

Groundwater Quality in Thiruvaiyaru Block, Thanjavur District

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Thiruvaiyaru block is one of the iron affected areas in Tamil Nadu. Iron content in the groundwaters of this block records in the range 1 to 4 mg/L. Sedimentary formation contributes iron to the groundwater. The relationship between total dissolved salts and other parameters have been developed. The various field oriented iron removal methods have been discussed for the water quality management.

PRELUDE

Water found in nature is never H_2O alone. Instead, it exhibits as $H_2O + X$ and X stands for the measurable and controllable chemical parameters. Groundwater is the main sources of drinking water supply schemes in most of the villages of Tamil Nadu and also in the most part of India. However, in some parts of our country, dissolved iron in groundwater makes it difficult to be used for domestic and industrial water supply. Excessive iron in groundwater is a well-known problem at global level. In Tamil Nadu, about 1189 habitations have been identified as no safe source habitations in lieu of presence of excessive iron in the drinking water sources. Commonly, iron shows its presence in the form of bivalent, ferrous iron (Fe^{2+}) and trivalent ferric iron (Fe^{3+}). The ferric iron exhibits in insoluble, precipitate form. The ferrous state is soluble in water and invites scientific interventions. Iron forms complexes of hydroxides and other inorganic complexes in solution with substantial amount of bicarbonate, sulphate and phosphate. Pyrites (FeS_2), oxides (Fe_3O_4) and carbonates (Fe_2CO_3) are some of the identities of iron. Rainwater leaches the iron from the earth crust and keeps either in colloidal or dissolved state in groundwater (Damodara Rao and Sastry, 1986; Kelkar, 1999).

Detrimental effect

The water containing excessive iron (more than 0.30 mg/L) content appears blackish or turbid in higher ranges. The precipitates settle at the bottom of container. The taste of such

water becomes metallic taste. Clothes get stained. High iron bearing water when comes in contact with leaf tea renders blue colour due to reaction with tannin. The adverse effects on dyeing, paper and film industries are well known. The excessive iron precipitates and deposits in pipelines and storage tanks causing trouble in water works. Recent researches report that excessive ingestion of iron may lead to heart problems. Iron bacteria become active in such environments. These are rendering dirty odour in anaerobic conditions. The stains produced are yellowish to reddish brown and are very difficult to be removed. The water is not suitable for washing of clothes, since they can become stained and spotted. Even traces of iron in domestic water supply cause deposition in the distribution pipes and reservoirs slowly over a period of time. Due to change in velocity or pressure in water mains these deposits are likely to be flushed out to consumers alongwith the water supplied which may give rise to complaints of taste, colouration and turbidity. Bacteria form sticky masses and reduce the carrying capacity of the pipes and may even clog (small size) valves, nozzles and meters.

Description of the study area

Thiruvaiyaru block is located in the northeastern part of Thanjavur district in between east longitude $78^{\circ}57'00'' - 79^{\circ}09'30''$ and north latitude : $10^{\circ}47'30'' - 10^{\circ}56'10''$ with an area extent of 161.36 km. River, Vennar, flows from west to east along the southern border of the block. Kodamurutti river and Cauvery river flows from

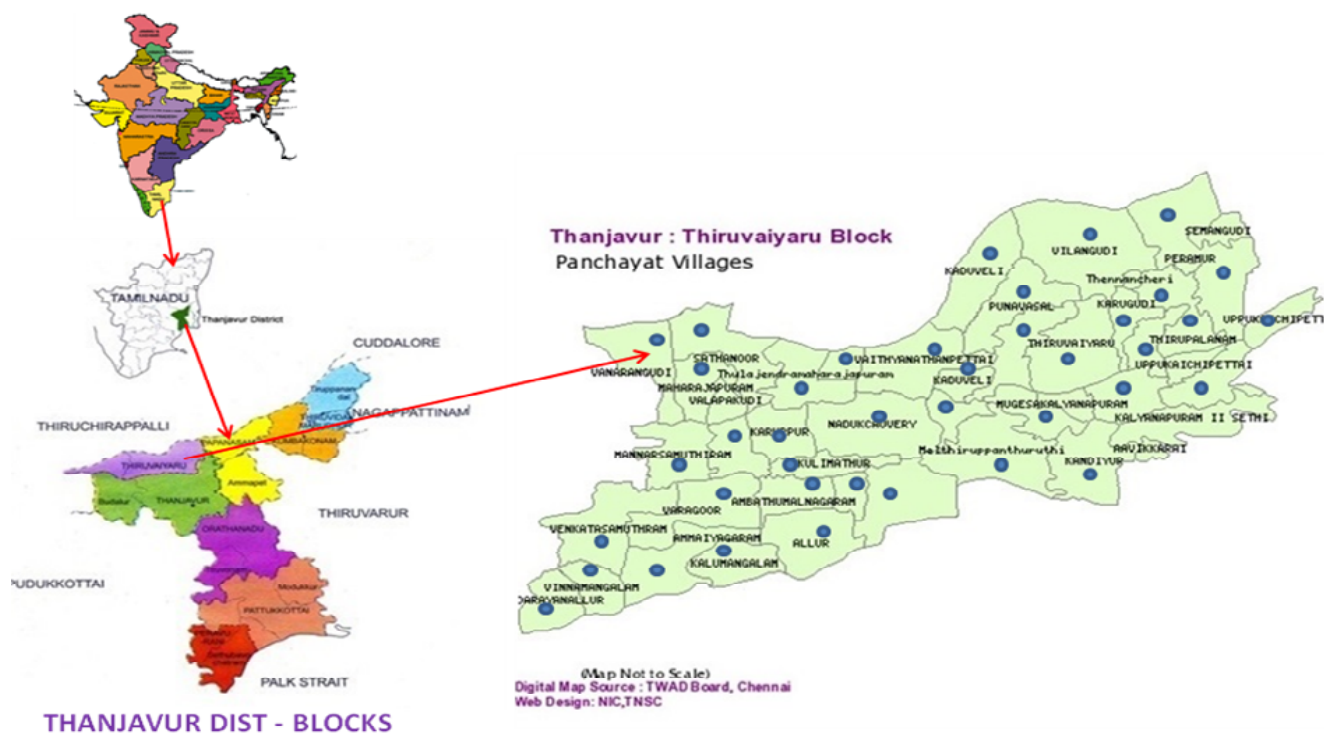


Figure 1. Location map of the study area

west to east at the central part . River Coleroon flows from west to east along the northern boundary of the block. Climate prevailing is arid to semi arid. Rainfall is occasional and is received through south-west during June to September and north-east monsoons during October and November. Major portion falls in the later case. Quaternary formations consisting of fluvial and fluviomarine deposits occupy the entire block area. There is a wide variation in the proportions of sands, clays and silts both laterally and depthwise. The hydrological soil group 'A' with high infiltration and low runoff potential covers about 42% area of the block. The soil group 'B' with moderate infiltration and moderate runoff potential occurs in 32% area. The soil group 'C' with low infiltration rate and moderate runoff potential covers about 22% area. Soil group 'D' with very slow infiltration and high runoff potential covers the remaining 4% area (Figure 1).

MATERIAL AND METHOD

Groundwater quality

Water samples were collected from the 10 se-

lected bore wells scattered over the entire Thiruvaiyaru block during summer and winter seasons during the year 2014 and the same were analysed for physico-chemical characteristics in TWAD Board laboratory as per standard methods.

RESULT AND DISCUSSION

Static groundwater level

The groundwater table observation in the Thiruvaiyaru block indicates that it is fluctuating from 3.70 m to a maximum of 8.50 m below ground level. It is noted that the groundwater table fluctuation from winter to summer is in the order of 2 to 4 m (Figures 2 and 3). Thiruvaiyaru block falls within the command area of Cauvery river ayacut. Canal irrigation from June to January contributes groundwater recharge besides recharge through rainfall during monsoon. This may be the reason for the shallow water table than the other part of Tamil Nadu.

Physical and chemical characteristics

The physical and chemical characteristics of sum-

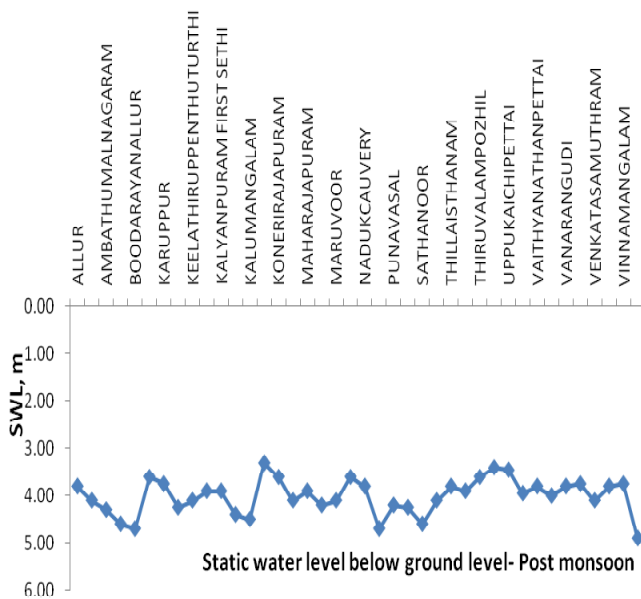


Figure 2. Post monsoon static groundwater level

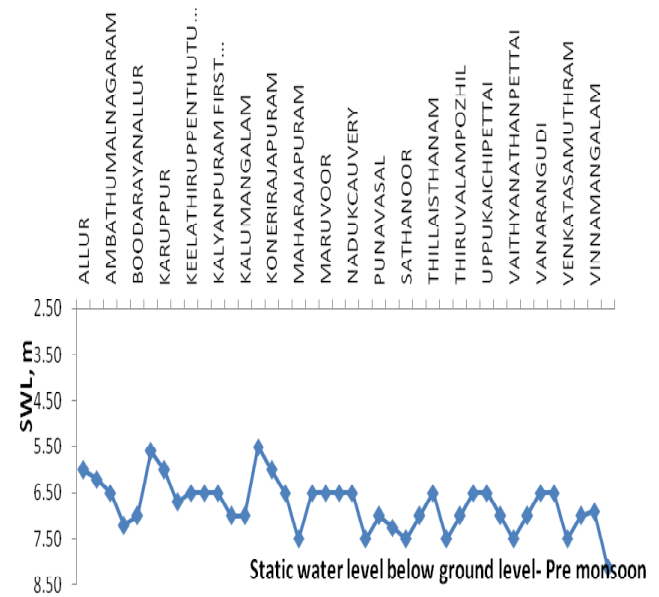


Figure 3. Pre- monsoon static groundwater level

mer and winter water samples show all the parameters are within the allowable limit as per CPHEEO standards for drinking purpose except iron (Table 1). It is inferred from the table 1 that the total dissolved solids is less than 500 mg/L in 12 sources and is in the order of 518 to 560 in 2 sources. At Karuppur the total dissolved solids is 1022 mg/L. The pH value is observed to be above 7.2 with a maximum of 8.3. It indicates that the water is alkaline in nature. As the total dissolved salts (TDS) is an index of water quality, all the parameters are having a similar pattern as

total dissolved salts has. The summer water quality results shows, the little rise in total dissolved salts concentration in some of the bore wells, In the case of Karuppur the total dissolved salts has come down to 805 mg/L from 1022 mg/L. The pH value does not fluctuate much but it has come down in the order of 0.1 to 0.5 out of 15 sources. 10 sources are having excess iron concentration in both the seasons. In total, 66 percentage of sources are affected by excess iron concentration. The relationship between total dissolved salts and alkalinity is shown in figures 4, 5 and 6 ex-

Table 1. Minimum, maximum, range mean of water quality parameter, in mg/L

Parameter	Winter				Summer				CPHEEO standards (maximum)
	Mini- mum	Max.	Range	Mean	Mini- mum	Max.	Range	Mean	
TDS	203	1022	816	402	224	833	609	463	2000
pH	7.2	8.3	1.1	7.9	7.2	8.9	1.7	7.7	< 6.5 and > 9.2
Total hardness	118	464	346	197	120	404	284	226	600
Calcium	22	54	32	38	34	112	78	58	200
Magnesium	8.0	88	80	25	8.0	36	28	19	150
Iron	0.2	3.9	3.7	1.4	0.1	3.1	3.0	1.26	0.3
Chloride	18	262	244	58	22	190	168	64	1000
Fluoride	0.1	1.0	0.9	0.20	0.1	1.0	0.9	0.3	1.5
Alkalinity	nt	nt	-	-	140	368	228	238	-

nt-Not tested

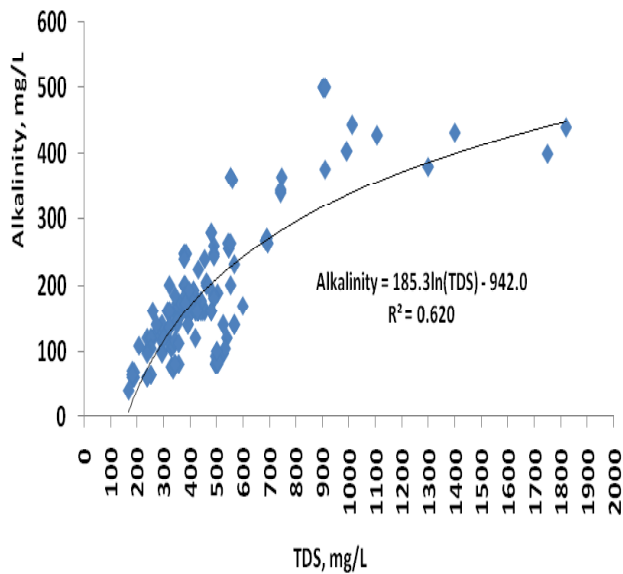


Figure 4. Total dissolved salts vs alkalinity in the groundwaters of Thiruvaiyaru block

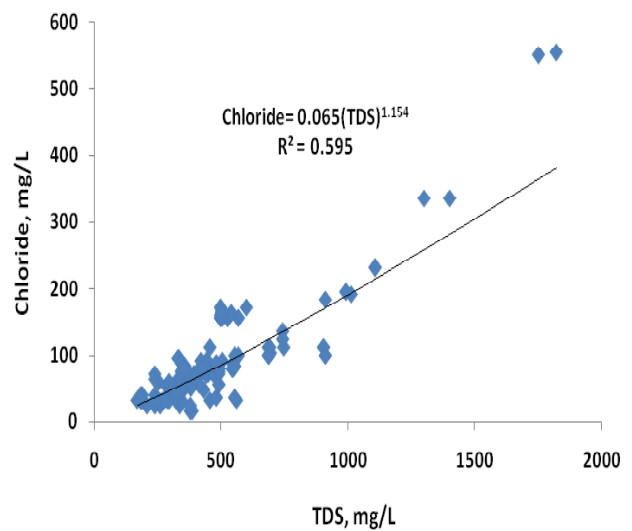


Figure 6. Total dissolved salts vs chloride content in the groundwaters of Thiruvaiyaru block

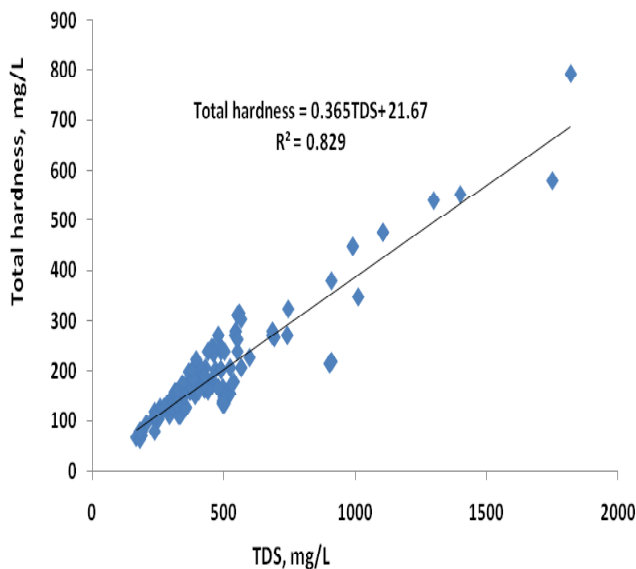


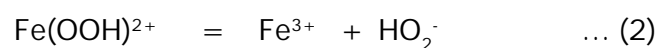
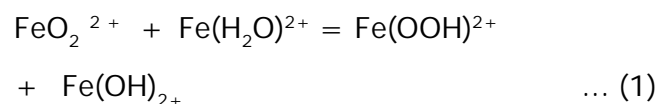
Figure 5. Total dissolved salts vs total hardness in the groundwaters of Thiruvaiyaru block

hibit the equation with the correlation coefficient value between total dissolved salts and total hardness and total dissolved salts and chloride, respectively.

Iron removal method

The methods of removal of dissolved iron from groundwater can be grouped under the following 4 headings: (1) Aeration / gas transfer, (2) absorption, (3) ion exchange and (4) electro chemi-

cal. By aeration, dissolved ferrous iron is oxidized to insoluble, ferric precipitate. Aeration followed by sedimentation and filtration accomplishes the removal of iron. Gravity aeration, spray, air blowing and mechanical aeration are the common ways adopted in the aeration process. The oxidation of the Fe^{2+} state to Fe^{3+} is accomplished by molecular oxygen is reported to involve the initial formation of FeO_2^{2+} which then reacts in the following manner:



Normally, when iron in ferrous (Fe^{2+}) form is in dissolved state, on oxidation it becomes ferric (Fe^{3+}) and then gets precipitated in the form of ferric oxide. This process goes well in the pH range, 6.7 to 8.4. In the acidic range, the process retards. Four types of hand-pump attached iron removal plants have been tried and reported so far. They are : (1) DANIDA (Maharashtra State), (2) WHO, (3) BASTAR and (4) IRP (upflow type) Raised platform, gravity aeration arrangement, filter media, sludge removal component form the common system in all the said 4 methods. DANIDA and IRP (upflow) type, function as upflow and rest use gravity down flow principle. Each

type has its own merits and demerits. Bastar type has the provision of a detention chamber for pre aeration and sedimentation besides arrangements for lime addition to raise pH. All the above methods were constructed in different villages and put into use. The material of construction was brick masonry in cement mortar. Pre fabricated ferro cement plants were also installed under DANIDA programme. DANIDA type has higher size filter media and flow is upwards. It deserves the advantage of less chocking and easy backwash. However, efficiency is low. In WHO type, the media is like slow sand filter. Efficiency is high. It requires frequent cleaning. Backwash is not possible and maintenance cost is also high. In case of Bastar type, the maintenance needed solicits skilled personnel. Applicable where water is blackish or turbid and has low pH. It needs addition of lime for enhancing sedimentation. Close supervision is essential for effective operation and maintenance.

Lepidocrocite and pyrolusite have been studied for the characteristics of absorption of Fe^{2+} ion. Lepidocrocite ($O = Fe-OH$) is a ferric oxyhydroxide. The findings confirm that lepidocrocite and pyrolusite are both effective for the removal of dissolved iron including its complexed and organic forms. The pyrolusite, however, is reported to be more advantageous in cases where the contaminated waters have low alkalinities. Both of these materials are hygienically safe besides being economical. Costwise ion exchange methods are costlier and it further requires high recurring cost for O and M. Removal of iron by the principle of electro-coagulation, flocculation has also been studied at laboratory (Sihorwala and Sharad, 1995; Richard *et al.*, 2001; Klueh and Robinson, 1988). A combination of aluminum and graphite electrodes is employed for the electrolysis process. The field test is not yet performed. Removal of dissolved iron from ground water using bio-filtration technique has also been reported (Srinivasa Rao and Sree Rekha, 2004). As it is evident from the literature, aeration followed by sedimentation and filtration will be the cost effective and simple method. And it involves no handling of any chemicals and invites less care. Hence, an attempt has been made to study the groundwater quality in Thiruvaiyaru block and to develop an improved method of iron removal plant for

handpump scheme.

CONCLUSION

The following conclusions are derived from this study:

1. Thiruvaiyaru block in Thanjavur district of Tamil Nadu is having excess iron concentration in the existing water supply sources. The water level during summer is deeper than in winter. The iron concentration is varying from place to place depends upon the depth of bore wells.
2. Iron concentration in this block is observed in the order of 1 – 4 mg/L. The iron concentration falls down alongwith water table.
3. Source of iron in this area is due to quaternary formations consisting of fluvial and fluviomarine deposits in the top layers of earth crust. There is no anthropogenic pollution.
4. Aeration and filtration will help to remove the excessive iron.
5. As the iron concentrations in the ground waters of study area dip down with the falling water table, the iron bearing top sedimentary layers may be sealed while constructing bore wells.

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