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POTABLE WATER QUALITY WITH RESPECT TO TOTAL DISSOLVED SALT AND NITRATE CONTAMINANT IN GROUND WATER OF AKOLA CITY OF MAHARASHTRA (INDIA)

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ABSTRACT

Peoples on the Earth are under tremendous fear due to desired and undesired chemical, physical, biological and environmental changes in air, water and soil. The ground water is the major resource for drinking water for human being as well as animals. The ground water resources include, open wells, tube wells and hand pumps. The availability of fresh, safe and unpolluted ground water in rural and urban areas is very rare and restricted due to peculiar geological, hydrological, geomorphic and demographic features. A variety of chemicals such as fluorides, nitrites, nitrates, TDS, total hardness and some organic materials are dominant in ground water contamination. Present study has been carried out to determine color, odor, temperature, pH, electrical conductivity, and more emphasis is given to detailed study of total dissolved solids and nitrates in ground water resources used for drinking purpose in ward number 35 and 36 of Akola city area.

Key words: Water quality, Potable, Total dissolved solids, Nitrates.

INTRODUCTION

Water is one of the most important and abundant source of the ecosystem. All living organisms on the Earth need water for their survival and growth. Since the beginning of time, water has been praised for good health and also blamed for human ills. It is known that the real functions of water in the human body are to serve as a solvent and medium for transport of nutrients and wastes to and from cells throughout the body, a regulator of temperature, a lubricator of joints and other tissues, and a participant in biochemical reactions of our body. It is only the water and not the dissolved and suspended minerals and other constituents that carry out these functions.

Clean water has become one of the most precious and inaccessible resources for a common man. The surface water gets polluted due to discharge of industrial effluents, agricultural runoff, discharge of partially treated domestic sewage, washing of animals and fecal discharge [1,2]. Ground water is used for domestic, irrigation and industrial water supply all over the world. In the last few decades, there has been tremendous increase in the demand for water due to rapid growth of population and accelerated rate of industrialization. Water source available for drinking and other domestic purpose must possess high degree

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of purity, free from chemical contamination and microorganisms. The potential and quality of bore well water, is an economic resource and essential component of our life, but it is getting deteriorated in major rural centers due to pollution by population, exposition, ruralization and industrialization[3,4]. Man made activities highly pollutes water with different harmful contaminants. In the rural areas, due to use of different insecticides, pesticides, vidicides and decay of several wastes, the water in rivers, wells and bore wells is highly polluted. Total dissolved salt (TDS) is the concentration of non-volatile substances present in the water in colloidal and molecular dispersed state as a result of movement of water on or below the ground surface. It is total dissolved inorganic water contaminants/impurities (minerals) in solution as ions, cations (+ve charge) and anions (-ve charge). These electrically charged dissolved ions, when their concentrations are high, make water an effective electrical conductor; thereby, causing galvanic corrosion in copper or galvanized plumbing giveing bitter taste. Dissolved cationic solids including calcium (Ca^{2+}), magnesium (Mg^{2+}), sodium (Na^{+}), iron (Fe^{2+}) and manganese (Mn^{2+}) cause hardness, scale formation and damage. Dissolved anionic solids including bicarbonate (HCO_3^{-}), chloride (Cl^{-}), sulphite (SO_2^{2-}), nitrate (NO_3^{-}) and carbonate (CO_3^{2-}) cause taste and odor problem.

Nitrate is one of the most commonly identified ground water contaminant. Nitrogen accumulates in the soil naturally from rainfall, plants debris, animal residues and microbial fixation of N_2 from atmosphere. Anthropogenic nitrate (NO_3^{-}) comes to ground water through nitrogenous fertilizers, organic manures, and human and industrial wastes. Nitrogen leaching from ungrazed grassland in rural areas is normally low since grass provides continuous ground cover. However leaching from intensively grazed land can be a problem since 80% of nitrogen consumed by grazing animals is returned to the soil as urine and dung[5,6]. In the urban cities, nitrogen is present in sewage in a range of reduced and organic forms, such as ammonia and urea. These can be oxidized in aerobic ground water system to nitrate. There is a major concern with the subsurface contaminant load associated with unsewaged sanitation units such as septic tanks, cesspits and latrines. Survey of ground water quality in range of cities with incomplete or no piped drainage out of the city have shown that nitrate concentration can reach very high level.

One of the common diseases caused by nitrates in the drinking water is Methamoglobinemia. It reduces the ability of blood to carry vital oxygen around the body. In turn, it reduces the level of normal hemoglobin. Actually nitrate is not a cause of methamoglobinemia, its converted form nitrite (NO_2^{-}) on absorption in blood stream oxidizes hemoglobin to methaemoglobine, (Fe^{2+} to Fe^{3+}). This compound contains iron in its higher oxidation state, which is incapable of binding oxygen reducing oxygen transport capacity.

EXPERIMENTAL

Ward number 35A, 35B, 36A and 36B of Akola city of Akola district having pin code 444001 of Maharashtra are covered under the survey of India toposheet numbers 55 H/2, H/3, H/5 and H/16 and bounded by latitude 20° 25”- 20° 47” 50’ and longitude 77° - 77° 25”. Akola district is a western part of Vidarbha region. The samples were collected from the ward number 35, which includes Hingna road, Gayatri nagar, Nage layout, Kaulkhed, Zabaji Mandir, Krishna nagari and ward number 36, which includes Samata colony, New Khetan nagar, Madhav nagar, Sant Tukaram Square.

The samples were collected in clean, pure and dry sterilized polyethylene bottles from bore wells after running them for 5 mins[7,8] (all bore wells were more than 100 feet deep). All samples were collected and tested for a range of physical and chemical water quality parameters according to the specified methods for examination of water and waste matter.[9] This includes the eight water quality parameters namely color, odor, taste, TDS, electrical conductivity, nitrate, pH and temperature, from which color, odor, taste, TDS

and temperature were measured at the sample station immediately and electrical conductivity, pH and nitrate were measured in laboratory. All parameters were measured by following methods.

S. No.	Parameter	Technique used	Source of occurrence
1.	Color	Visual	Due to presence of dissolved salts
2.	Odor	Physiological sense	Due to biological degradation
3.	Taste	Physiological sense	Due to presence of salt and impurities
4.	Temperature	N/10 Thermometer, Thermometer presence in TDS meter	Due to heat of water
5.	pH	Digital pH meter	pH is changed due to different dissolved gases, solids, and ions.
6.	Electrical conductivity	Digital conductivity meter	Due to different dissolved solids, ions.
7.	Total dissolved Salt	Aqua pro TDS meter	Due to presence of dissolved salts.
8.	Nitrate (NO_3^-)	UV-Visible spectrophotometer	Run off from fertilized use, leaking from septic tanks, sewages, erosion of natural deposits, urinal outlets.

RESULTS AND DISCUSSION

The physico-chemical data of the bore wells water samples form the ward number 35 and 36 in August, 2014 (rainy season), December 2014 (winter) and May 2015 (summer season) have been shown in Table 01-06. The results of samples were different from different collecting places because of different nature of soil contamination. Details of the findings in different parameters are given as below :

Color

Transparent water with a low accumulation of dissolved material appears blue and indicates low productivity. Suspended and dissolved particles in water influence color. Suspended material in water may be the result of natural cause and/or human activity. Water color is referred as an apparent color and true color is based on the type of solid material is present in it. Most common cause is minerals, red and brown colors are due to iron, and black due to manganese, yellow is due to tannins, etc.

In the present study, the color of all the water samples from three seasons in both the wards was found to be clear, transparent and colorless even though the soil of ward number 35 is black and ward number 36 is hard rock.

Odor

Odor in drinking water may be defined as that sensation, which is due to presence of substances that have an appreciable vapor pressure and stimulates the human sensory organ in nasal and sinus cavities. Odor in water is usually measured in terms of its threshold odor number (TON). In general, offensive odor in drinking water may be due to a biological degradation or of a industrial origin. Some of the odor may be indirectly due to human activities.

In the present study, samples collected from more than 100 feet deep bore wells from different places of ward number 35 and 36 have no specific smell and were acceptable.

Taste

All water sources contain number of naturally occurring minerals, such as calcium, magnesium and iron. The varying concentrations of these minerals in drinking water gives rise to different taste that can be detected by people. Water also contains dissolved gases, such as oxygen, carbon dioxide, which may also gives tap water a characteristic taste. Without these elements, water would taste flat and unappetizing.

In present study, the samples collected from the ward number 35 A and B were having somewhat higher TDS values in all three seasons and have slight bitter taste but it is near to agreeable.

Temperature (°C)

It is the established fact that water temperature controls the role of all chemical reactions and affects the changes in all water parameters like pH, conductivity, surface tension, viscosity etc. Temperature alters the reaction rate.

In the present study, the water samples collected from the ward number 35 has the temperature ranging from 28.8-29.6°C in rainy season, 22.5-23.9°C in post rainy season while 30.0-30.20°C in summer season and samples collected in ward number 36 ranges from 28.7-29.9°C, 22.9-24.3°C and 31.8-34.8°C in rainy season, post rainy season and in summer season, respectively.

pH

The pH is an important variable in water quality assessment, as it influences many biological and chemical processes within a water body and all processes associated with water supply and treatment[9]. In unpolluted water, pH is principally controlled by the balance between the carbon dioxide, carbonate and bicarbonate ions as well as other natural compounds such as humic and fluvic acids. A change in pH indicates the presence of certain effluents. pH is also important in determining the corrosive nature of water. Lower is the pH value, higher will be the corrosive nature of water. pH is positively correlated with electrical conductance and total alkinity[10].

In the present study, water samples collected from the ward number 35 shows pH values ranging from 7.30- 8.20 in monsoon, 7.18-7.90 in post monsoon and 7.24-7.76 in summer season. Water samples collected from ward number 36 shows the pH range from 7.15-7.89 in monsoon, 7.18-8.00 in post monsoon and 7.27-8.00 in summer. From above values, it may be concluded that the leaching of effluents is more in rainy season.

Electrical conductivity (EC)

The electrical conductivity of drinking water is a parameter for dissolved and dissociated substances. Its value depends on the concentrations and degree of dissociation of the ions as well as the temperature and migration velocity of the ions in electric field[11]. Conductivity is the ability of water to conduct electric current using dissolved ions as conductors. The major positively charged ions are sodium (Na^+), calcium (Ca^{2+}), potassium (K^+), and magnessium (Mg^{2+}) and major negatively charged ions are chlorides (Cl^-), sulphates (SO_4^{2-}), carbonates (CO_3^{2-}) and bicarbonates (HCO_3^-). The minor contributors to conductivity are nitrates (NO_3^-) and phosphates. The electrical conductivity indicates the concentration of dissolved electrolytes present in water, but it does not give an idea about the type of ions being present. Conductivity will vary with water source, ground water, water drained from agricultural field, municipal waste water, rain fall, etc. Therefore, conductivity can indicate ground water sewage or sewage leak.

In the present study, the sample collected from ward number 35 was having the conductivity range from 818-836 μ mhos cm^{-1} in rainy season, 712-741 μ mhos cm^{-1} in winter season and 785-791 μ mhos cm^{-1} in summer season while water samples collected from ward number 36 have the conductance range from 588-792 μ mhos cm^{-1} in monsoon, 605-692 μ mhos cm^{-1} in post monsoon and 602-663 μ mhos cm^{-1} in hot season. All observed conductance of the drinking water samples are in potable water zone[12].

Water type	Conductivity μ mhos cm^{-1}	Water type	Conductivity μ mhos cm^{-1}
Distilled water	0.5 to 3.0	Potable water (in US)	30 – 1500
Melted snow	2.0 to 42	Fresh water stream	100 - 2000

Total dissolved solids (TDS)

Total dissolved solid is a measure of the combined content of all inorganic and organic substances or the total amount of mobile charged ions including minerals, salts and/or metals in the given volume of water (mg L^{-1}) expressed in unity mg per unit volume of water, which is also referred as ppm. TDS is directly related to purity of water. This is an important parameter for analysis of costal, marine, lake, and saline water. TDS level does not posses a health problem unless chemicals like chlorine and chloroamines are present. Drinking water can be rated as per the TDS value is shown below :

Level of TDS (mgL^{-1})	Rating
Less than 300	Excellent
301 – 600	Good
601 – 900	Fair
901 – 1200	Poor
1200 and above	Unacceptable

In present study, the sample collected from the ward number 35 was the black soil to soft rock upto 100 feet and the area is near to Morna river having TDS value from 500 to 713 mg L^{-1}. So the drinking water of the bore well falls in 'good to fare' rating, whereas the samples collected from ward number 36 having TDS value from 455 to 596 mg L^{-1} comes in the range of 'Good' for drinking (Table 1 to 6).

Nitrate (NO_3^-)

Nitrate is one of the chemical forms of nitrogen. It co-exists with other forms of nitrogen in a complex cycle. Nitrogen in soil and water originates from atmospheric deposition, application of fertilizers, waste material, dead plants and animal tissues. Because nitrate is a natural substance found in both; water and plants, peoples are exposed it to primarily through the diet. In the United states, the average person consumes about 75 to 100 milligram of nitrate per day. Vegetable like beets, celery, lettuce and spinach are very rich in nitrate. Drinking water generally accounts 5 to 10 percent of nitrate that people consume. Nitrates become toxic primarily, when bacteria in our digestive system convert it to nitrite. The nitrite oxidizes iron in the hemoglobin of our red cell to form methemoglobine (i.e. Fe^{2+} to Fe^{3+}) and the converted Fe^{3+} is enable to bind the oxygen and therefore, cannot supply oxygen to the body.

In the present study, the samples collected from the ward No. 35 were having the range of nitrate (NO_3^-) from 6.12-8.00 mg L^{-1} in rainy season, 5.12-7.17 mg L^{-1} in post mansoon and 5.17-6.90 mg L^{-1} in summer season. All values were found below the maximum contamination level (MCL = 45 mg L^{-1}).

Table 1: Observed physico-chemical data (during August – 2014)

Parameters	S1	S2	S3	S4	S5	S6	S7	WHO Standard	Indian Standard	US EPA Standard
Color	Colorless / blue	Colorless / blue	Colorless / blue	Colorless / blue	Colorless / blue	Colorless / blue	Colorless / blue	--	5 Hazen unit	--
Odor	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable	--
Taste	Agreeable / Bitter	Agreeable / Bitter	Agreeable / Bitter	Agreeable / Bitter	Agreeable / Salty	Agreeable / Bitter	Agreeable / Bitter	Agreeable	--	--
TDS (ppm)	601	618	627	603	702	612	612	500	--	--
pH	7.35	7.24	7.28	7.90	7.13	7.20	8.02	6.5-8.5	6.5-8.5	6.5-8.5
EC µmho cm^{-1}	823	828	832	818	836	826	825			30 to 1500
Nitrate (NO_3^-) mg L^{-1}	6.12	7.98	6.99	6.27	7.01	7.18	8.00	45	45	50
Temp. (°C)	29.2	29.6	28.8	29.7	30.0	28.8	29.0	--	--	--

Table 2: Observed physico-chemical data (during December – 2014).

Parameters	S1	S2	S3	S4	S5	S6	S7	WHO Standard	Indian Standard	US EPA Standard
Color	Colorless / blue	Colorless / blue	Colorless / blue	Colorless / blue	Colorless / blue	Colorless / blue	Colorless / blue	--	5 Hazen unit	--
Odor	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable	--
Taste	Agreeable / Bitter	Agreeable / Bitter	Agreeable / Bitter	Agreeable / Bitter	Agreeable / Bitter	Agreeable/ Bitter	Agreeable / Salty	Agreeable	--	--
TDS (ppm)	678	628	629	672	607	618	719	500	--	--
pH	7.40	7.18	7.42	7.28	7.48	7.29	7.90	6.5-8.5	6.5-8.5	6.5-8.5
EC µmho cm^{-1}	712	728	732	720	715	732	741			30 to 1500
Nitrate (NO_3^-) mg L^{-1}	5.12	5.28	6.02	9.17	6.12	6.47	7.17	45	45	50

Table 3: Observed physico-chemical data (during May – 2015)

Parameters	S1	S2	S3	S4	S5	S6	S7	WHO Standard	Indian Standard	US EPA Standard
Color	Clear transparent	Clear transparent	Clear transparent	Clear transparent	Clear transparent	Clear transparent	Clear transparent	--	5 Hazen unit	--
Odor	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable	--
Taste	Bitter	Bitter	Salty	Salty	Bitter	Bitter	Salty	Agreeable	--	--
TDS (ppm)	602	616	713	706	609	609	701	500	--	--
pH	7.24	7.35	7.22	7.40	7.45	7.38	7.76	6.5-8.5	6.5-8.5	6.5-8.5
EC µmho cm^{-1}	785	790	801	788	784	906	791			30 to 1500
Nitrate (NO_3^-) mg L^{-1}	5.17	6.90	6.60	5.85	6.12	8.02	5.19	45	45	50
Temp. (°C)	29.1	29.1	29.8	30.10	30.00	29.20	30.20	--	--	--

Table 4: Observed physico-chemical data (during August– 2014)

Parameters	S1	S2	S3	S4	S5	S6	S7	WHO Standard	Indian Standard	US EPA Standard
Colour	Clear transparent	Clear transparent	Clear transparent	Clear transparent	Clear transparent	Clear transparent	Clear transparent	--	5 Hazen unit	--
Odour	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable	--
Taste	Salty	Bitter	Bitter	Fair bitter	Agreeable	Agreeable	Agreeable	Agreeable	--	--
TDS (ppm)	512	518	499	488	468	463	455	500	--	--
pH	7.15	7.26	7.80	7.42	7.58	7.62	7.89	6.5-8.5	6.5-8.5	6.5-8.5
EC µmho cm^{-1}	792	682	670	669	647	588	579	--	--	30 to 1500
Nitrate (NO_3^-) mg L^{-1}	4.26	4.12	6.36	5.28	4.32	4.00	6.27	45	45	50
Temp. (°C)	28.7	28.7	28.5	29.3	29.6	29.0	29.9	--	--	--

Table 5: Observed physico-chemical data (during December– 2014)

Parameters	S1	S2	S3	S4	S5	S6	S7	WHO Standard	Indian Standard	US EPA Standard
Color	Colorless	Colorless	Colorless	Colorless	Colorless	Colorless	Colorless	--	5 Hazen unit	--
Odor	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable	--
Taste	Salty	Fair bitter	Fair Bitter	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	--	--
TDS (ppm)	596	520	510	503	502	485	466	500	--	--
pH	7.18	7.32	8.02	7.56	7.78	7.66	8.00	6.5-8.5	6.5-8.5	6.5-8.5
EC µmho cm^{-1}	800	692	704	670	667	620	605			30 to 1500
Nitrate (NO_3^-) mg L^{-1}	5.02	4.32	4.18	5.29	5.62	6.00	6.09	45	45	50
Temp . (°C)	27.9	28.2	28.2	28.7	29.0	28.6	29.3	--	--	--

Table 6: Observed Physico-chemical data (during May – 2015)

Parameters	S1	S2	S3	S4	S5	S6	S7	WHO Standard	Indian Standard	US EPA Standard
Color	Colorless	Colorless	Colorless	Colorless	Colorless	Colorless	Colorless	--	5 Hazen unit	--
Odor	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable	--
Taste	Agreeable	Salty	Bitter	Bitter	Salty	Agreeable	Agreeable	Agreeable	--	--
TDS (ppm)	468	503	500	501	497	470	461	500	--	--
pH	7.27	7.38	7.90	7.42	7.80	7.57	7.87	6.5-8.5	6.5-8.5	6.5-8.5
EC µmho cm^{-1}	650	668	674	660	662	602	582			30 to 1500
Nitrate (NO_3^-) mg L^{-1}	4.60	4.43	4.27	6.50	4.82	5.92	4.12	45	45	50
Temp. (°C)	28.8	29.0	29.8	30.0	29.6	29.6	29.6	--	--	--

CONCLUSION

The results of all parameters of collected drinking water samples from ward No. 35 and 36 in rainy season, in winter and in summer were below maximum contaminant level (MCL) e.g. color of water was colorless, odor was acceptable, taste was agreeable to bitter in taste, where TDS, pH, nitrate, temperature are with in the level of maximum contamination level, and therefore, water is useful for drinking.

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