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RESEARCH ARTICLE

TO ASSESS MONITOR THE DRINKING WATER QUALITY FOR THE TRIBAL VILLAGERS, ROHA-TAHSIL, DIST-RAIGAD (MAHARASHTRA)

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ABSTRACT

Assessment of physicochemical characteristics of well water of six tribal villages of Roha Tahsil has been carried out during the year 2011-12 for instance water moving through underground rocks and soils may pick up natural contaminates, even with no human activity or pollution in the area. In addition to nature's influence, water is also polluted by human activities, such as open defecation, dumping garbage, poor agricultural practices, and chemical spills at industrial sites.

The present study was undertaken for six tribal villages of Roha tahsil,viz. Warvatane, Bhatsai, Ainghar, Bangalwadi, Kansai and Shenvai where the well water is the only source of drinking water . The water analysis was performed for the selected parameters such as Temperature, pH, Total Solids, Turbidity, Conductivity, D.O., etc. It was concluded from the study that the well water can be used for the drinking purpose after a suitable treatment.

INTRODUCTION

Having safe drinking water and basic sanitation is a human need and right for every man, woman and child. People need clean water and sanitation to maintain their health and dignity. Having better water and sanitation is essential in breaking the cycle of poverty since it improves people's health, strength to work, and ability go to school. Yet 884 million people around the world live without improved drinking water and 2.5 billion people still lack access to improved sanitation, including 1.2 billion who do not have a simple latrine at all (WHO / UNICEF, 2008). Many of these people are among those hardest to reach: families living in remote rural areas and urban slums, and families living in the poverty- disease trap, for whom improved sanitation and drinking water could offer a way out.

The World Health organization (WHO) estimates that 88% of diarrheal disease is caused by unsafe water, inadequate sanitation and poor hygiene. As a result, more than 4,500 children die every day from diarrhea and other diseases. For every child that dies, countless others, including older children and adults, suffer from poor health and missed opportunities for work and education. To safe guard the long term sustainability of well water and ground water resources, the quality of water needs to be continuously monitored (NEERI 1981).

Study area

Roha is a small city and taluka in the Raigad district of the Maharashtra state of India. It is located 120 km southeast of Mumbai. It is the starting point of kokan railways and end point of central railways. Raigad is one of the industrially developed districts in the Maharashtra state. It lies at the bank of Arabian Sea. The geometrical position of it has latitude 18.45^0 and 73.12^0 longitude. Hilly area is one of the silent features of this area. The present investigation was carried out at the six selected villages in the Roha tahsil between June 2011 to December 2012. By considering the different physico-chemical parameters.

MATERIALS AND METHODS

For the purpose of study of well water quality in some selected tribal villages, the samples were collected quarterly, in early morning hours, in clean plastic carboy of 2 litres capacity. Air temperature, water temperature was recorded on the spot. The samples for DO were fixed immediately in the field itself.

Other parameters such as pH, Total Solids, Turbidity, Conductivity, B.O.D., Chlorides, Carbon Dioxide, Total Alkalinity, Total Hardness, Calcium Hardness, Magnesium

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Hardness, Silicates etc., were analysis as per the methods describe in the standard methods (APHA, 1990); Trivedi and Goel (1984) and Kodarkar (1992).

RESULT AND DISCUSSION

The variations in analysised physical and chemical characteristics are tabulated along with the standard values in the Table No. 1 to 17.

Temperature

Temperature is an important abiotic factor as it has effect on certain chemical and biological activities performed by the organisms living in aquatic media. It not only varies seasonally and spatially, but also shows diurnal variation (Ramdas *et al*.2005).

In fresh water environment, temperature regulates self purification capacity of water (Shaikh and Yeragi, 2004). It influences the viscosity, density, vapour pressure, surface tension and gas diffusion rates (Parker and Krenkel, 1969). Increased temperature decreases the capacity of water to keep oxygen in solution and increases BOD (Ghavzan *et al*., 2005).

Air Temperature

The air temperature was found ranging between 23^{0}C to 32^{0}C (Table No. 1). The minimum was observed in the month of December-12 and the maximum was in the month of March-12. There was no site to site variation in air temperature. The radiation from the sun as well as evaporation, relative humidity, wind, length of the day and cloud cover affect the air temperature (Shaikh and Yeragi, 2003).

Table No 1 Quarterly values of Air Temperature (0C) at 6 Sampling Stations from June 2011 to Dec. 2012

Site / Month	Warvatane (S1)	Bhatsai (S2)	Ainghar (S3)	Bangalwadi (S4)	Kansai (S5)	Shenvai (S6)
Jun-11	31	30	31	30	31	30
Sept-11	29	29	30	28	29	29
Dec-11	24	24	24	23	24	24
Mar-12	32	32	32	32	32	32
Jun-12	28	28	27	26	27	28
Sept-12	29	29	28	29	29	28
Dec-12	23	23	23	23	23	23
Max.	32	32	32	32	32	32
Min.	23	23	23	23	23	23
Average	28.00	27.85	27.86	27.28	27.86	27.71

Water Temperature

The surface water temperature depends on air temperature, wind, turbulence in water and biological activities taking place in the water. It is one of the important parameter as it directly affects the water chemistry and thus affects the biota in the water. During the present study the water temperature ranged from 17 to 23.5^{0}C (Table No. 2).

The minima was noted in the month of December 12. The maximum temperature was in March 2012 corresponding to air temperature.

Table No 2 Quarterly values of Water Temperature (0C) at 6Sampling Stations from June 2011 to Dec. 2012

Site / Month	Warvatane (S1)	Bhatsai (S2)	Ainghar (S3)	Bangalwadi (S4)	Kansai (S5)	Shenvai (S6)
Jun-11	22.1	20	21.5	21.9	21.3	22.1
Sept-11	20.1	20	21	21.2	21.4	20.2
Dec-11	20.5	19.2	21.3	19.5	21	20
Mar-12	23.5	22.5	22.2	22.7	23.4	23.5
Jun-12	21	21.5	20.5	21.3	20.4	21.3
Sept-12	21	21	21.1	20.2	21	21
Dec-12	18	17	18	17.8	18.1	18.2
Max.	23.5	22.5	22.2	22.7	23.4	23.5
Min.	18	17	18	17.8	18.1	18.2
Average	20.89	20.17	20.8	20.65	20.94	20.90

pH

pH is one of the most important attributes of any aquatic ecosystem since all biochemical activities depend on pH of the surrounding medium.

It is important to determine pH because most of the plants and animals can survive within a narrow range of pH from slightly acidic to slightly alkaline (Pawar and Pulley, 2005). pH also governs the distribution , transport and fate of heavy metals in aquatic ecosystems (Manna and Das, 2004). It has synergistic effects that determine the toxicity of elements like iron, aluminium, ammonia etc.

The average pH values during the present study show water was slightly alkaline except in the village Warvatane. (Table No. 3). Alkalinity of pH is seen at every site except S1 due to unknown reason. Eutrophication and Sewage inflow are few of the causes of increased pH as stated by Ghavzan *et al*.(2005) and Chatterjee and Raziuddin, (2001)

Table No. 3 Quarterly values of pH (range of 1 to 14) at 6 Sampling Stations from June 2011 to Dec. 2012,

Site / Month	Warvatane (S1)	Bhatsai (S2)	Ainghar (S3)	Bangalwadi (S4)	Kansai (S5)	Shenvai (S6)
Jun-11	6.8	7.2	7.5	7.2	7.6	7.6
Sept-11	7.2	7.3	7.2	7.1	7.5	7.9
Dec-11	7.3	7.0	7.3	7.1	7.6	7.8
Mar-12	6.8	6.9	7.0	7.3	7.2	7.8
Jun-12	7.0	7.0	7.4	7.0	7.0	7.6
Sept-12	6.3	7.3	6.9	6.9	7.5	7.8
Dec-12	6.7	7.5	7.5	7.4	7.6	7.7
Max.	7.30	7.50	7.50	7.40	7.60	7.90
Min.	6.30	6.90	6.90	6.90	7.00	7.60
Average	6.87	7.17	7.26	7.14	7.43	7.74

Total Solids

Total Solids are also referred as total residues and are related to turbidity. Total solids include suspended solids such as any particulate matter and dissolved solids such as mineral ions, calcium, phosphorus, iron, sulphur and bicarbonates.

The amount of solids in a water body may include many pollutants that happen to be solids. A certain level of these ions is essential for life. Cells also depend on the density of total solids to determine the amount of water that flows in and out of the cell. However, dissolved solids in excess in water can affect humans by inducing a laxative effect and giving the water a mineral taste. Increased total solids reduce water clarity, rise water temperature and reduce oxygen levels as a result of less photosynthesis. Moreover the solids can bind to toxic compounds and heavy metals.

The amount of total solids depend on various parameters such as geological character of the water shed, rainfall and the amount of surface run off (Akuskar and Gaikwad, 2006). The highest total solids elevate the density of water and such medium increases the stress on aquatic biota (Verma *et al.* 1978).

The present study indicates total solids ranging from 550 mg to 1100 mg/l (Table No. 4). The ISI-limit for total solids is 1000 mg/l. Present study indicates values crossing the permissible limit during some period of the year, especially at Kansai and Shenvai.

Table No. 4 Quarterly values of Total solids mg/l at 6 Sampling Stations from June 2011 to Dec. 2012,

Site / Month	Warvatane (S1)	Bhatsai (S2)	Ainghar (S3)	Bangalwadi (S4)	Kansai (S5)	Shenvai (S6)
Jun-11	550	740	610	760	880	950
Sept-11	620	630	750	860	750	1000
Dec-11	590	850	790	780	860	780
Mar-12	750	750	860	900	900	950
Jun-12	620	960	800	700	1100	840
Sept-12	750	870	900	800	760	840
Dec-12	820	840	950	820	780	980
Max.	820.00	960.00	950.00	900.00	1100.00	1000.00
Min.	550.00	630.00	610.00	700.00	750.00	780.00
Average	671.43	805.71	808.57	802.86	861.42	905.71

Total Suspended Solids

The amount of particles that suspended in a water sample is called total suspended solids (TSS). It is mentioned as mg/l. Total Suspended Solids (TSS), also known as non-filterable residue, are those solids (minerals and organic material) that remain trapped on a 1.2µm filter (U.S.EPA, 1998). Total suspended solids enter in water body through sanitary and industrial water. The non point sources are soil erosion, agriculture and construction sites. To remain permanently suspended in water (or suspended for a long period of a time), particles have to be light in weight (they must have a relatively low density or specific gravity), be relatively small in size, and/or have a surface area that is large in relation to their weight. The greater the TSS in the water, the higher is its turbidity and the lower is its transparency (clarity).

Table No 5 Quarterly values of Total Suspended solids mg/l at 6 Sampling Stations from June 2011 to Dec. 2012

Site / Month	Warvatane (S1)	Bhatsai (S2)	Ainghar (S3)	Bangalwadi (S4)	Kansai (S5)	Shenvai (S6)
Jun-11	100	250	210	120	150	180
Sept-11	160	250	160	220	250	150
Dec-11	250	120	100	200	210	260
Mar-12	150	150	200	350	200	310
Jun-12	260	160	250	150	110	230
Sept-12	250	150	210	240	250	140
Dec-12	450	210	110	240	200	210
Max.	450.00	250.00	250.00	350.00	250.00	310.00
Min.	100.00	120.00	100.00	120.00	110.00	140.00
Average	231.43	184.28	177.14	217.14	195.71	211.43

TSS has no drinking water standard. Therefore, data in this report are compared to the general standards for surface water discharge of effluents that indicate the value 100mg/L.

The present study reveals that the suspended particles were found to be very noticeable (Table No. 5) for most of the period, however, it was found to be ranging between 100 and 450mg/l. Chatterjee and Raziuddin (2003) noted high values in monsoon. However such seasonal trend was not noted during the present study.

Total Dissolved Solids

Total dissolved solid is a measure of all the materials that are dissolved in water and are less than 2 µm in size. These materials, both natural and anthropogenic, are mainly inorganic solids, with minor amounts of organic material. Depending on the types of water, TDS can vary greatly from few mg/l to percents (tens of hundreds of mg/l). The principal application of TDS is in the study of water quality for streams, rivers and lakes, although TDS is generally considered not as a primary pollutant, but it is rather used as an indication of aesthetic characteristics of drinking water and as an aggregate indicator of presence of a broad array of chemical contaminants.

Primary sources for TDS in waters are agricultural runoff, leaching of soil contamination and point source water pollution discharge from industrial or sewage treatment plants. More exotic and harmful elements of TDS are pesticides arising from surface run off. Certain naturally occurring total dissolved solids arise from the weathering and dissolution of rocks and soils. Elevated TDS has been due to natural environmental features such as, mineral springs, carbonate deposits, salts deposits, and sea water intrusion, but other sources may include, salts used for road de-icing, anti-skid materials, drinking water treatment chemicals, storm water and agricultural runoff, and point/non-point wastewater discharges. The most common chemical constituents are calcium, phosphates, nitrates, sodium, potassium and chloride.

The present study indicates high concentration of dissolved solids throughout the study period ranging from 340 to 990 mg/l (Table No. 6).However, the highest permissible limit according to ICMR and WHO is 500 mg/l. During the present study, high dissolved solids were noted almost throughout the year. The open wells and the direct run off from the surface might be some of the reasons.

Table No 6 Quarterly values of Total Dissolved Solids mg/l at 6 Sampling Stations from June 2011 to Dec. 2012,

Site / Month	Warvatane (S1)	Bhatsai (S2)	Ainghar (S3)	Bangalwadi (S4)	Kansai (S5)	Shenvai (S6)
Jun-11	440	490	400	650	750	750
Sept-11	470	410	600	640	500	860
Dec-11	340	730	690	580	650	520
Mar-12	600	600	660	550	700	640
Jun-12	370	800	550	550	990	610
Sept-12	500	710	690	560	510	700
Dec-12	370	640	840	580	560	770
Max.	600.00	800.00	840.00	650.00	990.00	860.00
Min.	340.00	410.00	400.00	550.00	500.00	520.00
Average	441.43	625.71	632.86	587.14	665.71	692.86

Turbidity

Turbidity is caused due to the scattering of light by suspended and colloidal particles present in the water. Turbidity is correlated with number of particles present rather than the weight of suspended particles. In natural waters, it is caused by the presence of clay, slit, organic matter, algae, zooplankton and other microorganisms. It is an expression of certain light scattering and light absorbing properties of water (Kataria *et al*., 2006).

High water turbidity is undesirable from aesthetic point of view. The colloidal matter present in the river imparts turbidity to water on account of pollution from organic matter, through sewage discharge, industrial waste and presence of large number of microorganisms.

The turbidity associated with soil erosion during rainy season is usually temporary and once such matter settles down, the water quality improves. However turbidity caused by sewage and industrial waste is much more harmful as it has many microorganisms and other chemicals that take longer period to settle down. When such water used by human beings or other animals, it has direct impact on their health.

The present study indicates that the turbidity ranged from 1.6 to 7 NTU (Table No. 7).

The increased turbidity in water may be correlated with anthropogenic activities like washing clothes and vehicles near the water body which drains the water again to the well.

Table No 7 Quarterly values of Turbidity NTU at 6 Sampling Stations from June 2011 toDec. 2012,

Site / Month	Warvatane (S1)	Bhatsai (S2)	Ainghar (S3)	Bangalwadi (S4)	Kansai (S5)	Shenvai (S6)
Jun-11	2	3.7	4.4	3.6	2.8	3.5
Sept-11	2.7	5.7	7	3.7	3.4	3.2
Dec-11	1.6	4.9	1.6	3.9	2.2	4.2
Mar-12	4.6	1.7	3.0	3.7	3.5	2.9
Jun-12	7	6	2.6	3.5	4.2	2.8
Sept-12	4.6	4.2	4.8	3.4	2.9	3.2
Dec-12	4.5	2.6	3.5	3	2	4
Max.	7	6	7	3.9	4.2	4.2
Min.	1.6	1.7	1.6	3	2	2.8
Average	3.86	4.11	3.84	3.54	3.00	3.40

Conductivity

Conductivity is the measure of conduction of electricity by water. It is a numeric expression of the ability of an aqueous solution to carry an electric current which is the property derived from ions suspended in it. As conductivity is a function of ion concentration, it is used for quick checking of dissolved substances in water. It also reflects the status of inorganic pollution qualitatively and evaluates total dissolved solids and ionized species in water (Almeida *et al*., 2007). Electrical conductivity of water is useful and easy indicator of its salinity or total salt content (Morisson *et al*., 2001) During the present study the minimum conductivity was noted 49 mho cm-1 at Warvatane and maximum conductivity 312 mho cm-1 at Shenvai (Table No. 8)

Table No. 8 Quarterly values of Conductivity (µ mho/cm) at 6 Sampling Stations from June 2011 to Dec. 2012,

Site / Month	Warvatane (S1)	Bhatsai (S2)	Ainghar (S3)	Bangalwadi (S4)	Kansai (S5)	Shenvai (S6)
Jun-11	120	89	158	243	124	130
Sept-11	125	95	145	235	160	125
Dec-11	49	165	145	126	251	162
Mar-12	51	117	265	132	210	254
Jun-12	110	236	208	281	97	230
Sept-12	125	120	200	200	154	312
Dec-12	130	210	156	192	147	217
Max.	130	236	265	281	251	312
Min.	49	89	145	126	97	125
Average	101.43	147.43	182.43	201.29	163.29	204.29

Dissolved Oxygen

Dissolved Oxygen is one of the most important parameters in aquatic systems. It is considered as water quality indicator (Manna and Das, 2004; Ghavzan *et al*.2005; Koshy, 2005; Mathur and Maheshwari, 2005). Dissolved Oxygen (DO) refers to the volume of oxygen that is dissolved in water. The atmosphere is an only major source of dissolved oxygen in river water. Waves and tumbling water mix atmospheric oxygen with river water. Oxygen is also produced by rooted aquatic plants and algae as a product of photosynthesis. The amount of oxygen that can be held by the water depends on the water temperature, salinity and pressure. Usually cold water holds more oxygen than warm water (Tiwary *et al*.2005; Bhalla *et al*. 2007; Cerqueiria *et al*.2007; Prakash *et al*. 2007; Kennedy and Whalen,2008). It is also affected by water flow as stagnant water has less oxygen because of less internal mixing.

Natural stream purification processes require adequate oxygen levels in order to provide for aerobic life forms. This gas is an absolute requirement for the metabolism of aerobic organisms and also influences inorganic chemical reactions. Therefore, knowledge of the solubility and dynamics of oxygen distribution is essential to interpret both biological and chemical processes within water bodies. Decrease in dissolved oxygen is an index of increased organic pollution which is mainly due to the addition of waste through point and non-point sources from its catchment area. These organic matters undergo degradation by microbial activity in the presence of dissolved oxygen resulting in deoxygenating process and swift depletion of dissolved oxygen. The inflow of domestic sewage is one of the major point sources as reported by Maity *et al*.(2004); Ghavzan *et al*.(2005); Shah *et al*. (2005).

Table No. 9 Quarterly values of Dissolved Oxygen mg/l at 6 Sampling Stations from June 2011 to Dec. 2012,

Site / Month	Warvatane (S1)	Bhatsai (S2)	Ainghar (S3)	Bangalwadi (S4)	Kansai (S5)	Shenvai (S6)
Jun-11	5.1	6.3	6.9	7.2	6.9	7.2
Sept-11	7.2	6.2	6.3	7.8	5.9	7.0
Dec-11	5.1	6.5	5.9	7.4	6.9	6.5
Mar-12	6.3	7	6.5	6.9	6.4	6.0
Jun-12	6.4	7.2	5.8	6.9	6.5	6.6
Sept-12	4.9	6.9	6.3	7	6.3	5.9
Dec-12	5.9	6.2	6.3	7.2	6.4	7.2
Max.	7.2	7.2	6.9	7.8	6.9	7.2
Min.	4.9	6.2	5.8	6.9	5.9	5.9
Average	5.84	6.61	6.29	7.20	6.47	6.63

The present study reveals that the dissolved oxygen in the water body was neither too high nor too low which is the indication of good water quality. It ranged between 4.9 to 7.8 mg/l (Table No. 9). Though it was low occasionally, the average values where satisfying.

Biochemical Oxygen Demand (BOD)

Biochemical Oxygen Demand or Biological Oxygen Demand (BOD) is a chemical procedure for determining how fast biological organisms use up oxygen in a body of water. It measures the amount of oxygen consumed in the biological processes that break down organic matter in water. It is used in water quality management and assessment, ecology and environmental science. Most of pristine rivers have a 5-day BOD below 1 mg/l. For non-polluted water, the BOD_5 is less than 5mg/l (Singh *et al* .2008).

During the present study the BOD ranged from 0.1 to 4 mg/l (Table No. 10).It was within permissible limit for with occasional higher values which may be attributed to increased organic load.

Table No. 10 Quarterly values of Biochemical Oxygen Demand mg/l at 6 Sampling Stations from June 2011 to Dec. 2012

Site / Month	Warvatane (S1)	Bhatsai (S2)	Ainghar (S3)	Bangalwadi (S4)	Kansai (S5)	Shenvai (S6)
Jun-11	0.3	1	0.3	0.7	0.5	0.6
Sept-11	0.1	0.5	0.4	0.5	1.3	0.8
Dec-11	4	0.2	0.1	0.6	0.4	1.2
Mar-12	0.5	0.4	0.5	0.9	0.8	0.9
Jun-12	0.4	3.5	0.6	1.2	0.4	0.2
Sept-12	0.2	0.4	0.2	0.8	1.5	0.7
Dec-12	0.3	0.2	0.7	0.7	1.5	0.9
Max.	4	3.5	0.7	1.2	1.5	1.2
Min.	0.1	0.2	0.1	0.5	0.4	0.2
Average	0.83	0.89	0.40	0.77	0.91	0.76

Chlorides

Chlorides are salts resulting from the combination of the gas chlorine with a metal. Chloride is widely distributed in nature, generally in the form of sodium (NaCl) and potassium (KCl) salts. It constitutes about 0.05% of the earth's outer crust. Chloride is an essential element for an aquatic and terrestrial biota, representing the main extra cellular anion in animals, including humans. It is a highly mobile ion that easily crosses cell membranes and is involved in maintaining proper osmotic pressure, water balance and acid -base balance in animal tissues. Chloride ion also plays and active role in renal function, neurophysiology and nutrition.

Chloride ions are conservative (Newton *et al*.2007), which means that they are not degraded in the environment and tend to remain in solution, once dissolved. Chloride ions that enter ground water can ultimately be expected to reach surface water and therefore, influence aquatic environments and humans.

During the present study the chloride concentration ranged between 12.035 to 35.425 mg/l (Table No. 11). The higher values obtained in summer may be attributed to the evaporation of water.

Table No. 11 Quarterly values of Chlorides mg/l at 6 Sampling Stations from June 2011 to Dec. 2012

Site / Month	Warvatane (S1)	Bhatsai (S2)	Ainghar (S3)	Bangalwadi (S4)	Kansai (S5)	Shenvai (S6)
Jun-11	20.018	12.035	24.235	17.321	18.652	25.321
Sept-11	18.023	18.032	18.023	16.231	16.452	21.450
Dec-11	21.320	21.036	18.965	14.256	17.362	19.045
Mar-12	22.352	25.321	28.658	32.587	29.236	35.425
Jun-12	23.016	15.023	17.568	18.325	18.145	15.254
Sept-12	25.036	18.325	15.569	15.325	26.356	17.450
Dec-12	18.036	17.012	20.145	15.023	23.145	16.325
Max.	25.036	25.321	28.658	32.587	29.236	35.425
Min.	18.023	12.035	15.569	14.256	16.452	15.254
Average	21.11	18.11	20.45	18.44	21.34	21.47

Free Carbon Dioxide

Free carbon dioxide (CO_2) refers to carbon dioxide gas dissolved in water. The term is used to distinguish a solution of the gas from the combined carbon dioxide present in bicarbonate and carbonate ions. This gas on solution in water produces carbonic acid resulting in lowering of pH. With a decrease in pH corrosive characteristics is induced in water resulting severe corrosion of heat exchanger, pipes, valves etc. The present study indicates the concentration of carbon dioxide ranging from 24 to 42 mg/l (Table No.12). Very high values are suggesting the formation of carbonic acid in a water.

Table No 12 Quarterly values of Free CO_2 mg/l at 6 Sampling Stations from June 2011 to Dec. 2012

Site / Month	Warvatane (S1)	Bhatsai (S2)	Ainghar (S3)	Bangalwadi (S4)	Kansai (S5)	Shenvai (S6)
Jun-11	34	32	42	30	24	29
Sept-11	32	32	42	25	29	29
Dec-11	28	41	42	24	25	26
Mar-12	26	42	40	30	31	31
Jun-12	32	36	39	31	24	28
Sept-12	41	33	31	32	26	29
Dec-12	26	32	40	24	31	32
Max.	41	42	42	32	31	32
Min.	26	32	31	24	24	26
Average	31.28	35.42	39.42	28	27.14	29.14

Alkalinity

Alkalinity refers to the acid-neutralizing capacity of water. It is a factor that accounts for the buffering ability of water. Water without sufficient alkalinity will drop in pH when even small amounts of acids are present, disturbing the living systems within the water supply.

According to Dey *et al*.(2005) alkaline nature of water is harmful to man whereas Mathur and Maheshwari (2005) stated that high alkalinity has little public health significance.

There are two types of alkalinities namely phenolphthalein alkalinity (PA) and total alkalinity (TA).

Phenolphthalein alkalinity (PA) is present only when free carbon dioxide (CO_2) is absent and therefore exists only when the pH exceeds 8.3.

The phenolphthalein alkalinity measures hydroxyl ions rather than carbonates (Sechriest, 1960). It should never be over half the total alkalinity; otherwise, a caustic alkalinity is produced.

The present study reveals that the phenolphthalein alkalinity is zero throughout the study period. Total alkalinity varied from 82 to 158 mg/l (Table No. 13). According to Rajalakshmi and Sreelatha (2005), the higher values coincide with pollution load. Chatterjee and Raziuddin (2003) stated that TA is governed by photosynthesis and microbial decomposition.

Table No. 13 Quarterly values of Alkalinity mg/l at 6 Sampling Stations from June 2011 to Dec. 2012

Site / Month	Warvatane (S1)	Bhatsai (S2)	Ainghar (S3)	Bangalwadi (S4)	Kansai (S5)	Shenvai (S6)
Jun-11	115	95	82	85	89	115
Sept-11	120	89	87	102	92	153
Dec-11	125	102	89	95	96	158
Mar-12	126	125	98	89	89	148
Jun-12	98	111	83	87	90	120
Sept-12	102	114	85	86	82	135
Dec-12	110	128	82	87	90	141
Max.	126	128	98	102	96	158
Min.	98	89	82	85	82	120
Average	113.71	110.42	86.57	90.14	89.71	138.57

Total Hardness

Hardness is defined as the concentration of calcium and magnesium ions expressed in terms of calcium carbonate. Hard water has high minerals, primarily calcium and magnesium. Other minerals, such as iron, may contribute to the water hardness to some extent. The principle sources of hardness in water are sedimentary rocks, seepage and runoff from soil. The hardness may be due to sewage and pollution and is reported by Trivedy and Goel (1986), Chaudhary *et al*.(2004), Maity *et al*.(2004), Rajalalakshmi and Sreelatha (2005).Leaching of rocks and dissolution by flood waters are the reasons of hardness as noted by Bhalla *et al*.(2007). According to Abassi *et al*.(1996) presence of toxic heavy metals in the water may also cause high hardness in water.

The total hardness of water may range from trace amounts to hundred of milligrams per liter. The total hardness is of two types namely, temporary and permanent. Temporary hardness is caused by combination of calcium ions and bicarbonate ions in the water. It can be removed by boiling the water or by the addition of lime (calcium hydroxide). Permanent hardness is hardness (mineral content) that cannot be removed by boiling. It is usually caused by the presence of calcium and magnesium sulfates and/or chlorides in the water, which become more soluble as the temperature rises.

Table No. 14 Quarterly values of Hardness mg/l at 6 Sampling Stations from June 2011 to Dec. 2012

Site / Month	Warvatane (S1)	Bhatsai (S2)	Ainghar (S3)	Bangalwadi (S4)	Kansai (S5)	Shenvai (S6)
Jun-11	415	325	511	456	515	415
Sept-11	496	365	492	456	525	485
Dec-11	488	356	429	465	492	485
Mar-12	496	369	485	486	498	495
Jun-12	475	385	465	486	502	497
Sept-12	475	365	465	486	515	485
Dec-12	480	301	485	478	515	425
Max.	496	385	511	486	525	497
Min.	415	301	429	456	492	415
Average	475	352.28	475	473.28	508.85	469.57

The present investigation reveals that the hardness of water ranged between 301 and 525 mg/l (Table No. 14). According to the Indian standard specification for drinking water (IS 10500), the hardness of drinking water ranges between 300 to 600 mg/l. Though within the limit, the hardness of water was always towards upper side throughout the study period imparting unpalatable taste to the water and cosmetic problems.

Calcium Hardness (Ca-H)

Calcium Hardness is caused by the presence of calcium ions in the water. Calcium, in the form of the Ca++ ion, is one of the major inorganic cations, or positive ions, in saltwater and freshwater. Calcium salts can be readily precipitated from water and high levels of calcium hardness tend to promote scale formation in the water system. Calcium Hardness is an important control test in industrial water systems such as boilers and steam raising plants and for swimming pools.

Most calcium in surface water comes from streams flowing over limestone, gypsum and other calcium-containing rocks and minerals. Groundwater and underground aquifers leach even higher concentrations of calcium ions from rocks and soil. Calcium carbonate is relatively insoluble in water, but dissolves more readily in water containing significant levels of dissolved carbon dioxide.

During the preset study, the Ca-hardness ranged between 80 and 220 mg/l (Table No. 15). According to Indian standard specification for drinking water the Ca-hardness ranges between 75 to 200 mg/l. The Ca- hardness was always towards higher side.

Table No. 15 Quarterly values of Ca-Hardness mg/l at 6 Sampling Stations from June 2011 to Dec. 2012

Site / Month	Warvatane (S1)	Bhatsai (S2)	Ainghar (S3)	Bangalwadi (S4)	Kansai (S5)	Shenvai (S6)
Jun-11	415	325	511	456	515	415
Sept-11	496	365	492	456	525	485
Dec-11	488	356	429	465	492	485
Mar-12	496	369	485	486	498	495
Jun-12	475	385	465	486	502	497
Sept-12	475	365	465	486	515	485
Dec-12	480	301	485	478	515	425
Max.	496	385	511	486	525	497
Min.	415	301	429	456	492	415
Average	475	352.28	475	473.28	508.85	469.57

Magnesium Hardness

Along with total hardness magnesium hardness was also calculated. Magnesium hardness gives idea regarding magnesium salts dissolved in the water. The source of magnesium is leaching from the rock and the salts that come through soaps and detergents.

Though magnesium ions impart in increasing hardness of the water, it has no significant impact on the water quality.

The magnesium hardness was found varying from to 60 to 417 mg/l (Table No. 16). According to Indian standard specification for drinking water the Mg-hardness ranges between 30 to 100 mg/l. The Mg-hardness was always towards higher side.

Table No 16 Quarterly values of Mg-Hardness mg/l at 6 Sampling Stations from June 2011 to Dec. 2012

Site / Month	Warvatane (S1)	Bhatsai (S2)	Ainghar (S3)	Bangalwadi (S4)	Kansai (S5)	Shenvai (S6)
Jun-11	205	60	311	271	295	220
Sept-11	286	100	292	271	305	295
Dec-11	278	86	219	275	282	275
Mar-12	296	99	300	276	298	285
Jun-12	265	135	280	301	302	417
Sept-12	275	90	255	276	295	295
Dec-12	270	121	300	293	410	235
Max.	296	135	311	301	410	417
Min.	205	60	219	271	282	220
Average	267.86	98.71	279.57	280.43	312.43	288.86

Silicates

Silica is widespread and always present in surface and ground waters. It exists in water in dissolved, suspended and colloidal states. Dissolved forms are represented mostly by silicic acid, products of its dissociation and association and organosilicon compounds. Reactive silicon (principally silicic acid but usually recorded as dissolved silica (SiO_2) or sometimes as silicate (H_4SiO_4)) mainly arises from chemical weathering of siliceous minerals.

Table No. 17 Quarterly values of Silicates mg/l at 6 Sampling Stations from June 2011 to Dec. 2012

Site / Month	Warvatane (S1)	Bhatsai (S2)	Ainghar (S3)	Bangalwadi (S4)	Kansai (S5)	Shenvai (S6)
Jun-11	12	18.85	15.25	17.25	15.45	14.52
Sept-11	12.5	20	12.55	17.5	18.55	15.25
Dec-11	16.85	18.25	14.55	16.9	19.25	15.25
Mar-12	12.95	15.55	15.55	15.15	18.9	15.25
Jun-12	12.35	17.85	12.25	15.65	19	18.52
Sept-12	12.45	16.56	15.25	17.55	14.25	17.58
Dec-12	15.5	18.55	15.25	18.55	15.52	15.35
Max.	16.85	20	15.55	18.55	19.25	18.52
Min.	12	15.65	12.25	15.15	14.25	14.52
Average	13.51	17.96	14.38	16.94	17.27	15.96

Silica may be discharged into water bodies with wastewaters from industries using siliceous compounds in their processes such as potteries, glass works and abrasive manufacture. Silica is also an essential elements for certain aquatic plants (principally diatoms). It is taken up during cell growth and released during the decomposition and decay giving rise to seasonal fluctuations in concentrations, particularly in lakes. Silicon is known to be present in all living organisms. This element occurs in the form of hydrated amorphous silica, referred to as opal and is required for the production of structural materials in all organisms from single-celled organisms to higher plants and animals. For many live forms, silicon can even be considered to be an essential element.

The norms/standards for drinking water contained in IS 10500 (Bureau of Indian Standards) do not prescribe any permissible or desired limit for these two elements. The silicates ranged from 12 to 20 mg/l (Table No. 17) during the present study. The values are very high compared to the surface water.

Table No. 18 Standards of various physico-chemical parameters

Sr.No.	Parameters	USPH Standards	ISI Standards	WHO Standards	BIS Standards
1	pH	6.0-8.5	6.0-9.0	-	-
2	Conductivity	300µmhocm-1	-	-	-
3	Turbidity	<5NTU	-	-	-
4	TDS	500mg/lit	-	-	-
5	Free CO_2	-	-	-	-
6	Alkalinity	-	200 mg/lit	-	-
7	Total Hardness	-	300 mg/lit	-	-
8	Calcium	0.05	100-500 mg/lit	150 mg/lit	-
9	Magnesium	< 10 mg/lit	30-50 mg/lit	150 mg/lit	-
10	Chlorides	250 mg/lit	600 mg/lit	500 mg/lit	600 mg/lit
11	Sulphates	< 0.3 mg/lit	-	200-400 mg/lit	1000 mg/lit
12	Iron	< 0.3 mg/lit	0.3 mg/lit	0.1-1.0 mg/lit	-
13	DO	4-6 ppm	3.0 ppm	-	-
14	COD	4.0 ppm	10.0 ppm	-	-

CONCLUSION

The water was slightly acidic to alkaline but within permissible limit. Total solids were very high at some sites. Turbidity and conductivity were also high due to excess dissolved and suspended solid. Dissolved solids, Dissolved oxygen, Biological oxygen dissolved and chlorides were within permissible limits. CO_2 were high imparting acidity to the water where as alkalinity was low indicating low buffering capacity. Total hardness, Ca-hardness and Mg-hardness were high. Silicates were also slightly high than other surface waters. Hence application of water quality techniques for the overall assessment of the water body could be useful tools. The awareness must be created in the villagers about safe drinking water. The villagers should be made aware of basic water treatments to improve water quality. Finally safe drinking water must be made available for the villagers.

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