Evaluation of Groundwater Quality of Phreatic Aquifers along Urban Clusters of Kozhikode Coast, Kerala, India.

JESIYA N P[1] AND GIRISH GOPINATH[2]

[1]*Research Fellow, Geomatics Division, Centre for Water Resources Development and Management, Kozhikode, Kerala, email id: jesynp@gmail.com*

[2]*Scientist, Geomatics Division, Centre for Water Resources Development and Management, Kozhikode, Kerala, email id: gg@cwrdm.org*

Abstract

It is essential to assess the impact of urbanization on quality and quantity of groundwater for its optimal utilization and sustainable environment. An attempt has been made in this study to evaluate the groundwater chemistry along phreatic aquifers of Kozhikode coast, Northern Kerala, India. The entire study area is categorized into three, based on their degree of urbanization.75 Groundwater samples were collected during pre-monsoon period of 2013 and analyzed for various physical and chemical parameters such as Electrical Conductivity(EC), pH, Total Dissolved Solids(TDS),Na^+, K^+, Ca^{2+},Mg^{2+},HCO_3^-,$Cl^-$$SO_4^{2-}$,$NO^{3-}$, PO_4^{2-}. The analytical results present the abundance of the ions in the following order $Na^+ > Ca^{2+} > Mg^{2+} > K^+ = HCO_3^- > Cl^- > SO_4^{2-}$. pH Ranges from 5 to 8.4 with an average value of 6.5. The Total Dissolved Solids (TDS) of the sample ranges from 28 mg/L to 2210 mg/L with an average value of 220 mg/L, which shows that most of the groundwater sample comes under freshwater category except some sample which lies in the higher order urban aquifers. Nitrate and phosphate concentration are well within the limit for drinking water as per BIS 2012. The Sodium content in groundwater of the area varies from 1mg/L to 585 mg/L and its concentration is high in certain locations (>200 mg/L) of higher order urban clusters. Chloride is the second major anion next to bicarbonate and exceeds the permissible limit of 250 mg/L for drinking at two locations of urban cluster. Na/Cl ratio indicates that 14% of the wells in the study area are affected by Saline Water Intrusion to some degree and 10% showing Na/Cl ratio (>1) may be an indicative of anthropogenic contamination. The quality assessment of the groundwater samples in the study area reveals that, certain wells that lies in higher order urban clusters showing quality deterioration.

Keywords*: Groundwater; higher order urban clusters; Saline Water Intrusion; Kozhikode*

1. Introduction:

Water in urban areas has several functions for nature and man, as a natural resources as well as providing space for recovery and well-being. The natural hydrological cycle and water balance are very much influenced in urban areas by activities of the population [5].Water in urban areas is used for many times, even reused several times and finally drained into environment carelessly. This leads to strong impacts on the groundwater and the surface water bodies. Heavy and concentrated groundwater abstraction leads to a continuous decline of groundwater level, provoking an expensive and inefficient cycle of well deepening. Associated major changes in hydraulic head distribution within aquifer lead to reversal of groundwater flow direction. This reversal can induce serious water quality deterioration as a result of the ingress of sea water/ sewage waste [3]. A comparative estimate of groundwater availability, utilization and quality aspects on areas in different stages of urban development have to be obtained to improve the present water demand and to meet the future requirements [10]. Kozhikode coast, one among the major higher order urban zones of the state where the demand for groundwater resources has accelerated in recent times has been selected as a model for such a comprehensive study. The high density of population in this coastal zone has necessitated a large scale housing development and near the urban centre, the density of housing has reached such alarming proportions. The unusual shortage of surface water and a great demand for groundwater resource, salt water intrusion, quality problems in drinking water, and coastal erosion are some of the problems faced by the coastal zones [6]. Quality of groundwater is equally important to its quantity owing to the suitability of water for various purposes. Variation of groundwater quality in an area is a function of physical and chemical parameters that are greatly influenced by geological formations and anthropogenic activities.

Knowledge on hydrochemistry is more important to assess the quality of groundwater for understanding its suitability for various needs [9]. In the present study, an attempt has been made to characterize the groundwater quality of this region with respect to their chemical composition. It is expected that, this preliminary study may throw light on groundwater quality of this region, with the objective of comparing the drinking water quality with BIS recommended drinking water quality standard.

1.1 Study area:

The area chosen for the study is all along the coast of Arabian Sea, at a distance of about 10 km from the coast and it forms a part of Kozhikode District, northern Kerala. Topographically the area has two regions, viz-sandy coastal zone (Lowland) and Lateritic midland region. The study area includes important urban clusters and the area with low to high degree of urbanization. It is geographically located 11^o 71'N to 11^o 43' N latitude and 75^o 32' to 75^o 55' E Longitude. The aerial extent of the study area is 483km^2.

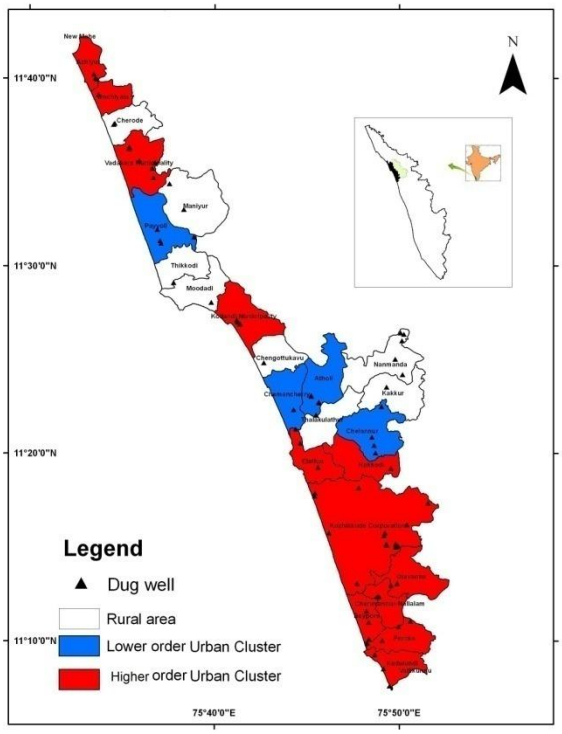

Figure 1. Location map

2. Material and methods:

Groundwater Samples were collected from 75 dug wells distributed over the study area for the pre-monsoon season (April) of 2013. The chemistry of groundwater is sensitive to environmental change, therefore electrical conductivity, pH, Salinity were measured and recorded in-situ using Digital meters.

The samples were collected for the analysis of major cations such as Na^+, K^+, Ca^{2+}, Mg^{2+} and anions such as Cl^-, HCO_3^-, SO_4^{2-} , NO_3^- and PO_4^{2-}. Analysis of groundwater samples were carried out using the standard methods for water analysis as suggested by the American Public Health Association [1].

3. Results and Discussion:

The pH of the sample ranges from 5 to 8.4 showing an average value of 6.5.According to BIS standards pH of the majority of samples lie within the desirable range with some exceptions. Electrical conductivity is a measure of capability of water to transmit electrical current and it represent the total concentration of soluble salts in water. The EC values

of the study area vary from 49.1µs/cm to 3810 µs/cm. High values are noticed in the areas, which lie very close to sea, and it is under higher order urban clusters. The Total Dissolved Solids (TDS) of the sample ranges from 28 mg/L to 2210 mg/L with an average value of 220 mg/L, which shows that most of the groundwater sample comes under freshwater category [4] and within the permissible limit for drinking water as per BIS standard except some sample which lies in the coastal aquifers. The figure.2 shows the isocone maps of sodium, chlorine and sulphate.

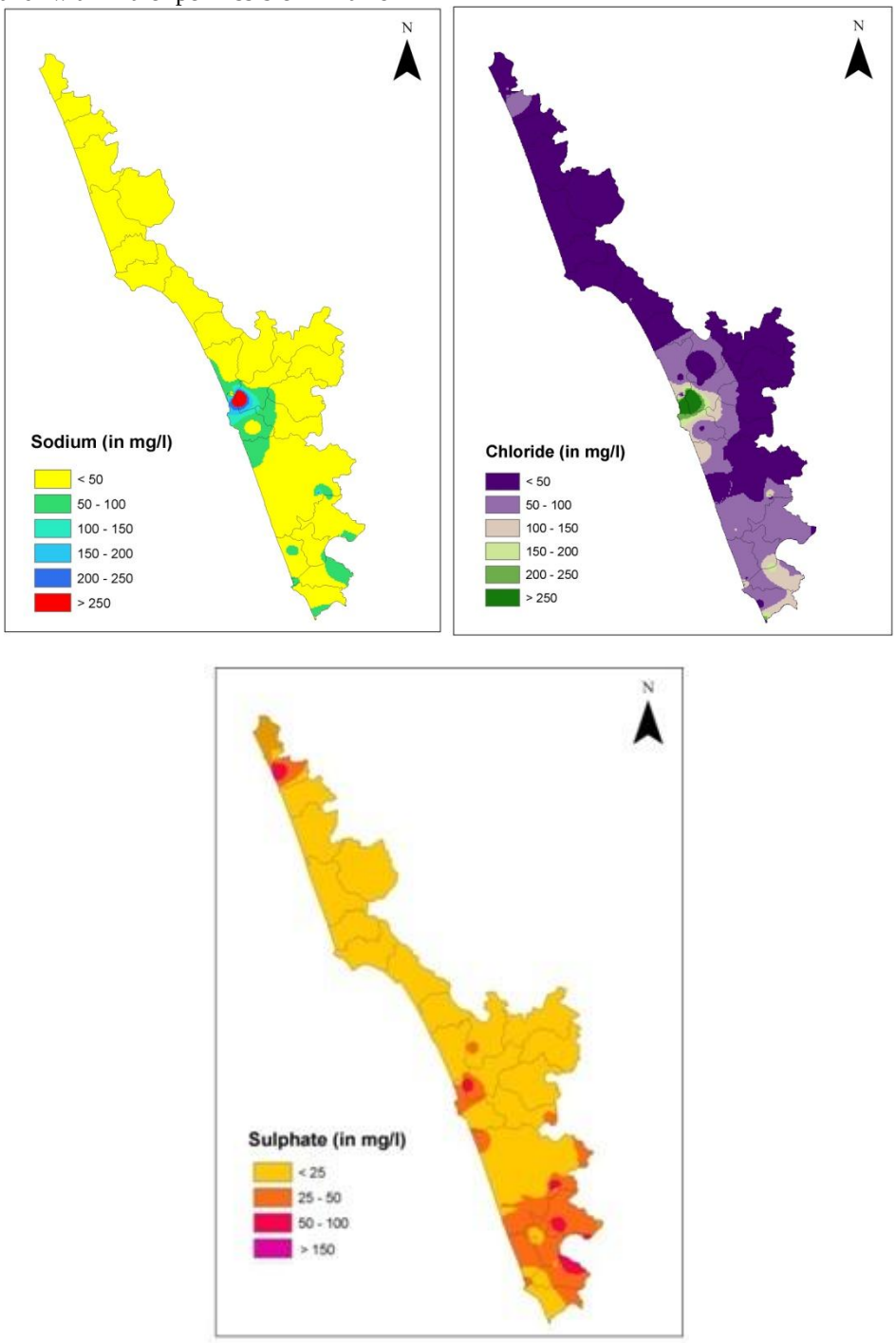

Figure 2. Map showing the concentration Sodium, Chloride and Sulphate in the study area

The concentration of major cations and anions are found more near the coastal region of Kozhikode Corporation. The analytical results present the abundance of the ions in the following order $Na^+ > Ca^{2+} > Mg^{2+} > K^+$ and $HCO_3^- > Cl^- > SO_4^{2-}$. Sodium is the major cation and its concentration in groundwater varies from 1mg/L to 585 mg/L. According to BIS its concentration is beyond the acceptable range in certain locations (> 200 mg/L) in coastal urban clusters. Chloride is the second major anion next to bicarbonate and exceeds the permissible limit for drinking water as per BIS 2012 at two locations in urban cluster. The high level of TDS in these places may be because of sewage waste, urban runoff and salinity in the aquifer system. Nitrate and phosphate concentration are well within the limit for drinking water as per BIS 2012. High concentrations of these major ions are found in the higher order urban clusters of Kozhikode District, where the population density is high. High correlation is observed between Na^+ and Cl^- for the pre-monsoon period of 2013 as shown in Figure 3.

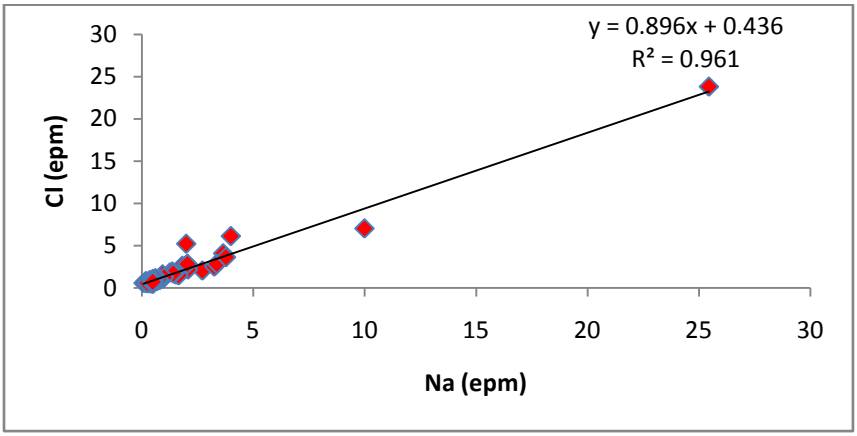

Figure 3. Na vs Cl

Seawater intrusion is characterized by the ratio Na/Cl. When saltwater enters in to fresh aquifers, an exchange of cations occurs and the exchanger [7, 8] takes Na^+. Na/Cl ratio of the present study indicates that 14% of the wells in the study area are affected by saline water intrusion.10percentage showing Na/Cl ratios greater than 1 suggesting other sources (natural or human) of contamination of freshwater [2]. The water samples which showing the above results comes under higher order urban aquifer. The urban aquifers showing a tendency to saline water intrusion may be due to the over extraction of groundwater in those areas. The quality assessment of the groundwater samples in the study area reveals that, certain wells that lies in higher order urban clusters showing quality deterioration.

3. Conclusion:

One of the major challenges faced by global community in present era is the availability of potable water. Qualitative understanding of spatial groundwater chemistry plays a vital role in the sustainable groundwater development and management. The order of abundance of major cations in the samples is $Na^+ > Ca^{2+} > Mg^{2+} > K^+$ and $HCO_3^- > Cl^- > SO_4^{2-}$. 14% of the wells in the study area are affected by saline water intrusion and 10% of the wells showing Na/Cl ratios greater than 1, suggesting anthropogenic sources of contamination of freshwater. The study reflects that, the quality deterioration in the groundwater system in the study area is found near the higher order urbanized area.

4. Acknowledgements:

The authors express their sincere thanks to the Executive Director, CWRDM (Centre for Water Resources Development and Management) and acknowledge gratefully the funding received under the scheme of KSCSTE

5. References:

1. APHA.. "Standard Methods for the Analysis of Water and Wastewater", *American Public Health Association*. 33rd edition, Washington. DC: 949p., 2002.
2. El, Moujabber, M., Bou, Samra, B., Darwish, T., Atallah, T, "Comparison of different indicators for groundwater contamination by seawater intrusion on the Lebanese coast",Water Resources Management, 20:161–180p., 2006
3. Foster S.S.D., A review on the inter dependence of groundwater and urbanization in rapidly developing cities, Urban Water 3,185-192p., 2001.
4. Freeze, R.A. and Cheery, J.A., *Text Book of Groundwater*. Prentice Hall, Englewood Cliffs., 1979.
5. Lindh, G., Water in the city, UNESCO, Paris., 1983
6. M. Nazimuddin, Thesis on "Coastal hydrogeology of Kozhikode, Kerala"., 1993.
7. Petalas, C., Pisinaras, V., Gemtizi, A., Tsihrintzis, V.A., Ouzounis, K.,"Current conditions of saltwater intrusion in the coastal. Rhodope aquifer system, North-Eastern Greece", *Deaslination*, 237:22-41., 1993.
8. S.I. Korfali and M. Jurdi., Deterioration of coastal water aquifers: Causes and Impacts, *Europian Water*, 29:3-10p., 2010
9. T. Subramani, L.Elango, S.R. Damodarasamy.,"Groundwater quality and its suitability for drinking and agricultural use in Chithar River Basin, Tamil Nadu, India"' *Environ Geol* 47: 1099–1110p.,2005.
10. Yoshikoshi, A., Adachi I, Taniguchi T, Kagawa Y, Kato M, Yamashita A, Todokoro T,Taniguchi M , Hydro-E nvironmental changes and their influence on the subsurface environment in the contextof urban development, Science of the total Environment, 407, 3105-3111p., 2009