COMPARATIVE STUDY ON GROUND WATER QUALITY IN PROXIMITY OF SALEM DISTRICT, TAMILNADU, INDIA

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Abstract: *The objective of this study is to reveals that groundwater quality with respect to Physical chemical contamination in a particular winter season and Coliform count is the major tool to determine the bacteriological quality of water. In Salem district, Tamil Nadu, India, both urban and rural areas had their ground water quality assessed using physico-chemical parameters following the North-East monsoon. Water samples were taken throughout Salem district's urban and rural areas. Numerous indices, including pH, EC, TDS, alkalinity, hardness, chloride, sulfate, DO and BOD were investigated in this study. The heavy metal contamination may due to the discharge of industrial, municipal wastes, disposal of solid wastes, land filling and other anthropogenic influences in this region. Groundwater suitability for domestic and irrigation purposes was examined by using WHO and BIS standards. Water quality interpretation was done by using Water quality index, Piper and Wilcox's diagram. The influence of anions and cations was done by Piper's trilinear diagram. Groundwater quality for irrigation purpose during winter season is in doubtful category in almost all parts of the study area.*

Keywords: *Groundwater, Physico-chemical Parameters, Hydrogeochemical facies, Wilcox diagram, Total coliform and Fecal coliform.*

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INTRODUCTION

The water problem was made worse by the increase in demand for water brought on by population growth, industrial expansion, and other developmental activities. There has been a severe shortage of water resources for the last few decades. Many emerging nations, including India, are increasingly at risk from water pollution [1]. Undoubtedly, water—an essential element to life—is a necessary and irrefutable part of the planet. It is regarded as a crucial resource that is essential to maintaining life on Earth [2]. A renewable resource and all-purpose solvent is water. Water pollution is caused by its special characteristics. Determining the source of the chemical composition of groundwater requires understanding of hydrochemistry. The local climate, geology, and irrigation practises are only a few examples of the natural and human-made factors that affect water quality [3]. Any groundwater's quality and utility depend on its chemical composition. The quality depends on the physical, chemical, and biological factors and may be arbitrary because it depends on the intended purpose. Groundwater quality deteriorates as a result of the quickening pace of urban and industrialization [4]. In general, water quality tests provide crucial information for the management of the coastal zone and are a crucial component of a programme for environmental monitoring of tourist beaches [5].

Numerous scientists have investigated the hydrogeochemistry of various coastal aquifers worldwide for quality assessment and seawater intrusion [6]. Groundwater is one of the freshwater sources used for drinking, residential use, irrigation, and industrial purposes in a number of coastal communities. In most coastal aquifers around the world, seawater intrusion is thought to be a widespread issue [7-9]To determine the governing parameters and get a thorough understanding of the source, origin, distribution, and driving force of organic and inorganic chemicals in distinct coastal aquifers, hydrogeochemistry research is necessary [10-12]. When water undergoes a natural or anthropogenic change in quality or composition, it can be viewed as contaminated. Rainfall and the subsequent percolation of the water into the earth are the main sources for ground water supply. The soil's quality is another key consideration. Thirty samples of groundwater were examined for electrical conductivity (EC), bicarbonate (HCO_3), calcium, magnesium, chloride, sodium, potassium, and sulphate (SO_4). The hydrogeochemical technique was used to interpret the groundwater quality.

MATERIALS AND METHODS

Study Area

The Salem district is in the western region of Tamil Nadu, between latitudes of 11°15' and 12°00' north and longitudes of 77°35' and 78°50' east. The Stanley reservoir takes up around 164.5 sq. km of the approximate 5207 sq. km total geographic area. The districts of Dharmapuri, Namakkal, Erode, and South Arcot form the northern, southern, western, and eastern boundaries of the research area.

The maximum and minimum temperatures in the district are respectively 40°C and 13°C. The district is crossed by the rivers Cauvery, Vashista, Swedha, Sarabhanga, and Thirumanimuthar. This area has hills and undulating plain landscape as its topography. The district is divided of eastern and northern hills and western, central, and southern undulating plains. Shevaroys, Kalrayan, Pachamalai, Palamalai, and Chitteri hills are significant hills in the district. In the Shevaroys Hills, Solaikarudu is this district's tallest peak. This location's average sea level is 1649 metres.

This area has seen subtropical weather with moderate humidity and temperatures. From March to June, the territory has a torrid climate, although November to February is comfortable. The northeast and southwest monsoons both provide rain to the district. The northeast monsoon provided the most rain.

Collection of Samples Water samples were collected in 100 mL plastic bottles from the selected 30 spots. Thereafter, samples for total Coliform and fecal Coliform were tested.

Estimation of Water Quality Index (WQI)

Water Quality index (WQI) is defined as a technique of rating that provides the composite influence of individual water quality parameter on the overall quality of water. It is calculated from the point of view of human consumption. The average means concentration of the physico-chemical parameters such as pH, turbidity, total dissolved solids, total alkalinity, total hardness, nitrate, chloride, calcium, magnesium, iron and fluoride was used for the calculation of WQI.

The critical pollution index considered unacceptable is 100 .

Water Quality Index was calculated by the below mentioned procedure.

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

$$W_i = k/S_i \qquad (1)$$

Where, K - Constant of proportionality

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

W_i is the unit of weightage

Individual quality rating is given by the expression

$$Q_i = 100V/S_i \quad (2)$$

Water Quality Index (WQI) is then calculated as follows

$$WQI = \sum_{i=1}^{n}(QiWi) / \sum_{i=1}^{n} Wi \quad (3)$$

Where, Q_i is the subindex of i^{th} parameter. W_i is the unit weightage for i^{th} parameter, n is the number of parameters considered. Generally, the critical pollution index values is 10.

Analytical Techniques

Total Coliform

Count 100 mL of water samples were filtered into a membrane filter using a sterile filtration unit. After filtration, forceps were used to place the membrane filter on M-Endo Broth in invert plate. The plate was then incubated in an incubator at a temperature of 45 °C for 24 h. The plates were then checked for bacteria colony growth [4-6].

Fecal Coliform

Count The same method was followed in total coliform count but after filtration, forceps were used to place the membrane filter on an MEC Broth in invert plate and the plate was then incubated in an incubator at a temperature of 37 °C for 24 h. Growing bacteria colony was the checked for growth.

RESULTS AND DISCUSSION

The results of the measured physicochemical parameter values with the cation and anion concentrations of groundwater collected in the month of January 2022 (winter).

Table 1: Physico - Chemical parameters of Groundwater collected in the month of January 2022 (winter)

Sample Station	pH	EC	TDS	DO	BOD	COD	SO_4	HCO_3	Ca	Mg	Na	K	Cl	Cu	Ni	Fe	Cr
01	7.8	1534	898	6	13	25	26	305	196	156	125	56	128	0.01	0.04	0.41	0.03
02	8.3	1687	1144	5	12	24	33	289	278	148	120	54	157	0.05	0.03	0.28	0.02
03	7.6	1698	1063	3	13	26	72	274	190	146	115	52	297	0.02	0.02	0.32	0.01
04	7.7	1565	845	4	10	20	27	357	256	143	110	45	159	0.01	0.04	0.41	0.05
05	8.1	1547	1052	6	10	19	44	412	227	145	89	49	240	0.04	0.03	0.28	0.04
06	7.9	1772	1215	5	13	35	35	364	220	142	134	42	236	0.03	0.02	0.45	0.06
07	8.2	1629	965	4	7	14	43	255	235	140	128	45	145	0.04	0.03	0.56	0.02
08	6.8	1517	1025	3	8	16	27	354	227	156	132	46	100	0.02	0.02	0.29	0.04
09	8.2	1668	1289	6	9	19	39	251	215	186	156	79	169	0.03	0.04	0.33	0.03
10	6.9	1654	877	5	14	28	3	261	212	184	142	75	128	0.01	0.02	0.35	0.02

							4											
11	8.1	1741	1164	6	11	21	45	286	212	80	136	74	256	0.02	0.03	0.54	0.02
12	7.1	1609	832	4	12	23	56	334	215	179	126	76	176	0.02	0.04	0.36	0.03
13	8.3	1628	1058	3	13	26	48	400	241	254	145	75	164	0.03	0.02	0.33	0.02
14	7.6	1719	841	5	9	18	64	341	261	152	178	76	182	0.04	0.01	0.24	0.02
15	8.1	1760	1052	6	7	14	15	384	213	128	156	89	177	0.05	0.02	0.33	0.02
16	6.9	1645	1245	5	10	19	41	408	298	156	123	74	182	0.01	0.03	0.29	0.02
17	7.9	1690	1135	4	12	24	30	346	220	234	180	50	145	0.02	0.01	0.4	0.01
18	7.8	1680	1086	3	13	22	21	416	205	261	170	50	156	0.03	0.02	0.44	0.02
19	8.5	1624	841	6	8	16	24	396	301	194	106	50	175	0.01	0.03	0.35	0.01
20	7.5	1542	1035	5	10	19	34	317	353	216	120	50	146	0.02	0.02	0.48	0.02
21	8.3	1654	1114	4	7	14	28	509	384	253	140	30	165	0.02	0.03	0.39	0.01
22	7.9	1750	1106	3	9	17	32	452	365	247	130	30	176	0.01	0.02	0.28	0.02
23	7.7	1685	1128	6	15	27	34	450	387	213	120	30	185	0.04	0.03	0.35	0.02
24	8.1	1701	956	5	7	14	46	367	365	178	120	35	195	0.02	0.02	0.48	0.02
25	7.9	1630	1008	4	15	26	21	328	321	194	120	80	192	0.04	0.01	0.46	0.01
26	7.6	1647	915	3	8	15	24	419	310	182	110	70	214	0.03	0.03	0.28	0.02
27	6.9	1530	1040	6	9	17	34	369	365	241	110	70	254	0.02	0.03	0.32	0.02
28	8.0	1606	1165	5	14	19	47	337	316	121	102	70	213	0.01	0.02	0.29	0.01
29	8.2	1706	1264	4	13	27	22	364	321	170	120	50	197	0.02	0.01	0.37	ND
30	7.9	1610	854	6	10	18	18	346	310	165	100	40	194	0.02	0.02	0.44	0.01

All the values are expressed in ppm expect EC (micromhocm^{-1})

Hydrogeochemical Facies Analysis

Piper Diagram

Analytical findings from water sampling depicted on a piper diagram. Pipers' diagram incorporates the creation of cation and anion triangles based on the findings. The quadrilateral field that displays the overall chemical characteristics of the water sample is created by combining the two data points from the cation and anion triangles. Plotting the concentrations of major cations (Ca, Mg, Na, and K) and anions

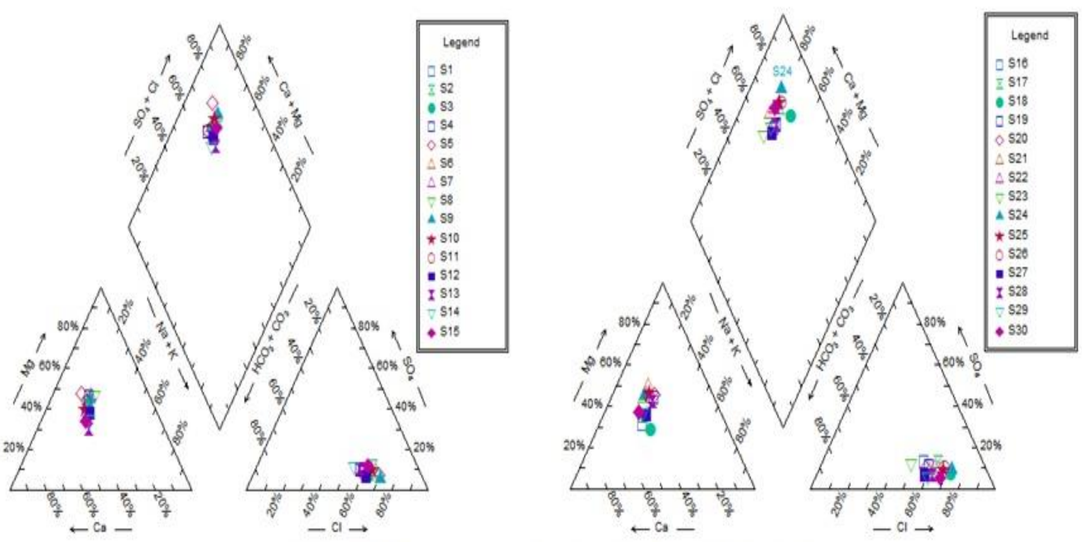
(CO_3, HCO_3, SO_4, and Cl) in milliequivalents per litre to assess the geochemical evolution/hydrochemistry of groundwater in the study area can help one understand the geochemical evolution of groundwater. The idea of hydrochemical facies was established in order to comprehend and identify the water composition in distinct classes, and these diagrams illustrate the analogies, differences, and various types of waters in the studied area [13].

Water types

Using the analytical information from the hydrogeochemical facies analysis, a Piper diagram for the Salem District. Anion and cation dominance can be used to categorise the sample points in the piper diagram. A-Ca type, B-No Dominant type, C-Na and K type, and D-Mg type are all cation types. E-HCO_3 type, F-Cl type, G-SO_4 type, and H-No dominating type are present in the anion triangle [14-16].

The cation triangle for the groundwater quality in January 2022 (winter) shows that Ca type water covers 10% of the total area, Na and K type water covers 3.3% of the total area, Mg type water covers 16.7% of the total area, and no dominating ion type water covers 70% of the whole area. In the anion triangle, F stands for the Cl type of water, which makes up 76.7% of the area, G for the SO_4 type of water, which makes up 3.3% of the area, and H for the 20% of the area that has no dominating ion type of water. (Figure 1).

The Ca-Mg and SO_4-Cl contents of the water samples are confined in the triangles marked by the numbers 3 and 6 respectively in the diamond part of the diagram (Figure 1 & 2). The majority of the samples fall within the triangle 3 & 6 representing $CaMgSO_4Cl$ type water.



Winter -2022 groundwater samples plotted in Piper-Trilinear diagram

Figure 1

Wilcox Diagram

Percent Sodium vs. EC Plot (Na %)

To assess the appropriateness of groundwater for irrigation, Wilcox [17] plotted the percent Na value versus the EC value. He classified groundwater into five categories in his plot: excellent to good, good to permissible, permissible to doubtful, doubtful to unsuitable, and inappropriate.

Richards [18,19] offered the Wilcox diagram as a USSL diagram for assessing the quality of irrigation water by modifying it to include the SAR value as a sodium hazard and the EC value as a salt hazard.

According to the SAR and EC values, he also assigned the water quality the following ratings: low, medium, high, and extremely high for sodium and salinity concerns. According to the USSL graphic, the groundwater quality for January 2022 (Winter) was spread as follows: One sample in S1C4 (low sodium-very high salinity), three samples in S1C2 (low sodium-medium salinity), three samples in S1C3 (low sodium-high salinity), and nine samples in S2C4 (medium sodium–very high salinity), Seven samples of S3C4 (middle sodium-very high salinity), two samples in S4C3, and two samples in S3C3 (high sodium-high salinity) (very high sodium–high salinity).

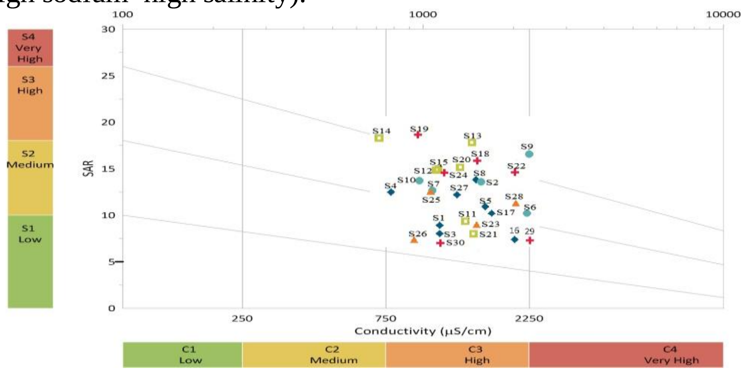


Figure 2

Coliforms are bacteria that are always present in the digestive tracts of animals, including humans, and are found in their wastes. They are also found in plant and soil material. The most basic test for bacterial contamination of a water supply is the test for total coliform bacteria. Total coliform counts give a general indication of the sanitary condition of a water supply [20,21].
Coliform populations are indicators for pathogenic organisms. They should not be found in drinking water but are usually present in surface water, soil and faeces of humans and animals. Human waste contaminant in water causes water-borne diseases such as diarrhea, typhoid and hepatitis. High coliform populations in all the water samples are an indication of poor sanitary conditions in the community. Inadequate and unhygienic handling of solid-wastes in the rural area could have generated high concentration of microbial organisms [22].

Table: 2 Calculation of WQI values for the physico- chemical parameters of Groundwater collected during January 2022 winter season

Parameters	**Mean value in ppm (Vi)**	**Highest permitted value (WHO) (Si)**	**Unit weightage (wi)**	**Wi×Qi**
pH	7.7	8.5	0.117	62.228
EC	1207	600	0.001	1.810
TDS	1069	500	0.002	2.351
TH	383	500	0.002	0.842
HCO_3	254	500	0.002	0.558
SO_4	34	500	0.002	0.074
NO_3	19	50	0.02	4.408
Ca	162	100	0.01	9.396
Mg	45	150	0.006	1.14
Na	154	200	0.005	2.233
Cl	218	250	0.004	2.005

$$WQI=\sum_{i=1}^{n}(QiWi)/\sum_{i=1}^{n}Wi \qquad WQI=83.05$$

Table: 3 Status Categories of WQI

WQI	**Quality of Water**
0-25	Very Good
26-50	Good
51-75	Poor
Above 75	Very Poor (Unsuitable for Drinking)

In this study, the computed WQI value is 83.05 and therefore can be categorized into unsuitable water for drinking purposes (Table 4) the high value of WQI at is mainly due to the higher values of EC, TDS, BOD, COD and Ca in the ground water.

Table: 4 The Faecal Coliform and Total coliform count of groundwater samples by MPN method in January 2022

stations	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**1**	**11**	**12**	**13**	**14**	**15**
FC	13	18	10	11	19	14	13	11	14	13	15	20	11	9	10
TC	20	22	19	27	21	40	62	20	26	22	29	21	27	40	29
stations	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
FC	7	14	18	19	19	12	17	13	13	11	12	13	13	15	11
TC	22	36	27	29	66	33	37	30	32	49	27	45	49	46	41

Types	**Average**
Faecal Coliform	**13.2**
Total coliform	**33.1**

The Faecal Coliform counts in water samples are observed to be 13.2 in January 2022 summer seasons, respectively. The values are higher than that of WHO permissible limit (0/100 ml MPN coliforms). The mean average value was found to be 13.2. It indicates that the water in all the station is unsuitable for drinking and agricultural purpose. The TC bacterial count found in January are found to be higher than the permissible limit of WHO (10/100 mL of MPN coliforms). The mean average value of TC in three seasons is 33.1 and it indicates that the water in the above stations are unsuitable for drinking and agricultural purposes.

Organic matters occurring in polluted waters serve as excellent nutritional source for the growth and proliferation of microorganisms. Bacteria are the most commonly used microbial tracer organism since they grow well in aqueous media and they are also easily detectable. The most probable number (MPN) is a suitable and widely used parameter to determine the microbial quality of water. In the observation of our study areas the MPN for total coliform and bacterial count are noted to be very high than the permissible limit of WHO (0/100 mL of MPN coliforms) in all the three seasons. The increase in microbial load is probably due to the accumulation of human and animal excreta, the addition of sewages, dumping of cabbages and industrial wastes [23]. The microorganisms in the stagnant surface water resources happen to grow in abundance as they attain ample of nutrients in the water bodies. The polluted surface water on percolation into the ground may contaminate the deep-well water even though some amounts of the organisms get filtered by the soil layers. High MPN values suggest that the water is not suitable for drinking purposes.

The total coliform count amounting to collective pathogens like Escherichia coli, Enterobacter aerogenes, Staphylococcus aureus, Sulmonella and Shigella on the biological examination of our study water samples shows potable higher value during rainy season whereas decreased value to some extent in the summer season. Land washings and domestic wastes by rain will augment the high potent of bacterial count [24,25]. The considerable depleted value of microorganisms during summer may be due to less biological activities at very low humidity and unfavourable conditions for bacterial growth such as pH, temperature, DO, nutrient, sunlight and other biological factor. Thus the presence of harmful microbes in the groundwater is said to be the reason for causing dysentery, typhoid, cholera, etc., [26]. The World Health Organization has reported that about 30,000 people die every day in developing countries because of unsanitary water supply. The absence of bacterial organisms in some stations indicates that the environmental conditions (temperature, etc.,) are not favourable for the bacterial growth.

CONCLUSION

This study investigated the physico-chemical properties of the groundwater to understand the status of water quality and also the ions sources. The combined diamond plot of the cationic and anionic triangular fields of the piper diagram shows that 90% of the groundwater samples fell in to the $CaCl_2$ and Mixed NaCl types. Most of the calculated indices for irrigation water quality showed that the study area water quality is unsuitable for irrigation. The calculated irrigation water quality indices shows in the graphs Na% versus EC an USSL diagram showed the quality of the irrigation of the water in the study area during January 2022 (winter seasons). The WQI calculated values ranged above 30 for seasons. This shows that the water quality of the study area is very poor and not suitable for drinking purpose. The study reveals that the investigation of hydrogeochemical process to approach the groundwater quality in and around Salem District had the purpose of providing a simple, valid method for expressing the results of several parameters in order to assess the groundwater quality. The microbiological quality that adversely affected the quality of groundwater is likely to arise from a variety of sources. Hence it is important to apply strong prevention measures to save groundwater from contamination in these studied locations. In most of the states, the problem of groundwater depletion and quality deterioration has appeared in last few years. Monitoring of groundwater quality should be undertaken regularly to identify the sources of principal contaminants and other inhibitory compounds that affect the portability of water and also to identify the wells which are safe for drinking and irrigation water to protecting them from further contamination.

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