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A Study on Spatial Changes of Groundwater using Statistical Method and Hydro-Geochemical Facies in Cheyyar River Basin, Tamilnadu

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***Abstract:** The attempt is made along the Cheyyar river basin, Kancheepuram district. The total sample collected along study area is 20. The physio-chemical parameters were tested. The pH are ranges from 6.5-8.1 and they are neutral. The other values such as EC, TDS, Turbidity, Total hardness are within the permissible limit comparing the standard specification. The chemical parameter such as calcium, magnesium value 75% within the permissible limit as specified in standard. The bicarbonate has high value, sodium, chloride and other parameters are as follows. The order of abundance of chemical concentration is $Na^{+}> Ca^{2+}> Mg^{2+}> K^{+} = HCO^{3-}> Cl^{-}> So_4$. The type of water present in the study area is Ca-Mg-So_4 type, Ca-Mg-HCO_3 type and Ca-Mg-Cl-So_4 type. The Ground water qualities are compared with the Indian Standard and World Health Organization (WHO). The SAR value of the samples ranges from 0.825 to 7.829 (meq/L), Sodium percentage value ranges from 20.376 to 65.007(meq/L) .Then comparing SAR 65% is suitable and by sodium percentage 72.45% of water is suitable for the agriculture.*

***Index Terms:** Bicarbonate, Calcium, Chloride, Electrical Conductivity, EDTA (Ethylene Diamine Tetra Acetic acid), Magnesium, NTU (Nephelometric Turbidity Unit), pH, Potassium, SAR (Sodium Adsorption Ratio), Sodium, Sulphate, Total Hardness, Turbidity, Total Dissolved Solids, WHO (World Health Organization).*

I. INTRODUCTION

Groundwater is one of the great natural resource in the Biosphere. Freshwater is a finite and a vulnerable resource, essential to sustain life, development and the environment. India is a tropical country with a vast diversity of climate, topography and vegetation. The scarcity of surface water especially in the lean season in most parts of the country means that ground water plays a decisive role. Though blessed with fairly high annual rainfall, it is not uniformly distributed in time and space resulting in bulk of the rainfall escaping as runoff. Groundwater though contributes only 0.6% of the total water resource on earth, it accounts for nearly 80% of the rural domestic water needs and 50% of the urban water needs in the developing countries like India. The water resource potential or annual water availability of the country in terms of natural runoff (flow) in rivers is about 1,869 Billion Cubic Meter (BCM)/Year. However, the usable water resources of the country have been estimated as 1,123 BCM/Year. Out of 1,123 BCM/year, the share of surface water and ground water is 690 BCM/year and 433BCM/year respectively. Setting aside 35 BCM for natural discharge, the net annual groundwater availability for the entire country is 398 BCM. Although statistics, the WHO reports 36% of urban and 65% of rural Indian were without access to safe drinking water. India is facing a serious problem of natural resource scarcity, especially in view of population growth and economic development. Most of the fresh water bodies all over the world are getting polluted, thus decreasing the portability of water.

A. Need for the Study

High level of ground water development in large area in the western and southern part of the district both in hard rock and sedimentary aquifers and failure of abstraction structures with time. The water level depletion in the eastern part of the district is mainly due to exploitation of ground water for domestic drinking and other purposes. Natural geochemical and biochemical, as well as anthropogenic impact on groundwater do not only threaten the quality of human health but also poses a threat to sustainable development and management of groundwater resources. Groundwater may, thus, be prone to chemical contamination. It is, therefore, imperative to carry out an extensive groundwater quality assessment of the basin, as well as water types of the different water sources, in order to understand the hydrochemistry of ground-water and, therefore, ensure its potable supply in the area. The rapid development of industrial, urban and agricultural sectors is adding contamination to the water resources system at an increasing rate. In some situations these contaminations join the aquifers and cause quality of ground water problems. This necessities and accurate prediction of time and rate of detoriation of ground water quality for effective pollution control. In many places continuous discharge of effluents over a period, this probably exceeds assimilative capacity of environment leads to accumulation of pollutants in ground water and soil.

B. Objective of the Study

The objective of this study is about the changes for physical and chemical parameter in the groundwater. As, there is a drinking water scarcity due low intensity of rainfall in many of this region.

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This study used to classify the water according to their parameter values then they are classified for various purposes such as drinking, Irrigational uses and other purposes. Water Quality is an important factor to judge environment changes, which are strongly associated with social and economic development. The evolution of water in the developing countries has become a critical issue in recent years, especially due to the concern that fresh water will be scarce in near future. Groundwater contains various types of pollutants and several other substances are dissolved in it. Concentration of which is useful for human body but in a specific limit. The study was conducted to know the physic-chemical properties of ground water and its impact on human life. Being a significant part of the hydrological cycle, its occurrence and availability depends on the rainfall and recharge conditions. It acts as the indicator of the quality of water. The objective of the water quality index is to turn multifaceted water quality data into simple information that is useable by the public. Chemical composition of geologic formations affects the hydrochemical characteristics of groundwater during their circulation in the subsurface. This underground passage through the pore spaces and weathered zones may alter the natural composition of the groundwater by the action of various hydrochemical processes. Suitability of water for various uses depends on type and concentration of dissolved minerals and groundwater has more mineral composition than surface water. In this study the particular region is selected and the samples were collected.

C. Study Area

The area selected for the study is Cheyyar river basin, Tamil Nadu, India as shown in fig.1. This Cheyyar, a tributary of Palar originates from the Jawadu Hills of Tiruvannamalai district. It has a northeasterly flow in Kancheepuram district and confluences with the Palar near Pazhaiyaseevaram. Alluvial soils are found on the banks of Cheyyar and other rivers. The river alluvium is transported and is seen in coastal area of this district. Sandy coastal alluvial (Arenacious soil) occurs along the seacoast as a narrow belt. These unconsolidated formations occur mainly along the banks of Cheyyar River and the sand layers of this alluvium form the potential aquifer. The shallow alluvial aquifer along Cheyyar River serves as an important source of drinking water between Kancheepuram to Ayyapakkam and Chengalpat to Tambaram. As, the flow of river is long so that the end part of the river in kancheepuram district is selected for the study. The village along cheyyar river basin in kancheepuram district is from Magral to Angampakkam and Puthali to Tirumukkudal. The samples are collected along 18km of each side of the bank of the river.

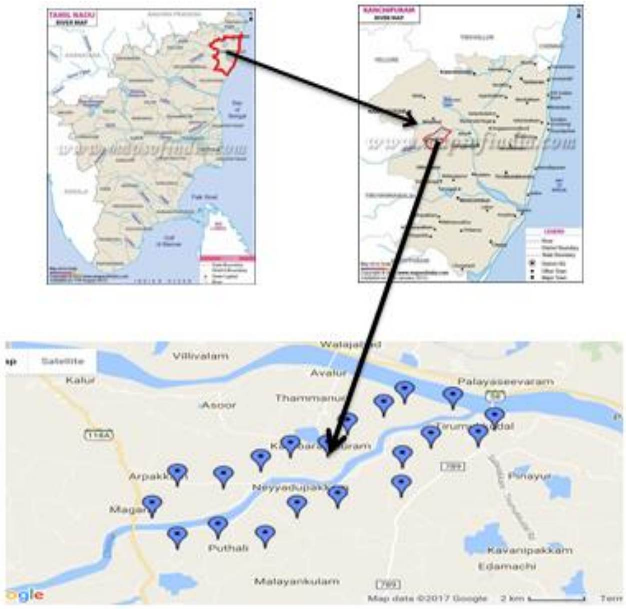

Fig.1 Groundwater Sample Location and Geology Map of the Area

II. COLLECTION OF SAMPLES

A. Sampling Method

The villages along cheyyar river basin in kancheepuram district are from Magral to Angampakkam and Puthali to Tirumukkudal. The samples are collected along 18km of each side of the bank of the river. The total distance covered for collecting the sample is 36km and the distance between the collections of each sample is approximately from 1.5km to 1.6km. The sample is collected either in open well or hand pump in that place. The polyethylene bottle of 1000ml is used for the collection. If the location point is surrounded by an agricultural land the sample is collected from open well or if the location point is living area then the sample is collected from hand pump.

i. Open Well

The water is collected in a 1000ml of polyethelyne bottle and it is sealed after verifying that no air gap is inside the bottle. The collected sample is taken to the laboratory and all the physical parameter is tested. Then the water is filtered with the 0.4 micrometre and all the other chemical parameter was tested.

ii. Hand Pump

The hand pump is first pumped for 5minutes to get the fresh water. After pumping the sample is collected in a 1000ml polyethelyene bottle and the bottle is sealed after verifying that the no air gap is present inside the bottle. Then the sample bottle is taken to the laboratory and all the physio-chemical parameter is tested.

B. Latitude and Longitude

The latitude and longitude of the sample collected places are listed as below in table 1. The values are at time when the sample is collected at that point. The value is noted using the application.

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Table 1: Latitude and Longitude of the Sample Collected Area

Sample No.	Latitude	Longitude
1	12° 42' 54.79"	79° 45' 33.72"
2	12° 43' 45.98"	79° 46' 2.15.3"
3	12° 43' 42.34"	79° 46' 54.06"
4	12° 44' 10.07"	79° 47' 36.08"
5	12° 44' 32.97"	79° 48' 9.46"
6	12° 44' 34.76"	79° 48' 50.86"
7	12° 45' 10.94"	79° 49' 13.72"
8	12° 45' 40.48"	79° 49' 54.51"
9	12° 44' 32.13'	79° 50' 12.42"
10	12° 45' 52.53"	79° 51' 11.76"
11	12° 45' 18.78"	79° 51' 59.349"
12	12° 44' 51.07"	79° 51' 40.89"
13	12° 44' 48.64"	79° 50' 47.66"
14	12° 44' 16.09"	79° 50' 15.52"
15	12° 43' 27.879"	79° 50' 14.29"
16	12° 43' 9.78"	79° 49' 2.604"
17	12° 42' 54.12"	79° 48' 16.87"
18	12° 42' 4.683"	79° 47' 41.031"
19	12° 42' 19.15"	79° 46' 47.88"
20	12° 42' 2.271"	79° 46' 2.15"

III. ANALYTICAL PROCEDURE

It is very essential and important to test the water before it is used for drinking, domestic, agricultural or industrial purpose. Water must be tested with different physic-chemical parameters as shown in fig.2. Selection of parameters for testing of water is solely depends upon for what purpose we going to use that water and what extent we need its quality and purity. Water does content different types of floating, dissolved, suspended and microbiological as well as bacteriological impurities. Some physical test should be performed for testing of its physical appearance such as temperature, color, odor, pH, turbidity, TDS etc, while chemical tests should be perform for its BOD, COD, dissolved oxygen, alkalinity, hardness and other characters. For obtaining more and more quality and purity water, it should be tested for its trace metal, heavy metal contents and organic i.e. pesticide residue. It is obvious that drinking water should pass these entire tests and it should content required amount of mineral level. Only in the developed countries all these criteria's are strictly monitored. Due to very low concentration of heavy metal and organic pesticide impurities present in water it need highly sophisticated analytical instruments and well trained manpower. Following different physic chemical parameters are tested regularly for monitoring quality of water.

A. pH

pH is most important in determining the corrosive nature of water. Lower the pH value higher is the corrosive nature of water. pH was positively correlated with electrical conductance and total alkalinity. The reduced rate of photosynthetic activity the assimilation of carbon dioxide and bicarbonates which are ultimately responsible for increase in pH, the low oxygen values coincided with high temperature during the summer month. Various factors bring about the changes in the pH of water. The higher pH values observed suggests that carbon dioxide, carbonate & bicarbonate equilibrium is affected more due to change in physic-chemical condition.

B. Electrical Conductivity (EC)

Conductivity shows significant correlation with ten parameters such as temperature pH value, alkalinity, total hardness, calcium, total dissolved solids, chemical oxygen demand, chloride and iron concentration of water. The underground drinking water quality of study area can be checked effectively by controlling conductivity of water and this may also be applied to water quality management of other study areas. It is measured with the help of EC meter which measures the resistance offered by the water between two platinized electrodes. The instrument is standardized with known values of conductance observed with standard KCl solution.

C. Turbidity (NTU)

The origin of turbidity may be clay particles, sewage solids, silt and sand washings, organic and biological sludges or some other factors. Direct health effects depend on the precise composition of the turbidity-causing materials, but there may be other implications. Turbidity in water arises from the presence of very finely divided solids which are not filterable by routine methods. The particles forming the turbidity may also interfere with the water treatment techniques and in the case of the disinfection process the consequences could be grave. As turbidity can be caused by sewage matter in water there is a risk that pathogenic organisms could be shielded by the turbidity particles and hence escape the action of the disinfectant. The NTU found were all below the 5 units. In fact they were generally either 1 or 2 units which mean the water supply from the boreholes and wells are acceptable as far as NTU are concerned.

D. Calcium

It is measured by complexometric titration with standard solution of ETDA using Patton's and Reeder's indicator under the pH conditions of more than 12.0. These conditions are achieved by adding a fixed volume of 4N Sodium Hydroxide. The volume of titre (EDTA solution) against the known volume of sample gives the concentration of calcium in the sample.

E. Magnesium

It is also measured by complexometric titration with standard solution of EDTA using Eriochrome black T as indicator under the buffer conditions of pH 10.0. The buffer solution is made from Ammonium Chloride and Ammonium Hydroxide. The solution resists the pH variations during titration.

F. Sodium

It is measured with the help of flame photometer. The instrument is standardized with the known concentration of sodium ion (1 to 100 mg/litre).

The samples having higher concentration are suitably diluted with distilled water and the dilution factor is applied to the observed values.

G. Potassium

It is also measured with the help of flame photometer. The instrument is standardized with known concentration of potassium solution, in the range of 1 mg to 5 mg/litre. The sample having higher concentration is suitably diluted with distilled water and the dilution factor is applied to the observed values.

H. Chloride

It is measured by titrating a known volume of sample with standardized silver nitrate solution using potassium chromate solution in water or eosin/fluorescein solution in alcohol as indicator. The latter indicator is an adsorption indicator while the former makes a red colored compound with silver as soon as the chlorides are precipitated from solution.

I. Sulphate

It is measured by nephelometric method in which the concentration of turbidity is measured against the known concentration of synthetically prepared sulphate solution. Barium chloride is used for producing turbidity due to barium sulphate and a mixture of organic substance (Glycerol or Gum acetia) and sodium chloride is used to prevent the settling of turbidity.

J. Bicarbonate

It is also measured by titration with standardized hydrochloric acid using methyl orange as indicator. Methyl orange turns yellow below pH 4.0. At this pH, the carbonic acid decomposes to give carbon dioxide and water.

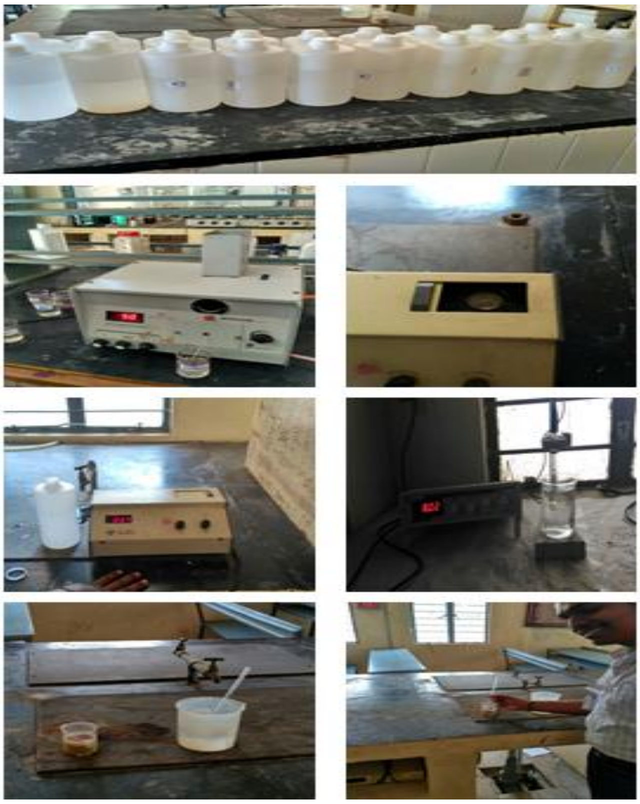

Fig.2: Experiments Conducted with the Collected Samples

IV. RESULTS AND DISCUSSION

The Physical and Chemical parameters were identified for the samples which are collected various places and are listed in the table 2.

Table 2: Physico-Chemical Parameters Reading for the Collected Samples

Sample no.	pH	EC	TDS (mg/L)	Turbidity (NTU)	Hardness (mg/L)	Ca (mg/L)	Mg (mg/L)	Na (mg/L)	K (mg/L)	Cl (mg/L)	SO_4 (mg/L)	HCO_3 (mg/L)
1	8.1	1450	446	3.0	175	56.02	32.8	128	37	128	17	219.6
2	6.8	1448.5	435	3.2	168.03	72.05	28	129	41	129	20	215.2
3	7.2	1452	430.3	2.8	165	70.1	30.4	131	39	131	19	220.8
4	6.7	1441	441	3.6	172	65.13	29	135	36	135	22	221.3
5	7.6	1458	442.5	4	179	74.65	36	139	47	139	16	218
6	7.3	1449	439	3.1	164.2	89.5	40.1	132	45	132	23	211.4
7	7.85	1460.2	450	3.7	180	97.9	34	137	43	137	21	222
8	6.5	1443	432.6	3.2	166	61.43	27.2	130	38	130	18	225.7
9	8	1456	449	3.8	171.08	59.5	41	134	44	134	15	228.1
10	7.89	1443.9	452	3.3	169	80.5	33	136	35	136	20.5	216.1
11	6.57	410	224	4.2	150	88	13.6	23	3	25	17	148.2
12	6.61	404	220	3.15	147	76.5	16	25	9	18.5	20	130.5
13	7.52	408	229.5	2.95	154	60	19	17	5	23.3	12.5	139
14	6.51	410	218	4.3	140	84.2	14	28	6	28	9	150
15	7.21	407	221.9	4.25	158	70	12.3	19	2	16.4	22.7	155.7
16	7.6	413	215	3.7	160	71.5	10.2	22	8	32	12	142
17	7.1	418	228	2.5	155	55.5	20.5	30	4	22.7	18.5	140.8
18	8.02	403	231.8	2.8	143	65	15.4	25	7	17	26.7	152.3
19	6.9	412	216	3.15	148	69.6	17.8	32	6	27	12.8	157.5
20	6.85	413	227.3	4.03	152	71.4	21.3	27	7	15.8	11.9	140

A. Physical Parameter

The Physical parameter identified from the water sample collected are Potential of Hydrogen (pH), Electrical conductivity (EC), Total Dissolved solids (TDS), Total hardness (TH) and Turbidity.

i. Potential of Hydrogen (pH)

The pH of water is very important of its quality and provides an important piece of information in many types of geochemical equilibrium or solubility calculations. The limit of pH value for drinking water is 6.5-8.5 specified as in IS 10500:2004. The range of pH in the collected sample is varying from 6.5-8.1 and according to Indian Standard they are within the limit.

ii. Electrical Conductivity (EC)

The conductivity measurement provides an indication of ionic concentrations. It depends upon temperature, concentration and types of ions present. The maximum limit of EC in drinking water is 1500 (μ Siemens/cm) prescribed as in IS 10500:2004. The value of EC ranges from 403-1460.2 (Micro Siemens/cm) and according to Indian Standard they are within the limit.

iii. Total Dissolved Solids (TDS)

The mineral constituents dissolved in water constitute dissolved solids. The concentration of dissolved solids in natural water is usually <500 mg/L while water with more than 500 mg/L is undesirable for drinking and many industrial uses.

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The total concentration of dissolved minerals in water is a general indication of the over-all suitability of water for many types of uses. Water with high dissolved solid content would, therefore, be expected to pose problems such as taste, laxative and other associated problems with the individual minerals. Such waters are usually corrosive to well screens and other parts of the well structure. If the water contains <500 mg/L of dissolved solids, it is generally satisfactory for domestic use and for many industrial purposes. Water with more than 1000 mg/L of dissolved solids usually gives disagreeable taste or makes the water unsuitable in other respects. TDS can be removed by reverse osmosis, electro-dialysis, exchange and solar distillation process. The maximum limit of TDS in drinking water is less than 500 mg/L specified as in IS 10500:2004. The value of TDS ranges from 215-452 mg/L and according to Indian Standard they are within the limit.

iv. Total Hardness (TH)

Calcium and magnesium mostly cause the hardness of water. The TH of water may be divided into two types, carbonate or temporary and bi-carbonate or permanent hardness. The hardness produced by the bi-carbonates of calcium and magnesium can be virtually removed by boiling the water and is called temporary hardness. The hardness caused mainly by the sulphates and chlorates of calcium and magnesium cannot be removed by boiling and is called permanent hardness. TH is the sum of the temporary and permanent hardness. Water that has a hardness of <75 mg/L is considered soft. A hardness of 75-150 mg/L is not objectionable for most purposes. Water having more than 150 mg/L hardness, is unsafe. The removal of temporary hardness by heat causes the deposition of calcium and magnesium carbonates as a hard scale in kettles, cooking utensils, heating coils, and boiler tubes resulting in a waste of fuel. The maximum allowable limit of TH for drinking purpose is 300 mg/L as prescribed in IS 10500:2004. The value of hardness ranges from 140-179 mg/L and according to Indian standard they are within the limit.

v. Turbidity

Suspension of particles in water interfering with passage of light is called turbidity. Turbidity is caused by wide variety of Suspended particles. Turbidity can be measured either by its effect on the transmission of light which is termed as Turbiditymetry or by its effect on the scattering of light which is termed as Nephelometry. As per IS: 10500-2004 the acceptable and permissible limits are 1 and 5 NTU respectively. The value ranges from 2.5-4 NTU and according to Indian standard they are within the limit.

B. Chemical Parameter

The Chemical parameters that are identified from the water are Calcium (Ca), Magnesium (Mg), Chloride (Cl) and Sulphate (SO_4).

i. Calcium (Ca)

The range of calcium content in groundwater is largely dependent on the solubility of calcium carbonate, sulphate and rarely chloride. The solubility of calcium carbonate varies widely with the partial pressure of CO_2 in the air in contact with the water. The salts of calcium and magnesium are responsible for the hardness of water. The permissible limit of calcium in drinking water is 75 mg/L as specified in IS 10500:2004. According to Indian Standard there are 14 samples are within the limit and 6 samples are not within the limit.

ii. Magnesium (Mg)

A large number of minerals contain magnesium; Magnesium is washed from rocks and subsequently ends up in water. Magnesium has many different purposes and consequently may end up in water in many different ways. Chemical industries add magnesium to plastics and other materials as a fire protection measure or as filler. It also ends up in the environment from fertilizer application and from cattle feed. The permissible limit of magnesium in drinking water is 30 mg/L as prescribed in IS 10500:2004. According to Indian Standard there are 15 samples within the limit and 5 samples are not within the limit.

iii. Chloride (Cl)

Chloride is minor constituent of the earth's crust. Rain water contains <1 ppm chloride. Chloride in drinking water originates from natural sources, sewage and industrial effluents, urban runoff containing de-icing salt, and saline intrusion. Its concentration in natural water is commonly <100 mg/L unless the water is brackish or saline. High concentration of chloride gives a salty taste to water and beverages and may cause physiological damages. Water with high chloride content usually has an unpleasant taste and may be objectionable for some agricultural purposes. The level of chloride taste perception is variable from person to person, but is generally of the order of 250 mg/L. Animals usually can drink water with much more concentration than humans can tolerate (300-400 mg/L). Chloride is also relatively free from effects of exchange adsorption and biological activity. Once taken into solution it is difficult to remove it through natural process reported that the higher concentration of Chloride is considered to be an indicator of pollution due to higher animal waste. The maximum limit of chloride specified by IS 10500:2004 is 250 mg/L. The value ranges from 15.8-139 mg/L and according to Indian standard they are within the limit.

iv. Sulphate(SO_4)

The sources of sulphate in underground waters may be rocks, geological formation, and so on. Excess sulphate has a laxative effect, especially in combination with magnesium and/or sodium. Sulphates exist in nearly all natural waters, the concentrations varying according to the nature of the terrain through which they flow. They are often derived from the sulphides of heavy metals (Iron, Nickel, Copper and Lead). Iron sulphides are present in sedimentary rocks from which they can be oxidised to sulphate in humid climates; the latter may then leach into watercourses so that ground waters are often excessively high in sulphates. As magnesium and sodium are present in many waters, their combination with sulphate will have an enhanced laxative effect of greater or lesser magnitude depending on concentration. Natural water contains sulphate ions and most of these ions are also soluble in water. Many sulphate ions are produce by oxidation process of their ores, they also present in industrial wastes. The method to measure quantity of sulphate is by UV Spectrophotometer.

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As per IS: 10500-2004desirable limit for sulphate is 200 mg/l. The value sulphate ranges from 9-23 mg/L and they are within the limit.

C. Ground Water Quality

Table 3: Statistics of Chemical Parameter in Groundwater

S. No	Parameter	Minimum	Maximum	Standard deviation (n=20)
1	pH	6.51	8.1	0.5507
2	EC (µ Siemens/cm)	403	1460.2	533.72
3	TDS (mg/L)	215	452	112.33
4	Turbidity (NTU)	2.8	4.3	0.5371
5	Hardness (mg/L)	140	180	11.909
6	Calcium (mg/L)	55.5	97.9	11.542
7	Magnesium (mg/L)	10.2	41	9.7131
8	Sodium (mg/L)	17	139	55.708
9	Potassium (mg/L)	2	47	18.14
10	Chloride (mg/L)	15.8	139	56.885
11	Sulphate (mg/L)	9	26.7	4.5208
12	Bicarbonate (mg/L)	130.5	228.1	36.673

Table 4: Relative weight of the Chemical Parameter

Parameter	IS 10050-2004	Weight (w_i)	Relative Weight (W_i)
TDS(mg/L)	50	5	0.178
Bicarbonate(mg/L)	-	1	0.035
Chloride(mg/L)	250	5	0.178
Sulphate(mg/L)	200	5	0.178
Calcium(mg/L)	75	3	0.107
Magnesium(mg/L)	30	3	0.107
Sodium(mg/L)	-	4	0.142
Potassium(mg/L)	-	2	0.071
Total		**28**	**0.996**

The groundwater quality of the collected sample is compared with the Indian Standard and WHO as shown in table 3, 4 & 5. The limit of each parameter is compared with the prescribed limit and the percentages of collected samples which are within the limit are calculated.

Table 5: Comparison of groundwater quality with drinking water standards (Indian Standard 10090:2004 and WHO)

Parameter	IS	Percent (%)	WHO	Percent (%)
pH	6.5-8.5	100	7-8	55
TDS(mg/L)	500	50	1000	100
Hardness(mg/L)	300	100	-	-
Bicarbonate(mg/L)	-	-	-	-
Chloride(mg/L)	250	100	250	100
Sulphate(mg/L)	200	100	250	100
Calcium(mg/L)	75	85	75	85
Magnesium(mg/L)	30	65	30	65
Sodium(mg/L)	-	-	200	100
Potassium(mg/L)	-	-	-	-

D. Water Quality for Irrigation Purposes

i. Sodium Adsorption Ratio (SAR)

SAR and EC reciprocally can be used to evaluate irrigation water quality as shown in table 6. The SAR recommended by the salinity laboratory of the US Department of Agriculture is calculated using the formula

$$SAR = Na^{+} / \{\sqrt{(Ca + Mg)/2}\}$$

The SAR greater than 2 is not suitable for irrigation. The value of the samples ranges from 0.825 to 7.829 (meq/L) and comparing the value 65% of water is suitable for the agriculture.

ii. Sodium Percentage

Sodium in soil is considered vital for determining groundwater suitability for irrigation purpose because Na reacts with soil to reduce its permeability and support little or no plant growth. Sodium content is usually expressed in terms of percentage sodium calculated by,

$$Na\% = (Na + K) \times 100 / \{(Ca + Mg + Na + K)\} \text{ (meq/L)}$$

Based on Na%, <35 meq/l in groundwater is suitable for irrigation purposes. The value ranges from 20.376 to 65.007(meq/L) and comparing the value 72.45% of water is suitable for irrigation purpose.

iii. Total Hardness

Water hardness has no known adverse effects. However, some evidence indicates its role in heart diseases. Hard water is unsuitable for domestic use and it is a measure of the calcium and magnesium content, customarily expressed as the equivalent of calcium carbonate. Hardness of water is defined as the inhibition of soap action in water due to precipitation of magnesium and calcium salts such as carbonates, sulphates, and chlorides. It can be temporary or permanent hardness. Temporary hardness is mainly due to the presence of calcium carbonate and is removed by boiling water. Permanent hardness is caused by the presence of calcium, magnesium chlorides, and sulphates and can be cured only with ion exchange processes. TH is calculated as follows,

$$TH\ (CaCO_3)\ mg/l = (2.497)\ Ca + (4.115)\ Mg$$

The value ranges from 220.508 to 388.493 mg/L. By comparing to IS10090:2004 the 70% of water suitable for drinking.

Table 6: Water Quality for Irrigation Purpose

S. No.	SAR	Na%	Total Hardness(TH)
1	0.163	65.006	274.853
2	5.793	62.951	295.128
3	1.134	62.846	300.135
4	7.829	64.496	281.964
5	0.428	62.700	334.541
6	3.190	57.729	388.493
7	3.857	57.710	384.366
8	1.617	65.463	265.318
9	6.733	63.913	317.286
10	5.531	60.105	336.803
11	1.563	20.376	275.700
12	1.198	26.877	256.860
13	0.825	31.782	228.005
14	1.651	25.718	267.857
15	1.188	30.329	225.404
16	1.867	26.857	220.508
17	0.882	30.909	222.941
18	5.576	48.469	225.676
19	0.845	30.303	247.038
20	5.608	26.835	265.935

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V. CONCLUSION

The groundwater quality along the Cheyyar river basin has been evaluated for their chemical composition and suitability for domestic and agricultural uses. The Physical parameter are tested and range of pH is varying from 6.5-8.1, EC ranges from 403-1460.2 (μ Siemens/cm), TDS ranges from 215-452 mg/L, total hardness ranges from 140-179 mg/L and turbidity ranges from 2.5-4 NTU according to Indian standard 10050: 2004 they are within the limit. The chemical parameters tested and are concluded. The limit of Calcium according to Indian Standard there are 14 samples are within the limit and 6 samples are not within the limit and for Magnesium there are 15 samples within the limit and 5 samples are not within the limit. The value sulphate ranges from 9-23 mg/L and Chloride value ranges from 15.8-139 mg/L according to Indian standard they are within the limit. Then according to the plot the value are decrease as follows Bicarbonate, Sodium, Chloride, Calcium, Potassium, Sulphate, Magnesium. The order of abundance of chemical concentration is are Na^{+}> Ca^{2+}> Mg^{2+}> K^{+} = HCO^{3-}> Cl^{-}> So_4. The Groundwater quality is also compared with IS 10050:2004 and World Health Organization (WHO) and more 70% of Physico-chemical parameter are satisfying limit prescribed. The SAR value of the samples ranges from 0.825 to 7.829 (meq/L), Sodium percentage value ranges from 20.376 to 65.007(meq/L) .Then comparing SAR 65% is suitable and by sodium percentage 72.45% of water is suitable for the agriculture.

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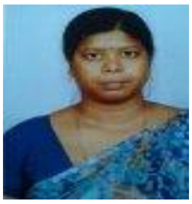

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