Variations in Water Quality from Source to Point of Use in Abeokuta - Nigeria

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***Abstract*—Water related diseases are predominant in rural areas of developing. This paper focuses on determination of the factors causing variations in water quality from source of abstraction to the point where water is used.**

The approach to the study includes field survey of study area; and identification self-supply systems in these communities. Data collection approach involved the quantitative and the qualitative.

The findings confirm 75% of samples collected at the source were contaminated with E. coli and had high total bacteria count. Groundwater pollution results from industrial activities. 90% of well users use multiple buckets & rope to draw from source, of which where the bucket & rope is being kept on cannot ascertain the hygienic condition of place. 40% of respondent drink water from the well without noticing ill-health.

It is concluded that the quality of water deteriorates from the source to the point of use and this brings about the variations in water quality.

***Keywords*— Variation, Water Quality, Water Source, Point of Use, Abeokuta - Nigeria.**

I. Introduction

Due to the inability of government to provide water which is one of the basic fundamental human need people have resulted to sourcing for water for themselves.

In developing countries, there is inadequate and no dependency on public water supply, people therefore results to source for water themselves hence the birth of self-supply systems. In the quest of this, a large number of people are concerned about the nearest, easiest way of getting water and also the quantity, little attention is paid to the quality of water.

Various reasons have been proposed for the deterioration of water quality between the source and point-of-use (POU). The hygienic condition of the water storage containers and the environment in which these containers are stored are believed to be major factors leading to the deterioration of stored water [1, 2, 3 and6].

Self-supply systems is defined as improvements to household or community water supply systems achieved through user investment water treatment, supply construction and up-grading, and rainwater harvesting [5]. They are constructed to serve as alternatives to the erratic and unreliable public water supply. They also fulfil the two requirements at the household level; to deliver adequate amounts of water to meet consumer consumption requirements and the required amount of water needs to be available 24 hours a day, 365 days a year.

It has been affirmed that the Self-Supply conceptual framework considers incremental improvements to supply (ground or rainwater) and to its quality mainly by owners themselves [4]. Self-supply systems are constructed to serve as alternatives to the erratic and unreliable public water supply. They are constructed and managed by the owner of the landed property (landlords) to meet the water demand of primarily the residents of his property. An example of such a system is a hand dug well. The point at which water is needed is referred to as the point of use or point of consumption. Access to potable and safe drinking water is essential to health, a basic human right and a component of effective policy for health protection. The importance of Water quality therefore cannot be over emphasised. Water quality measures of the suitability of water for a particular use based on selected physical, chemical, and biological characteristics. Safe water prevents the spread of water borne diseases and sanitation related diseases.

II. The Study Area

Abeokuta, the capital of Ogun State in Nigeria is the sub-humid tropical zone of South-western found between latitude 7.5° N to 7.20° N and longitude 3.17° E and 3.27° E. The city covers a geographical area of 1,256km2, which includes Abeokuta North, Abeokuta South and part of Obafemi Owode and Odeda Local Government Area of Ogun State. The research focused on self-supply hand dug wells in the selected township located at Sapon, Itoku, ake, Adatan, and Ilugun the densely populated areas of Abeokuta South Local Government Area of Nigeria.

III. Methodology

The research methodology involved water sampling and water quality determination from source to POU. Samples used for analysis of physical and chemical parameter were collected and analysed in accordance with standard practice.

IV. Results

The results of all the water quality parameters (temperature, PH, electrical conductivity, chloride, nitrate, sulphate, sodium, potassium, calcium hardness) from source to point of use are presented in Table 1. Table 2 represents the descriptive

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statistics of maximum, minimum, mean and standard deviation of the analysed parameters.

A. Discussion

1. Physical and Chemical Analysis

Slight variations in the PH values of the source water to the point of use, indicates no significant difference in the means of the paired samples. Generally, PH values increased from the well source to POU, this increase can be explained as a result of dissolved oxygen during transport of water from source to POU (Gundry S, et al, 2006)

In Itoku, the highest values of EC must have been attributed to the tie & dye cottage industry in the area.. Ilugun shows the least values in the amount of chloride in groundwater and Itoku shows the highest in the values of chloride. While Itoku has the highest in value of nitrate and Ilugun shows the least. Similarly, Itoku has the highest level of sulphate and sodium content in the groundwater and Ilugun has the least. A sharp increase in the potassium content of groundwater is seen Adatan well 4 compared to the rest of the location. This is as a result of the characteristics of the type of geologic formation found in the location. Sapon shows the highest value of calcium hardness, this must be an attribute of the type of rock beneath the location.

Wells at Itoku showed considerable increase in EC, chloride, sodium, nitrate, and sulphate content. A high value of the listed parameters confirms the nature of anthropogenic activities in the area having an effect on the water quality. Itoku area of Abeokuta is known for their indigenous activity in tie and dye business. Dyeing is a combined process of bleaching and colouring which generates voluminous quantities of wastewater and in turn causes percolation of waste water which is highly mineralized. The effluents consist of high concentrations of dye chemicals, biochemical oxygen demand, total dissolved solids, sodium, chloride, sulphate, hardness, heavy metals and carcinogenic dye ingredients.

2. Microbial Analysis

There was a considerable increase of TCC at POU than at the source and also an increase of E.coli at the POU compared to the source; the result shows that water quality deteriorates over distance and time. Microbiological quality of water at source and point of use declines after collection, as depicted in Ilugun, Adatan, and itoku. The high TCC and E.coli could be attributed to the poor sanitary condition around well area, the presence of anthropogenic activities e.g. washing, cooking, urinating etc. and contamination of bucket and rope. Similarly, temperature of environment can induce the growth of these bacteria. 75% of samples tested positive with the presence of an indicator (bacteria). The parameters measured are presented in Table 1 shows that variations in water quality deteriorate. There was increasing trend in the values of PH from well source to POU. Other parameters showed increase or decrease at the source or POU. In Ilugun, the values of electrical conductivity, potassium, sodium, nitrate, sulphate, calcium hardness reduced from the source to POU. While the chloride content at the POU is higher than at source. Similarly, at Adatan, the value of electrical conductivity reduced from the source to point of use while the chloride content, potassium, sodium, nitrate, sulphate and calcium hardness are at higher level at POU to that obtained at source. At Itoku, the PH, EC, sodium, potassium, calcium hardness increased from source to point of use while the chloride, nitrate and sulphate are at source is lower than at POU. Increase in particularly the EC may be due to existence of massive tie & dye cottage industrial activity at the location. The PH, EC, sulphate, potassium increases from the source to point of use while the chloride, nitrate, sodium and calcium hardness content at source are lower than at POU in Sapon.

Lastly at Ake, the PH, nitrate and Calcium hardness at higher at the source while sulphate, sodium, potassium measures the same at source and POU. The EC and chloride at source are higher than at POU.

TABLE I: RAW DATA

		PH		TEMP(°C)		EC(µS/cm)		Cl (mg/l)		NO_3^{2-}(mg/l)		SO_4^{2-}(mg/l)	
	WELLS	SOURCE	POU	SOURCE	POU	SOURCE	POU	SOURCE	POU	SOURCE	POU	SOURCE	POU
ILUGUN	1	6.93	7.115	29.1	29.4	615	621.5	56	56.5	6.5	5.5	71.945	74.525
	2	7.02	7.21	29.7	29.5	706	698.5	55	53.5	19	6.5	79.99	73.86
	3	7.52	7.625	29.4	29.3	592.5	493.5	51	42	11	8	76.805	66.14
	4	7.33	7.54	29.4	29.4	686	695	62	58.5	12.5	24.5	86.33	93.885
	5	7.32	7.45	29.5	29.5	427	427	22.5	66	22.5	17.5	75.665	74.345
ADATAN	1	7.41	8.37	29.7	29.8	788.5	788	75.5	65.5	16	16	87.05	92.63
	2	7.15	7.405	29.7	29.8	962	960	115.5	125	14.5	14	76.475	80.31
	3	6.86	7.15	29.8	29.7	800.5	128.5	120	121	17.5	36.5	86.955	26.93
	4	6.95	7.04	29.5	29.8	983.5	986.5	56	58.5	8	13.5	82.95	93.385
	5	6.975	7.03	29.9	29.9	834.5	823.5	77.5	96.5	22	24.5	58.395	58.05
ITOKU	1	7.47	7.74	28.9	28.9	1128.5	1153	193.5	145	25.5	27.5	101.76	101.295
	2	7.525	7.8	28.9	28.8	1205	1195	159.5	159	43	50.5	78.88	84.195
	3	8.135	8.08	28.9	28.8	1245	1249.5	160	0	126	15.5	103.7	95.5
	4	8.095	7.925	28.9	28.9	1032	1058.5	130.5	128.5	32.5	24.5	89.67	87.75
	5	8.05	8.065	28.9	29.1	1483.5	1495	211	256.5	46.5	33.5	101.295	105.34
SAPON	1	7.34	7.26	29.2	29.1	1286	1290	176	174.5	99.5	24	112.41	94.85
	2	7.275	7.345	29	29.1	912	915.5	105.5	105.5	21	29	68.215	74.04
	3	7.33	8.035	29.1	29.2	994.5	988.5	107	114.5	29	31.5	68.05	78.54
	4	7.35	7.45	29.2	29.1	855	877.5	105.5	95	24.5	21.5	68.855	69.045
	5	7.26	7.31	29.1	29.2	896	906	106	103.5	12	30	62.8	73.865
AKE	1	7.175	7.36	29.5	28.9	439	453.5	39.5	46.5	1.985	1.85	60.47	63.55
	2	7.27	7.35	29.3	29.3	532.5	539.5	57.5	53.5	1.975	1.625	67.25	69.045
	3	7.28	7.475	29.2	29.3	567.5	568.5	52	50.5	7.395	3.78	64.755	60.81
	4	8.17	8.265	29.2	29.2	919	918.5	94.5	97.5	3.965	4.32	81.95	77.75
	5	8.075	8.095	29.1	29.1	632	629.5	49.5	50	3.43	2.885	70.325	70.33

		Na^+(mg/l)		K^+(mg/l)		$CaCO_3$(mg/l)		TCC(cfu/100ml)		E.COLI(cfu/100ml)	
	WELLS	SOURCE	POU	SOURCE	POU	SOURCE	POU	SOURCE	POU	SOURCE	POU
ILUGUN	1	5.5	6.3	16.5	13.5	125	123	97000	27100	0	400
	2	8.5	6.5	47.5	24.5	132	123.5	180	17400	0	600
	3	8	6	24	11.5	109	105	19500	4950	700	0
	4	11	8.5	12.5	13.5	154	161	4000	796000	0	1200
	5	4	4	14.5	5.5	86.5	84	1250000	17300	1800	0
ADATAN	1	7	6.5	18.5	30.5	155	161	8700	1200000	0	1600
	2	13.5	9	31	52	92.5	84	26700	18000	0	4000
	3	9.5	3.5	35	5.5	67.5	41	24000	28800	3150	0
	4	11.5	8	57.5	33	131	137.5	27900	4500000	0	1300
	5	6.5	7	26.5	34	104.5	119	56000	15800	1700	0
ITOKU	1	21	21	24	24	127	122.5	300	160	0	900
	2	21	22	24	24	81	95	130	24000	0	1800
	3	24	25	26	26	84.5	109	800	28900	0	1200
	4	16.5	18.5	18.5	19.5	88.5	98.5	27000	450000	9600	350000
	5	29	28	28.5	29	103.5	137.5	560000	900000	560000	85000000
SAPON	1	24.5	24	25	25.5	190	172.5	25900	500000	2200	13000
	2	18.5	18	19	19.5	161	145.5	450000	1100	12000	0
	3	19	17.5	20.5	20.5	154.5	155.5	3000	6800	0	0
	4	17	17	18	19.5	154	141	1300	3700	0	0
	5	16	15	17	16.5	141	151	3700	15300	0	400
AKE	1	12	13.5	13	13	78	81	1100	2200	0	0
	2	12	14	15	15	68	66	1000	3200	0	0
	3	12.5	12.5	13	13	91	79.5	4800	6900	0	0
	4	17.5	19	19.5	20.5	147	121.5	3500	1900	0	0
	5	11	11	12	12	126.5	90	1200	1000	0	0

TABLE II: DESCRIPTIVE STATISTICS

LOCATION	PARAMETERS	MAX	MIN	MEAN	SD
ILUGUN	TEMP	29.7	29.1	29.5	0.216795
	PH	7.52	6.93	7.224	0.019799
	EC(µS/cm)	706	427	605.3	1.549193
	CL(mg/l)	62	22.5	49.3	2.969848
	NO_3^{2}(mg/l)$^-$	22.5	6.5	14.3	0.424264
	SO_4^{2-}(mg/l)	86.33	71.945	78.147	0.168291
	Na^+(mg/l)	11	4	7.4	0.848528
	K^+(mg/l)	47.5	12.5	23	0.848528
	$CaCO_3$(mg/l)	154	86.5	121.3	1.838478
	TCC(cfu/100ml)	1250000	180	274136	546935.2
	E COLI(cfu/100ml	1800	700	500	787.4008
ADATAN	TEMP	29.9	29.5	29.72	0.148324
	PH	7.41	6.86	7.069	0.217669
	EC(µS/cm)	983.5	788.5	873.8	1.131371
	CL(mg/l)	120	56	88.9	1.555635
	NO_3^{2-}(mg/l)	22	8	15.6	0.848528
	SO_4^{2-}(mg/l)	87.05	58.395	78.365	0.041012
	Na^+(mg/l)	13.5	6.5	9.6	0.565685
	K^+(mg/l)	57.5	18.5	33.7	1.272792
	$CaCO_3$(mg/l)	155	67.5	110.1	0.989949
	TCC(cfu/100ml)	56000	8700	28660	17117.33
	E COLI(cfu/100ml	3150	1700	970	1423.728
ITOKU	TEMP	28.9	28.8	28.88	0.044721
	PH	8.135	7.47	7.855	0.057663
	EC(µS/cm)	1483.5	1032	1218.8	2.545584
	CL(mg/l)	880	130.5	314.9	204.071
	NO_3^{2-}(mg/l)	126	25.5	54.7	0.989949
	SO_4^{2-}(mg/l)	103.7	78.88	95.061	0.012728
	Na^+(mg/l)	29	16.5	22.3	1.178511
	K^+(mg/l)	28.5	18.5	24.2	0.707107
	$CaCO_3$(mg/l)	127	81	96.9	1.272792
	TCC(cfu/100ml)	560000	130	117646	247551.4
	E COLI(cfu/100ml	9600		2400	4800
SAPON	TEMP	29	29.2	29.12	0.083666
	PH	7.35	7.26	7.311	0.035355
	EC(µS/cm)	1286	855	988.7	2.969848
	CL(mg/l)	176	105.5	120	0.848528
	NO_3^{2-}(mg/l)	99.5	12	37.2	0.282843
	SO_4^{2-}(mg/l)	112.41	62.8	76.066	0.042426
	Na^+(mg/l)	24.5	16	19	0.282843
	K^+(mg/l)	25	17	19.9	0.141421
	$CaCO_3$(mg/l)	190	141	160.1	0.707107
	TCC(cfu/100ml)	450000	1300	96780	197714
	E COLI(cfu/100ml)	12000	2200	3550	5728.001
AKE	TEMP	29.5	29.1	29.26	0.151658
	PH	8.17	7.175	7.594	0.019799
	EC(µS/cm)	919	439	618	2.262742
	CL(mg/l)	94.5	39.5	58.6	0.848528
	NO_3^{2-}(mg/l)	7.395	1.975	3.75	0.008485
	SO_4^{2-}(mg/l)	81.95	60.47	68.95	0.715592
	Na^+(mg/l)	17.5	11	13	0.282843
	K^+(mg/l)	19.5	12	14.5	0.141421
	$CaCO_3$(mg/l)	147	68	102.1	0.707107
	TCC(cfu/100ml)	4800	1000	2320	1734.07
	E COLI(cfu/100ml)	0		0	0

V. Conclusion

It is evident from this research that the quality of water deteriorates from the source to the point of use and this brings about the variations in water quality. Itoku area was distinct with high values in the water quality parameters measured compared with the other locations; this shows a gradual contamination in the groundwater in the area as a result of the tie & dye business. Also, the findings confirm 75% of samples collected at the source were contaminated with E. coli and had high total bacteria count but more at POU.

Recommendations

1. A minimum distance of 30m is advised from pollution sources such as sewerage systems, burial site, gutters and pit privy to well.
2. The use of a dedicated bailer is compulsory to prevent introduction of contaminants into the well. A waterproof well cover is important especially during rainy season
3. Water treatment practices should be encouraged at household level, at least boiling methods.

References

[1] Gundry, S; Wright, J and Conroy, R (2004): "A systematic review of the health outcomes related to household water quality in develop¬ing countries." J. Water and health 2 (1) 1-13. https://doi.org/10.2166/wh.2004.0001

[2] Jagals, P; Bokako, TC and Grabow Wok (1999): "Changing con¬sumer water use patterns and their effect on microbiological water quality as a result of an engineering intervention". Water sa 25 (3) 297-300.

[3] Jagals, P: Nala, NP; Tsubane TJ; Moabi, M and Motaung KC (2004): "Measuring changes in water-related and hygiene practices by developing community households". Water sci. Technol. 50 (1) 91-97. https://doi.org/10.2166/wst.2004.0027

[4] Sally Sutton (2007): Rural household investment in water supply. Proposal for study of potential for Self Supply in Ethiopia, preparatory to large Scale Implementation End user affordable Steps Consultancy report prepared for rwsn/wsp.

[5] Sutton, s. (2009). An introduction to self-supply: putting the user first, wsp field Note: rural water supply series.