# GIS BASED ASSESSMENT OF GROUNDWATER QUALITY

*-A study of Kanchipuram District*

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***Abstract:*** The urbanization, climatic changes, population density and agriculture are the most important factors that influence the depletion of groundwater quality. The district of Kanchipuram is pre-historically important and its proximity to Chennai leads to fastest growth of urban in the 21st century. This paper deals with the assessment of Ground Water Quality (GWQ) for both pre-monsoon (2016) and post-monsoon (2017) using GIS techniques. For estimation of GWQ, this study uses seven chemical parameters of water such as Total Dissolved Solids (TDS), Calcium ($Ca^{2+}$), Chloride ($Cl^{-}$), Magnesium ($Mg^{2+}$), Sodium ($Na^{+}$), Sulfate ($SO_4^{2-}$) and Nitrate ($NO_3^{-}$). This study found out that the maximum GWQ index level in pre-monsoon ranges from 80 to 86 and ranges from 75 to 85 in post-monsoon season. These two results has been analyzed based on taluk wise and found out that the lowest water quality stands around Chennai metropolitan taluks of Kanchipuram. The Alandur taluk shows the 100 % of area having low water quality in pre-monsoon and 95.6% area in post-monsoon in 2017. In the overall study area, Cheyyur taluk records very high quality dispersion of 78.90% area and 70.19% area in pre and post monsoon respectively.

***Index Terms-*** **Urbanization, Chemical parameters, WHO, Contamination, Groundwater Quality Index**

## I. INTRODUCTION

The quality of groundwater represents the purity of the water present under the sub- surface of earth. It is a very importance source for drinking and other purpose for people around the world. Ground water contamination recently has increased by various anthropogenic activity and natural way (Bilgehan Nas et al 2008). Especially, in Asia and African continents there is a more threaten for ground water quality. In developing countries, water resources often gets polluted mainly because of anthropogenic interfering due to the permeation of harmful physical and chemical agents and biological pathogens. Therefore, to preserve good human health, water needs to be safe to drink and should meet the national and international standards of taste, colour, odour and appearance (Cheesbrough 2006; Adetunde et al. 2011; Banerji 2018). In India, groundwater plays a main role in shaping the economic and social health of many urban center (Patel A et.al 2008). Urbanization, population growth, climatic changes and industrialization are the factors which more intensive to the degradation of groundwater. The degradation has become a serious environmental alarm in Asian expansive metropolises undergoing economic growth (Foster and Chilton 2004; Hosono et al. 2010; Nasrabadi, T et.al 2013). In the Kanchipuram district of Tamilnadu, the GWQ is under-going severe contamination in recent trends. This study analyses GWQ index based on GIS perspectives. The site suitability analyses, managing site inventory data, estimation of groundwater vulnerability to contamination, groundwater flow modeling, modeling solute transport and leaching, and integrating groundwater quality assessment models with spatial data to create spatial decision support systems nowadays are commonly generated in GIS techniques.(Engel and Navulur 1999; Khan 2010).

## II. STUDY AREA

Kanchipuram district is located between 11°00' and 12°00' North latitude and 77°28' and 78°50' East longitude. According to the 2011 census, the total population of Kanchipuram district was 7.214 crores in person. For the administrative purpose, the district is been divided into 3 revenues and 10 taluks. It is the 15th largest district in Tamilnadu, occupying an area of about 4483 square kilometres. Most of the area in Kanchipuram district is been covered by undulated plains with some residual hills. The coastal region is been covered by a very gentle plain. The Palar River is one of the most important river of this district. Vegavathi and Cheyyar are the main tributaries of Palar River. Adyar and Coovam, flowing across Chennai city are also important rivers in this district. The district has plenty of lakes such as Madhuranthagam Lake, Kalavai Lake and Chembarambakkam Lake, which acts as a main source of drinking water for the major parts of district. In summer season, the district becomes too hot. The Northeast monsoon brings more rainfall than the Southwest monsoon. The average annual rainfall from Northeast monsoon is 56% and from Southwest is 34% respectively. The overall quality of soil of this district is comparatively poor than other districts of Tamilnadu.

Paddy cultivation is the major agriculture activity in the district. The proximity of Chennai Metropolition City, harbours, airports and other transport facilities leads to a high industrial and urban growth in and around this region.

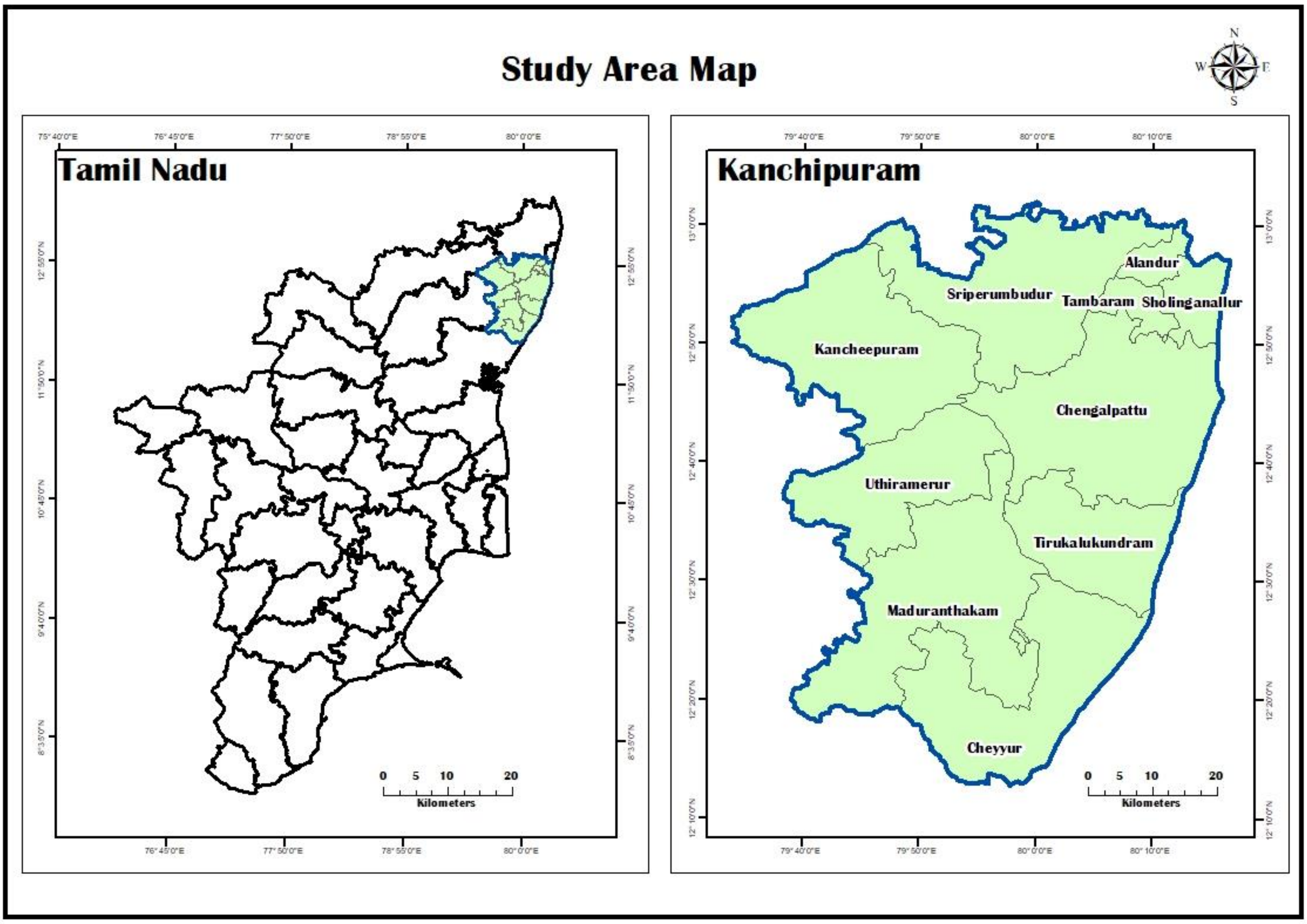


**Figure-1. Study Area Map**

## III. DATA AND METHODS

The study analyses the ground water quality based on secondary data for pre-monsoon in the month of September 2016 and for post-monsoon in the month of January 2017. The Groundwater Quality Index (GQI) estimation involves major processes as follows:

### 3.1 Selection of parameters

The parameters required for estimation of GQI were selected based on the guidelines of WHO. TDS, $Ca^{2+}$, $Cl^-$, $Mg^{2+}$, $Na^+$, $SO_4^{2-}$ and $NO_3^-$ are the seven chemical parameters considered for estimation of GQI. The drinking water standard/ threshold values are according to WHO and Bureau of Indian standard (2012).

**Table-1. Threshold values for each parameter according to drinking water standard of WHO & BIS**

| S.No | Parameter | Threshold Value (BIS & WHO - 2012) in mg/l |
|---|---|---|
| 1 | Total Dissolved Solids (TDS) | 500 |
| 2 | Calcium ($Ca^{2+}$) | 75 |
| 3 | Sodium ($Na^+$) | 200 |
| 4 | Magnesium ($Mg^{2+}$) | 30 |
| 5 | Sulfate ($SO_4^{2-}$) | 200 |
| 6 | Chloride ($Cl^-$) | 250 |
| 7 | Nitrate ($NO_3^-$) | 45 |

### 3.2 Data Conversion

The samples of the selected seven parameters were converted into spatial point data with appropriate projection system using the software ArcGIS 10.3. Then, the sample points of each parameter were interpolated by ordinary kriging method with 50m pixel size. Now, we have seven number of raster images for both pre-monsoon and post-monsoon respectively. These seven rasters represents concentration index of each parameter.

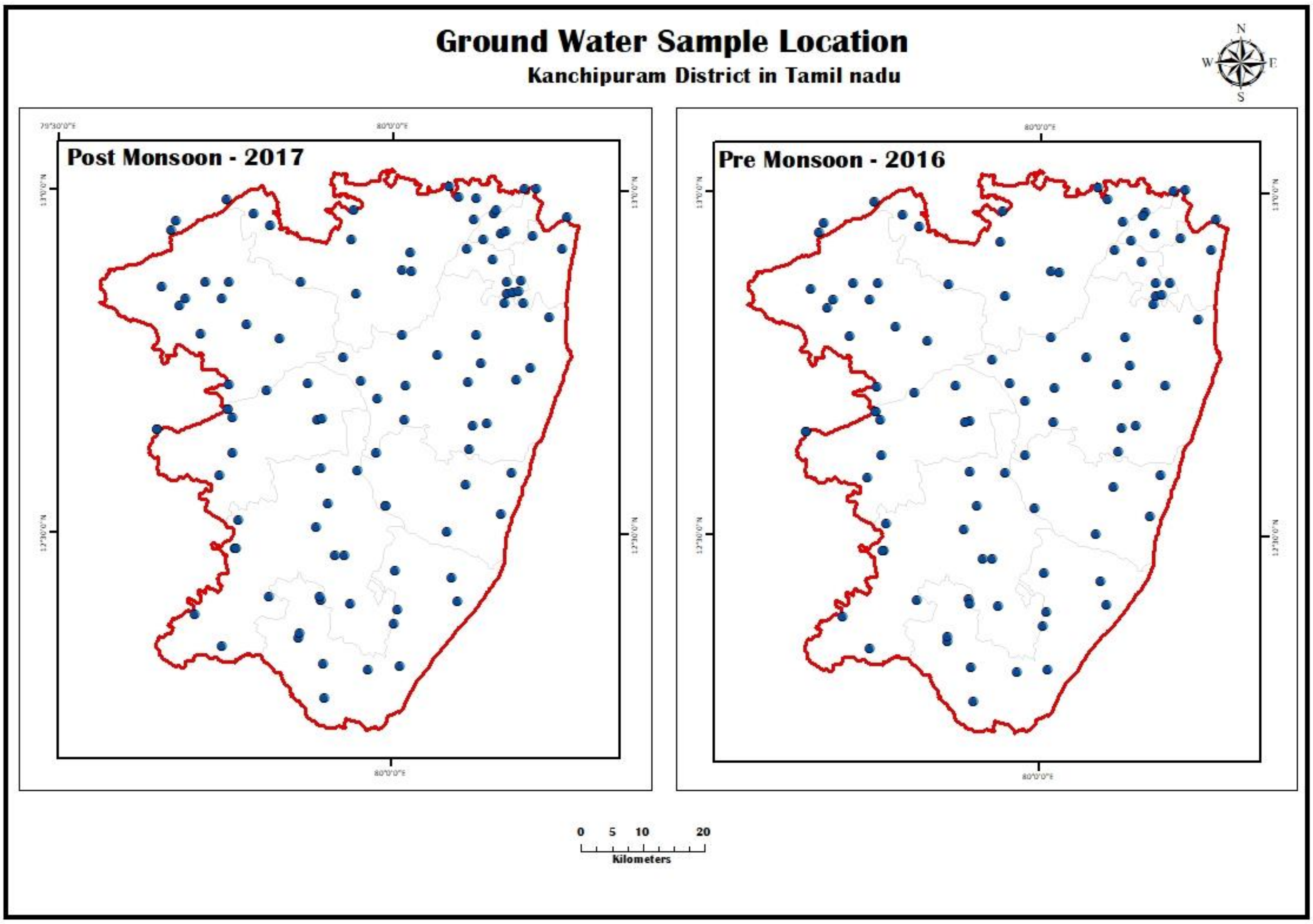


**Figure-2. Groundwater Sample Location Map**

### 3.3 Normalization

The seven concentration index maps has different unit of values. Therefore, the standardization of common scale is unavoidable for estimating the water quality index. The following formula has been used for normalizing the concentration values:

$$C = (X' - X) / (X' + X) \qquad (1)$$

Where, **C** is the Normalized Differential Index/ Contamination Index, **X'** is each pixel value of concentration map. **X** is permissible limit of each parameter by guidelines of WHO and BIS. In the output map of the Normalized difference index values ranges between -1 and 1.

### 3.4 Rank Map

The Normalize difference/ Contamination index maps are further transformed into rank map in order to eliminate the negative values. Then, rank maps were generated using the following polynomial function:

$$r = (0.5 \times C^2) / (4.5 \times C) + 5 \qquad (2)$$

Where **'r'** stands for the corresponding rank value, **'C'** stands for contamination value of each pixel in the normalised differential index. The output of the rank value lies between 1 & 10. Where 10 indicate maximum impact and 1 indicate minimum impact of ground water quality.

### 3.5 Estimation of Groundwater Quality Index(GQI)

The Groundwater Quality Index has been estimated by using the following equation with combination of rank, weight and the number of parameters:

$$GQI = 100 - ((r_1w_1 + r_2w_2 + \dots + (r_nw_n)/N) \qquad (3)$$

Where, 'r' denotes rank value for the each parameter, 'w' denotes the weightage of the parameters. (Weight was been estimated by finding the mean of rank values for each parameter respectively. Since, Nitrate [$NO^3$] is highly toxic in depleting the drinking water quality, **'2'** was been added to its rank mean. 'N' stands for total number of parameters considered (in this case its '7').

Weight (w) for TDS, $Ca^{2+}$, Cl, $Mg^{2+}$, $Na^+$, $SO_4^{2-}$ = rank(r) mean of respective parameters.

Weight (w) for Nitrate ($NO^{3-}$) = rank(r) mean of $NO^{3-}$ + 2

The GQI values ranges from 1 to 100. Towards 1, it denotes minimum water quality and towards 100 is maximum water quality concentrate.

### 3.6 Classification

Once, the Groundwater Quality Index is estimated, the values are classified into nine categories for quality analysis and visual representation. The classification was done by a particular method given by Chung and Fabbri (2001). In this method, the classification was done by selecting each 10% of the overall pixels in the study area. For that, the index values were first arranged in ascending order. Then, total number of pixels is divided into 10 divisions and labelled as '1, 2, 3, ….., 9' (in which $9^{th}$ & $10^{th}$ divisions are combined and labelled as '9').

Each number represents the water quality as 10%, 20%, …….., 90%. Out of these, the regions having values below 30% were considered as minimum or poor quality. The regions having the range of 30% to 60% were considered as medium or moderate quality. The places having values above 60% were considered to have a maximum or very high quality of groundwater, which is well suitable for drinking purpose.

## IV. Result and Discussions

From the current study, it have been found that, the overall ground water quality index is very low in the taluks such as, Alandur, Tambaram and Sriperumbathur in the pre-monsoon season of 2016. Those are the regions having high population density and high-urbanized area comparatively with other taluks. Taluks of Cheyyur, Tirukalukundram, Chengalpattu and Madurandagam stands high in the very good ground water quality in pre-monsoon.

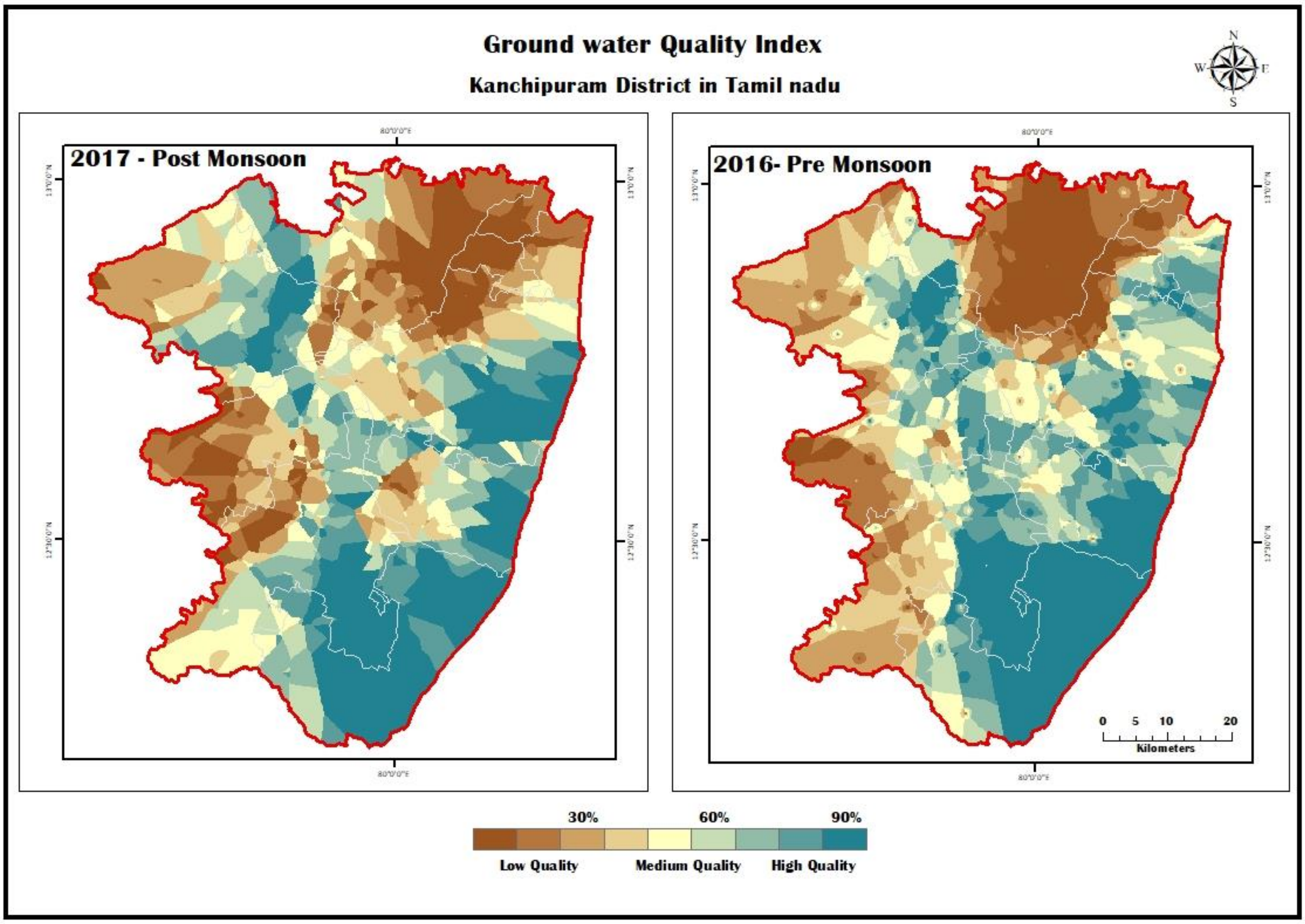


**Figure-3. Groundwater Quality Index (GQI) Map**

Due to the Chennai urban expansion, the Alandur and Tambaram taluks has a very low quality and Sriperumbathur has more concentration of industrial with high density of population and urbanization which is main reason for this region to have a very low ground water quality in pre-monsoon(2016). In the post-monsoon (2017) the taluks of Alandur, Sriperumbathur and Tambaram has a very low quality. The taluks of Cheyyur, Tirukalukundram and Sholinganallur records very high quality water due to low concentration of urban and low density of population.

**Table-3. Percentage of area covered by each category of groundwater quality**

| Taluks | % area of groundwater quality | | | | | |
|---|---|---|---|---|---|---|
| | Pre-monsoon (2016) | | | Post-monsoon (2017) | | |
| | Low | Medium | High | Low | Medium | High |
| Sriperumbudur | 63.05% | 22.10% | 14.58% | 80.88 % | 15.98 % | 2.28 % |
| Sholinganallur | 52.34% | 47.40% | -Nil- | 1.66 % | 58.03 % | 39.79 % |
| Kancheepuram | 30.52% | 38.02% | 31.31% | 34.08 % | 50.66 % | 14.88 % |
| Chengalpattu | 17.64% | 50.17% | 32.07% | 13.16 % | 61.52 % | 25.17 % |
| Uthiramerur | 54.78% | 30.23% | 14.88% | 39.21 % | 44.78 % | 15.73 % |
| Tirukalukundram | 7.93% | 39.58% | 52.38% | 0.08 % | 47.60 % | 52.16 % |
| Cheyyur | -Nil- | 20.94% | 78.90% | 2.64 % | 26.88 % | 70.19 % |
| Maduranthakam | 20.73% | 47.33% | 31.80% | 26.35 % | 37.41 % | 35.94 % |
| Tambaram | 92.45% | 7.47% | -Nil- | 48.58 % | 33.30 % | 18.03 % |
| Alandur | 100.00 | -Nil- | -Nil- | 95.16 % | 4.45 % | -Nil- |

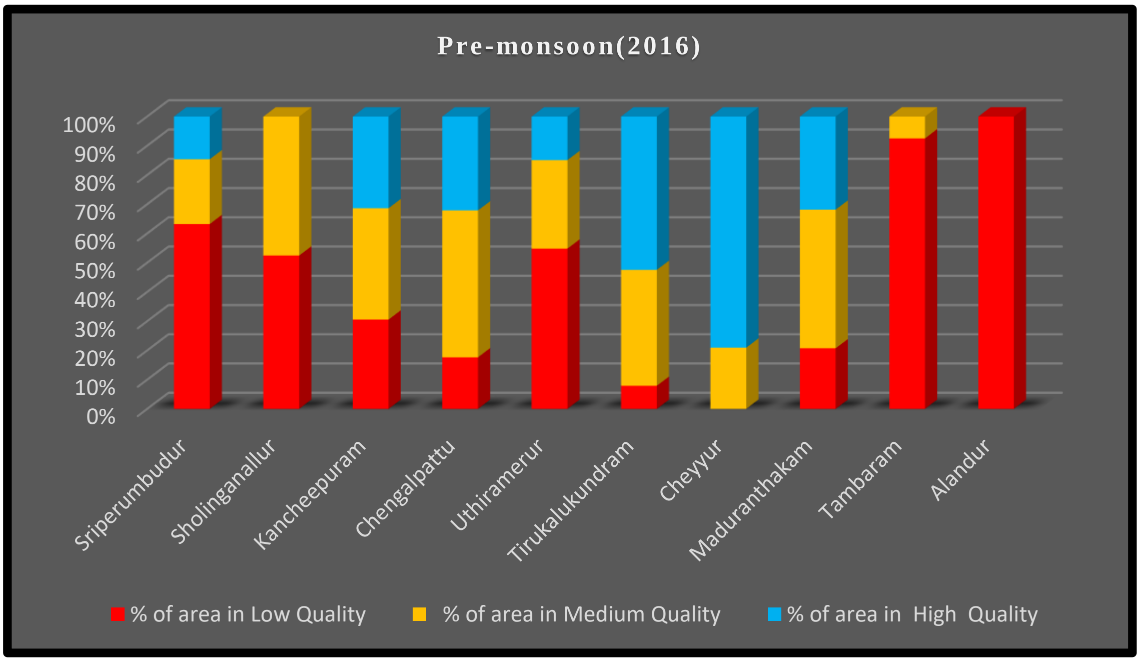


**Figure-4. Graph showing the taluk-wise groundwater quality for pre-monsoon**

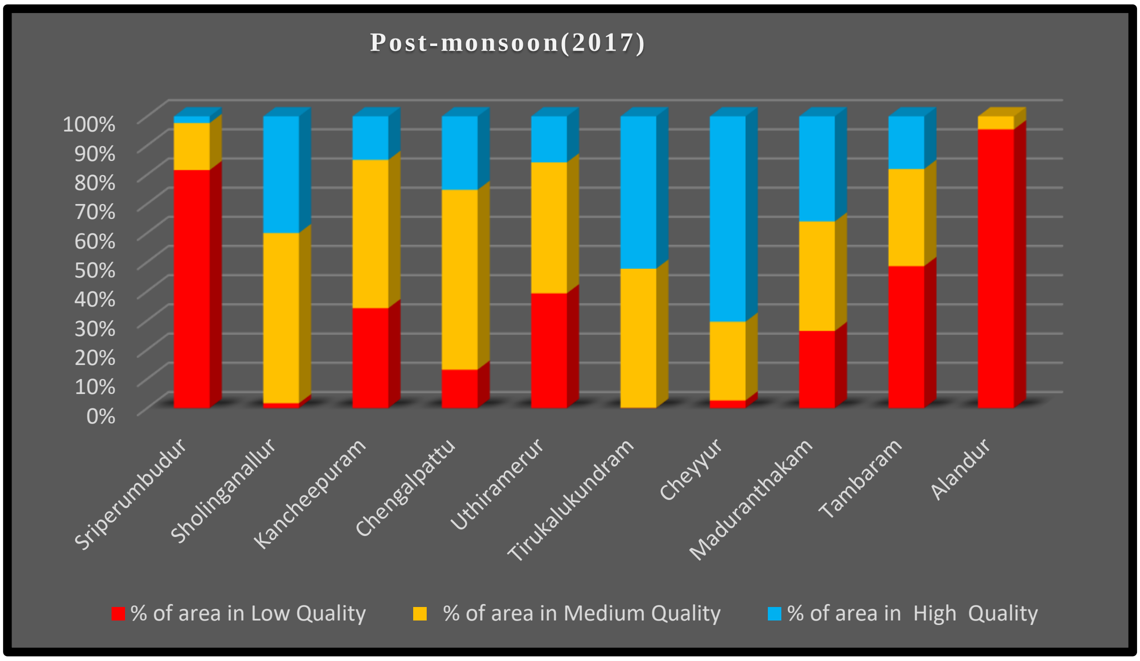


**Figure-5. Graph showing the taluk-wise groundwater quality for post-monsoon**

**Table-4. Statistics of concentration of each parameter in pre & post-monsoon**

| S.No | Parameter | Post-monsoon(2017) | | | | Pre-monsoon(2016) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Min | Max | Mean | SD | Min | Max | Mean | SD |
| 1 | Total Dissolved Solids | 126.50 | 1614.08 | 592.64 | 87.33 | 376.58 | 792.66 | 583.63 | 73.84 |
| 2 | Calcium | 28 | 97.5 | 53.36 | 12.31 | 22.83 | 61.33 | 40.87 | 6.76 |
| 3 | Sodium | 5.46 | 359.97 | 111.55 | 25.68 | 47.911 | 167.5 | 113.61 | 22.53 |
| 4 | Magnesium | 24.61 | 51.39 | 36.29 | 5.46 | 24.19 | 51.94 | 37.27 | 5.39 |
| 5 | Sulphate | 14.41 | 127.27 | 52.59 | 21.21 | 35.9 | 100.8 | 58.28 | 13.39 |
| 6 | Chlorite | 94.58 | 294.41 | 170.25 | 82.58 | 51.94 | 248.166 | 165.01 | 27.49 |
| 7 | Nitrate | 1.03 | 26.23 | 6.97 | 2.00 | 3.83 | 13.58 | 7.8 | 1.96 |

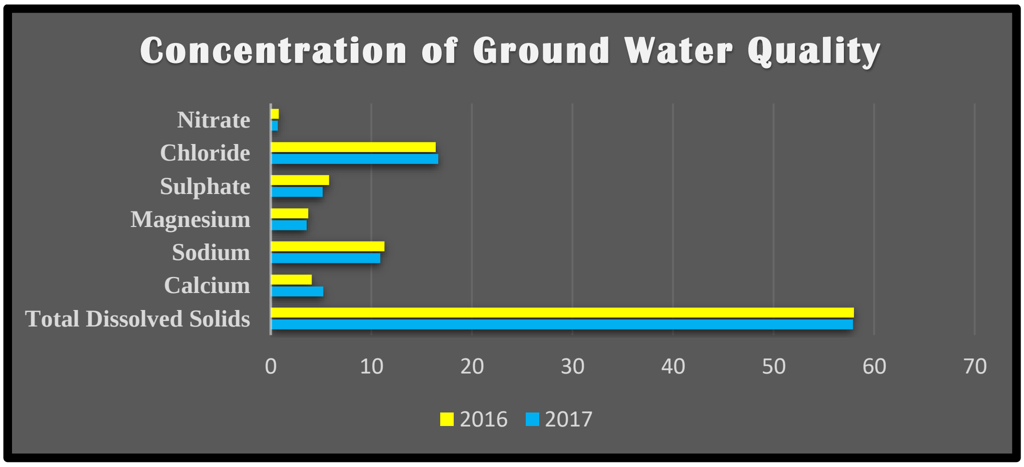


**Figure-6. Graph showing the concentration of each parameter for groundwater quality**

## V. CONCLUSION

From the overall study, it was been found that the overall groundwater quality is low in pre-monsoon compared with post-monsoon season. The low quality region stands second highest percentage in the study area. The areas having high quality of water is less percentage than the areas of low quality and medium quality. The Northern and Eastern part of the district record very low quality due to the high concentration of population and urban expansion. The Southern and Western part of the district records very high quality due to the coastal influence, sufficient amount of rainfall, low density of population and low concentration of population compared with Northern and Eastern region of the Kanchipuram district.

## VI. REFERENCES

**[1]** Banerji, Suranjana, and Deblina Mitra. 2018. "Geographical Information System-Based Groundwater Quality Index Assessment of Northern Part of Kolkata, India for Drinking Purpose."Geocarto International 6049: 1–16. https://doi.org/10.1080/10106049.2018.1451922.

**[2]** Babiker, Insaf S., Mohamed A.A. Mohamed, and Tetsuya Hiyama. 2007. "Assessing Groundwater Quality Using GIS." Water Resources Management 21 (4): 699–715. https://doi.org/10.1007/s11269-006-9059-6.

**[3]** Chung, Chang Jo F., and Andrea G. Fabbri. 2003. "Validation of Spatial Prediction Models for Landslide Hazard Mapping." Natural Hazards 30 (3): 451–72. https://doi.org/10.1023/B:NHAZ.0000007172.62651.2b.

**[4]** Khan, Haris H., Arina Khan, Shakeel Ahmed, and Jerome Perrin. 2010. "GIS-Based Impact Assessment of Land-Use Changes on Groundwater Quality: Study from a Rapidly Urbanizing Region of South India." Environmental Earth Sciences 63 (6): 1289–1302. https://doi.org/10.1007/s12665-010-0801-2.

**[5]** Nasrabadi, T., and P. Abbasi Maedeh. 2014. "Groundwater Quality Degradation of Urban Areas (Case Study: Tehran City, Iran)." International Journal of Environmental Science and Technology 11 (2): 293–302. https://doi.org/10.1007/s13762-013-0340-y.

**[6]** Nas, Bilgehan, and Ali Berktay. 2010. "Groundwater Quality Mapping in Urban Groundwater Using GIS." Environmental Monitoring and Assessment 160 (1–4): 215–27. https://doi.org/10.1007/s10661-008-0689-4.

**[7]** Patel, A, and S Krishnan. 2008. "Groundwater Situation in Urban India: Overview, Opportunities and Challenges." Strategic Analysis of the National River-Linking Project of India, Series 1: India's Water Future: Scenarios and Issues, 367–80. http://www.iwmi.cgiar.org/Publications/Other/PDF/Paper 19 of NRLP series 1.pdf.