Indexed in
Scopus Compendex and Geobase Elsevier,
Geo-Ref Information Services-USA, List B of Scientific
Journals, Poland, Directory of Research Journals

International Journal of Earth Sciences and Engineering

www.cafetinnova.org ISSN 0974-5904, Volume 09, No. 06 December2016,P.P.2466-2471

Assessment of Groundwater Quality in a Part of Chinnar Watershed, Perambalur District, Tamil Nadu, India

S ANBARASU AND L ELANGO
Department of Geology, Anna University, Chennai – 600 025, Tamil Nadu, India
Email: *elango34@hotmail.com, geoarasu.s@gmail.com*

Abstract: Hydrochemical studies play a major role in the chemical composition of groundwater. The present study was carried out to assess the groundwater quality in a part of Chinnar watershed located in the western part of Perambalur District, Tamilnadu, India.The dominance of ions present in the groundwater follows the order as Na^+,Ca^{2+},K^+ and Mg^{2+} for cations and HCO_3^-,Cl^- and SO_4^{2-} for anions. Based on electrical conductivity the groundwater of this region is generally brackish and a few of them are classified as fresh. About 70 % of the groundwater samples were in the category of good to permissible based on the recommendation of Bureau of Indian Standards. Ca-HCO_3, Na-Cl along with Ca-Mg-Cl are the dominant hydrochemical facies of the study area. The groundwater in general is mostly alkaline with moderate salinity. The groundwater is suitable for drinking and irrigation purposes in most of the areas except for a few locations, where they are unsuitable for drinking purpose.

Keywords: *groundwater, sodium percent, irrigation, drinking water, salinity, Perambalur, Tamil Nadu, India*

Introduction

Groundwater is one of the most important natural resources in the earth. Contamination of groundwater due to various reasons is a major challenge faced by several regions of the world and it is likely to aggravate due to climate change. Groundwater is mostly used for drinking, industrial and agricultural purposes. Quality of groundwater mainly depends upon the geological formation through which it flows. Further anthropogenic activities may also either directly or indirectly affect the quality of groundwater. The dissolution and transport of fertilizers from agricultural lands into the soil and aquifers is the major cause of groundwater contamination (Elhatip et al. 2003). Though irrigation is one of the major reason for economic development in most of the countries, the quality of groundwater used for play an important role. In India, more than 90% of rural area and nearly 30% of urban areas depend on groundwater for drinking and domestic requirements (Jaiswal et al.2003). Hence, periodical assessment of groundwater for various uses is necessary. The Chinnar watershed in Perambalur district, Tamil Nadu, India is one such region where the local population and their agricultural requirment is met mostly by groundwater. The groundwater potential mapping (Velmurugan and Srinivasan 2014), quality assessment (Kasthuri et al.2007; Ahamed et al.2013) and pumping test to estimate aquifer parameters (CGWB, 2009) in some parts of Perambalur district have been studied earlier. However, no systamatic studies on evaluation of groudwater quality for drinking water and agricululral purposes on Chinnar watershed has not been studied. The present study was carried out with the objective of understanding the groundwater quality for drinking and irrigation purposes in a part of Chinnar watershed in Perambalur district, Tamil Nadu, India.

Study Area

The study area is located in a part of Chinnar watershed in the western part of Perambalur district, Tamilnadu (Fig.1). The area lies in between latitudes of $10^0 00'$ N and $20^0 02'$N and longitudes of $78^0 39'$E and $78^0 56'$E with a total area of about 450 km^2. This area is bounded by the eastern ghats in the northern, southern and western sides and is bounded by plains in the eastern side. The annual temperature of this region ranges from 20^0C to 42^0C. The atmospheric temperature vary between 28^0C and 42^0C during summer period from March to May and it vary from 20^0C to 32^0C during winter from November to January. The annual rainfall of this region is about 950 mm, in which 60% is received from northeast monsoon (October-December) and 21% is received from southwest monsoon (July-September).

Methodology

Field and laboratory methods

Based on intensive geological field studies forty three representative wells distributed more or less uniformly over this area were identified for groundwater sampling in the month of September 2015 (Fig. 1). All these wells are open wells of about 7 to 10 diameter. Initially the groundwater level these wells were measured using a waterlevel indicator (Solinist101). Then the groundwater samples were collected from these wells from 30 m below the water table. The sampling bottles were soaked in 1:1 dilute hydrochloric acid for one day and then washed 2 or 3 times with distilled water. The bottles were also rinsed three times with the water samples before collection. Immediately after the collection of water samples, that Electical Conductivity (EC) and pH were measured in the field using portable meter. Then the water samples were filtered using 0.45µm millipore filter paper and were brought to the lab for geochemical analysis. The concentration of carbonate and bicarbonate were also estimated by titration using 0.01N H_2SO_4 in the field. The concentration of other major ions were analysed by using an ion chromatograph. Blanks and standards were run intermittently to check the accuracy of analysis. Further the ion balance error was also used to verify the chemical analyses which was within ±10%.

Geology and Hydrogeology

The study area is characterised by a gentle undulating upland, hilly, gullied areas with small hillocks. Pachamalai hills of Eastern Ghats is an important feature in study area and the average height of Pachamalai hill ranges from 600 m to 1020 m above mean sea level. The surface runoff resulted in the development of subdendritic and trellis drainage pattern in this area.The area is composed mainly of crystalline formations with fissile hornblende-biotite gneiss and charnockite (Geological Servey of India, 1995) (Fig.2).

Groundwater occurs in this area under unconfined condition. The thickness of aquifer in the study area ranges from 15 to 35m. The well yield in this area ranges from 80 to 210 lpm and the top soil thickness ranges from 0.05 to 2.25m (Central Ground Water Board, 2009). The depth of the wells range from 20 to 30 m. The groundwater level in these wells fluctuate from 1 m to 20 m in a year.

Results and discussion

Groundwater chemistry

The pH of the groundwater of this area was varying from 6.6 and 8.6 with an average of 7.6 which indicates that the groundwater is slightly acidic to alkaline. The EC of groundwater ranges from 570 to 5700 µs/cm with an average of 1732 µs/cm. Based on the EC the groundwater is classified as permissible to unsuitable as per the recommendations of Bureau of Indian Standard (BIS, 2014). The dominance of ions present in the groundwater follows the order as Na^+,Ca^{2+},K^+ and Mg^{2+} for cations and HCO_3^-,Cl^- and SO_4^{2-} for anions. The geochemistry of groundwater has been understood from Piper trilinear diagram. In the study area, Na-Cl, Ca-HCO_3 and Ca-Mg-Cl are the dominant hydrochemical facies (Fig.3). Gibbs plot (1970) shows that water-rock interaction is responsible for the chemical composition of groundwater (Fig.4). This figure shows that most of the points are plotting in water- rock interaction zone except for a few samples in the evaporation zone.

Drinking Water Quality

Total Dissolved Solids

Groundwater quality is mainly based on total dissolved solids in the water (Catroll 1962; Freeze and Cheery 1979). Based on the TDS, 23% of groundwater samples exceed the permissible limit suggested by World Health Organization (WHO, 1993). TDS ranges from 364 to 3648 mg/l with an average of 1108 mg/l. In a few places of study area, groundwater is unsuitable for drinking with respect to TDS values. Based on TDS values, the groundwater in the study area is fresh to brackish.

Total hardness

Hardness of groundwater is an important component of calcium, magnesium and carbonate ions. Hardness is used to determine the suitability of groundwater quality for drinking and domestic purposes.The hardness is expressed in mg/l and is calculated using relation,

$$\text{Total hardness } [CaCO_3]= 2.5.[Ca^{2+}]+4.1.[Mg^{2+}]$$

Hardness of groundwater in this region vary from 117.18 to 971.8 mg/l with an average of 355.47 mg/l. According to Sawyer and McCarty (1967) classification of groundwater based on TH (mg/l), 5% of groundwater wells are moderate to high, 32% of groundwater wells are hard water and 63% of groundwater wells are very hard.

Major Ions

Cations

In general the concentration of calcium in groundwater is about 100 mg/l. The concentration of calcium in groundwater of the study area is ranging between 27 and 310 mg/l with an average of 102 mg/l. Only two wells (Well No.10 and 34) exceeded the BIS permissible limit of calcium, which is 200 mg/l. Calcium ions in the groudnwater of this granitic terrain might be derived from minerals like feldspar, pyroxene and amphiboles. In general, the concentration of magnesium in groundwater is 50mg/l and it vary from 4.8 to 48 mg/l with an average of 24 mg/l in the study area. Based on the magnesium concentration, the groundwater is suitable for drinking and domestic purposes. The permissible limit of magnesium is generally 100 mg/l as recommended by BIS and WHO. The concentration of sodium is generally about 200 mg/l in groundwater and in study area it varies from 22 to 756 mg/l with an average of 143 mg/l. About 16% of groundwater wells in this region exceed the permissible limit of sodium, which is 200 mg/l (BIS, 2014). The concentration of potassium in the groundwater is generally about 10 mg/l and in study area, it ranges between 16 and 234 mg/l with an average of 34 mg/l. The maximum permissible limit is exceeded in well collected from well no.34.

Anions

The concentration of chloride in the groundwater is generally 1000 mg/l in arid regions. In study area, it is ranging from 18.5 to 1514 mg/l with an average of 265 mg/l. In well no 34 the permissible limit of chloride which is 1000 mg/l as recommended by BIS (2014) has exceeded. The concentation of bicarbonate in the groundwater is 500 mg/l. Bicarbonate is the dominant anion in the study area, which is ranging from 122 to 646 mg/l with an average of 329 mg/l. About 12% of wells in the study area exceed the permissible limit of bicarbonate, which is 500 mg/l (BIS, 2014). The concentration of sulphate in the groundwater is commonly 300 mg/l. In this area, it ranges between 14 and 86 mg/l with an average of 56 mg/l. Based on sulphate concentration the groundwater is found suitable for drinking and domestic purposes.

Irrigation water quality

Salinity and alkalinity hazard

The dissolved salt content plays an important role on irrigation water quality. Based on EC, irrigation water is classified as excellent, good, permissible and unsuitable (Ragunath, 1987). In the study area, 14% of wells are good, 58% of wells are permissible limit and 28% of wells are unsuitable for irrigation purpose (Fig.4).

Sodium Adsorption Ratio (SAR) determines sodium or alkali content present in water used for irrigation. Sodium adsorption ratio is calculated by sodium, calcium and magnesium ions and it is expressed in meq/l. Sodium adsorption ratio is formulated by Richards (1954), which is used to calculate sodium adsorption ratio and expressed as

$$SAR = \frac{Na^{+}}{\sqrt{\frac{Ca^{2+}+Mg^{2+}}{2}}}$$

The EC and salinity values of groundwater are plotted in the United States Salinity Laboratory diagram (Freeze and Cherry, 1979). Based on SAR about 65 percent of wells are excellent, 23 percent of wells are good and 12 percent of wells are unsuitable for irrigation (Fig.4).

Sodium Percent

Sodium is an important cation. when excess of sodium present in irrigation water, affects the soil structure and crop yield. Sodium percent in water is used to evaluate quality of groundwater for irrigation purpose. Sodium percentage(Wilcox, 1955) is calculated by

$$Na\% = \frac{Na^{+} + K^{+}}{Ca^{2+} + Mg^{2+} + Na^{+} + K^{+}} * 100$$

where the concentrations are expressed in meq/l.

Sodium percentage against electrical conductivity of groundwater is plotted in Wilcox diagram (Fig.6). This figure shows that 19% of wells are excellent to good, 40% of wells are good to permissible, 31% of wells are permissible to doubtful and 10% of wells are unsuitable for irrigation. Most of the groundwater wells are suitable for irrigation in the study area.

Residual sodium carbonate (RSC)

Residual sodium carbonate is used to indicate alkalinity hazard in irrigation water. When there is an increase in sodium concentration in groundwater, it will precipitate calcium and magnesium on soil. The carbonate and bicarbonate concentration higher than calcium and magnesium concentration is suitable for irrigation purposes. The calculation of RSC (Raghunath 1987) is carreid out by

$$RSC = (CO_3^{-} + HCO_3^{-}) – (Ca^{2+} + Mg^{2+})$$

where the concentrations are expressed in meq/l.

Based on residual sodium carbonate values of groundwater in the study area about 82% of wells are classified as good, 9% of wells are doubtful and 9% of wells are unsuitable for irrigation purpose.

Permeability index (PI)

Permeability index is given by Donean in (1964), which is calculated with calcium, sodium, magnesium and bicarbonate concentrations as

where the concentrations are expressed in meq/l. The permeability index of groundwater of study area is ranging between 10.06 and 105.56 meq/l with an average of 28.6 meq/l. This figure shows that 74 % of groundwater wells are good category and 23 % of groundwater wells are in the permissible category and one well is unsuitable for irrigation purpose (Fig.7).

Conclusion

Groundwater is an important source for drinking, industrial, domestic and agricultural purposes. In this area, groundwater is generally brackish and a few samples are fresh, based on electrical conductivity. Based on the total hardness, most of the groundwater samples are very hard. The dominance of ions present in the groundwater follows the order as Na^{+},Ca^{2+},K^{+} and Mg^{2+} for cations and HCO_3^{-},Cl^{-} and SO_4^{2-} for anions. Na^{+}-Cl^{-}, Ca^{2+}-HCO_3^{-}, along with Ca^{2+}-Mg^{2+}-Cl^{-} are the dominant hydrochemical facies of the study area. The groundwater is mostly alkaline with moderate salinity. The groundwater is suitable for drinking as well as irrigation purposes in most of the areas except for a few locations. The chemistry of groundwater is mostly controlled by rock-water interaction and evaporation processes. This research work will serve as a baseline study on groundwater quality of the area.

Acknowledgement

The author would like to thank the UGC and CSIR NET scheme (Sr.No.2121220427, 23/12/2012) for financial support.

References

[1] Ahamed, A., Ananthakrishnan., S, Loganathan, K., Manikandan, K. 2013. Assessment of groundwater quality for irrigation use in Alathur Block, Perambalur district, Tamil Nadu, South India. Appl Water Science, 3: 763-771pp.

[2] BIS (2014). Bureau of Indian Standards specification for drinking water, IS: 14543:2014. Revised 2014, Bureau of Indian Standard, New Delhi.

[3] Catroll, D. 1962. Rainwater as a chemical agent of geologic processes- A review. U.S. Geological Servey Water supply paper, 1533: 18-20.

[4] CGWB (Central Ground Water Board) (2009) Groundwater information. Perambalur district, Tamilnadu, 1-17 pp.

[5] Doneen L.D.1964. Water quality for Agriculture, Department of Irrigation, University of California, Davis, 48 pp.

[6] Elhatip, H., Afsin, M., Kusar, L., Dirik, K., Kurmac, A., Kavurmac, M. 2003. Influences of human activities and agriculture on groundwater quality of Kayseri. Environmental Geol 44: 490-494pp.

[7] Freeze R.A., Cherry J.A.1979. Groundwater, Prentice Hall Inc. Eaglewood Cliffs, NewJersey, 604 pp.

[8] Gibbs R.J. 1970. Mechanisms controlling World Water Chemistry: Science, Vol. 170, 795-840pp.

[9] GSI (Geological Servey of India) (1995). Geology map of Perambalur district, Tamil Nadu, India.

[10] Jaiswal RK., Mukherjee, S., Krishnamurthy, J., Saxena, R. 2003. Role of remote sensing and GIS- techniques for generation of groundwater prospect zones towards rural development- an approach. Int J Remote sen 24 (5)- 1008.

[11] Kasthuri, R., Kalaivani, D., Banumathi, Shanmugapriya, R. 2007. Evaluation of water quality in A.Mettur area of Perambalur district. Indian J of Environ Protection 27(11): 1011-1014pp.

[12] Piper A.M.1944. A graphical procedure in the geochemical interpretation of water analysis, Transactions-American Geophysical Union, 25, 914-928 pp.

[13] Ragunath H.M. 1987. Groundwater. Wiley Eastern Ltd., New Delhi, 563 pp.

[14] Richards , L.S. 1954. Diagnosis and improvement of saline and alkali soils. U.S. Department of Agriculture handbook.

[15] Sawyer, C.N., McCarty, P.L.1967. Chemistry for sanitary engineers and classification of naturally soft and naturally hard waters to sources and hardness of their water supplies, J. Hygiene.

[16] Velmurugan, T., Srinivasan S. 2014. Groundwater potential mapping in Chinnar watershed using Remote Sensing and GIS. International Journal of Engineering Research and technology, Vol. 3, 2278-0181.

[17] WHO. 1993. Guidelines for drinking water quality, Vol.1, 2nd edn, Recommendations, WHO, Geneva, 130 pp.

[18] Wilcox, L.V. 1955. Classification and use of irrigation waters, USDA, circular 969, Washington DC, USA.

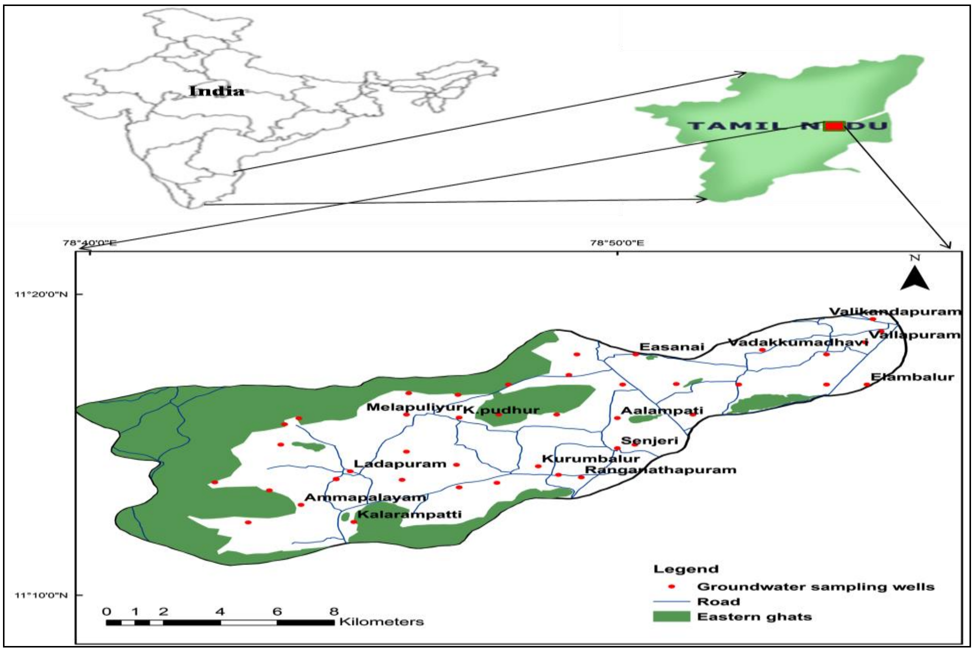

Fig.1 *Location of the study area and groundwater sampling wells*

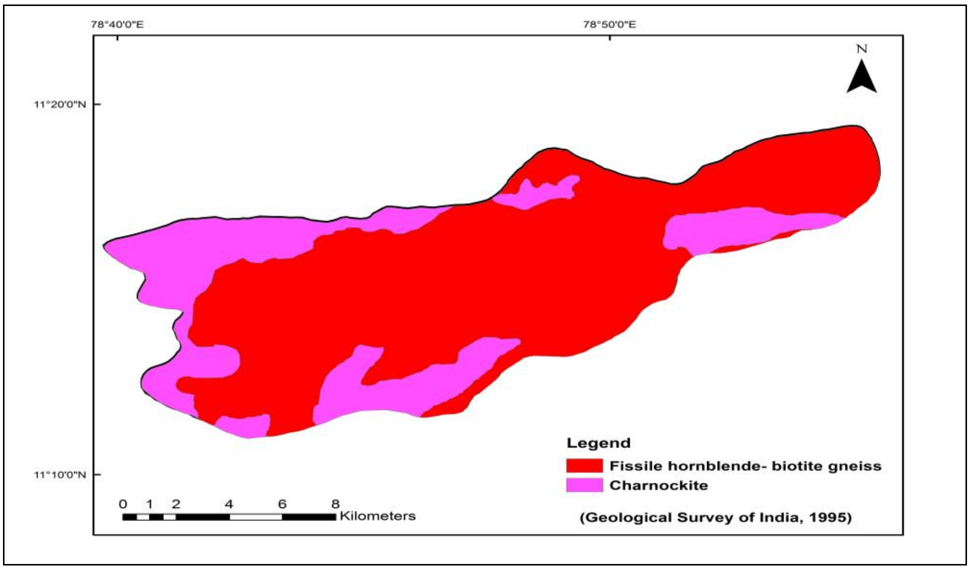

Fig.2 *Geology of the study area*

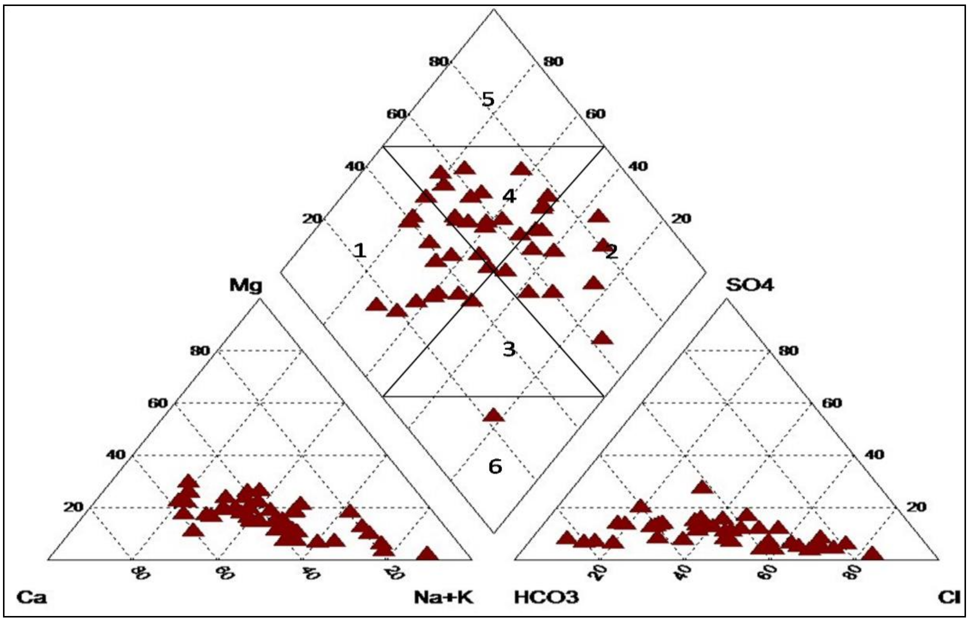

Fig. 3 *Piper trilinear diagram showing major hydrochemical facies of groundwater*

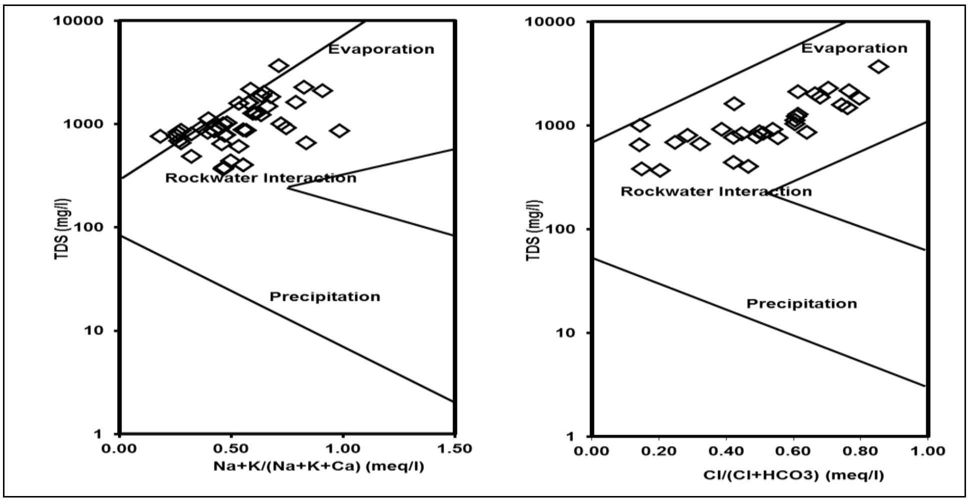

Fig. 4 *Gibbs plot showing the major processes controlling the chemistry of groundwater*

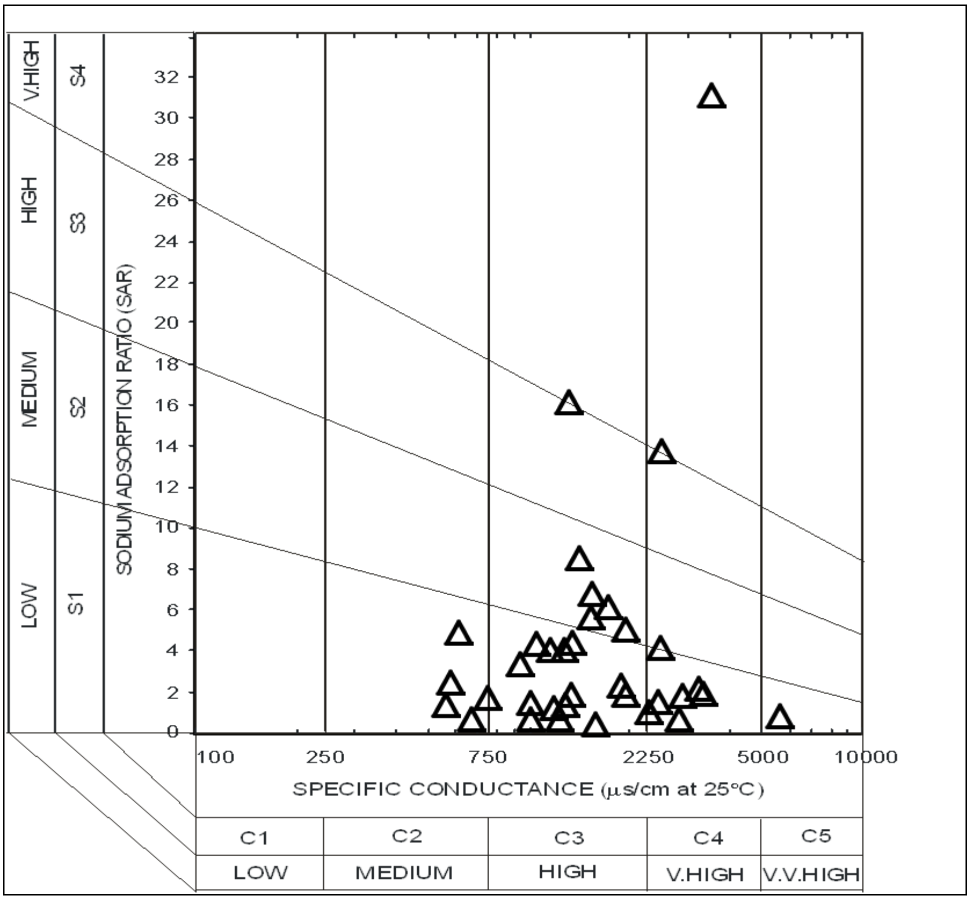

Fig. 5 *Suitability of groundwater for irrigation based on sodium and salinity hazard*

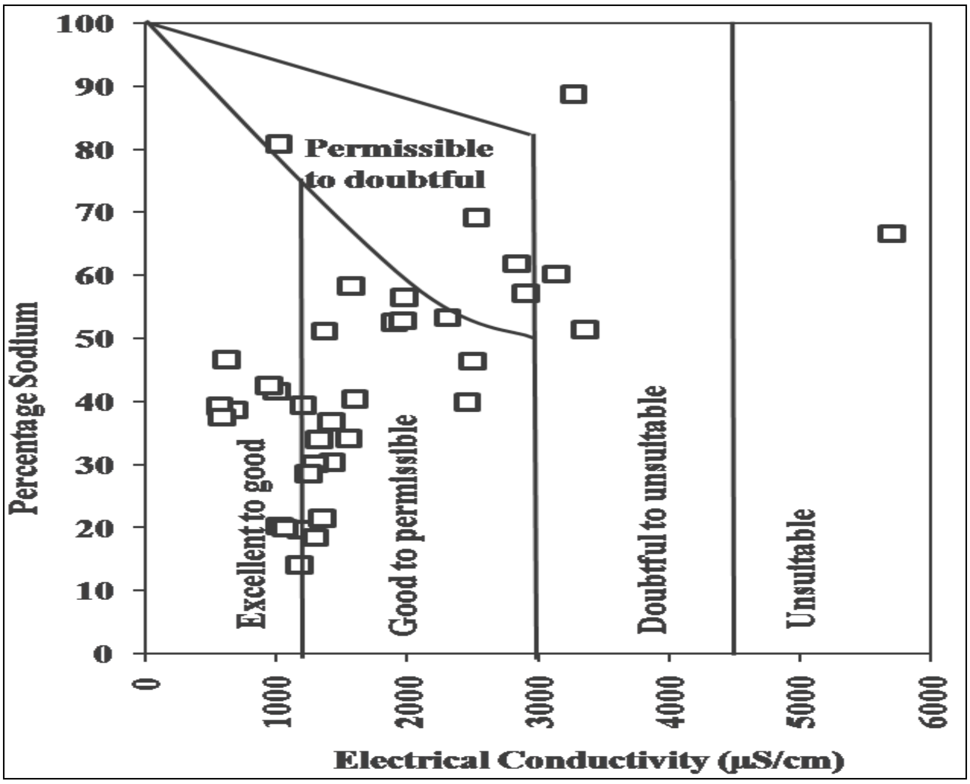

Fig. 6 *Suitability of groundwater based on EC and sodium percent*