Environment Conservation Journal 18(3) 27-37, 2017
ISSN 0972-3099 (Print) 2278-5124 (Online)
Abstracted and Indexed

# An overview of groundwater quality in Tamil nadu

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**Received: 25.07.2017** **Revised: 17.08.2017** **Accepted: 01.10.2017**


## Abstract

**Ground water is considered to be very clean and safe in past days but in recent decades rapid industrialization causes severe environmental problems in most of the countries, due to the discharge of effluents into groundwater by industries like textile, dyeing, leather, tannery, pulp and paper processing industries etc., The effluent discharged by these industries leads to serious pollution which altered the geochemical parameters of surface water and ground water. Since the quality of public health depends to a greater extent on the quality of drinking water. Safe drinking water is primary need of every human being. Pollution of groundwater has been growing increasingly in several parts of India, particularly in areas of industrial development. Over burden of population pressure, unplanned urbanization, over exploitation of groundwater resources, dumping of polluted water at inappropriate place enhance the infiltration of harmful compounds to the groundwater. With the increasing demand for groundwater resources caused by an acute shortage of surface water, there is a noteworthy depletion of groundwater levels and quality due to geogenic as well as anthropogenic activities. The tanning industry is one of the oldest and fastest growing industries in south and south-east Asia. The states of Tamil Nadu, West Bengal and Uttar Pradesh together have 88% of the tannery units of the country. About 55% of total leather processed in the county is from Tamil Nadu and tannery units mainly spreads over Ranipet, Ambur, Vaniyambadi, Pernambut of Vellore district, Pallavaram and Chrompet in Chennai, Dindigul, parts of Erode district and Sembattu in Trichy district (CLRI, 1990). Water, due to its great solvent power, is constantly threatened to get polluted easily.**


**Keywords: Contamination, water quality, permissible limits, standards**

## Introduction

Groundwater quality comprises the physical, chemical, and biological qualities of ground water. Temperature, turbidity, color, taste, and odor make up the list of physical water quality parameters. Since most ground water is colorless, odorless, and without specific taste, we are typically most concerned with its chemical and biological qualities. Although spring water or groundwater products are often sold as "pure," their water quality is different from that of pure water. Naturally, ground water contains mineral ions. These ions slowly dissolve from soil particles, sediments, and rocks as the water travels along mineral surfaces in the pores or fractures of the unsaturated zone and the aquifer. They are referred to as dissolved solids. Some dissolved solids may have originated in the precipitation water or river water that recharges the aquifer. A list of the dissolved solids in any water is long, but it can be divided into three groups: major constituents, minor constituents, and trace elements (Table 1). The total mass of dissolved constituents is referred to as the total dissolved solids (TDS) concentration. In water, all of the dissolved solids are either positively charged ions (cations) or negatively charged ions (anions). The total negative charge of the anions always equals the total positive charge of the cations. A higher TDS means that there are more cations and anions in the water. With more ions in the water, the water's electrical conductivity (EC) increases. By measuring the water's electrical conductivity, we can indirectly determine its TDS concentration. At a high TDS concentration, water becomes saline. Water with a TDS above 500 mg/l is not recommended for use as drinking water (EPA secondary drinking water guidelines). Water with a TDS above 1,500 to 2,600 mg/l (EC greater than 2.25 to 4 µmho/cm) is generally considered problematic for irrigation use on crops with low or medium salt tolerance.

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**Potential sources of groundwater contamination (Table 1)**

- **Storage Tanks**

May contain gasoline, oil, chemicals, or other types of liquids and they can either be above or below ground. If the contaminants leak out and get into the groundwater, serious contamination can occur.

- **Septic Systems**

Onsite wastewater disposal systems used by homes, offices or other buildings that are not connected to a city sewer system. Septic systems are designed to slowly drain away human waste underground at a slow, harmless rate. An improperly designed, located, constructed, or maintained septic system can leak bacteria, viruses, household chemicals, and other contaminants into the groundwater causing serious problems.

- **Uncontrolled Hazardous Waste**

Abandoned and uncontrolled hazardous waste sites can lead to groundwater contamination if there are barrels or other containers laying around that are full of hazardous materials. If there is a leak, these contaminants can eventually make their way down through the soil and into the groundwater.

- **Landfills**

Landfills are the places that our garbage is taken to be buried. Landfills are supposed to have a protective bottom layer to prevent contaminants from getting into the water. However, if there is no layer or it is cracked, contaminants from the landfill (car battery acid, paint, household cleaners, etc.) can make their way down into the groundwater.

- **Chemicals and Road Salts**

The widespread use of chemicals and road salts is another source of potential groundwater contamination. Chemicals include products used on lawns and farm fields to kill weeds and insects and to fertilize plants, and other products used in homes and businesses. When it rains, these chemicals can seep into the ground and eventually into the water. Road salts are used in the wintertime to put melt ice on roads to keep cars from sliding around. When the ice melts, the salt gets washed off the roads and eventually ends up in the water.

**Table 1. Primary (major), secondary, and trace constituents in natural ground water**

| Major constituents (1.0-1.000 mg/l) | Secondary constituents (0.01-10 mg/l) | Trace constituents (0.0001-0.1 mg/l) | Trace constituents (< 0.001 mg/l) |
|---|---|---|---|
| Cations | | | |
| Sodium | Potassium | Antimony | Beryllium |
| Calcium | Iron | Aluminum | Bismuth |
| Magnesium | Strontium | Arsenic | Cerium |
| Anions | | Barium | Cesium |
| Bicarbonate | Carbonate | Bromide | Gallium |
| Sulfate | Nitrate | Cadmium | Gold |
| Chloride | Fluoride | Chromium | Indium |
| Silica | Boron | Cobalt | Lanthanum |
| | | Copper | Niobium |
| | | Germanium | Platinum |
| | | Iodide | Radium |
| | | Lead | Ruthenium |
| | | Lithium | Scandium |
| | | Manganese | Silver |
| | | Molybdenum | Thallium |
| | | Nickel | Thorium |
| | | Phosphate | Tin |
| | | Rubidium | Tungsten |
| | | Selenium | Ytterbium |
| | | Titanium | Yttrium |
| | | Uranium | Zirconium |
| | | Vanadium | |
| | | Zinc | |

- **Atmospheric Contaminants**

Since groundwater is part of the hydrologic cycle, contaminants in other parts of the cycle, such as the atmosphere or bodies of surface water, can eventually be transferred into our groundwater supplies.

- **Nitrate pollution**

The major hydro chemical parameters for ascertaining the quality of water for potable purposes are Total dissolved solids, Nitrate & Fluoride. Nitrogen is a major constituent of the earth's atmosphere and occurs in many different gaseous forms such as elemental nitrogen, nitrate and ammonia.

Natural reactions of atmospheric forms of nitrogen with rainwater result in the formation of nitrate and ammonium ions. Nitrate is one of the most common groundwater contaminants in rural areas and is reported from several areas in Tamil Nadu (Table 2). The sources of nitrate in the groundwater were attributed to bedrock dissolution in the course of groundwater migration. Other common sources of nitrate include human sewage and livestock manure. Nitrate is also a common constituent of chemical fertilizers. As per the BIS Standard for drinking water the maximum desirable limit of Nitrate concentration in ground water is 45 mg/l with no relaxation.

**Table 2. List of districts showing localized occurrence of Nitrate (>45 mg/litre) in groundwater in Tamil Nadu**

| State | Districts |
|---|---|
| **Tamil Nadu** | Chennai, Coimbatore, Cuddalore, Dharmapuri, Dindigul, Erode, Kancheepuram, Kanyakumari, Karur, Madurai, Namakkal, Nilgiris, Perambalur, Pudukkottai, Ramanathapuram, Salem, Sivagangai, Theni, Thiruvannamalai, Thanjavur, Tirunelveli, Thiruvallur, Trichi, Tuticorin, Vellore, Villupuram, Virudhunagar. |

**Major sources of nitrate pollution**

1. There are numerous sources in environment that contribute to the total nitrate content of natural waters, e.g. atmosphere, geological features, anthropogenic sources, atmospheric nitrogen fixation and soil nitrogen. It has been observed that in sandy soil with low water holding capacity and high permeability, movement of pollutants like chloride and nitrate is much quicker than in clayey soil. This is probably the main cause for high nitrate in areas with sandy soil. Nitrate is highly soluble and readily moves with water through the soil profile. In areas of excess rainfall or over-irrigation, nitrate will be leached below the plant's root zone and may eventually reach the groundwater.

2. Wastewater in the upper soil layer either from the cesspools or the disposal ponds could infiltrate to the groundwater aquifer. The absence of a sewage system encourages such types of contamination by nitrate. Thus, the level of nitrate in groundwater will continue to increase as the sources of contamination. These sources are more dangerous than the leaching ones, because of the daily use of water, which then recharges the aquifer.

3. Nitrate in ground water can be derived from natural sources or from point sources, such as sewage disposal systems and livestock facilities causes pollution of surface water, ground water and wells through percolation. Waste materials are one of the anthropogenic sources of nitrate contamination of groundwater. Surface water runoff from fertilized farmland and animal feedlots is a major potential source of nitrate contamination. Septic tanks are another example of anthropogenic source nitrogen contamination of the groundwater. Ground water contamination is usually related to the density of septic systems.

4. The use of nitrogen (N)-fertilizer in agriculture has significantly increased over the past 30 years to meet the food and living requirements of the speedily growing population. Therefore, the use of nitrate in fertilizers causes a foremost predicament in groundwater contamination. Some of the fertilizers infiltrate with the irrigation and/or rainwater to recharge the aquifer. The increased uses of nitrate fertilizers in the villages enhance the contamination of groundwater.

5. The interaction of nitrogen compounds with the surrounding media leads to oxidation of nitrogen

compounds, which finally contaminate the aquifer. Generally, organic matter nitrate bearing is distributed on the surface or near surface of the ground (sewage water, cesspools and drainage) produces nitrate.

**Toxic effects of high nitrate**

High nitrate level in drinking water leads to infant methaemoglobinaemia (blue-baby syndrome), gastric cancer goiter, metabolic disorder, birth malformations, hypertension and livestock poisoning. In fact the increased concentration of hydro toxicants have created socio-economic problem and adversely affected the livelihood of inhabitants. Therefore, for sustainable health and development, immense and immediate efforts are required to combat the problem (Khandare, 2013).

**Table 3. Groundwater quality at Coimbatore city. (All parameters are expressed in mg/l except pH and EC)**

| S. No | Parameters | Pre monsoon | | | | Post monsoon | | | | IS 10500 limits | | IS 2296 limits |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Minimum | Maximum | Mean | SD | Minimum | Maximum | Mean | SD | Desirable | Maximum | Desirable |
| 1 | pH | 6.98 | 7.74 | 7.44 | 0.21 | 6.65 | 7.23 | 6.98 | 0.17 | 6.5-8.5 | 6.5-8.5 | - |
| 2 | TDS | 220 | 1050 | 635.8 | 267.4 | 250 | 1070 | 683.3 | 295.6 | 500 | 2000 | <1500 |
| 3 | EC (µ mhos/cm) | 0.96 | 5.68 | 3.15 | 1.47 | 1.14 | 5.81 | 3.4 | 1.60 | - | - | <0.25 |
| 4 | TH | 430 | 1650 | 954.6 | 415.6 | 660 | 1720 | 1139 | 179.8 | 300 | 600 | - |
| 5 | $Ca^{2+}$ | 90 | 590 | 256.7 | 114.1 | 195 | 590 | 374.2 | 127.2 | 75 | 200 | - |
| 6 | $Mg^{2+}$ | 335 | 1220 | 697.9 | 284.8 | 370 | 1385 | 764.6 | 298.7 | 30 | 100 | - |
| 7 | Alkalinity | 335 | 805 | 585.3 | 131.7 | 585 | 1110 | 845.8 | 130.4 | 200 | 600 | - |
| 8 | $Na^+$ | 2 | 9 | 5.00 | 2.00 | 2 | 11 | 5.75 | 3.20 | - | - | - |
| 9 | $SO_4^{2-}$ | 72 | 372 | 119.9 | 78.1 | 45 | 220 | 115.1 | 45.80 | 200 | 400 | <1000 |
| 10 | $Cl^-$ | 82 | 1678 | 799.2 | 526.8 | 154 | 1574 | 774.8 | 486.1 | 250 | 1000 | <600 |
| 11 | K | 6.33 | 13.67 | 9 | 3.51 | 12.7 | 42.67 | 23 | 14.75 | - | - | - |

(Santhosh and Revathi, 2014)

- **Chromium pollution**

Tannery effluents are ranked as the highest pollutant (indicates single elements like chromium) among all the industrial wastes. It is estimated that in India alone about 2000-3000 t of chromium escapes into the environment annually from tannery industries, with chromium concentrations ranging between 2000 and 5000 mg/l in the aqueous effluent compared to recommended permissible limits of 2 mg/l. the tanning industries are especially large contributors of chromium pollution in India. Currently, it has been estimated that more than 50,000ha of productive agricultural lands have been contaminated with chromium alone due to disposal of tannery wastes in Tamil Nadu, where more than 60 % of Indian tanneries located in Vellore district. Leather processing requires largeamount of chemicals like sodium chloride, chromium sulphate, calcium salts, ammonium salts, sodium sulphide, acids, alkalis, fat, liquor and organic dyes. However, one of the major emerging environmental problems in the tanning industry is the disposal of chromium contaminated sludge produced as a by-product of waste water treatment (Amita *et al.,* 2005). Tannery effluents severely affect the mitotic process and reduce seed germination in extensively cultivated pulse crops (Thangapandian *et al.,* 1995). The chromium concentration in ground waters is also markedly higher than the average background value reported in different parts of India (Mahimairaja *et al.,* 2000).

**Groundwater quality in few districts of Tamil**

Table 4 shows district wise details of ground water quality in Tamil Nadu for the year 2011 while table 5 shows hydrogeology of the state.

**Nadu Noyyal River (Coimbatore)**

Coimbatore city is the one of the major cities in Tamil Nadu and it is well known for industrial activities. The Noyyal river originates from the Vellingiri hills of the Western Ghats in Coimbatore and passes through Coimbatore, Erode and Karur districts of Tamil Nadu and joins to the river Cauvery at Noyyal village of Karur district. The river has a length of 160 km and it has average width of 25m. Noyyal river and its connected tanks are the main sources of ground water which provide water for all the purposes in Coimbatore region. It was found that the decrease in various quality characteristics clearly indicated the possibilities of pollution due to industrial activities such as coffee vegetable oils, leather tanning, textiles and foundries in and around Coimbatore city. The population of Coimbatore has also a strong impact on the Noyyal river with regard to pollution and due to this Noyyal river acts as a carrier for the pollutants. During the non-flow period of the river, water can be stagnated and the pollutants may enter into the groundwater. So the ground water quality gets depleted. Santhosh and Revathi, 2014 analysed ground water quality of Coimbatore (Table 3). If the improper disposal of municipal and industrial waste is continued in the Noyyal River basin, then there is a greater chance of pollution in the future, which will affect the ground water in the basin. Hence there is an urgent need for integrated water resource management strategies for the long-term sustainability of groundwater resources in the basin.

**Groundwater quality in Vellore district**

Vellore District is one of the most polluted area in Tamil Nadu, India. It occupies around 240 tanneries, 17 Red category industries and small scale chemical industries. Partially treated industrial effluents combined with sewage and other wastes discharged on the surface cause severe groundwater pollution in the industrial belt. This poses a problem of supply of safe drinking water in the rural parts of the country. The most serious pollution threat to groundwater is from TDS, Total Hardness, salinity, Calcium, chloride and Fe, which are associated with sewage and pollution of tannery waste.

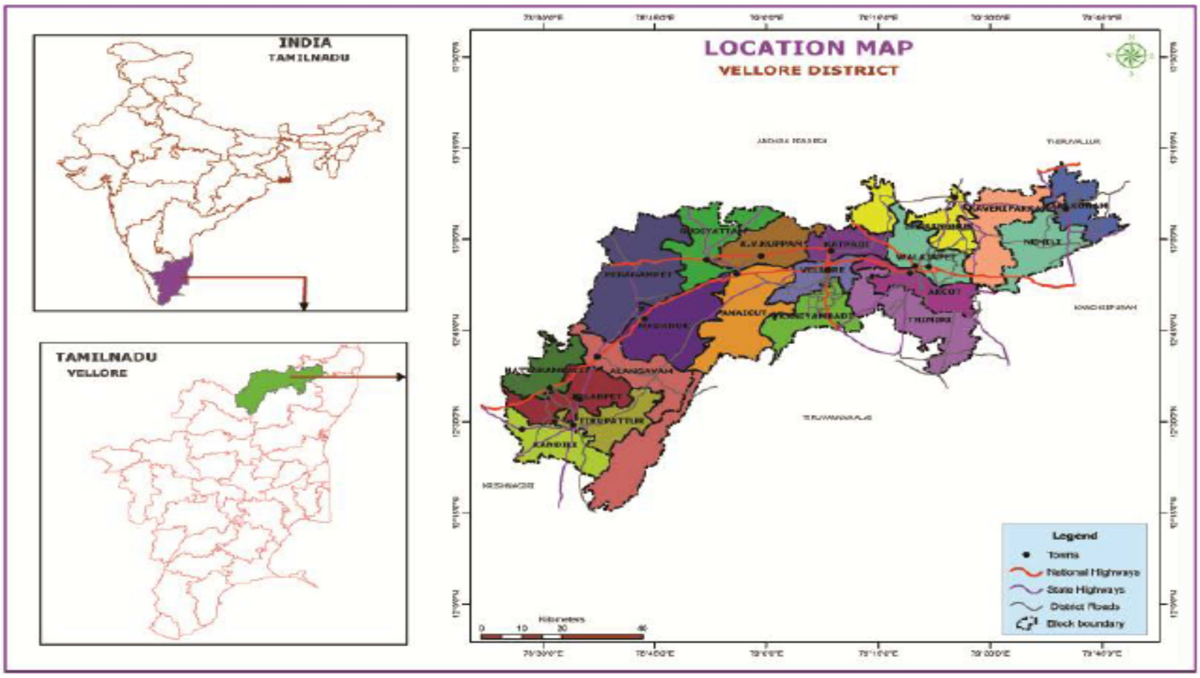


**Fig. 1. Location map of Vellore district**

**Table 4: District wise details of ground water quality in Tamil Nadu for the year 2011**

| S. No. | District | No. of samples collected | No. of samples having Chloride > 1000 mg/l | No. of samples having Fluoride > 1.5 mg/l | No. of samples having Nitrate > 45 mg/l |
|---|---|---|---|---|---|
| 1 | Chennai | 10 | 0 | 0 | 2 |
| 2 | Coimbatore | 37 | 3 | 6 | 20 |
| 3 | Cuddalore (Composite) | 13 | 1 | 0 | 2 |
| 4 | Dharmapuri (Composite) | 17 | 0 | 3 | 9 |
| 5 | Dindigul | 15 | 0 | 1 | 8 |
| 6 | Erode | 29 | 0 | 4 | 21 |
| 7 | Kanchipuram | 18 | 0 | 0 | 5 |
| 8 | Kanyakumari | 14 | 0 | 0 | 7 |
| 9 | Karur | 8 | 1 | 2 | 3 |
| 10 | Madurai | 4 | 0 | 2 | 1 |
| 11 | Nagaipattinam | 10 | 0 | 0 | 2 |
| 12 | Namakkal | 17 | 2 | 3 | 7 |
| 13 | Nilgiris | 8 | 0 | 0 | 2 |
| 14 | Perambalur (Composite) | 12 | 2 | 3 | 2 |
| 15 | Pudukkotai | 16 | 3 | 3 | 7 |
| 16 | Ramnad | 19 | 7 | 1 | 7 |
| 17 | Salem | 24 | 5 | 6 | 12 |
| 18 | Sivaganga | 11 | 2 | 1 | 5 |
| 19 | Thiruvannamalai | 8 | 0 | 1 | 1 |
| 20 | Thanjavur | 21 | 6 | 7 | 3 |
| 21 | Theni | 9 | 1 | 0 | 3 |
| 22 | Thiruvallur | 16 | 0 | 0 | 1 |
| 23 | Thiruvarur | 8 | 0 | 1 | 2 |
| 24 | Thirunelveli | 26 | 1 | 1 | 4 |
| 25 | Trichirappalli | 14 | 1 | 0 | 10 |
| 26 | Tuticorin | 21 | 1 | 0 | 2 |
| 27 | Vellore | 15 | 2 | 2 | 6 |
| 28 | Villupuram | 17 | 0 | 1 | 5 |
| 29 | Virudunagar | 10 | 0 | 0 | 2 |
| 30 | Puduchery | 4 | 0 | 0 | 0 |
| **Total** | | **451** | **38** | **48** | **161** |

**(CGWB, 2012)**

**Table 5: Hydrogeology of the state**

| | |
|---|---|
| **Dynamic Ground Water Resources** | |
| Annual Replenishable Ground water Resource | 23.07 BCM |
| Net Annual Ground Water Availability | 20.76 BCM |
| Annual Ground Water Draft | 17.65 BCM |
| Stage of Ground Water Development | 85 % |
| **Ground Water Development & Management** | |
| Over Exploited | 142 Blocks |
| Critical | 33 Blocks |
| Semi- critical | 57 Blocks |
| Ground Water User Maps | 29 districts |
| Artificial Recharge to Ground Water (AR) | • Area identified for AR: 17292 sq km<br>• Quantity of Surface Water to be Recharged: 3597 MCM<br>• Feasible AR structures: 8612 percolation tanks, 18170 check dams, 5 lakh rain water harvesting structure |
| **Ground Water Quality Problems** | |
| **Contaminants** | **Districts affected (in part)** |
| **Salinity** (EC > 3000 µS/cm at 25 ° C) | Dharmapuri, Pudukkottai, Thoothukkudi, Coimbatore, Dindigul, Ramanathanpuram, Salem, Karur, Namakkal, Perambalor, Thiruvannamalai, Vellore, Villupuram, Cuddalore |
| **Fluoride** (>1.5 mg/l) | Coimbatore, Dharmapuri, Dindigul, Erode, Karur, Krishnagiri, Namakkal, Perambalor, Puddukotai, Ramanathanpuram, Salem, Sivaganga, Theni, Thiruvannamalai, Trichurapally, Vellore, Virudhunagar |
| **Chloride** (> 1000 mg/l) | Pudukkottai, Thoothukkudi, Ramanathanpuram, Namakkal, Cuddalore, Thirunamalai, Thanjavur, Shivaganga |
| **Iron** (>1.0 mg/l) | Namakkal, Salem, |
| **Nitrate** (>45 mg/l) | Chennai, Coimbatore, Cuddalore, Dharmapuri, Dindigul, Erode, Kancheepuram, Kanyakumari, Karur, Madurai, Namakkal, Nilgiris, Perambalor, Puddukotai, Ramanathanpuram, Salem, Sivaganga, Theni, Thiruvannamalai,Thanjavur, Tirunelveli, Tiruvallur, Trichi, Tuticorin, Vellore, Villupuram, Virudhunagar |

**(CGWB, 2014**

**Table 6. Results of water analyzed in comparison with WHO standards**

| Parameters | Permissible limit as per, WHO 2011 | Concentration observed | | No of samples exceeding permissible limit* | Percentage (%) |
|---|---|---|---|---|---|
| | | Minimum | Maximum | | |
| pH | 7.0-8.5 | 6.5 | 7.3 | 22 | 73.3 |
| EC | 1000 | 886 | 3900 | 25 | 83.3 |
| Total Hardness | 300 | 210 | 990 | 21 | 70.0 |
| TDS | 1000 | 670 | 2750 | 17 | 57.0 |
| Alkalinity | 200 | 180 | 415 | 25 | 83.3 |
| Chloride | 250 | 210 | 970 | 27 | 90.0 |
| Nitrate | 45 | 35 | 96 | 26 | 87.0 |
| Suphate | 200 | 165 | 432 | 27 | 90.0 |
| Fluoride | 1.5 | 0.6 | 2.2 | 12 | 40.0 |
| Calcium | 75 | 55 | 400 | 24 | 80.0 |
| Magnesium | 50 | 28 | 96 | 25 | 83.3 |
| Iron | 0.3 | 0 | 0.7 | 4 | 13.0 |
| COD | 10 | 5 | 80 | 22 | 73.3 |
| BOD | 5 | 0.8 | 4.5 | Nil | - |

***Total number of sample is 30.**

Table 6 shows results of various parameters analyzed during course of study while table 7 shows classification of ground water based on hardnes range

**Total Hardness (TH)**

The classification of groundwater based on total hardness (TH) shows that a majority of samples fall in the hard water category & very hard water category. Hard and very Hard water might lead to pre-natal mortality, cardio-vascular diseases etc (Agrawal and Jagetai, 1997) and is unsatisfactory for domestic purpose and hence water softening processes for removal of hardness are needed (Todd, 1980).

**Table 7. Classification of ground water based on Hardness range**

| Total Hardness (mg/l) | No. of. samples | Percentage % | Description |
|---|---|---|---|
| 0-75 | Nil | -- | Soft |
| 75-150 | Nil | -- | Moderately hard |
| 150-300 | 9 | 30% | Hard |
| >300 | 21 | 70% | Very hard |

**Total Dissolved Solids (TDS)**

To ascertain the suitability of groundwater for any purposes, it is essential to classify the ground water depending up on their hydro chemical properties based on their TDS values which are presented in (Table 8). Most of the groundwater samples are within the maximum permissible limit for drinking as per the WHO international standard, except 13 samples in study area. Most of the samples in the study area shown above 1000 mg/l of TDS indicating low content of soluble salts in groundwater which can be used for drinking without any risk. The TDS values range from 670 mg/l to 2750 mg/l. The maximum TDS value of (2750 mg/L) was found in Shozhingar road (Walajapet) and the minimum value of (670 mg/L) was found in Mettuthangal (Ranipet). The underground water in Vellore is deteriorating and the maximum sampling stations needs special attention, as all the parameters such as TDS, electrical conductivity, chloride, hardness and salinity is found high. It may cause laxative effects on health of the people consuming that water and it is not much suitable for irrigation purpose also. The minimum sampling stations have their respective physico-chemical parameters slightly above WHO limits. The reason for higher values of physico-chemical parameters at certain sampling locations may be due the unsciencitific disposal of solid wastes, the depth of the wells and nature of the geological materials with which the groundwater comes in contact may influence the quality of the water. Hence proper water treatment is required in terms of community health (Riaz Ahamed and Manikandan, 2015).

**Table-8 Classification of ground water based on TDS Classes.**

| TDS mg/L | No. of. samples | Percentage % | Description | |
|---|---|---|---|---|
| <500 | Nil | -- | Non-saline | Excellent |
| 500-1000 | 13 | 44 | Non-saline | Good |
| 1000-2000 | 10 | 33 | Slightly saline | Fair |
| >2000 | 7 | 23 | Moderately saline | Poor |

**Chromium in Vellore**

Another experiment was conducted by Sunitha et al. (2012) and concluded that most (>90%) of the soil samples collected from 65 locations in Vellore district had high concentration of Cr (>200 mg kg-1) which exceeding the permissible (threshold) limit prescribed by the Environmental Protection Agencies (EPA) in different countries especially fixed the concentration by India. In ground water, the Cr concentration ranged from trace (below detectable level) to 36.7 mg/l. About 67.6 per cent of the groundwater samples had only traces of Cr or the concentration below the detectable level. Twenty eight per cent of the samples had relatively higher concentration of Cr, exceeding the safer limit of drinking water (0.05 mg/1) and irrigation water (2 mg/l), prescribed by the WHO and FAO, respectively. The most disturbing fact about this contamination is that these waters are currently in use for potable purpose. The soil chromium concentration was decreased at the same time water chromium was increased due to leaching process. The chromium was leached from upper layer of soil to deeper layer of aquifer. Most of the Cr contaminated ground water exhibited greater risk in terms of both salinity and sodicity hazards and were found unsuitable for both human consumption and irrigation purpose.

**Water quality in Dindigul**

Dindigul is one of the important places for its tannery units. It has more than 80 tannery units in and around the city and nearly 50 units are under processing of leather. It is the fact that the processing of leather requires large amount of freshwater along with various chemicals. Groundwater is the main source of drinking water in Dindigul. The leather industry in and around the Dindigul city pollute both surface and groundwater by discharging their wastes. Mohamed Hanipha and Zahir Hussain (2013) studied the groundwater samples from 23 different parts of Dindigul town and analyzed for pH, EC, TDS, CO3, HCO3, Cl, Na, K, Ca, Mg, NO3, SO4, PO4, F, DO, BOD and COD using standard procedures (Table 9). The values of all the groundwater samples are compared with the standard permissible value. Fluoride, dissolved oxygen, biochemical oxygen demand and chemical oxygen demand are exceeding the permissible limit in most of the groundwater samples. From the obtained results, it is suggested to monitor the groundwater quality and assess periodically in this study area to prevent the further contamination.

**Water quality in Tiruchirappalli**

Cauvery River is the lifeline of the population residing in Tiruchirappalli district. They are dependent on ground water as their prime source of drinking water. Hence, monitoring the quality of ground water is necessary in order to provide the public with potable water. As per Central Ground Water Board, groundwater in phreatic aquifers in Tiruchirappalli district is colourless, odourless and slightly alkaline in nature. The electrical conductivity of ground water in phreatic zone (in Microsiemens at $25^{o}$ C) during May 2006 was in the range of 570 to 4550 µS/cm and major parts of the district are having the electrical conductivity above 1700 µS/cm. It is observed that in general the ground water is suitable for drinking and domestic uses in respect of all the constituents except Fluoride of higher concentration at Siruganallur (1.85 mg/L) and at few places are having higher concentration of $NO_3$ than BIS permissible limit (CGWB, 2008). The physiochemical analysis of well water and bore well water indicate that some of the parameters were found to be exceed the permissible limits, which were could be ascribed to seepage of treated waste water into ground water.

**Table 9. Statistical evaluations of groundwater samples collected in and around Dindigul town.**

| Parameters | Minimum | Maximum | Mean | Median | SD | WHO (1992) | |
|---|---|---|---|---|---|---|---|
| | | | | | | Acceptable | Allowable |
| pH | 7.02 | 7.65 | 7.25 | 7.21 | 0.17 | 7.0-8.5 | 6.5-9.2 |
| EC | 0.69 | 1.56 | 1.07 | 1.06 | 0.21 | - | - |
| TDS | 442 | 998 | 692 | 678 | 140 | 500 | 1500 |
| CO3 | - | - | - | - | - | - | - |
| HCO3 | 119 | 186 | 143 | 142 | 20.31 | 30 | 150 |
| Cl | 103 | 258 | 154 | 136 | 44.65 | 250 | 1000 |
| Na | 20 | 96 | 42 | 32 | 23.90 | 175 | 200 |
| K | 0.11 | 0.25 | 0.14 | 0.14 | 0.02 | - | 12 |
| Ca | 74 | 220 | 128 | 125 | 39.84 | 75 | 200 |
| Mg | 48 | 95 | 76 | 84 | 15.28 | 50 | 150 |
| NO3 | 0.02 | 0.09 | 0.05 | 0.05 | 0.02 | 45 | 100 |
| SO4 | 42 | 97 | 64 | 59 | 16.80 | 200 | 400 |
| PO4 | 0.01 | 0.06 | 0.03 | 0.03 | 0.01 | 0.1 | 1 |
| F | 2.47 | 5.26 | 3.46 | 3.48 | 0.88 | - | 1 |
| DO | 0.20 | 0.60 | 0.33 | 0.3 | 0.12 | 5.0 | - |
| BOD | 48 | 150 | 90 | 87 | 30.14 | 3.0 | 5.0 |
| COD | 25 | 95 | 45 | 36 | 21.13 | 10.0 | 20.0 |

(Mohamed Hanipha and Zahir Hussain, 2013)

## Conclusion

Groundwater has been called the great hidden resource. It conjures up images of vast underground rivers or lakes, pure and pristine, flowing from distant places. In fact, groundwater is quite different from that. It's more like the water within a saturated sponge, moving slowly through the earth's pores and cracks and it is replenished locally. Most available fresh water is groundwater. Groundwater is an important source for our drinking water and stream flow. Although most of our groundwater supplies are clean, they are, due to human neglect and carelessness, vulnerable and threatened. Groundwater contamination can last for years and be difficult and expensive to clean up. Pollution prevention is the key to control. Proper disposal of all waste/ chemicals down drains or on the ground might reduce the contamination at certain level. With respect to industries effluent proper treatment as per the norms should follow before let into the soil or water bodies. Should ensure that land use plans and regulations protect important water supply aquifers and also monitor and inspect important water bodies and recharge areas to know the status of groundwater quality. Conduct an environment audit to account the contamination level, it will help to prepare pollution prevention plan for future. Water quality should be improved by treating the effluent by different chemical and bio-remediation methods. Strict legislation and programs over industries could reduce the contamination and can provide clean/good quality water for future generations.

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