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Comparative Study of Quality of Sources of Water from Developing Communities of Nigeria and India

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Abstract: ***Quality of water use by man will continue to be an issue of concern since water itself is life to man. In these days of globalization, and cross-border health issues, we are interested in comparative study of quality of water sources beyond borders perhaps there may be lessons from such study. Oke-Bale community in Oshogbo in Osun State, Nigeria and Nitte community in Udupi District of Karnataka State, India are two similar communities selected for this study. Records of water samples from the two communities were obtained for five sources of water. The sources of water in order of use within the communities are the open well, borehole, stream or Monsoon river water, Harmattan river water and rain water. Water quality parameters considered which are physical/organoleptic, chemical and bacteriological, include colour, odour, taste, temperature, turbidity, pH, electrical conductivity, total hardness, calcium hardness, magnesium hardness, alkalinity, chloride, nitrate, zinc, and bacteriological. The parameters were assessed based on permissible levels of five water quality standards of SON, MUD, WHO, USEPA and BIS. Results show that the quality parameters for water resources of Oke-Bale in Nigeria are generally higher than those of Nitte, India. Conductivity follows increasing trend from well to river. Conductivity for rain needs to be accessed by SON. Results of bacteriological analysis indicate that the stream and rivers in both case studies are polluted. Results also indicated that rain collected from roof gutter can be polluted as indicated by Oke-Bale rain.R which is polluted. Oke-Bale alkalinity levels are higher than the Nitte levels and alkalinity levels of all water sources in Oke-Bale except rain sources are not permitted by WHO and USEPA levels of 100mg/L, although permitted by SON standards which is 5 times those of WHO and USEPA. All water sources are within chloride, nitrate and zinc permissible levels. SON is advised to review standard for alkalinity which is 5 times those of WHO and USEPA. BIS is to review chloride permissible high and wide range of 250-1,000mg/L in line with others whose range is 200-250mg/L. MUD may need to review Zinc permissible range of 5-15mg/L, being too much where SON and WHO are both 3mg/L while USEPA . Further studies are recommended in the following areas: (i) To confirm or otherwise observation of higher stream turbidity over that of river; (ii) To establish if ratio of river to stream conductivity levels is high and greater than 5 as is the case in the Oke-Bale and Nitte case study; (iii) To establish a functional relationship between total hardness, calcium hardness and magnesium hardness; (iv) Study on Variation in the quality of rain water collected directly and from different roof materials and ages of roofs.***

Keywords: Water sources; Quality parameters; Permissible level; Developing communities; Standards Organizations

1. General Introduction

Water is necessary to living on earth. All organisms contain it, some live in it, some use it domestically. Others use it for electrical energy supply, transportation, recreations, while it is also utilized in the industries. Water is the most useful to life if it is not polluted. Contaminated streams, lakes, rivers, ground waters, bays, or oceans are harmful to living and non-living things. People suffer from water related diseases such as diarrhoea, cholera, typhoid, and guinea worm as a result of inadequate safe water supply and sanitation facilities, in many communities (ADF, 2007). Plants and animals require water that is moderately pure, and they cannot survive if their water is loaded with toxic chemicals or harmful microorganisms. Pollution makes streams, lakes, and coastal waters unpleasant to look at, to smell, and to swim in. NIS (2007), has shown some of the effects of contaminated waters as, objectionable odour, and taste, colour level greater than 15TCU, turbidity level greater than 5NTU, and cyanosis, and asphyxia („blue-baby syndrome") in infants under 3 months for nitrate level greater than 50mg/L. Similarly, MUD (1997) indicated these effects as unclear colour objectionable odour, un-accessed level of taste, colour level greater than 2.5-10NTU range turbidity level. The standards for many water quality parameters are presented by WHO, (1993), USEPA, (1995) and BIS, (1993). People who ingest polluted water can become ill, and, with prolonged exposure, may develop cancers or bear children with birth defects.

Monitoring of quality of water sources is required in determination of sanitation level of any community. Oginni, (2013) assessed variation of water quality within an urbanized stretch of a river. 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. Oginni and Ojoawo, (2014), Ojoawo et al., (2014) have been involved in the estimation of water sources quality. Olajire and Imeokparia, (2011) worked on the Inorganic constituents of River Osun, a river close to Oke-Bale. Oginni and Alaka, (2014) determined quality of laboratory influent and effluent to determine laboratory water use recyclability.

Quality of water use by man will continue to be an issue of concern since water itself is life to man. Globalization, and cross-border health issues, from the point of effects of contaminated water sources is being initiated in this paper. Nigeria is the most populous Nation in Africa while India is the world's second most populous country. Both countries are regarded as developing nations. A comparative study of quality of water sources beyond borders is aimed at comparing Indian and Nigerian communities.

India is divided into 28 states while Nigeria is divided into 36 states. Nitte and Oke_Bale are two similar communities in the developing Countries of India and Nigeria respectively. Nitte is a village in Karkala taluk of Udupi District of Karnataka State in Indian, while Oke-Bale community is in Oshogbo Local Government Areas of the Osun State in Nigeria. The official language of Nitte community is Kannada though the language mostly spoken is Tulu. Official language for Oke-Bale community is English while Yoruba language is the one mostly spoken.

2. Methods and Materials

The commonest source of water in developing countries is well, followed by borehole, stream, river and rain in that order. 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.

Water Sources from well, borehole, stream, river, and rain were identified for the two Nitte and Oke-Bale communities respectively for Udupi District, in Karnaka State, India and Oshogbo Local Council in Osun State, Nigeria. The normal experimental protocols considered those of Oginni and Ojoawo, (2014) and Ojoawo et al., (2014) for the sets of sources from Oke-Bale and Nitte communities respectively. Water sample storage and treatment were according to Fresenius, et al., (1988), APHA, (1989) and APHA, (2005).

2.1 Determination of Water Quality of each Source

Quality of the water sources were determined by analyzing the physical / organoleptic parameters and the chemical and bacteriological parameters obtained. The physical / organoleptic parameters for analysis are Colour, Odour, Taste, Temperature and Turbidity.

Other parameters for analysis include:

pH	Conductivity	T. Hardness	Ca. Hardness
Mg. Hardness	Alkalinity	Chloride	Nitrate
Zinc	Bacteriological		

Level of the qualities of each parameter was compared with some water quality standards. ICMR, (1975) prepared Manuals for drinking water supplies and ISI, (1983) were involved in works on specification for drinking water. The water quality standards used in the analysis include:

1. Standards Organizations of Nigeria, SON approved Nigerian Industrial Standards NIS 554 2007 - Nigerian Standard for Drinking Water Quality, SON
2. Ministry of Urban Development, Physical, chemical and bacteriological quality Standards for drinking water, India, 1997. World Health Organization, WHO, - Guidelines for drinking water, 1993.
3. United States Environmental Protection Agency, 1995 – National primary drinking water regulations. http://www.epa.gov/safewater/consumer/pdf/mcl.pdf
4. Bureau of Indian Standard - Code of basic requirements for water supply, 1993 drainage and sanitation,. IS: 1172, 1993.

The physicochemical and bacteriological analyses of various sources for Oke-Bale were obtained from office of Rural Water and Sanitation Agency, RWESA in Osun State Government Secretariat in Abere. For Nitte water sources, Visual and physical observations were made on the colour, taste and the odour of the samples. Electrochemical measurements of the pH and temperature were carried out simultaneously on same digital Systronics μpH meter, System 361 model. Digital Systronic Nephelo-turbidity meter, System 132 model was engaged in determining the turbidity level of all samples. Electrical conductivity was also measured electrochemically using digital Systronic μSiemens conductivity meter, System 306 model that functions under room temperature (Ojoawo et al., 2014). All the analyses were carried out at both the Environmental Engineering and the Biotechnology Instrumentation Laboratories of the NMAMIT using Standard Method (Shridhara et al., 2014).

3. Results and Analysis

The permissible levels of each water quality parameter involved in this study is analyzed and discussed in section 3.1 Results of the water quality parameters considered as physical / organoleptic and are discussed in section 3.2. The chemical and bacteriological parameters results are analyzed in section 3.3.

3.1 Variations in the Quality Standards

An overview of the yardsticks for determining the quality of the water resources parameters can be obtained from the presentation of the various water quality standards. Available water quality standards organizations are presented by in section 2.1. Variations in the permissible levels of each of the water quality standards organizations are presented in Table 1.

Table 1: Water Quality Standards

S/N	*Parameter*	*Water Quality Standards Permitted Levels*				
		SON	MUD	WHO	USEPA	BIS
1	Colour (TCU)	15	Clear	2	5	
2	Odour	UO	UO	UO	UO	
3	Taste	UO	N/A	N/A	N/A	
4	Temperature 0C	AMBIENT	N/A	N/A	N/A	
5	pH	6.5-8.5		7-8.5	6.5-8.5	6.5-9.0
6	Conductivity (µS/cm)	1000		N/A	N/A	N/A
7	Turbidity (NTU)	5	2.5-10	5	5	
8	T. Hardness (Mg/L)	500		100	N/A	50-100
9	Ca. Hardness (Mg/L)	150		N/A	N/A	N/A
10	Mg. Hardness (Mg/L)	150		N/A	N/A	N/A
11	Alkalinity (Mg/L)	500		100	100	N/A
12	Chloride (Mg/L)	200		250	250	250-1000
13	Nitrate (Mg/L)	50		50	10	45
14	Zinc (Mg/L)	3	5.0-15.0	3	N/A	
15	Bacteriological (Mg/L)	-Ve/Nil	Nil	Nil	Nil	

The standard permitted for colour of water range from 2 - 15 total colour units, WHO to SON, while odour is unobjectionable. Only SON indicated that unobjectionable taste is permitted, while the others did not assess (N/A meaning not assessed) the standard. The temperature permitted is that of the surrounding area, i e, ambient. The baseline for pH is 6.5 for all the standards organizations except WHO which is 7.0 ranging to a maximum of 8.5 except BIS whose maximum is 9.0. Only SON has an assessment for permissible electrical conductivity level, which is 1,000µS/cm. All the organizations permit a maximum of 5NTU for turbidity, except MUD with a range of 2.5-10. This range is considered high and its maximum too doubles maximum permitted by others.

The permitted total hardness level ranged from 50 to 500mg/L. While WHO and BIS maximum permitted levels is only 100mg/L, SON raised it to a very high 500mg/L. There is need for SON to revisit this total hardness and also for both Calcium hardness and Magnesium hardness. Similarly SON's permitted alkalinity level, 500mg/L is 5 times those of WHO and USEPA. Standards permitted for Chloride level ranged from SON's level of 200 to 250 for others where the 250mg/L is the low level for BIS ranging to a high 1,000mg/L. This will need to be re-examined. Permitted levels of nitrate ranged from 45mg/L to 50mg/L for three of the Standards organizations, while USEPA permitted was only 10mg/L. This seems too low compared with the others. Zinc level permitted is from 3mg/L for both WHO and SON. MUD permissible level is from a baseline higher than the above, (5mg/L) to 15mg/L, which is 5 times the level permitted by others. There is no permissible bacteriological level by all the standards organizations.

3.2 Organoleptic / Physical Parameters of Water sources in both Nitte and Oke-Bale

Results of physical / organoleptic water quality level per water source is shown in Table 2. Comparing the results with the permissible levels of each parameter for each source, the colour of all the water sources is clear except in the stream and river sources of Nitte, India which are yellowish in colour. Nitte stream is Murky yellow while the river is pale yellow.

Table 2: Results of Physical / Organoleptic Water Quality Levels per Source

S/N	*Parameter*	*Sources Of Water*										
		Well		*Borehole*		*Stream*		*River*		*Rain*		
		OKE-BALE	*NITTE*	*OKE-BALE*	*NITTE*	*OKE-BALE*	*NITTE*	*OKE-BALE*	*NITTE*	*OKE-BALE/D*	*OKE-BALE/R*	*NITTE*
1	Colour (TCU)	<15	Clear	<15	Clear	<15	Murky Yellow	<15	Pale yellow	<15	<15	Clear
2	Odour	UO	None	UO	None	UO	Faint	UO	None	UO	UO	None
3	Taste	UO	None	UO	None	UO	Slightly salty	UO	None	UO	UO	None
4	Temperature 0C	25	27.6	25	27.4	25	27.4	25	27.6	25	25	27.3
5	Turbidity (NTU)	<5	0.6	<5	1.7	>5	16.8	<5	9.7	<5	<5	1

The odour and taste are unobjectionable except at Nitte stream which has a faint odour and slightly salty taste. Temperature in all the sources can be described as ambient and are within permitted levels. Considering the MUD standard, turbidity in all the sources can be said to be permissible except at Nitte stream where it is greater than the maximum 10NTU permitted. The turbidity levels for streams at both Oke-Baale and Nitte are greater than at their river site sources. This is probably raising a question on the possibility of stream turbidity levels to be greater than river turbidity levels.

3.3 Chemical and Bacteriological Analysis

Results of chemical and bacteriological water quality parameters are indicated in Table 3. All the pH levels at the various water sources are permitted by the BIS standards organizations

Table 3: Results of Chemical and Bacteriological Water Quality Parameter Levels per Source

S/N	*Parameter*	*Sources Of Water*										
		Well		*Borehole*		*Stream*		*River*		*Rain*		
		OKE-BALE	*NITTE*	*OKE-BALE*	*NITTE*	*OKE-BALE*	*NITTE*	*OKE-BALE*	*NITTE*	*OKE-BALE/D*	*OKE-BALE/R*	*NITTE*
1	pH	7.9	6.59	7.8	6.6	8.72	6.96	8.23	6.88	8.12	8.89	6.61
2	Conductivity (µS/cm)	22.7	45.8	48.2	69.2	53.65	72	322	730	21.4	42.3	1020
3	T. Hardness (Mg/L)	60	52	60	32	125	16	60	24	195	300	12
4	Ca. Hardness (Mg/L)	24	7.2	18	23.2	65	15.2	44	11.2	60	75	1
5	Mg. Hardness (Mg/L)	174	44.8	42	8.8	60	0.8	62	12.8	135	225	11
6	Alkalinity (Mg/L)	178	40	115	24	215	24	105	20	90	95	12
7	Chloride (Mg/L)	4.4	10.0	34	8.0	10.5	4.0	10.12	4.0	4.6	4.5	4.0
8	Nitrate (Mg/L)	1.88	1.38	0.003	2.36	0.023	2.28	0.05	1.4	0.001	0.012	1.78
9	Zinc (Mg/L)	1.2	0.059	0.05	0.587	0	0.047	0	0.377	0.12	0.15	0.545
10	Bacteriological (Mg/L)	-VE	Nil	-VE	Nil	+VE	+VE	+VE	+VE	-VE	+VE	Nil

whose maximum range is 9.0. The pH of the stream and rain roof sources at Oke-Bale are not permitted by the other standards organizations whose maximum permissible is 8.5. The pH levels as it varies within water sources are shown in Figure 1. Conductivity follows an increasing trend from well to river water sources, except for the rain water sources. This is shown in Figure 2. There is very wide gap between the conductivity level of rain water sources in Oke-Bale, Nigeria and that of Nitte, India. Ratio of river to stream conductivity levels is high and greater than 5 in both Oke-Bale and Nitte. The ratio is 6 for Oke-Bale and 10 for Nitte. There is a need to consider justification of this claim through extension of this study.

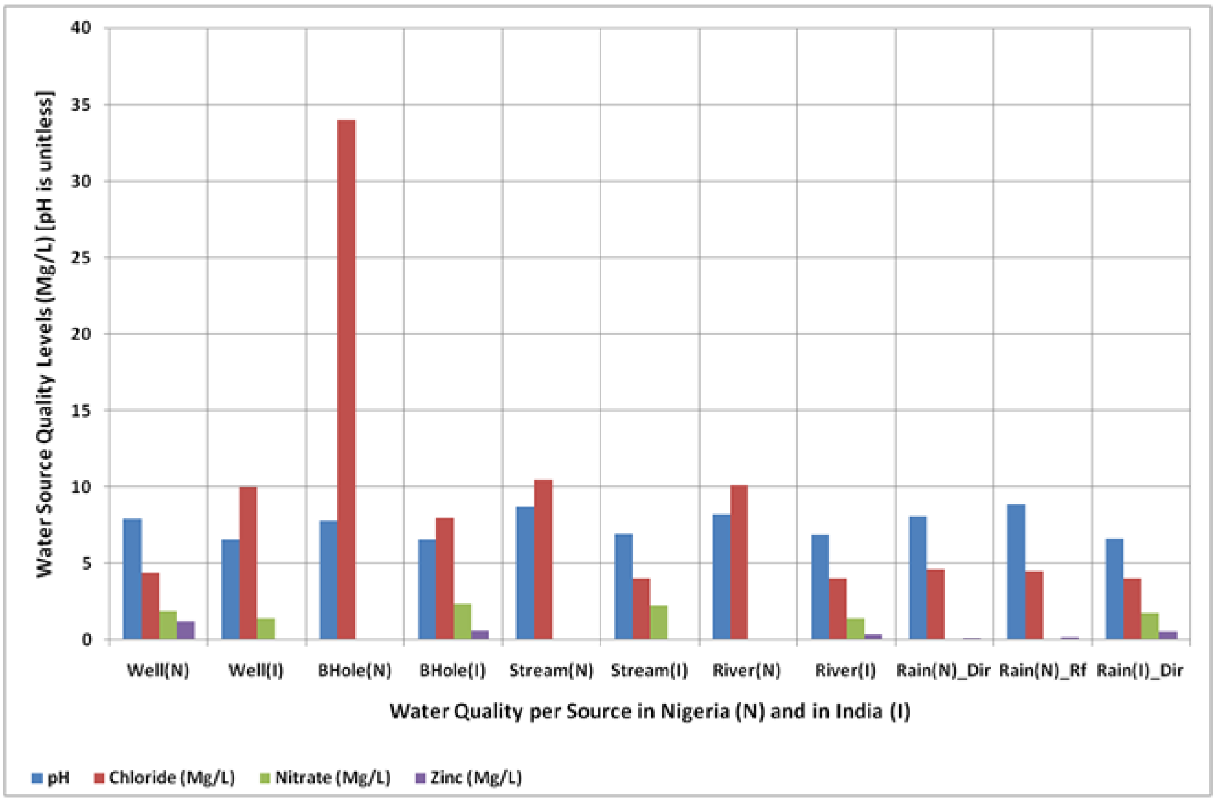

Figure 1: Concentrations of pH, Chloride, Nitrate and Zinc per Water Source in Nigeria (N) and in India (I)

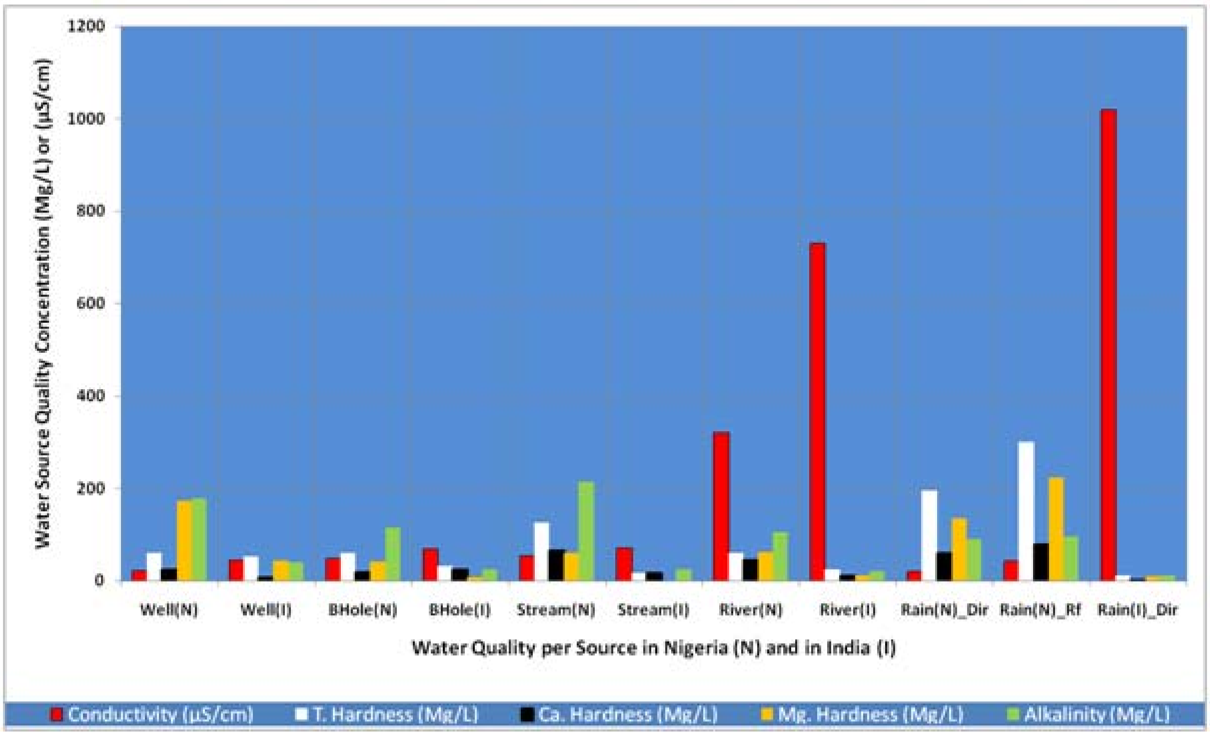

Figure 2: Concentrations of Conductivity, Total Hardness, Ca Hardness, Magnesium Hardness and Alkalinity per Water Source in Nigeria (N) and in India (I)

Total hardness ranged from 12mg/L in Nitte rain to 195mg/L in Oke-Bale direct rainwater or from 12mg/L in Nitte rain to 300mg/L in Oke-Bale roof rainwater. The trend between Total hardness, Calcium hardness and Magnesium hardness gives a relationship given by

Total hardness = Calcium hardness +Magnesium hardness

This trend manifests in all the water sources from Nitte and in Borehole, stream, and rain sources. The disparity observed in the Oke-Bale well and river hardness distribution will need further studies to establish this stand.

Alkalinity levels in Nitte sources ranged from 12mg/L in Nitte rain to 40mg/L in Nitte well, while for Oke-Bale sources, it ranged from 90mg/L in rain to 215mg/L in stream. Alkalinity levels of all water sources in Oke-Bale except rain sources are not permitted by WHO and USEPA levels of 100mg/L, although permitted by SON standards. Generally Oke-Bale alkalinity levels are higher than the Nitte levels. There is a need for SON to check the standard for Alkalinity which is 5 times that of WHO and that of USEPA levels. Chloride in the water sources ranged from 4.0 to 10.5 in all except in Oke-Bale borehole where this value is multiplied about 3 times to 34mg/L. The variation of Chloride levels is shown in Figure 1. Even though, all the sources are within chloride permissible levels there is the need for BIS to check its range (250 – 1,000mg/L) because it is wide compared with other Water Standard Organizations.

There is no nitrate level that is up to 2.5mg/L obtained in any of the water sources. Nitte nitrate levels ranged from 1.38mg/L for well to 2.36mg/L for borehole, which is also the highest in all the water sources. This is shown in Figure 1. Oke-Bale water sources nitrate levels ranged from 0.001mg/L for direct rain water to 1.88mg/L for well. The lowest nitrate permissible level is 10mg/L for USEPA Standards Organization while the other Standards Organizations have permissible nitrate levels ranging from 45mg/L to 50mg/L. This implies that all the water sources have no course for concern on nitrate in the water.

Zinc concentration in the water sources ranged from zero to 1.2mg/L. The permissible levels from the Standards Organizations ranged from 3mg/L to 15mg/L. This also implies that the water sources are free from Zinc as a contaminant. Variation of Zinc concentrations within the various water sources is indicated in Figure 1. However MUD may need to revisit its range of 5-15mg/L for Zinc as too much where SON and WHO are both 3 while USEPA is even yet to assess since its not been such a metal of concern.

Results of bacteriological analysis indicate that the streams and rivers in both cases are polluted. The case of rain collected from the roof can be polluted as indicated by Oke-Bale rain.R which is polluted.

4. Conclusions and Recommendations

Conclusions from the physical / organoleptic parameters of the water sources are that the stream and river at Nitte with unclear colour, and the slightly salty stream taste is an indication of the stream pollution. The turbidity levels for streams at both Oke-Baale and Nitte are greater than at their river site sources. This is probably raising a question on the possibility of stream turbidity levels to be greater than river turbidity levels.

Conductivity follows an increasing trend from well to river water sources, except for the rain water sources. Ratio of river to stream conductivity levels is high and greater than 5 in both Oke-Bale and Nitte. The ratio is 6 for Oke-Bale and 10 for Nitte. This suggests a need to extend this study in order to justify the claim or otherwise.

Total hardness ranged from 12mg/L in Nitte rain to 195mg/L in Oke-Bale direct rainwater or from 12mg/L in Nitte rain to 300mg/L in Oke-Bale roof rainwater. This implies that rain water collected through the roof increased the hardness level by some 100%. The trend that Total hardness is a sum of Calcium hardness and Magnesium hardness was realized in Nitte water sources and in Oke-Bale borehole, stream, and rain sources. However a disparity was observed in the Oke-Bale well and river hardness distribution which will need further studies to establish this stand.

Generally, Oke-Bale alkalinity levels are higher than the Nitte levels. Alkalinity levels of all water sources in Oke-Bale except rain sources are not permitted by WHO and USEPA levels of 100mg/L, although permitted by SON standards. There is a need for SON to check the standard for Alkalinity which is 5 times the WHO and USEPA levels. It is observed from the study that although the Chloride levels of all the water sources are within chloride permissible levels there is the need for BIS to check its range (250 - 1,000mg/L) because it is wide compared with other Water Standards Organizations.

The highest concentration of nitrate in the water sources is not up to 2.5mg/L which is lesser than 25% of the lowest permissible standard of 10mg/L for USEPA, which is not comparable to the other Standards Organizations' permissible nitrate levels ranging from 45mg/L to 50mg/L. All the water sources are therefore far below permissible nitrate levels. Zinc level is also free from any possible effect of being a contaminant, rather it is the MUD that may need to revisit its range of 5-15mg/L for Zinc as being too much considering that SON and WHO are both 3 while USEPA is even yet to assess since its not been such a metal of concern.

Bacteriological analysis indicates that the streams and rivers in the two communities are polluted. However, there is warning signal that rain water collected from roof gutters may be polluted as indicated by the case study of Oke-Bale rain collected from the roof.

Generally the borehole water sources rank as highest on the sanitation scale among the group of sources, followed by the well sources and rain sources in descending order. Rain sources are ranked third because of the mode of collection. Stream sources are considered as 4th while the river sources are on the lowest scale on this platform.

General recommendations for further studies are in the following areas: (i) To confirm or otherwise observation of higher stream turbidity over that of river; (ii) To establish if ratio of river to stream conductivity levels is high and greater than 5 as is the case in the Oke-Bale and Nitte case study; (iii) To establish a functional relationship between total hardness, calcium hardness and magnesium hardness; (iv) Study on Variation in the quality of rain water collected directly and from different roof materials and ages of roofs is also suggested.

References

[1] African Development Fund, ADF, 2007: Rural Water Supply And Sanitation Sub- Programmes In Yobe And Osun States, Nigeria. Appraisal Report by Water and Sanitation Department (OWAS) of ADF May 2007.

[2] APHA, 1989: Standard methods for examination of water and wastewater (17th Edition); prepared and published jointly by: American Public Health Association (APHA); American Water Works Association (AWWA), and Water Pollution Control Federation (WPCF), New York.

[3] APHA, 2005: AWWA and WEF, "Standard Methods for the Examination of Water and Wastewater", 21st Edition, 2005, pp 6-15

[4] Bureau of Indian Standard, BIS, 1993: Code of basic requirements for water supply, drainage and sanitation". IS: 1172, 1993, pp 1-2.

[5] Fresenius, W., K. E. Quentin, and W. Scheider, 1988: Water Analysis – A practical guide to physic-chemical, chemical and microbiological water examination and quality assurance, Springer Verlag, pp. 804.

[6] ICMR, 1975: Manual of Standards of quality for drinking water supplies. Indian Council of Medical Research, Spe. Rep. No. 44, 27.

[7] IndiaMapped, "Map of Udupi District, India", accessed online on 16th December, 2014, @http://www.indiamapped.com/karnataka/udupi/karkal/nitte/ISI, 1983: ISI Specification for drinking water, 15:10500: 1983. Indian Standard Institution, New Delhi.

[8] Marmot, M. G., C. D. Ryff, L. L. Bumpass, M. Shipley, and N. F. Marks, 1997: Social Inequalities in Health – A Major Public Health Problem. Social Science and Medicine 44:901-910

[9] MUD, 2013: Physical, chemical and bacteriological quality Standards for drinking water. Ministry of Urban Development, India, 1997. In B.C. Punmia, A.K. Jain, and Arun K. Jain, "Water supply Engineering", Laxmi publications (P) Ltd, Reprint Edition, 2013, pp. 209 – 211.

[10] Nigerian Industrial Standard, (NIS), 2007: Nigerian Standard for Drinking Water Quality. Nigerian Industrial Standard NIS 554, Standard Organization of Nigeria, pp: 30.

[11] Oginni, F. (2013): Variations in the Water Quality of an Urban River in Nigeria. Computational Water, Energy, and Environmental Engineering, 2, 81-91. doi: 10.4236/cweee.2013.22B014.

[12] Oginni, F. A. and O. E. Alaka, 2014: Study of Laboratory Water Consumptive Use and Recyclability. IAEME International Journal of Civil Engineering & Technology (IJCIET), ISSN 0976 – 6308 (Print), ISSN 0976-6316 (Online), Volume 5 Issue 9, 103-113 (September, 2014).

[13] Oginni, F. A. and S. O. Ojoawo, 2014: Assessment of Sanitation Levels of Sources of Water In Osun State Capital, Nigeria. International Journal of Engineering Research and Applications (IJERA). ISSN: 2248-9622, Vol. 4, Issue 12 (Part 1), December 2014, pp.94-104.

[14] Ojoawo, S. O. and A.O Akinyele, 2005: Determination of pollution levels of selected water source in Ogbomoso North Local Government Area". Unilorin Science and Engineering Periodicals, Journal of Information in Civil Engineering, Nigeria, Vol. 2, No. 1, 2005, pp 1-16.

[15] Ojoawo, S. O., G. Udayakumar and S. Shetty, 2014: Potability Assessment of Notable Water Sources in Nitte Community, India. Civil and Environmental Research www.iiste.org, ISSN 2224-5790 (Paper) ISSN 2225-0514 (Online) Vol.6, No.11, 2014

[16] Olajire, A. A. and Imeokparia, F. E., 2001: Water Quality Assessment of Osun River: Study of Inorganic Nutrients. Environmental Monitoring and Assessment 69: 17-28, 2001. Kluwer Academic Publishers, Printed in the Netherlands.

[17] Satone, A. K., J. R. Bajoria, P. V. Tekade and N. P. Mohabansi, 2011: Monitoring of Drinking Water Quality of M.I.D.C. of Wardha City, Maharashtra. RASAYAN Journal of Chemistry, Vol.4, No.4 (2011), 910-913 ISSN: 0974-1496. CODEN: RJCABP

[18] Shridhara, T. N., S. O. Ojoawo, P. V. Mahaganesha, M. R. Thippeswary, R. Anand and B. P. Sharath "C-Language Programming for Development of Conventional Water Treatment Plants Decision Support System", Computational Water, Energy, and Environmental Engineering, Vol. 3, No.9, 2014, pp 129-139.

[19] USEPA, 1995: National primary drinking water regulations. United States Environmental Protection Agency, 1995, accessed online on 12th October, 2014@ http://www.epa.gov/safewater/consumer/pdf/mcl.pdf

[20] WHO, "Guidelines for drinking water 1993", World Health Organization, accessed online on 14th October, 2014 @http://www.lenntech.com/applications/drinking/standards/who-s-drinking-water- standards.htm.

[21] World Health Organization (WHO), 2007: Water for Pharmaceuticals Use. In: Quality Assurance of Pharmaceuticals: A Compendium of Guidelines and Related Materials. 2nd Updated Edn. World Health Organization, Geneva, 2: 170-187