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.

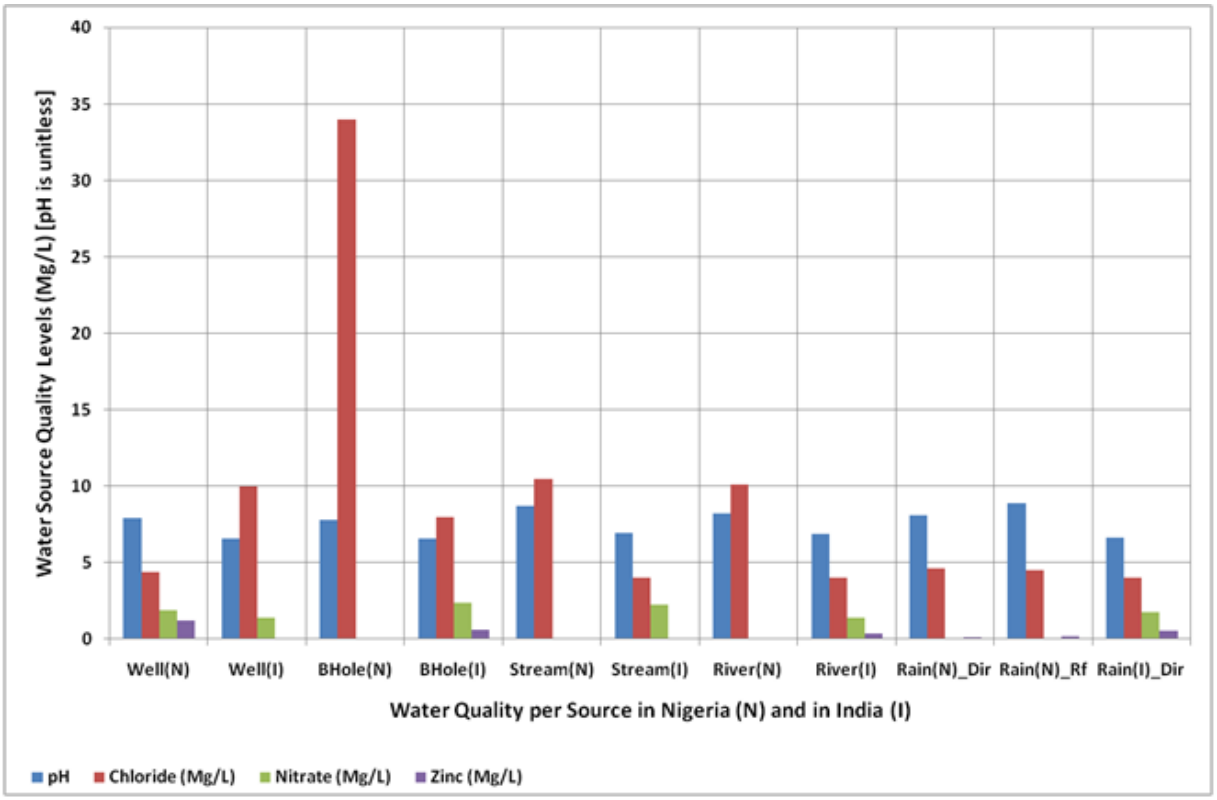

Figure 1: Concentrations of pH, Chloride, Nitrate and Zinc per Water Source in Nigeria (N) and in India (I)

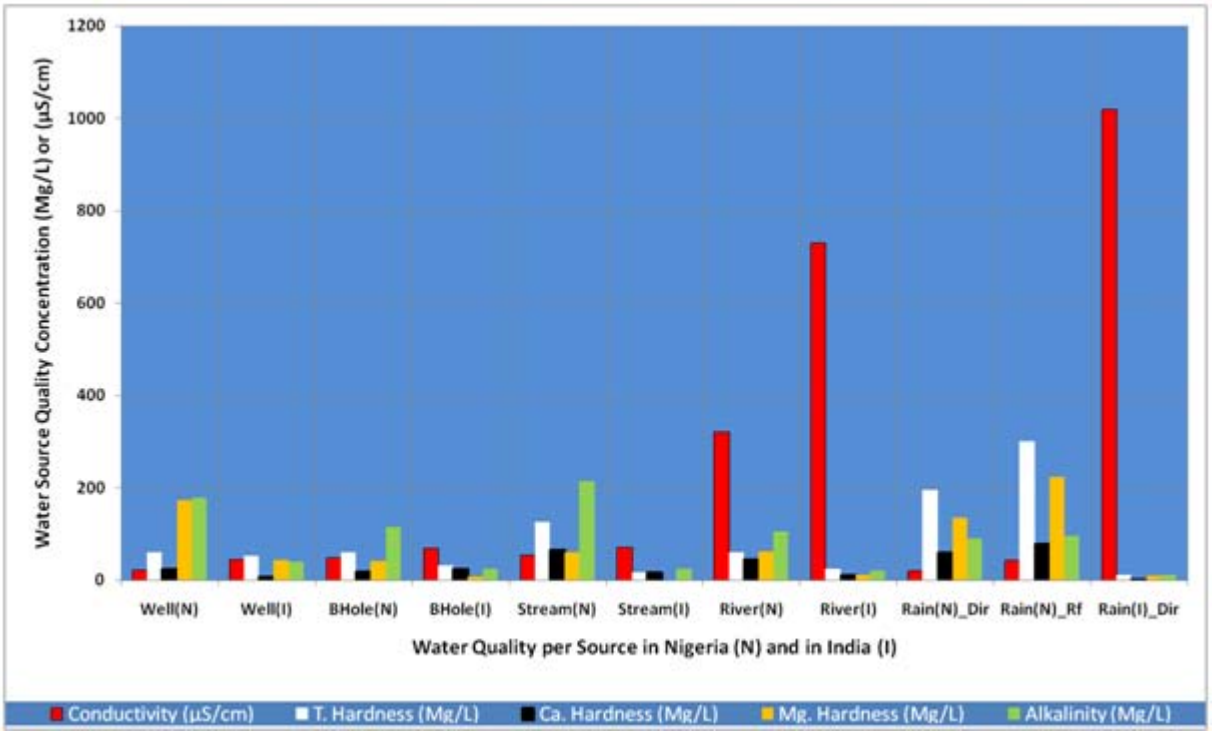

Figure 2: Concentrations of Conductivity, Total Hardness, Ca Hardness, Magnesium Hardness and Alkalinity per Water Source in Nigeria (N) and in India (I)

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.

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