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RESEARCH ARTICLE

GROUND WATER QUALITY OF BOGOLE MANDAL, S.P.S.R.NELLORE DISTRICT, ANDHRA PRADESH, INDIA

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ABSTRACT

Water is the mirror of life and is essential for drinking purpose. Protected water supply is very essential for population. In the present study, pH, chlorides, total alkalinity, total hardness, calcium, magnesium, total dissolved solids, fluoride, nitrate and phosphates were assessed to note the chemistry and quality of bore well water in Bogole mandal, Nellore district. The pH of J.P. Gudur was 5.5 and Nagulavaram 6.0 mg/L which is below the permissible limits given by WHO (1984) and BIS (1983). These waters are acidic and cannot be used for drinking purpose. Extremely high amounts of total alkalinity and chlorides were recorded. The housewife complained of scale formation in the cooking vessels and white precipitate formation in the buckets. Highest Calcium concentration of 422.44 mg/L was seen in Nagulavaram which is double the limits given by WHO. Total Dissolved Solids in Bogole was 3600 mg/L which was 2 – 3 times more than the permissible limits given by WHO and BIS. Based on Bruvold *et.al.,* 1966, T.D.S of Nagulavaram and Talluru fall into good category. A.B.K falls into fair category, Kovurupalli, J.P. Gudur, S.G.V.K falls under poor category and V.N.R pet and Bogole into unaccepatable category. Highest phosphate concentration was seen in Bogole which was 208 times more than the limits given by BIS which may be due to use of artificial fertilizers in this region. High chlorides and total alkalinity in these ground waters forced people to buy mineral plant water for drinking purpose. This problem can be solved by simple techniques which are economically feasible among the consumers. Individual environmental awareness has to be created among the public to boil and to use ground water to protect their health.

INTRODUCTION

Groundwater is water that is located below the earth's surface. Water from rain and rivers migrates through the ground and is stored in porous soils and rocks. The study of groundwater is known as hydrogeology. Groundwater is found in vast quantities filling the spaces between grains of soil or rock; it slowly flows through aquifers; it connects with rivers, streams, lakes and wetlands; it feeds trees and vegetation. Groundwater makes up 98% of the fresh water on the planet. It currently makes up around a third of our total water consumption. The areas beyond municipal corporation limits and also when there is shortage of adequate supply of drinking water the dwellers depend on alternate source of drinking water i.e. ground water. In many regions, particularly in the outback, groundwater is the only available source of water – numerous townships, farms and mines are totally reliant on groundwater. Farmers sink bores to bring water to the surface from artesian basins, and windmills use wind energy to pump water from hidden aquifers. In irrigation areas, vast quantities of bore water supplies thousands of hectares of crops and pastures. Even large cities are dependent on groundwater.

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In many places, groundwater discharges naturally to the surface, bubbling into natural springs or contributing to rivers and wetlands. Groundwater often plays a crucial role in sustaining rivers and streams, particularly during droughts when it becomes a valuable buffer. Many ecosystems, including some of our most iconic, depend on groundwater. Groundwater is a finite resource, and aquifers can become depleted when extraction rates exceed replenishment, or 'recharge', rates. Like surface water, groundwater can become polluted or contaminated. Despite its importance, groundwater is poorly understood and often undervalued. This may in part derive from the nature of groundwater: a complex, hidden resource that is difficult to conceptualise. It is for this reason that the NCGRT is working hard to learn more about groundwater. The contamination of ground water has received great significance during recent years due to the toxicity and accumulation behaviour.

Much work on drinking water was did by many researchers. Cynthia, M.E. 1997 in her project report worked on "A survey and analysis of different types of drinking water of Hyderabad and its effect on school children", Johnson and Kauser, 2004 in her paper worked on Chemical and Microbial Quality of different types of drinking waters of Hyderabad. Kiran and Johnson, 1988 in their paper worked on Quality Analysis of

Bottled and its source water, a study on Water Quality Assessment.

Bogole is a mandal with 16 revenue panchyats, where only 8 panchayats were selected and studied in this paper as shown in Fig.1. Bitragunta received its name when the British found good drinking water and named it "Better-gunta" which later became Bitragunta. Bitragunta is situated in the south eastern part of Andhra Pradesh. Agriculture is an important practice. It is endowed by good rainfall and surface water. The latitude of Bitragunta is 14.7784439 and the longitude is 79.9598262. The soil types are Red loamy soils, Black cotton soils, Sandy soils, Lateritic soils and Alluvial soils. The geological formations are Alluvium & Laterites, Sandstone, Quartzite & shale, Gneiss, Amphibolites & Pelitic schists. Ground water quality in general is good and suitable for drinking and irrigation purposes, except in the coastal area. Coastal salinity is the major considerable problem. The main objectives of this study is to assess changes in chemistry, quality and portability of drinking water. In this paper an attempt has been made to examine the ground water quality of Bogole mandal, Bitragunta, nellore dt, Andhra Pradesh.

The values of all the physico – chemical parameters are shown in Table: 1 and the averages of all the physico - chemical parameters are shown in Table: 2.

RESULTS AND DISCUSSION

p^H

The p^H of the solution is the negative logarithm of the Hydrogen ion concentration. The p^H of an aqueous medium is a measure of the acid base equilibrium achieved by various dissolved compounds and in most natural waters, is contributed by CO_2 – HCO_3 – CO_3 equilibrium. In the 8 panchayats of Bogole mandal pH ranged from 5.5 to 7.5 and averaged to 6.5 mg/L. Lowest pH of 5.5 was observed in J.P. Gudur and 7.5 pH in A.B. Kandrika. In Nagalavaram panchayat the pH was 6.0 which were below the permissible limits given by BIS (1983) & WHO (1984). Water used for drinking purpose should have pH 7 which was seen in Bogole Mandal. According to BIS & WHO standards the permissible limit is 6.5 – 8.5.

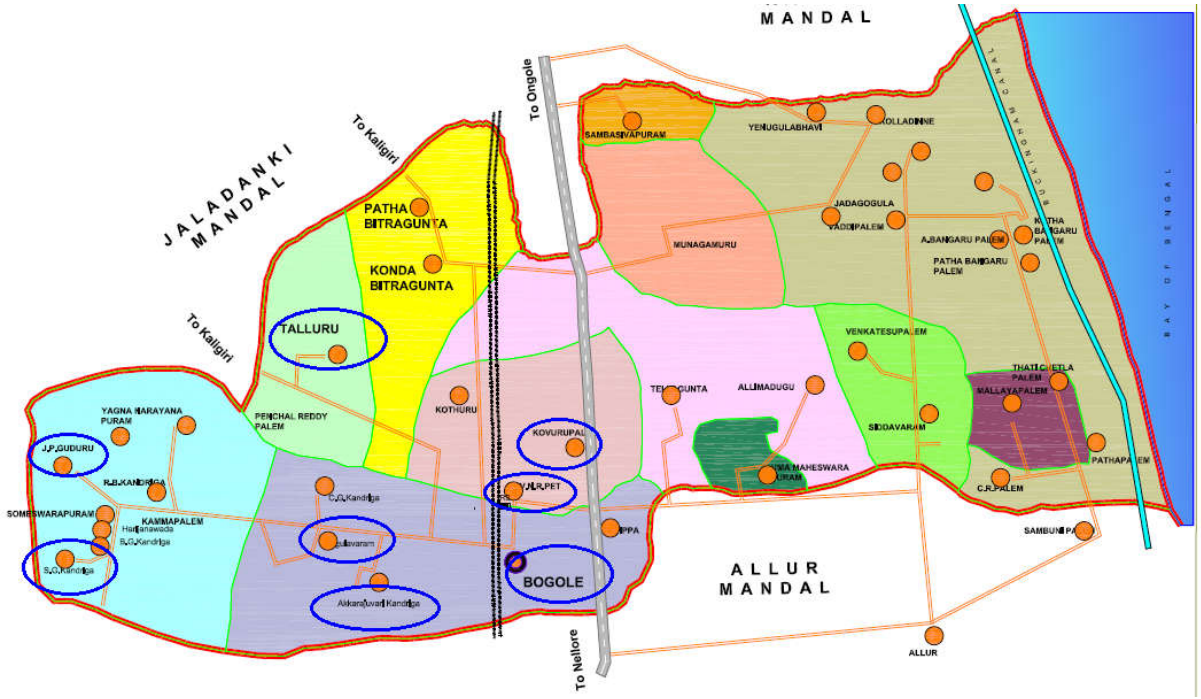

Fig. 1. Bogole Mandal Showing the Eight Panchayaths Studied

MATERIALS AND METHODS

Ground water samples from bore wells were collected at 8 panchayats and analysed for the various physico – chemical parameters according to APHA (1995) and the specific titrimetric procedures as follows.

- p^H – Universal indicator
- Total Alkalinity, Total Hardness – Trivedy, Goel & Trishal (1987)
- Chlorides – Wilcox and Hatcher (1950)
- Phosphates, Nitrates, Total Dissolved Solids, Calcium, magnesium– APHA (1995)
- Fluoride– APHA (1995)

The pH values of all the 8 panchayats surveyed is given in the Table 1.

Chlorides

Chlorides in nature are the salts of calcium, potassium and sodium. They constitute about 0.05% of the lithosphere. The presence of chlorides in natural waters can be due to dissolution of salt deposits, sewage discharges, irrigation seepage and contamination from refuge leachaetes. Chloride is one of the major inorganic anion in water and is responsible for the salty taste. During the survey chloride values ranged from 195 mg/L to 1776 mg/L and averaged to 1027.25 mg/L. The lowest value was seen in J.P. Gudur and the highest in A.B. Kandrika.

According to BIS and WHO, the permissible limits of chlorides were 250 mg/Lin drinking waters. All the panchayats showed more than permissible limit. The ground waters in these 8 mandals are used for drinking, cooking, washing and irrigation. The high chloride content in these mandals was due to sewage discharge and irrigation seepage from agricultural fields. These mandals are rich in agricultural fields; hence the chloride values are high. Probably the rocks/soils are rich in chloride content. During titration of chlorides white thick precipitate was seen which is shown in Fig.2 A and B. The chloride content values are shown in Table 1.

A

B

Fig. 2. Chlorides titration: A – during titration; B – white thick precipitate after removing the supernatant liquid

Fluorides

Earth's crust contains abundant fluoride as high in calcium granite, low calcium granite, alkaline rocks, shales, sandstones, deepclays and in deep-sea carbonates (Bulusu *et al.,* 1985). Fluoride exists as fluorite, sallaite, fluorspar, cryolite, fluor-apatite, phosphorite, topaz, tourmaline, muscorite, phlogopite, biottie and lepidolite. Fluoride content was estimated by Cynthia, 2008 and given in her project report "Survey of fluoride content in ground waters of Ranga Reddy district and its effect on Human health" and Johnson and Sudha, 1996 in their paper mentioned about fluoride content in drinking waters around Hyderabad city. It is interesting to know that in all the 8 panchayats of Bogole mandal fluoride is absent. The permissible limit of fluoride given by BIS is 0.6 – 1.2 and WHO is 1.5 mg/L.

Total Alkalinity

Alkainity is an index of the buffering capacity of water. Anions like hydroxides, bicarbonate and carbonate and also borates, phosphates, silicates and organic acids contribute to the alkalinity in natural waters and ground waters. It is expressed in terms of calcium carbonate. In the present 8 panchayats total alkalinity ranged from 190 – 580 mg/L and average to 400 mg/L. According to BIS and WHO (1983-84) the permissible limits are 0.6 – 1.2 and 1.5 mg/L respectively. In the survey it is very clear that all the 8 panchayats have very high alkaline waters which are 190 times and 580 times more than the permissible limits. The housewife's of particular region complain of scale formation in the vessels when it is boiled and bore well waters when it is stored in the buckets a white precipitate is seen settled at the bottom. The total alkalinity average of the residential area and industrial area of telangana district is 376 mg/l and 491 mg/l respectively as reported by Malini (2002).This value is comparable to the bogole mandal panchayats of S.P.S.R. Nellore district. The values can be seen in Table 3.

Total Hardness

The presence of minerals like calcite, gypsum and dolomite in rocks which dissolve in the presence of carbonic acid contribute to hardness of water and due to this the total hardness reaches several thousand mg/l. (Sawyer and Mc-Carty - 1967 and De Fluvio and Olori - 1967). Mining industries and inorganic chemicals are the other sources of hardness in ground water. In the present survey Total Hardness ranged from 122 mg/l – 826 mg/l and averaged to 508.25 mg/l. Lowest value was seen in V.N.R pet and highest in A.B.K. It is interesting to note that in Bogole panchayat the Total Hardness was 216 mg/l. In the remaining panchayats i.e., Taluru, J.P. Guduru, Kovurupalli, A.B.K, S.G.V.K. and Nagalavaram the Total Hardness was well above 400 mg/l which is seen in Table 1.

According to BIS and WHO standards the recommended value of Total Hardness for drinking purpose is 300 mg/l and 500 mg/l respectively. In V.N.R pet and Bogole mandal Total Hardness was within permissible limits while in other panchayats i.e., Taluru, J.P.Guduru, Kovurupalli, A.B.K., S.G.V.K. and Nagalavaram it was above the permissible limits. These waters cannot be used for drinking purpose.

The traditional measure of detecting the hardness of water is its capacity to react with soap to produce lather and scum formation in household utensils. From the Glohmann 1976 in Table 5, V.N.R. Pet falls into hard category while the remaining fall into very hard water. In many countries the Belgian Standards regarding hardness in Farenheit degrees is applied which is clearly stated in Table: 4.

Calcium

The concentration of calcium in ground water is due to the weathering of pyroxenes, feldspar and apatite. The abundance of these materials in almost rock types and their solubility, leads to the presence of calcium almost everywhere in ground water. (Karanth, 1987)

Table 4. Belgian Standards of Hardness applied to a number of countries in Fahrenheit degrees

Soft Water	$<5^0$F
Moderately Soft Water	$5^0 - 10^0$F
Slightly Soft Water	$10^0 - 15^0$F
Moderately Hard Water	$15^0 - 25^0$F
Hard Water	$25^0 - 35^0$F
Very Hard Water	735^0F

Table 5. Categorization of Water based on Total Hardness given by Glohmann (1976)

Soft	0-60mg/L
Medium Hard	60 – 120 mg/L
Hard	120 – 180 mg/L
Very Hard	180 mg/L and above

In the present survey calcium ranged from 75 mg/L to 422 mg/L and average to 241.73 mg/L. According to BIS 75 mg/L and WHO 200 mg/L is the permissible limit.V.N.R pet, Taluru, A.B.K are within the permissible limits and can be used for drinking purpose. Bogole, Nagalavaram, J.P.Gudur, Kovurupalli and S.G.V.K panchayats exhibit beyond the permissible limits and hence cannot be directly used for drinking purpose. However, these waters can be boiled, cooled and filtered and may be used for drinking purpose during acute shortage of water.

Magnesium

Magnesium is used in textile, taming and paper industries; alloys of Magnesium used in household goods, luggage, tools, moulds and dye castings; salts of Magnesium used in fertilizers, ceramics and explosives, ultimately find their way into the soil to reach waters, contributing to hardness. In the present survey Magnesium ranged from 12 mg/L to 175 mg/L and averaged to 79.42 mg/L. Lowest value of 12 mg/L was seen in V.N.R pet and highest of 175 mg/L in A.B.K. According to BIS and WHO the permissible limits are 30 and 150 mg/L. A.B.K panchayat shows well above the permissible limits.

Total Dissolved Solids

The important ions contributing to T.D.S are carbonates, bicarbonates, chlorides, sulphates, nitrates, sodium, potassium, calcium and magnesium.

All these solids influence the taste, hardness and corrosion properties of drinking water. In addition to the natural salts contributing to the natural Total Dissolved Solids, sewage effluent discharges, urban runoff or industrial waste discharge and leaching processes also lead to a further increase.

Table 6. Bruvold *et al.* (1966) have related the palatability of drinking water according to the TDS level

Grades	TDS levels
Excellent	< 300 mg/L
Good	300 – 600 mg/L
Fair	600 – 900 mg/L
Poor	900 – 1200 mg/L
Unacceptable	>1200 mg/L

In the present survey T.D.S ranged from 500 – 3600 mg/L and average to 1225 mg/L. According to BIS and WHO the T.D.S permissible limit is 1500 and 1000 respectively. It is interesting to note that all the 7 panchayats were within the permissible limit and remaining one i.e., Bogole exceeded the limit (i.e., 3600 mg/L). An important aspect of T.D.S on drinking water quality is on taste. The sensations of taste and odour are complimentary. The palatability is shown in the Table: 6, given by Bruvold *et al.,* 1966. From the above Bruvold *et al.,*1966, Nagallavaram and Talluru fall into Good Category. A.B.K falls into Fair Category; Kovurupalli, J.P. Gudur, S.G.V.K falls under Poor Category and V.N.R pet and Bogole into Unaccepatable Category.

Nitrates

Nitrates occur in large quantities in most waters whereas nitrites occur in low level. Nitrates used as fertilizers are converted to nitrites in the soil. Nitrates are used in explosives and as food preservatives. Excessive fertilizers, decayed vegetables and animal wastes, domestic effluents, sewage sludge, industrial discharges, leakages from refused dams, atmosphere wash outs (oxides of nitrogen produced during lighting) contribute to the contamination of ground water by percolation over a period of time. The level of nitrates is much higher than the levels of nitrites. (National Research Council 1977, Washington)

The presence of nitrate ions indicates pollution of ground water. Numerous sources in the environment contribute to the total nitrate content of natural water (Handa et.al, 1982). Normally high concentrations of nitrates are mostly found in ground water from domestic wells. The sources are from septic tanks, sewer pipes, decayed vegetables, animal matter, fertilizer use (Sudharshan and Sravanthi, 1966 and Sravanthi *et al.,* 1997) and changes in land use may also give rise to increase in nitrate levels. In the present survey the nitrates ranged from 2.09 to 33 mg/L and averaged to 7.76 mg/L. From the table given above, it is obvious that the content of nitrates exceeds the value recommended by WHO but the values are within the range given according to BIS. All the panchayats are within the limits given by WHO, whereas Bogole nears to the BIS standard.

Table 1. Physico – Chemical Parameters of Ground Water in Bogole Mandal, S.P.S.R Nellore, A.P

S. No	Parameters	Bogole	V.N.R. pet	Talluru	J.P.Gudur	Kovurupalli	S.G.V.K	Nagulavaram	A.B.K	WHO (1984)	BIS (1983)
1	p^{H*}	7.0	6.5	6.5	5.5	6.5	6.5	6.0	7.5	6.5 – 8.5	6.5 – 8.5
2	Chlorides mg/L	886	1014	1606	195	578	851	1312	1776	250	250
3	Total Alkalinity mg/L	580	515	450	350	215	495	405	190	1.5	0.6 – 1.2
4	Total Hardness mg/L	216	122	404	508	580	666	744	826	500	300
5	Calcium mg/L	369	75	150.70	206.81	286.97	317.43	422.44	105.81	200	75
6	Magnesium mg/L	-	12	62	73	71	85	78	175	150	30
7	Total Dissolved Solids mg/L	3600	1500	600	900	900	1000	500	800	1000	1500
8	Fluoride mg/L	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	1.5	0.6 – 1.2
9	Nitrate mg/L	32.73	3.13	2.09	2.45	9.05	4.61	5.62	2.47	10	45
10	Phosphate mg/L	207.5	8.5	2.5	2.5	21.0	6.5	3.5	42.5	-	1.0

Table 2. Average of Physico – Chemical Parameters of Ground Water in 8 panchayats of Bogole Mandal, S.P.S.R Nellore, A.P

S.No	Parameters	Average mg/L
1	p^{H*}	6.5
2	Chlorides mg/L	1027.25
3	Total Alkalinity mg/L	400
4	Total Hardness mg/L	508.25
5	Calcium mg/L	241.73
6	Magnesium mg/L	79.42
7	Total Dissolved Solids mg/L	1225
8	Fluoride mg/L	NIL
9	Nitrate mg/L	7.76
10	Phosphate mg/L	36.81

*no unit

Table 3. Standard Maximum Permissible limits by BIS and WHO and the values of Bogole, A.P and Telangana Residential and Industrial Areas

S.No	Parameters	BIS (1983)	WHO (1984)	Average of Bogole Panchayats	Telangana Residential Area (Malini 2002)	Telangana Industrial Area (Malini 2002)
1	p^{H*}	6.5 – 8.5	6.5 – 8.5	6.5	7.3	7.3
2	Chlorides mg/L	250	250	10	393	495
3	Total Alkalinity mg/L	0.6 – 1.2	1.5		376	491
4	Total Hardness mg/L	300	500		1066	2064
5	Calcium mg/L	75	200		307	688
6	Magnesium mg/L	30	150		772	1483
7	Total Dissolved Solids mg/L	1500	1000		2716	6200
8	Fluoride mg/L	0.6 – 1.2	1.5		1.233	1.225
9	Nitrate mg/L	45	10		23.34	35.30
10	Phosphate mg/L	1.0	-		0.143	0.135

*No unit

Phosphates

The ground water from granite formation contain about 0.1 mg/L of phosphates. Large stone, sand stone, shale and other formations do not contain phosphates (White et.al., 1952). The most important source of phosphates is the discharge of domestic sewage, detergents and agricultural run – off, lentic system etc. The most significant form is the orthophosphate (PO_4) which is the only directly utilizable form of soluble inorganic phosphorous. A number of investigators have reported high values of phosphates in the water receiving domestic sewage (Young *et al.,* 1973, Johnson 1991). In the present survey phosphates ranged from 2.5 mg/L to 207.5 mg/L and average to 36.81 mg/L. According to BIS the standard limit recommended for the phosphate level is 1.0 mg/L. All the 8 panchayats have more phosphate concentrations. Among the 8 panchayats surveyed A.B.K. with 42.5 mg/L was 42 times more and Bogole with 207.5 mg/L was 208 times more. The extremly high concentration of PO_4 may be due to discharge of domestic sewage, detergents and agricultural seepage in these panchayat areas which were densely populated.

Conclusions

From the Ground Water Survey the following conclusions are drawn. The p^H values of V.N.R pet is 6.5, Talluru - 6.5, Kovurupalli - 6.5, S.G.V.K - 6.5, J.P. Gudur – 5.5, Nagulavaram – 6. These panchayats shows acidic waters hence use of these waters must be taken with care i.e, they cannot use this water for drinking purpose. Bogole with 7 p^H is neutral while A.B.K with p^H of 7.5 is on the alkaline side and J.P. Gudur with p^H of 5.5 is on acidic side. High concentrations of chlorides above the permissible limits of 250 mg/L in Bogole, V.N.R pet, Talluru, S.G.V.K, Nagulavaram and A.B.K makes the water very salty and domestic use of these waters is unpleasant.

The extreme high Total Alkalinity in the 8 panchayats is almost 300 times more than the permissible limits. The housewife complains of scale formation in the cooking vessels and white precipitate formation in the buckets. J.P. Gudur, Kovurupalli, S.G.V.K, Nagallavaram and A.B.K have total hardness above the permissible limits given by WHO i.e., 500 mg/L. Phosphates concentration was more than the permissible limits given by BIS in all the 8 panchayats. In Bogole it is 208 times highest and in Talluru and in J.P. Gudur it is least i.e.,3 times. This may be mainly due to agricultural seepage and domestic seepage.

Bogole>ABK>Kovurupalli>VNR pet>SGVK>Nagallavaram>Talluru.
208>43>21>9>7>4>3

The Fluorides were completely absent in all these 8 panchayats.The nitrates are also within permissible limits.
Water is the mirror of life and water is essential for drinking purpose. Water and life are inseparable. So protected water supply is very essential for population. In panchayats, municipal water supply i.e., potable water must be supplied to the population to protect their health. There is municipal water supply in bogole mandal,it is not sufficient to the inhabitants. Hence use of bore well waters for washing, cooking, bathing etc is inevitable. From the survey it is clear that even the municipal water is having high chloride, alkalinity, total hardness, total dissolved salts and phosphates (shown in Table). Bitragunta received its name when the British found good drinking water and named it "Better-gunta" which later became Bitragunta, but basing on the above results it is not an exagration to say that it became “Bitter – gunta” than “Better – gunta”. Hence I request the Sarpanch of the Bogole Mandal to purify the source water which may be either lake or bore well water according to drinking water standards and then only supply to citizens and bring back the glory and previous status to the village.

Remedial Measures

1. Purification of water used for drinking.
2. Supply of potable water to 8 panchayats.
3. To educate the people to boil water, filter and then use them so that the chlorides, alkalinity and hardness may be removed to some extent.
4. To educate to use toilets in every home.
5. Slogan – Potable water protects the health of consumers.
6. To conduct environment awareness camps at schools.
7. To educate to keep clean environment.
8. To encourage to use natural fertilizers.

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REFERENCES

Bruvold, W.H. and Pangborn, R.M. 1966. Rated acceptability of mineral taste in water. *Journal of applied Psychology,* 50:22.

Bulusu, K.R., Nawalakha, W.G., Kulkami, D.M. and Litada, S.L., 1985. Fluoride its incidence in natural water and defluoridation methods. Silver Jubilee Commemorative Volume, NEERI, Nagpur.

Bureau of Indian Standards, 1983. Indian Standards Drinking Water Specifications. IS: 10500.

Cynthia, M.E. 1997. A survey and analysis of different types of drinking water of Hyderabad and its effect on school children. U.G.C. *MJRP,* Project Report, pp: 1-8.

Cynthia, M.E. 2008. Survey of fluoride content in ground waters of Ranga Reddy district and its effect on Human health. U.G.C. MRP, Project Report, pp: 1 – 18.

Fulvio, De S. and Olori, L. 1976. Definitions and classification of naturally soft and naturally hard waters. Chemical and Physical characteristics of the water in some member states of the European Community. In: Amavis, R. Et.al., ed. Hardness of drinking water and public health. Proceedings of the European Scientific Colloquim, Luxemburg, 1975. Oxford Pergamon Press, 1976. Pp: 95 – 123.

Glohmann, A. and Harte dae Wassers. In : Amavis, R., et.al., ed. 1976. Hardness of drinking water and public health. Proceedings of the European Scientific Colloquim, Luxemburg, Oxford, Pergamon Press, pp: 129.

Handa, B.K., Goel, D.K., Kumar, A. and Sondhi, T.N. 1982. Pollution of ground water by No 3 in Uttar Pradesh. IAWPC. Tech.

Johnson, M.E.C. 1991. Phosphate content in two fresh water lakes. *Journal of Aquatic Biology,* Vol.6 (1& 2), pp: 24 – 26.

Johnson, M.E.C. and Kauser, R. 2004. Chemical and Microbial Quality of different types of drinking waters of Hyderabad, Hi – Tech City. A.P., India. *J. Auqa. Biol.,* Vol. 19 (1), pp: 93 – 97.

Johnson, M.E.C. and Sudha, J., 1996. Fluoride content in drinking waters around Hyderabad city. *J. Aqua. Biol.,* Vol.11 (1 & 2), pp: 48 – 50.

Karanth, K.R. 1987. Ground water assessment, Development and Management. Tata Mc Graw Hills Publication Company Limited. New Delhi.

Kiran, C.M. and Johnson, M.E.C. 1998. Quality Analysis of Bottled and its source water, a study on Water Quality Assessment. *J. Aqua. Biol.,* Vol. 13 (1 & 2), pp: 60 – 61.

Malini, Y. 2002. Ground Water Quality in an Industrial and Residential Area in Relation to Consumer Health. Thesis submitted to the Osmania University for the degree of Doctor of Philosophy in Botany.

National Research Council, 1977. Drinking water and health. Washington. D.C. National Academy of Science.

Sawyer, C.N. and Mc. Carty, P.L., 1967. Chemistry for Sanitary Engineers. II Ed. New York, Mc. Graw – Hill (Series in sanitary Science and Water Resources Engineering).

Shailaja, K. 2003. Ecological Study on Drinking Water Quality of Hyderabad City and its Impact on the Consumer. Thesis submitted to the Osmania University for the degree of Doctor of Philosophy in Botany.

Sravanthi, K., Sudharashan, V. and Reddy, U.V.B. 1997. Nitrate pollution in the ground water of Nacharam industrial area, Ranga Reddy district, A.P, India. *Journal of Indian Academy of Geoscience,* Vol. 40, No.2, pp: 17 – 22.

Sudharshan, V. and Sravanthi, K. 1996. Nitrate Pollution in the ground water of Nacharam industrial area, Ranga Reddy district, A.P, India. 30th International Geological Congress, Beijing, China, Vol. 3 (3).

WHO, 1984. Guidelines for Drinking Water Quality, Vol. 1, Recommendations, WHO, Geneva.

WHO, 1984. Guidelines for Drinking Water Quality, Vol. 2, Health criteria & other supporting information, WHO, Geneva.

Young, Y.C., Hannah, H. and May hew, J., 1973. Nitrogen and Phosphorous in a stretch of Guadgulp River, Texas; with five main stream impoundments. *Hydrobiol.,* Vol. 43 (3), pp: 419 – 441.

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