Chemical analysis of ground water from various parts of Thanjavur District, Tamil Nadu (India)

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Abstract. The present study was to assess the quality of ground water from various parts of Thanjavur district, and check its fitness for drinking purpose. The pH was determined by pH metric method, calcium, magnesium, chloride were analyzed by titration method, sulphade, iron, nitrate, nitrite, chromium were estimated by spectrometric method, total dissolved solids of the water samples were determined by gravimetrically, colour of the water samples were determined by platinum-cobalt method, taste of the water samples were determined by taste rating method, turbidity of the water samples were determined by Nephelometric method etc., are determined for some parts of Thanjavur district water samples and compared with standard limits recommended by BIS. Comparative study of groundwater for this region can be used for the quality of water is suitable for drinking purpose, but the ground water sample numbers S2, S3, S4, S5, S6, S7 and S9 is not suitable for drinking purpose, because in the presence of excess of hardness (Ca2+, Mg2+), chloride, and TDS.

1. INTRODUCTION

In general ground water has become the major source of water supply for domestic, industrials and agricultural sectors of many countries. Unfortunately in lots of countries around the world including India some regions ground water was contaminated by excess hardness (Ca2+, Mg2+). If an excess of hardness in ground water cause many diseases to human beings such as cardiovascular disorder, urolithosis, kidney problems, etc. According to the report of NRC (1977), fifty studies in nine countries have established a consistent statistical association between drinking water hardness and incidence of cardiovascular problem [16].

In Thiruvarur and Nagapattinam region ground water samples have excess of hardness were compared with BIS drinking water quality guideline. So the water quality of Thiruvarur and Nagapattinam regions most of the ground water samples are not suitable for drinking purpose [5].

All metabolic and physiological activities and life process of aquatic organisms are generally influenced by such polluted waste and hence, it is essential to study physicochemical characteristics of groundwater [12].

In present study involve the determination of physicochemical parameters of ground water from Thanjavur District. The objective of the study is to assess the water quality parameters like Phosphate, pH, TDS, Ca2+, Mg2+, Fe2+, Cr6+, etc., to compare the result with BIS.

2. MATERIALS AND METHODS

2.1. Study area

Thanjavur is located at 11° 38’ N and 75° 45’ E latitude. Fig – 1 showed the location of the ground water samples collected from various parts of Thanjavur district and table – 1 are given about sampling points of Thanjavur district.
Figure-1: Ground water collected from various parts of Thanjavur region

Table-1: Sampling points of Thanjavur region.

| Sampling Point                  | Sampling Point Number |
|---------------------------------|-----------------------|
| Thirubuvanam                    | S1                    |
| Pattukkottai                    | S2                    |
| Papanasam                       | S3                    |
| Thiruvidaimaruthur              | S4                    |
| Ammapet                         | S5                    |
| Adirampattinam                  | S6                    |
| Alivalam                        | S7                    |
| Thanjavur (Near Railway Station)| S8                    |
| Thanjavur (Srinivasapuram)      | S9                    |
| Thiruvaliyaru (New Bus Stand)   | S10                   |
| Kumbakonam (Near Railway Station)| S11                   |
| Kumbakonam                      | S12                   |
2.2. Methodology

Water samples were collected in previously sterilized poly propylene plastic bottles with cap. The sampling has been carried out in month of NOV-2013. The samples in the canes (Bottle) were kept in the refrigerator. The physicochemical parameters were determined by IS analytical method. Table-2 is given about methods used for estimation of variation physicochemical parameters.

| Parameters        | Methods                        | References               |
|-------------------|--------------------------------|--------------------------|
| Temperature       | Thermometer                    | IS 3025 : 1964           |
| pH                | pH – Metric                    | IS : 3025 (Part II)      |
| Colour            | Platinum - Cobalt method       | IS : 3025 (Part 4)       |
| Taste             | Taste rating method            | IS : 3025 (Part 8)       |
| Odour             | Olfactory method               | IS : 3025 (Part 5)       |
| Turbidity         | Nephelometric method           | IS : 3025 (Part 10)      |
| Electrical Conductivity | Conduct metric               | IS 3025 : 1964           |
| Total Dissolved Solid | Gravimetric method         | IS : 3025 (Part 16)      |
| Total Alkalinity  | Titrimetric method             | IS : 3025 (Part 23)      |
| Chloride          | Argento metric method          | IS : 3025 (Part 32)      |
| Sulphate          | Turbidity method               | IS : 3025 (Part 24)      |
| Calcium           | EDTA Titrimetric method        | IS : 3025 (Part 40)      |
| Magnesium         | EDTA Titrimetric method        | IS : 3025 (Part 46)      |
| Nitrate           | Chromotropic acid method       | IS : 3025 (Part 34)      |
| Nitrite           | Spectrometric method           | IS : 3025 (Part 34)      |
| Phosphate         | Spectrometric method           | IS 3025 : 1964           |
| Fluoride          | Zirconium alizarin method      | IS 3025 : 1964           |
| Manganese         | Colour comparison method       | IS 3025 : 1964           |
| Iron              | 1, 10, Phenanthroline method   | IS : 3025 (Part 53)      |
| Aluminium         | Eriochrome Cynine R method     | IS : 3025 (Part 55)      |
| Copper            | Neocuprine method              | IS : 3025 (Part 42)      |
| Nickel            | Dimethyl Glyoxime method       | IS : 3025 (Part 54)      |
| Chromium          | Diphenyl carbazide method      | IS 3025 : 1964           |
3. RESULTS AND DISCUSSION

The various physicochemical parameters of groundwater collected from Thanjavur region and its range (concentration) are presented in table – 3 and 4 respectively.

3.1 Temperature:

The temperature of the water is an important for its effect on the chemical and biological reactions of the organisms in water. Temperature is an essential factor in the determination of other parameters like conductivity, pH, etc., the temperature of water samples was noted at collection points. Temperature of ground water samples range between 28.4°C to 29.7°C, (Table– 3).

3.2. Colour:

Colour in water may be due to the inorganic ions, such as iron, manganese, plankton, weeds and industrial wastes. The term apparent colour includes not only the colour due to substances in solution but also that due to suspended matter. An entire collected water samples had colour less (Table- 3).

3.3. Odour and Taste:

Odour is recognized as a quality factor affecting acceptability of drinking water and food prepared from it, tainting of fish and other aquatic organisms. Most organic and some inorganic chemicals contribute taste and odour. These chemicals may originate from municipal and industrial waste discharges, natural sources, such as decomposition of vegetable matter or from associated microbial activity. An entire collected water samples had odour less and agreeable taste, (Table- 3).

3.4. Turbidity:

Turbidity is the measure of relative clarity of a liquid. Clarity is important when producing drinking water for human consumption. Turbidity can provide food and shelter for pathogens. If not removed, turbidity can promote growth of pathogens in the distribution system, leading to water borne disease outbreaks. Although turbidity is not a direct indicator of health risk, numerous studies show a strong relationship between removal of turbidity and removal of protozoa. In Thanjavur region ground water samples turbidity recorded range between 0.2 NTU to 01.2 NTU (Table-3).

3.5. Electrical Conductance (EC):

Electrical conductivity is the capacity of water to convey an electric current and it is a tool to assess the purity of water. This property related to the total concentration of the ionized substances in water. The ionic strength of the water sample vitally affects the specific conductance, the conductivity of samples range between 0.50 mS/cm to 2.51 mS/cm, (Table- 3).

3.6. Total dissolved solids (TDS):

Many dissolved substances are undesirable in water. Dissolved minerals, gases and organic constituents may produce aesthetically displeasing colour, taste and odour. Some dissolved organic chemicals may deplete the dissolved oxygen in the receiving waters and some may be inert to biological oxidation, yet others have been identified as carcinogens.

Water with higher solids content often has a laxative and sometimes the reverse effect upon people whose bodies are not adjusted to them. If the TDS of drinking water is more than 2000 mg/l, it result to affect gastro intestinal irritation for human beings. Total dissolved solids of Thanjavur region ground water range between 230 mg/l to 1106 mg/l (Table- 3), (Fig- 2).

3.7. Hydrogen ion concentration (pH value):

The pH value is the logarithm of reciprocal of hydrogen ion activity in moles per liter. Dissolved gases such as carbon di oxide, hydrogen sulphide and ammonia also affect the pH of water. Overall pH range of natural water is generally in between 6.5 to 8.5. Industrial wastes may be strongly acidic or basic and their effect on pH value of receiving water depends on the buffering capacity of water. The pH lower than 4 will produce sour taste and higher value above 8.5 bitter taste.
Higher value of pH, hasten the scale formation in water heating apparatus and reduce the germicidal potential of chlorine. The pH below 6.5 starts corrosion in pipes, thereby releasing toxic metals such as Zn, Pb, Cd, Cu etc. The pH of Thanjavur region ground water range from 6.52 to 8.18. The ground water samples had lying within BIS limit (6.5 to 8.5). The pH variations of samples are given in table number - 4, fig - 3.

3.8. Total alkalinity (TA):
Alkalinity of water is its quantitative capacity to react with a strong acid to a designated pH. Highly alkaline waters are usually unpalatable. Excess alkalinity in water is harmful for irrigation which leads to soil damage and reduce crop yields. The total alkalinity of ground water from Thanjavur region range between 45.11 mg/l to 235.39 mg/l, (Table- 4), (Fig- 4). Total alkalinity of ground water samples number S3 and S4 is high compare than BIS drinking water quality guideline. An excess of total alkalinity is boiling rice turn yellowish.

3.9. Calcium (Ca$^{2+}$)
Calcium is a mineral; it’s an essential part of bones and teeth. The heart, nerves, and blood-clotting systems also need calcium to work but higher amount of calcium causes harmful effects on the health. The calcium hardness was recorded 25.64 mg/l to 164 mg/l in ground water of Thanjavur district. The calcium variations of samples are given in table number - 4, fig - 5. Ground water samples number S2, S3, S4 and S9 have high concentration of calcium ion compare than BIS drinking water quality guideline. Calcium salts are nontoxic except at very high doses. In human body Hypercalcimia cause coma and death, if serum calcium level rises to 160 mg/100 ml.

3.10. Magnesium (Mg$^{2+}$)
Magnesium is a common constituent in natural water. Magnesium salts are important contributors to the hardness of water which break down when heated, forming scale in boilers. The magnesium concentration may vary from zero to several hundred milligrams. Magnesium hardness of ground water samples in Thanjavur region was recorded 14.09 mg/l to 103.90 mg/l. The magnesium variations of the studied area are shown in fig - 6 and its data are given about table number – 4. The magnesium content of samples number S2, S3, S4, S5, S6, S7 and S9 from Thanjavur region is above the BIS drinking water quality guideline (30 mg/l). Excess of magnesium ions (above 400 mg/l) in water causes nausea and muscular weakness.

3.11. Chlorides (Cl$^-$)
Chloride is one of the major inorganic anion in water. Discharge of domestic sewage is main source of chloride in water. In potable water, the salty taste is produced by the chloride concentrations is variable and dependent on the chemical composition. There is no known evidence that chlorides constitute any human health hazard. For this reason, chlorides are generally limited to 200 mg/l in supplies intended for public use. The chloride content estimated in the samples ranged between 14.99 mg/l to 339.89 mg/l. The chloride variations of the ground water samples are given in table- 4, and fig- 7. The ground water samples number S2, S3, S4 and S6 from Thanjavur district have high concentration of chloride compare than BIS limits. High concentration of chloride ion is irritating an eye to human beings.

3.12. Nitrate (NO$_3^-$)
This is the highest oxidized form of nitrogen. Nitrates are contributed to freshwater through discharge of sewage and industrial wastes and run off from agricultural fields. The amount of nitrate recorded in the water of Thanjavur region ranges between 0.61 mg/l to 14.60 mg/l.
An entire water samples had nitrate content lying within BIS limit. The nitrate variation of ground water samples are given in table- 4, and fig- 8. Nitrate can be toxic to certain aquatic organisms even at concentration of 1 mg/l. In excessive limits, if nitrate of drinking water is more than 100 mg/l is cause blue baby disease.
3.13. Nitrite (NO$_2^-$)
Nitrite in water is due to incomplete oxidation of organic matter containing nitrogen. Nitrites should never be present in drinking water. Nitrite of the water samples was found to range from 0.0002 mg/l to 0.0048 mg/l. The nitrite content of ground water was found to within BIS desirable limit, (Table- 4), (Fig- 9).

3.14. Sulphate (SO$_4^{2-}$)
Sulphate occurs naturally in all kinds of water. Drainage wastes are the main source of high sulphate concentration. The major physiological effects resulting from the ingestion of large quantities of sulfate are dehydration, and gastrointestinal irritation. Water containing magnesium sulfate at levels above 600 mg/l acts as a purgative in humans.

The ground water samples had sulphate level ranging between 1.04 mg/l to 14.49 mg/l. Entire water samples sulphate content had lying within BIS limits. The sulphate variations of samples are given in table number - 4, fig - 10. If excess of sulphate in drinking water is affect the taste.

3.15. Phosphate (PO$_4^{3-}$)
Naturally phosphate occurs in ground water as inorganic or organic phosphates. Domestic sewage, agricultural effluents and detergent are the main source of phosphate in water. If an excess phosphate may lead to growth of unwanted algae. The collected ground water samples had phosphate content ranging from 0.16 mg/l to 0.94 mg/l. The data are given in table- 4, and fig- 11.

3.16. Fluoride (F$^-$):
Industrial waste is the main source of fluoride. The fluoride content was recorded 0.1 mg/l to 0.4 mg/l. The values are given in table number- 4, and figure- 12. High fluoride levels in drinking water has become a critical health hazard of this century as it induces intense impact on human health including skeletal and dental fluorosis.

3.17. Aluminium (Al$^{3+}$):
Aluminium content was recorded 0.0029 mg/l to 0.0098 mg/l. Entire samples had aluminium content lying within BIS desirable limit, (Table- 4), (Fig- 13). If above 0.2 mg/l of aluminium concentration in drinking water is cause neurological disorders to human beings.

3.18. Iron (Fe$^{3+}$)
Iron usually exists in ferrous and ferric form at concentrations up to several milligrams per liter without discoloration or turbidity in the water when directly pumped from a bore well. Taste is not usually noticeable at iron concentrations below 0.3 mg/l, although turbidity and colour may develop in piped systems at levels above 0.05 to 0.1 mg/l. Iron is an essential element in human nutrition. Estimates of the minimum daily requirement for iron depend on age, physiological status, and iron bio-availability and range from about 10 to 50 mg/day. Long time consumption of drinking water with a high concentration of iron can lead to liver diseases.

Iron also promotes the growth of iron-bacteria. This gives a rusty appearance to the waters. Colonies of these bacteria may also form a slime which causes problems in water closets, pipes, pumps and distribution system. High concentration of iron in water is not suitable for processing of food, ice, dyeing, bleaching and many other items.

Water with high concentration of the iron when used in preparation of tea and coffee, interacts with tanning giving a black inky appearance with a metallic taste. In Thanjavur region ground water samples had iron level ranging between 0.52 mg/l to 1.15 mg/l, (Table- 4), (Fig- 14). Entire samples had iron content lying above the permissible limit.
3.19. Copper (Cu\(^{2+}\))

Copper is found mainly as a sulphide, oxide, or carbonate in the minerals. Copper enters the water system through mineral dissolution, industrial effluents, and corrosion of copper alloy water distribution pipes. It may occur in simple ionic form or in one of many complexes with groups, such as cyanides, chlorides, ammonia or organic ligands.

The tests for copper is essential because of dissolved copper salts even in low concentrations are poisonous to some biota. The copper content of ground water samples from Thanjavur region range between 0.003 mg/l to 0.023 mg/l (Table-4), (Fig-15). The collected water samples lying within BIS desirable limit (0.05 mg/l).

3.20. Manganese (Mn\(^{2+}\))

In general, intake of manganese can be high as 20 mg/day without apparent ill effects. It should be noted that manganese may be objectionable to consumers if it is deposited in water mains and causes water discoloration. Although concentrations below 0.1 mg/liter are usually acceptable to consumers, this may vary with local circumstances. In Thanjavur region entire collected samples had manganese content lying well below the detection limit, (Table-4).

3.21. Nickel (Ni\(^{2+}\))

Nickel is less toxic element and it is contributed through sewage and metal plating water when discharged into water courses. The nickel concentration of ground water samples from Thanjavur region range from 0.009 mg/l to 0.30 mg/l. The values of nickel ion are given in table number-4, and fig-16.

3.22. Chromium (Cr\(^{6+}\))

Chromium is one of the toxic elements. High content of chromium is attributed through septic systems, and industrial effluents. If excess of chromium content is affect the skin and damage the nervous system. Chromium content of ground water samples range from 0.006 mg/l to 0.01 mg/l (Table-4).
Figure - 2: Total Dissolved Solids Variation of the Study area.

Figure - 3: pH Variation of the Study area.

Figure - 4: Total Alkalinity Variation of the Study area.

Figure - 5: Calcium Variation of the Study area.

Figure - 6: Magnesium Variation of the Study area.

Figure - 7: Chloride Variation of the Study area.
Figure - 8: Nitrate Variation of the Study area.

Figure - 9: Nitrite Variation of the Study area.

Figure - 10: Sulphate Variation of the Study area.

Figure - 11: Phosphate Variation of the Study area.

Figure - 12: Fluoride Variation of the Study area.

Figure - 13: Aluminium Variation of the Study area.
Figure - 14: Iron Variation of the Study area.

Figure - 15: Copper Variation of the Study area.

Figure - 16: Nickel Variation of the Study area.
| Parameters       | S1  | S2  | S3  | S4  | S5  | S6  | S7  | S8  | S9  | S10 | S11 | S12 | BIS Desirable Limit |
|------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|---------------------|
| Temperature (°C) | 29.7| 29.4| 29.1| 29.6| 28.9| 28.4| 29.5| 29.5| 28.7| 29.5| 29.2| 29.7 | -                   |
| Colour           | 1 HU| 1 HU| 1 HU| 1 HU| 1 HU| 1 HU| 1 HU| 1 HU| 1 HU| 1 HU| 1 HU| 1 HU | 2 HU |
| Odour            | Odour less | Odour less | Odour less | Odour less | Odour less | Odour less | Odour less | Odour less | Odour less | Odour less | Odour less | Agreeable |
| Taste            | Agreeable | Agreeable | Agreeable | Agreeable | Agreeable | Agreeable | Agreeable | Agreeable | Agreeable | Agreeable | Agreeable | Agreeable | Agreeable |
| Turbidity        | 0.3 | 1.2 | 1   | 0.9 | 0.7 | 0.6 | 0.4 | 0.2 | 0.4 | 0.3 | 0.2 | 0.2 | 2 NTU |
| Electrical Conductance (mS/cm) | 0.60 | 2.2 | 2.1 | 1.88 | 1.45 | 1.43 | 0.98 | 0.55 | 1.26 | 0.65 | 0.50 | 0.52 | - |
| Total Dissolved Solids (mg/l) | 278 | 1106 | 1071 | 879 | 701 | 681 | 440 | 251 | 566 | 292 | 230 | 237 | 500 mg/l |
In the present study, it concluded that the quality of water in Thanjavur region is good for the utilization in agricultural, industrial, and domestic purposes. However, few water samples were found 'unsuitable' for drinking purpose, due to the presence of excess hardness (Ca\(^{2+}\), Mg\(^{2+}\)), total alkalinity and total dissolved solids. If the same continue in future, the ground water source will be found unsuitable for drinking purpose.

| Parameters | S1     | S2     | S3     | S4     | S5     | S6     | S7     | S8     | S9     | S10    | S11    | S12    | BIS Desirable Limits |
|------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|----------------------|
| pH         | 7.08   | 7.29   | 7.25   | 6.84   | 6.96   | 7.20   | 7.22   | 6.52   | 6.98   | 7.19   | 8.18   | 7.38   | 6.5-8.5               |
| Total Alkalinity (TA) | 72.33  | 107.88 | 235.39 | 228.03 | 170.65 | 180.46 | 125.54 | 45.11  | 147.12 | 113.77 | 102   | 92.19  | 200 mg/l             |
| Calcium (Ca\(^{2+}\)) | 36.87  | 120.23 | 164.31 | 92.17  | 69.73  | 49.69  | 48.89  | 32.06  | 75.34  | 35.26  | 26.45  | 25.64  | 75 mg/l             |
| Magnesium (Mg\(^{2+}\)) | 14.09  | 85.06  | 103.90 | 68.05  | 43.26  | 41.31  | 42.77  | 8.26   | 40.83  | 19.44  | 15.55  | 18.23  | 30 mg/l             |
| Chloride (Cl\(^{-}\)) | 64.97  | 339.89 | 229.92 | 239.92 | 129.95 | 199.93 | 59.98  | 34.98  | 49.98  | 24.99  | 34.98  | 14.99  | 200 mg/l            |
| Nitrate (NO\(_3^-\)) | 1.35   | 14.60  | 0.94   | 1.56   | 1.32   | 3.83   | 3.35   | 5.87   | 6.02   | 0.61   | 0.96   | 1.80   | 45 mg/l             |
| Nitrite (NO\(_2^-\)) | 0.0048 | 0.0015 | 0.0002 | 0.0006 | 0.0006 | 0.0031 | 0.0011 | 0.0006 | 0.0008 | 0.0008 | 0.0004 | 0.0008 | 0.02 mg/l          |
| Sulphate (SO\(_4^{2-}\)) | 5.62   | 1.35   | 1.04   | 14.49  | 1.77   | 1.35   | 6.77   | 5.41   | 9.06   | 6.66   | 4.89   | 5.72   | 200 mg/l            |
| Phosphate (PO\(_4^{3-}\)) | 0.22   | 0.34   | 0.39   | 0.66   | 0.16   | 0.94   | 0.22   | 0.33   | 0.45   | 0.4    | 0.27   | 0.22   | 0.2 mg/l           |
| Fluoride (F\(^-\)) | 0.25   | 0.3    | 0.2    | 0.3    | 0.2    | 0.1    | 0.4    | 0.15   | 0.2    | 0.1    | 0.15   | 0.1    | 1 mg/l              |
| Aluminium (Al\(^{3+}\)) | 0.0098 | 0.0088 | 0.0049 | 0.0059 | 0.0039 | 0.0069 | 0.0059 | 0.0029 | 0.0070 | 0.0029 | 0.0029 | 0.005 | 0.03 mg/l           |
| Iron (Fe\(^{3+}\)) | 0.57   | 0.55   | 1.15   | 0.52   | 1.07   | 0.57   | 0.63   | 0.72   | 0.76   | 0.50   | 0.53   | 0.56   | 0.1 mg/l          |
| Copper (Cu\(^{2+}\)) | 0.013  | 0.011  | 0.006  | 0.005  | 0.01   | 0.01   | 0.023  | 0.015  | 0.003  | 0.001  | 0.003  | 0.013  | 0.05 mg/l         |
| Nickel     | 0.009  | 0.067  | 0.019  | 0.05   | 0.30   | 0.15   | 0.029  | 0.21   | 0.27   | 0.04   | 0.19   | 0.01   | 0.02 mg/l        |
| Manganese (Mn\(^{2+}\)) | BDL    | BDL    | BDL    | BDL    | BDL    | BDL    | BDL    | BDL    | BDL    | BDL    | BDL    | BDL    | 0.1 mg/l        |
| Chromium (Cr\(^{6+}\)) | BDL    | BDL    | BDL    | BDL    | BDL    | 0.006  | 0.01   | BDL    | BDL    | BDL    | BDL    | 0.006  | 0.005 mg/l      |
completely polluted and becomes unfit for drinking and other purpose. This study given a knowledge and awareness created among the people.

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