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Potability Assessment of Notable Water Sources in Nitte Community, India

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Abstract
Quality is believed to best describe any given water more than other yardsticks. Water quality assessment is therefore a worthwhile study. Potable water is that which possesses the quality that renders it fit and safe for drinking. This research is necessitated by the need for ensuring consumption of wholesome water by all, and particularly in the study area. This study focuses on the quality assessment of some selected water sources in Nitte community, Udupi District of Karnataka State, India. Eight Samples from notable water sources were collected for the study, they include: Monsoon river water, Harmattan river water, distilled/deionized water, borehole, open well, rain water, UV sterilized, and mineral/bottled water. These were subjected to laboratory analysis at the NMAM Institute of Technology (NMAMIT), Nitte. Parameters that were measured include: colour, odour, taste, turbidity, temperature, pH, electrical conductivity, acidity, alkalinity, chloride, sulphate, nitrate, total hardness, calcium hardness, zinc, copper, magnesium, lead, and total coliform. Findings reveal that all sampled sources, apart from the river water, have most of the characteristics within the limits provided for drinking water by the MUD, WHO and USEPA standards. Samples are clear, tasteless and odourless, with the exception of Parappadi river water samples in both seasons of the year that have slightly objectionable physical properties. Some of the samples need slight modifications in their pH values to meet the drinking standard's specifications. Electrical conductivity of rain water is observed to be extremely higher than all other samples. Groundwater sources, borehole and well, possess higher chloride levels and greater hardness values as compared to others. Well water tops others in the hardness scale with soft permanent hardness. The most acidic sample is borehole water while distilled, well and mineral water samples are all with the higher alkalinity levels. River water samples exceed others in their sulphate concentrations while distilled water has the least value. Heavy metals concentrations in the samples are generally minimal, found in microgram per litre levels as compared to the milligrams of the Standards. Traces of lead and coliform bacteria are detected only in river water samples. The study concludes that the order of potability of the sampled water sources is Mineral/table > UV sterilized > Distilled water > Borehole > Rain > Well > Harmattan River > Monsoon River water. Mineral/table and UV sterilized water are directly potable without further treatments. For quality improvement, full scale treatment with all the unit processes is recommended for the river water. Lime treatment and disinfection are strongly suggested for rain, borehole, distilled and well water. The well water should be further subjected to softening by either lime soda or ion exchange treatment. Arising from this study, it is therefore highly imperative for all the concerned authorities to, as a matter of priority, cite a Water Treatment Plant in Nitte community.
Keywords: Potability, Pollution, Water Quality, Nitte

1. Introduction

Water is an essential commodity, aside light it has been generally believed to be the most indispensable substance for human existence [1]. Water forms about 70 per cent of our body fluids and serves many other purposes among which are domestic, industrial, agricultural, fire protection and others [2]. Natural water is available from river, groundwater, precipitation, lakes, ponds, surface runoff and sea water. The characteristics of natural water include particulates and organic matters in river water; salts of carbonates, chlorides, sulphates from groundwater; gases, vapours, particulates and radio-active fall-outs from precipitation water; algae, odour and tastes from lakes and ponds; organic matters, nitrates, and phosphates from surface runoff; and salts from sea water [3].

Supply of potable water has progressively attracted the attention of International community and therefore significant advances are being made in investigating the viability of any given water source to support life [4]. Water quality is the primary target of treatment and purification. The various types of impurities present in water can be determined by analysis carried out on both the raw and the purified water. This analysis essentially encompasses the physical examination (for colour, taste, odour, temperature and turbidity); chemical examination (for pH, total solids, total hardness, chlorides, sulphates, fluorides, nitrates, calcium, magnesium, iron, lead, cadmium, mercury etc); and bacteriological (for coliforms and *E.coli*). The main purposes is to classify, prescribe treatment, control treatment and purification processes, and maintain public supplies of an appropriate standard of organic quality, clarity and palatability [3,5].

The present study has a central aim of assessing the quality of notable water sources identified in Nitte community of Udupi District, Karnataka State, India. The key objectives are to determine the potability of the selected water sources and recommend appropriate treatment measures to those with qualities below the Water Standards.

2. Materials and Method

2.1 The study area

Nitte is a community located on latitude 13.1815 ^{0}N and longitude 74.9354 ^{0}E and under Karkal Taluk and in the Udupi District of Karnataka State, India. The total population is 11,381 people. Its elevation/altitude is 20 meters above the mean seal level. It is near to Arabian sea, during the daytime has an average temperature range of 24 to 31°C thus there is a chance of higher humidity in the weather ranging between 40-58% [6]. Nitte is surrounded by Udupi City towards west, Mangalore towards South, Bantval towards South, and Sringeri City towards East. The water demand of Nitte community is estimated to be 100 lpcd [7]. There is no public pipe-borne water supply from any treatment plant in the community, the nearest waterworks being at Karkal some 9kms away [8]. The map of the study area is as shown in Fig. 1.

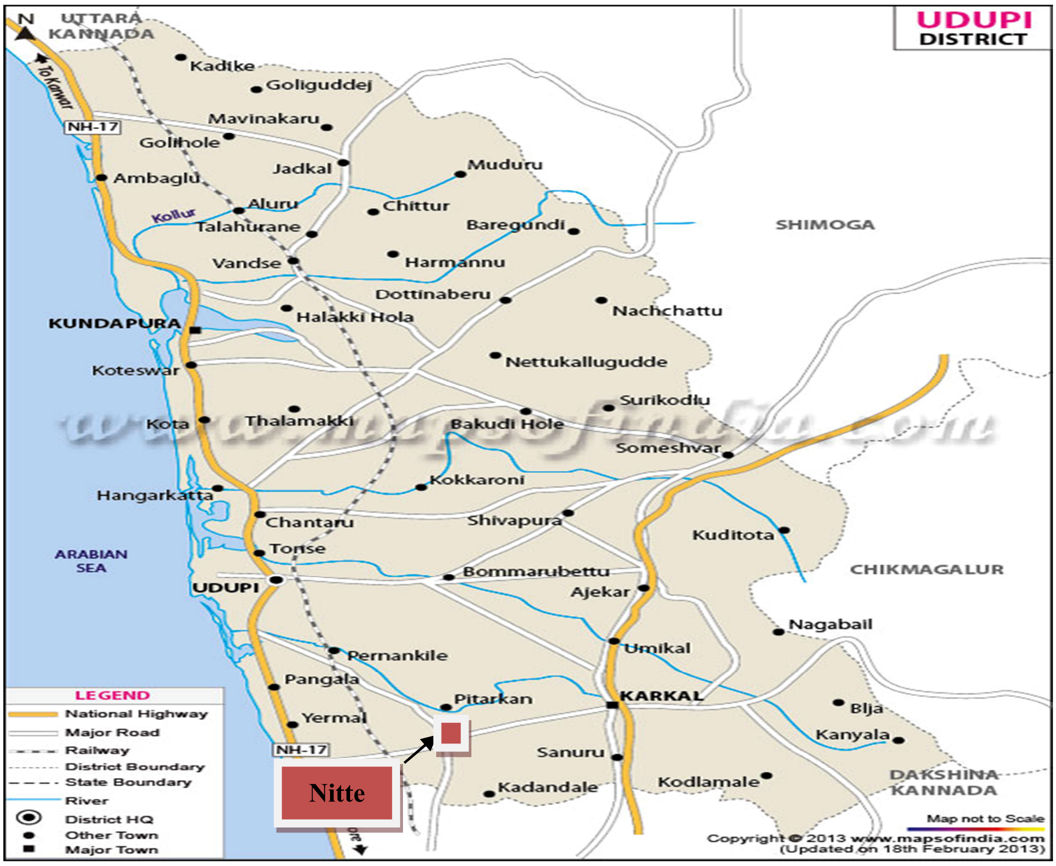

Fig. 1: Map of Udupi district of Karnataka State, showing Nitte the Study area

2.1 Sampling

Eight samples from notable water sources in Nitte community were collected into 1-litre plastic bottles in line with Standard Method [9]. The samples include: harmattan water collected in the month of March from Parappadi river, near Parappadi village; monsoon water collected in August from same river; distilled/deionized water from the Biotechnology Department of NMAMIT; borehole water from NMAMIT; open well from Meenakshi Guest House, rain water obtained from Sport's Complex open field, UV sterilized water from a household's kitchen, and mineral/bottled water obtained from a retailer's shop at Nitte. The samples with their representation are as presented on Table 1. These were immediately transferred from the collection points to the Laboratory for analysis.

Table 1: Representation of the samples

S/N	*Sample Label*	*Sample Description*
1	NRvHW	Nitte River Harmattan Water
2	NRvMW	Nitte River Monsoon Water
3	NDsW	Nitte Distilled/Deionized Water
4	NBhW	Nitte Borehole Water
5	NWeW	Nitte Well Water
6	NRnW	Nitte Rain Water
7	NUVW	Nitte UV Sterilized Water
8	NMnW	Nitte Mineral Water

2.2 Laboratory Analysis

All the analyses were carried out at both the Environmental Engineering and the Biotechnology Instrumentation Laboratories of the NMAMIT using Standard Method [8]. Parameters that were measured include: colour, odour, taste, temperature, turbidity, pH, electrical conductivity, acidity, alkalinity, chloride, sulphate, nitrate, total hardness, calcium hardness, zinc, copper, magnesium, lead, and total coliform. 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.

Titrimetric method using a Standard NaOH (0.02N) titrant by neutralization to pH 4.3 was employed in the measurement of acidity while same titrimetric approach of Standard H2SO4 (0.02N) tritrant was used in determining the alkalinity. Chloride concentrations/levels in the samples were determined using Argentometric titration method with Standard $AgNO_3$ solution (0.0141N). Standard sulphate solution was allowed to react with $BaCl_2$ in an active acid medium thereby precipitating sulphate ions and the absorbance of the solution measured with Systronics Spectrophotometer169 (λ = 420nm) equipment. Nitrate determination too was by spectrophotometry, using phenol disulphonic acid (PDA) method in which nitrate reacted with PDA and produced a nitro-derivative which in alkaline medium developed a yellow colouration. The spectrophotometer measured the nitrate absorbance at λ = 410nm. Total hardness of the sample was through Versenate Method using ethylene diamine tetra acetic acid (EDTA) Standard solution (0.01N). Calcium hardness was through titration method with EDTA till pink colour of the NaOH adjusted sample changes to purple. The difference between the total hardness and the calcium hardness accounted for the magnesium hardness.

The contents of Zn, Cu, Mg and Pb metals in the samples were determined with the use of Flame Atomic Absorption Spectrometer (FAAS). The flame used in the analysis was air-acetylene. The temperature formed in the air-acetylene flame was around 2300˚C. The FAAS technique made use of the fact that neutral or ground state atoms of an element can absorb electromagnetic radiation over a series of very narrow, sharply defined wavelengths. Multiple tube fermentation technique was employed in performing coliform tests that entails presumptive, confirmed and completed tests using the Standard method.

3. Results and discussion

The summary of results for physical, chemical, metal and bacteriological tests is presented in Tables 2, 3, 4 and 5 respectively. A comparison is made on same Tables with the Drinking Water Standards provided by the World Health Organization (WHO), Indian Ministry of Urban Development (MUD), and United States Environmental Protection Agency (USEPA) [10-12]. Fig. 2 represents the chemical characteristics of the samples in form of histograms.

3.1 Physical parameters

The colours of all the samples are clear with the exception of those from Parrapadi river. The one taken in the pre-monsoon season appears pale yellow unlike the monsoon's murky yellow colour. The 2 samples, especially the monsoon one, show traces of faint odour and slightly salty taste (Table 2). These could have been due to the fact that rivers and lakes usually produce algae growth giving rise to colour, odour and taste. The faint odour of monsoon river water sample could be due to reduction of its higher sulphate concentration (1.49mg/l as shown on Table 3) into hydrogen sulphide through inorganic process.

Table 2: Results of the physical parameters as compared with the Water Standards

S/N	*Water Source/Parameters*	*Colour*	*Odour*	*Taste*	*Temperature ^0C*	*Turbidity (NTU)*
1	NRvHW	Pale yellow	None	None	27.6	9.7
2	NRvMW	Murky yellow	Faint	Slightly salty	27.4	16.8
3	NDsW	Clear	None	None	30.6	1.3
4	NBhW	Clear	None	None	27.4	1.7
5	NWeW	Clear	None	None	27.6	0.6
6	NRnW	Clear	None	None	27.3	1.0
7	NUVW	Clear	None	None	27.5	0.6
8	NMnW	Clear	None	None	27.6	0.4
	MUD Standard	Clear	unobjectionable	N/A	N/A	2.5 - 10
	WHO Standard	2 TCU	unobjectionable	N/A	N/A	5.0
	USEPA Standard	5 Colour Units	unobjectionable	N/A	N/A	5.0

N/A = Not Accessed

Table 3: Results of the chemical parameters as compared with the Water Standards

S/N	*Water Source /Parameters*	*pH*	*Electrical Conductivity (mS/cm)*	*Chloride (mg/l)*	*Acidity (mg/l)*	*Alkalinity (mg/l)*	*Sulphate (mg/l)*	*Nitrate (mg/l)*	*Total Hardness (mg/l)*	*Calcium Hardness (mg/l)*	*Magnesium Hardness (mg/l)*
1	NRvHW	6.88	730.00	3.99	6.00	20.00	1.13	1.40	24.00	11.20	12.80
2	NRvMW	6.96	72.00	3.99	6.00	24.00	1.49	2.28	16.00	15.20	0.80
3	NDsW	6.46	20.00	5.99	8.00	60.00	0.35	1.28	20.00	ND	20.00
4	NBhW	6.60	69.20	7.99	12.00	24.00	0.75	2.36	32.00	23.20	8.80
5	NWeW	6.59	45.80	9.99	6.00	40.00	0.60	1.38	52.00	7.20	44.80
6	NRnW	6.61	1020.00	3.99	6.00	12.00	0.77	1.78	12.00	1.00	11.00
7	NUVW	6.60	42.70	5.99	8.00	24.00	0.62	3.31	12.00	1.00	11.00
8	NMnW	7.83	84.00	9.99	6.00	40.00	0.79	2.47	8.00	ND	8.00
	BIS Standard ***(mg/l)***	6.5 - 9.0	N/A	200 – 1000	N/A	N/A	200 – 400	45	50 – 100	N/A	N/A
	WHO Standard ***(mg/l)***	7 – 8.5	N/A	250	N/A	100	250	50	100	N/A	N/A
	USEPA Standard***(mg/l)***	6.5 - 8.5	N/A	250	N/A	100	250	10	N/A	N/A	N/A

N/A = Not Accessed, ND = Not Detected

In the same vein, the turbidity of the 2 samples stands clearly above the limits provided by the Standards. The monsoon river water possess about thrice the value of turbidity expected in wholesome water. Vegetal decay in the rivers may equally be accountable for this distortion in quality posing threat to the potability of their waters and making them to be laden with objectionable physical characteristics. As shown in Table 2, mineral/bottled water with turbidity of 0.4 NTU is found to be the clearest of all the samples. UV sterilized and well water both have turbidity values of 0.6 NTU each, while rain water and borehole possess slightly higher values perhaps due to some dissolved substances in them.

3.2 Chemical Characteristics

From Table 3 it is observed that the entire 8 samples nearly satisfied the chemical concentration levels stipulated by the Standards. Virtually all the samples have their pH within the specifications by the Standards with the distilled water being at the lower borderline and the most alkaline is the mineral water with 7.83 pH value. The result justifies an earlier report that groundwater is usually characterized with lower pH value in comparison with other water sources [3]. Again, the pH value of the well sample correlates with those reported by [5]. Electrical conductivity of rain water is observed to be extremely higher than all other samples. This could be attributable to various dissolved salts and the gases it may contain. According to virtual amrita laboratory (*amrita.vlab.co.in*), the electrical conductivity of total pure water should be 55, of distilled water: 100, and of other raw water 100 to 150 mS/cm. The distilled, UV sterilized and well water, all satisfy the criterion for pure water in terms of electrical conductivity. However, rain and the river water of harmattan season both pose pollution threats due to electrical conductivity, while borehole and monsoon river water are potentially affected by the conductivity.

The groundwater sources (borehole and well) possess higher chloride levels as compared to others while the least values are noticed in the river water. All the samples are however not constituting chloride pollution when matched with the Standards. The finding on chloride content of 4mg/l is in line with an established report that rain water has been known to carry not more than 20mg/l of chloride [3, 4]. The most acidic sample is borehole water with 12mg/l, perhaps due to some dissolved soil minerals. Distilled, well and mineral water samples are with the higher alkalinity levels (Fig. 2). The acidity observed in the rain water may be due to dissolved CO_2, SO_2 and other acidic gases in the atmosphere during its downpour. Rain water normally absorbs O_2, CO_2, rare gases, particulate matters and so on that may increase acidity, as it drops that are capable of triggering acid rain if in excess. Both river water samples exceed others in their sulphate concentrations while distilled water has the least value. All the sampled waters have sulphate levels within the specified limits of the Standards. The sulphate content of rain water could be due to oxidation of the SO_2 gas likely to have dissolved in it as it falls. The UV sterilized water has the highest nitrate concentration of 3.31mg/l followed by the other surface water sources; well water on the other hand only has traces of nitrate. All other samples possess tolerable nitrate values.

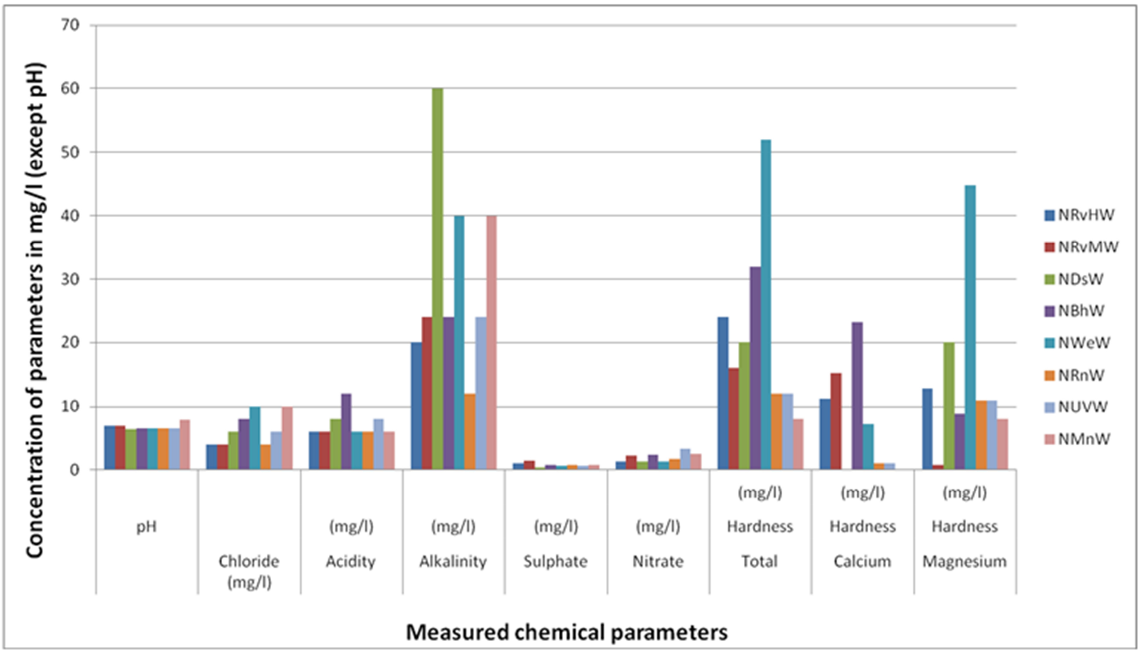

Fig. 2: The trend of the concentrations of chemical parameters in the water sources

The groundwater sources have the highest hardness values. Soil minerals are usually dissolved in groundwater; carbonates, sulphates and chlorides are evident, all resulting in hardness. Well water has a total hardness value of 52mg/l, a value which is about 5 times those of mineral and the UV sterilized samples. By the standard classification of hardness, the well water with $CaCO_3$ hardness degree of 3.64 is soft, while borehole and harmattan River samples degrees around 2.00 are very soft water. The rest water sources are found to be extremely soft with their hardness degrees of in the neighbourhood of 1.00. It is however observed that borehole sample is dominated with more calcium hardness than all other ones. While distilled and UV sterilized water samples have 100% magnesium hardness. As shown in Fig. 2, well water is the most hard of all the samples. The hardness of the well water could be classified as permanent as it contains relatively high sulphate and chloride ions, coupled with its magnesium content. Heavy metals concentrations in the samples were generally minimal, the microgram per litre levels as compared to the Standards are as shown on Table 4.

Zinc has its maximum presence the borehole rain water samples with 0.59 and 0.55 µg/l respectively. These are still within the recommended limits. Concentrations of Cu are found lower in the mineral water and monsoon river water. Rain, borehole and UV sterilized samples all show higher presence of Cu but falls within the acceptable recommended values. The concentration of magnesium is at peak in the borehole sample (3.89 µg/l) and also of significant values in the rain and harmattan river water samples. This could be due to the dissolved salts in the soil and eroded water as in the case of river sample. Most samples do not have lead concentration detected in them, except with slight traces in harmattan river and the UV sterilized water samples. This agrees with an earlier report of presence of lead in Kuye stream water sample [4]. These trace values of lead are however within the Standards. The rate of metal dissolution in water has been observed to be inversely proportional to the alkalinity, it corroborates an earlier report by [3].

Table 4: Results of the metals as compared with the Water Standards

S/N	*Water Source/Parameters*	*Zn (µ/l)*	*Cu (µg/l)*	*Mg (µg/l)*	*Pb (µg/l)*
1	NRvHW	0.377	1.078	2.419	0.028
2	NRvMW	0.047	0.109	0.445	ND
3	NDsW	0.357	0.945	1.560	ND
4	NBhW	0.587	1.702	3.884	ND
5	NWeW	0.059	0.117	0.528	ND
6	NRnW	0.545	1.706	3.020	ND
7	NUVW	0.419	1.506	2.700	0.248
8	NMnW	0.043	0.206	0.518	ND
	MUD Standard ***(mg/l)***	5.0 - 15.0	0.05 - 0.5	125 - 150	0.1
	WHO Standard ***(mg/l)***	3.0	2.0	200	0.01
	USEPA Standard ***(mg/l)***	N/A	1.3	N/A	0.015

N/A = Not Accessed, ND = Not Detected

3.3 Bacteriological properties

After the microbial analysis, only samples of river origin have coliforms found as 14 and 64 respectively for the harmattan and monsoon periods (Table 5). This corroborates an earlier knowledge that river water is prone to presence of bacteria and other organisms. More bacteria could have thrived in the monsoon sample owing to its favourable temperature. The rest samples are coliform-free in the tested 100ml quantities.

Table 5: Results of the bacteriological quality as compared with the Water Standards

S/N	**Water Source /Parameters**	**Coliform's Most Probable Number (Number/100ml)**
1	NRvHW	14
2	NRvMW	64
3	NDsW	Nil
4	NBhW	Nil
5	NWeW	Nil
6	NRnW	Nil
7	NUVW	Nil
8	NMnW	Nil
	MUD Standard	Nil/100ml for drinking water, 10/100ml for unpiped water supplies
	WHO Standard	Nil/100ml of drinking water
	USEPA Standard	Nil/100ml of drinking water 5/100ml for unpiped water supplies

4. Conclusion

This study on eight notable water sources in Nitte community has found that all sampled sources, apart from the river water, have most of the characteristics within the limits provided for drinking water by the MUD, WHO and USEPA standards. Parappadi river water samples in both seasons of the year have slightly objectionable physical properties. Some of the samples need slight modifications in their pH values to meet the drinking standard's specifications. Electrical conductivity of rain water is observed to be extremely higher than all other samples. The groundwater sources, borehole and well, possess higher chloride levels and greater hardness values as compared to others. The well water tops others in the hardness scale with soft permanent hardness. The most acidic sample is borehole water while distilled, well and mineral water samples are with the higher alkalinity levels. The river water samples exceed others in their sulphate concentrations while distilled water has the least value. Heavy metals concentrations in the samples were generally minimal, the microgram per litre levels as compared to the Standards. Traces of lead and coliforms are detected only in river water samples. The study concludes that the order of potability of the sampled water sources is Mineral/table > UV sterilized > Distilled water > Borehole > Rain > Well > Harmattan River > Monsoon River water. Mineral/table and UV sterilized water are directly potable without further treatments. For quality improvement, full scale treatment with all the unit processes in recommended for the river water. Lime treatment and disinfection are strongly suggested for rain, borehole, distilled and well water. The well water should be further subjected to softening by either lime soda or ion exchange treatment. Arising from this study, it is therefore highly imperative for all the concerned authorities to, as a matter of priority, cite a Water Treatment Plant in Nitte community.

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