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Groundwater quality Monitoring in Shallow and Deep coastal aquifers of Minjur block, TN

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Abstract: Groundwater survey is an important process for determining its suitability for various uses in daily human life by measurement of its physical and chemical characteristics. The present study is aimed to establish the water quality of shallow well and bore well in and around some parts of Minjur block, Tiruvallur district, Tamil Nadu. Totally, 26 groundwater samples were collected randomly from wells during the pre-monsoon (PRM) in September 2019 and for post-monsoon (POM) in January 2020. Major ions were analyzed according to APHA standards and compared with BIS standards. In coastal aquifers, the extraction of groundwater by over pumping leads to seawater intrusion. The consequent over extracting of groundwater and sea water intrusion has also grown to be a major issue in the in Minjur block which has in turn, affected the agricultural cultivation and livelihood of many farmers and residents. Water of almost all study area is hard to very hard and also increase concentration of EC and other parameters in groundwater. Abundance of these ions are in the following order Na>Ca>Mg>K and Cl> HCO3>SO4>NO3.The Hydro chemical facies also show that the Na-Cl water type is predominant in most parts of the study area. Higher concentrations ions are seen in the eastern part of the study area and are comparatively very low in the western part, thus the concentration of ions is increasing from eastern to western parts. High value of EC in the groundwater is due to sea water intrusion. Generally, the deep water is harder than the shallow water. Based on these parameters, groundwater had been assessed and was not suitable for drinking and irrigation purposes. From this study, it is inferred that groundwater is undergoing quality deterioration near coastal areas. The study concludes the migration of sea water intrusion into the land and avoids overexploitation of groundwater to future development.

Index Terms*–*Shallow and deep wells, Physio-chemical parameters, water quality index, irrigation water quality.

I. INTRODUCTION

Groundwater is the main resource for drinking, irrigation and industrial purposes. Quality of groundwater is equally important to its quantity, owing to the suitability of water for various purposes. Coastal regions and related human influences have led to an increase in the abstraction of groundwater reserves. Groundwater salinization is one of the most importance problems that threaten the global groundwater resources in coastal areas of the world. In coastal aquifers, over exploitation of groundwater have not only influenced water quality but also declined the water table. Coastal areas often exhibit a complex distribution of fresh water and salt water or in general of different water types. Degradation of groundwater quality in coastal region generally occurs due to natural processes such as sea water intrusion, marine aerosols deposited on the top soil, evaporation and interaction of groundwater with brines and sedimentary formation [1]. Large numbers of coastal aquifers are threatened by salt water intrusion. Salt water intrusion may occur due to human activities, climate change and sea level rise. Apart from the natural process, anthropogenic contamination such as industrial effluents, agricultural fertilizers, municipal waste water, septic tank effluent and land fill are other major causes of water quality deterioration [2]. Water having TDS more than 1000 mg/l is called salt water [3]. As it has more density due to salt content, it displaces less dense fresh water when it comes into contact at coastal areas.

Groundwater along the coastal area of Tamil Nadu has been exploited heavily for agricultural, domestic and industrial purposes. Further, structural and climatic circumstances were found amenable for sea water intrusion [4]. Therefore, in the assessment of fresh groundwater potential, hydrochemistry plays an important role in coastal region. Hydrochemistry parameters were used to evaluate the impact of seawater intrusion process, the knowledge of which can be helpful to control the water quality in the coastal area [5]. In urban areas, dense population and rapid unplanned urbanization are directly related to increases in water consumption and contamination. The vast population and ever-increasing industrial activities in India, makes its water resources more vulnerable to water quality deterioration. Groundwater is threatened by several factors related to its mismanagement. Today's groundwater pollution problem mostly from human's short-term exploitation and mismanagement of water resources. As public health directly linked with quality of drinking water, its systematic monitoring is highly needed. Groundwater chemistry is governed primarily through both natural and anthropogenic variables. Groundwater chemistry can be altered through different anthropogenic sources which include point sources [6]. Many scientists have researched physicochemical and hydro chemical parameters to evaluate the groundwater characteristics [7]. Groundwater quality has changed as one of the most crucial environmental issues. Salt water intrusion into the confined and unconfined aquifers along the coastal belts of Indian territory is being increasingly reported. The problem is particularly severe in the coastal belts of Tamil Nadu, Gujarat and Kerala, Groundwater is mainly extracted from the coastal aquifers through large number of existing wells, filter wells and ponds. Number of studies on groundwater quality in respect to drinking and irrigation purpose have been carried out in different parts of India. Hence, the present work to explore the groundwater quality by carrying out water qualitative analysis of some physic-chemical parameters of groundwater in Minjur coastal region in Tamil Nadu, India. A clean and dependable supply of water is necessary to ensure a high quality of life and strong economy.

II. Study Area

The study is conducted in the Minjur block of Tiruvallur district, which is the northern part of Chennai metropolitan area. It is one developing area as the suburbs of the Chennai city. The study area is bound by the Arani River in the south, Pulicat Lagoon in the North, and Bay of Bengal in the East. Minjur is located at 13.27°N and 80.27°E. It has an average elevation of 11 meters (36 feet). With Ponneri as its north, Cholavaram as its west, Manali, and Thiruvottiyur as its South, it is situated about 30 km from the North of Chennai (Fig.1).

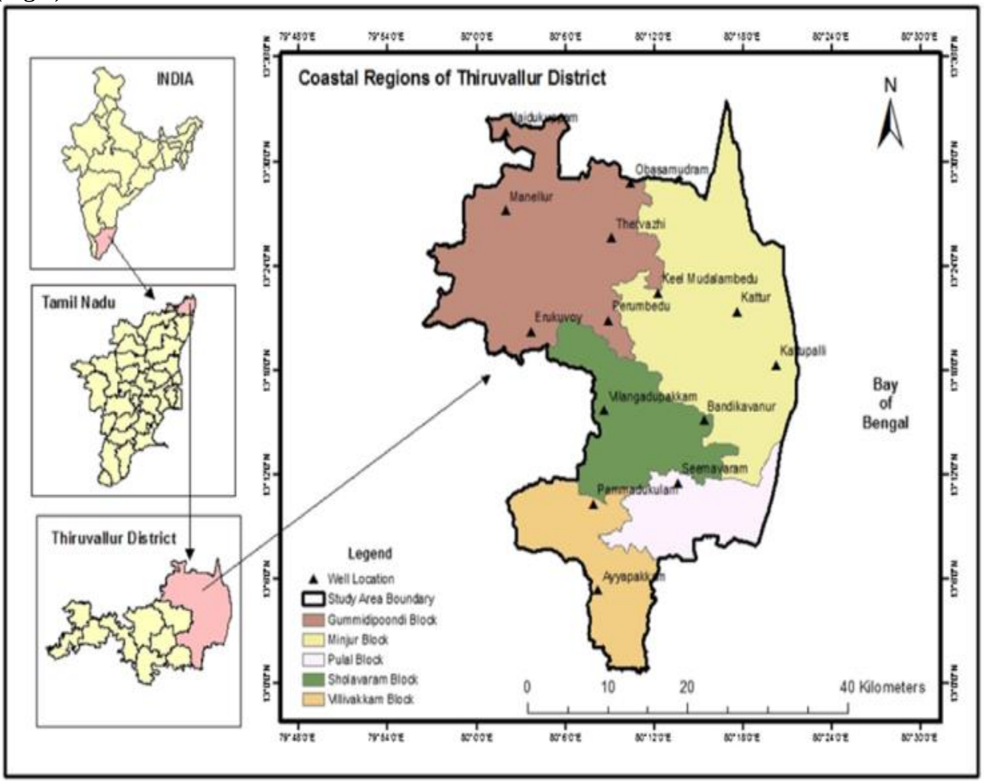

Fig.1 – Study Area Map

Minjur experiences a tropical climate. The annual mean minimum and mean maximum temperature in the study area are 24.3° C and 32.9°C respectively. It is generally hot and dry from April to June and the weather is pleasant from November to January. The temperature is increasing during the period from March to May and decreasing during the period from September to December due to the monsoon**.** Northeast monsoon i.e. from October to December is prevalent in this sub-basin. The northeast monsoon chiefly contributes to the rainfall to the study area. The average annual rainfall in the study area is about 1291 mm. The predominant soil type found in the study area is Inceptisols which are young soils with limited profile development. They are formed from colluvial and alluvial materials. Entisols are found along the coastal region of the study area. Alfisols are found near the lower part of Gummidipoondi in very few places. Minjur comprises of sandstone, conglomerate, and alluvium. The Araniyarsub-basin is occupied mostly by alluvium type. Alluvium consists of coarse-grained materials, has high groundwater potential, and is suitable for agriculture. Agriculture is the main occupation of the population. Intensive cropping activities are seen on the central portion. Paddy is the main crop cultivated here followed by dry crops such as groundnuts, pulses, vegetables, etc. Sugarcane, banana, coconut, chilies are also grown in a few places. The main source of irrigation is water drawn from rivers and tanks during regular monsoon. On other periods groundwater is withdrawn from bore wells located in the old river course, flood plain, and buried channels. Tube well irrigation is predominant in many places. Coarse sands and gravels are predominant in the study area. There is discontinuous clay interbeds near the coastal area.

III. Collection of groundwater samples

Totally 26 wells were identified during the reconnaissance survey for the collection of water samples to carry out chemical analysis (Table.1). Shallow well and deep well samples were collected during the pre-monsoon (PRM) in September 2019 and for post-monsoon (POM) in January 2020.The groundwater samples collected were analyzed for various physicochemical parameters as described by the American Public Health Association [8], and tested in the Wet Chemistry lab in Centre for Water Resources, Anna University. The measure parameters were compared with the BIS 10500: 2012 specifications and Water Quality Index is computed to identify the suitability of water for drinking. Prior to the collection, bottles were thoroughly washed with dilute

HNO_3 acid and then with distilled water in the laboratory before filling the bottle with the sample. The in-situ parameters like EC, pH, were measured in the field using a portable meter**.** The samples were collected based on the Systematic-Grid sampling method. Wells with depth less than 15m are considered as Shallow wells and wells with a depth greater than 15 m are considered as Deep wells. The well locations of the groundwater samples are given in Fig.2.

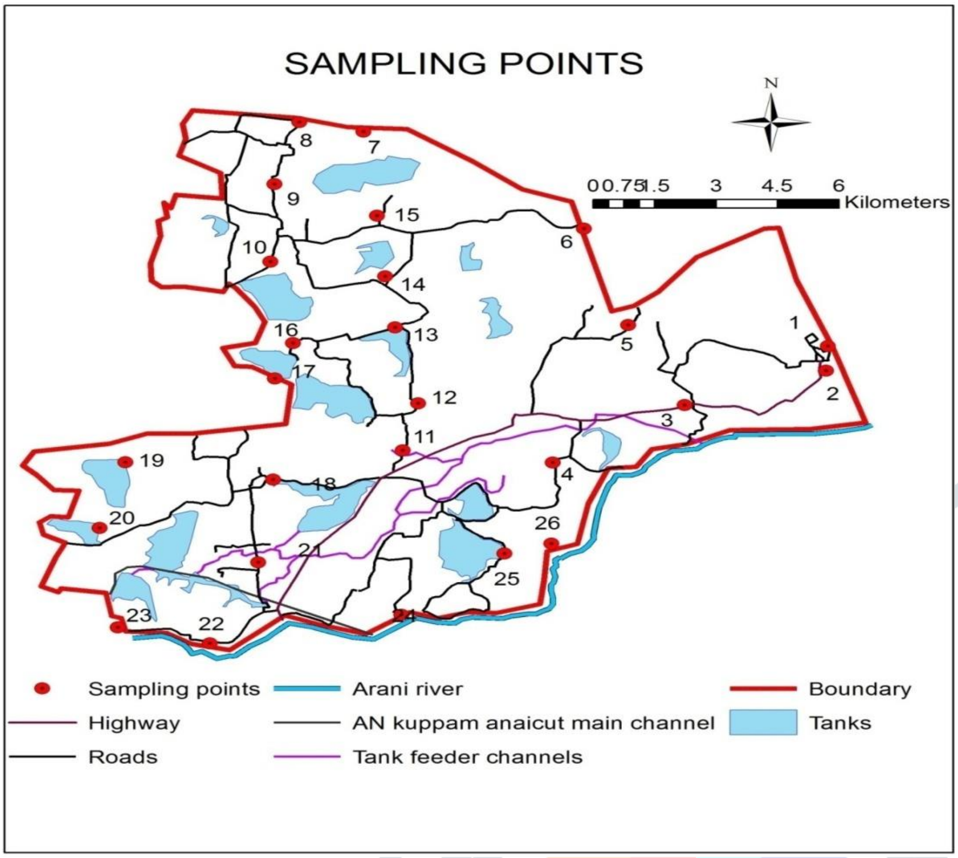

Fig.2 Map of study area showing locations of groundwater sampling

Table .1 Locations of Groundwater samples collected

Sample No.	**Location**	**Latitude**	**Longitude**	**Depth B.G.L(m)**	**Source type**	**Purpose**
1	Jamilabadh	13° 25'19.32"	80° 18'56.51"	4.5	Open well	Domestic
2	Pulicat	13° 24' 53.53"	80° 18'54.94"	4.5	Bore well	Domestic
3	Pollachiammankulam	13° 24' 17.4"	80° 17'3.27"	7.5	Bore well	Domestic
4	Vanjivakkam	13° 23' 17.26"	80° 15'18.85"	12	Bore well	Domestic
5	Aurivakkam	13° 25' 41.57"	80° 16'18.63"	3	Open well	Domestic
6	Annamalai cherry	13° 27' 22.68"	80° 15'45.72"	4.5	Open well	Domestic
7	Puthukuppam	13° 29' 14.5"	80° 12'49.22"	4.5	Open well	Domestic
8	Kallur	13° 29' 14.65"	80° 11'58.31"	4.5	Bore well	Domestic
9	Royampallayam	13° 28' 9.36"	80° 11'38.63"	4.5	Open well	Irrigation
10	Sengayam	13° 26' 48.19"	80° 11'35.6"	60	Bore well	Irrigation
11	Medhur	13° 23' 29.97"	80° 13'20.08"	40	Bore well	Irrigation
12	Avoor	13° 24' 19.21"	80° 13'32.31"	30	Bore well	Irrigation
13	Kolur	13° 25' 38.89"	80° 13'14.22"	45	Bore well	Irrigation
14	Panapakkam	13° 26' 32.49"	80° 13'6.27"	30	Bore well	Irrigation
15	Uppunelvoyal	13° 27' 36.41"	80° 12'59.77"	10	Bore well	Irrigation
16	Illupakkam	13° 25' 22.48"	80° 11'53.53"	40	Bore well	Irrigation
17	Kumanancheri	13° 24' 45.39"	80° 11'39.02"	50	Bore well	Irrigation

18	Arasur	13° 22' 59.21"	80° 11'37.5"	50	Bore well	Irrigation
19	Sombattu	13° 23' 17.43"	80° 9'40.96"	40	Bore well	Irrigation
20	Killikodi	13° 22' 8.4"	80° 9'20.47"	50	Bore well	Irrigation
21	Guduvancheri	13° 21' 32.53"	80° 11'25.99"	50	Bore well	Irrigation
22	Ponneri	13° 20' 7.53"	80° 10'47.79"	40	Bore well	Irrigation
23	Peruvoyal	13° 20' 24.28"	80° 9'34.73"	45	Bore well	Irrigation
24	Lakshmipuram	13° 20' 37.48"	80° 13'19.2"	35	Bore well	Irrigation
25	Perumbedu	13° 21' 41.9"	80° 14'40.74"	30	Bore well	Irrigation
26	Perumbedukuppam	13° 21' 52.18"	80° 15'17.85"	30	Bore well	Irrigation

IV. Results and Discussion

4.1 General Characteristics

Hydrogeochemical study helps to understand and relate the concentration of different physico-chemical parameters. The comparative graph showing the concentration of various parameter of groundwater samples collected from different locations during pre-monsoon (PRM) and post-monsoon (PSM) are discussed below.

4.2 Hydrogen Ion Concentration (pH)

The variations in pH values may be due to increase or decrease of human and other biological activities. The pH of natural water is an important factor which is influenced by the chemical and biological parameters of the water as well as toxicity of many compounds [9]. pH of the water indicates the form in which CO2 is present. The presence of carbonic acid is indicated when pH is less than 4.5, bicarbonates is present when the pH is between 4.5 to 8.2 and carbonate is associated with in pH of more than 8.2. pH values of the samples ranged between 6.4 to 7.8 in PRM and in 6.5 to 7.4 in PSM. In the study area, overall pH of the samples was found to be within the permissible limits as 6.5 to 8.5 of Indian Standards [14]. Thus, the water quality varies from slightly acidic to alkaline. The given graph depicts the pH of different samples with their respective permissible limit and

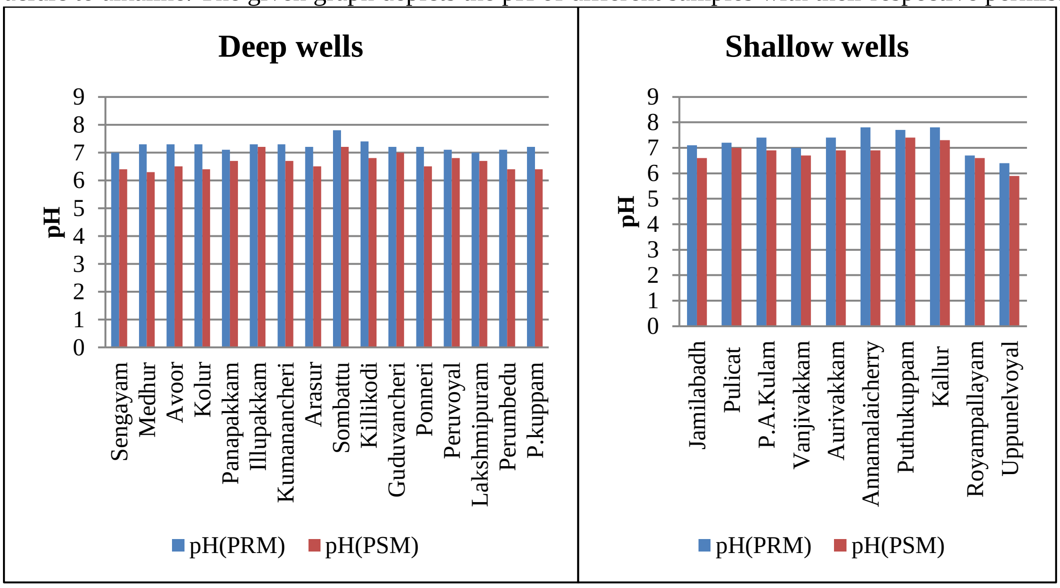

Fig.3: Graph showing village wise variation of pH

acceptable limit (Fig.3). The maximum value has been recorded among the shallow wells is in Kallur which is about 7.9 and 7.2 in PRM and PSM season. The minimum has been recorded in Uppunelvoyal which is 6.2 and 5.4 in PRM and PSM season. The maximum value has been recorded in deep wells is in Sombattu which is about 7.9 and 7.6 in PRM and PSM season respectively. The minimum value has been recorded in Seganyam which is 7.0 and 6.3 in PRM and PSM season respectively.

4.3 Electrical Conductivity (EC)

EC increases as there is salt water intrusion in the aquifer. For normal water, EC value will be maximum of 750 µS/cm. If EC is 1600 to 4700 µS/cm, water will be slightly saline and more than 4700 µS/cm, water will be saline and sea water has an electrical conductivity of 35000 µS/cm [3]. The effect of saline intrusion may be the reason for medium enrichment of EC in the study area. Hence, EC of water sample is a direct indication of sea water intrusion and EC is directly proportional to impact of intrusion. Conductance generally varies according to the season. Conductance ions from dissolved salts and inorganic materials such as alkalis, chlorides, sulphides and carbonate compounds present in water. It is directly related to the concentration of ions in the water. The higher concentration of acid base and salt in water higher will be the electrical conductance [10]. In the present study EC values ranges from 2052 µS/cm to 6889 µS/cm in PRM and in POM it ranges from 1655µS/cm to 6022µS/cm (Fig.4). In PRM when water gets concentrated the conductance goes on higher side. Conductance is not too harmful but water with higher conductance is not suitable for drinking, irrigational and other purpose. EC is the most important parameter to demarcate salinity hazard and suitability of water for irrigation purpose. The high conductivity value might be due to increase in the dissolved matter of inorganic salts. It may change the taste of water. The given graph shows the reported conductivity of the variations across the study region and identical data for different seasons monitored. The permissible limit is <1500 µS/cm for domestic use. EC values in all the samples are higher than permissible limit. Maximum EC among the shallow wells is seen at Pollachiammankulam with a value of about 6689µS/cm and 6226µS/cm in PRM and PSM. The value is extremely high in Pollachiammankulam due to saltpan activity in that area that is being practiced as a traditional business for several years, where the people directly use the Lagoon water for their business and also owing to closeness to the Coast. EC is least in Royampallayam with a value of 2052µS/cm in PRM and 1755µS/cm in PSM respectively, which is located at a distance of nearly 14 Km from the Coastline. EC is maximum among the deep wells at Kolur with a value of 4327µS/cm in PRM and 4273µS/cm in PSM; this is because of excessive pumping of water used for irrigation and reaching depth up to 45m. EC is minimum at Sombattu with a value of 2163µS/cm in PRM and 1969µS/cm in PSM. Sombattu is located at a distance of nearly 20 Km from the Coastline and villages at these stretches have comparatively low EC.

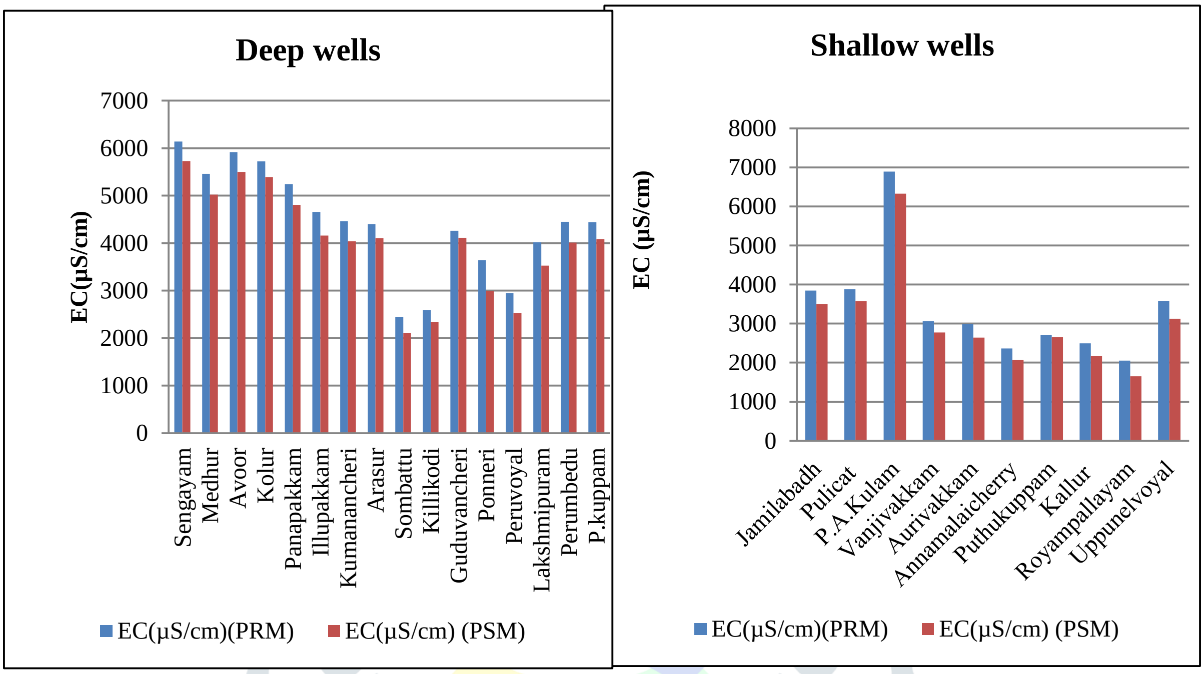

Fig.4: Graph showing village wise variation of EC

4.4 Total Hardness (TH)

Total hardness of water samples shows the presence of calcium and magnesium in groundwater. It mainly occurs from weathering of limestone, sedimentary rock and calcium bearing minerals. Locally it may occur in groundwater from chemical and mining industry effluent or excessive application of fertilizers to the soil in agricultural areas. Hardness is temporary if it is associated mainly with carbonates and bicarbonates and permanents if with sulphates and chloride. Water hardness has no known adverse effects; however, some evidences indicate its role in heart diseases [11] and hardness of 150-300 mg/l and above may cause kidney problems and kidney stone formation [12], as it causes unpleasant taste and reduce ability of soap to produce lather. Total harness is an important parameter of water for its use in domestic purpose. The acceptable and permissible limit set by Indian Standard should range between 200 mg/l and 600 mg/l [14]. The given graph (Fig.5) demonstrates the value of all the samples exceed the desirable limit for drinking and nearly 81% and 77% of samples exceed the permissible limit in PRM and PSM. Pollachiammankulam has the highest total hardness among shallow wells with a value of 1388mg/l and 1322mg/l in PRM and POM. It is the least at Vanjivakkam, with a value of 379mg/l and 349mg/l in PRM and PSM; this is due to the low amount of calcium deposits in Vanjivakkam. The least content of hardness seen in deep wells is in Ponneri. The highest content is seen in Kolur with a value of 1814mg/l and 1744mg/l in PRM and PSM because of high deposits of calcium and magnesium.

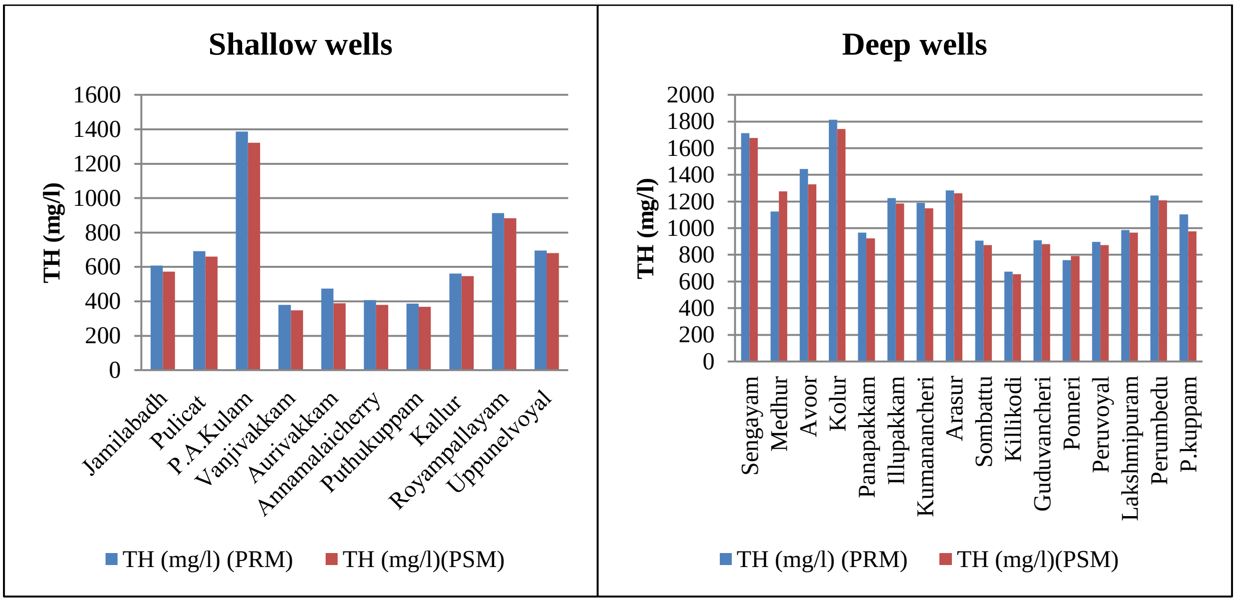

Fig.5: Graph showing village wise variation of Total Hardness

4.5 Calcium (Ca^{2+})

Calcium occurs in water naturally. The normal concentration of calcium in groundwater ranges from 10 to 100 mg/l [13]. One of the main reasons for the abundance of Ca^{2+} in water is its natural occurrence in the earth's crust. Ca^{2+} is found mostly as limestone, gypsum and fluorite. Stalagmites and Stalactites contain calcium carbonate. Ca^{2+} is a determinant of water hardness, because it can be found in water as Ca^{2+} ions. Ca^{2+} content is very common in groundwater, because they are abundantly available in most of the rocks and also due to its higher solubility. However, the range of its availability depends on

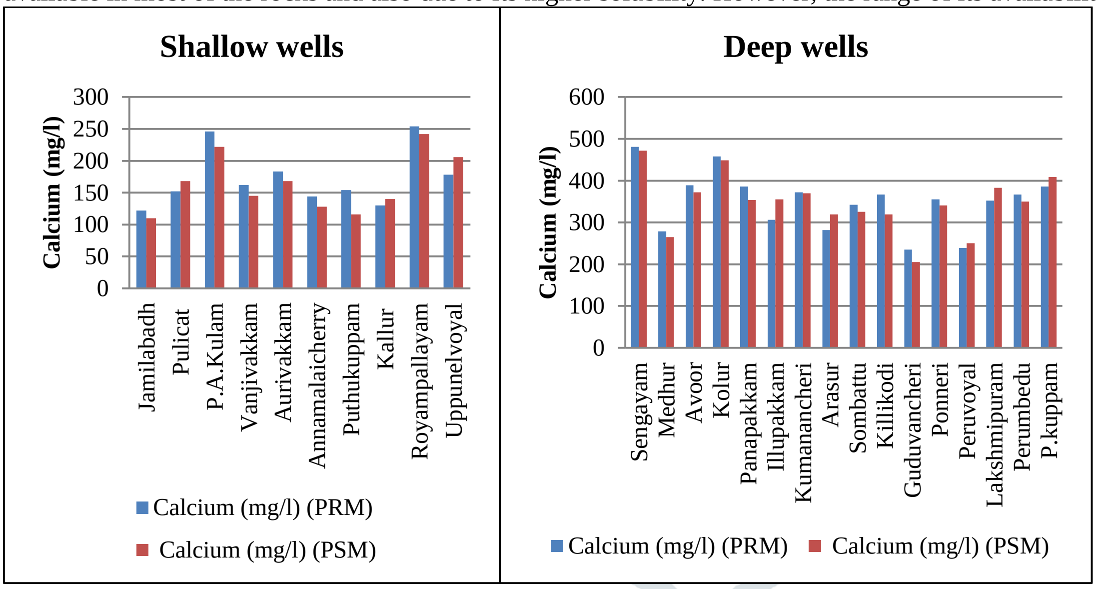

Fig.6: Graph showing village wise variation of Calcium

the solubility of calcium carbonate and sulphate. The acceptable limit is 75 mg/l and permissible limit is 200 mg/l as per Indian standards [14]. All the samples (Fig.6) exceed the desirable limit for drinking and nearly 62% and 58% of samples exceed the Permissible limit in PRM and PSM. The maximum value is seen among the shallow well in Royampallayam is about 254mg/l and 242mg/l in PRM and POM season respectively. The minimum value is seen in Annamalaicherry is 84mg/l and 71mg/l in PRM and PSM season. The maximum value is seen among the deep wells is in Seganyam is about 493mg/l and 481mg/l in PRM and POM season respectively. The minimum value is seen in Guduvancheri is about 236 mg\l and 218 mg/l in PRM and PSM season.

4.6 Magnesium (Mg^{2+})

Magnesium (Mg^{2+}) is present in large quantities in saltwater. It causes most of the hardness and scale-forming properties of water. Mg^{2+}content of water is considered as one of the most important qualitative criteria in determining the quality of water for irrigation. More Mg^{2+} in water will adversely affect crop yields as the soils become more alkaline. Mg^{2+}usually occurs in lesser concentration than calcium due to dissolution of magnesium rich minerals is slow process and that of calcium is more abundant in the earth's crust. The acceptable limit is 30 mg/l and permissible limit is 100 mg/l as per Indian Standards [14]. If the concentration of Mg^{2+} in drinking water is more than the permissible limit, it gives unpleasant taste to the water. Mg^{2+} is an essential for functioning of cells in enzyme activation, but at higher concentrations it is considered as laxative agent, while deficiency may cause structural and functional changes in human beings [15]. Therefore, most of the samples exceed the desirable limit for drinking and nearly 42% and 46% of samples (Fig.7) exceed the permissible limit in PRM and PSM in the area. The maximum value is seen in shallow well in Pollachiammankulam which is about 128mg/l and 114mg/l in PRM and PSM season. The minimum value is seen in Royampallayam is about 22mg/l and 15mg/l in PRM and PSM season. The maximum value is seen in deep well in Medhur which is about 121mg/l and 113mg/l in PRM and PSM season. The minimum value is seen in Peruvoyal is about 21mg/l and 14mg/l in PRM and PSM season.

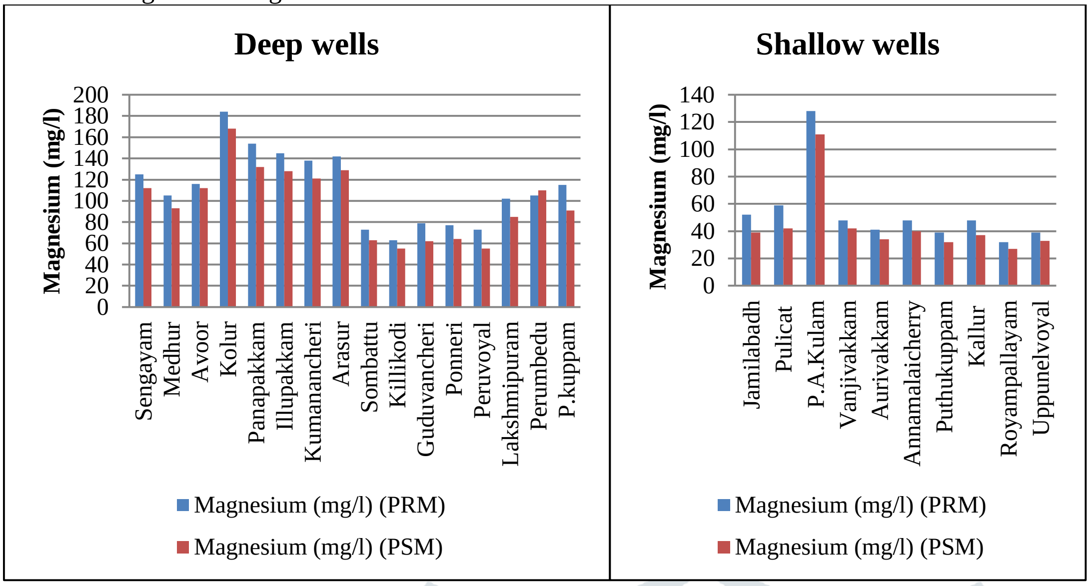

Fig.7: Graph showing village wise variation of Magnesium

4.7 Sodium (Na^{2+})

Sodium (Na^{2+}) concentration is important in classifying irrigation water because sodium reacts with soil to reduce its permeability. Excess sodium in water produces undesirable effects by changing soil properties and reducing soil permeability. Hence, the assessment of Na^{2+} concentration is of utmost importance while considering the suitability of irrigation water. Na^{2+}combining with carbonate can lead to the formation of alkaline soil, while sodium combining with chloride for saline soil. Both these soils do not help for growth of plants. Na^{2+} toxicity is recorded as a result of high Na^{2+} in water as Na% and SAR ratio. Typical toxicity symptoms to plants and trees are leaf burn and dead tissue along the outside edges of leaves. Symptoms appear first on the older leaves, starting at the outer edges and when the severity increases it moves progressively inward between the veins toward the leaf center large amounts in combination with chloride give a salty taste. It is found that deep wells all the samples are exceed the limit (>200 mg/l). Hence, air and water circulation is restricted during wet conditions and such soils are

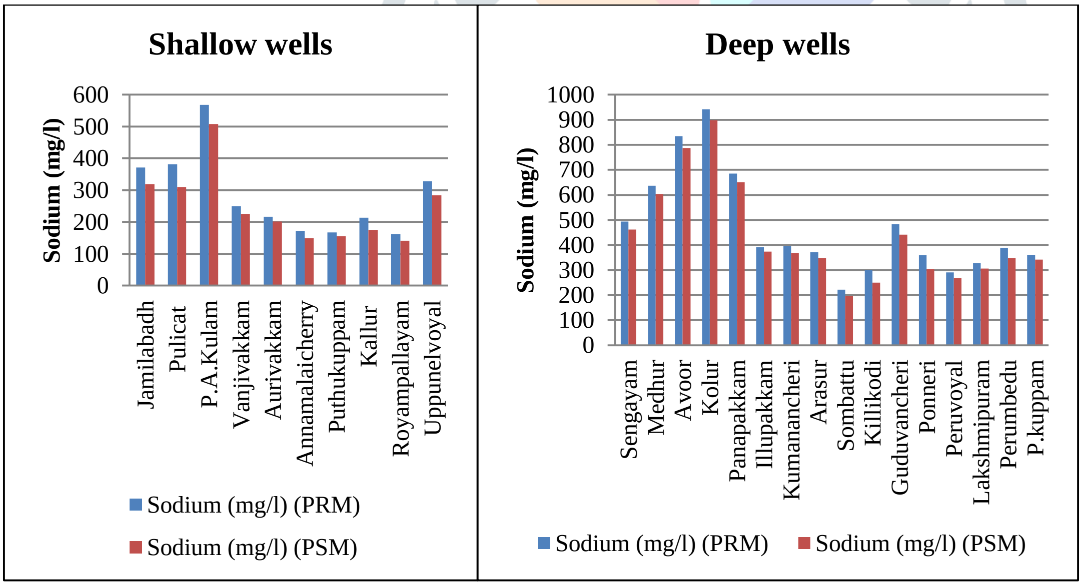

Fig.8: Graph showing village wise variation of Sodium

usually hard when dry [16]. High Na^{2+} content commonly limits the use of water for irrigation. The maximum value is seen among the shallow wells in Pollachiammankulam is about 568mg/l and 507mg/l in PRM and PSM (Fig.8) season. The minimum value is seen in Royampallayam is about 163mg/l and 142mg/l in PRM and PSM season. The maximum value is seen among the deep wells in Kolur is about 941mg/l and 859 mg/l in PRM and PSM season. The minimum value is seen in Sombattu is about 221mg/l and 196mg/l in PRM and PSM. Sodium values are high in Pollachiammankulam where saltpans are located. Because of this not only the values of Na^{2+} but the values of all the ions are very high. Na^{2+} is the dominant cation in groundwater.

4.8 Bicarbonate (HCO_3^-)

BicarbonateHCO_3^- is of little significance in public supplies except in large amounts, where taste is affected or where the alkalinity affects the corrosiveness of the water. Due to the exchange of atmospheric CO_2 with water, the CO_2 entering the system change into HCO_3.The possible source of bicarbonate include the presence of organic matter in the aquifer that is oxidized to produce carbon dioxide, which promotes dissolution of minerals [17]. The possible source of bicarbonate includes the presence of organic matter in the groundwater which is oxidized to produce carbon dioxide, which in turn promotes dissolution of minerals

This weathering enriches groundwater in Calcium, magnesium and bicarbonate ions. HCO_3^- concentration is high in some locations which are mainly due to the dissolution of carbonate minerals and agricultural return flow. The maximum value seen among the shallow wells is at Pollachiammankulam which is about 474mg/l and 413mg/l in PRM and PSM (Fig.9) season. The minimum value is seen in Aurivakkam is 157mg/l and 120mg/l in PRM and PSM season.

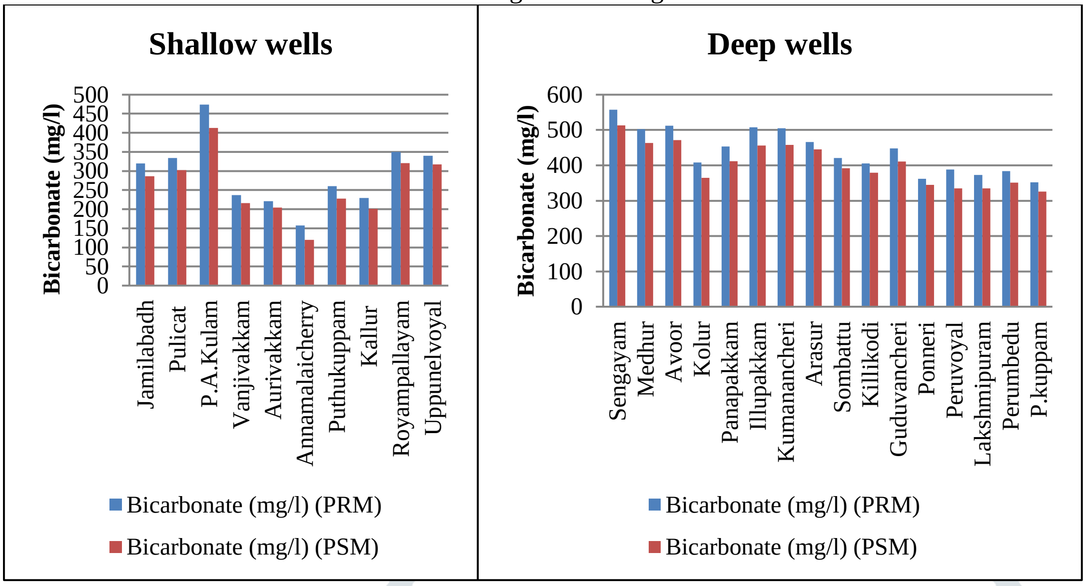

Fig.9: Graph showing village wise variation of Bicarbonate

The maximum value seen among the deep wells is at Peruvoyal which is about 557mg/l and 513mg/l in PRM and PSM season. The minimum value is noted at Killikodi which is about 205mg/l and 179mg/l in PRM and PSM season. The value of Bicarbonate is generally less near the sea and it gradually increases as the distance from the sea increases except for Pollachiammankulam where the value of all the ions is high due to saltpans. The value is very high at the ends of the study area that is at Killikodi, Sombattu, and Peruvoyal.

4.9 Chloride Cl^-

Cl^- is an important anion found in inconsistent amounts in natural water and waste-water. The Cl^- content usually increases as the mineral content increases [18]. Cl^- ion occurs in natural waters is fairly low concentrations, usually less than 100 mg/l. The concentration varies considerably according to the mineral content of the earth in any given area. Mostly, the $Cl^-$are found in the form of sodium chloride in the groundwater. Besides this, excessive concentration of the Cl^- indicates presence of pollution and is considered as tracer for groundwater contamination. Soil porosity and permeability is built up in the soil by chloride concentration. The limit of Cl^- concentration is 250-1000 mg/l and 600 is maximum allowable limit for drinking water specification [14]. High concentration of chloride gives a salty taste to water and may cause physiological damages.

The given graph represents the values of Cl^- for different samples with reference to the shallow and deep wells. High concentration of Cl^-could be dangerous from health point of view. The maximum value seen among the shallow wells is at Pollachiammankulam which is about 1160mg/l and 1015mg/l in PRM and PSM (Fig.10) season. The minimum value is seen among the Shallow wells is at Royampallayam which is about 324mg/l and 240mg/l during PRM and PSM season. The maximum value is seen in deep wells in Avoor which is about 1161mg/l and 1030mg/l in PRM and PSM season. The minimum value seen in deep wells is at Killikodi which is about 398mg/l and 305mg/l during PRM and PSM season. The values are high in shallow wells near the sea whereas at greater depths the values are even higher at very large distances from the sea this confirms the cone of depression of Saltwater intrusion at higher depths. The increased chloride concentration in a freshwater aquifer is one of the indicators of seawater intrusion.

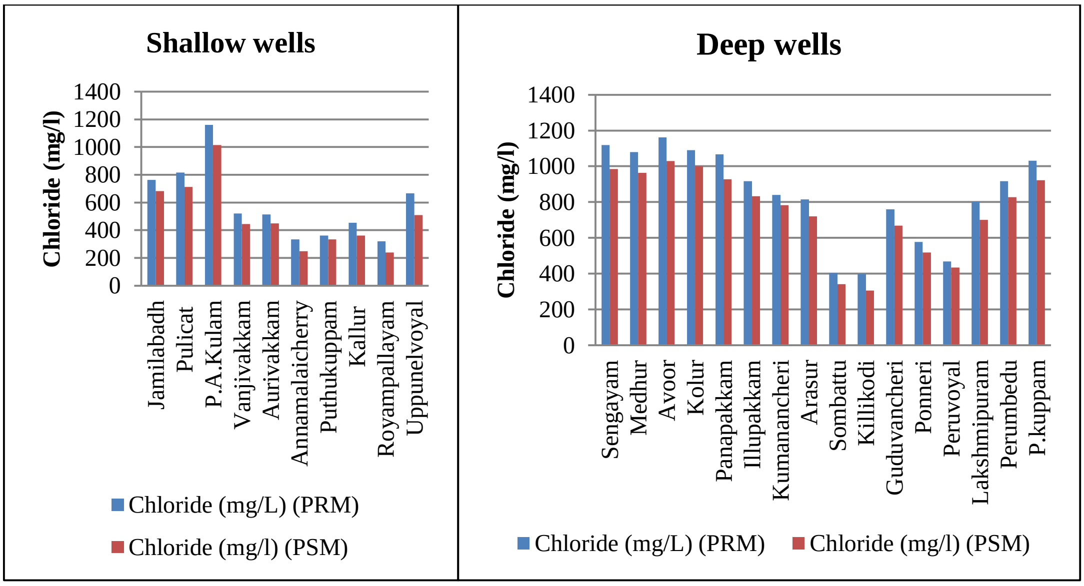

Fig.10: Graph showing village wise variation of Chloride

4.10 WATER QUALITY INDEX

The Water quality index (WQI) is one of the most effective indices to communicate the information on water quality to the stakeholders and policymakers [19]. It thus becomes an important parameter for the assessment and management of groundwater. WQI is defined as a rating, reflecting the composite influence of different water quality parameters. WQI is calculated from the point of view of the suitability of groundwater for human consumption. Several researches in India and abroad have made use of WQI for a better understanding of groundwater quality status over space. The WQI is a dimensionless number which is obtained by combining multiple water quality factors into a single number. It serves as an important parameter for groundwater assessment and management. The WQI estimation gives a single value which reduces the huge quantity of parameters and aims at representing data in a simple way. Based on the computed WQI values, the water quality is classified into five types, from "poor" to "unsuitable for drinking.

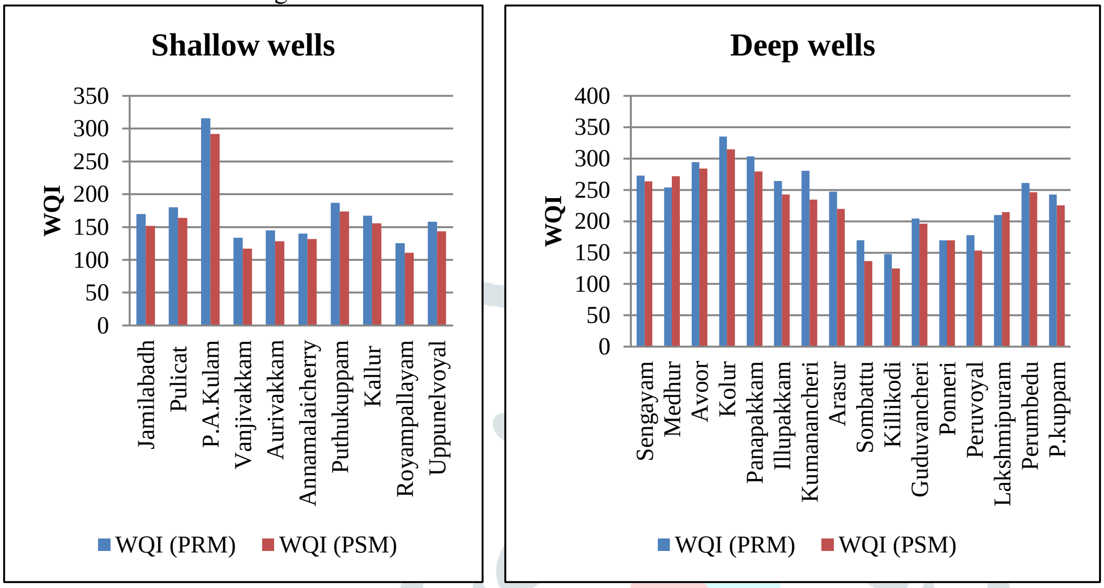

Fig.11: Graph showing village wise variation of WQI

Table 2 Water Quality classification based on WQI Value

WQI Value	Water Quality Status	Sample under respective limit
Less than 50	Excellent	Nil
50 – 100	Good	Nil
100 – 200	Poor	13
200 – 300	Very poor	10
Greater than 300	unsuitable for drinking	3

The water quality index is Poor in 50% of samples. Nearly 39% of the samples have very poor WQI and 11% of the samples are completely unsuitable for drinking. The water quality is worst among Shallow wells in Pollachiammankulam which is very close to the sea and due to the presence of Saltpans in that region. The Water quality is very good and highly suitable for drinking in Royampallayam among the shallow (Fig.11) wells, even though the WQI lies in the poor category only in this region still the value is at the border range of good and poor quality. The value is highest among the deep wells in Avoor where the highest amount of saltwater intrusion is observed. The water here is unsuitable for drinking. Similarly, the value is least in Killikodi and the villages Sombattu and Peruvoyal located at these stretches have value nearly the same value as Killikodi.

4.11 Hydrochemical Characteristics

Hydrochemical parameters dominating the groundwater characteristics can be identified by Piper diagram (Fig.12). It was created using the Aqua programme. The concentrations of major ionic constituents of groundwater samples were plotted in the Piper trilinear diagram [20] to determine the water type. The interpretation of distinct facies from the 0 to 10 ٪ and 90 to 100٪ domains on the diamond shaped cation to anion graph is more helpful than using equal 25٪ increments. It is clearly explaining the variations of cation and anion concentration during PRM and PSM. Among the geochemical facies, the Na-Cl group and mixed Ca-Mg-Cl types group are the prime water groups. The groundwater characteristics of this area most of the samples come under the Na-Cl type will generally influence a strong seawater intrusion; anthropogenic contamination is caused by excessive use of fertilizers in the coastal area The remaining samples come under mixed Ca-Mg-Cl type. This indicates cation exchange reaction, when seawater intrusion arises. The higher salinity of the groundwater samples is may be due to mixing of fresh water with seawater.

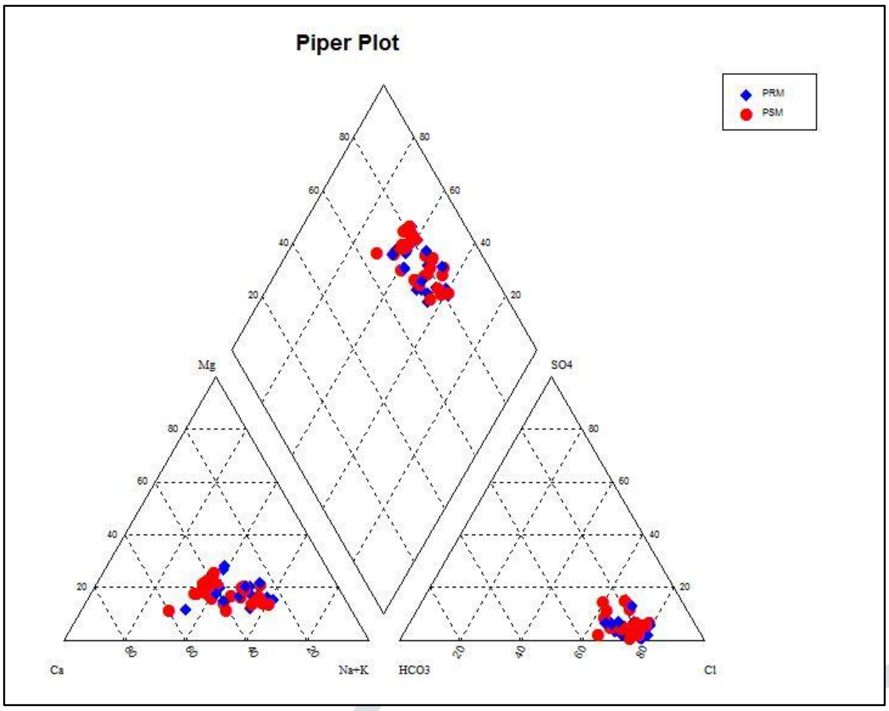

Fig.12: Piper plot

4.12 Wilcox Diagram

The chemical quality of groundwater samples was studied from plots of percentage sodium and electrical conductivity on the Wilcox diagram. A Wilcox plot can be used to quickly determine the viability of water for irrigation purposes. The agricultural crop yields are generally low in lands irrigated with waters belonging to permissible to doubtful category. This is probably due to the presence of excess sodium salts, which causes osmotic effects on soil plant system. Hence, air and water circulation are restricted during wet conditions and such soils are usually hard when dry. Also, sodium concentration more than 50 mg/l makes the water unsuitable for domestic uses because it causes severe health issues like hypertension [21]. The higher concentration of sodium may pose a risk to person suffering from cardiac, renal and circulatory diseases [22].

From Wilcox Diagram (Fig.13), in PRM, it can be inferred that 30.76% of samples are at doubtful to unsuitable limits and the remaining 69.23% come under completely unsuitable for Irrigation in the PRM period. Only at this season majority of the people go for the cultivation of crops like Babbatla paddy variety, though the water is unsuitable for irrigation in the majority of villages. People try to make use of the water that is saved in the Tank from the catchment area during the monsoon and also make use of the groundwater conjunctively in an alternate pattern during this period.

In the PSM period (Fig.14), Royampallayam alone falls under the good to permissible limit. Nearly 35% of samples fall under the doubtful to unsuitable category. Still, more than 62% of samples fall under the Completely Unsuitable category. Reduced EC values were seen in all the values due to the rain. Almost all the samples fall under the doubtful to unsuitable limit and unsuitable limit which illustrates that the groundwater from these wells are not fit for agricultural usages. Still only very few people only go for Navarai season Cultivation in the study area. This is because all those waters that were stored in that tank would have been used for the Samba period itself.

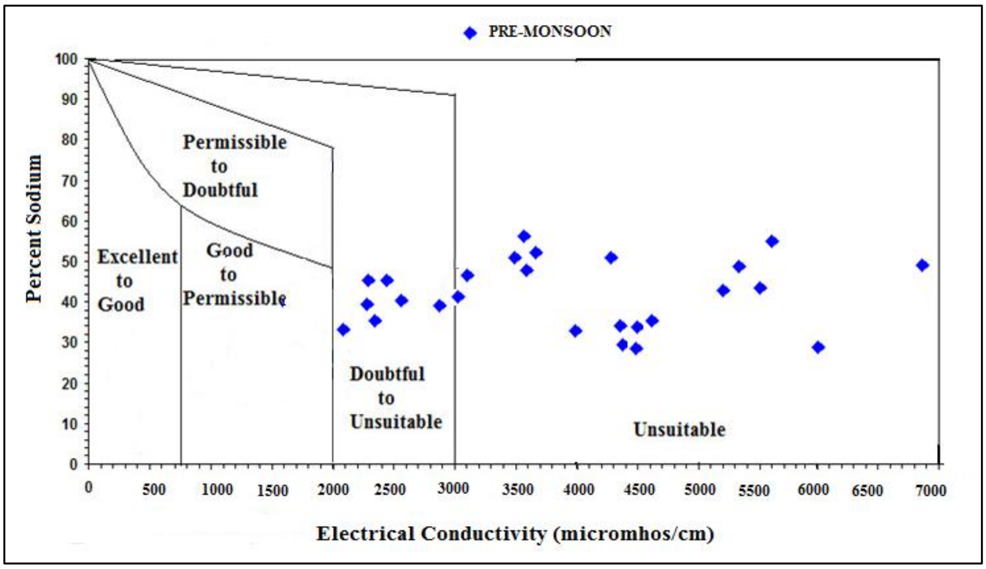

Fig.13: Wilcox Diagram (PRM)

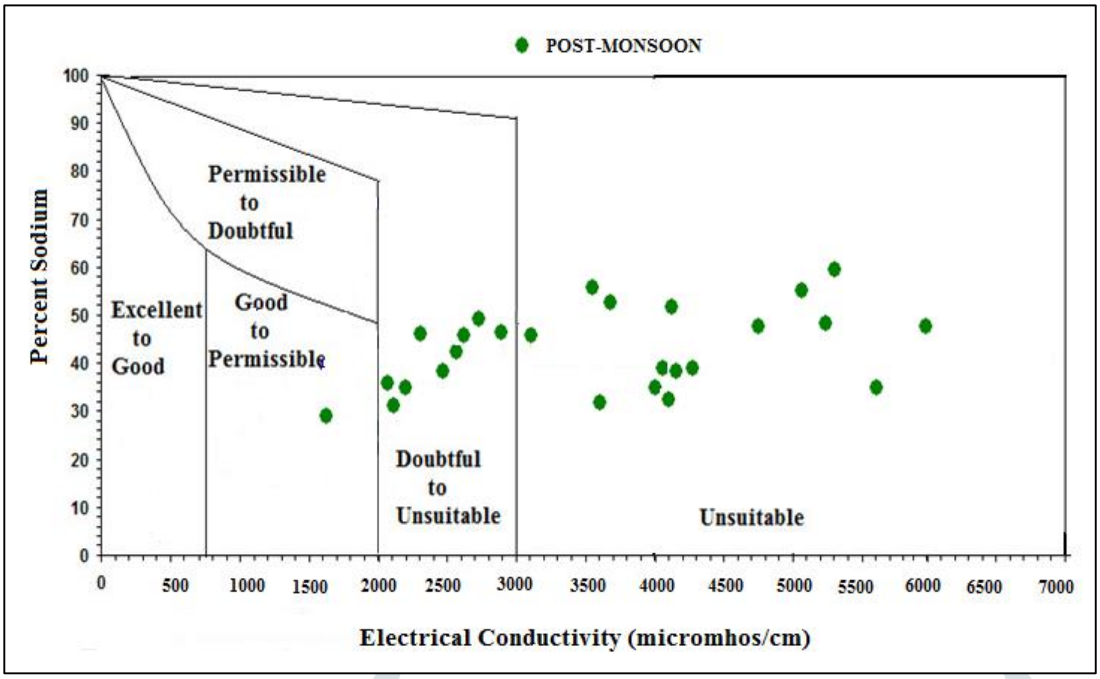

Fig.14: Wilcox Diagram (PSM)

V. Conclusion

Increasing population, urbanization and expansion in agriculture has led in the scientific exploitation of groundwater creating a water stress condition over the years. Similarly, in deep wells, nearly 70% of samples indicate saltwater intrusion at higher depths. The Sodium and Chloride content of most of the samples are very high when compared with other parameters. The order of abundance of ions are Na>Ca>Mg>K and Cl>HCO3>SO4>NO3.The Hydro chemical facies also show that the Na-Cl water type is predominant in most parts of the study area. Higher concentrations are seen in the eastern part of the study area and are comparatively very low in the western part, thus the concentration of ions is increasing from eastern to western parts. This indicates that this pollution is through Sea. Due to excessive pumping, the saltwater intrusion gets increased more and more into the freshwater aquifer making the groundwater unsuitable for irrigation.

Further, it is seen from the report that the EC level is high in the water collected from the bore wells and water quality index, total hardness, chloride, sodium is not in conformity with the standard provided and it is not fit for drinking purpose. The study on the water quality parameters for drinking and irrigation shows that most of the groundwater samples are not suitable for drinking and irrigation purposes. The harmful nature of groundwater may be due to natural saline water intrusion and also because of anthropogenic activities. It can be controlled by minimizing the over pumping and recharging groundwater through rainwater harvesting, construction of percolation tanks, ponds are constructed parallel to coast, and also artificial recharge structure across the river.

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