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Original Research Paper

Groundwater Quality Evaluation in Salem District, Tamil Nadu, Based on Water Quality Index

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ABSTRACT

Groundwater is considered a vital natural resource due to its significant use for drinking, irrigation and industrial purposes. Groundwater has been a big variant in quality and quantity with respect to time and space. So the quality of groundwater has been assessed in Salem district. A detailed study was made in the study area for the quality of groundwater for drinking in premonsoon and postmonsoon based on the Water Quality Index (WQI). Groundwater samples were collected in sixty six locations in both premonsoon and postmonsoon in the year 2007. Various physicochemical tests were carried out and WQI was calculated based on pH, turbidity, total dissolved solids, total alkalinity, total hardness, nitrate, chloride, calcium, magnesium, iron and fluoride. The comparison between the premonsoon and postmonsoon reveals that in premonsoon season 56.06 %, and in postmonsoon 65.15 % of the water samples were fit for drinking. The groundwater quality was found to be unfit for drinking in 22.72% of the samples in premonsoon and 18.18% of the samples in postmonsoon.

INTRODUCTION

Groundwater is one of the most important natural resources required for human consumption, domestic purposes, irrigation, industrialization, urbanization, etc. (Rokade et al. 2004). Overexploitation and unabated pollution of this vital resource is threatening our ecosystems and even the life of the future generation (Madhan Jha et al. 2007). Groundwater is available in various permeable geologic formation called aquifers which can store and transmit water. Groundwater is not available in the same quality and quantity everywhere. It varies depending upon the geological, geomorphological, type of soil and the amount of water mined. The increase in population, industrialization and the pressure for development in agriculture has led to the overexploitation and pollution of groundwater in most of the places.

India receives annual precipitation of about 4000 km^3 including snowfall. Out of this monsoon rainfall was of the order of 3000 km^3. Rainfall in India depends on southwest and northeast monsoons. As per the international norms, if per capita availability is less than 1700m^3 per year then the country is categorized as water stressed and if it is less than 1000 m^3 per capita per year it is categorized as water scarce. In India per capita surface water availability in the year 1991 and 2001 was 2309m^3 and 1902m^3 and these are projected to be reduced to 1401m^3 and 1191m^3 by the years 2025 and 2050 respectively. Hence, there is a need for proper planning, development and management of the greatest assets of the country like water (Rakesh Kumar et al. 2005).

Salem district is one of the fast developing districts in the State of Tamil Nadu. It has its importance due to the availability of mineral deposits like magnesite, bauxite, limestone, etc. Rate of urbanization is also high and intensive agriculture is also carried out in this district. These amounts to high demand for quality water in this district. So an attempt has been made to assess the quality of groundwater in this district.

Quality of groundwater cannot be assessed by a single parameter. So it is usually assessed by Water Quality Index (WQI). Water quality index relates a group of water quality parameters to a common scale and combines them into a single number in accordance with a chosen method of computation (Chaturvedi et al. 2008). WQI implies that the water under consideration is fit for human consumption if its WQI is less than 100 and is unfit for drinking without treatment if its WQI is greater than or equal to 100 (Shankar & Balasubramanya 2008). Water quality index is a very useful tool for communicating the information on overall quality of water (Pradhan et al. 2001). So in the present study WQI was used to assess the quality of groundwater in Salem district.

STUDY AREA

Salem district lies in the western part of Tamil Nadu, located between 11°15'-12°00' north latitudes and 77°35'-78°50' east longitudes. The total geographical area is about

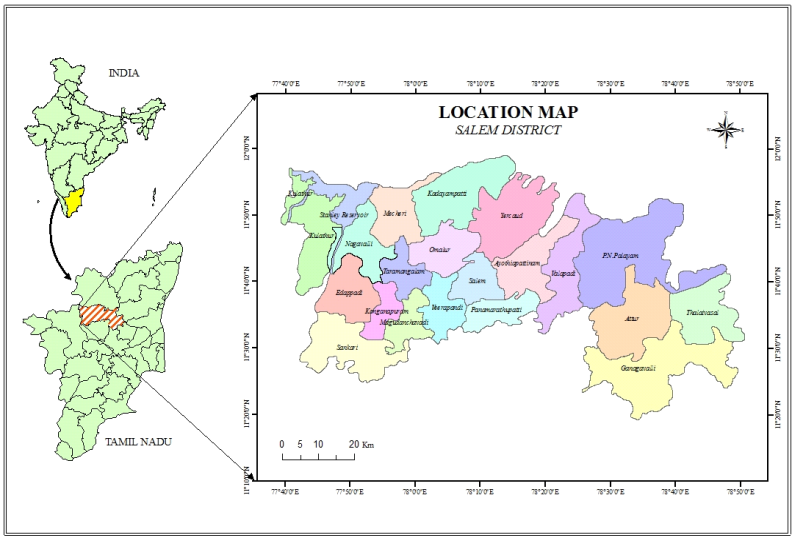

Fig. 1: Location map and administrative blocks of the study area.

5207 sq.km out of which the Stanley reservoir covers an area of about 164.5 sq.km. The study area is bounded by the districts Dharmapuri in the north, Namakkal in the south, Erode in the west and South Arcot in the east.

The district has a maximum and minimum temperature of 40°C and 13°C. The rivers Cauvery, Vashista Nadhi, Swedha Nadhi, Sarabhanga Nadhi and Thirumanimuthar flow in the district. The topography of this district is hilly terrain with undulating plain terrain. The western, central and southern parts of the district is covered by undulated plains, and eastern and northern parts with hills. Important hills in the district are Shevaroys, Kalrayan, Pachamalai, Palamalai and Chitteri hills. The highest peak of this district is Solaikarudu in Shevaroys hills. The mean sea level of this place is 1649m.

The climatic condition of this district has been sub-tropical with a moderate humidity and temperature. The district experiences hot climate from March to June but it would be pleasant from November to February. The district receives rainfall from both northeast and southwest monsoon. The maximum rainfall was received from northeast monsoon (October-December). The average annual rainfall of the district is 979.65mm.

MATERIALS AND METHODS

The quality of groundwater in the study area was assessed by collecting groundwater samples from 66 locations. The sampling locations were designated starting from P1 to P66 which is shown in Figs. 1 and 2.

The sample numbers and their corresponding village names are given in Table 1. Water samples were collected during the month of January 2007 (postmonsoon) and May 2007 (premonsoon) in cleaned polythene bottles by grab sampling method (samples collected at a particular time and place). The samples were collected and tested by the procedures prescribed in IS 3025-1983 which is for methods of sampling and testing (physical and chemical) for water and wastewater. A statistical summary indicating minimum, maximum, mean and standard deviation of the geochemical parameters in the premonsoon and postmonsoon was also made.

Suitability of the groundwater samples for drinking in both the seasons was interpreted based on the water quality index for drinking water. WQI was calculated based on pH, turbidity, total dissolved solids, total alkalinity, total hardness, nitrate, chloride, calcium, magnesium, iron and fluoride

Determination of Water Quality Index (WQI): Water Quality Index was calculated by the below mentioned procedure.

***Step 1*:** The unit weight (w_n) was calculated as given below:

$$w_n = \frac{K}{S_n}$$

Where, K - Constant of proportionality

S_n - Standard value of the n^{th} parameter

***Step 2*:** The quality rating (q_n) was calculated by the following formula:

$$q_n = \frac{V_n - V_{id}}{S_n - V_{id}}$$

Where, V_n - Observed value of the n^{th} parameter; V_{id} - Ideal

Table 1: Details of the sampling locations.

No.	Sample Location	No.	Sample Location	No.	Sample Location
P1	Chitirapattypudur	P23	Redimaniyakaranur	P45	Kuppanur
P2	Mulakkadu	P24	Ariyanur	P46	Poovanur
P3	Kovilpalayam	P25	Veerapandi	P47	Aramanur
P4	Kunjandiyur	P26	Vembadithalam	P48	Nadupatti
P5	Potaneri	P27	Arisipalayam.	P49	Vellalapatti
P6	Veerakkal	P28	Seelanaickenpatty	P50	Aayilpatty
P7	Nangavalli	P29	Kattukottaipudur	P51	Valapady
P8	Kattuvalavu	P30	Gajalnaickenpatty	P52	Ethappur
P9	Erangnapattypudur	P31	Hasthampatty	P53	Pedhanaickenpalayam
P10	Kudiraikaranur	P32	Edappady	P54	Ramanathapuram
P11	Kailasanathar Temple	P33	Konganapuram	P55	Karutharasapalayam
P12	Kovilvellar	P34	Vaigundam	P56	Thandavarayapuram
P13	Jodukuli	P35	Talaiyur	P57	Attur town
P14	Thevatipatty	P36	Magudanchavadi	P58	Manjini
P15	Thoppur	P37	Attaiyampatty	P59	Sadasivapuram
P16	Kadayampatty	P38	Kakapalayam	P60	Gangavalli
P17	Danishpet	P39	Kalarampatty	P61	Anayampatti
P18	Poosaripatty	P40	Gorimedu	P62	Rayarpalayam
P19	Kuppur	P41	Kuralnattam	P63	Illupalanatham
P20	Uthamacholapuram	P42	Panamarathupatty	P64	Thalaivasal
P21	Omalur	P43	Mallur	P65	Deviakurichi
P22	Karukalvadi	P44	Achankutapatty	P66	Morur

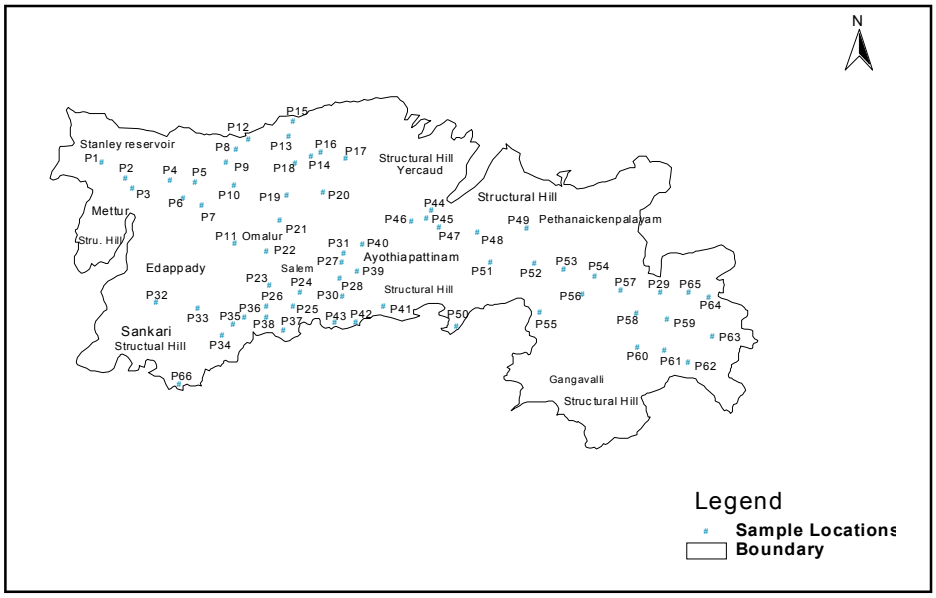

Fig. 2: Base map showing the sampling locations in the study area.

value of the nth parameter (7.0 for pH and 0 for all other parameters).

***Step 3*:** The WQI was calculated by the below mentioned formula.

$$WQI = \left[\frac{\Sigma(q_n w_n)}{\Sigma w_n}\right]$$

Where, q_n- Quality rating of the nth parameter

w_n- Quality Unit weight of the nth parameter

Determination of unit weight: The WQI was calculated based on eleven influencing parameters in the study area and their unit weights are given in Table 2. The different categories of water for drinking based on WQI are depicted in Table 3.

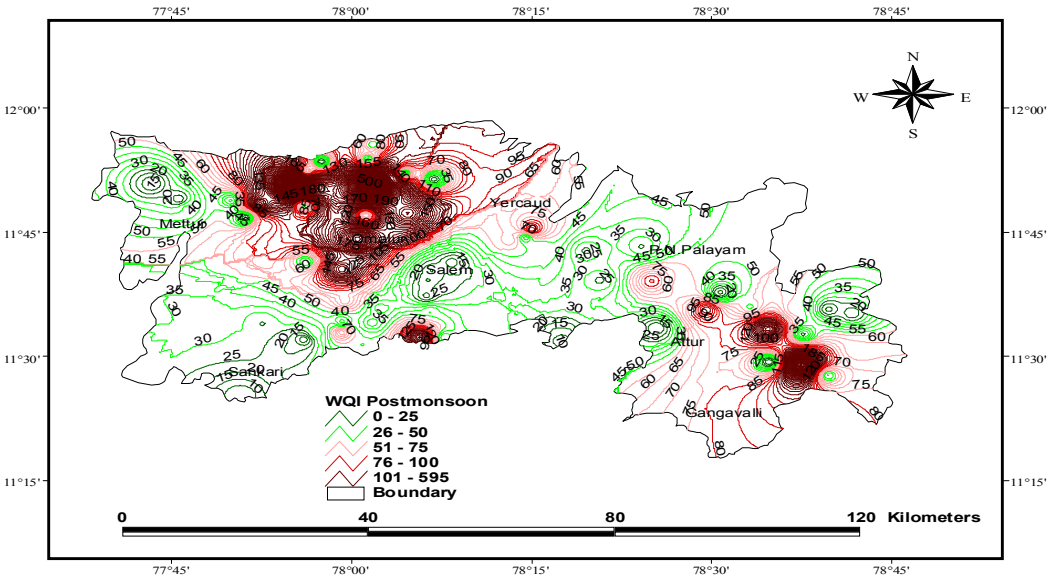

Fig. 3: Spatial distribution of WQI (postmonsoon).

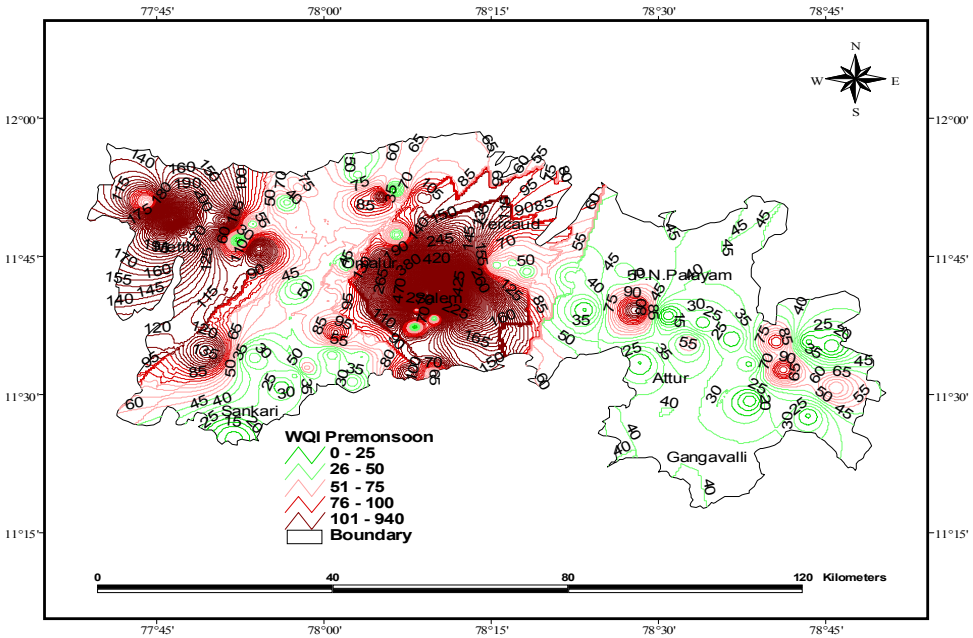

Fig. 4: Spatial distribution of WQI (premonsoon).

The value of S_n was based on the desirable limits of all the parameters based on IS: 10500-1991 (Indian Standard Drinking Water Specification).

RESULTS AND DISCUSSION

Table 4, indicating the statistical summary of the analysed parameters in premonsoon and postmonsoon, reveals that during premonsoon the minimum and maximum value of total dissolved solids was 216 and 11550mg/L, electrical conductivity was 542 to 16500 µmhos/cm, pH was 7.02 to 8.16, total alkalinity was 200 to 776 mg/L, nitrate was 5 to 558 mg/L, chloride was 36 to 4900 mg/L, total hardness was 136 to 3940 mg/L, sulphate was 10 to 650 mg/L, calcium was 25 to 1195 mg/L, magnesium was 6 to 533 mg/L, sodium was 33 to 2643 mg/L, potassium was 4 to 291 mg/L, iron was 0 to 3.8 mg/L and fluoride was 0.3 to 3.6. Maximum values were observed for chloride, calcium and sodium in the premonsoon.

Table 2: Water quality parameters with their standard value and unit weights. Standard values are in mg/L except pH and turbidity.

S. No.	Parameters	Standard value based on IS (Sn)	Unit Weight (Wn)
1	pH	8.5	0.025899
2	Turbidity, NTU	5	0.044028
3	Total Dissolved Solids	500	0.00044
4	Total Alkalinity	200	0.001101
5	Total Hardness	300	0.000734
6	Nitrate	45	0.004892
7	Chloride	250	0.000881
8	Calcium	75	0.002935
9	Magnesium	30	0.007338
10	Iron	0.3	0.733805
11	Fluoride	1	0.220142

Table 3: Categories of Water Quality Index.

S.No	Water Quality Index	Description
1	0-25	Excellent
2	26-50	Good
3	51-75	Poor
4	76-100	Very poor
5	Greater than 100	Unfit for drinking

During postmonsoon the minimum and maximum value of total dissolved solids was 343 and 11808 mg/L, electrical conductivity was 499 to 16940 µmhos/cm, pH was 6.96 to 8.01, total alkalinity was 196 to 712 mg/L, nitrate was 5 to 315 mg/L, chloride was 32 to 5020 mg/L, total hardness was 188 to 4450 mg/L, sulphate was 12 to 400 mg/L, calcium was 30 to 1414 mg/L, magnesium was 12 to 632 mg/L, sodium was 17 to 2275 mg/L, potassium was 2 to 249 mg/L, fluoride was 0.2 to 4.8 and iron was 0 to 2 mg/L. Maximum value was observed for chloride, calcium and sodium in postmonsoon.

The WQI ranges from 7.66 to 947.71 in premonsoon and 5.83 to 598.39 in postmonsoon. The comparison between premonsoon and postmonsoon is given in Table 5.

Spatial distribution of groundwater quality for drinking in the entire study area was represented with contours using GIS software Arc view 3.2a. So the suitability of groundwater for drinking in a block can be visualized easily. The spatial distribution of WQI for postmonsoon and premonsoon are shown in Figs. 3 and 4 respectively.

In premonsoon and postmonsoon, 43.94 % and 34.85 % of the samples resulted with WQI rating greater than 50. The number of sampling locations which fall under poor category in premonsoon was three, and in postmonsoon was four. Eight samples in premonsoon and two samples in postmonsoon fall under very poor category and 15 samples in premonsoon and 12 samples in postmonsoon were unfit for drinking purpose.

The overall result of the water quality index in the study area reveals that in premonsoon 56.06 % and in postmonsoon 65.15 % of the water samples had WQI rating less than 50 and were fit for drinking purpose.

The following locations resulted with WQI rating greater than 50 and less than 100 during premonsoon: Chitirapattupudur, Kattuvaluvu, Eragnapattypudur, Poosaripatty, Kuppur, Uthamacholapuram, Karukalvadi, Kattukottaipudur, Aayilpatty, Achankutapatty, Ariyanur, Pedhanaickenpalayam, Thandavarayapuram, Manjini, Anayampatti, Illupalanatham , Kovilvellar, Magudanchavadi and Kudiraik-aranur.

The following locations resulted with WQI rating greater than 50 and less than 100 during postmonsoon: Nangavalli, Kattuvalavu, Kuppur, Redimaniyakaranur, Kattukottaipudur, Gajalnaickenpatty, Kakapalayam, Poovanur, Ethappur, Pethanaickenpalayam and Illupalanatham.

During premonsoon the following sampling locations were found to be unfit for drinking purpose (WQI greater than 100): Mulakkadu, Kovilpalayam, Kunjandiyur, Nangavalli, Thevatipatty, Danishpet, Gajalnaickenpatty, Hasthampatty, Gorimedu, Kuralnattam and Sadasivapuram were influenced by iron, Redimaniyakaranur, Mallur and Edappady were influenced by fluoride, and Ethappur by electrical conductivity.

During postmonsoon, the following sampling locations were found to be unfit for drinking purpose (WQI greater than 100): Potaneri, Eragnapattypudur, Thevatipatty, Poosaripatty, Uthamacholapuram, Omalur, Karukalvadi, Mallur, Achankutapatty, Thandavarayapuram, Manjini and Anayampatti.

During premonsoon maximum number of samples which were unfit for drinking purpose were located (13 out of 15 samples) on the western part of the study area and only two samples were located in the eastern part, and during postmonsoon maximum number of samples which were unfit drinking purpose were located (9 out of 12 samples) on the western part of the study area and only three samples were located on the eastern part of the study area.

Based on the spatial distribution of WQI, groundwater was found to be potable for drinking in both the seasons in Pedhanaickenpalayam, Valapadi, Magudanchavadi, Konganapuram and major portions of Sankari blocks. Groundwater was not potable for drinking in both the seasons in Omalur, Nangavalli, Tharamangalam, Mecheri and Kadayampatti blocks. Groundwater was found to be potable in any one of the seasons in Gangavalli, Attur and major portions of Thalaivasal, Panamarathupatty,

Table 4: Statistical summary of the analysed parameters (premonsoon and postmonsoon). Values in mg/L except pH.

S. No	Parameters	Minimum		Maximum		Mean		Standard Deviation	
		Pre monsoon	Post monsoon	Pre monsoon	Post monsoon	Pre monsoon	Post monsoon	Pre monsoon	Post monsoon
1	TDS	216	343	11550	11808	1448	1498	1445	1451
2	Electrical Conductivity	542	499	16500	16940	2085	2149	2057	2080
3	pH	7.02	6.96	8.16	8.01	7.61	7.44	0.25	0.20
4	Alkalinity	200	196	776	712	393	401	132	110
5	Nitrate	5	5	588	315	54	52	72	46
6	Chloride	36	32	4900	5020	393	400	626	633
7	Total Hardness	136	188	3940	4450	566	516	491	509
8	Sulphate	10	12	650	400	66	75	82	58
9	Calcium	25	30	1195	1414	143	125	154	165
10	Magnesium	6	12	533	632	62	54	69	74
11	Sodium	33	17	2643	2275	220	247	328	303
12	Potassium	4	2	291	249	29	29	40	33
13	Iron	0	0	3.8	2	0.25	0.225	0.66	0.44
14	Fluoride	0.2	0.2	3.6	4.8	1.11	1.09	0.79	0.78

Table 5: Comparison of Water Quality Index between premonsoon and postmonsoon for drinking purpose.

S.No	Description	Percentage of sampling locations	
		Premonsoon	Postmonsoon
1	Excellent	24.24	37.88
2	Good	31.82	27.27
3	Poor	16.67	10.61
4	Very poor	4.55	6.06
5	Unfit for drinking	22.72	18.18

Ayothiapattinam, Salem, Veerapandi, Edappady and Mettur blocks.

CONCLUSION

According to Water Quality Index in premonsoon and postmonsoon 24.24 % and 37.88 % of the samples respectively were found excellent for drinking purpose and 31.82 % and 27.27 % of the samples respectively were found good for drinking

Spatial distribution maps of Water Quality Index reveal that only five blocks (Pedhanaickenpalayam, Valapadi, Magudanchavadi, Konganapuram, Sankari) in the study area were potable for drinking in both the monsoons.

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