FORECASTING THE QUALITY OF MANIKANDAM LAKE IN TRICHY USING GIS TECHNIQUES

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***Abstract*:-** Surface and ground water are the important source of drinking water. Groundwater has become a necessary resource over the past decades because of increasing usage for drinking, water supply, irrigation and industrial uses etc. Surface water resource is now facing threats due to various anthropogenic activities. As that of quantity the Surface water quality is equally important. Mapping and modeling of spatial variability of Surface water and its quality is of vital important and it is particularly significant where Surface water is primary source of portable water. The present study on Surface water quality modeling, relates it to the water quality maps prepared using Remote Sensing and GIS techniques for a study area in Manikandam lake of Trichy district. Thematic map has been collected and digitized using Arc GIS software version10.1.Collected ground water samples are analyzed through physico-chemical analysis at pre-determined location of study area which form the attribute database for the study. From the statistical analysis, the Surface water quality is represented and compared with CPCB permissible limit to establish the quality.

***Keywords*:-** *Water sample, thematic map, Arc GIS software, map digitization.*

INTRODUCTION

In earth water is the basic requirement of all life. The origin of life has been attributed is water along with. Water the source of life is passionate. Too passionate to manage excess of it leads to flood and lack of it results in drought and famine. It must be noticed that any natural or manmade activity on the surface of the earth will carry its own impact on the quantity and quality of water this will be taken into the biosphere systems and ultimately lead to cross in hydrological limit. Water pollution not only affects water

quality but also human health, economic development and social prosperity (V. Rajagopalan et al., 2007). The increase in population and urbanization demands for more fresh water for increasing agricultural and industrial sectors growth. Ground water is alternative source when surface water is not available.

In past decades dependability on Surface water has reached high due to reasons such as excess supplies from ground water due to changes in monsoon, increase in demand for domestic, agricultural and industrial purposes. All over the country this has resulted in over exploitation and in certain places it has reached critical levels like drying up of the aquifers. One of the basic necessities for life is fresh water. The source of life in its natural state is free from pollution but when man comes in contact with water body it loses its natural conditions. Over the past few decades surface water has become an essential resource due to the increase in its usage for drinking, irrigation and industrial uses etc. For water quality mapping GIS and Remote sensing are effective tools, Visual Modflow for modeling the Quality and monitoring.

METHODOLOGY

Description of the Study Area

Location: Manikandam is a village panchayat which located in the Tiruchirappalli district of TamilNadustate,India.The latitude 10.7272787 and longitude 78.6314678 are the geocoordinate of the Manikandam. Manikandamlake covers about 75 hectares of land area.

Fig 1: Study Area

Population: As per records of Census India, population of Tiruchirappalli in 2011 is 847,387; of which male and female are 418,400 and 428,987 respectively. Although Tiruchirappalli city has population of 847,387; its urban population is 1,022,518 of which 507,632 are males and 514,886 are females.

Climate and Rainfall: The Tiruchirappalli lies on 84m above sea level Tiruchirappalli has a tropical climate. The summers are much rainier than the winters in Tiruchirappalli. The average temperature in Tiruchirappalli is 28.8 °C | 83.8 °F. The rainfall here is around 860 mm | 33.9 inch per year.

Soil: The most common soil types in this district are Red soil, Red sandy soil and Black Cotton soil.

Basin and sub-basin: The Cauvery and Capecomerin are basin, Agniyar and Ayyar and sub basins.

Geomorphology: Difference in geological condition and formation which leads various land forms, viz., structural hills, residual hills, linear ridges and pediment terrains in the district. Bazada zones are coalescence of alluvial cones and fans, formed after composite slope boundary. These zones are seen in northern part of Trichy. The valley fill

sediments are found to be occurred in the southern slopes of Trichy. The major land forms in the district is structured hills.

Hydrogeology: The aquifer systems in the district are classified into i) Fissured, fractured and weathered crystalline.ii) Valley fill sediments (Unconsolidated Sediments) comprising clay, and, silt. Kankar Valley fill sediments had been observed along valley in the depth of range 35 to 40 m. Deeper water levels fluctuations is so high.

Georeferencing

Direct georeferencing is a procedure that enables imageryto be georectified without the need for GCPs (M. Nagai et al 2004). Georeferencing is defined as the fixing of the locations of real-world features within the spatial framework of a particular coordinate system. The term is used both when establishing the relation between vector images and coordinates, and when evaluating the spatial location of other geographical features. Examples of georeferencing are establishing the correct position of an aerial photograph within a map and finding the geographical coordinates of a place name or street address. When data from different sources need to be combined to use in GIS application. By keeping topographic map as a reference this study area was georeferenced using the geocoordinates.

Digitization Process

Digitization is the process of capturing the spatial data on a map manually and storing them into a computer file. The spatial features namely, points, lines, polygons that constitute a map, are converted into x and y coordinates. The GIS software used for digitization and spatial analysis in the present study are Arc GIS 10.1.

Arc GIS is raster-based software with various analysis capabilities. It is used for geo-referencing and digitization of the collected map. It is capable of accessing large amount of spatially varying data. It is used to create the spatial database, analysis and produce the output for the present study. Base map is a map which displays the planimetric and/or topographic information and which may be used for a thematic layer. Topographic map of the study area was used as the base map for the present study (E. Eric Boschmann & Emily Cubbon (2014).

Preparation of Thematic Maps

A thematic map is a type of map which mainly designed to show a particular matter connected with a specific geographic area or location. This thematic map “used to visualize the aspect of a city, state, region, nation or continent”.Thematic maps show spatial distributions. The theme refers to the phenomena thatis shown, which is often demographical, social, cultural, or economic (Martijn 2018). Thematic maps are an important source of GIS information. These are tools to communicate geographic concepts such as climate, forest, land use pattern, soil type, roads and political boundaries etc. The following thematic maps are to be prepared for this study, Surface Water quality maps. The Manikandam lake map is digitalized and georeferenced using Arc GIS software. Ground Co-ordinates are obtained from Google map. Using these co-ordinates pixel co-ordinates of digitalized image are converted into ground co-ordinates. The georeferenced map is formed by creating personal geo database and feature classes like point, line, and polygon. For better understanding and more informative the layout of the map is prepared with latitude and longitude.

Physio – Chemical Analysis of Water

A total of 25 samples of water were collected from the open surface in the study area. Accrording to the

standard procedure(APHA 1998) samples were analyzed for physical and chemical parameters. Analysis were carriedfor different ions like TDS, Mg+, Ca+, Na+, Cl-, pH, EC, TH were measured to understand the geochemical behavior. Thus, obtained surface water quality data forms the attribute database for the present study.

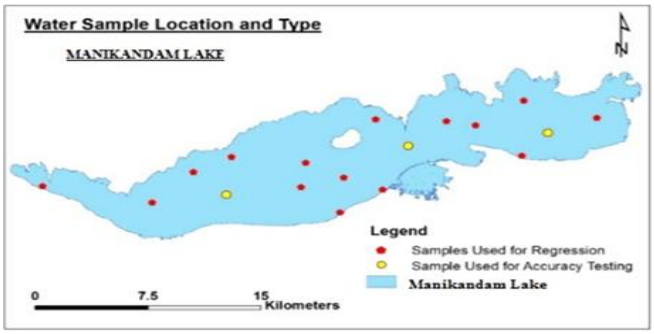

Fig 2: Location of samplescollected in ManikandamLake

Integration of Spatial and Attribute Data

The spatial and the attribute data generated are integrated for the preparation of spatial distribution maps of selected water quality parameters like pH, alkalinity, chlorides, sulphate, nitrates, TDS, total hardness, fluoride and Water Quality Index (WQI) which is over laid on satellite imagery. The water quality data (attribute) is linked to the sampling location (spatial) in Arc GIS. Using interpolation technique of Arc GIS 10.1 maps showing spatial distribution are prepared to identify the variation in concentrations of the above parameters in the ground water at various locations of the study area.

Spatial Interpolation

GIS is effective tool for finding solutions for water resources problems, for evaluating water quality, finding water availability, managing water resources on a regional scale and understanding the natural environment. Though there are a many spatial modeling technique are available with GIS application, spatial interpolation technique through Inverse Distance Weighted (IDW) approach has been used in the present study to delineate the location distribution of water pollutants. For estimating the output grid cell value this method uses a selected set of sample points (Rishikeshan et al. 2014). Using a linearly weighted combination of a set of sample points cell values determined and also controls the significance of known points upon the interpolated values based on their distance from the output point thereby generating a surface grid. With the help of cartographic techniques important water quality indicating parameters and their distribution patterns were studied in Dindigul district also. Thus, GIS helps us to the cause and effect relationship with clear presentation.

Table1:Result of physical and chemical analysis of water samples

PARAMETERS	pH	TDS (mg/l)	Total Hardness (mg/l)	Total Alkalinity (mg/l)	DO (mg/l)	BOD (mg/l)	Chloride (mg/l)	Sulphate (mg/l)	Nitrate (mg/l)	Calcium (mg/l)
SAMPLE-01	8.4	410	169	200	7.7	1.9	51	13.2	0.01	40.1
SAMPLE-02	8.8	500	162	210	8	1.6	86	24.6	0.15	32.5
SAMPLE-03	8.6	500	160	190	7.8	0.9	94	28.6	0.1	38.5
SAMPLE-04	8.6	470	163.67	200	7.83	1.47	77	22.13	0.087	37.03
SAMPLE-05	8.4	480	154	210	7.9	0.7	60	18.1	0.014	36.1
SAMPLE-06	8.7	500	171	220	7.8	2.3	83	26.8	0.1	33.2
SAMPLE-07	8.6	520	180	210	7.7	1.5	100	28.6	0.1	43.3
SAMPLE-08	8.57	500	168.33	213.33	7.8	1.5	81	24.5	0.071	37.53
SAMPLE-09	8.4	480	154	210	7.9	0.7	60	18.1	0.014	36.1
SAMPLE-10	8.7	500	171	220	2.3	1.5	83	26.8	0.1	33.2
SAMPLE-11	8.6	520	180	210	7.7	1.5	100	28.6	0.1	43.3
SAMPLE-12	8.57	500	168.33	213.33	7.8	1.3	81	24.5	0.071	37.53
SAMPLE-13	8.5	460	154	200	7.8	4.2	46	16.9	0.006	39.3
SAMPLE-14	8.2	610	194	250	6.3	6	108	30.1	0.41	46.2
SAMPLE-15	8	670	214	260	5.6	3.83	121	31.1	0.25	54.5
SAMPLE-16	8.23	580	187.33	236.67	6.57	1	91.67	26.03	0.222	46.67
SAMPLE-17	8.5	407.5	165.1	205	7.8	3.1	48.9	12.05	0.01	40.1
SAMPLE-18	8.6	550	184	235	7.3	4.3	96.6	28.18	0.25	38.25
SAMPLE-19	8.5	605	202.5	240	7.2	2.8	114.9	30.13	0.23	49.5
SAMPLE-20	8.5	520.8	183.9	226.7	7.4	1.5	86.8	23.45	0.16	42.62
SAMPLE-21	8.5	500	171	213.33	7.7	1.5	83	26.8	0.1	33.2
SAMPLE-22	8.57	520	180	200	7.8	1.3	100	28.6	0.1	43.3
SAMPLE-23	8.5	500	168.33	250	7.8	4.2	81	24.5	0.071	37.53
SAMPLE-24	8.2	460	154	260	6.3	6	46	16.9	0.006	39.3
SAMPLE-25	8	610	194	236.67	5.6	3.83	108	30.1	0.41	46.2

Map and Data Integration

Surface water samples were collected in 25 locations. The samples are plotted in the digitized map using ArcGIS software. Effluents were identified from industrial, agricultural and residential areas.

Statistical Analysis

Surface water analysis was made with the distribution of chemicals in the study area over the years. The Surface water quality parameters are given as input for calculating the distribution of chemicals. From the statistical analysis of the surface water quality the graph has been plotted and their linear equation has been obtained. From the linear equations the water quality of the Manikandam Lake has been forecasted. The spatial interpolation has been made with the water quality data and the results shows the quality spatial distribution of Manikandam Lake in Trichy district. The result reveals that the variation in the quality of surface water based on the physico-chemical parameters. Monitoring done by using statistical analysis including correlation analysis, factor analysis and regression analysis. With the help of correlation analysis, the significant relationship among parameters is found out. The results of this analysis showed the important chemical parameters. The predicted model was derived from regression analysis and the validation of this analysis was proved. The tested results are compared with the collected samples value. Hence, the parameters are varying from -25.45 % to 37 %. From this study it is clear that Trichy city is under threat.The reason for this threat is water scarcity and Pollution of water. Hence it is advised that the monitoring the quality of Surface water by statistical analysis occasionally is best way to prevent further contamination.

RESULTS AND DISCUSSION

Spatial Variation Maps

GIS is used to determine the Surface water quality in Manikandam lake, Trichy district. The variations of the physico-chemical characteristics of the Surface water in the study area were presented through the figures. The quality of Surface water varies in all region. It related with the surface and subsurface characteristics. The quality of Surface water changes in the presence of landfills, open dump, usage of fertilizers, disposal of industrial wastes, etc.The spatial distribution maps of major water quality parameters like TDS, Ca, Mg, Cl, Na,pH, EC, Total Hardness and some of the heavy metals which is too costly to analyze in laboratory has been prepared using spatial interpolation technique in Arc GIS and ENVI software for the study area.

The following figure represents the range of salinity,sand ratio,carbonate and organic carbon in percentage.It is noted that the salinity of Manikandam lake ranges from 22-23% of total water quality. Then sand ratio ranges from 60-80% of total water quality. Then carbonate ranges from 10-20% of total water quality. This has been predicted by using the meta data of Manikandam lake and by using IDW in ArcGIS software the ranges have been obtained.

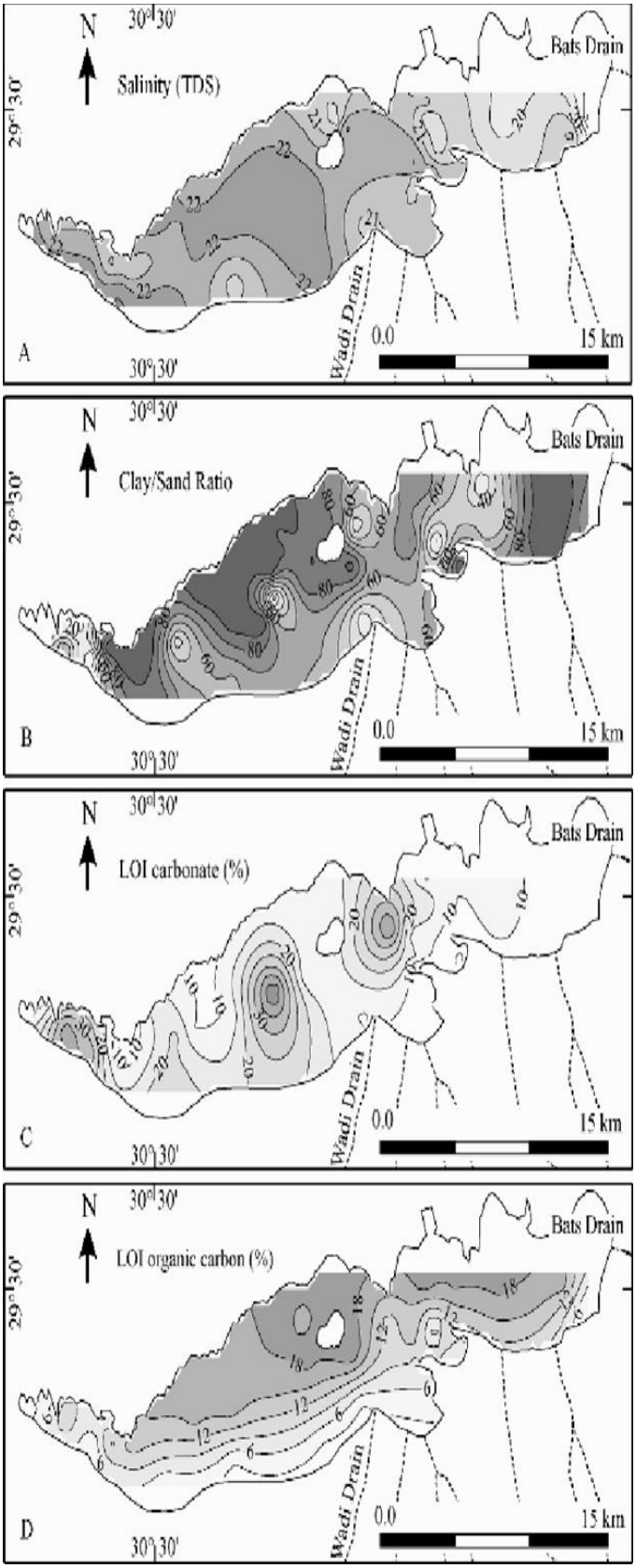

Fig 3: IDW of water quality in Manikandam Lake

GIS was a powerful tool for spatial analysis and interpretation of the Surface water quality. The study has established the utility of GIS technology combined with analysis in evaluation and mapping of Surface water quality in Manikandam Lake. Results of the study revealed that the lower part of the transitional zone has acidic nature where later part has high conductivity, TDS, total coliform, fecal coliform, nitrite, BOD and hardness which indicate increasing tendency of all parameters towards to the down part of the Manikandam Lake. Meandering zone of the Manikandam Lake is having highly populated areas, industries; urbanized cities which are produce pollutants to the environment. Thus,for better conclusion the GIS spatial distribution maps give better visual picture to understand the present Surface water quality of the Manikandam Lake to overlook. The results suggest that the Surface water of the meandering part of the Manikandam Lake needs some of treatment before consumption and it is indicating need to develop suitable management practices to protect the ground water resources in Manikandam Lake. GIS is commonly used for site suitability analyses, estimation of Surface water vulnerability to contamination and integrating Surface water quality assessment models with spatial data to create spatial decision support systems for Surface water studies. Water management in Manikandam Lake is important for present and future Surface water quality assessment is important to ensure sustainable safe use of water, therefore aim of the present study is to provide an overview of Surface water quality condition of the Manikandam Lake.

Because of high cost and time consumptions the heavy metals can be interpolated by sing remote sensing data by comparing the spectral library. The following heavy metals has been interpolated and given in spatial format for better understanding. The figure-6 shows the range of iron (Fe) from 300-600µg/g. then zinc (zn) ranges from 0-25µg/g, lead ranges from 0-20µg/g, Cobalt ranges from 12-14µg/g, Chromium ranges from 0-14µg/g, Copper ranges from 0-30µg/g, Cadmium ranges from 0-2.5µg/g. They found significant correlations between ground-derived spectral parameters and heavy metal concentrations for with the depth of the absorption at 500 nm (Depth550 nm) for Pb and Zn, with the ratio of 610 to 500 nm (R610,550 nm) for Cu, Pb and Zn, with the depth of the absorption at 2200 nm (Depth2200 nm) for Zn and As, with the area of the absorption at 2200 nm (log(Area2200 nm)) for Cu, Pb, Zn and As, and with the asymmetry of the absorption feature at 2200 nm (Asym2200 nm) for As. They applied these parameters to a hyperspectral aerial image acquired with the HyMAP sensor. The pixels classified in the rule image of Depth 500 nm, the ratio R1344,778 nm, and Area2200 nm derived from a HyMAP image shows the similar spatial patterns to the gradient maps of ground-derived spectral parameters.

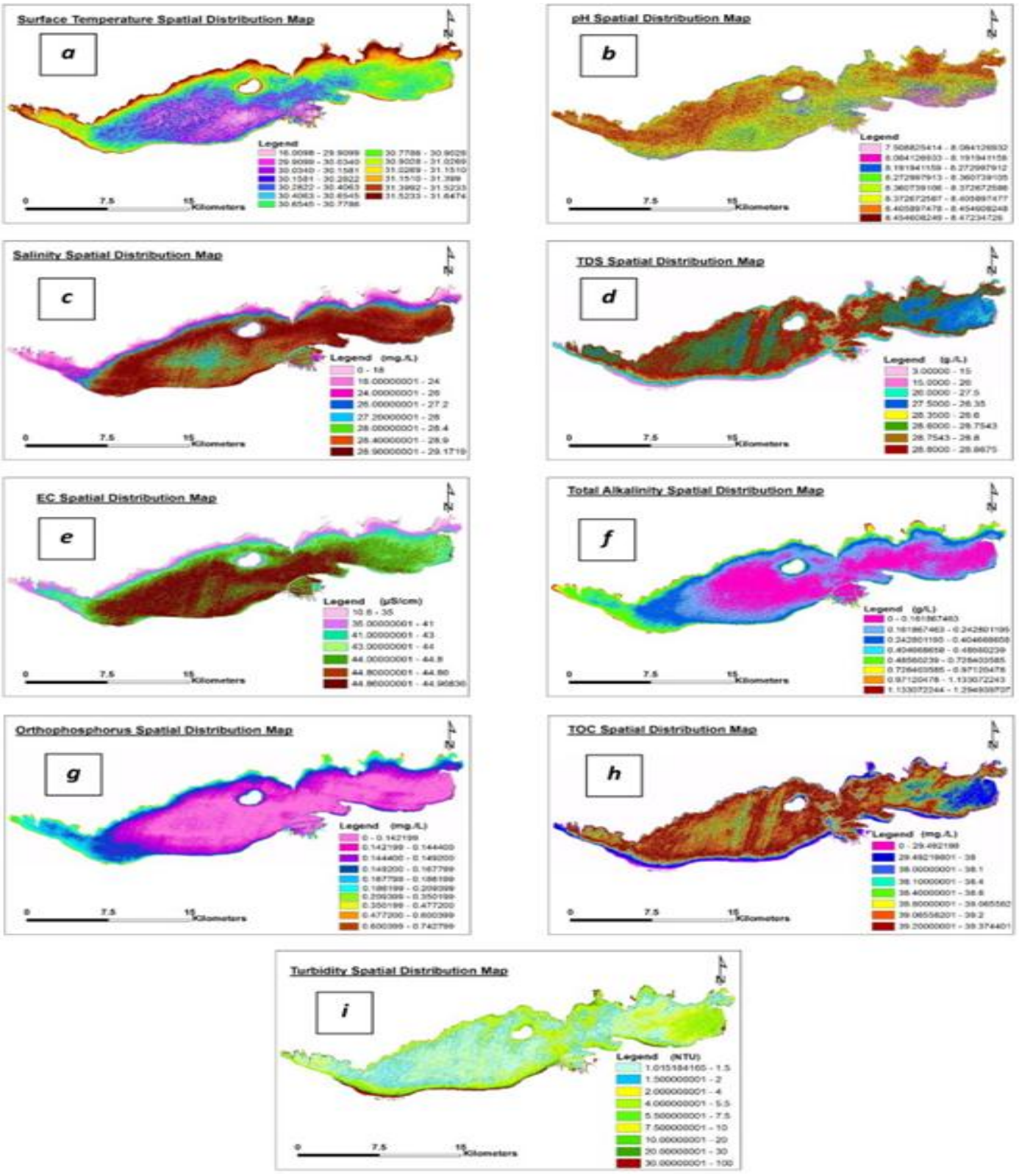

Fig 4: Satellite interpolation of water quality

Heavy metals are pollutants of great importance for human health and ecosystems. The use of remote sensing techniques to determine the presence of these pollutants in surface water is a good tool for this purpose. However, not too many research and studies are done. To know the level of heavy metal pollution in water is vital for most of the human activities in the Earth surface, thus the improvement of remote sensing techniques to study surface water pollution are needed. The development of new sensors join to the improvement of the imaging analysis are the key factors to aid us to locate heavy metals in large areas and favors to take the best decisions for land management and pollution control.

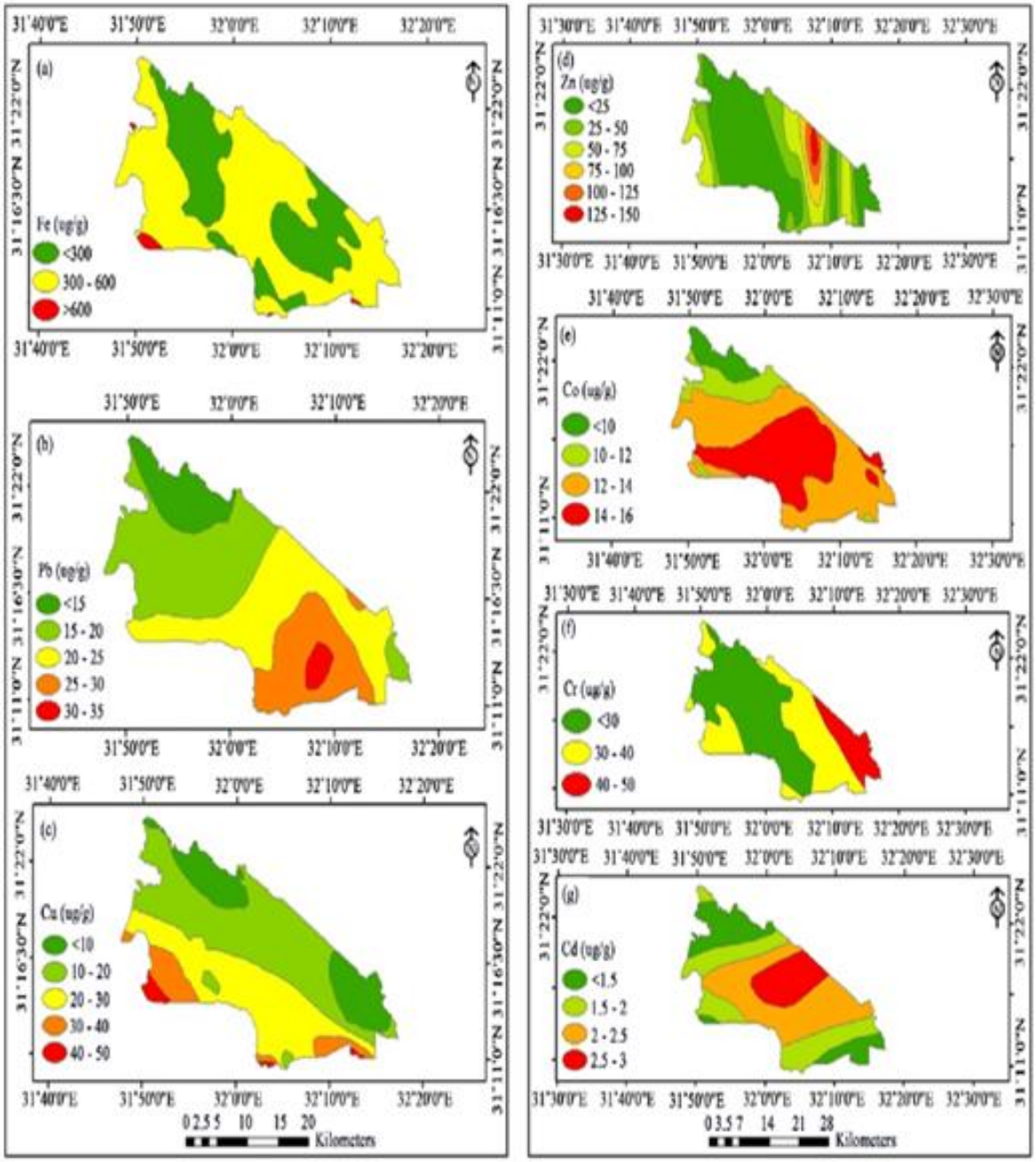

Fig 5: Satellite interpolation of heavy metals

Forecasting of Surface Water Quality

pH:

pH is most important parameter, which determines the suitability of water. The pH values of the analyzed samples range from 8-8.8 in the study area.

Y = -0.012x + 8.632

Where y is the pHto be estimated

X is the average pH value

Here average pH=8.4

Thus the forecasted pH range in upcoming year will be

y = -0.012 (8.4) + 8.632

y = 8.5312

Thus the forecasted pH range in upcoming year will be 8.5312

Total Dissolved Solds (TDS):

Mineral constituents dissolved in water are called dissolved solids. In natural water the concentration of dissolved solids is usually less than 500 mg/l, while water with more than 500 mg/l is unsuitable for drinking. The TDS values ranges from … mg/l in the study area.

Y = 2.950x + 476.5

Where y is the TDS to be estimated

X is the average TDS value

Here average TDS=500

Thus the forecasted TDS range in upcoming year will be

y = 2.950 (500) + 476.5

y = 1951.5

Thus the forecasted TDS range in upcoming year will be 1951.5 mg/l

Total Hardness:

Calcium and magnesium are main reason for hardness of water. When hardness is less than 300 mg/l it considered soft. When is more than 300 mg/l hardness it unsafe. The hardness values range from 150 to 200 mg/l in the study area.

Y = 0.822x + 163.4

Where y is the TH to be estimated

X is the average TH value; Here average TH=160

Thus the forecasted TH range in upcoming year will be

y = 0.822 (160) + 163.4

y = 294.92. Thus the forecasted TH range in upcoming year will be 294.92 mg/l

Total Alkalinity:

The Total Alkalinity varied from 200 to 250 mg/l.

y = 1.629x + 199.6

Where y is the Total Alkalinity to be estimated

X is the average Total Alkalinity value

Here average Total Alkalinity =200

Thus the forecasted Total Alkalinity range in upcoming year will be

y = 1.629 (200) + 199.6

y = 525.4

Thus the forecasted Total Alkalinity range in upcoming year will be 525.4 mg/l

Dissolved Oxygen (DO):

The Dissolved Oxygen varied from 6 to 8 mg/l..

y = -0.036x + 7.649

Where y is the Dissolved Oxygen to be estimated

X is the average Dissolved Oxygen value

Here average Dissolved Oxygen =7.7

Thus the forecasted Dissolved Oxygen range in upcoming year will be

y = -0.036(7.7) + 7.649

y = 7.3718

Thus the forecasted Dissolved Oxygen range in upcoming year will be 7.3718 mg/l

BOD:

The BOD varied from 1 to 6 mg/l..

y = 0.110x + 0.986

Where y is the BOD to be estimated

X is the average BOD value

Here average BOD =1.5 which s clearly extracted from the graph

Thus the forecasted BOD range in upcoming year will be

y = 0.110 (1.5) + 0.986

y = 1.151

Thus the forecasted BOD range in upcoming year will be 1.151 mg/l

Chloride:

Chloride is important parameter in assessing the water quality and concentration of chloride indicates degree of organic pollution. The chloride ion concentrated from 50 to 100 mg/l. ,

y = 0.576 x + 76.01

Where y is the Chloride to be estimated

X is the average Chloride value

Here average Chloride =83.51 .Thus the forecasted Chloride range in upcoming year will be

y = 0.576(83.51) + 76.01

y = 124.111

Thus the forecasted Chloride range in upcoming year will be 124.111mg/l

Sulphate:

The Sulphate varied from 13 to 30 mg/l.

y = 0.148x + 22.44

Where y is the Sulphate to be estimated

X is the average Sulphate value

Here average Sulphate =24.37

Thus the forecasted Sulphate range in upcoming year will be

y = 0.148(24.37) + 22.44

y = 26.04676

Thus the forecasted Sulphate range in upcoming year will be 26.04 mg/l

Nitrate:

The Nitrate varied from 0 to 0.4 mg/l.

y = 0.005x + 0.057

Where y is the Nitrate to be estimated

X is the average Nitrate value

Here average Nitrate =0.125

Thus the forecasted Nitrate range in upcoming year will be

y = 0.005(0.125) + 0.057

y = 0.057625

Thus the forecasted Nitrate range in upcoming year will be 0.05 mg/l

Calcium:

Calcium is the most abundant substances in the water. Dissolve Calcium and Magnesium in water is the two most common minerals that make water hard. Analyzed sample varies from 30to 50 mg/l.

y = 0.281x + 36.54

Where y is the Calcium to be estimated

X is the average Calcium value

Here average Calcium =40.20 which s clearly extracted from the graph

Thus the forecasted Calcium range in upcoming year will be

y = 0.281(40.20) + 36.54

y = 47.83; Thus the forecasted Calcium range in upcoming year will be 47.83 mg/l

It is inferred that the Total Dissolved Solids, Total Alkalinity, Dissolved oxygen will be more than the

desirable limits in the upcoming years. Hence proper remediation should be taken to reduce the further contamination in Manikandam Lake.

Table 2: Forecasted Physical and chemical parameters of Manikandam Lake

S.NO	PARAMETERS	VALUE
1	pH	8.5
2	TDS (mg/l)	1951.5
3	Total Hardness (mg/l)	294.92
4	Total Alkalinity (mg/l)	525.4
5	DO (mg/l)	7.3718
6	BOD (mg/l)	1.151
7	Chloride (mg/l)	124.111
8	Sulphate (mg/l)	26.04
9	Nitrate (mg/l)	0.05
10	Calcium (mg/l)	47.83

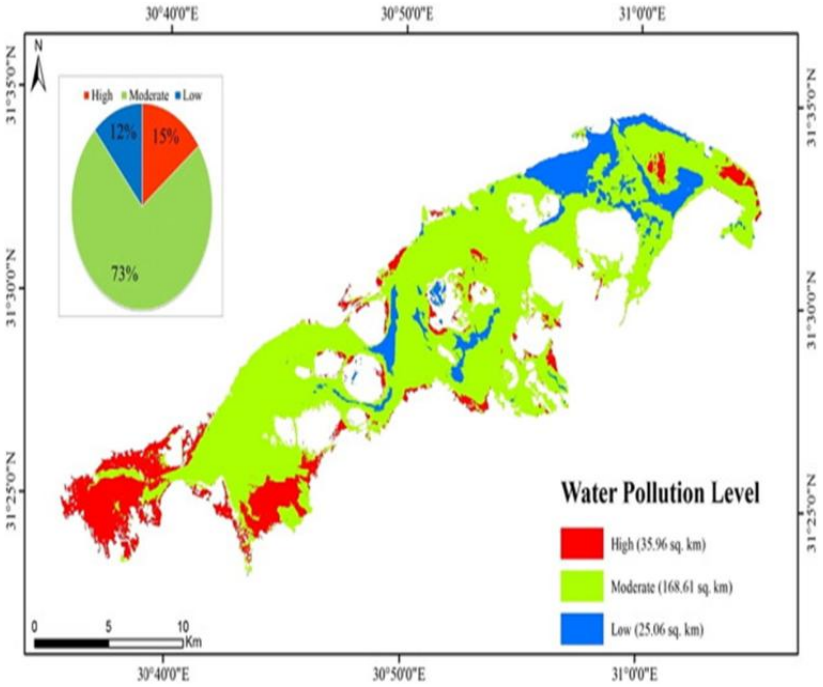

Fig 6: Water pollution level of Manikandam Lake

CONCLUSION:

Physico-chemical characterization of Surface water samples were taken from Manikandam Lake. 25 samples were collected from different parts of Manikandam Lake. These samples were plotted in graph diagram and it shows the range of chemicals present in the samples. Total Dissolved Solids, Total Alkalinity, Dissolved oxygen content is larger. It is forecasted that these chemical concentrations will be much heavier than the permissible limits given by CPCB. This forecasting is done by linear regression statistical techniques derived from the graph. Salinity of the water also increases in certain areas. Hence it is suggested that monitor the quality of Surface water periodically in the study area to prevent further contamination. Thus, the remote sensing and GIS helps in bringing the spatial pictures of the current surface water quality. The integrated statistical technique greatly helped to forecast the surface water quality of Manikandam Lake with maximum level of accuracy.Due to various reasons the quantity of the lake remains unchanged so this project deals with the quality of the water.

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