Mapping and Statistical Analysis of Groundwater Quality a Case Study of Dindigul City, Tamilnadu, India

M.Ramaraj[1] V.Dhayalan[2]
[1,2]M.E. Student
[1,2]Department of Environmental Engineering
[1]MAM College of Engineering, Trichy [2]Gnanamani College of Engineering, Namakkal

Abstract— The Groundwater quality is equally important as that of quantity. Mapping and statistical analysis of groundwater and its quality is of vital important and it is particularly significant where groundwater is primary source of portable water. The present study is focus on spatial and temporal variability. Groundwater quality was prepared using GIS technology and other related maps were prepared from remote sensing data in ArcGIS. The statistical analysis of the water quality data is determined. From the statistical analysis, the groundwater quality is represented and compared with BIS permissible limit to establish their quality. Samples were collected from fifteen locations in the study area. Physio-chemical analysis of ground water samples are done for 2014 at Madurai Tamilnadu Water Authority Department (TWAD) laboratory.

Key words: Mapping, Spatial, Temporal, Remote sensing, GIS, Arc Gis, TWAD, BIS

I. INTRODUCTION

Surface and ground water are the major source of drinking water. Groundwater has become a necessary resource over the past decades due to the increase in its usage for drinking, water supply, irrigation and industrial uses etc. Ground water resource is now facing threats due to various anthropogenic activities. The dependability on groundwater has reached high in recent decades due to reasons such as unreliable supplies from surface water due to vagaries of monsoon, increase in demand for domestic, agricultural and industrial purposes. Remote sensing and GIS are effective tools for water quality mapping. The Statistical analysis is used to investigate the water quality data composed from dindigul city. Correlation analysis is used to measure the strength of relationship between two endless variables. It expresses that the one of variable increase with the increase of the other if the relationship among the variables is positive or negative. The co-variation is observed from correlation analysis. The most common method of correlation is Pearson‘s correlation (linear correlation coefficient). It gives the linear relationship between two variables.

II. STUDY AREA

The study area is a part of Kodavanar watershed basin in Dindigul district in Tamilnadu, India. This area is one of the sub-urban region of Dindigul district. This area is famous for its tannery industries. A part of Kodavanar watershed basin which composes the city and its sub-urban region. It lies between 10°22’7.04’’N and 10°18’32.07’’ S latitude, 77°53’2.34’’ W and 78°01’E longitude. The study area covers an area of about 491sq.km. In 2011, Dindigul district had the population of 21, 61,367 of which male and female populations were 10, 81,934 and 10, 79,433 respectively. The district had the population density of 357 inhabitants per square kilometre. The growth rate of this district is 12.39%.The literacy rate is 76.85%.

A. Climate and Rainfall:

- South West Monsoon (June-Sep) 295.4
- North East Monsoon (Oct-Dec) 436.4
- Winter Season (Jan&Feb) 30.9
- Hot Season (Mar – May) 168.0

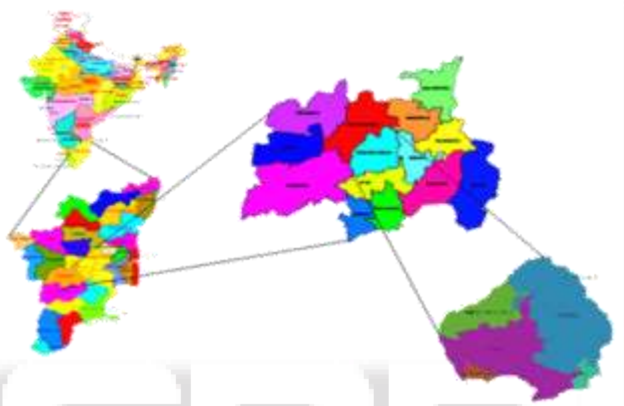

Fig. 1.1: Study Area

III. METHODOLOGY

The samples were collected by means of the ordinary methods recommended for sampling. Fifteen water samples were collected in the season of post monsoon during the year 2014. The collection of each samples by the use of plastic bottles having capacity of 1.5 litres. The plastic bottles was washed with nitric acid and rinsed thrice with distilled water before the collection of sample. The collected samples must be analysed within forty eight hours. To determine the concentration of TDS, NO2+NO3, Ca, Mg, Na, K, Cl, SO4, CO3, HCO3, F, Ph_GEN, EC_GEN, the samples were analysed in the Madurai TWAD board. All the tests for the determination of concentration of those parameters were carried out in accordance with the techniques prescribed by the American Public Health Association (APHA). A thematic maps are an important source of GIS information. The dindigul town map is scanned and georeferenced using ArcGIS software. Using ground coordinates pixel coordinates of scanned image are converted into ground coordinates. The georeferenced map is digitized by creating personal geodatabase and feature classes(point, line, polygon). The map is digitized and is projected for accurate information. The layout of the map is prepared with latitude and longitude for better understanding and more informative. The statistical analysis (descriptive analysis, correlation analysis) of the experimental data was achieved using SPSS 17.0 Software.

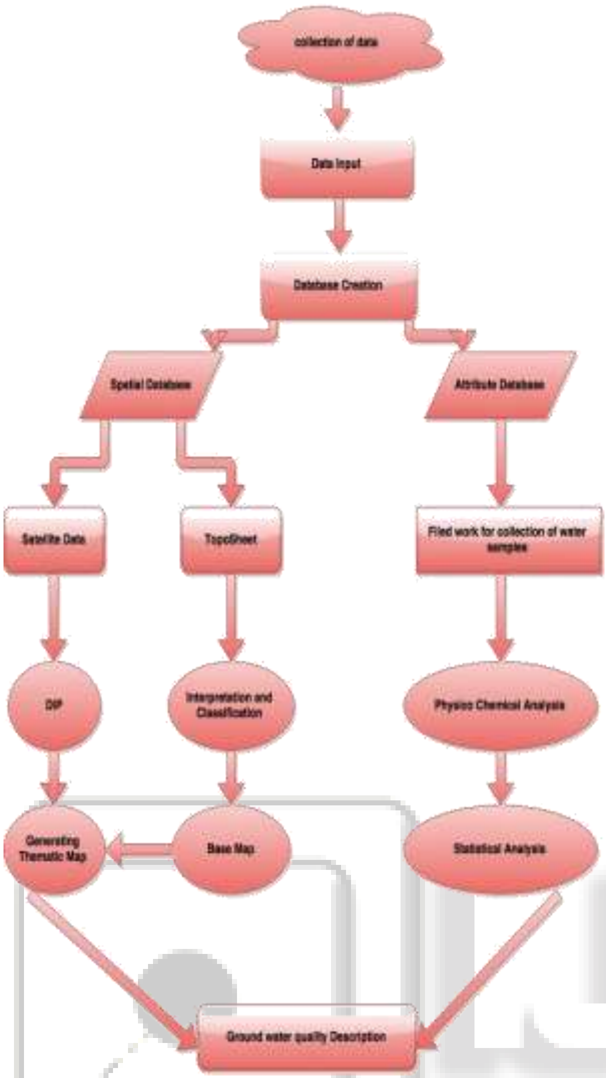

Fig. 1.2: Methodology

IV. RESULTS & DISCUSSIONS

A. Watershed Flow Direction Map

This below map shows the flow direction of the watershed in a study area to collect samples.

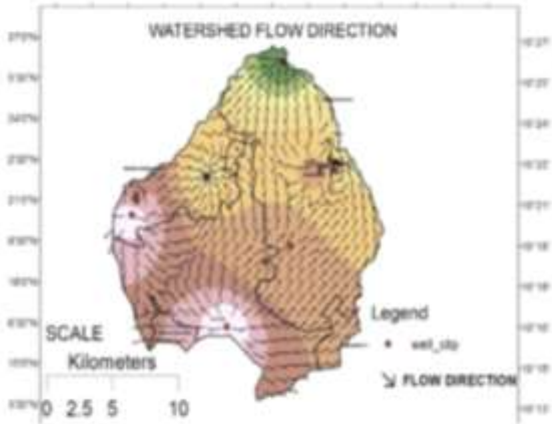

Fig. 1.3: Watershed Flow Direction Map

B. Stream Map

The district is a part of cauvery and capecomerin to cauvery basin and parts of vaigai and pambar sub basins.

Fig. 1.4: Stream Map

C. Geomorphology Map

The Valley fill residues are found to be arose in oddanchatram, Reddiarchatram, Sanarpatti and Natham blocks and the southern slopes of kodaikanal hills. Structured hills are the main land forms in the district. Surface supressed pediments are the results of denotational land forms. Along the river sequences, flood plains of recent origins are found out.

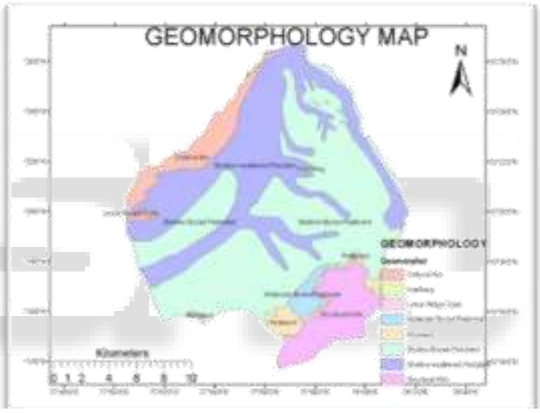

Fig. 1.5: Geomorphology Map

D. Geology Map

The major part of the district is underlain by Archaean crystalline metamorphic complex. The important aquifer systems encountered in the district are classified into i) Fissured, fractured and weathered crystalline formation consisting of Granite Gneisses, ii) Valley fill residues comprising clay, silt and kankar valley fill residues had been observed along valley portions in the depth range of 38 to 42 m bgl Natham and Sanarpatti blocks.

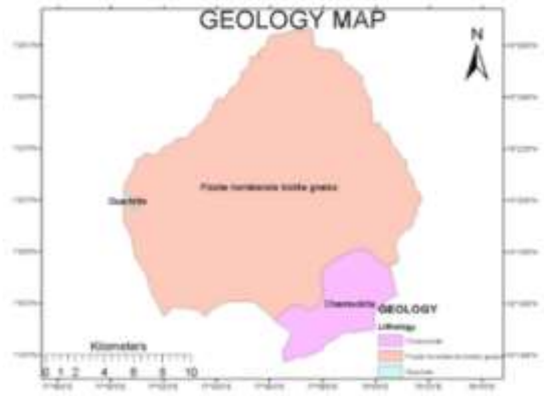

Fig. 1.6: Geology Map

E. TDS (Total Dissolved Solids)

Total Dissolved Solids encompasses inorganic salts and small amounts of organic matter that are dissolved in water. Usually the cations, calcium, magnesium, sodium, and potassium and the anion carbonate, bicarbonate, chloride, sulphate and particularly nitrogen are the principal constituents of TDS. TDS values in the study area varies from 1666 mg/l to 19810 mg/l with an average value of 7029 mg/l in post monsoon period. In the present study all samples of TDS value is exceeded the allowable limit prescribed by BIS.

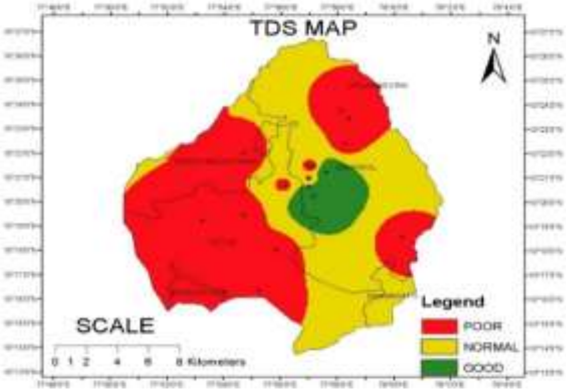

Fig. 1.7: TDS Map

F. Turbidity

Turbidity is a measure of the mistiness or darkness of water due to suspended particles. In these present study turbidity values of study area varies from 1 NTU to 17 NTU. Highest amount of turbidity in water causes the degradation of water clearness.

G. EC(Electrical Conductivity)

Electrical conductivity is a measurement of the aqueous solution of dissolved material which associate to the capability of the material to conduct electrical current over it. To indicate the salinity hazard, Electrical conductivity is a useful parameter. In this study area EC values varies from 2380 µmohs/cm to 28300 µmohs/cm.

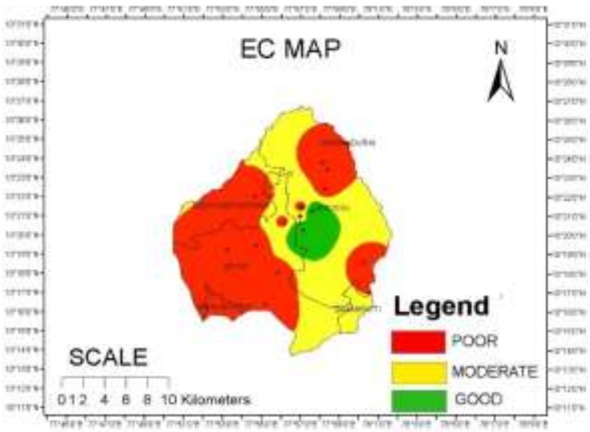

Fig. 1.8: Ec Map

H. pH

It is a measure of the acidity or hydrogen ion concentration of the water and is mathematically defined as the negative logarithm of the hydrogen ion concentration. The pH values of the study area vary from 6.86 to 8.85 with an average value of 7.57.

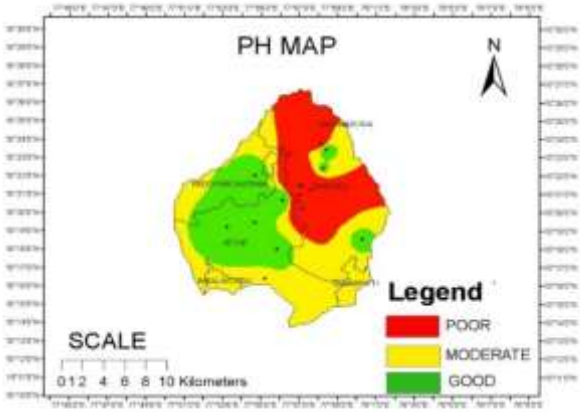

Fig. 1.9: Ph Map

I. Calcium

Calcium is one of the most abundant substance in water that makes water harder after dissolving into the water. The calcium values in this study area vary from 125 mg/l to 538 mg/l.

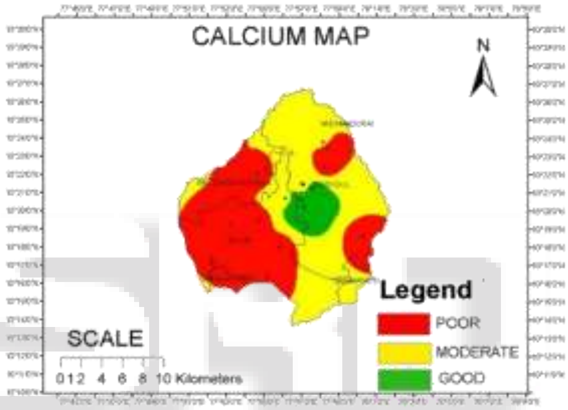

Fig. 1.10: Calcium Map

J. Magnesium

Magnesium is one of the most abundant metals in the earth's layer and usually occurs together with calcium. Magnesium concentration in water samples varies from 125 mg/l to 538 mg/l.

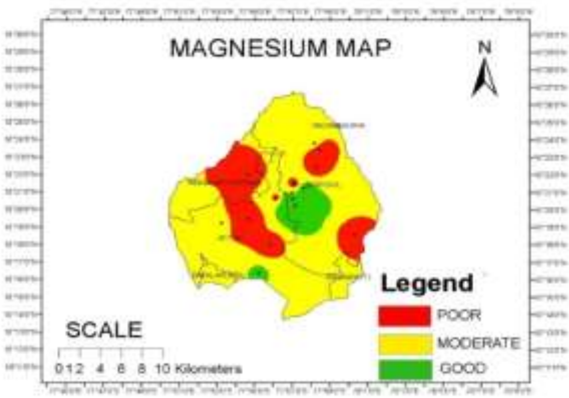

Fig. 1.11: Magnesium Map

K. Chloride

Chloride concentration is widely varying in all natural waters. If the chloride content is increases, the mineral content is also increases. Chloride values in this area vary from 420 mg/l to 10800 mg/l. All 100% chloride values are exceeded the prescribed permissible limit (i.e.) 250 mg/l. There is no health impact on the human, if highest amount of chloride content is present in water. Water obtains salty taste when the chloride content is above 250 mg/l. This may causes corrosion in construction.

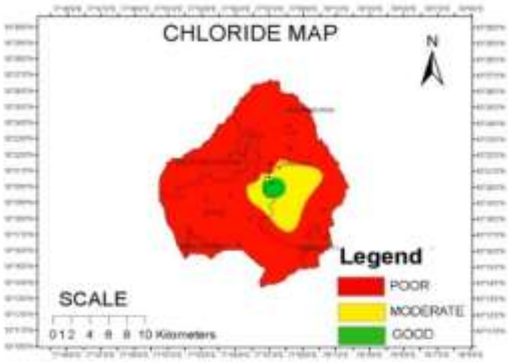

Fig. 1.12: Chloride Map

L. Sodium

Sodium values in this study area ranges from 92 mg/l to 500 mg/l.

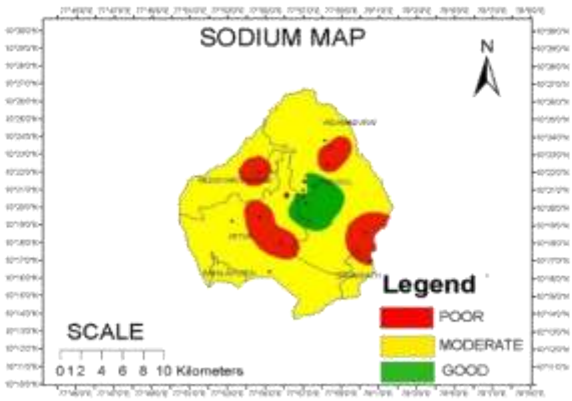

Fig. 1.13: Sodium Map

M. Statistical Analysis

Statistical analysis is a mathematical measure used to defining a features of a sample. In this study eighteen water quality parameters of fifteen locations of study area have been taken for statistical analysis.

1) Descriptive Statistics

Parameters	Minimum	Maximum	Mean	Median	Std. Dev	Skewness	Kurtosis
Turbidity	1	17	6.286	2	6.6	0.58	1.73
TDS	1666	19810	7029	2142	7504.56	0.913	2.1
EC	2380	28300	10041.42	3060	10720.799	0.913	2.10
pH	6.86	8.85	7.5757	7.47	0.6459	1.06	3.29
Alkalinity	400	750	582.85	540	134.74	0.147	1.66
Hardness	500	2150	1100	800	636.42	0.69	1.96
Ca	125	538	275.1429	200	159.17	0.69	1.96
Mg	48	207	105.71	77	61.22	0.70	1.97
Fe	0	0	0	0	0	0	0
Manganese	0	0	0	0	0	0	0
NH3	0.2	10	2.1	1	3.51	1.98	5.03
NO2	0.5	1.5	0.79	0.5	0.48	0.94	1.90
NO3	7	42	30.71	42	15.27	-0.67	1.72
Cl	420	10800	2485.71	660	3744.09	1.87	4.78
F	0.8	1.4	1.06	1	0.22	0.19	1.86
SO4	11	6584	1066.71	98	2441.68	2.01	5.10
PO4	0.2	1	0.64	0.6	0.36	-0.15	1.39
CHROMIUM	0.042	1.26	0.34	0.08	0.50	1.13	2.52

Table 1: descriptive Statistics

Table 1 represents the descriptive analysis of different water quality parameters where the parameters TDS, EC, Hardness, Cl, Alkalinity & Ca have highest values of standard deviation which indicates that the concentration of all these parameters is not the same at all sample locations of the study area.

In this analysis there is a substantial variations between mean and median for some parameters namely TDS, Turbidity, EC, Hardness, Cl, SO4, Alkalinity & Ca, which indicted that these parameters were not brought into fully distributed in a regular and symmetric way in the samples.

Though, minor difference between mean and median for the parameters namely pH, Fe, Manganese, NO2, NH3, NO3, F, PO4 &Chromium which represents that those parameters are regularly distributed over the samples.

The negative skewness values were found in the two parameters NO3, and PO4 which represents that this parameters having undesirable end in the undesirable direction. The other parameters were found to having positive skewness values, so the parameters are distributed in the desirable direction.

2) Correlation Analysis

The correlation analysis is used to describing an amount to which one variable is linearly associated with another variable. It is also used for implementing the water quality management programs.

The parameters having correlation values up to 0.5 do not have any significant relation between them, for example in this study area pH with TDS & EC, Alkalinity with Turbidity, TDS, EC & pH, Hardness with turbidity & pH, Ca with turbidity & pH, Mg is also with turbidity & pH, NH3 with alkalinity & Ca, likewise many parameters has no significant correlation between them.

The correlation values are greater than 0.5 tolerates significant linear correlation between them, for example the parameters, TDS with Turbidity, EC with turbidity, Hardness with TDS, EC & Alkalinity, Ca with TDS & EC, Mg with TDS & EC, NH3 with turbidity, TDS & EC, NO2 with turbidity, NO3 with TDS, EC, Hardness, Ca & Mg, Cl with Alkalinity, Hardness, Ca & Mg, F with turbidity, TDS, EC, pH, NH3 & NO3, SO4 with TDS, EC & F, PO4 with TDS, EC, Hardness, Ca, NH3, Cl & F, Chromium with pH, Cl, F & PO4, are having significant relationship between them.

The correlation coefficient value is greater than 0.8 will indicate the very strong correlation between the parameters, for example in this study area the parameters EC with TDS, Ca with Alkalinity & Hardness, Mg with Alkalinity, Hardness & Cl, NH3 with pH, Fe & Manganese, NO2 with Fe & Manganese, NO3 with Fe & Manganese, Cl with TDS, EC, Fe & Manganese, F with pH, Mg, Fe, Manganese, SO4 with Mg, Fe, Manganese & NH_3, PO4 with Mg, Fe, Manganese & NO_3 and Chromium with Turbidity, TDS, EC, Mg, Fe, Manganese, NH3 & SO4 are having very strong correlation. The correlated values are independent of one another.

Many parameters are exhibited negative correlation with pH. Hence, none of the parameters have substantial effect in changing the pH value of the groundwater samples of the study area. NO2 content exhibited negative correlation with TDS, Alkalinity, Hardness, and Ca, NH3. This will shows that these variables have reverse relation.

	Turbidity	TDS	EC	pH	Alkalinity	Hardness	Ca	Mg	Fe
Turbidity	1								
TDS	0.76	1							
EC	0.76	0.93	1						
pH	0.55	0.21	0.21	1					
Alkalinity	0.12	0.39	0.43	-0.67	1				
Hardness	0.22	0.62	0.67	-0.34	0.80	1			
Ca	0.24	0.65	0.63	-0.38	0.88	0.98	1		
Mg	0.22	0.61	0.69	-0.30	0.85	0.91	0.95	1	
Fe	0.91	0.92	0.94	0.99	0.91	0.95	0.91	0.99	1
Manganese	0.91	0.92	0.95	0.99	0.93	0.94	0.92	0.91	1
NH3	0.70	0.53	0.54	0.82	-0.24	0.17	0.16	0.18	0.98
NO2	0.54	-0.47	-0.48	0.17	-0.57	-0.48	-0.47	0.47	0.99
NO3	0.12	0.58	0.59	0.183	0.04	0.57	0.56	0.57	0.92
Cl	0.48	0.86	0.87	-0.21	0.58	0.58	0.57	0.55	0.95
F	0.50	0.69	0.69	0.62	-0.08	0.32	0.33	0.92	0.99
SO4	0.74	0.56	0.53	0.84	-0.29	0.12	0.11	0.99	0.98
PO4	0.36	0.77	0.77	0.14	0.33	0.80	0.80	0.83	0.90
Chromium	0.86	0.88	0.88	0.61	0.009	0.32	0.31	0.94	0.93
	Manganese	NH3	NO2	NO3	Cl	F	SO4	PO4	Chromium
Manganese	1								
NH3	0.98	1							
NO2	0.94	-0.30	1						
NO3	0.98	0.36	0.17	1					
Cl	0.99	0.04	-0.36	0.43	1				
F	0.95	0.71	0.13	0.70	0.40	1			
SO4	0.98	0.99	-0.282	0.37	0.008	0.71	1		
PO4	0.99	0.50	-0.17	0.91	0.57	0.75	0.48	1	
Chromium	0.99	0.82	-0.382	0.48	0.57	0.79	0.85	0.64	1

Table 2: Correlation Analysis

V. CONCLUSION

Water is the major necessity for the existence of life ground water is a precious reserve of determinate extent. Over the years increasing population urbanization and expansion in agriculture has head in the scientific exploitation of ground water creating a water stress condition. Dindigul area is under thread due to the critical problems of environmental pollution and water shortage problems.

The ground water quality in dindigul study area has been bargained due to pollution. The study was carried out in a part of Kodavanar watershed basin in Dindigul district. GIS technologies can provide appropriate platform for convergent analysis of large volume of multi-disciplinary data and decision making for ground water studies can be effectively done.

The estimations by the statistical analysis provide a better understanding of the variation in the quality in the study area. Hence it is suggested that statistical analysis of ground water quality periodically in the study area is necessary to identify the rate of contamination.

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