GROUNDWATER QUALITY STUDIES USING GIS IN SALEM TOWN TAMILNADU

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ABSTRACT

This scientific report deals with the quality of groundwater for drinking purpose in the hard-rock aquifer of Salem District, Tamil Nadu South India. 30 Groundwater samples were collected based on the equal grid method and groundwater quality was assessed. Geographically the aerial extent of the study area is 5207 Sq. km. groundwater samples was analyzed in various physicochemical parameters and major ion chemistry like pH, EC, TDS, Ca2+, Mg2+, Na+, HCO3-, Cl-, SO42-, NO3- and F-. Based on the analytical results, to prepared spatial distribution maps with help of WHO standard. ArcGIS was employed. Attributes were linked and spatial interpolation tool was used. IDW technique was followed for raster and vector mapping. The analysis was carried out to locate the worst quality zone. Based on the analysis, most of the samples are suitable for drinking. The final integrated map (Drinking quality) reveals that for suitable for drinking and domestic purpose. "Not permissible" water quality zone cover about area 80.6 sq. km respectively. While "Maximum allowable" water quality zone cover an area of 438.7 sq. km. The "Most desirable" water quality zone an area 162.95 sq.km for drinking and domestic purposes.

KEYWORDS: spatial distribution map,overlay.

ACADEMIC DISCIPLINE

Water Resources Engineering

SUBJECT CLASSIFICATION

Water quality

TYPE (METHOD/APPROACH)

Spatial approach

INTRODUCTION

Assessment of groundwater quality is as important as the quantity, in many groundwater studies. Groundwater physico-chemical ions in the form of solution, the type and concentration of these elements depends upon the surface and sub-surface environment, rate of groundwater movements and the source of groundwater. Contamination of water is mainly due to the anthropogenic activity and effluents that are discharged as waste or sewage from residences and industries, and so on. The most important source of pollutants that deteriorate and decrease the quality of groundwater are the discharge of wastes from industries and effluents from residence.

STUDY AREA DESCRIPTION

Salem district lies in the western part of Tamil Nadu, located between 11◦15′–12◦00′N latitudes and 77◦35′–78◦50′E longitudes. The total geographical area is about 5207 km2 out of which the Stanley reservoir covers an area of about 164.5 km^2 . The study is bounded by the districts Dharmapuri in the north, Namakkal in the south, Erode in the west and South Arcot in the east directions. The district has a maximum and minimum temperature of 40◦C and 13◦C. The city is surrounded by hills: Nagaramalai on the north, Jarugumalai on the south, Kanjamalai on the west, Godumalai on the east and the Shevaroy

Hills on the northeast. Kariyaperumal Hill is in southwestern Salem. The Thirumanimutharu River flows through the city, dividing it in two.

The fort area is the oldest part of Salem. Salem has a tropical savannaclimate. January and February are generally pleasant; the hot summer begins in March, with the year's highest temperatures during April.

Pre-monsoon thunderstorms occur during April and May. The Southwest monsoon season lasts from June to September. The northeast monsoon occurs from October to December.

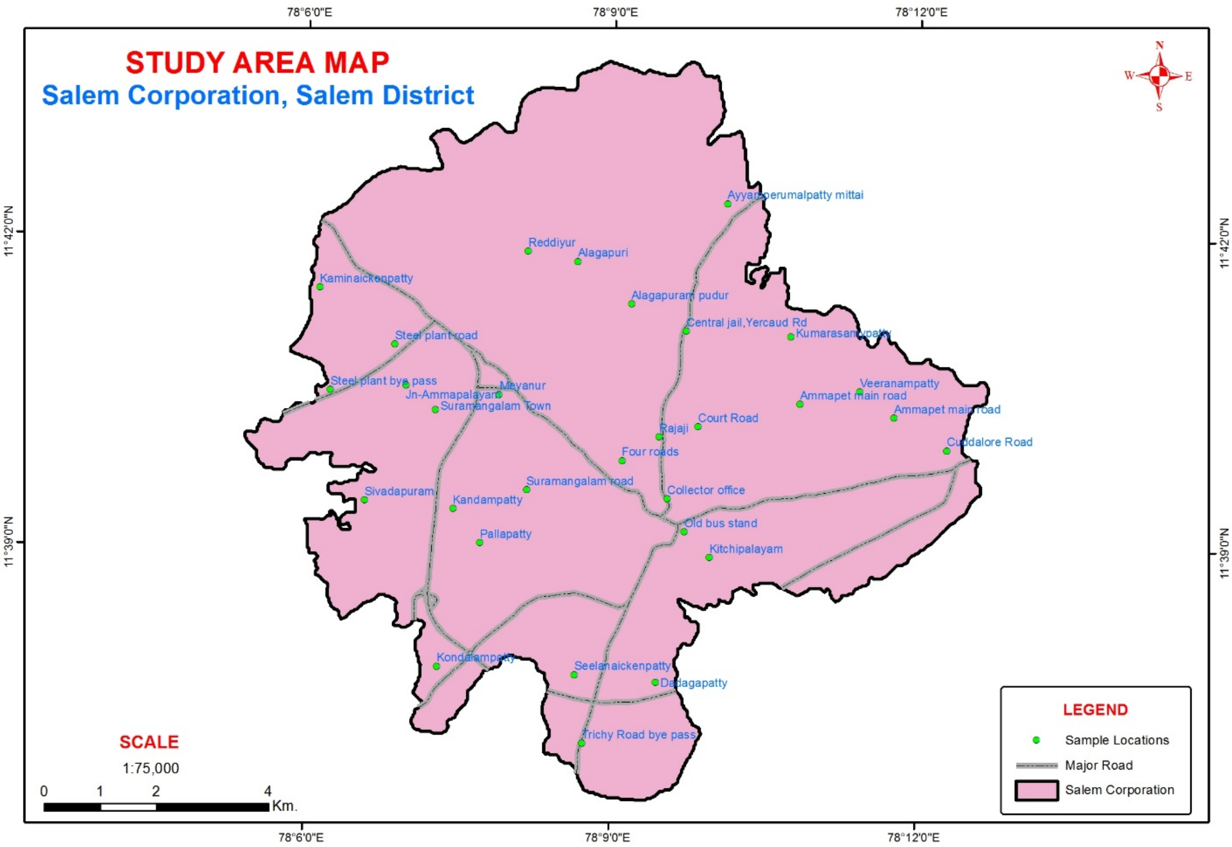

Fig .1 Base map of Salem

METHODOLOGY

This methodology involves in the collection of spatial data and non-spatial data and integrating this data to identify potable and non-potable areas of ground water in the study area. GIS software adds intelligence to spatial data, whether the data is generated in the field with GPS or remotely with LIDAR and photogrammetry.Youcanenterrawdata,measurements,andfieldsketchesdirectly in to the GIS, enabling you to efficiently manage your data in a geo-database with other spatialinformation.

WATER QUALITY PARAMETERS FOR DRINKINGPURPOSES

The ground water quality studies were carried out in Salem district region to determine the suitability for drinking and domestic purposes. Then these parameters are compared with the World Health Organization standards (WHO 1996). The Ground water quality studies show that majority of the samples fell in most desirable and maximum allowable limits of analytical parameters.

Table 1 Statistical Analysis Data with WHO Limiting Values and Exceeding Samples

Parameters	WHO International standard (1996)		Pre-monsoon No. of Samples exceeding permissible limits	Post-monsoon No. of Samples exceeding permissible limits	Undesirable effect
	Most desirable limits	Maximum allowable limits			
pH	6.5 – 8.5	9.2	Nil	Nil	Taste effects mucus membrane andwater supply system
TDS (mg/l)	500	1500	18	11	Gastrointestinal Irritation
EC	1500	-	30	29	Gastrointestinal Irritation
TH (mg/l)	100	500	29	29	(i) Scale formation in boilers (ii) Cardio vasculardisease
Na^{+} (mg/l)	-	200	13	12	-
K^{+} (mg/l)	-	12	25	25	Bitter taste
Ca^{2+} (mg/l)	75	200	6	11	Scale formation
Mg^{2+} (mg/l)	50	150	Nil	Nil	Scale formation
Cl^{-} (mg/l)	200	600	10	5	Salty taste indicates pollution
SO_4^{2-} (mg/l)	200	400	4	4	Laxative effective, Cause gastrointestinal irritation when Mg and Na sulfate
NO_3^{-} (mg/l)	45	-	32	32	Blue baby diseases in children
Fe^{2+} (mg/l)	-	0.3	22	22	Taste, colour, turbidity and staining problems
F^{-} (mg/l)	-	1.5	1	1	Fluorosis
HCO3	300	500	2	13	Temporary hardness.
CO3	-	-	-	-	-
Alk	500	-	7	6	Rice on cooking turns yellow.

CALCIUM(CA)

One of the alkaline earth metals and the one that is widely scatteredover the Earth's crust and also is the second dominating ion in the ground water of the study area. Calcium is naturally present in ground water. It is because of the rate of decomposition of feldspar group of minerals (Hem,1985) this study area is cover edin crystal line metamorphic rock complex. Calcium concentration is a determinant of water hardness, because it can be found in water as Ca ions.The value of calcium varies during pre-monsoon is 35 to 400 mg/l, with an average value of 143.84mg/land the concentration of post-monsoon calcium varies from 54 to 423 mg/l, with a mean of 167.40 mg/l. Most of the samples within most desirable limit is 10.69 sq.km tomaximumallowablelimits is 85.57 sq.km prescribed by the WHO (1996). If the presence of calcium is more in drinking water, it will cause formation of renal calculi (Kidneystones).ca spatial distribution map (Fig. 3) reveals that more are less entire study areas are classified as not permissible limit.

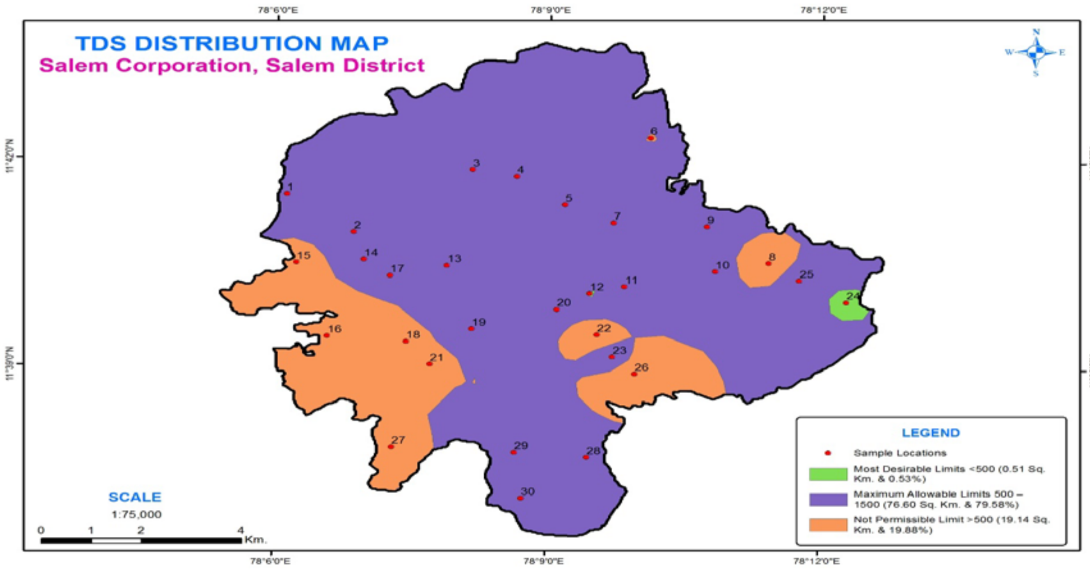

Fig. 2 TDS Spatial Distribution Map

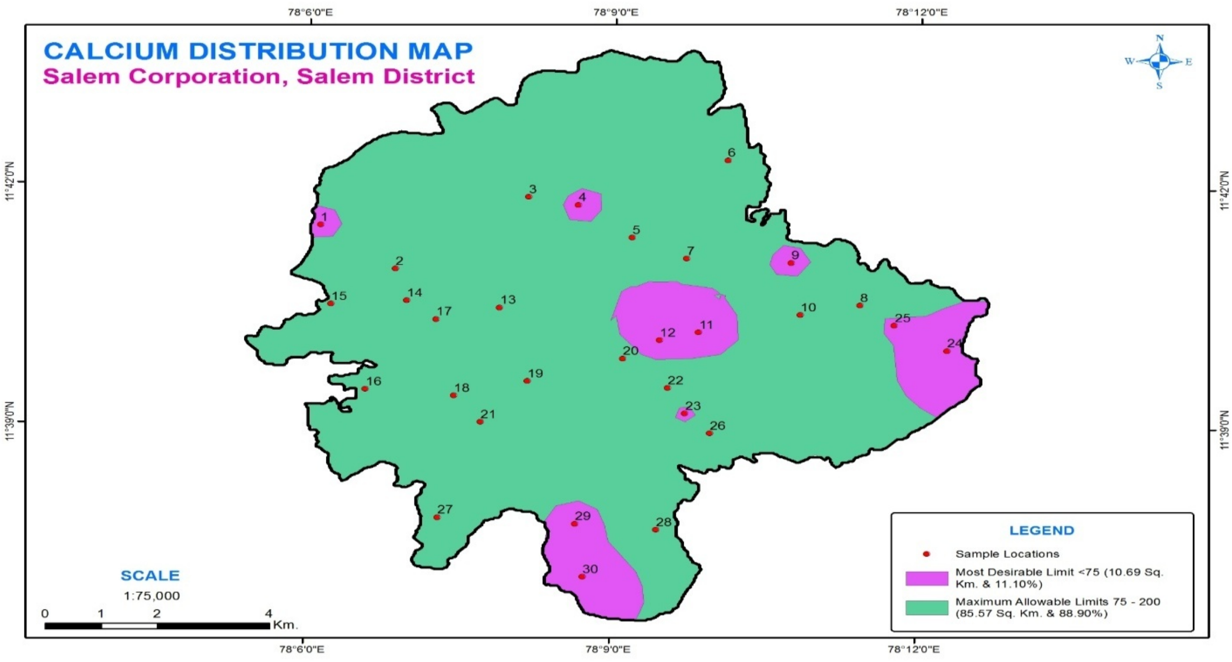

Fig.3 ca Spatial Distribution Map

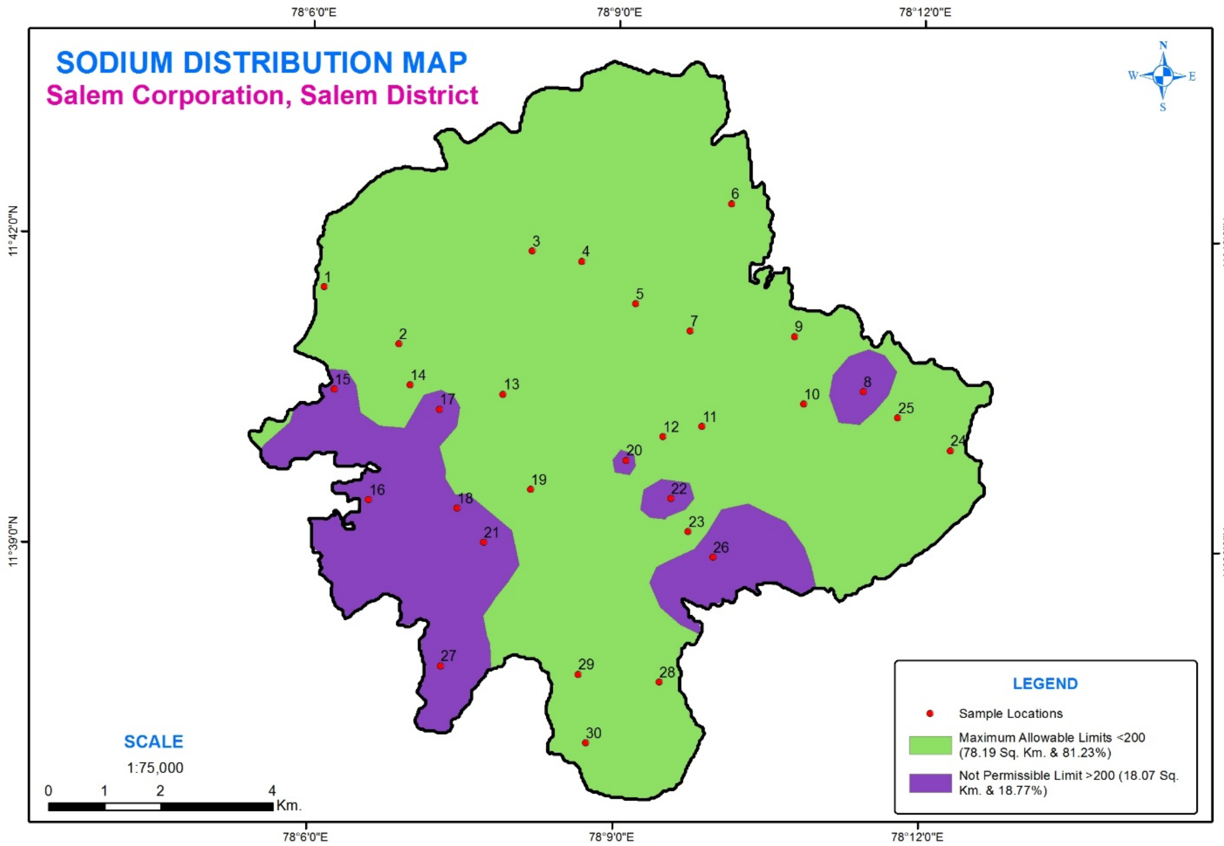

Fig.4 NA Spatial Distribution Map

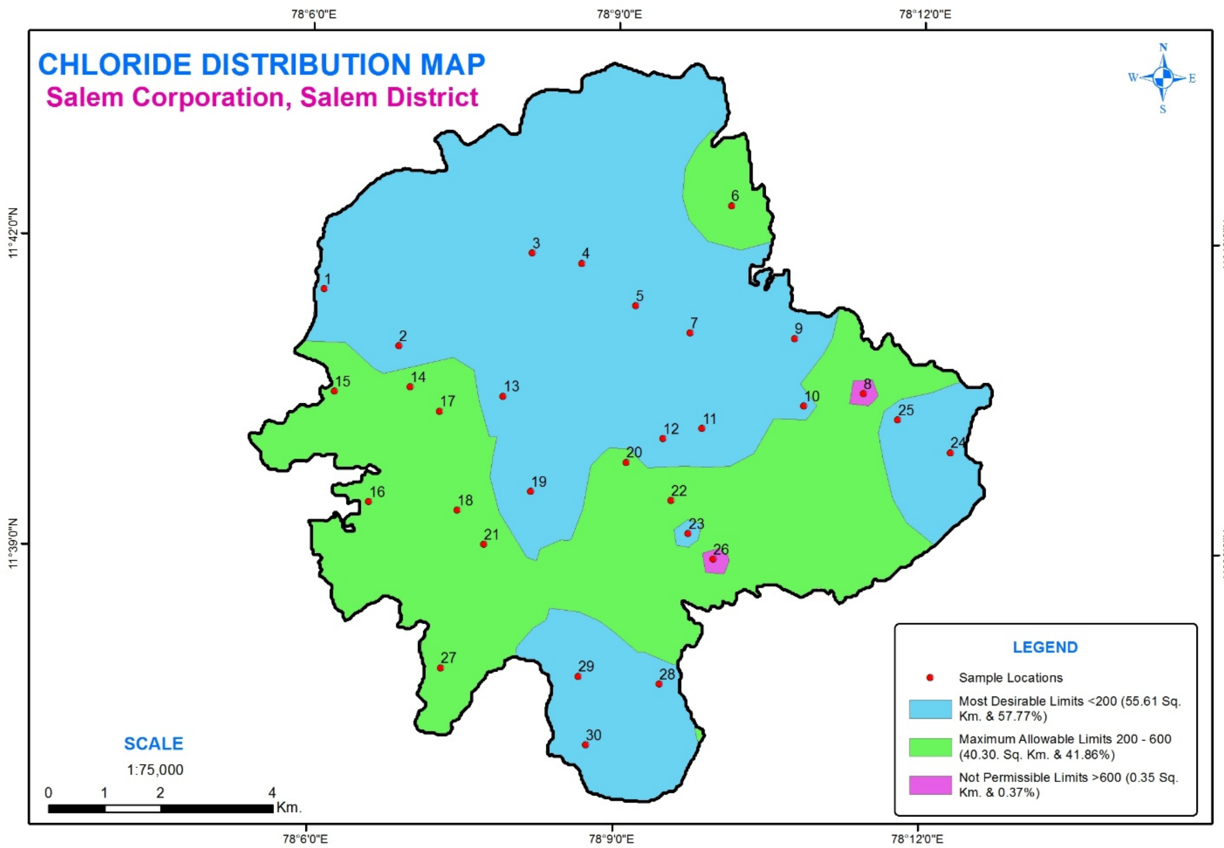

Fig. 5 Cl Spatial Distribution Map

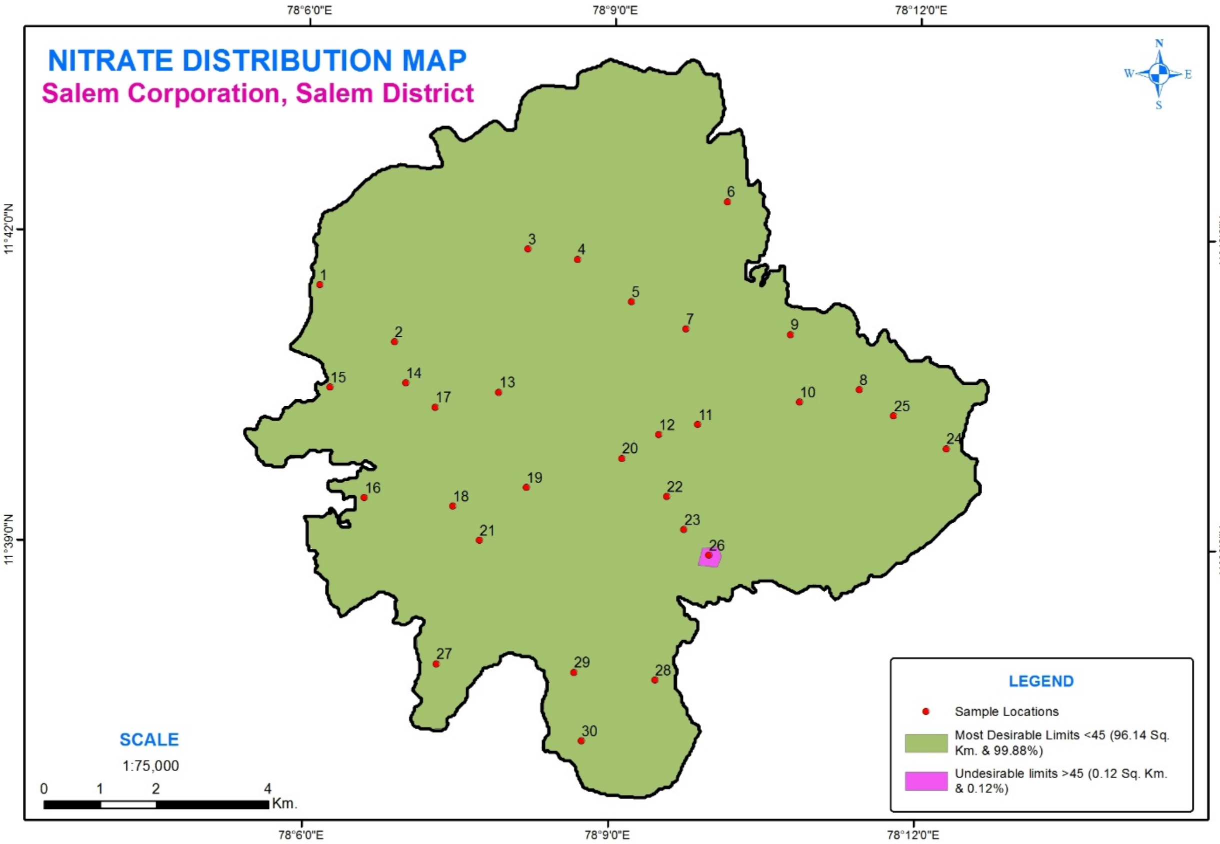

Fig 6 NO_3 Spatial Distribution Map

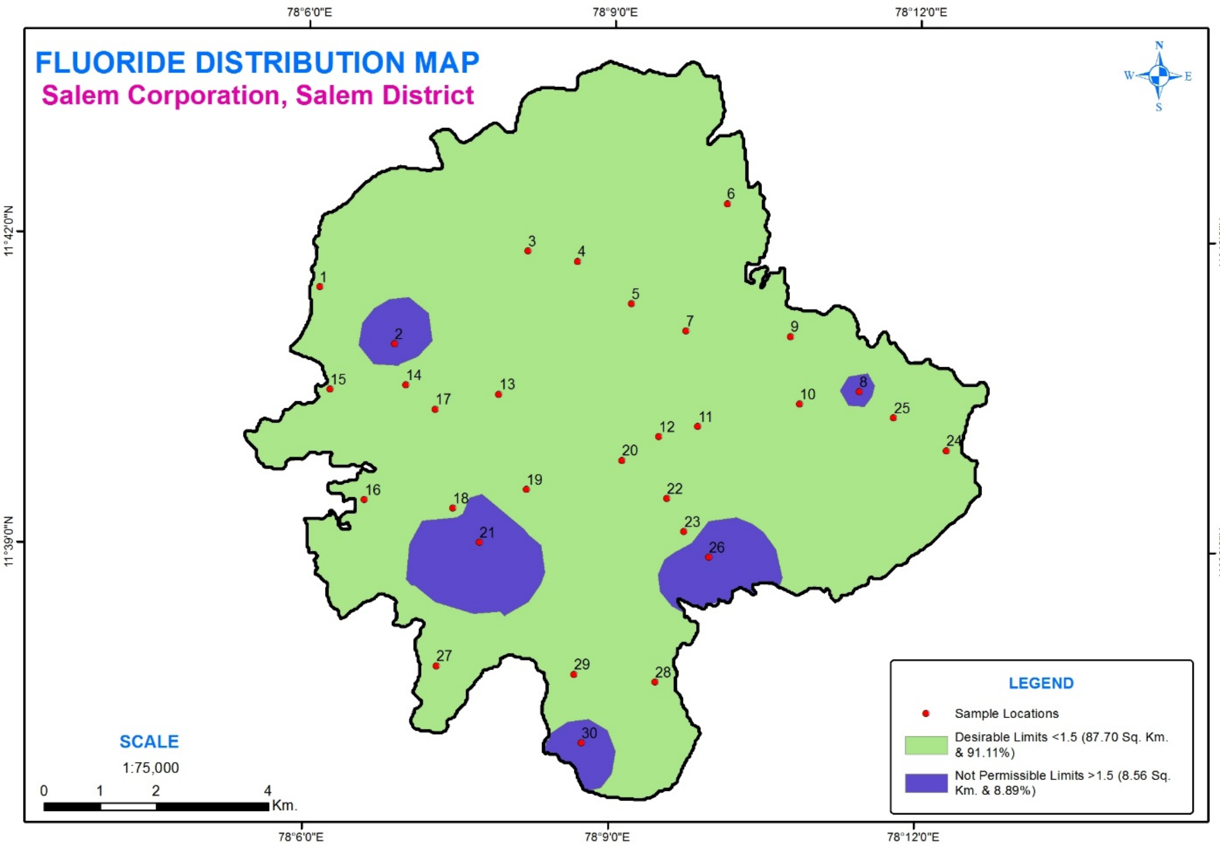

Fig .7 F Spatial Distribution Map

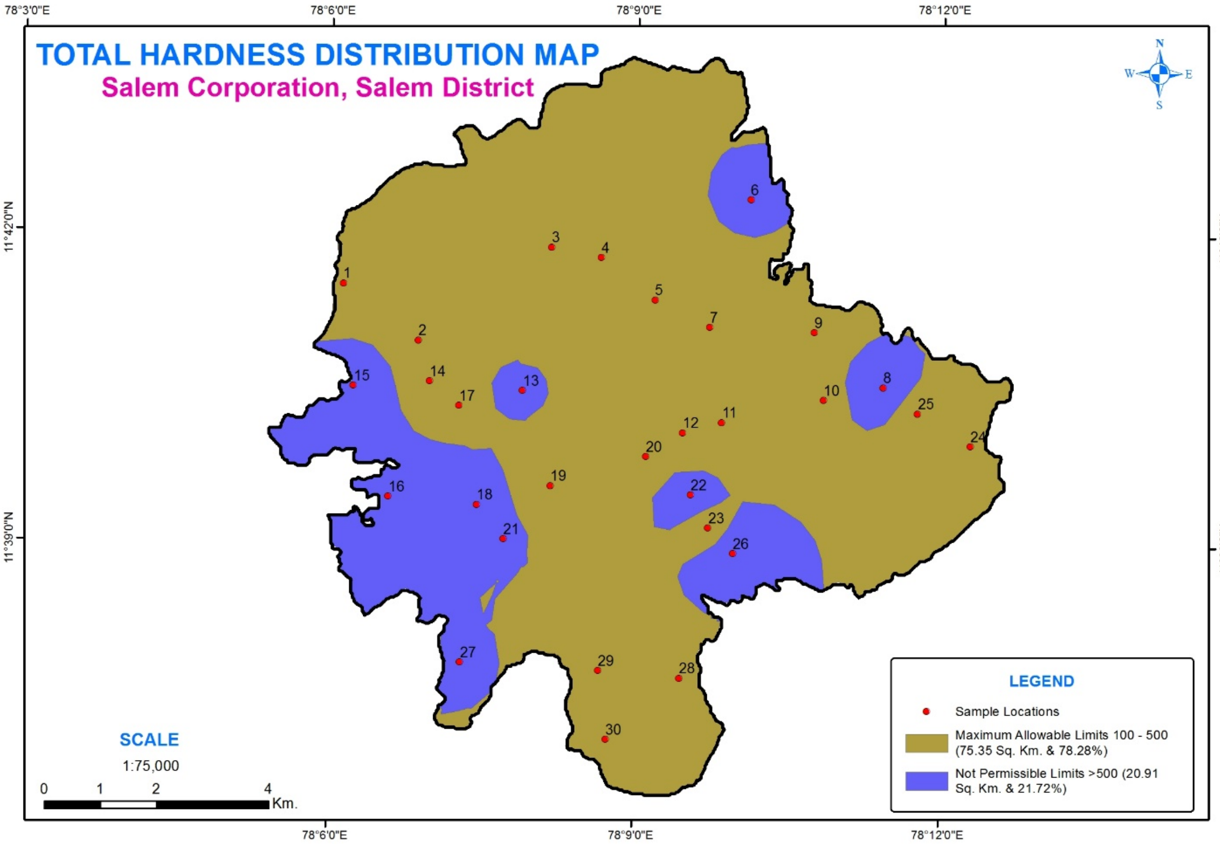

Fig. 8 TH Spatial Distribution Map

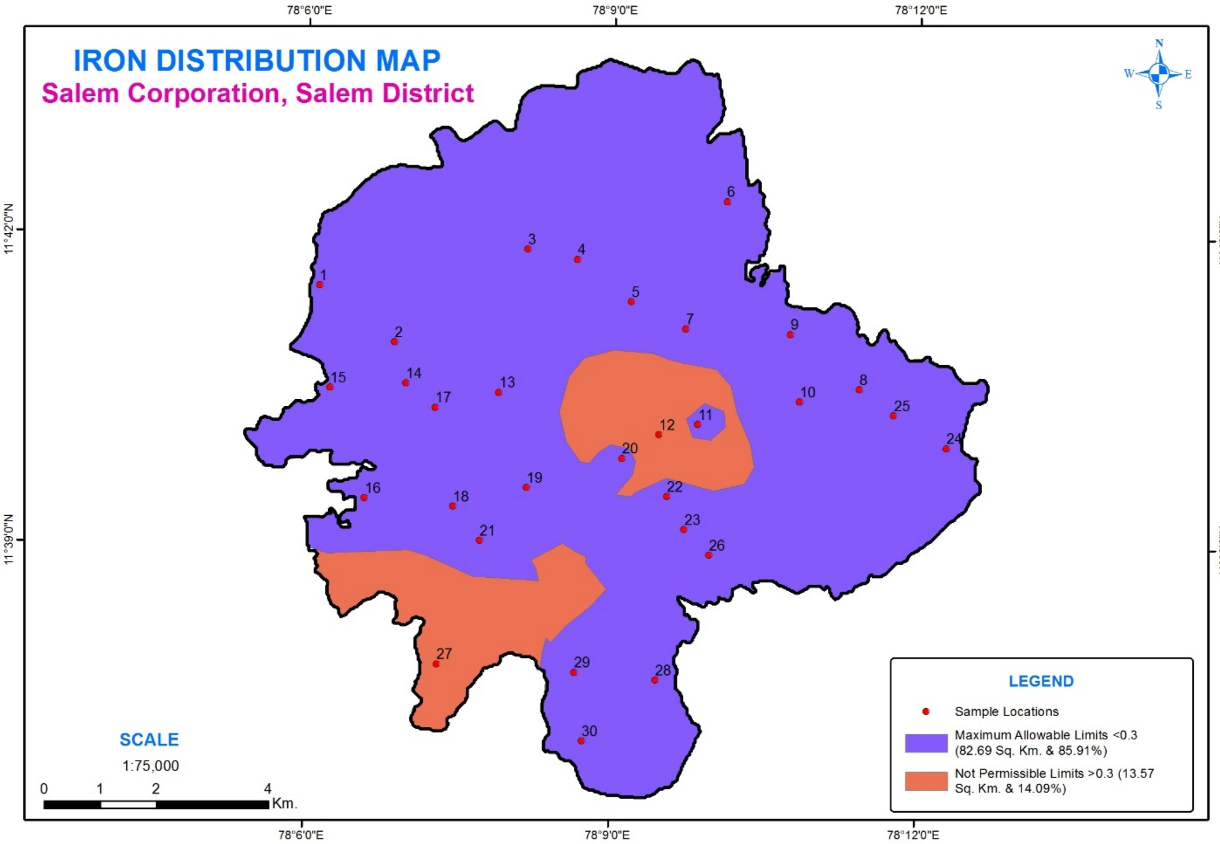

Fig .9 Fe Spatial Distribution Map

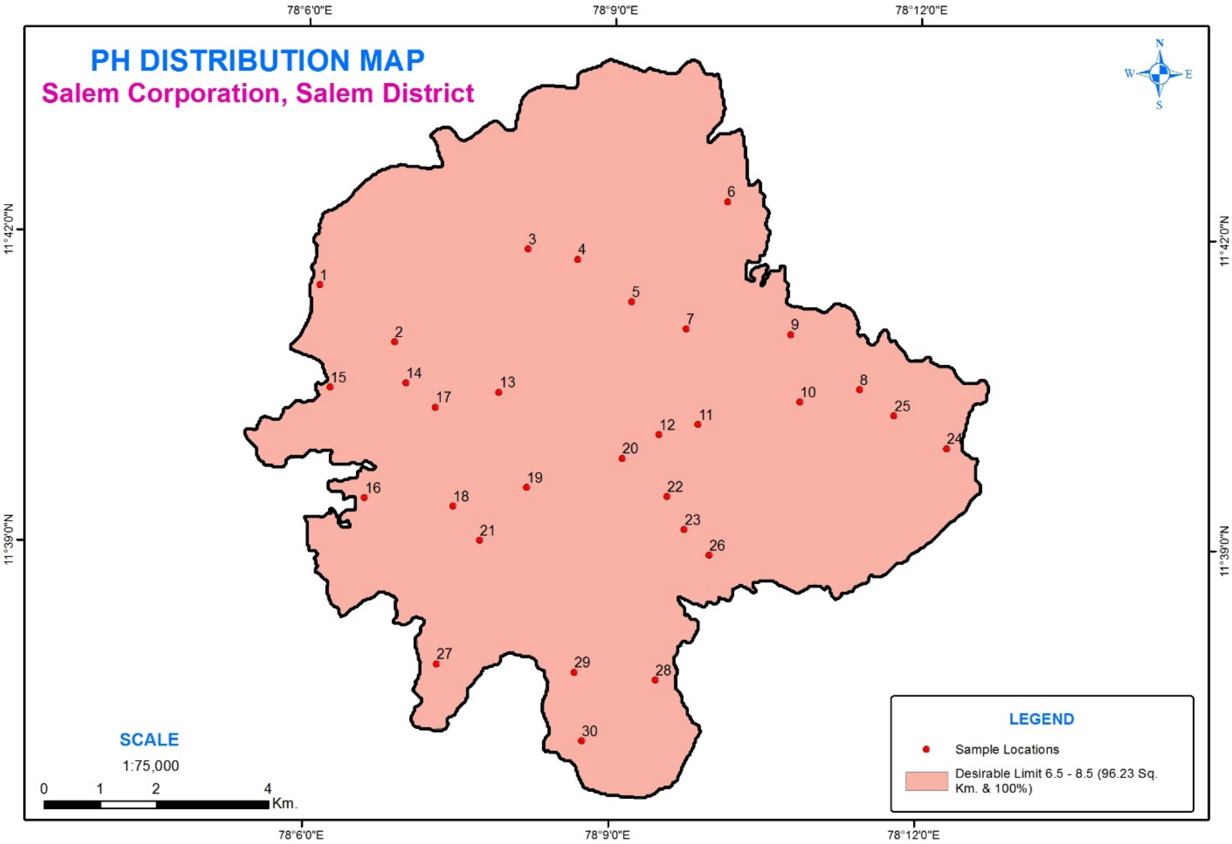

Fig.10 Spatial Distribution Map

Chloride(Cl)

Chloride is a less abundant constituent of the earth's crust but a major dissolved constituent of most natural waters. The chloride concentration varies between 40.01 and 1420.40mg/l and 30.01to1109.31mg/l during pre and post- monsoon seasons respectively. All common chlorides are soluble and contribute to the total salt content of soils. The high chloride concentration was noticed in only few locations for both the seasons. The chloride ions in drinking water are generally not harmful to human beings. A high concentration of chlorides may be due to improper disposal of wastes (Kesavanetal.,2005). The most desirable limit is 55.61 sq.km of the limitingvalue, the most allowable limit 40.30 sq.km. Cl spatial distribution map (Fig. 3) It reveals that 0.35 Sq.Km areas are classified as not permissible limit.

NITRATE(NO3)

Nitrate contaminationin ground water is one of the major issues in water quality studies (Schilling and Wolter 2007; Raju et al. 2009). Increased concentration of NO_3^- and Cl^- in ground water contaminated by municipal waste waters .

This is a testimony to man- made pollution responsible for the inferior quality of ground water in fast urbanizing areas (Raju et al. 1992; Raju and Reddy 2007). The main reason of nitrogen transformations associated with the soil-ground water environment is domestic sewage, cesspools/septictanks. Bulk ratio of nitrogen in waste wate rat the septictank is in the form of urea, organic nitrogen, and aqueous ammonium. Urea can be hydrolyzed under anaerobic conditions, and ammonium anion can be produced (Wilhelm et al. 1994). Nitrate (NO^{3-}) is the main form of N in the groundwater. Several authors (Steinich et al., 1998; Daskalaki et al., 1998; Antonakos and Lambrakis, 2000) have related ground water nitrates todifferent sources, such as leaching of organic and inorganic fertilizers, animal waste, domestic effluents and industry. Nitrate is a common surface water and ground water contaminant that can cause health problems in infants and animals, as well as the eutrophication of water bodies (Fennesy and Cronk, 1997). The limiting values for nitrate are given in the nitrate concentration in pre-monsoon ground water samples ranged from 1 to 119 mg/l, with an average value of 44.31 mg/l. Nitrateis also an indicator of pollution.

Nitrogen is fixed from the atmosphere and then mineralized by soil bacteria into ammonium and the aerobic conditions. The nitrogen is finally converted into nitrate by nitrifying bacteria. The desirable limitofnitrateis45mg/lasperWHOstandards.Thehighconcentrationof nitrate in drinking water is toxic and causes blue baby or methemoglobinemia disease in children and gastric carcinomas. Nitrate is very loosely bound to the soil particles and easily leaches out and raises the groundwater level (Lalitha et al., 2004). NO3 spatial distribution map (Fig. 6) reveals that most desirable limit 96.14 sq.km and undesirable limit 0.12.

FLUORIDE(F)

Fluoride is one of the chief trace elements in ground water, which occurs as a natural constituent. Bedrock containing fluoride mineral is mainly responsible for high concentration of the ion in ground water. Different forms of fluoride exposure affect the body's fluoride content increasing the risks of fluoride - prone diseases. Also, fluoride has beneficial effects on teeth at low concentrations of 1 mg/l by avoiding the risk of toothdecay. Fl spatial distribution map (Fig. 7) reveals that Desirable Limit 87.70sq.km . Not permissible Limit 8.56 sq.km.

TOTAL HARDNESS(TH)

Ingeneral, surface water is softer than ground water. Hardness represents the concentration of calcium and magnesium ions. Because, these are the most polyvalent cations and other ions, such as iron, manganese contribute to the hardness of water and they are present in lower concentrations. The hardnessof water is classified as hard and soft. The hightotal hardness value is termed as "hard", while water of low hardness values is termed as 'soft". The hardness value ranged from 123mg/l to 1480mg/l with an average value of 622.47mg/l and 100mg/l to 1401mg/l with an average value of 589.20mg/l during pre -monsoon season samples respectively. The spatial distribution map (Fig. 7) reveals that maximum allowable limit 75.35 Sq.km. Not permissible Limit 20.91 sq.km.

IRON (Fe)

As per the World Health Organization (WHO-1996) guidelines for more than 0.3 mg/l iron concentration was considered to be secondary contaminants. The Fe concentration varies from 0 to 11.61mg/l ,with an average value of 1.15 mg/l during pre-monsoon season samples. Iron concentration in pre-monsoon season varies from 0 to 11.61mg/l, with a mean of 1.15mg/l. Ferrous and ferric the common forms of Fe found in drinking water.

The presences of iron in water are not considered as health hazards. Iron is rarely found in water source and generally found with dissolved iron. The high iron concentrations in ground water of the study area may be due to the organic content of municipal domestic waste and presence of iron minerals in the soils/weathered materials favourable for reduction of ferriciron into ferrous iron in the circulating ground water (Hem 1991). Raju (2006b) found that the iron contamination in the ground water is caused by dissolution of ferruginous minerals in rocks and seepage of domestic sewageef fluents. The spatial distribution map (Fig.9) reveals that maximum allowable limit 82.69 Sq.km and Not permissible Limit 13.57 sq.km.

HYDROGEN ION CONCENTRATION(PH)

The pH of aqueous solutions / water can be taken as the negative logarithm of hydrogen ion activity or concentration.

PH values from 0 to 7 are diminishingly acidic, 7 to 14 are increasingly alkaline and 7 is neutral. A brooder classification is as below

Stronglyacid	–	pH <5
Acid	–	pH 5 to7
Neutral	–	pH =7
Alkaline	_	pH 5 to7

The pH of natural water usually lies in the range of 4.4 to 8.5. The pH-values for underground water vary within a wide range from 1.8 to 11.0. However, the most common pH-values for underground waters are those between 5 and 8. The pH-values for drinking water should be limited to the range of 6.5 –8.5. The pH-value of water is governed largely by the carbon dioxide / bicarbonate / carbonate equilibrium. It may be affected by humic substances by changes in the carbonate equilibria due to the bio activity of plants and in some cases by hydrolysable salts.

pH values are indicates the ground water is slightly acidic nature and dominating by alkaline nature. All the samples are within most desirable limit prescribed by WHO standardThe spatial distribution map (Fig.10) reveals that desirable limit 96.23 Sq.km.

SODIUM(NA)

Sodium is the sixth most abundant element in the Earth's crust and sodium stems from rocks and soils. Not only seas, but also rivers and lakes contain significant amounts of sodium. All the cations, sodium cations are the most abundant. Sodiumis present in number of minerals, the principal one being rock salt (sodium chloride). The increased pollution of surface water and ground water during the past decade shas resulted in a substantial increase in the sodium content of drinking water in different regions of the world.Concentrations however are much lower, depending on geological conditions and waste water contamination sodium compounds serve many different industrial purposes, and may also end up in water from industries. The value of pre-monsoon season varies from 47 to 650mg/l, with a mean value of 189.71 mg/l and 40 to 550 mg/l, with a mean value of 177.98 mg/l

All the samples are within most desirable limit prescribed by WHO standard. The spatial distribution map (Fig.4) reveals that maximum allowable limit 78.19 Sq.kmandNot permissible Limit 13.57 sq.km.

TOTAL DISSOLVED SOLIDS(TDS)

Total Dissolved Solids (TDS) is the total amount of all inorganic andorganic substances including cations or anions and other impurities that are dispersed within a volume of water. For the suitability of groundwater for any purpose, TDS is considered for evaluation.

The total dissolved solids (TDS) are the concentrations of all dissolved elements in the ground water indicate the general nature of salinity of water. The total dissolved solids pre and a post-monsoon season varies from 337 to 4064 mg/l and mean value for 1448.31 mg/l and 298 to 4001 mg/l 1341.89 and average value for 1341.89. The samples are within the limit prescribed by WHO standard The spatial distribution map (Fig.2) reveals that most desirable limit 0.51 Sq.km, maximum allowable limit 76.60 sq.km and Not permissible limit 19.14 sq.km.

SPATIAL ANALYSIS FOR DRINKING

Thematic maps like TDS (Fig. 2), calcium (Fig. 3), sodium (Fig. 4), chloride (Fig. 5), NO_3 (Fig. 6), F (Fig. 7), TH (Fig.8), Fe (Fig.9) and PH (Fig 10) provides certain clues on for the quality of groundwater. In order to get all these informations unified, it is essential to integrate these data with appropriate factor. Therefore, numerically these informations are integrated through the application of GIS.

CONCLUSION

The groundwater quality parameters in the study area with reference to the WHO standards were used to prepare the spatial distribution map. The final integrated map (Drinking quality) reveals the various parameters suitable for drinking purpose. "Not permissible" groundwater quality domains cover about area 80.6sq.km respectively. While "Maximum allowable" groundwater quality domains cover an about area 438.7sq.km. The "Most desirable" water quality zone an area 162.95 sq.km for drinking and domestic purposes.

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