.97	-0.11	6.62	-0.01	0.00	-0.25	24.24	0.46	1.93	0.30	26.68	GOOD	BH
WQI7	13.77	0.00	1.57	-0.11	6.65	-0.01	-0.01	-0.25	11.02	1.10	4.59	0.77	17.23	EXCELLENT!	RIVER
WQI8	15.60	0.10	1.57	3.26	6.66	-0.01	0.01	0.47	47.38	1.29	5.36	0.22	54.74	POOR	BH
WQI9	9.54	0.02	1.48	4.39	6.64	-0.01	0.00	-0.16	18.73	0.13	0.55	0.19	19.45	EXCELLENT!	BH
WQI10	8.05	0.00	1.57	11.13	6.71	-0.01	0.33	0.82	61.71	1.47	6.12	0.83	71.27	POOR	RIVER
WQI11	12.29	0.01	1.48	1.01	6.59	-0.01	0.00	-0.13	11.02	0.69	2.88	0.88	15.34	EXCELLENT!	BH
WQI12	16.23	0.07	1.57	1.01	6.53	-0.01	0.01	0.47	60.61	0.14	0.58	0.72	62.53	POOR	BH
WQI13	5.93	3.82	1.48	28.00	6.59	-0.03	0.83	1.01	69.42	1.61	6.70	0.00	79.58	VERY POOR	BH
WQI14	4.28	7.07	1.67	72.97	6.92	-0.03	1.55	0.70	77.13	2.07	8.60	0.99	91.05	VERY POOR	RIVER
WQI15	9.49	0.17	1.77	11.13	6.62	-0.02	0.03	1.46	49.59	0.28	1.16	0.00	52.51	POOR	BH
WQI16	15.55	0.02	1.48	-0.11	6.56	-0.01	0.00	-0.06	37.47	0.36	1.53	0.19	39.49	GOOD	BH
WQI17	15.68	0.04	1.57	-0.11	6.56	0.00	0.00	0.22	39.67	0.60	2.48	0.55	43.52	GOOD	BH
WQI18	15.05	0.02	1.48	2.14	6.61	-0.01	0.00	-0.19	26.45	0.14	0.58	0.74	27.72	GOOD	BH
WQI19	14.83	0.03	1.38	3.26	6.61	-0.01	0.00	0.41	39.67	0.36	1.53	0.88	42.86	GOOD	BH
WQI20	17.42	0.06	1.38	3.26	6.58	-0.01	0.01	0.28	38.57	0.23	0.95	0.55	40.59	GOOD	BH
WQI21	11.95	0.01	1.48	2.14	6.74	-0.01	0.00	-0.19	25.34	0.14	0.58	0.74	26.62	GOOD	RIVER

WQI22	17.00	0.07	1.57	1.01	6.56	-0.01	0.01	-0.09	27.55	0.28	1.16	0.94	29.84	GOOD	BH
WQI23	11.10	0.04	1.57	1.01	6.69	-0.01	0.00	0.32	35.26	0.32	1.35	0.66	37.91	GOOD	BH
WQI24	4.37	9.70	2.07	87.59	6.89	-0.02	2.13	0.79	82.64	1.65	6.89	0.44	94.55	VERY POOR	RIVER
WQI25	11.19	0.01	1.57	1.01	6.67	-0.02	0.00	-0.22	16.53	0.51	2.11	0.99	19.91	EXCELLENT!	BH
WQI26	9.49	0.02	1.67	2.14	6.66	-0.02	0.00	-0.09	27.55	0.87	3.64	0.47	32.43	GOOD	BH
WQI27	14.92	0.03	1.57	2.14	6.52	-0.01	0.00	-0.06	31.96	0.19	0.77	0.25	33.09	GOOD	BH
WQI28	16.74	0.01	1.57	-0.11	6.66	-0.01	0.00	0.16	37.47	0.60	2.48	0.36	41.05	GOOD	RIVER
WQI29	12.59	0.01	1.57	-0.11	6.60	-0.01	0.00	-0.22	14.33	0.14	0.58	0.74	15.57	EXCELLENT!	RIVER
WQI30	14.88	0.00	1.67	-0.11	6.47	-0.01	-0.01	-0.25	11.02	0.28	1.16	0.50	12.70	EXCELLENT!	BH
WQI31	5.55	5.54	1.62	16.75	6.69	-0.02	1.21	0.63	74.93	1.84	7.65	0.06	86.32	VERY POOR	RIVER

Secondly, the tabulation of the study was also repeated in consideration of heavy metals, Table 8 shows the observed values of all the parameter sowing the source of water sample collected either river or borehole (BH).

Table 8: Observed Experimental Parameter Values for tested Water Samples with heavy metals

SAMPLE NO.	pH	Cond. (µ/cm)	Temp. (oC)	Turbidity (NTU)	DO (mg/l)	Redox Potential (mV)	TDS (mg/l)	PO_4^{3-} (mg/l)	NH4+ (mg/l)	BOD5 (mg/l)	COD (mg/l)	E-Coli (MPN/ 100ml)*10^2	Pb (mg/l)	Cd (mg/l)	Mn (mg/l)	Cu (mg/l)	Hg (mg/l)	Cr (mg/l)	SOURCE OF WATER
1	4.78	48	22	0	8.4	167	26	0.05	0.28	0.25	0.38	0.8	0.117	0	0	0	0	0	RIVER
2	3.6	292	24.5	5	8	206	161	0.28	0.38	0.13	0.19	3.5	0	0	0.105	0	0	0	BH
3	4.55	9	22	0	8	170	5	0.01	0.1	0.46	0.69	2.8	0	0	0	0	0	0	BH
4	4.11	60	24	2	8.5	181	33	0.07	0.18	0.21	0.31	0.4	0	0	0	0	0	0	BH
5	4.59	15	20	0	8.1	168	8	0.02	0.15	0.13	0.19	2.5	0.168	0.075	0	0	0	0	RIVER
6	4.19	28	26	0	7.7	181	15	0.02	0.22	0.42	0.63	1.1	0	0	0	0	0	0	BH
7	4.25	15	22	0	7.3	195	8	0.02	0.1	1	1.5	2.8	0.084	0.087	0	0	0	0	RIVER
8	3.82	311	22	3	7.2	252	171	0.25	0.43	1.17	1.75	0.8	0	0	0.775	0	0	0	BH

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9	5.25	52	21	4	7.5	212	29	0.05	0.17	0.12	0.18	0.7	0	0	0.033	0	0	0	BH
10	5.6	4.93	22	10	6.4	197	2,712	0.36	0.56	1.33	2	3	0	0.022	0.155	0	0	0	RIVER
11	4.6	20	21	1	8.2	220	11	0.06	0.1	0.63	0.94	3.2	0	0	0	0	0	0	BH
12	3.67	243	22	1	9	255	134	0.25	0.55	0.13	0.19	2.6	0	0	0	0	0	0	BH
13	6.1	12,470	21	25	8.1	85	6,859	0.42	0.63	1.46	2.19	0	0	0.008	0.05	0	0	0	BH
14	6.49	23,100	23	65	3.5	16	12,705	0.32	0.7	1.88	2.81	3.6	0.084	0.212	0.043	0	0	0	RIVER
15	5.26	553	24	10	7.7	151	304	0.56	0.45	0.25	0.38	0	0	0	0	0	0	0	BH
16	3.83	69	21	0	8.5	251	38	0.08	0.34	0.33	0.5	0.7	0	0.023	0.022	0	0	0	BH
17	3.8	120	22	0	8.6	263	66	0.17	0.36	0.54	0.81	2	0	0	0	0	0	0	BH
18	3.95	56	21	2	7.9	195	31	0.04	0.24	0.13	0.19	2.7	0	0	0.038	0	0	0	BH
19	4	90	20	3	7.8	204	50	0.23	0.36	0.33	0.5	3.2	0	0	0	0	0	0	BH
20	3.39	183	20	3	8.3	222	101	0.19	0.35	0.21	0.31	2	0	0.013	0.151	0	0	0	BH
21	4.68	20	21	2	6	184	11	0.04	0.23	0.13	0.19	2.7	0.185	0	0	0	0	0	RIVER
22	3.49	233	22	1	8.5	228	128	0.07	0.25	0.25	0.38	3.4	0	0.116	0	0	0	0	BH
23	4.88	133	22	1	6.8	183	73	0.2	0.32	0.29	0.44	2.4	0	0.018	0	0.03	0	0	BH
24	6.47	31,700	27	78	4	130	17,435	0.35	0.75	1.5	2.25	1.6	0	0.006	0	0	0	0	RIVER
25	4.86	39	22	1	7	166	21	0.03	0.15	0.46	0.69	3.6	0	0	0	0	0	0	BH
26	5.26	61	23	2	7.2	176	34	0.07	0.25	0.79	1.19	1.7	0	0.013	0	0	0	0	BH
27	3.98	87	22	2	9.1	228	48	0.08	0.29	0.17	0.25	0.9	0.034	0	0	0	0	0	BH
28	3.55	40	22	0	7.2	223	22	0.15	0.34	0.54	0.81	1.3	0	0	0	0	0	0	RIVER
29	4.53	21	22	0	8	197	12	0.03	0.13	0.13	0.19	2.7	0.067	0.079	0	0	0	0	RIVER
30	3.99	14	23	0	9.8	211	8	0.02	0.1	0.25	0.38	1.8	0	0	0	0	0	0	BH
31	6.19	18,080	22.5	15	6.8	127	9,928	0.3	0.68	1.67	2.5	0.2	0.117	0.078	0.144	0	0	0	RIVER

The ideal limit state vi and standard si values of all the parameters were sourced which enable us compute for the relative weight 1/s and unit weight wi of each parameter as shown in Table 9.

Table 9: Unit Weight of Individual Parameters from the Permissible Standards and Ideal Limit State with heavy metals

	pH	Conductivity (µs)	Temp (^{0}C)	Turbidity (NTU)	DO (mg/l)	Redox Potential (mV)	TDS mg/l	PO_4^{3-} (mg/l)	Ammonia NH4+ mg/l	BOD5 (mg/l)	COD (mg/l)	E-Coli (MPN/100ml) *10^2	Lead (Pb)	Cd (mg/l)	Mn (mg/l)	Cu (mg/l)	Hg (mg/l)	Cr (mg/l)	
Standard Si	6.5	300	20	5	4	650	500	3	0.50	5	3.00	10	0.05	0.003	0.05	0.05	0.01	0.1	
Vi	7.5	0.05	6	0.1	100	300	50	0.1	0	0	0	0	0	0	0	0	0	0	∑
Relative Weight 1/s	0.154	0.003	0.050	0.200	0.250	0.002	0.002	0.333	2.000	0.200	0.333	0.100	20.000	333.333	20.000	20.000	100.000	10.000	506.96
Unit Weight Wi	3E-04	7E-06	1E-04	4E-04	5E-04	3E-06	4E-06	7E-04	4E-03	4E-04	7E-04	2E-04	4E-02	7E-01	4E-02	4E-02	2E-01	2E-02	1.00

However the computation of the quality (Q-values) of all the parameters were done and was tabulated in Table 10.

Table 10: Quality index of Individual Parameters (Q-values) with heavy metals

Qi	pH	Conductivity (µs)	Temp (^{0}C)	Turbidity (NTU)	DO (mg/l)	Redox Potential (mV)	TDS mg/l	PO_4^{3-} (mg/l)	Ammonia NH4+ mg/l	BOD5 (mg/l)	COD (mg/l)	E-Coli (MPN/ 100ml)*10^2	Lead (Pb)	Cd (mg/l)	Mn (mg/l)	Cu (mg/l)	Hg (mg/l)	Cr (mg/l)
Q1	272.00	15.99	114.29	-2.04	95.42	-38.00	-5.33	-1.72	56.00	5.00	12.67	8.00	234.00	0.00	0.00	0.00	0.00	0.00
Q2	390.00	97.33	132.14	100.00	95.83	-26.86	24.67	6.21	76.00	2.60	6.33	35.00	0.00	0.00	210.00	0.00	0.00	0.00
Q3	295.00	2.98	114.29	-2.04	95.83	-37.14	-10.00	-3.10	20.00	9.20	23.00	28.00	0.00	0.00	0.00	0.00	0.00	0.00
Q4	339.00	19.99	128.57	38.78	95.31	-34.00	-3.78	-1.03	36.00	4.20	10.33	4.00	0.00	0.00	0.00	0.00	0.00	0.00
Q5	291.00	4.98	100.00	-2.04	95.73	-37.71	-9.33	-2.76	30.00	2.60	6.33	25.00	336.00	2500.00	0.00	0.00	0.00	0.00
Q6	331.00	9.32	142.86	-2.04	96.15	-34.00	-7.78	-2.76	44.00	8.40	21.00	11.00	0.00	0.00	0.00	0.00	0.00	0.00
Q7	325.00	4.98	114.29	-2.04	96.56	-30.00	-9.33	-2.76	20.00	20.00	50.00	28.00	168.00	2900.00	0.00	0.00	0.00	0.00

Q8	368.00	103.67	114.29	59.18	96.67	-13.71	26.89	5.17	86.00	23.40	58.33	8.00	0.00	0.00	1550.00	0.00	0.00	0.00
Q9	225.00	17.32	107.14	79.59	96.35	-25.14	-4.67	-1.72	34.00	2.40	6.00	7.00	0.00	0.00	66.00	0.00	0.00	0.00
Q10	190.00	1.63	114.29	202.04	97.50	-29.43	591.56	8.97	112.00	26.60	66.67	30.00	0.00	733.33	310.00	0.00	0.00	0.00
Q11	290.00	6.65	107.14	18.37	95.63	-22.86	-8.67	-1.38	20.00	12.60	31.33	32.00	0.00	0.00	0.00	0.00	0.00	0.00
Q12	383.00	81.00	114.29	18.37	94.79	-12.86	18.67	5.17	110.00	2.60	6.33	26.00	0.00	0.00	0.00	0.00	0.00	0.00
Q13	140.00	4157.34	107.14	508.16	95.73	-61.43	1513.11	11.03	126.00	29.20	73.00	0.00	0.00	266.67	100.00	0.00	0.00	0.00
Q14	101.00	7701.27	121.43	1324.49	100.52	-81.14	2812.22	7.59	140.00	37.60	93.67	36.00	168.00	7066.67	86.00	0.00	0.00	0.00
Q15	224.00	184.35	128.57	202.04	96.15	-42.57	56.44	15.86	90.00	5.00	12.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Q16	367.00	22.99	107.14	-2.04	95.31	-14.00	-2.67	-0.69	68.00	6.60	16.67	7.00	0.00	766.67	44.00	0.00	0.00	0.00
Q17	370.00	39.99	114.29	-2.04	95.21	-10.57	3.56	2.41	72.00	10.80	27.00	20.00	0.00	0.00	0.00	0.00	0.00	0.00
Q18	355.00	18.65	107.14	38.78	95.94	-30.00	-4.22	-2.07	48.00	2.60	6.33	27.00	0.00	0.00	76.00	0.00	0.00	0.00
Q19	350.00	29.99	100.00	59.18	96.04	-27.43	0.00	4.48	72.00	6.60	16.67	32.00	0.00	0.00	0.00	0.00	0.00	0.00
Q20	411.00	60.99	100.00	59.18	95.52	-22.29	11.33	3.10	70.00	4.20	10.33	20.00	0.00	433.33	302.00	0.00	0.00	0.00
Q21	282.00	6.65	107.14	38.78	97.92	-33.14	-8.67	-2.07	46.00	2.60	6.33	27.00	370.00	0.00	0.00	0.00	0.00	0.00
Q22	401.00	77.66	114.29	18.37	95.31	-20.57	17.33	-1.03	50.00	5.00	12.67	34.00	0.00	3866.67	0.00	0.00	0.00	0.00
Q23	262.00	44.32	114.29	18.37	97.08	-33.43	5.11	3.45	64.00	5.80	14.67	24.00	0.00	600.00	0.00	60.00	0.00	0.00
Q24	103.00	10568.41	150.00	1589.80	100.00	-48.57	3863.33	8.62	150.00	30.00	75.00	16.00	0.00	200.00	0.00	0.00	0.00	0.00
Q25	264.00	12.99	114.29	18.37	96.88	-38.29	-6.44	-2.41	30.00	9.20	23.00	36.00	0.00	0.00	0.00	0.00	0.00	0.00
Q26	224.00	20.32	121.43	38.78	96.67	-35.43	-3.56	-1.03	50.00	15.80	39.67	17.00	0.00	433.33	0.00	0.00	0.00	0.00
Q27	352.00	28.99	114.29	38.78	94.69	-20.57	-0.44	-0.69	58.00	3.40	8.33	9.00	68.00	0.00	0.00	0.00	0.00	0.00
Q28	395.00	13.32	114.29	-2.04	96.67	-22.00	-6.22	1.72	68.00	10.80	27.00	13.00	0.00	0.00	0.00	0.00	0.00	0.00
Q29	297.00	6.98	114.29	-2.04	95.83	-29.43	-8.44	-2.41	26.00	2.60	6.33	27.00	134.00	2633.33	0.00	0.00	0.00	0.00
Q30	351.00	4.65	121.43	-2.04	93.96	-25.43	-9.33	-2.76	20.00	5.00	12.67	18.00	0.00	0.00	0.00	0.00	0.00	0.00
Q31	131.00	6027.65	117.86	304.08	97.08	-49.43	2195.11	6.90	136.00	33.40	83.33	2.00	234.00	2600.00	288.00	0.00	0.00	0.00

The water quality index WQI values for each of all the parameters and their sum up of the individual values yield the wqi value for each water sample collected was shown in Table 11. It also shown the status of the water quality and the source of water either borehole or river.

Table 11: Water Quality index for individual Parameters and Water Samples Status with heavy metals

WQIi	pH	Conductivity (µs)	Temp (^{0}C)	Turbidity (NTU)	DO (mg/l)	Redox Potential (mV)	TDS mg/l	PO_4^{3-} (mg/l)	Ammonia NH_4^+ mg/l	BOD5 (mg/l)	COD (mg/l)	E-Coli (MPN/ 100ml)*10^2	Lead (Pb)	Cd (mg/l)	Mn (mg/l)	Cu (mg/l)	Hg (mg/l)	Cr (mg/l)	WQI	WATER QUALITY STATUS	SOURCE OF WATER
WQI1	0.08	0.00	0.01	0.00	0.05	0.00	0.00	0.00	0.22	0.00	0.01	0.00	9.23	0.00	0.00	0.00	0.00	0.00	9.46	EXCELLENT!	RIVER
WQI2	0.12	0.00	0.01	0.04	0.05	0.00	0.00	0.00	0.30	0.00	0.00	0.01	0.00	0.00	8.28	0.00	0.00	0.00	8.60	EXCELLENT!	BH
WQI3	0.09	0.00	0.01	0.00	0.05	0.00	0.00	0.00	0.08	0.00	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.10	EXCELLENT!	BH
WQI4	0.10	0.00	0.01	0.02	0.05	0.00	0.00	0.00	0.14	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15	EXCELLENT!	BH
WQI5	0.09	0.00	0.01	0.00	0.05	0.00	0.00	0.00	0.12	0.00	0.00	0.00	13.26	1643.79	0.00	0.00	0.00	0.00	1657.17	UNSUITABLE	RIVER
WQI6	0.10	0.00	0.01	0.00	0.05	0.00	0.00	0.00	0.17	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.19	EXCELLENT!	BH
WQI7	0.10	0.00	0.01	0.00	0.05	0.00	0.00	0.00	0.08	0.01	0.03	0.01	6.63	1906.79	0.00	0.00	0.00	0.00	1913.54	UNSUITABLE	RIVER
WQI8	0.11	0.00	0.01	0.02	0.05	0.00	0.00	0.00	0.34	0.01	0.04	0.00	0.00	0.00	61.15	0.00	0.00	0.00	61.54	POOR	BH
WQI9	0.07	0.00	0.01	0.03	0.05	0.00	0.00	0.00	0.13	0.00	0.00	0.00	0.00	0.00	2.60	0.00	0.00	0.00	2.74	EXCELLENT!	BH
WQI10	0.06	0.00	0.01	0.08	0.05	0.00	0.00	0.01	0.44	0.01	0.04	0.01	0.00	482.18	12.23	0.00	0.00	0.00	494.92	UNSUITABLE	RIVER
WQI11	0.09	0.00	0.01	0.01	0.05	0.00	0.00	0.00	0.08	0.00	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.11	EXCELLENT!	BH
WQI12	0.12	0.00	0.01	0.01	0.05	0.00	0.00	0.00	0.43	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.45	EXCELLENT!	BH
WQI13	0.04	0.03	0.01	0.20	0.05	0.00	0.01	0.01	0.50	0.01	0.05	0.00	0.00	175.34	3.95	0.00	0.00	0.00	179.85	UNSUITABLE	BH
WQI14	0.03	0.05	0.01	0.52	0.05	0.00	0.01	0.00	0.55	0.01	0.06	0.01	6.63	4646.43	3.39	0.00	0.00	0.00	4657.11	UNSUITABLE	RIVER
WQI15	0.07	0.00	0.01	0.08	0.05	0.00	0.00	0.01	0.36	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.38	EXCELLENT!	BH
WQI16	0.11	0.00	0.01	0.00	0.05	0.00	0.00	0.00	0.27	0.00	0.01	0.00	0.00	504.09	1.74	0.00	0.00	0.00	506.11	UNSUITABLE	BH
WQI17	0.11	0.00	0.01	0.00	0.05	0.00	0.00	0.00	0.28	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.31	EXCELLENT!	BH
WQI18	0.11	0.00	0.01	0.02	0.05	0.00	0.00	0.00	0.19	0.00	0.00	0.01	0.00	0.00	3.00	0.00	0.00	0.00	3.20	EXCELLENT!	BH
WQI19	0.11	0.00	0.01	0.02	0.05	0.00	0.00	0.00	0.28	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.31	EXCELLENT!	BH
WQI20	0.12	0.00	0.01	0.02	0.05	0.00	0.00	0.00	0.28	0.00	0.01	0.00	0.00	284.92	11.91	0.00	0.00	0.00	297.13	UNSUITABLE	BH
WQI21	0.09	0.00	0.01	0.02	0.05	0.00	0.00	0.00	0.18	0.00	0.00	0.01	14.60	0.00	0.00	0.00	0.00	0.00	14.79	EXCELLENT!	RIVER
WQI22	0.12	0.00	0.01	0.01	0.05	0.00	0.00	0.00	0.20	0.00	0.01	0.01	0.00	2542.39	0.00	0.00	0.00	0.00	2542.60	UNSUITABLE	BH
WQI23	0.08	0.00	0.01	0.01	0.05	0.00	0.00	0.00	0.25	0.00	0.01	0.00	0.00	394.51	0.00	2.37	0.00	0.00	397.15	UNSUITABLE	BH
WQI24	0.03	0.07	0.01	0.63	0.05	0.00	0.02	0.01	0.59	0.01	0.05	0.00	0.00	131.50	0.00	0.00	0.00	0.00	132.18	UNSUITABLE	RIVER
WQI25	0.08	0.00	0.01	0.01	0.05	0.00	0.00	0.00	0.12	0.00	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.14	EXCELLENT!	BH
WQI26	0.07	0.00	0.01	0.02	0.05	0.00	0.00	0.00	0.20	0.01	0.03	0.00	0.00	284.92	0.00	0.00	0.00	0.00	285.15	UNSUITABLE	BH
WQI27	0.11	0.00	0.01	0.02	0.05	0.00	0.00	0.00	0.23	0.00	0.01	0.00	2.68	0.00	0.00	0.00	0.00	0.00	2.92	EXCELLENT!	BH

WQI28	0.12	0.00	0.01	0.00	0.05	0.00	0.00	0.00	0.27	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.29	EXCELLENT!	RIVER
WQI29	0.09	0.00	0.01	0.00	0.05	0.00	0.00	0.00	0.10	0.00	0.00	0.01	5.29	1731.45	0.00	0.00	0.00	0.00	1736.85	UNSUITABLE	RIVER
WQI30	0.11	0.00	0.01	0.00	0.05	0.00	0.00	0.00	0.08	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	EXCELLENT!	BH
WQI31	0.04	0.04	0.01	0.12	0.05	0.00	0.01	0.00	0.54	0.01	0.05	0.00	9.23	1709.54	11.36	0.00	0.00	0.00	1730.75	UNSUITABLE	RIVER

This research is targeted at getting the actual state of water quality from different water sources in Rivers state, used for everyday activities, which is basically surface and groundwater. Samples from most of their major rivers and boreholes from selected local government areas were collected and in all, a total of 31 samples were considered and analyzed. Out of the 31 samples of water collected, 11 were rivers which are useful to the people of Rivers state, both for domestic and aquatic use and other agro businesses especially Woji and Portharcourt rivers which are good for oil transportation and other businesses. While most of their boreholes are for drinking, domestic, carwash and other uses, the consumption of treated bottled water is on the high side, and most people believed that some of their waters are salt water in the terms of stream/river.

Secondly, this study will check their entire claim by interpreting the result to know the true state of the water samples collected and advice where appropriate.

However, the method used in analyzing the water sample will be explain in detail based on the contributions of each parameter and the total contribution of all the parameters involved. Consequently, the conclusion will be drawn and recommendation will be suggested.

The Google earth study area topography is shown in Figure 1, where the collecting points of water samples were indicated in blue color placemark and the landmark name of the location. Therefore, easy location were imprinted on the drawline, which is a traceable line of distance measurement and showing how the study started and ended at every field trip, and the total valid point that was used is 31 point.

Table 3 presents the field survey data of the study area showing the full details of the collection points. The table 3 shows that 31 samples were used and 20 were borehole samples while 11 were Rivers samples.

However, the local government that was cut across are: Ndoni, Ahoada East, Emohua, Ikwere, Obio/Akpor, portharcourt, Oyigbo, Etche, Okirika, Tai, Gokhana, Khana and Eleme. So in all, thirteen local governments were significantly touched and about nine of them were based on density of population. We also called for the sample analysis to know its quality in regards to drinking purpose using water quality index WQI by Armah et al., 2012 and FLINN 2018, the water sample used was characterized in physical, chemical and Bio-bacteriological parameter state, with addition of heavy metals. We considered it in two stages, firstly without heavy metal and secondly with heavy metals or parameters.

From the first stage, the twelve (12) physico-chemical parameters are shown in Table 4 as observed experimental parameters value for the tested water samples which are Ph, conductivity, temperature, turbidity, dissolve oxygen, Redox potential, total dissolved solid, phosphate, ammonia, biological oxygen demand, chemical oxygen demand, and E-coli were all considered in the computation of WQI for each sample of water collected from surface and underground water. Source of water was also indicated at the last column of the table 4 as surface water with colour for those from stream and BH for those from Borehole i.e. groundwater.

The twelve observed experimental parameter were studied further in order of their limit or permissible standard values which enable the study to compute for the unit weight, ***wi*** of each parameter. Their description is as follows; According to WHO (2011) Standards, its permissible range in drinking water is 75 mg/L for Calcium (Ca), America agreed that the mean of calcium for water is 6.8 to 135 mg/L.

The pH value of drinking water supply varies between 6.5 to 8.5. Typical ideal value for Tap water is 7.5.

Electrical conductivity for drinking water is 200 to 800 µs/cm while distilled and deionized water is 0.05µs/cm.

The normal temperature for drinking water is room temperature that is (20^0c/68^0F) and on chilled cold or the ideal value is (6^0c or 0^0c/43^0F).

In the vain WHO state that turbidity of drinking water shouldn't be more than 5NTU and the ideal value is 0.1 for EPA USA standard.

DO that should be maintain in the water where living organism habits should be minimum of 4mg/L due to high temperature but when the temperature reduce the DO increase vias vasa upto 100mg/L. And for drinking water adiequate disinfected ORP should be 650µv and for distilled water ORP is +300uv.

According to the BIS, the ideal TDS for drinking water is less than 300mg/L and the allowable limit is 600mg/L.

According to WHO standards the permissible Phosphate limit in drinking water is 50µg/L or 3mg/L while the ideal value is 0.1mg/L. And the permissible limit of Ammonia in drinking water is 0.5ppm, ideal is zero.

BOD value of drinking water is 1.2ppm when the level of the BOD after 5 days is of the range 3 – 5 ppm, the water can be considered moderately clean but polluted water has a BOD value in the range of 6- 9 ppm. So therefore the ideal BOD_5 is ranges from 0 – 1ppm.

The chemical oxygen demand COD value for river water were high when compared to ground water with value of (BOD 9.5 mg/L) and COD is 19.2mg/L while the permissible limit is 5mg/L for BOD and 10mg/L for COD for drinking water supply COD is less than 3mg/L.

According to WHO a zero count of E-coli per 100mL of water is considered safe for drinking while a count of 1 to 10 MPN/100mL is regarded as low risk.

These values were categorized as S_i standard value, V_i the ideal limit state value. Sn enable the calculation of K the relative weight and unit weight W_i. However, the table for the expression of computation is as shown in Table5. Then S_i and V_0 which is the experimental value and V_i the ideal was use for the computation of the quality of individual parameters *Q* values without considering the heavy metal and this computation action was shown in Table 6 for each and every 12 parameters.

Finally, the Q-value and the unit weight of Table 5 was used for the computation of water quality index WQI for the twelve parameters for all the thirty-one water sample both surface (river) and groundwater (borehole) as can be seen in Table 7.

The second stage of this water quality index analysis considered the heavy metals which brought all the tested parameters to 18 parameters. Six additions are the heavy metals called Pb, Cd, Mu, Cu, Hg, and Cv as seen in Table 8 and most water sample do not have it.
The processes are the same but the value of heavy metal in water should be condemned in serious term because of its harmful nature to human and aquatic life. It's better to be absent, or at a very small or insignificant quantity as we can see in Table 9.
The computation of the quality index of each of the water parameters with heavy metals were presented in Table 10 and the Q-value was used to calculate the water quality index for each of the water parameters. The value of the WQIi were presented in Table 11 and their summation yielded the actual water quality index for each water sample. This second stage shows more of excellent and unsuitable status of water quality, unlike the first stage where we had water quality status of the middle ranges of good, poor and very poor in addition to the excellent and unsuitable water status.

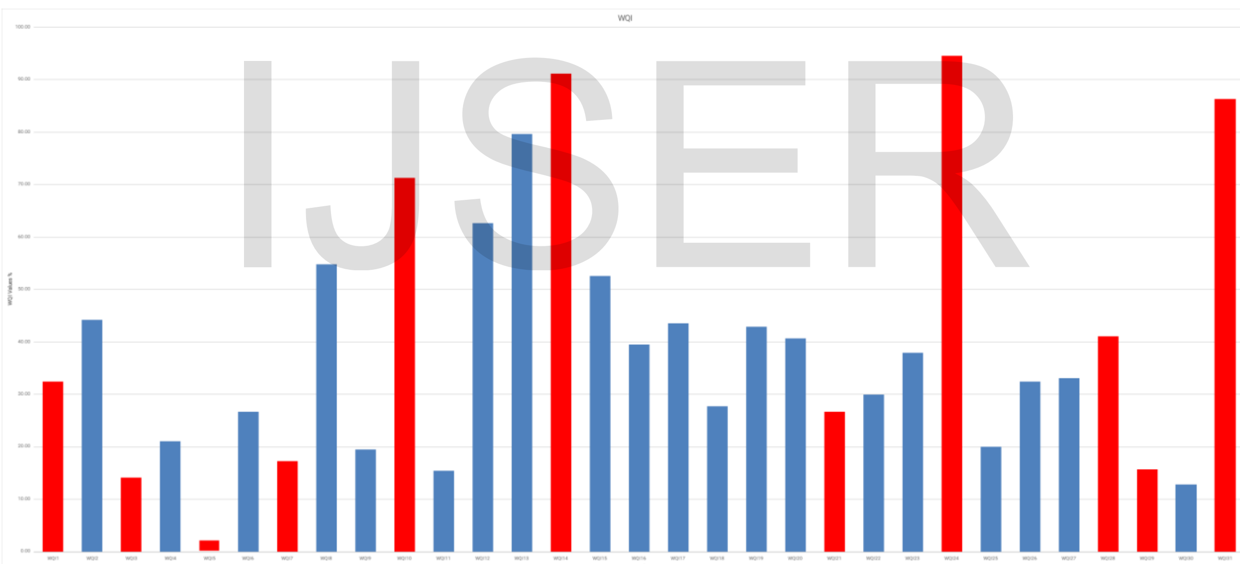

Figure 2: Water Sample Quality index for Borehole and River (First Stage)

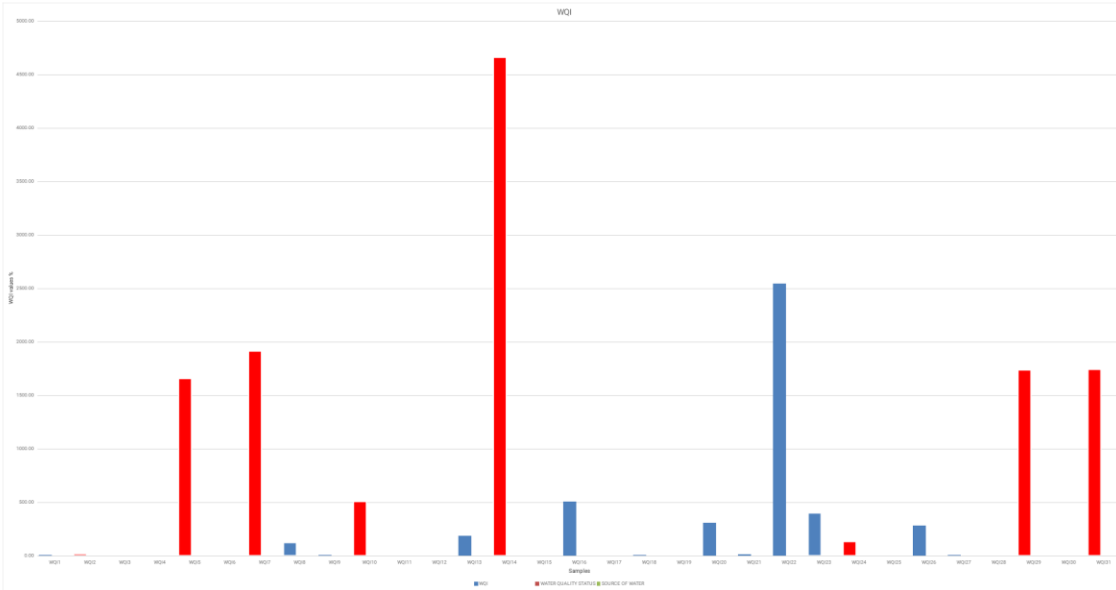

Figure 3: Water Sample Quality index considering heavy metals for Borehole and River (Second Stage)

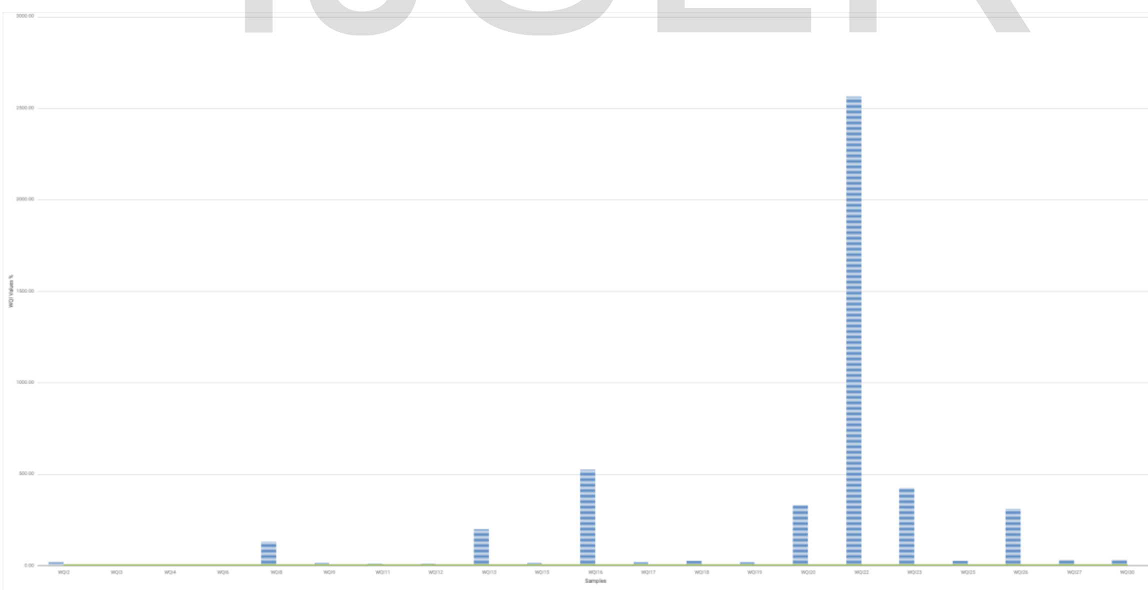

Figure 4: Water Sample Quality index considering heavy metals for Borehole

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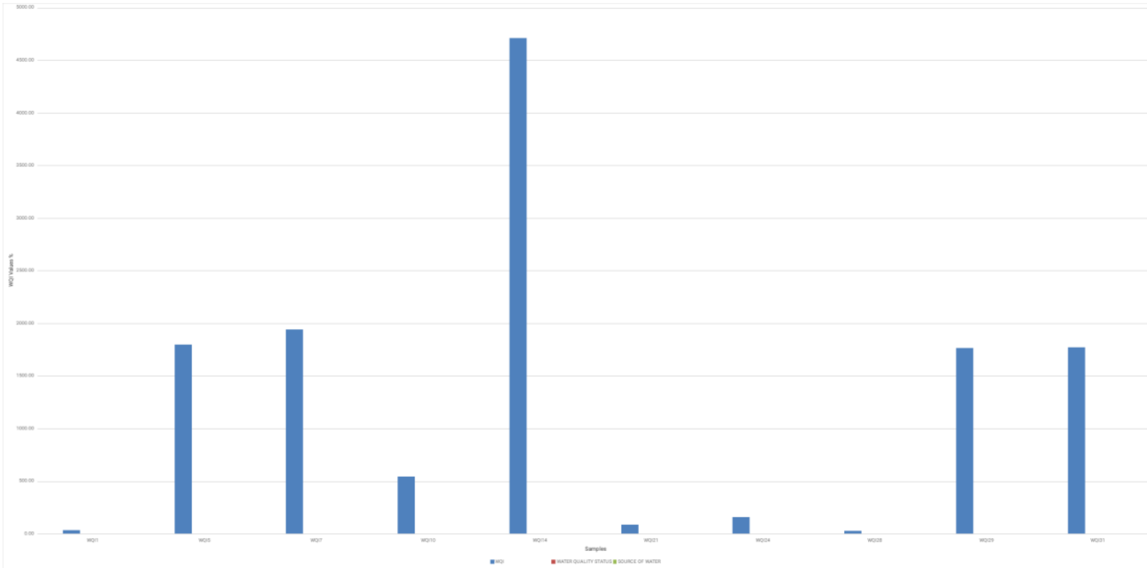

Figure 5: Water Sample Quality index considering heavy metals for River

The presence of heavy metals gave us a big factor because if any water sample do not contain any of them, it will automatically move to excellent position and if it contains it, it will move to unsuitable position and vice versa. They were presented in graphic form in Figures 2 – 5. Figure 2, show results of water quality status of the thirty-one (31) water samples collected from the thirty-one (31) sample locations (study area). Eleven (11) water samples were collected from the river (surface water), shown with red color while twenty (20) were collected from Boreholes (groundwater), depicted with Blue color in the graph. The WQI values (%) was plotted against WQIi of water samples. At this point, heavy metals were not considered and the WQI values in percentages were less than 100% with well distributed range. They almost show all the statuses: Excellent, good, poor, very poor and unsuitable and this is a full presentation of the first stage.

The second stage where the heavy metals were considered because some of the water samples were found to be constant in one or two of the metals. That was why we calculated them by considering all at the same time. The factor result reacted badly on the middle range of water quality status and this can be easily seen in Figure 3. Only borehole sample 22, WQI_{22} has a presence of lead, pb in it and the water is unsuitable and others that appeared in the graph except WQI_8 which is poor and very tiny. WQI_{13}, WQI_{16}, WQI_{20}, WQI_{23} and WQI_{26}; That is six out of 21 samples which turns out to be excellent.

WQI_5, WQI_7, WQI_{10}, WQI_{14}, WQI_{24}, WQI_{29} and WQI_{31} are surface water samples and were found to be unsuitable. That is seven (7) out of Eleven (11) that have Excellent and for obvious reason, the two water samples (River and Borehole) were separated and plotted as shown in Figures 4 and 5.

Conclusion

The weighted Arithmetic method was used to calculate the water quality index successfully. The study shows that the presence of heavy metals increased the values of water quality index. During the beginning of rainy season, we observed that a good number of water samples in River State were good and Excellent without the use of heavy metal in the computation, but we observed more of unsuitable water samples when heavy metals were considered. We observed that some samples that originally had no heavy metals were affected by the factor of the relative unit weight and pushed the WQI to unsuitable water status. Therefore, we recommend that WQI should be computed considering only parameters that is present in each sample based on heavy metals.

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