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Inventory And Quality Evaluation Of Some Water Sources In Isuikwuato, Uturu And Okigwe Communities, Abia State, Nigeria.

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Abstract
An inventory and quality examination of water sources in Isuikwuato, Uturu and Okigwe communities were carried out between May and December, 2016. Water sources comprising boreholes, streams, rivers, a spring and a well were enumerated in Isuikwuato. 1 spring, 7 streams, and 5 boreholes were noted for Uturu. The records for Oki gwe were 14 bore holes, 3 streams and 1 well. Significant differences were not noticed in most of the parameters across the the water sources and their locations and the ranges were water temperature 25.77± 1.03 to 27.77 ± 1.44°C, Conductivity 34.78 ± 10.51 to 41.69 µcm^{-1} , Total dissolved solids (TDS) 23.46 ± 8.21 to 28.03 ± 8.28mgl^{-1}
, pH 6.09 ± 0.86 to 6.53 ± 0.41, Hardness 72.27 ± 41.53 to 131.89 ± 16.27mgl^{-1} , Alkalinity 38.64 ± 14.15 to 57.78 ± 22.79 mgl^{-1} , Dissolved oxygen (DO) 6.84 ± 0.72 to 8.40 ± 1.57 mgl^{-1} , Biochemical oxygen demand (BOD) 2.70 ± 0.61 to 3.95 ± 3.70 mgl^{-1}, Silica 0.26 ± 0.44 to 0.44 ± 0.40 mgl^{-1}, Sulphate 16.18 ± 0.11 to 21.31 ± 6.50 mgl^{-1}, Total phosphorus 0.04 ± 0.004 ± 0.019 mgl^{-1}, Chloride 25.24 ± 13.30 to 31.56 ± 10.67 mgl^{-1}, Nitrate 0.135 ± 0.15 to 0.29 ± 0.16, mgl^{-1} Magnesium 0.316 ± 0.19 to 0.65 ± 0.15 mgl^{-1}, Potassium 1.26 ± 0.78 to 1.30 ± 0.103 mgl^{-1}, Sodium 0.99 ± 0.12 to 1.60mgl^{-1} ,Calcium 0.14 ± 0.11 to 0.27 ± 0.46 mgl^{-1} , and Total Coliform (MPN) 1.57 X 10 ± 38 to 1.97 X 10 ± 18. All stipulated parameters by SON, WHO, EU and USEPA were within permissible limits except total Coliform which exceeded SON's limit in all samples. The parameters also passed the FMNEV guidelines for carbonate beverage, confectionary and dairy and 47.92%the allowable levels for bakery while hardness and chloride were above limits for brewery. The recorded cationic order Na>K>Mg>Ca was expected where sodium dominated in surface and underground water because sodium is usually retained by soils and living organisms. Considering the water quality index (WQI) , 6.25% of the water sources were excellent, 14.58% poor, 25% very poor and 47.92% unsuitable for drinking and domestic purposes. Tables of of the quality of all the water sources are provided.

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I. Introduction

Safe drinking water, sanitation and good hygiene are basal to health, survival, growth and development, there is an elephantine task facing the world and Nigeria today, that of reducing by half, the population of people without sustainable access to portable drinking water in keeping with the stipulations of the minelium development goal (MDG) as opined by WHO (2005). Contamination of water the world over has been a major subject of discussion (Onuobia et al. 2013; Umeham et al., 2012). Drinking water comes from two (2) different sources; water from streams, rivers and lakes (surface water) and water from springs and boreholes (ground water). Pollution of ground water though seldomly encountered is usually attributable to industrial though seldomly encountered is usually attributable to industrial effluents and municipal waste water especially in many industrial clusters in Nigeria Groundwater is difficult to remediate except in small defined areas, therefore the emphasis has to be on prevention.

Africa has recorded many deaths due to water bone infections due to location of lavatories next to water sources. The target of the new Nigerian standard for drinking water quality is to help improve the process of upgrading non-protected water systems and improving the management of all drinking water system in the country (SON, 2004). In the same vein WHO (2005) conducted a programme on water resources in 12 out of 39 states of Nigeria for microorganism, faecal streptococci, arsenic and nitrate levels. Sake drinking water is a basic need for good health and is also a basic right of humans. Water is already a limiting resource in many parts of the world due to increased population, urbanization and climate change (Jackson et al., 2001). Serious ill health can be caused by faeces passed or washed into the river, stream, pool or if allowed to seep into a well or borehole (Cheesbrough, 2006).

In Nigeria, improving the quality of drinking water has necessitated better management strategies and sanitation organizations. These goals are achievable with requisite baseline information. This study is there an addition to the existing literature and baseline for the Northern part of Abia State, Nigeria; its target is to locate and enumerate the different water sources, determine the physical, chemical and bacteriological characteristics. It will also compare, the quality with WHO, FEPA, EEC and SON. Lastly the water quality index (WQI) for the different water sources will be calculated.

II. Materials And Methods

Isuikwuato LGA is in Abia State, Nigeria located between coordinates 5^0 32^0N 7^0 29^{01}E.

It has an estimated population of 50,000 people with iron ore and kaolin as natural resources. Oil pipe lines carrying crude and refined products transverse the area and cases of burst pipes with its consequent effects on the local economy and environment have been reported (Umeham, 2014). Enumeration of the water sources for the inhabitants was carried out between May and August, 2016. This was followed by subjecting representative samples to physico – chemical analyses. Samples for various physico-chemical assays were taken from the listed water sources as tabulated in Tables 1, 2 and 3 between May and December, 2016 irrespective of seasonal influences as ground water comprised over seventy five percent of the samples and usually not prone to seasonal fluctuations (Umeham, Etesim, Opara and Ubah, 2002).

Table 1. Location, type and code assigned to sampled water sources in Isuikwato

S/no.	Location	type	code
1.	Ovim	Borehole	BH10
2.	Ahaba Imenyi	Borehole	BH11
3.	Amaiyi	Borehole	BH12
4.	Eluama	Borehole	BH 13
5.	Eke Amiyi Uhu	Borehole	BH 14
6.	Amaba	Borehole	BH 15
7.	Umuokogbuo	Borehole	BH 16
8.	Umuobiala	Borehole	BH 17
9.	Eke Amiyiuhu	Borehole	BH 18
10	Amiyi Obilohia	Borehole	BH19
11.	Ovim	Stream	STR9
12.	Ahaba Imenyi	Stream	STR10
13.	Amiyi	Stream	STR11
14.	Amaogudu	Stream	STR12
15.	Ahahia Ahaba	Stream	STR13
16.	Eluama	Stream	STR14
17.	Eke Amiyi Uhu	Stream	STR15
18.	Umuasua	Stream	STR16
19.	Umuokogbuo	Stream	STR17
20.	Umuobiala	Stream	STR18
21.	Eke Amiyiuhu	Stream	STR19
22.	Amiyi Obilohia	Stream	STR20
23.	Isiala Ezera	River	River2
24.	Amuta	River	River3
25.	Umuokogbuo	Well	Well2
26.	Amuta	Spring	SPR4

Table 2- Legend, name, location and preliminary observation on sampled water sources in Uturu

S/no & Code	Name	Location	Preliminary observation
1. SPR1	Nwaogba Spring	Owerri-isinabo	Drinking water source
2. STR1	Ihube Stream	Owerri-Isinabo	Laundry, bathing, cleaning purposes
3. BH1	Country cave borehole	Country Cave	Drinking / all purpose
4. BH 2	Lodge borehole	Outside Country cave	Drinking/all purpose
5. BH 4	M Brothers borehole	M Bro Sec. School	Drinking/All purpose
6. BH 3	Aku River	Onu-Aku village	Drinking, laundry, car wash
7. River 1	Atuma Stream	Ukwuokwe	Drinking/other purposes
8. STR 2	Atuma Stream	Umuamara	Drinking/other purposes
9. STR 3	Edee Stream	Nvurunvu	Muddy, Drinking/other purposes
10. STR 4	Ihuku Stream	Ukwunwangwu	Clean, drinking/other purposes
11. STR 5	Ihuku Stream	Amanaku – Eziama	Water board extraction point
12. STR 6	Borehole	Ahia ohuru	Drinking/other purposes
13. BH 5		Pace Lodge	UPGATE, ABSU hostel

Table 3. – Legend, name and location of sampled water sources in Okigwe

S/no.	Code	Name	Location / Name
1.	BH6	Borehole	Methodist Church

2.	BH7	Borehole	Umueze
3.	BH8	Borehole	Babae
4.	BH9	Borehole	Owoh
5.	Str7	Stream	Iyichi
6.	SPR2	Spring	Machine gun
7.	SPR3	Spring	Akoma Onuwa spring
8.	STR8	Stream	Umueze
9.	Well1	well	Obala

Water samples were collected in 1L plastic acid-washed bottles and transported to the laboratory in a cooler box containing ice. In the laboratory, water samples were analysed for the following parameters: Air-shade temperature, Surface Water Temperature, Electrical conductivity, Total Dissolved Solid, Total Hardness, Total Alkalinity, Dissolved Oxygen, Biochemical Oxygen Demand, Chloride, Nitrate, Sulphate, Silica, Total phosphorus, Ortho-phosphate phosphorus, Potassium, Sodium, Calcium, Magnesium, Zinc, Iron, and Manganese. The parameters were analysed using the standard limnological methods as described by Wetzel and Likens (2000). Analysis of all samples commenced within 24 hours of sampling.

The most probable number technique was used for the enumeration of total coliform in the water samples (Cheesborough,2006). Physical measurement readings, chemical concentrations and MPN were statistically subjected to mean ± SD, ANOVA and MPN calculations.

For the calculation of water quality index, all parameters were used. The WQI was calculated using the Nigerian drinking water Quality Index method classified the water quality according to the degree of purity by using the most commonly measured water quality variables. The method has been widely used and the calculation of WQI was made by Tyagi *et al.* (2013) using the following equation.

$$WQI = \sum QiWi/\sum Wi$$

The quality rating scale (Qi) for each parameter is calculated by using this expression:

$$Qi = 100[(Vi - Vo/Si - Vo)]$$

Where:
Vi is estimated concentration of the parameter in the analysed water
Vo is the ideal value of this parameter in pure water. Vo = 0 (except pH = 7.0 and DO = 14.6mg/l)
Si is recommended standard value of ith parameter.
The unit weight (Wi) for each water quality parameter is calculated by using the following formula:
Wi = K/Si
Where K= proportionality constant

III. Result

Sequel to the fact that this investigation anchored on Isuikwuato LGA, with neighbouring Uturu and Okigwe for comparison purposes, her different water resources were enumerated and presented as Table 4.

The overall picture of the recorded levels of the investigated parameters of the water sources in Isuikwuato, Uturu and Okigwe communities is presented in tabular form (mean + SD) as Table 5. and also compares the physico-chemical parameters with SON (2007), WHO (2012) EU and USEPA (2012) standards. The physico-chemical characteristics are compared with FMNEV water quality guidelines for food beverage industry (FMNEV, 2003) in Table 6. Results of the analysis of variance test conducted on streams and boreholes in Uturu, Isuikwuato and Okigwe communities are presented in tables 7 and 8.Table 9 holds ANOVA calculations for pooled samples from Uturu Isuikwuato and Okigwe. Water quality index calculations of various groups explained by the table captions have been presented in Table 10. Table 11 summarises water quality index and water quality for the various water sources.

Table 4. Comprehensive list of water sources enumerated in Isuikwuato LGA, Abia State, Nigeria.

S/NO	COMMUNITY	BORE HOLE	STREAM / SPRING	OTHERS	REMARKS
1	OVIM	34	13	1 RIVER	Ovim is a very large community with 34 boreholes which serve as drinking water source, 13 streams for all purposes and 1 river for laundry.
2	AHABA IMENYI	10	4	------	Ahaba Imenyi consists of four (4) areas (Ehuma Ehum-3 bore holes, Ihe nzu-1 stream, Uzuakoli road-3 bore holes and 2 streams, Ama Ogudu 4 bore holes and 1 stream
3	AMAIYI	7	1	------	Amaiyi community of 7 bore holes and 1 stream serving all purposes.
4	AMAOGUDU	---	1	------	The only source of water serving all purposes in Amaogudu is Isi Iyinta stream.

5	AMAHIA AHABA		1		In Amahia Ahaba, the only source of water serving all purposes is Emeabonsi stream.
6	ELUAMA	16	4		In Eluama community, there are 16 private and commercial bore holes serving all purposes and four 4 streams for cooking, laundry and fishing (Adaoma and Agbosha streams).
7	EKE AMIYI UHU	3	5		The three (3) bore holes in this community serve the purpose of drinking, cooking and washing while the streams serve all purposes especially Iyi Odo stream were fishing activity is carried out.
8	AMABA	7	------	------	The only sources of water in this community are seven (7) bore holes, serving the purposes of drinking, cooking and washing.
9	UMUASUA	------	1	------	Umuasua community has only one stream (Iyi Oka stream) for fishing and laundry services.
10	ISIALA EZERA	------	------	1	The only source of water in Isiala Ezera community is Nkwara river for fishing and doing household chores.
11	UMUOKOGBUO	8	4	1 WATER WELL	Eight 8 bore holes for drinking, cooking and doing other household chores. Three 3 streams for laundry services, washing vehicles, and fishing (Iyi-Ohu stream) One 1 water well for laundry services
12	UMUOBIALA	11	3	------	Umuobiala community has eleven 11 bore holes for drinking, cooking and doing other household chores. There are also 3 streams for laundry, bathing and fishing (Iyi Okai stream).
13	EKE AMIYI UHU	3	5	------	Eke Amiyi Uhu community has three 3 bore holes for drinking, cooking and doing other household chores, in addition to five 5 streams for cooking, washing and fishing (Iyi Odo and Okwasu stream).
14	AMUTA		1	1	The sources of water in this community are Nneochi River (for fishing and laundry services) and Iyi Ama spring water (for drinking and doing all household chores).
15	AMIYI OBILOHIA	6	2	------	Amiyi Obilohia has six 6 bore holes for drinking and doing other household chores and 2 streams, serving all purposes.
16	MGBELU UMUNNEKWU	4	6	------	MGBELU UMUNNEKWU is an autonomous community consisting of four 4 villages. a. Amawo village has two 2 bore holes. b. Ohokabi village has a stram, a spring and a bore hole. c. Ugwunta village has three 3 streams and one 1 bore hole. d. Umezebele village share stream with their neighbouring village (Ugwunta) and has no bore holes.
17	UMUNNEKWU AGBO	3	6	1 WATER WELL	Umunnekwu Agbo community has 3 bore holes (for drinking and doing other household chore), six (6) streams (for cooking, washing and bathing) and one 1 water well for washing.
18	UMUANKWA	1	1	------	Umuankwa community has one 1 bore hole and one 1 stream for cooking and doing other household chores.
19	ECHIELE OTAMPA	6	5	------	There are 6 boreholes and 5 streams in Echiele Otampa community.
20	AKOBA	1	8	------	In Akoba community, there are 1 bore hole for cooking, washing and for doing other household chores, seven 7 streams for bathing and washing and one 1 spring for drinking, coking and doing other household chores.

Table 5. Physico Chemical parameters compared with SON, WHO, EU and USEPA

Parameter	Uturu	Isuikwuato	Okigwe	SON	WHO	EU	USEPA
Air shade temp. ^{O}C	29.76±1.66	27.31±1.12	30.44±2.24				
Water temp ^{o}C	27.77±1.44	25.77±1.03	26.89±2.52	ambient	-	25-28	-
Conductivity	41.69±11.65	35.22±12.01	34.78±10.51	1000	400	-	-
TDS mgl^{-1}	28.03±8.28	25.73±8.70	23.46±8.21	500	-	-	-
pH	6.53±0.41	6.33±0.45	6.09±0.86	6.5-8.5	7.0-8.5	6.5-8.5	
Hardness mgl^{-1}	77.46±62.54	72.27±41.53	131.89±160.27	500	-	-	-

Alkalinity mgl^{-1}	40.77±9.54	38.64±14.51	57.78±22.79				
BOD mgl^{-1}	3.19±1.13	3.95±3.78	2.70±0.61	4.0	4.0	-	-
DO mgl^{-1}	6.84±0.77	8.40±1.57	8.20±0.50	5.0	5.0	5.0	-
Silica mgl^{-1}	0.30±0.12	0.439±0.40	0.26±0.14				
Sulphate mgl^{-1}	21.31±6.50	16.18±10.11	18.11±10.18		100	4.0	
Total-P mgl^{-1}	0.012±0.02	0.070±0.19	0.004±0.004	100	200-400	5.0	250
Chloride mgl^{-1}	25.54±7.75	25.24±13.30	31.56±10.67	250	250		
Nitrate mgl^{-1}	0.135±0.15	0.290±0.16	0.17±0.12		5.0		
Magnesium mgl^{-1}	0.316±0.19	0.652± 0.15	0.393±0.36				
Potassium mgl^{-1}	1.258±0.78	1.303±.013	1.280±2.32				
Sodium mgl^{-1}	1.383±0.93	1.599±1.05	0.999±0.122				
Calcium mgl^{-1}	0.141±0.11	0.174±0.46	0.266±0.46				
Coliform(MPN)	1.97x10±18	1.67x10 ±53	1.57x10 ± 38	10			

Table 6. Concetration of physico-chemical parameters compared with FMNEV water quality guidelines for food beverage industry (FMNEV, 2003).

Parameter	Uturu	Isuikwuato	Okigwe	Brewing /Bakery	Carbonate beverage	Conf ectionary	Dairy
Air shade temp. ^{O}C	29.76±1.66	27.31±1.12	30.44±2.24				
Water temp ºC	27.77±1.44	25.77±1.03	26.89±2.52				-
Conductivity	41.69±11.65	35.22±12.01	34.78±10.51	13.0 bakery			-
TDS mgl^{-1}	28.03±8.28	25.73±8.70	23.46±8.21	800	850	<100	500
pH	6.53±0.41	6.33±0.45	6.09±0.86	<7	6.9	7.6	
Hardness mgl^{-1}	77.46±62.54	72.27±41.53	131.89±160.27	70 / NS	<250		80
Alkalinity mgl^{-1}	40.77±9.54	38.64±14.51	57.78±22.79				
BOD mgl^{-1}	3.19±1.13	3.95±3.78	2.70±0.61				-
DO mgl^{-1}	6.84±0.77	8.40±1.57	8.20±0.50				-
mgl^{-1}	0.30±0.12	0.439±0.40	0.26±0.14				
Sulphate mgl^{-1}	21.31±6.50	16.18±10.11	18.11±10.18				
Total-P mgl^{-1}	0.012±0.02	0.070±0.19	0.004±0.004				20
Chloride mgl^{-1}	25.54±7.75	25.24±13.30	31.56±10.67	20.6	250	250	30
Nitrate mgl^{-1}	0.135±0.15	0.290±0.16	0.17±0.12	10			
Magnesium mgl^{-1}	0.316±0.19	0.652±1.51	0.393±0.36				
Potassium mgl^{-1}	1.258±0.78	1.303±1.03	1.280±2.32				
Sodium mgl^{-1}	1.383±0.93	1.599±1.05	0.999±1.22				
Calcium mgl^{-1}	0.141±0.11	0.174±0.46	0.266±0.46				
Coliform(MPN)	1.97x10±18	1.67x102±53	1.57x10 ± 38				

Table 7. Results of Analysis of variance (ANOVA) to ascertain significant differences between all streams in Uturu, Isuikwuato and Okigwe.

S/N	Parameters	F-cal	F-tab	P	Decision
1	Air shade temp.	18.894	3.592	0.000	VS
2	Water temp	13.738	3.592	0.000	VS
3	Conductivity	1.535	3.592	0.124	NS
4	TDS	0.556	3.592	0.583	NS
5	pH	0.926	3.592	0.415	NS
6	Hardness	9.331	3.592	0.002	NS
7	Alkalinity	0.196	3.592	0.824	NS
8	BOD	0.457	3.592	0.641	NS
9	DO	1.11	3.592	0.352	NS
10	Silica	0.953	3.592	0.405	NS
11	Sulphate	0.928	3.592	0.414	NS
12	Total Phosph.	0.178	3.592	0.838	VS
13	Chloride	3.327	3.592	0.060	NS
14	Nitrate	1.682	3.592	0.216	NS
15	Magnesium	1.141	3.592	0.069	NS
16	Potassium	4.82	3.592	0.022	NS
17	Sodium	8.968	3.592	0.002	VS
18	Calcium	5.261	3.592	0.017	VS

* Significant ($P \leq 0.05$) (S)
** Very significant ($P \leq 0.01$) (VS)
$P > 0.05$ Not significant (NS)

Table 8. Results of Analysis of variance (ANOVA) to ascertain significant differences between all boreholes in Uturu, Isuikwuato and Okigwe.

S/N	Parameters	F-cal	F-tab	P	Decision
1	Air shade temp.	4.00	3.634	0.039	S
2	Water temp	1.825	3.634	0.193	NS
3	Conductivity	1.703	3.364	0.213	NS
4	TDS	1.684	3.364	0.217	NS
5	pH	0.363	3.364	0.703	NS
6	Hardness	1.501	3.364	0.253	NS
7	Alkalinity	5.416	3.364	0.016	S
8	BOD	0.133	3.364	0.876	NS
9	DO	0.464	3.364	0.000	VS
10	Silica	1.329	3.364	0.637	NS
11	Sulphate	0.596	3.364	0.277	NS
12	Total Phosph.	0.032	3.364	0.563	VS
13	Chloride	1.829	3.364	0.968	NS
14	Nitrate	1.053	3.364	0.193	NS
15	Magnesium	5.335	3.364	0.372	NS
16	Potassium	3.156	3.364	0.017	NS
17	Sodium	3.354	3.364	0.07	NS
18	Calcium	24.270	3.364	0.005	VS
19	Coliform (MPN)	24.270	4.664	0.000	VS

* Significant ($P \leq 0.05$) (S)
** Very significant ($P \leq 0.01$) (VS)
$P > 0.05$ Not significant (NS)

Table 9. Results of Analysis of variance (ANOVA) to ascertain significant differences between all samples from Uturu, Isuikwuato and Okigwe.

S/N	Parameters	F-cal	F-tab	P	Decision
1	Air shade temp.	1.451	2.606	0.234	NS
2	Water temp	0.291	2.606	0.882	NS
3	Conductivity	13.583	2.606	0.000	VS
4	TDS	40.905	2.606	0.000	VS
5	pH	0.580	2.606	0.679	NS
6	Hardness	1.666	2.606	0.175	NS
7	Alkalinity	2.203	2.606	0.085	VS
8	BOD	1.203	2.606	0.316	NS
9	DO	1.369	2.606	0.261	NS
10	Silica	10.731	2.606	0.000	VS
11	Sulphate	0.980	2.606	0.428	NS
12	Total Phosph.	11.604	2.606	0.000	VS
13	Chloride	1.370	2.606	0.260	NS
14	Nitrate	2.484	2.606	0.058	NS
15	Magnesium	14.913	2.606	0.000	VS
16	Potassium	9.222	2.606	0.000	VS
17	Sodium	4.304	2.606	0.005	VS
18	Calcium	38.740	2.606	0.000	VS
19	Coliform (MPN)	-	-	-	-

* Significant ($P \leq 0.05$) (S)
** Very significant ($P \leq 0.01$) (VS)
$P > 0.05$ Not significant (NS)

Table 10. Water quality index for all the sampled areas based on water types are contained in the five tables that follow-

Parameters	BH1	BH2	BH3	BH4	BH5	BH6	BH7	BH8	BH9	BH10
Conductivity	45.0	41.0	22.0	25.0	27.0	26.0	26.0	29.0	25.0	18.0
TDS	29.25	26.65	14.30	16.25	17.55	17.00	17.00	18.90	16.25	11.70
pH	6.1	6.7	6.6	7.3	6.4	6.2	5.7	7.8	5.6	6.7
Total Hardness	120.0	84.0	48.0	24.0	20.0	32.0	20.0	36.0	72.0	120.0
BOD	3.5	3.5	3.6	2.1	0.8	1.6	3.3	2.6	3.7	1.2
DO	6.0	7.0	6.5	6.1	6.5	8.4	8.7	7.6	8.6	8.2
Sulphate	28.0	28.0	6.0	20.0	24.0	6.0	4.0	12.0	30.0	12.0
Ortho Phosphate	0	0.001	0.001	0.014	0.001	0.001	0.001	0.003	0.001	0.001
Chloride	32	20	20	48	24	28	24	16	40	20
Nitrate	0.22	0.3	0.001	0.2	0.001	0.04	0.35	0.22	0.01	0.06
Magnesium	0.301	0.567	0.517	0.301	0.01	0.772	0.186	0.166	0.172	0.18
Sodium	1.863	3.644	1.863	1.27	0.188	0.875	0.27	0.305	0.273	0.26
Calcium	0.168	0.168	0.224	0.035	0.363	0.068	0.02	0.025	0.016	0
Coliform	1	5	41	34	35					102
qw	84.87	160.23	150.27	92.68	7.43	213.03	51.16	51.89	47.36	62.44
w	1.00	1.00	1.00	1.00	1.00	0.99	0.99	0.99	0.99	1.00
WQI	**84.87**	**160.23**	**150.27**	**92.68**	**7.43**	**215.18**	**51.67**	**52.42**	**47.84**	**62.44**
Quality	**V. poor**	**Unsafe**	**Unsafe**	**V. poor**	**Excel.**	**Unsafe**	**Poor**	**Poor**	**Good**	**Poor**

Parameters	BH11	BH12	BH13	BH14	BH15	BH16	BH17	BH18	BH19
Conductivity	32.0	26.0	25.0	28.0	25.0	30.0	30.0	25.0	21.0
TDS	20.80	17.00	16.25	18.20	16.25	19.50	19.50	16.25	13.65
pH	5.6	5.6	6.6	6.7	6.6	6.7	6.5	6.8	5.8
Total Hardness	44.0	52.0	60.0	140.0	25.0	56.0	125.0	120.0	48.0
BOD	2.3	2.5	3.0	2.4	2.9	3.0	2.7	3.8	1.6
DO	9.0	8.7	7.2	8.5	9.3	8.7	8.7	8.5	7.5
Sulphate	15.0	2.0	20.0	16.0	12.0	25.0	15.0	16.0	15.0
Ortho Phosphate	0.001	0.01	0.01	0	0.006	0.006	0.001	0.006	0.001
Chloride	20	72	36	32	1	32	25	30	25
Nitrate	0.35	0.4	0.4	0.21	0.28	0.28	0.07	0.25	0.37
Magnesium	0.2	0.26	0.2	0.25	0.28	0.2	0.2	0.152	0.255
Sodium	0.26	0.246	0.256	0.41	3.08	0.8	0.38	0.455	0.285
Calcium	0	0	0	0	0.24	0	0	0	0
Coliform	125	63	175	240	100	160	120	140	130
qw	67.76	78.83	78.26	97.59	90.93	76.07	70.24	61.55	83.92
w	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
WQI	**67.76**	**78.83**	**78.26**	**97.59**	**90.93**	**76.07**	**70.24**	**61.55**	**83.92**
Quality	**Poor**	**V. poor**	**V. poor**	**V. poor**	**V. poor**	**V. poor**	**Poor**	**Poor**	**V. poor**

Parameters	STR1	STR2	STR3	STR4	STR5	STR6	STR7	STR8	STR9	STR10
Conductivity	52.00	38.00	46.00	47.00	52.00	54.00	51.00	45.00	38.00	38.00
TDS	36.40	26.60	32.20	30.55	36.40	37.80	35.70	29.25	26.60	26.60
pH	6.2	6.0	6.4	6.6	7.1	6.9	6.4	5.8	6.2	6.7
Total Hardness	188.00	28.00	36.00	88.00	84.00	27.00	420.00	120.00	32.00	60.00
BOD	4.73	3.50	3.00	5.14	3.50	2.25	2.70	2.44	3.20	3.50
DO	6.30	6.70	7.00	6.50	8.00	8.00	8.20	8.10	6.50	7.10
Sulphate	16.00	14.00	26.00	26.00	21.00	28.00	28.00	30.00	16.00	18.00
Ortho Phosph.	0.01	0.001	0.01	0.019	0.07	0	0.01	0.01	0.002	0.006
Chloride	20.0	24.0	20.0	24.0	24.0	28.0	24.0	48.0	24.0	24.0
Nitrate	0.008	0.38	0.04	0.018	0.01	0.35	0.22	0.01	0.18	0.02

Magnesium	0.046	0.046	0.301	0.449	0.517	0.517	0.154	0.174	0.332	0.43
Sodium	1.822	0.533	0.41	1.277	1.863	1.822	0.36	0.385	1.315	2.355
Calcium	0.035	0.018	0.01	0.035	0.224	0.168	0.065	0.048	0.002	0.003
Coliform	37	10	4	3	38	5			175	178
qw	20.90	15.22	86.69	130.66	159.48	145.81	45.46	48.91	112.75	142.12
w	1.00	1.00	1.00	1.00	1.00	1.00	0.99	0.99	1.00	1.00
WQI	**20.90**	**15.22**	**86.69**	**130.66**	**159.48**	**145.81**	**45.92**	**49.4**	**112.75**	**142.12**
Quality	**Excel.**	**Excel.**	**V. poor**	**Unsafe**	**Unsafe**	**Unsafe**	**Good**	**Good**	**Unsafe**	**Unsafe**

Parameters	**STR11**	**STR12**	**STR13**	**STR14**	**STR15**	**STR16**	**STR17**	**STR18**	**STR19**	**STR20**
Conductivity	41.00	52.00	35.00	45.00	46.00	45.00	38.00	57.00	47.00	49.00
TDS	28.70	36.40	24.50	31.50	32.20	31.50	26.60	40.00	33.00	34.30
pH	5.6	6.3	6.8	6.3	5.6	6.5	5.5	6.7	6.6	6.6
Total Hardness	80.00	80.00	60.00	80.00	80.00	60.00	75.00	26.00	70.00	60.00
BOD	4.20	3.33	3.65	3.50	4.25	3.00	4.00	22.00	4.05	3.50
DO	9.20	10.40	8.50	10.00	9.50	7.50	9.00	3.60	9.50	8.00
Sulphate	4.00	40.00	25.00	40.00	4.00	16.00	5.00	0.01	28.00	18.00
Ortho Phosph.	0.004	0.002	0.008	0.001	0.01	0.005	0.015	0.45	0.02	0.007
Chloride	24.0	16.0	30.0	16.0	24.0	21.0	20.0	16.0	38.0	22.0
Nitrate	0.3	0.3	0.3	0.3	0.35	0.08	0.4	0.04	0.4	0.46
Magnesium	0.5	0.45	0.5	0.345	0.338	0.45	0.3	0.41	0.356	0.4
Sodium	2.45	2.55	2.5	1.425	1.665	2.455	1.75	1.456	1.453	2.425
Calcium	0.005	0.003	0.005	0.004	0.004	0.004	0.003	0.002	0.004	0.005
Coliform	178	143	178	243	255	165	240	185	190	170
Qw	157.92	141.27	161.74	123.45	122.48	145.05	110.62	205.26	124.33	132.6
w	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
WQI	**157.92**	**141.27**	**161.74**	**123.45**	**122.48**	**145.05**	**110.62**	**205.26**	**124.33**	**132.6**
Quality	**Unsafe**	**Unsafe**	**Unsafe**	**Unsafe**	**Unsafe**	**Unsafe**	**Unsafe**	**Unsafe**	**Unsafe**	**Unsafe**

Parameters	**River1**	**River2**	**River3**	**SPR1**	**SPR2**	**SPR3**	**SPR4**	**Well1**	**Well2**
Conductivity	58.00	50	52	35.00	32	30	26.00	49.00	48.00
TDS	37.70	37.5	40	22.75	20.8	19.5	17.00	36.75	33.60
pH	6.00	6.6	6.6	6.60	4.7	6.7	6.50	5.90	5.90
Total Hardness	212.00	18	180	48.00	11	80	125.00	396.00	3.00
BOD	3.50	4.92	4.65	2.45	3.24	2.24	2.70	2.59	3.00
DO	6.10	10.5	10.5	8.20	8.8	8.1	9.00	7.30	5.30
Sulphate	20.00	11.3	10.5	20.00	16	13	11.00	24.00	26.00
Ortho Phosph.	0.02	0.6	0.65	0.02	0.006	0.003	0.005	0.002	0.002
Chloride	20.00	22.7	22	28.00	40	24	1.50	40.0	42.00
Nitrate	0.22	0.6	0.65	0.01	0.18	0.24	0.25	0.24	0.25
Magnesium	0.27	0.9	0.8	0.26	0.615	0.179	0.27	1.122	8.00
Sodium	1.01	2.3	2.5	0.41	2.921	0.285	3.05	3.321	3.50
Calcium	0.17	1.02	1.04	0.22	0.938	0.023	0.22	1.188	1.95
Coliform	41.00	205	265	2.00			110		100.00
qw	82.42	347.19	332.27	76.09	167.01	51.89	88.87	309.81	2216.28
w	1.00	1.00	1.00	1.00	0.99	0.99	1.00	0.99	1.00
WQI	**82.42**	**347.19**	**332.27**	**76.09**	**168.69**	**52.42**	**88.87**	**312.94**	**2216.28**
Quality	**V. poor**	**Unsafe**	**Unsafe**	**V. poor**	**Unsafe**	**Poor**	**V. poor**	**Unsafe**	**Unsafe**

Table 11. Summary of water quality index and water quality for the various water sources

WQI Value	**Water quality**	**Water source**	**Total**	

		Borehole		Spring		River		Stream		Well		All sample	
		No	**%**	**No**	**%**	**No**	**%**	**No**	**%**	**No**	**%**	**No**	**%**
0 - 25	Excellent	1	5.3	2	10.0	0	0.0	0	0.0	0	0.0	3	**6.3**
26 - 50	Good water	1	5.3	2	10.0	0	0.0	0	0.0	0	0.0	3	**6.3**
51 - 75	Poor water	6	31.6	0	0.0	0	0.0	1	25.0	0	0.0	7	**14.6**
76 - 100	Very poor water	8	42.1	1	5.0	2	66.7	2	50.0	0	0.0	13	**27.1**
>100	Unsuitable for drinking	3	15.8	15	75.0	1	33.3	1	25.0	2	100.0	22	**45.8**
Total		**19**	**100.0**	**20**	**100.0**	**3**	**100.0**	**4**	**100.0**	**2**	**100.0**	**48**	**100.0**

IV. Discussion

This research was targeted at using Isuikwuato LGA water sources as background or base to compare with phsico-chemical characteristics evident in Uturu and Okigwe communities hence the complete enumeration of available water resources in the former as captured by by Table 4. Major drinking water sources in Isuikwuato are boreholes sunk in all communities except Amaogudu, Amahia-Ahaba, Umuasua, isiala-Ezera and Amuta. The other thirteen communities have boreholes ranging from one in Umuankwa to thirty-four in Ovim (Table 4). A few streams and springs also ramify the area. Generally the boreholes and springs serve as drinking and culinary water sources while streams, river and wells are for laundry and car-wash purposes.

The mean results of the physico-chemical and bacterial analyses of the water sources in the areas investigated –Uturu, Isuikwuato and Okigwe present a holistic picture of conforming with stipulations of water quality recommending agencies which include the Standards organization of Nigeria (SON), European economic community (EEC) and World health organization (WHO), Table 5. It is only in the area of total coliform that the water sources far exceeded the limits by SON. This is expected for streams and rivers in these areas were grouped together with boreholes in the presentation of this preliminary table. Several investigators have recorded above permissible level of total coliform in streams and rivers (Shittu et al 2008; Omoigberale et al, 2013;). For all the water sources sampled the lowest air shade temperature which ranged from 25^{o}C was recorded in streams in Uturu and Isuikwuato. This is understandable because these locations are semi-urban towns and overhanging vegetation and tree canopies which shade of solar radiation are characteristic of these locations. In the same vein air-shade temperature was highest in the borehole at Okigwe whose urban status outweighs what is evident in both Uturu and Isuikwuato sampling sites because the boreholes are located on the streets and are directly impacted on by solar radiation.

All the water samples conformed to the FMNEV, 2003 guidelines for carbonate beverage, confectionary, and dairy, excepting brewery, where, hardness and chloride concentrations exceeded stipulated levels. Chloride was also high for the Dairy industry (Table 6).

The most important physical assessment of water quality is the measurement of temperature. Temperature impacts both the chemical and biological characteristics of surface water. It affects the dissolved oxygen level in water, photosynthesis of aquatic flora, metabolic rates of aquatic fauna and sensitivity of organisms to pollution, parasites and disease. As opined by Umeham et al 2012, the hotness or coldness of surface water is determined by solar radiation. Shamar and Kumar, 2002 held that water temperature is a regular factor in various physical, chemical and biological activities in ecosystems and it distinctly fluctuates with air temperature. This observation is in agreement with the present work where air temperature of streams has a very significant relationship with surface water temperature and followed those of the air-shade (Table 7). Air temperature, surface water temperature also had very significant variation like calcium and sodium (Table 8), indicating autochthonously derivation of the composite ions resulting from evaporation stream from stream surfaces occasioned by high solar input. The significant variation noted for air-shade-temperature, dissolved oxygen (DO) and total phosphorous could also be due to different borehole-location characteristics.

Considering samples from all drinking water sources (Table 9), conductivity, TDS, alkalinity, silica, magnesium, potassium, sodium and calcium varied very significantly. The observed significant differences could be attributed to constituents of the underlying parent materials of the various water sources, a pointer to their intimate relationship that will be captured in another report. Phylllis et al., 2007 held that the concentration and and composition of TDS in natural waters is determined by the geology of the drainage, atmospheric precipitation and water balance; and water with a value of above 100mgl^{-1} is brackish or marine. This assertion explains the very significant differences observed in TDS values of the different water sources throughput the study period. The result is also indicative of the fact that all these streams ramify through the same drainage basin and the boreholes are supplied by aquifers with chemically same underlying parent material. This is surmised by the conductivity which is of prime importance since it shows at a glance the total ionic concentration or cationic and anionic levels of the water bodies which are paramount in calculation of water quality index (WQI), (Tyagi *et al*, 2013).

Water conductivity in all sources sampled showed characteristic fresh water levels (table 5). The observed levels were far below the permissible level of 500µScm^{-1} of the Standards Organization of Nigeria (SON, 2007).

Total dissolved solids followed the same trend as conductivity in all samples with the lowest value recorded in the borehole and the highest in the stream sample. The observation is plausible since boreholes are fed by aquifers as opposed to surface waters that are prone to influx of debris that eventually dissolve and impart higher readings. Phylllis et al., 2007 held that the concentration and composition of TDS in natural waters is determined by the geology of the drainage, atmospheric precipitation and water balance; and water with a value of above 100mgl^{-1} is brackish or marine. This assertion explains the very significant differences observed in TDS values of the different water sources throughput the study period.

The pH of all the samples were weakly acidic with the lowest value of 6.09 recorded in Okigwe and highest value of 6.62 noted for a borehole in Uturu. The observed pH values are typical of water bodies in Eastern Nigeria where humic acid contributed by leaf litter has been implicated as responsible for the levels (Umeham, 2014). It is also feasible that the noted level in Okigwe was due to her semi-urban status with acidity arising from pollution. There were no significant differences in the records for all water sources (Table 9) and the values were within acceptable limits for different purposes (FMNEV,2003; USEPA, 2012 and WHO,2012).

Total hardness of the different water sources in the different locations did not show any significant differences. The values were also within permissible levels of WHO (2012) for drinking water and FMNEV (2003) for cottage industrial use. Umeham and Elekwa (2005) recorded much higher values Ngwui, Ikwu and Eme streams in Umuahia North Local Government Area. WHO (2012) posited that hardness has no adverse effect on the human but may cause scale deposition in water distribution systems and more soap consumption in laundry (Umeham, 2014). Hard water usage has been deduced to correlate with increased excema in children. (Miyaka et al., 2004; Arnedo –penna, 2007).

Total alkalinity values recorded in this study were low and in consonance with the concentrations of the underground and surface waters of the lower Niger Delta where alkalinity values never exceeded 80mgl-1 (Akintola and Amadi, 2003; Olorede *et al*., 2015). This observation also agrees with the earlier record of "weak acid" pH. The variations were generally not significant across the locations though boreholes in Uturu, isuikwuato and Okigwe showed significant variation. Total alkalinity is not a life-threatening parameter as it is not tabulated by most standard organizations. However, WHO has the limit for drinking water as 200mgl-1 which is not close to the results of the investigation (WHO, 2012).

Biochemical oxygen demand (BOD), an index for assessing the polluting strength of any effluent, except for streams in Isuikwuato did not exceed permissible limit of 4 - 5mgl-1 (SON, 2006; WHO,2012). Dissolved oxygen (DO) and BOD are inevitable characteristics that help trace pollution profile and natural river purification upon which engineering calculations to predict pollution levels are anchored. DO like BOD only varied significantly among water sources. This was expected since surface waters (streams and rivers) were much more open to atmospheric oxygen than the ground water (springs and bore holes). The values obtained across the water sources were optimal for different uses and fell in line with stipulations of standard recommending agencies (FMNEV,2003; SON, 2007; USEPA, 2012 and WHO,2012).

Silica concentration varied very significantly in streams and boreholes in Isuikwuato. Very significant variation was also noted for stream and boreholes in Okigwe. There was no other clearly significantly discernible silica flux in the other water sources. Umeham and Nwadiaro (2007) held that silica frequently exhibits marked spatial and temporal variations. Degradation of alumina-silicate minerals in the drainage basin is a major source of silica in waters (Umeham and Onyeagba, 2001). Silica concentration in this study for boreholes and streams were lower than the documented values for waters of the lower Niger delta. Epidemiological studies have revealed that silica in drinking water may be protective with respect to the decrease of cognitive function. Performances to a cognitive test were positively correlated to consumption of silica and the risk of Alheimer's disease (AD) was reduced in subjects who had higher silica intake compared to others (Gillette et al., 2007). Primary drinking water standards are based on health considerations and secondary drinking water standards are based on aesthetics such as odour, colour, or corrosivity, there are no primary or secondary standards for silica (USEPA, 2012).

Sulphate concentrations in this study aligned with the records available for the region and only showed significant variation for streams in Okigwe. The observed variation was due to human and industrial waste such as paper, tanneries, textile that was commonplace around the Iyiechu stream that passes through Okigwe metroplolis. Sulphate may have a laxative effect that can lead to dehydration for infants but with time, people and young livestock become acclimated to the sulphate and the symptoms will disappear. However, observed range in all the water sources examined is far below the contaminate level of 250mgl^{-1}. According to WHO (2004), typical sulphate levels in freshwater is 20mgl^{-1}and only very high levels will have a laxative effect which may lead to diarrhea. SON (2007) did not tabulate sulphate as having any health impact but the recorded concentration is allowable by WHO (2012) guidelines.

Total phosphate though within acceptable limits of SON (2007) and WHO (2012) exhibited very significant variation across the different water sources and across the locations. This is understandable when viewed from the premise of its being a limiting nutrient in aquatic production and considering that streams, rivers were part of the samples. Public water systems even commonly add phosphates to the drinking water as a corrosion inhibitor to prevent leaching of lead and copper from pipes and fixtures. There are no negative health impacts of phosphate in drinking water though high levels as evident in fast foods may damage blood vessels and induce the aging process.

Chloride concentration recorded in this study ranged from 25 t0 40mgl^{-1}, which were within SON and WHO acceptable levels. The variations in all cases were not significant. It is one of the most common anions in tap water although there is no seriousness attached to enforcing the standard since the levels rarely reach the USEPA permissible limit of 250mgl-1. However, WHO (2012), holds that, concentrations above 2.5gl^{-1} has been reported to produce hypertension. This effect is largely attributed to the sodium component as a normal adult human body contains approximately 81.7g chloride.

Nitrate is one of the most common ground water contaminants in rural areas, and if not regulated could lead to excess levels that can cause methemoglobinemia or "blue baby" syndrome. This is a condition caused by the inability of the blood to deliver enough oxygen to the body. Nitrate levels were generally low in most of the water sources examined, at no time above 0.30mgl^{-1} the values were similar to the concentrations reported for other Niger delta waters (Chindah and Braide, 2004; Umeham, 2014) and within permissible level of WHO. Low nitrate levels in rivers and streams are usually indicative of low inorganic pollution (Kumari et al., 2011). The available nitrate in these water resources resulted from fertilizer run-offs and mineralized human excrement from farmlands in these locations (Umeham and Elekwa, 2005, Umeham, et al., 2012). Since the values are negligible, the noted significant variations in some of the locations and water sources were of no importance. Nitrate levels higher than 10mgl^{-1} are not favourable for aquatic life (Efe et al., 2005).

The major cations in the study location had the following order of dominance both in surface and underground water Na>K>Mg>Ca. the observed order where sodium is the highest cation was because sodium is usually retained by soils and living organisms. Cations are usually released to waters via biogenic fertilizers, carbonates, silicates, alkaline soils from the bank, atmospheric precipitation and weathering of parent rocks. Investigators have at different times recorded varying order of dominance of major cations for different water bodies. Umeham et al., (2007) had Ca>K>Na>Mg for Obiya Stream; Osibanjo and Adie,(2007; and Ikhuoriah and Oronssaye (2016) noted Ca>Na>K>Mg and Na>Ca>Mg>K for River Niger at Shagunu and Ossiomo river respectively. However, the concentrations of all the cations in all the water sources examined were within WHO and USEPA permissible limits rendering the significant variations noticed in a few water sources inconsequential. Several epidemiological investigations have demonstrated the correlation between risk of cardiovascular disease, growth retardation, reproductive failure, other health problems and calcium and magnesium hardness. WHO (2011) reported that inadequate intake of calcium has been associated with increased risks of osteoporosis, nephrolithiasis (kidney stones), colorectal cancer, stroke and obesity. WHO (2011) also posits that sodium is not acutely toxic because of the efficiency with which mature kidneys excrete sodium. However, acute effects include nausea, vomiting, convulsions, muscular twitching and rigidity. Potassium may cause some health effects in susceptible individuals but its intake from drinking water is well below the level at which adverse effects may occur (WHO.2011)

Considering all the water bodies sampled in the different locations and classifying them based on water quality index (WQI) as documented by Tyagi et. al., (2013), 6.25 % were excellent, 6.25% were good, 14.58% poor, 25% very poor and 47.92% unsuitable for drinking and domestic purposes (Table 11) The water sources and their potential water quality status have been tabulated to enable stake holders take appropriate steps toward improving the water quality of the various sources (Table 10) Contamination of the water sources could have been due to poor environmental hygiene for surface and ground water sources. Chemical contamination possibly would have been due to parent material underlying the water sources and also surface runoff into the wells, streams and rivers. The ground water sources were most likely contaminated via leaching and seepage from refuse dumpsites, Automobile mechanic workshops, make-shift abattoirs and markets that abound the banks and vicinity of these water sources.

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