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Assessment of sanitation levels of sources of water in Osun State Capital, Nigeria

Felix A. Oginni[1] and Samson O. Ojoawo[2]*
[1]Department of Civil Engineering, Osun State University, PMB 4494, Oshogbo, Nigeria.
[2]Department of Civil Engineering, NMAM Institute of Technology, Nitte-574110,
Udupi District, Karnataka, India.
* *Corresponding Author; email: soojoawo@lautech.edu.ng*

Abstract
A study of the physicochemical and bacteriological analysis including BOD and COD was carried out for sources of water in Oshogbo the Capital of the State of Osun. Seven water sampling areas were selected to cover the low, medium and high population density areas of the State Capital. Water samples were collected from five sources of water, namely, shallow well, borehole, stream, rain and river. Water samples were collected from the well, borehole and stream water sources from Dada Estate and Isale Oshun for low density population, Ayetoro, Ogo-Oluwa and Oke-Ayepe for medium density, and Oke-Bale and Igbona for high density population areas. Three sampling points were undertaken for the rain water source while River Oshun source at Isale-Oshun was the 25th water sampling point. A total of 25 water quality parameters were analyzed for each of the 25 water sources sampled using the facility at the Rural Water And Environmental Sanitation Agency, RUWESA in Osun State Government Secretariat in Abere. Results indicated that 8 of the water quality parameters, pH, Turbidity; Magnesium hardness, Free Chlorine, Nitrite, Bacteriological, BOD and COD were not within Standards Organization of Nigeria (SON) permitted water quality standards and are of concern to sanitation of potable water in the State Capital. The level of each parameter differs from source to source as well as from level of population densities. The sources that were adjudged polluted were Ogo-Oluwa and Oke-Ayepe well sources; Ogo-Oluwa, Oke-Bale and Igbona stream sources Oke-Bale Rain source.R and the River source at Isale-Oshun. The polluted sources are all within the medium and high population density areas of the State Capital.

Keywords : Population density; Water source; Sanitation level; Permissible level; Physicochemical; Bacteriological

I. General Introduction

Osun State, a 23 year-old state in the South Western part of Nigeria was one of the nine States created in 1991to make a total of 30 States, then. The Capital of the State is Oshogbo. Oshogbo is the economic center of Osun State even prior to its being elevated to the status of a State Capital in 1991. The map of Osun State located in Nigeria is shown in Figure 1.

Figure 1: Map of Nigeria with Osun State carved within.

Oshogbo, a 23 years old Capital city is considered for this study because of its peculiarities. It is a developing residential city in the Southwestern part of Nigeria. shares the same similarities with Ibadan, one of the large and old cities in Africa. Fadare and Hay (1990) noted that there exist three distinct residential densities (low, medium and high residential densities) in Ibadan. Olawuni (1999) identified similar pattern of three residential densities in Oshogbo as high, medium and low residential densities. The high residential density area in Oshogbo is comprised of housing that are laid out in traditional compounds with many small rooms, limited open space, almost no road, or formal recreation space, and homogeneous population. The medium residential density area is mostly well laid out, with a regular street plan, having many plots almost completely occupied by two or three-storey buildings. Although, there is an attempt to control land use, numerous retail services and other commercial activities exist within the zone, but industries are largely absent. The population in these areas is less homogenous, consisting of people of diverse ethnic origins. The low residential density area was initially established to provide low rent accommodation for public sector employees in government institutions.

Oshogbo with a population of 131, 761 at the 2006 census on an area of 97 km² is administratively divided into two local government areas. These are Oshogbo and Olorunda Local Government Areas.

Water forms about 70 per cent of human's body fluids and serves many other purposes among which are domestic, industrial, agricultural, fire protection and others (Ojoawo and Ogunrombi, 2014). Quality is mostly believed to best describe any given water more than other yardsticks; water quality assessment is therefore a worthwhile study (Ojoawo *et al.*, 2014). Monitoring of quality of water sources is required in determination of sanitation level of any community. Marmot, *et al.,* (1997) emphasized on implications of social inequalities in health as a sanitation issue. Satone, et al., (2011) recommended measures on the need to monitor drinking water quality. Access to safe water facilities is estimated at 43% for rural areas and 71% for urban centers while rural sanitation coverage is 32% and urban 75%. And that as a result of inadequate safe water supply and sanitation facilities, people suffer from water related diseases such as diarrhea, cholera, typhoid, and guinea worm in many communities (ADF, 2007). Fadare and Olawuni, (2008) indicated that there is a significant relationship between water sources and ill health in the three residential densities in osogbo. There is therefore the need to stem this trend. Workers in this field include Kaonga *et al.,* (2013), Yusuf *et al.,* Oginni, (2013), Oginni and Isiorho, (2014), Jiboye, (2004), Akindele and Adeniyi, (2013), Akan *et al.,* (2012), Olajire and Imeokparia, (2011).

Sanitation level of this State Capital City has been assessed in this paper to serve as bases for justifying Government's steps towards the Urban renewal programs on the water supply platform within the State. This will be at tandem with the commitment of the State Government to improvement of the environment.

II. Methods and materials

The method employed focused on collection of samples of water from various sources available within the two Local Government areas in the State Capital and evaluation of the quality of the various sources for their physical, chemical, and biological characteristics.

2.1 Study Area and water source types

The study area considered out is shown in Figure 2. The carved area covers all the three distinct residential densities known as low, medium and high residential densities. And the area covers as much as 80% of the entire City.

The sites for the water sources were selected randomly but representative of the carved area.

Various types of sources of water considered in this study are obtained from:

(i)	Well	(ii)	Borehole
(iii)	Rain	(iv)	Stream
(v)	River		

The common sources of water which this community depend upon for their water needs are well, borehole, stream and rainfall sources in that order. The entire City is being drained by the major river, River Osun, that gave the State its name to bear. This source is only considered as one of the sources.

2.2 Selection of Sub-areas for water sources

In considering the population structure of the State Capital, a total of seven areas were selected within the area demarcated by the City ring road. The areas represented the low density, medium density and the high density population structure of Oshogbo. The following areas and their population density of the City were selected:

(i)	Dada Estate	-	Low density
(ii)	Isale Oshun	-	Low density
(iii)	Ayetoro	-	Medium density
(iv)	Ogooluwa	-	Medium density
(v)	Oke Ayepe	-	Medium density
(vi)	Oke Baale	-	High density
(vii)	Igbona	-	High density

The sampling points are located in the Google earth map shown in Figure 2.

Figure 2: Google Earth Map of Water Sources and Sampling Points

2.3 Layout of water source sampling

Well water, borehole water rain water and stream water sources were identified for each of the population structures/densities identified in section 2.2. Water samples for each type of source were then collected from all the identified sources. This should give a total of 28(No) water sources from the four source types over the seven identified population sectors. Because of the unpredictability of rainfall, rain water could only be obtained for testing from only four of the population sectors.

The river as a source was only sampled at a location, Isale-oshun. Thus a total of 26 sampling points were assessed for their physical, chemical and biological quality parameters.

2.4 Determination of Water Quality of each Source

Physico-Chemical and bacteriological analysis are required for each source in order to determine the qualities of the sources. The water quality parameters determined include the following:

Colour	Odour
Taste	Temperature
Ph	Conductivity
Turbidity	T.D.S
T. Hardness	Ca. Hardness
Mg. Hardness	Alkalinity
Chloride	Fluoride
Free Chlorine	Total Chlorine
Nitrate	Nitrite
Iron	Manganese
Arsenic	Zinc
Bacteriological	BOD
COD	

The physicochemical and bacteriological analysis including BOD and COD of various sources of water obtained from office of Rural Water and Sanitation Agency, RWESA in Osun State Government Secretariat in Abere.

2.5 Collections of Samples and Sampling materials

Much care is required and was taken in the collection of the water samples used in this study to ensure the sample is representative of the water and waste water desired to be examined and to avoid accidental contamination of the samples.

The sampling materials include the following:

Sterile petri dishes	
Cuvet	
Air-tight plastic containers	
Measuring cylinder	
Distilled water	70% ethanol
Cotton wool	
pH meter	Turbidity meter
Reagents	
Photometer	

2.6 Sterilization of media and materials

All media were prepared from dehydrated commercial product with strict adherence to manufacturer's instructions and sterilizing by autoclaving at 121°C for 15 minutes (Fawole and Oso, 2004). All glass wares were thoroughly washed with detergent solution, rinsed with several changes of distilled water and subsequently allowed to drain, after they were sterilized in the oven at 170°C for 1 hour before use (Fawole and Oso, 2004). Heat sensitive wares were disinfected with 70% ethanol. The working bench was also swabbed with 70% alcohol to have a sterile environment.

III. Results and analysis

Results of the well water quality parameters listed in section 2.4 for the various sources are presented in Table 1. The water quality parameters whose levels were not within permissible levels specified by the Standards Organization of Nigeria, SON, for all samples from all the sources and sampling points are presented in Table 2 for all samples from well, borehole, stream, rain and river.

Table 1: Well Water Quality at Different Population Densities in Oshogbo

S/N	Parameters	POPULATION DENSITY							SON MPL
		Low		Medium			High		
		Dada Estate	Isale-Oshun	Ayetoro	Ogo-Oluwa	Oke-Ayepe	Oke-Baale	Igbona	
1	Colour (TCU)	<15	<15	<15	<15	<15	<15	<15	15
2	Odour	UO	UO	UO	UO	UO	UO	UO	UO
3	Taste	UO	UO	UO	UO	UO	UO	UO	UO
4	Temperature ^{0}C	25	25	25	25	25	25	25	Ambient
5	pH	7.6	7.8	8.01	7.6	7.9	7.9	7.4	6.5-8.5
6	Conductivity (µS/cm)	83	22.77	24	48.9	20.5	22.7	72.5	1000
7	Turbidity (NTU)	<5	<5	<5	<5	<5	<5	<5	5
8	T.D.S (Mg/L)	110	162	167	117	97	185	105	500
9	T. Hardness (Mg/L)	25	180	105	105	65	60	170	500
10	Ca. Hardness (Mg/L)	16	22	30	44	30	24	109	150
11	Mg. Hardness (Mg/L)	61	83	45	35	36	174	61	150
12	Alkalinity (Mg/L)	100	85	75	80	55	178	45	500
13	Chloride (Mg/L)	5.1	19	15.5	23	4.6	4.4	40	200
14	Fluoride (Mg/L)	0	0.67	0.89	0.46	0.35	0.53	0.06	1.5
15	Free Chlorine (Mg/L)	0.08	0.88	0.55	1.2	0.75	1.88	0.92	0.2-0.25
16	Total Chlorine (Mg/L)	0.16	0.51	0.05	0.14	0.28	0.25	0.15	-
17	Nitrate (Mg/L)	0.8	0.88	0.55	1.2	0.75	1.88	0.92	50
18	Nitrite (Mg/L)	0.014	0.24	0.02	0.28	0.15	0.08	0.013	0.2
19	Iron (Mg/L)	0.034	0	0	0	0	0	0.048	0.3
20	Manganese (Mg/L)	0.031	0.007	0.003	0.03	0.025	0.031	0.01	0.2
21	Arsenic (Mg/L)	0	0	0	0	0	0	0	0.01
22	Zinc (Mg/L)	0.95	0.3	0.14	0.69	0.15	1.2	0.34	3
23	Bacteriological (Mg/L)	-VE	-VE	-VE	+VE	+VE	-VE	-VE	-
24	BOD (Mg/L)	4.5	4.4	4.5	17	16	4.9	4.9	6
25	COD (Mg/L)	8	7.2	8	37.5	38.2	6.9	7.2	10

Table 2: Water Quality Parameters Not Within SON Levels For Water Sources at different Population Density Areas of Oshogbo

S/N	WELL Parameters	POPULATION DENSITY							SON
		LOW		MEDIUM			HIGH		
	Parameters	**Dada Estate**	**Isale-Oshun**	**Ayetoro**	**Ogo-Oluwa**	**Oke-Ayepe**	**Oke-Baale**	**Igbona**	**MPL**
	WELL								
11	Mg. Hardness (Mg/L)	61	83	45	35	36	**174**	61	150
15	Free Chlorine (Mg/L)	**0.08**	0.88	0.55	1.2	0.75	1.88	0.92	0.2-0.25
18	Nitrite (Mg/L)	0.014	**0.24**	0.02	**0.28**	0.15	0.08	0.013	0.2
23	Bacteriological (Mg/L)	-VE	-VE	-VE	**+VE**	**+VE**	-VE	-VE	
24	BOD (Mg/L)	4.5	4.4	4.5	**17**	**16**	4.9	4.9	6
25	COD (Mg/L)	8	7.2	8	**37.5**	**38.2**	6.9	7.2	10
	BORE-HOLE								
15	Free Chlorine (Mg/L)	0.34	**0.08**	0.58	**0.08**	**0.1**	**0.15**	**0.17**	0.2-0.25
	STREAM								
5	pH	8.13	9.06	8.72	9.02	8.73	8.72	8.39	6.5-8.5
7	Turbidity (NTU)	**>5**	**>5**	**>5**	<5	<5	**>5**	**>5**	5
11	Mg. Hardness (Mg/L)	98	32	134	146	78	60	**221**	150
15	Free Chlorine (Mg/L)	0.24	**0.12**	0.2	0.24	0.28	0.22	**0.19**	0.2-0.25
23	Bacteriological (Mg/L)	-VE	-VE	-VE	**+VE**	-VE	**+VE**	**+VE**	
24	BOD (Mg/L)	5.1	4.9	4.3	**26**	4.1	**23.2**	**22**	6
25	COD (Mg/L)	7.3	7	6.5	**47.2**	7.7	**45**	**49**	10
			RAIN				**OKE-BALE.R**	**OKE-BALE.D**	
5	pH		**8.72**				**8.89**	8.12	6.5-8.5
11	Mg. Hardness (Mg/L)		140				**225**	135	150
23	Bacteriological (Mg/L)		-VE				**+VE**	-VE	
24	BOD (Mg/L)		3.7				**15.4**	4.5	6
25	COD (Mg/L)		8.2				**34.6**	7.2	10
	RIVER								
15	Free Chlorine (Mg/L)		**0.16**						0.2-0.25
23	Bacteriological (Mg/L)		**+VE**						
24	BOD (Mg/L)		**13.6**						6
25	COD (Mg/L)		**36.5**						10

3.1 Quality of Well and Borehole Water Sources

The well water quality parameters greater than the SON permissible levels are Magnesium hardness, Free Chlorine, Nitrite, Bacteriological, BOD and COD. The Magnesium hardness level was below the SON permitted level only at Oke-Bale, a high density area of Oshogbo. This is shown in Figure 3a. Free Chlorine and Nitrite levels are charted in Figure 3b showing that Free Chlorine is above in all the areas except at Dada estate, a low density population area. This shows that the various communities apply Chlorine to their wells without consideration to known dosage. Nitrite level is higher than SON level at low density Isale-Oshun and medium density Ogo-Oluwa. Bacteriological levels at Ogo-Oluwa and Oke-Ayepe, both within medium population density, are positive and their BOD and COD levels are also greater than their SON permissible levels as shown in Figure 3c.

Most borehole water quality parameters are within permissible levels. It is only Free Chlorine at Dada estate and Ayetoro (low and medium population density areas) that are above the permissible level. This is shown in Figure 4.

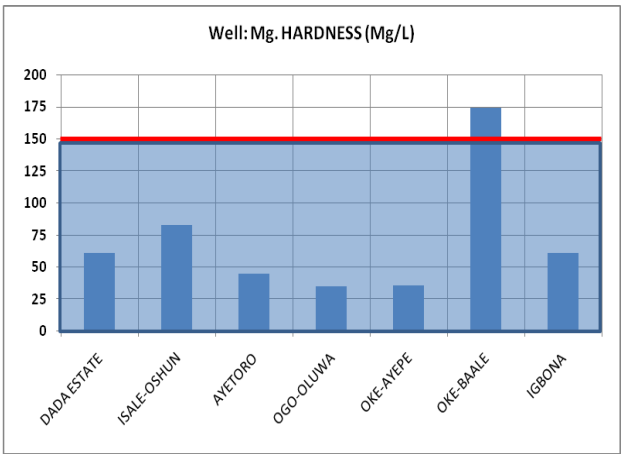

Figure 3a: Well water: Magnesium Hardness

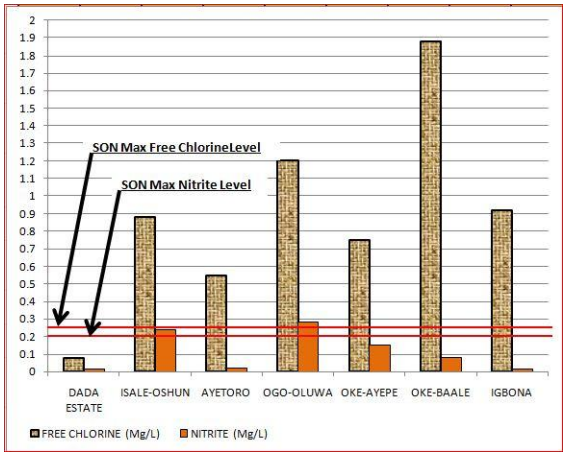

Figure 3b: Well water: Free Chlorine and Nitrite Levels

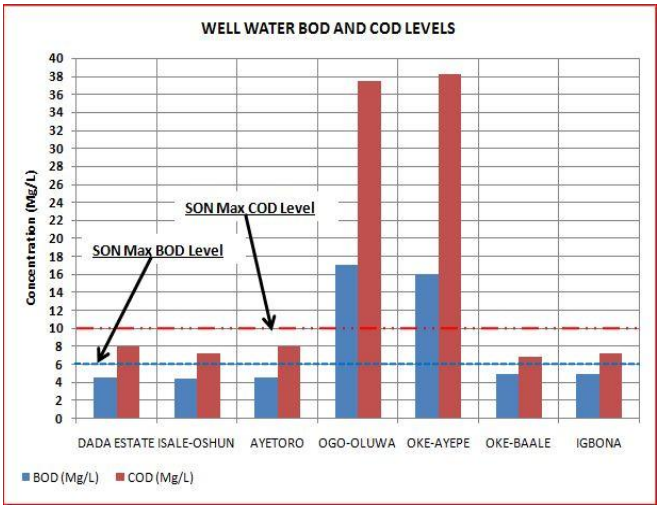

Figure 3c: Well water: BOD and COD Levels

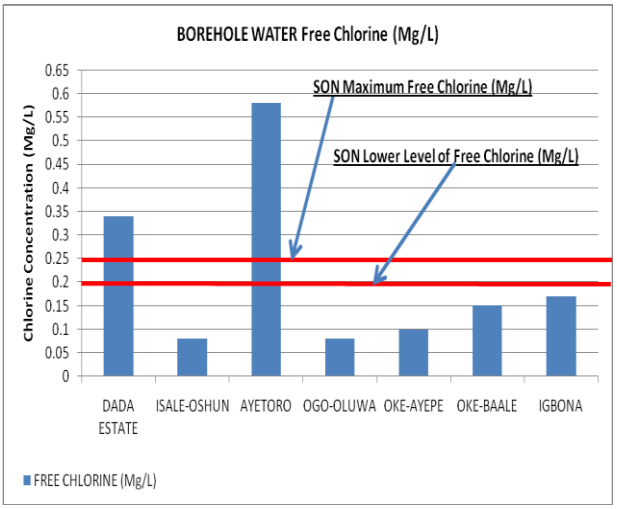

Figure 4: Borehole water: Free Chlorine

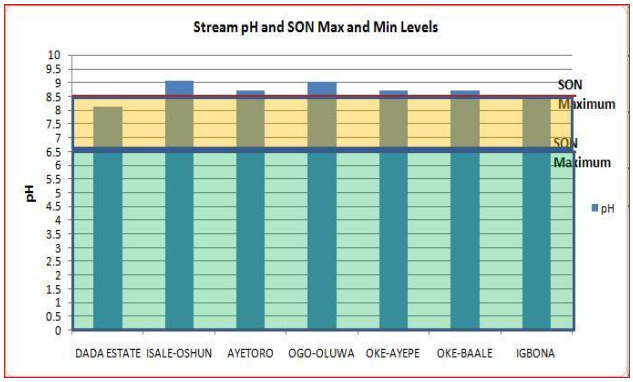

Figure 5a: Stream water pH and SON Maximum and Minimum Levels

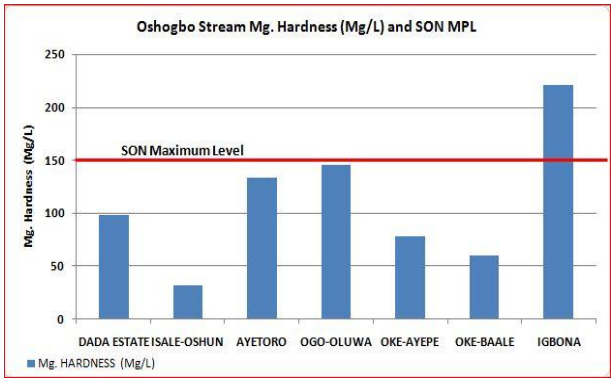

Figure 5b: Stream water Mg. Hardness and SON MPL Level

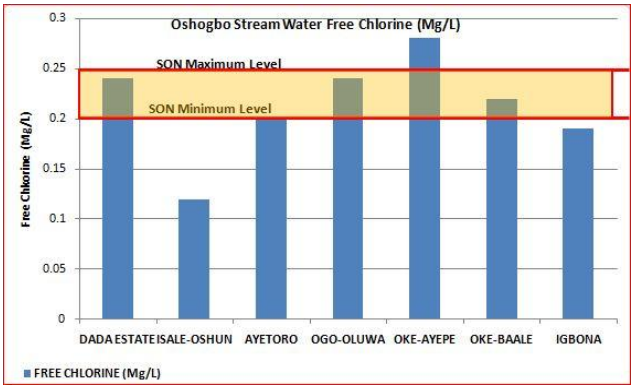

Figure 5c: Stream water Free Chlorine and SON Maximum and Minimum

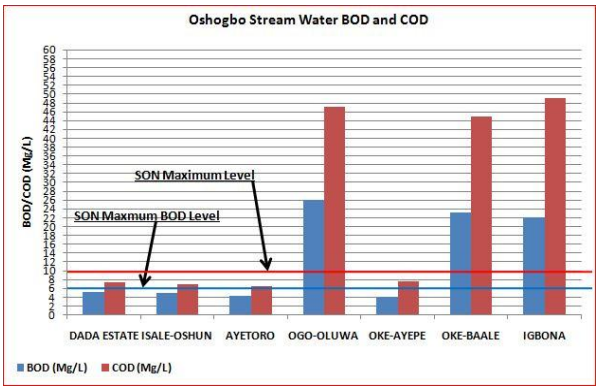

Figure 5d: Stream water BOD; COD and SON MPL Levels

3.2 Stream Water Quality Assessment

Stream water quality parameters of concern are indicated in Table 2 as pH, Turbidity, Magnesium hardness, Free Chlorine, Bacteriological, BOD and COD. pH values are generally high in the stream water and are only within permissible SON level in Dada Estate (low density) and Igbona (high density) as shown in Figure 5a. Turbidity is lower than permissible level only at two medium population density locations, Ogo-Oluwa and Oke- Ayepe. Magnesium hardness is shown in Figure 5b to be above SON level only at Igbona, high density area. Stream water sources that are not within SON Free Chlorine levels are from Isale_Oshun, Oke-Ayepe and Igbona. This can be deduced in Figure 5c. Positive bacteriological water sources are from Ogo-Oluwa, Oke-Baale and Igbona. Similarly, BOD and COD levels are above SON permissible level for the medium density Ogo-Oluwa area, and high density areas, Oke-Baale and Igbona. This is presented in Figure 5d.

3.3 Rain Water Quality Analysis Rain water quality parameters of concern are pH, Magnesium hardness, Bacteriological, BOD and COD. pH of rain water is above the SON maximum permissible level at Isale-Oshun and Oke-Baale respectively low and high density population areas of Oshogbo as indicated in Figure 6a.

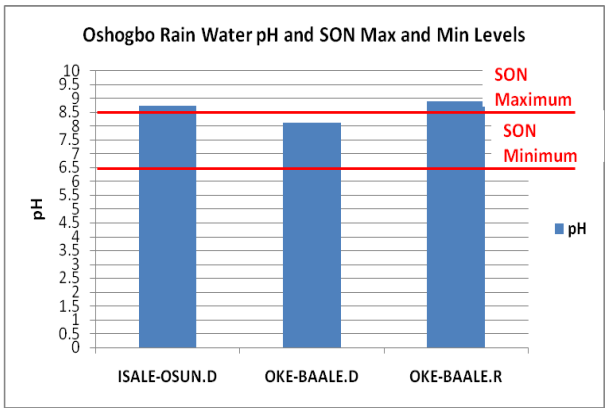

Figure 6a: Rain water pH and SON Maximum and Minimum Levels

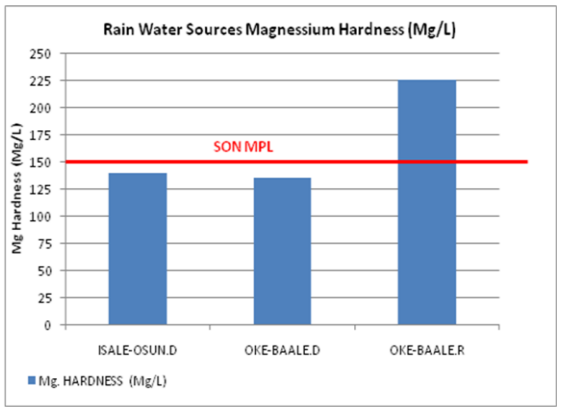

Figure 6b: Rain water Magnessium and SON MPL Levels

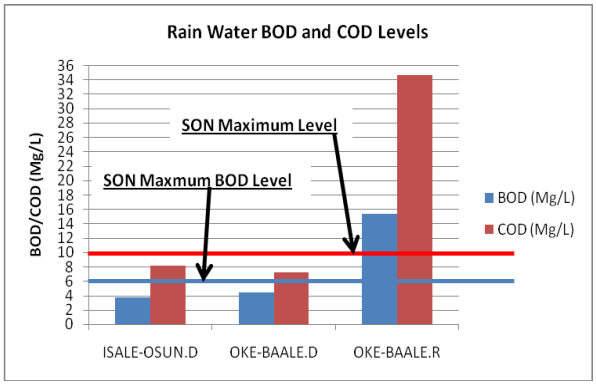

Figure 6c: Rain water BOD, COD and SON Maximum and Minimum Levels

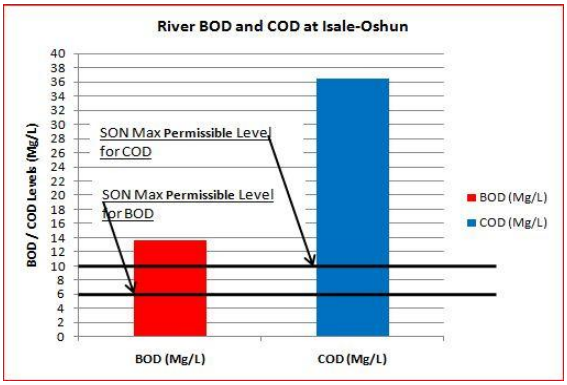

Figure 7: River water BOD, COD and SON MPL

The levels specified by the Standards Organization of Nigeria, SON, for all samples from all the sources and sampling points are presented in Table 2 for all samples from well, borehole, stream, rain and river.

Magnesium level is above the SON permissible level at Oke-Baale.R, high population density area, indicated in Figure 6b. The BOD and COD levels of the rain water source also for Oke-Baale.R are above the SON levels as shown in Figure 6c. This source has a positive Bacteriological level which shows that the rain water at this source is polluted.

3.4 Analysis of River Water Quality

River water quality parameters of concern are Free Chlorine, Bacteriological, BOD and COD. Free Chlorine is below the lower range permissible by SON. Positive Bacteriological level is obtained for the river while the BOD and COD levels are higher than the SON permissible levels as shown in Figure 7.

IV. Conclusions and Recommendations

The water quality parameters identified as being of concern to sanitation of potable water in the State Capital are as follows:

(i)	pH	(ii)	Turbidity
(iii)	Magnesium Hardness		
(iv)	Free Chlorine	(v)	Nitrite
(vi)	Bacteriological		
(vii)	BOD	(viii)	COD

Level of each parameter differs from source to source as well as from level of population densities. The concern of pH is only noticeable in the stream and rain water sources. Turbidity is expected to be of concern in water flowing sources such as in streams and the river. Turbidity of the river at Isale-Oshun is stable, while

water from stream sources of Ogo-Oluwa and Oke-Ayepe have turbidity levels greater than 5, the permissible level by SON standards.

Magnesium hardness levels are greater than permissible levels for the well, stream and rain water sources. Sanitation level can be measured by the level of Free Chlorine when it is below the minimum SON permissible range. These cases were observed only in Dada Estate for well sources; in all the Borehole sources except Dada Estate and Ayetoro; In Isale-Oshun and Igbona stream sources and in the River at Isale-Oshun.

The Bacteriological, BOD and COD levels were above SON standards in all the sources except the Borehole waters. Thus, giving the Borehole waters a clean bill of health. The positive bacteriological test and BOD and COD levels greater than the SON permissible levels show that the following sources are polluted: Ogo-Oluwa and Oke-Ayepe well sources; Ogo-Oluwa, Oke-Bale and Igbona stream sources Oke-Bale Rain source.R and the River source at Isale-Oshun.

The polluted sources are all within the medium and high population density parts of the State Capital.

In order to improve the sanitation level of the State Capital the following are recommended:

The use of Chlorine for sanitizing wells should be encouraged.

There is need for bringing the borehole water Chlorine levels to SON permissible range by the Communities concerned.

Awareness should be brought to the notice of the medium and high population areas that they should be weary of the use of the stream water being polluted.

This is an indication that toilet facilities are not adequate within these communities. Stakeholders should therefore take drastic measures towards this.

Ordinarily, rain water should not be polluted. But it was polluted in Oke-Bale. Since rain water is usually collected through roofs, owners of very old buildings, rusted roofs and asbestos cement roofs should be sanctioned in the use of rain water. There should be a campaign against the use or rain water for drinking without treatment.

There is need for Government to set up a Regulatory Agency to look into these sanitation issues raised in this paper.

Regular monitoring of the water quality parameters before they degenerate to an epidemic level is also recommended.

More studies should be carried out extending the water quality parameters to other areas not covered by this study.

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