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Original Research Paper

Assessment of Shallow Groundwater Quality in Usupur Village Panchayat in Chidambaram Taluk of Cuddalore District, Tamilnadu State

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ABSTRACT

Ever-increasing population and its increasing water needs due to improved life styles have led to more and more tapping of groundwater resources due to continuous deterioration of most surface water resources. This necessitates the urgent need to monitor the quality characteristics of groundwater being tapped for domestic activities. The study reported in this paper was undertaken to assess the physicochemical characteristics of shallow groundwaters in eight residential habitations of Usupur Village Panchayat near Chidambaram town in Cuddalore District, Tamilnadu State. The quality parameters namely, pH, total dissolved solids, total hardness, total alkalinity, chlorides, nitrates, fluorides and iron were analysed using standard procedures. The study revealed that the groundwater was not fit for drinking and cooking but with certain affordable ameliorations at household level it could be made fit for other domestic activities such as bathing, washing and gardening.

INTRODUCTION

Freshwater has become a scarce product due to overutilization and increasing contamination of water. Growing population and its improving life styles have put mounting pressures on water needs and also have led to the deterioration of both surface and subsurface waters. Comparatively speaking, due to anthropogenic activities, the degree of deterioration in surface waters is more rapid than that of sub-surface waters in most of the regions in the world.

Groundwater is a replenishable and an economic resource. It has inherent advantages over surface water. The wide distribution, negligible evaporation loss, low risk of pollution, fairly closeness at hand, more uniform character, relatively free from harmful microorganisms are some of the advantages. Groundwater forms the major source of domestic water needs inclusive of drinking in both urban and rural areas. New schemes are also formulated from time to time by various government agencies for tapping groundwater available in the regions mainly to cater to the drinking water needs of the population. The importance of groundwater for the existence of human society cannot be overemphasized. Groundwater accounts for nearly 100 per cent of water supply sources for many of the developing countries and this is true for our country too. Groundwater is particularly important as it accounts for about 88 per cent safe drinking water in rural areas, where population is widely dispersed and the infrastructure needed for treatment and transportation of surface water does not exist. Besides, it is an important source of water for the agricultural and industrial sectors.

Groundwater generally occurs under both confined and unconfined conditions. The disintegrated and highly weathered part of the rock form the water table of unconfined aquifer while the fractured

and slightly weathered zone contain groundwater under confined conditions in hard rock area. Sand and allied formations form the aquifer in sedimentary area under both confined and unconfined conditions.

The chemical composition of groundwater depends upon the soluble products of rock weathering and decomposition and changes with respect to time and space in addition to the polluting agents. Improper disposal of liquid wastes, defective well construction and failure to seal the abandoned well cause the contamination of groundwater through the natural processes of infiltration and percolation. Contamination of groundwater may also occur by the movement of wastewater through large openings and fissures in rock. In addition to these factors, seawater intrusion causes groundwater deterioration in coastal areas. The quality of groundwater can be viewed as the resultant of all the processes and reactions that act on the water from the moment it condensed in the atmosphere to the time it is discharged by a well or spring and varies from place to place and with the depth of water table (Jain et al. 1995). The quality standards of drinking water prescribed by Bureau of Indian Standards are given in Table 1.

LOCATION AND DESCRIPTION OF STUDY AREA

Usupur Panchayat is a rural village located 3 km south of the temple town of Chidambaram in Cuddalore district, Tamilnadu State. There are many residential habitations in the outskirts of Chidambaram town. Usupur has the residential habitations namely, VKA Nagar, Raja Nagar, Vallalar Nagar, Saba Nagar, Saradharam Nagar, Devadoss Nagar, Siva Nagar and Sakthi Nagar. The drinking water needs of the population in these habitations are served by a water distribution network drawing water from an overhead tank. The source of water supply is a deep bore well of depth about 600 m. The domestic water needs (except drinking) of each household are met by the shallow bore well driven in each of the house premises by the owner of the house. Most of these shallow bore wells have depths ranging from 4 m to 12.5 m. As there is no common sewerage system in Usupur Village Panchayat, each household is provided with an individual septic tank for receiving and treating the toilet waste. The shortest distance between the location of a bore well and the location of a septic tank in each house or the adjacent houses vary from as low as 3.5 m to a maximum of 18.8 m.

MATERIALS AND METHODS

Groundwater samples were collected from eight bore wells in each of the eight residential habitations mentioned earlier. The physicochemical characteristics of altogether 64 groundwater samples were analysed. The water samples were collected during the period January 2008 to March 2008 in clean polyethylene bottles without any air bubbles. The bottles were rinsed before sampling and tightly sealed after collection and labelled in the field. The temperature of water samples was measured in the field itself at the time of collection. The water samples were brought to the water testing laboratory and kept in refrigerator at 4°C for further analysis.

Water quality parameters such as pH, total dissolved solids, total hardness, total alkalinity, chlorides, nitrates, fluorides and iron were analysed using standard procedures.

RESULTS AND DISCUSSION

The results of the physicochemical analysis of groundwater samples collected from eight different bore well locations in each of the eight residential habitations in Usupur Village Panchayat are given in Table 2.

Table 1: Bureau of Indian Standards/specifications for drinking water (BIS: 10500-1991).

Sl. No.	Substance or characteristic	Requirement Desirable limit	Undesirable effect outside the desirable	Permissible limit in the absence of alternate source
1.	pH	6.5 to 8.5	Beyond this range the water will affect the mucous membrane and/or water supply system	No relaxation
2.	Total Hardness (mg/L) as $CaCO_3$	300	Encrustation in water supply structure and adverse effects on domestic use	600
3.	Iron (mg/L Fe) Max.	0.3	Beyond this limit taste/appearance are affected; has adverse effects on domestic uses and water supply structure and promotes iron bacteria	1.0
4.	Chlorides (mg/L, Cl) Max.	250	Beyond, effects outside the desirable limit	1000
5.	Dissolved solids (mg/L) Max.	500	Beyond this, palatability decreases and may cause gastrointestinal irritation.	2000
6.	Nitrate (mg/L, NO_3) Max.	45	Beyond this methaemoglobinaemia takes place.	100
7.	Fluoride (mg/L, F) Max.	1.0	Fluoride may be kept as low as possible. High fluoride may cause fluorosis.	1.5
8.	Alkalinity (mg/L,) Max.	200	Beyond this limit, taste becomes unpleasant	600

pH: pH is considered as an important ecological factor, which provides an important piece of information in many types of geochemical equilibrium or solubility calculations. It is an important parameter in water body since most of the aquatic organisms are adapted to an average pH and do not withstand abrupt changes.

The pH values of groundwater samples collected from all residential habitations varied between the permissible limits of 6.5 and 8.5 (BIS 1991). The pH values show slightly alkaline trend. Generally, pH of water is influenced by geology of catchment area and buffering capacity of water.

Total hardness: The total hardness of water samples collected was found to vary in the range of 200 to 750 mg/L as $CaCO_3$. As per Bureau of Indian Standards 10500-1991 specifications, the desirable limit of total hardness is 300 mg/L and the maximum permissible limit is 600 mg/L. Out of eight samples collected from each of the eight habitations, 7 samples in V.K.A. Nagar, 6 samples in Raja Nagar, 6 samples in Vallalar Nagar, 7 samples in Saba Nagar, 5 samples in Saradharam Nagar, 7 samples in Devadoss Nagar, all the 8 samples in Siva Nagar and 7 samples in Sakthi Nagar exceeded the desirable limit of 300 mg/L. In V.K.A. Nagar, two samples exceeded the maximum permissible limit of 600 mg/L, while in all other 7 habitations, the total hardness of all samples was within the maximum permissible limit. In the long run, usage of groundwater may cause encrustation in water supply pipelines.

Iron: The desirable and maximum permissible limits of iron in water are 0.3 mg/L and 1.0 mg/L as per BIS specifications. The iron content in water samples collected from different habitations was found to vary in the range of 0 to 10 mg/L. The iron content exceeded the maximum permissible limit

Table 2: Physicochemical analysis of groundwater in Usupur village Panchayat area.

Water quality parameter	Name of Residential Habitation								Desirable limit as per BIS: 10500-1991
	V.K.A. Nagar	Raja Nagar	Vallalar Nagar	Saba Nagar	Saradharam Nagar	Devadoss Nagar	Siva Nagar	Sakthi Nagar	
pH	6.5-7.0	6.5-8.0	6.5-7.0	7.0-8.5	6.0-7.5	7.0-8.5	6.5-7.5	6.5-7.5	6.5-8.5
TH	200-750	282-500	280-400	261-600	262-578	260-600	320-370	300-580	300
Iron	0.0-5.0	0.0-9.0	0.0-3.0	0.3-9.0	0.0-5.0	0.3-10.0	0.0-10.0	0.0-0.2	0.3
Chlorides	230-770	152-420	180-310	112-461	111-608	110-460	180-259	210-610	250
TDS	1020-2304	1056-1644	1032-1399	999-1674	1000-2250	996-1728	1032-1380	1104-2256	500
Nitrates	0.0-22.0	0.0-24.0	0.0-0.0	0.0-22.0	0.0-20.0	0.0-24.0	0.0-0.0	0.0-0.0	45
Fluorides	0.0-1.5	0.0-1.0	3.0-5.0	0.5-1.0	0.0-1.5	0.5-1.0	0.5-5.0	0.0-1.0	1.0
Alkalinity	370-430	362-472	350-540	361-460	380-689	360-460	348-540	390-740	200

Except pH all parameter are in mg/L

of 1.0 mg/L in 2, 3, 2, 6, 2, 6 and 2 samples collected from V.K.A. Nagar, Raja Nagar, Vallalar Nagar, Saba Nagar, Saradharam Nagar, Devadoss Nagar and Siva Nagar respectively. All the water samples except collected from different locations in Sakthi Nagar had no iron content. Nearly 75% of groundwater samples collected from Saba Nagar and Devadoss Nagar were objectionable showing high contents of iron above 3 mg/L. The taste and appearance of water having high contents of iron are affected. High iron content in water has adverse effects on domestic uses and water supply structure and promotes iron bacteria.

Chlorides: Chlorides are important in detecting the contamination of groundwater due to seawater invasion or wastewater migration. The desirable limit of chlorides in drinking water is 250 mg/L. The values of chloride observed varied from a low of 110 mg/L in a sampling location in Devadoss Nagar to a high of 770 mg/L in a sampling location in V.K.A. Nagar. Nearly 75%, 37.5%, 50%, 62.5%, 25%, 62.5%, 25% and 75% of the groundwater samples drawn from various bore wells in V.K.A. Nagar, Raja Nagar, Vallalar Nagar, Saba Nagar, Saradharam Nagar, Devadoss Nagar, Siva Nagar and Sakthi Nagar respectively were found to contain chlorides above the desirable limit of 250 mg/L. The presence of higher amounts of chlorides in wells may be due to the natural processes such as the passage of water through natural salt formations in the earth or it may be an indication of pollution from industrial or domestic use (Renn 1970).

Total dissolved solids (TDS): The BIS prescribed desirable limit of TDS is 500 mg/L. The maximum permissible limit of TDS in the absence of an alternate source of water is 2000 mg/L. From Table 2, it is found that all water samples drawn from all residential habitations have TDS higher than the desirable limit of 500 mg/L. The minimum recorded TDS was 996 mg/L for a water sample collected from a bore well in Devadoss Nagar while the maximum TDS was 2304 mg/L for a sample collected from V.K.A. Nagar. Except for 2 samples each in V.K.A. Nagar and Sakthi Nagar and one sample in Saradharam Nagar, all other water samples were found to have TDS within the maximum permissible limit of 2000 mg/L. High TDS content may be attributed to intrusion of seawater as the study area is close to east coast. High TDS in groundwater may be due to groundwater pollution when wastewaters from septic tanks migrate down to the water table because of their closeness in

relative locations. As the groundwater samples were collected during the early summer period (late January to March), the falling water tables might have aided the migration of waste water from nearby septic tanks particularly when the bore well location and septic tank location are very close to one another. The high TDS of water samples make the groundwater of all habitations non-potable as it is highly likely to cause gastrointestinal irritation.

Nitrates: Of the total 64 samples analysed, only 15 samples had nitrates. All other samples were found to possess zero concentration of nitrates. Even these 15 samples showing nitrates concentration were found to be well within the desirable limit of 45 mg/L. In fact, the maximum nitrates concentration recorded was only 24 mg/L in Raja Nagar and Devadoss Nagar.

Fluorides: The desirable and maximum permissible limits of fluorides in drinking water are 1.0 mg/L and 1.5 mg/L respectively. In four residential habitations namely Raja Nagar, Saba Nagar, Devadoss Nagar and Sakthi Nagar, the fluoride concentration in groundwaters was well within the desirable limit of 1.0 mg/L. All water samples drawn from V.K.A. Nagar and Saradharam Nagar showed fluorides concentration within the maximum permissible limit of 1.5 mg/L. In Vallalar Nagar, all groundwater samples collected were found to exceed the maximum permissible limit of 1.5 mg/L, out of which 3 samples have a concentration of 3 mg/L and 5 samples have a concentration of 5 mg/L, while in Siva Nagar, samples drawn from two and three bore well locations have concentrations of 3 mg/L and 5 mg/L respectively. The excess concentrations of fluorides in groundwater in most locations in these two habitations may cause fluorosis.

Alkalinity: The desirable limit of alkalinity in potable water is 200 mg/L (BIS 1991). The maximum permissible limit is 600 mg/L. The overall range of alkalinity for the total 64 samples analysed was between 348 mg/L and 740 mg/L. One sample in Saradharam Nagar and two samples in Sakthi Nagar possess alkalinity in excess of maximum permissible limit of 600 mg/L. The measure of alkalinity provides an idea of natural salts present in water. The cause of alkalinity is the minerals that dissolve in water from soil. The various ions that contribute to alkalinity include bicarbonates, hydroxides, phosphates, borates and organic acids. These factors are characteristics of the source of water and natural processes taking place at any give time (Sharma 2004).

CONCLUSION

The physicochemical analysis of groundwater samples drawn from different shallow bore wells in eight residential habitations in Usupur Village Panchayat reveals the following facts:

1. The pH and nitrates concentration of all samples are well within the desirable limits prescribed by the Bureau of Indian Standards.
2. The total hardness of more than 75% water samples in all the eight habitations were more than the desirable limit of 300 mg/L.
3. Nearly 75% of groundwater samples collected from Saba Nagar and Devadoss Nagar were objectionable showing high contents of iron ranging from 3 mg/L to 10 mg/L exceeding the maximum permissible limit of 1.0 mg/L prescribed by BIS. The problem of excess iron was found in few samples in other habitations too.
4. The chlorides concentration too was more than the desirable limit of 250 mg/L in nearly more than 50% bore wells in five out of eight residential habitations.
5. The total dissolved solids concentration and alkalinity in shallow ground waters in all the eight residential habitations were found to be far above the desirable limits of 500 mg/L and 200 mg/L respectively.

6. The fluorides concentration in many of the bore wells in two habitations namely Vallalar Nagar and Siva Nagar are objectionable as they exceed the maximum permissible limit of 1.5 mg/L. In the other six habitations, the concentrations are within the limit prescribed.

As the water drawn from the bore wells in the study area are presently used only for domestic activities and not for drinking and cooking, the observed excess concentrations of total hardness, iron, chlorides, total dissolved solids, alkalinity and fluorides may not pose any health hazards. But, high total hardness may cause problems in washing of clothes and encrustation in water supply pipelines. The high concentrations of total dissolved solids and chlorides prevent the groundwater from being fit for drinking without treatment. The ill effects of excess iron can be overcome if water drawn from well is stored and used. The storage permits aeration of water and iron gets oxidized to a stable form. This permits the waters from bore wells fit for domestic activities such as bathing and washing even though they are not fit for drinking and cooking.

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