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Degradation Assesment of Coastal Aquifer

S. Nandhini
Assitant Professor
Department of Civil Engineering
Easwari Engineering College
Chennai, India

K. Srinivasan
Scientist-C
Institution of Remote Sensing,
Anna University
Chennai, India

R. Aravind Kumar
Assitant Professor
Department of Civil Engineering
Vel-Tech Engineering College
Chennai, India

M. Marisakthi
Assitant Professor
Department of Civil Engineering
Easwari Engineering College
Chennai, India

G. K. Geethanjali
Assitant Professor
Department of Civil Engineering
Easwari Engineering College
Chennai, India

***Abstract*— India is blessed with vast stretch of coastline. Water resources in the urban area assume a special significance since any development activity largely depends on availability of fresh water to meet the needs of domestic, agricultural and industrial activities. It is one of the most valuable natal resources, which supports human health, economic development and ecological diversity. However, fresh water in these areas is experiencing irreversible impacts due to overexploitation of groundwater and sea level rise leading to sea water intrusion into coastal aquifers. Though sea water intrusion has not yet assumed serious magnitude, but in coming years it may turn into a major problem, if corrective measures are not initiated at this stage. The study area extends from Adyar to Muttukadu, Chennai and Kanchipuram district, Tamil Nadu, India, with an area of 126.69 Sq.Km. This study developed an approach for assessing the vulnerability of sea water intrusion using spatial variation index for various groundwater parameters and modelling the impact of sea water intrusion in coastal aquifer using GMS(MODFLOW and SEAWAT) software. Analysis of land use / land cover changes of study area were performed from the satellite images (LISS IV) to validate the vulnerability changes in the coastal aquifer.**

Keywords— Aquifer, Hydraulic conductivity, hydraulic head, storage coefficient, specific yield, Land use / Land cover, Vulnerability, MODFLOW, MT3DMS

I. INTRODUCTION

Ground water is one of the most valuable natural resources, which supports human health , economic development and ecological dversity. Most of the water of our planet (97.5%) occurs as saltwater in the ocean. Of the remaining 2.5% , two – thirds occurs as snow and ice in polar mountainous regions, which leave only about 1% of the global water as liquid freshwater. It has been estimated that about 98.7%of all liquid freshwater is available as groundwater, while only 0.98% is available in rivers and lakes. Out of total ground water , 50% is available within the top 800m of the earth crust which is accessible to human use. Nowadays groundwater has become the major sources of freshwater, which is being distorted by overdraft and thereby leading to declining of groundwater level, which leads to salt water intrusion in to coastal aquifer.

National water policy -2002 also stressed that “ over exploitation of ground water should be avoided especially near the coast to prevent the ingress of sea water into the water aquifer”. The management of ground water resources in the coastal aquifer needs special attention to minimize the ingress of sea water into the aquifer.

With the advent of powerful computers and the advances in space technology, efficient technologies for land management have evolved of which remote sensing and geographic information system are of great significance . These techniques have fundamentally changed our thoughts and ways to manage natural resources and water resources in particular. The main intent of the present study is to highlight remote sensing and geographic information system and present a comprehensive review on their application to ground water hydrology or hydrogeology.

II. DESCRIPTION ABOUT THE STUDY AREA

Coastal zone is the area of interaction between it includes both terrestrial and marine resources which are of renewable as well as non- renewable nature. Coastal zone in India assumes its importance because if high productivity of the area, its ecosystem and various extensive and growing use of the areas. A basic problem is the limited availability of location specific information of coastal zone. One of such important coastal aquifer is that extends from Adyar to Muttukadu and this compromise the study area.

A. LOCATION AND EXTENT

The study area lies within latitudes 12°50'00" N-13°03'00"N and longitudes 80°10'00"S-80°16'30"S. the study area extends maximum upto 6 kms from the sea coast. Adyar river in the north and muttukadu backwater in the south bound the study area . the area is covered by SOI toposheet no . 66C/4, 66C/8 and 66D/1&5.

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B. *PHSIYOGRAPHY AND RELIEF*

The altitude of the aquifer increases from mean sea level in the east to about 40 m in the west. The sea coast forms the eastern boundary. The aquifer is coastal alluvium, the general slope of the terrain is uniform and the average slope is 1°.

C. *CLIMATE*

The climate in this area is considered to be the best suitable climate in the South Asia. The temperature of the study area is pleasant in winter season . in summer, the dynamic temperature varies from 35° to 41° C, in winter it varies from 22° C to 32°.

D. *SOIL*

The exposed soil is mostly of sandy nature. The coastal alluvium consists of grave, fine to coarse sand , clay and sandy clay. The study of hole details indicate that these different types of alluvium deposits are interchanged in the form of lenses and pockets, which point out the erratic geometry of the deposition caused by the migration and varying flow velocities of old river.

E. *RAINFALL*

There is no rainfall station exactly in the study area. Hence the rainfall station available nearest to the study area (kovalam) was taken for analysis. Most of the rainfalls occur during the north-west monsoon period. About 47% of the rainfall occurs during the months of October and November which are the months of heavy rainfall. During the south-west monsoon period of June to September, about 32% of annual rainfall is the main source of recharge the recharge of the aquifer and consequent recovery of groundwater head mainly occurs during the month of October, November and December.

F. *GEOLOGY*

The Archean gneissic and plutonic rocks emerge from beneath the earlier sedimentary in the southern parts. No materials of any importance are available in the area. In the alluvial aquifer consists chiefly of sand and gravel.

G. *COASTAL LAND FORM*

The study area is marked by back waters, beach , sand , salt pans and salt affected area. Scrub land, crop land and plantation is mostly planted with casurine. A visual analysis of the satellite data product reveals the above land forms and wetlands.

H. *HYDRO-GEOLOGICAL CONDITION OF STUDY AREA*

The Precambrian gneiss of charnockite composition is at the basement of this area, which is overlaid by unconsolidated quaternary sediments with thickness ranging between 10 m and 23 m. These quaternary sediments comprise of sand, clay, sandy clay and clayey sand. The sandy formation covers most part of the area and the clay is dominant in the western boundary i.e., along Buckingham canal. The clay, sandy clay and clayey sand are also present as patches in the quaternary formation. The upper unconsolidated formation and lower weathered/fractured rocky formations function as an unconfined aquifer.

Rainfall recharge is the main source of aquifer replenishment. Wells that exist at the landward edge of the beach sand, in the dunes, supply significant amount of groundwater . Field observations indicate that only a few wells penetrate the weathered zone in the charnockite, whereas others tap only the upper Quaternary sediments. The average groundwater level fluctuation in a year is around 1.25 m. The maximum groundwater level fluctuation of 2.93 m occurred in the northern part of the area during the investigated period . the hydrogeological conditions is shown in the fig. 1.

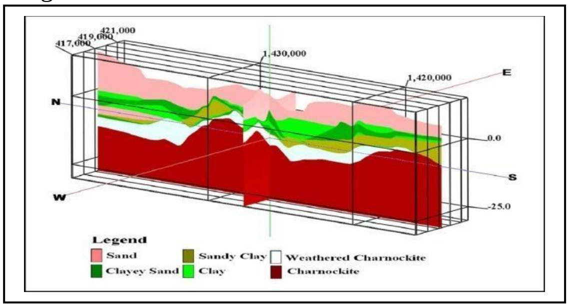

Figure.1. Hydro geological condition of study area

III. METHODOLOGY

The methodology has been decided based upon the various literature reviews and its flowchart is shown below.

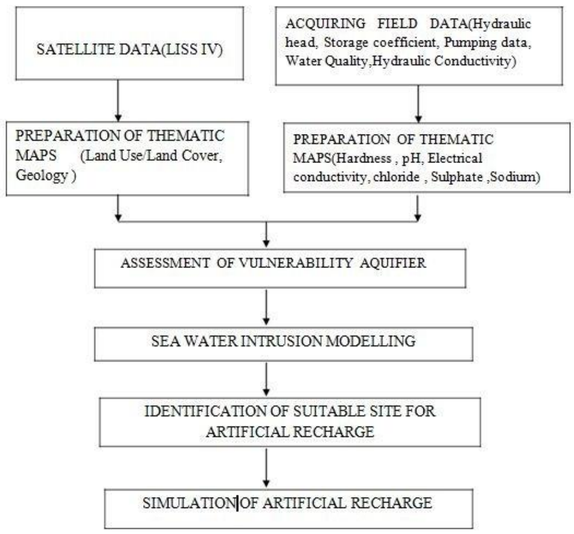

Figure 2. Flowchart showing Methodology

A. *SATELLITE DATA*

The LISS IV image of IRS satellite has been collected and it is clipped according to the district of study area required and that particular region is extracted. Based on the south Chennai aquifer map the study area is delineated.

B. *FIELD DATA*

The well locations present in the study area is been collected from PWD department, Taramani, Chennai. And water quality parameters for each well is collected. The major parameters which influence the quality of water are electrical conductivity , total hardness, chloride pH, Sodium, Sulphate.

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C. THEMATIC MAPS

Each quality parameter data is spatially distributed throughout the study area by the technique of interpolation(Inverse Distance Weightage) in Arc-GIS software. This interpolated map is reclassified based on the classification as Agricultural purpose, drinking purpose, domestic purpose, industrial purpose and unsuitable based on the quality recommended by WHO and BIS.

D. VULNERABILITY MAP

The Spatial Map of each quality parameter is overlaid and weight age is given for each parameter using water quality index(WQI) and the vulnerability map is prepared for the year of 2008 and 2012.

E. SEA WATER INTRUSION MODELLING

The ground water systems of the study area are modelled using Modular Three-Dimensional Groundwater Flow Model- MODFLOW. The input and output of the model is to be interfaced with the GIS layers.

MODFLOW is one of the sophisticated software packages available for the modeling of flow and transport process in porous media under saturated and unsaturated conditions based on the differential techniques. Integral components are interactive graphics, a GIS interface, data regionalization and visualization tools and process building the mesh boundary, assigning model properties and boundary conditions, running the mesh, assigning model properties and boundary conditions, running the simulation and visualizing the results with powerful numeric techniques.

F. MT3DMS

MT3DMS is a new version of the Modular 3-D Transport MODEL, where MS denotes the Multi-Species structure for accommodating add-on reaction packages. MT3DMS has a comprehensive set of options and capabilities for simulating advection, reactions of contaminants in Groundwater flow systems under general hydro geological conditions. The key features of MT3DMS are summarized below.

MT3DMS is unique in that it includes three major classes of transport solution techniques in a single code, i.e., the standard finite dispersion/diffusion, and chemical difference method; the particle tracking-based Eulerian-Lagrangian methods; and the higher-order finite-volume TVD method. Since no single numerical technique has been shown to be effective for all transport conditions, the combination of these solution techniques, each having its own strengths and limitations, is believed to offer the best approach for solving the most wide-ranging transport problems with desired efficiency and accuracy.

MT3DMS can be used to simulate changes in concentrations of miscible contaminants in groundwater considering advection, dispersion, diffusion and some basic chemical reactions, with various types of boundary conditions and external sources or sinks.

G. GROUNDWATER MODELLING SYSTEM

GMS is the most intuitive and capable software platform used to create groundwater and subsurface simulations in a 3D environment.

This software works with the help of transport modelling which helps to identify the sea water intrusion. The transport modelling has various modules in which I have used the SEAWAT package.

GMS provides a custom interface to the SEAWAT model offering a simple way to set model parameters and a graphical user interface to run the model and visualize the results. Gather background data from a variety of sources from GIS to CAD and access online data from numerous databases of maps, images, and elevation data. GMS allows you to interact with models in true 3D taking advantage of optimized OpenGL graphics and to create photo-realistic renderings and animations for PowerPoint, print, and web presentations.

H. SEAWAT

SEAWAT is a three dimensional variable density groundwater flow and transport model developed by the USGS based on MODFLOW and MT3DMS. SEAWAT v4 is based on MODFLOW 2000 and MT3DMS 5.2. SEAWAT includes two additional packages: Variable-Density Flow (VDF) and Viscosity (VSC).

GMS supports SEAWAT as a pre- and post-processor. The interface to SEAWAT relies on the interface to MODFLOW and MT3DMS. The input data for SEAWAT is generated by GMS and saved to a set of files including a MODFLOW model, an MT3D model if transport is used, and a SEAWAT model pointing to the MODFLOW and MT3D model's package files. These files are then read by SEAWAT and executed. SEAWAT uses the MODFLOW and MT3D interfaces for boundary condition display and for post-processing.

IV WORKDONE

The works carried out through the project work is explained in detail in this chapter. The following data are collected.

A. SATELLITE DATA

LISS IV image (spatial resolution 5m)

B. FIELD DATA

a. Hydraulic head

b. Storage coefficient

c. Pumping data

d. Borehole details

e. Ground water quality parameters (Electrical Conductivity, Total Hardness, Sodium, Chloride, Sulphate, pH)

f. Rainfall data

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C. PREPARATION OF THEMATIC MAPS OF STUDY AREA

The Landuse map is prepared for the year of 2006 and 2012. The change detection between the landuse maps of two years is found and is used to validate the vulnerability of the aquifer.

The soil map is used to find the influence of impurity seepage into the groundwater aquifer along the coastal region. The groundwater quality parameters is spatially distributed in the study area which is represented as thematic maps.

The following Maps has been prepared using the satellite data and Field data.

a. Land use map

b. Geology map

c. Soil map

d. Geomorphology map

e. Slope map

f. Drainage density map

D. STUDY AREA MAP

A basic problem is the limited availability of location specific information of coastal zone. One of such important coastal aquifer is that extends from Adyar to Muttukadu and this compromise the study area. Coastal zone is the area of interaction between it includes both terrestrial and marine resources which are of renewable as well as non- renewable nature.

The study area is chosen based on the south chennai aquifer map. The study area is bounded by Adayar river on the north side and Muttukadu Creek on the south side and Bay of Bengal on the east side .The map describes the boundary of the study area which is shown in the fig. 3.

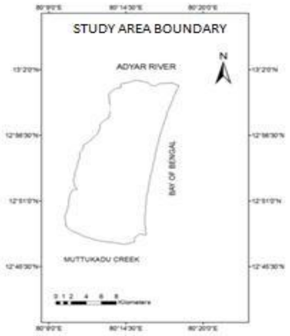

Figure 3. Study Area Map Outline

E. ANNUAL RAINFALL DATA

The rainfall data collected from PWD, Taramani, Chennai is shown in table I . It is seen that in the year of 2006 the rainfall is low.

TABLE I ANNUAL RAINFALL OF THE STUDY AREA

YEAR	RAINFALL IN mm
2002	1132
2003	1031.3
2004	1074.4
2005	1436.1
2006	974
2007	1745
2008	1345.4
2009	1413.6
2010	1404.4
2011	1339.5
2012	1052.7

F. WATER QUALITY STANDARDS

Bureau Of Indian Standards (BIS,1992) And World Health Organisation (WHO,2004) has purpose.

The ARS has recommended the quality of chemical parameters which can be used for irrigation purpose which is been recommended the standards of chemical parameters based on the condition for drinking and domestic shown in the table II.

In this project work, six water quality parameters is chosen which majorly affects the groundwater quality. Then each quality value is noted down for different purpose such as for drinking, domestic, agricultural, industrial and the category which is not suitable for any of the above mentioned purposes. All this different categories value are summarised below which is shown in the table II.

TABLE II WATER QUALITY STANDARDS

PARAMETERS	IRRIGATION	DOMESTIC	INDUSTRIAL
pH	6-7 pH units	6.5-8.5 pH units	Upto 9 pH
Electrical conductivity	<300 µS/cm	<780 µS/cm	2250 µS/cm
Hardness	<150 mg/L	<300 mg/L	1000 mg/L
Sodium	<70 mg/L	<200 mg/L	Upto 600 mg/L
Chloride	<355 mg/L	<250 mg/L	Upto 600 mg/L
Sulphate	<100 mg/L	<200 mg/L	Upto 1000 mg/L

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G. GROUND WATER MODELLING SYSTEM

It is a 3D software which comprises of Modflow MT3DMS and SEAWAT packages all together which helps in finding out the sea water intrusion into the coastal aquifers.

H. CREATING GRID

The first step in the modelling of groundwater aquifer is representing the aquifer either in the structural or unstructured grid. Here the Adyar aquifer is represented as a structural grid with 45X20 cells which covers about 126.69 Km^2 .Thus in GMS software the grid is created using the "new 3D grid "option whose dialogue box is shown in the fig. 4.

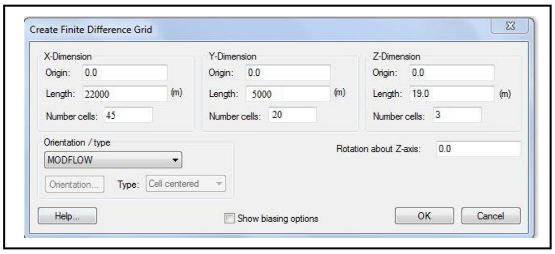

Figure 4. Creation of Grid in GMS software

I. DEFINE LAYER ELEVATIONS

In ground water modelling system, we can define the elevations of the tops and bottom of the model layers. Or we can have varying layer elevations defined from Surface data objects. Surfaces could be from data objects we imported from Surfer .GRD, ESRI .ASI, .DEM, or from Surfaces which are created through interpolating XYZ points. Here it is given as number of layers which import 3 surfaces (from Surfer .GRD files), then use these to define the layer elevations. This is shown in fig. 5.

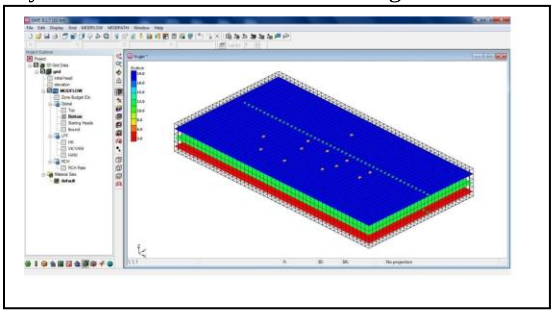

Figure 5. Three geological layers with elevation

J. DEFINE BOUNDARY CONDITIONS

The next step is to define the flow boundaries for the model. Based on the natural environmental conditions, the boundaries conditions (constant head boundary, variable head boundary, no flow boundary) are assumed based on the study area. In eastern side we have Bay of Bengal as *a constant head boundary* and in western side the lithology shows that it is covered by the charnockite which is taken as no flow boundary and remaining two sides (along north and south) we have political boundary so it is assumed as variable head boundary since the water extractions by the population keeps varying for every time by time. The boundary condition given for the study area is shown in the fig. 6.

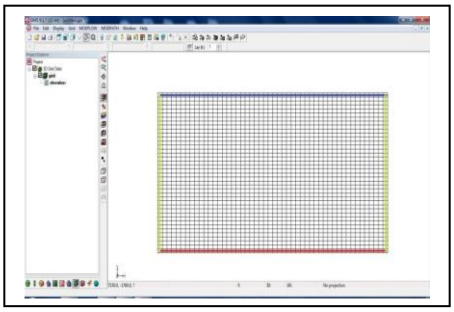

Figure 6. Boundary conditions

K. DEFINE PUMPING WELLS

The pumping well locations is given as input in GMS using excel sheet.. the pumping rate for each well is loaded as given by the CPWD department of Chennai. The steps of input of these parameters is shown in the following fig. 7.

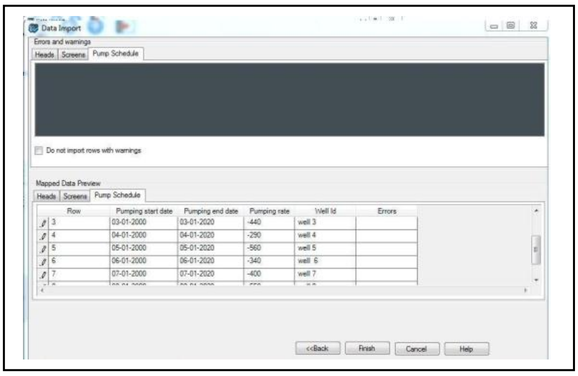

Figure 7. Input of Pumping Location in Study area

L. PROJECTION OF PUMPING RATE FOR THE FUTURE YEARS USING POPULATION DATA

The pumping rate data which was obtained from CPWD, is available only up to the year of 2012. But for finding the sea water intrusion up to the year of 2018, we require the pumping rate level for each year up to 2018.

Hence this is done using the population data and projecting the pumping rate with increase in population for each year. We have valid information of population for study area from NIC for the year of 2001 and 2011. From these data, we can arrive to the population of each year with the percentage increase by the "Decrease Growth Rate Method". The population calculated based on the "decrease growth rate "method is shown as chart in the fig. 8. The pumping rate calculated based on the population is shown in fig. 9.

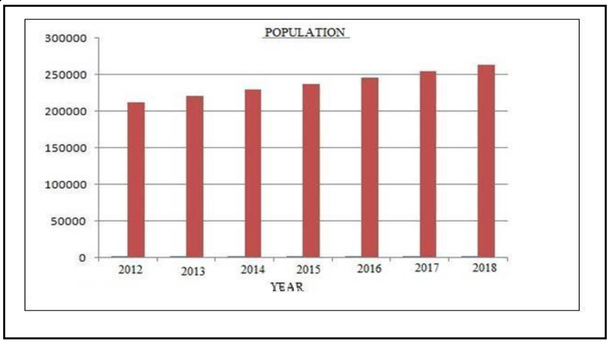

Figure 8. Chart showing the population projection

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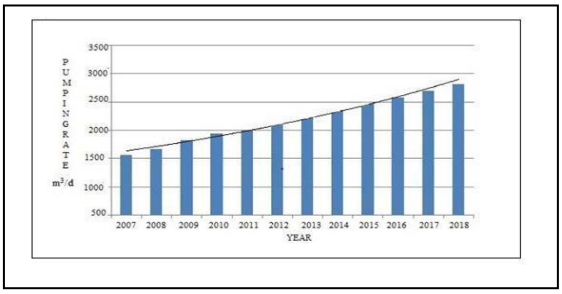

Figure 9. Chart showing the pumping rate

M. FACTOR ANALYSIS

Factor analysis is used to find factors among observed variables. In other words, if the data contains many variables then factor analysis can be used to reduce the number of variables. Factor analysis groups the variables of similar characteristics.

Kaiser-Meyer-Olkin and Bartlett's Test

Measures strength of the relationship among variables, the **Kaiser-Meyer-Olkin (KMO)** measures the sampling adequacy which should be greater than 0.5 for a satisfactory factor analysis to proceed. If any pair of variables has a value less than this, consider dropping one of them from the analysis.

Table III. KMO VALUE FOR DIFFERENT PARAMETERS

PARAMETERS	KMO value
TDS,Mg,Cl,pH,TH,Ca	0.522
TDS,Mg,TH,EC,HCO3,Na	0.535
TDS,Mg,TH,EC,HCO3,Ca	0.536
TDS,Mg,Cl,pH,TH,Na	0.541
TDS,Mg,Cl,TH,EC,HCO3	0.610
Ca, Na, k,Mg,Cl,SO_4	0.790

From above the table III KMO value for combination of parameters like Calcium, Sodium, Potassium, Chloride, Sulphate and Magnesium has given the KMO value of 0.749, which was in between the acceptable range. It is evident that Sulphate is one of the major parameter which is coming from the tannery effluent, because without Sulphate the KMO value of other combination of parameters range between 0.522 to 0.610, which shown in the table (5.4).The combination of Sulphate with other parameters will give the more KMO value 0.749.

N. OVERLAY ANALYSIS

The overlay analysis was carried out with selected parameters, which includes Geology map, Geomorphology map, Land Use/Land Cover map, Drainage Density Map, Slope Map, Soil Map as thematic layers. As they generally control the topography and hence the potential to retain the water for in aquifer. In arc GIS, the weighted overlay analysis tool was used to plot the variation of parameters in the study area. The weightage for each parameter is given based on expertise which is shown in the (Table IV).

TABLE IV. WEIGHTAGE FOR DIFFERENT THEMATIC LAYERS

S. NO	THEMATIC LAYERS	FEATURES	RANK	WEIGHTAGE
1	GEOLOGY	Archean	2	
		Fesozoic	1	
		Habitation Mask	3	15
		Paleocene	2	
		Quartenary	1	
		Water Body Mask	2	
		Nuaternary	4	
2	GEOMORPHOLOGY	Alluvium	1	
		Coastal Plain	2	
		Habitiation Mask	3	25
		Pediplain	3	
		Structural Hills	4	
		Water Mask	2	
3	SLOPE	0-1%	1	
		1-5%	2	
		5-10%	3	20
		>10%	4	
4	DRAINAGE DENSITY	High	1	
		medium	2	
		Less moderate	3	15
		low	4	
5	LANDUSE MAP	Agriculture	1	
		Forest	1	
		Waterbodies	3	
		Urban built up	4	10
		Wetland	2	
		wasteland	3	
6	SOIL	A	1	
		B	2	
		C	3	15
		D	4	

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V RESULTS

The following chapter shows the images of different thematic maps which is obtained by mapping the LANDSAT images in ArcGIS. GMS software is used to determine the sea water intrusion.

A. GEOLOGY MAP

The study area is covered majorly with archean age of charnockite along the western boundary and by quaternary rocks nearby Bay of Bengal over the study area which is shown in the fig. 10.

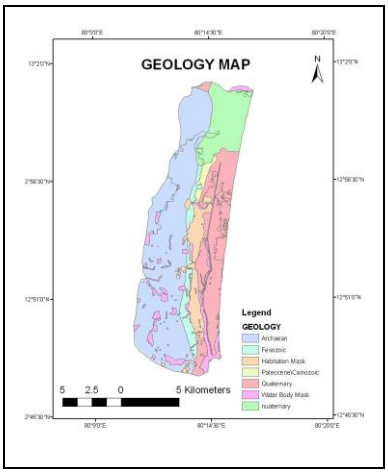

Figure 10. Geology Map

B. SLOPE MAP

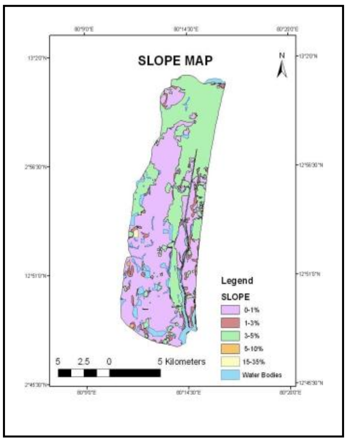

Figure 11. Slope Map

The fig.11. shows study area majorly has a slope of 0-1% which is considered superior for storing the water and it is found along and beyond the `Buckingham canal. The higher slope is found along the `Bay of Bengal and also in the regions of small lakes and ponds. The higher slope is considered inferior as the water cannot be stored in the places as it tends to flow away.

C. GEOMORPHOLOGY MAP

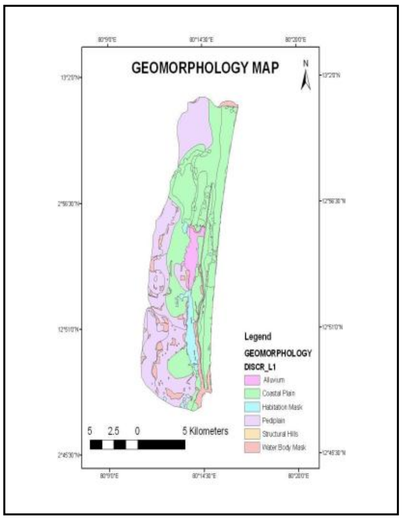

Figure 12 .Geomorphology Map

D. LANDUSE MAP

The land use map shows that the study area is majorly covered by built up area in Adyar region and agriculture and water bodies along Mutuukadu region. This is shown in the fig. 12.

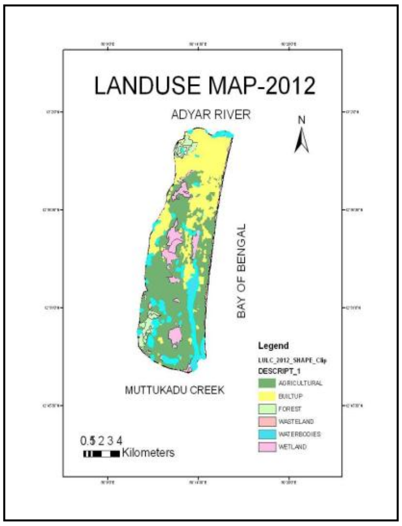

Figure 13. Landuse Map

E. DRAINAGE DENSITY

Drainage Density is the total length of all the streams and rivers in a drainage basin divided by the total area of the drainage basin . this is shown in figure 13.

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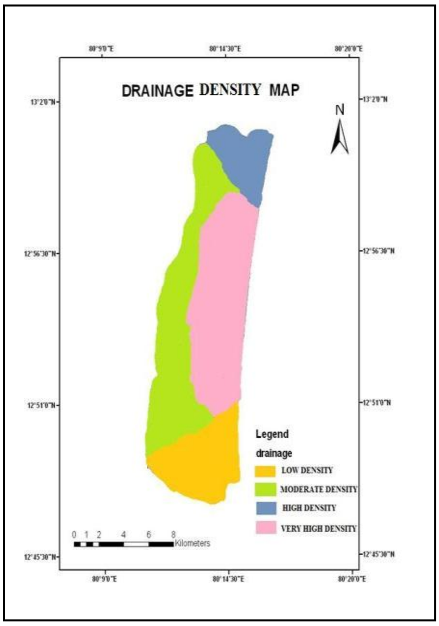

Figure 14. Drainage Density Map

F. SOIL MAP

Along the Bay of Bengal a coarse loamy soil is found and some traces of fine sand and some traces of fine loamy along and beyond Buckingham canal.

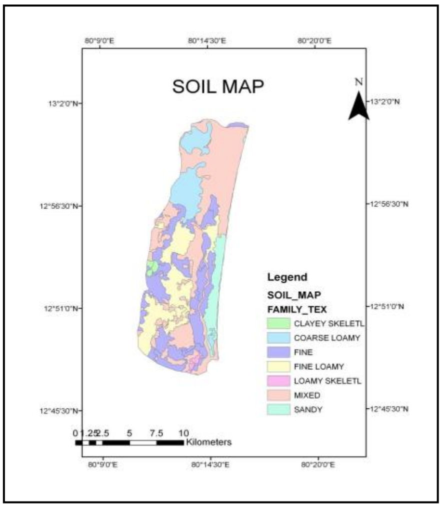

Figure 15. Soil Map

G. SEA WATER INTRUSION

The salt parameters for each well location is given as input which interpolates and produce a result. It takes from 35g/litre of salt concentration in water as sea (saline) water, since this is the initial concentration of salt in sea waterThe red colour indicates the saline water which is about 35g/litre of water. The orange colour indicates about 30g/litre. Green shows about 15-20g/litre which can be used for industrial purpose. Cyan colour shows about 10g/litre of water which is moderate for domestic purpose. Blue shows less than 5g/litre which is good for drinking purpose.

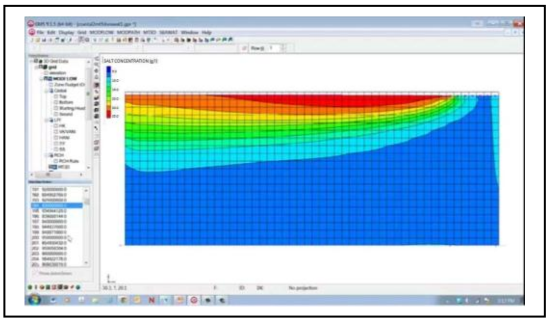

Figure 16. Sea Water Intrusion -2012

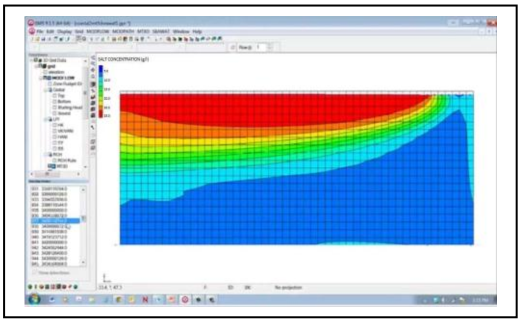

Figure 17. Sea water intrusion -2013

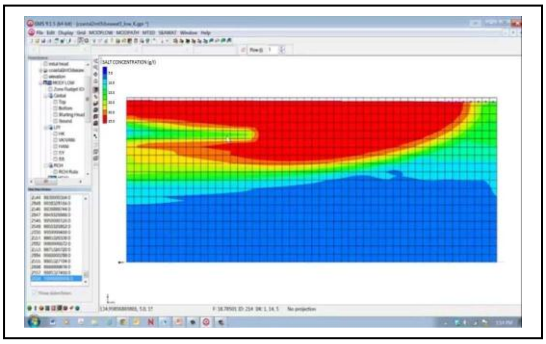

Figure 18. Sea Water Intrusion -2014

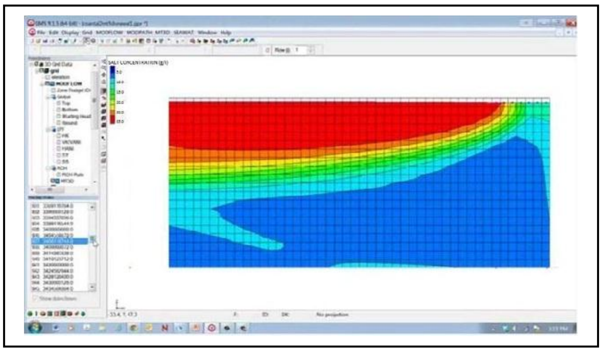

Figure 19. Sea Water Intrusion -2015

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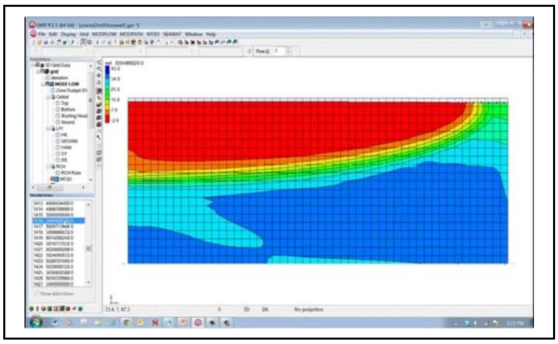

Figure 20. Sea Water Intrusion -2016

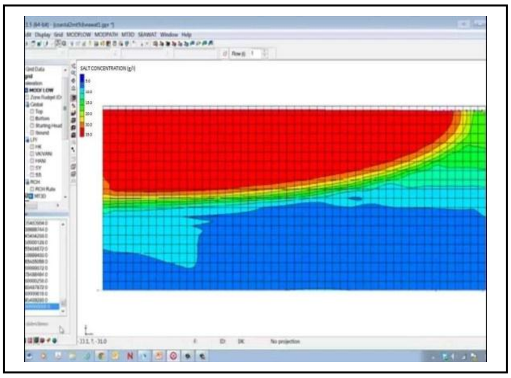

Figure 21. Sea Water Intrusion -2017

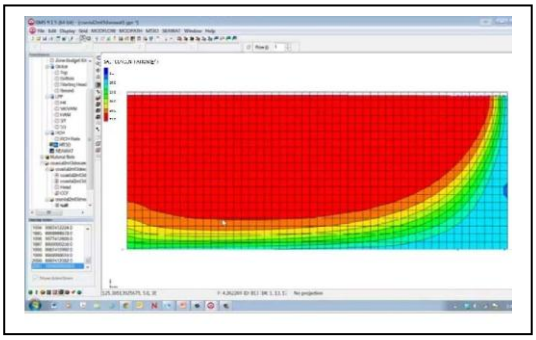

Figure 22. Sea Water Intrusion -2018

H. RECHARGE POTENTIAL ZONE

The six thematic layers are overlaid and given weight age and rank as given in the table IV and the following result obtained. Here 4 ranks are given , of which the first rank denotes the highly suitable region for recharge and the second denotes the moderately suitable, third denotes the less suitable and the last rank shows that the region is less suitable. The figure shows that the eastern side is poorly suitable and western side is highly suitable depending on topography. This is shown in the fig. 22

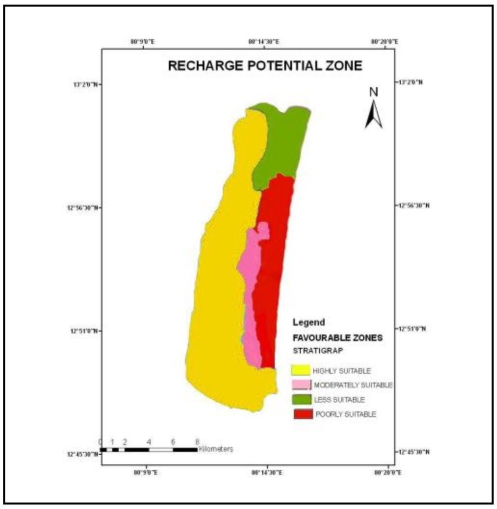

Figure 22 .Recharge Potential Zone

TIME SERIES CHART

Time series chart shows how the salt content in the ground water is increasing from time to time. It is found that the salt is increasing linearly for every month (30 days) with small delineation for every 5 months. The time series chart is generated with time in x axis and salt concentration (g/l) in y axis.

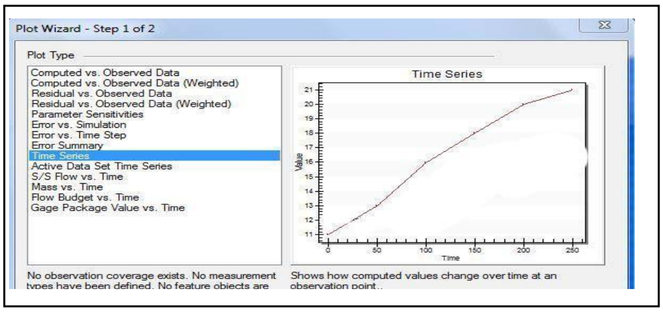

Figure 23 .Time Series Chart

J. RMSE ERROR CALCULATION FOR THE MEASURED SALT CONCENTRATION

The root-mean-square deviation **(RMSD)** or root-mean-square error**(RMSE)** is a frequently used measure of the differences between values (sample and population values) predicted by a model or an estimator and the values actually observed.

The RMSE error is found out using the formula which is given below.

$$RMSErrors = \sqrt{\frac{\sum_{i=1}^{n} (\hat{y}_i - y_i)^2}{n}}$$

To construct the R.M.S. error, we first need to determine the residuals. Residuals are the difference between the actual values and the predicted values. It is denoted by ($\check{y}_i - y_i$), where y_i is the observed value for the ith observation and $\check{y}_i$ is the predicted value. The RMSE chart is shown in the fig. 24.

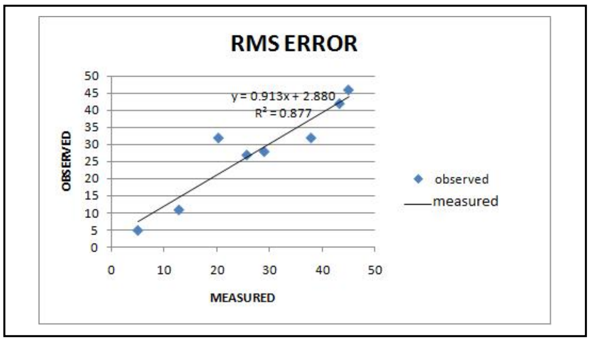

Figure 24. RMS Error Chart

K. VALIDATION

The validation is done for the salt concentration level in the groundwater for the year of 2014.the salt parameter data of the groundwater is collected from the CPWD department of Chennai. These values are compared with the measured value of salt concentration which is obtained from the GMS software. These values are shown in the table VI.

TABLE VI. SALT VALUES IN WELL LOCATIONS

WELL	MEASUR ED (g/l)	OBSERVED(g/l)
1	25.7	27
2	20.3	32
3	5	5
4	12.8	11
5	45	46
6	37.9	32
7	43.3	42
8	29	28

VI SUMMARY AND CONCLUSION

Water Quality Index (WQI) is calculated to determine the sustainability of water for drinking purpose. In year 2012 due to lack of rainfall, increase in pumping rate, lack of good water recharge structure, encroachment of water catchments area by built up area and industries, the following areas like Pallikaranai, Madurappakkam, Solaiyur, had unfit for drinking and the remaining areas like, Sozhinganallur, Uthandi, Pallavaram, Injambakkam Thiruneermalai had very poor water quality index. Due to the lack of ground water, within the last 6 years from 2006 to 2012, agricultural land reduced to 7.011% built up increased to 15.927 %, forest be as the same, wasteland reduced to 3.645 %, water bodies decreased to 4.073 % and wet lands reduced to 1.198%.
Factor analysis is used to find factors among observed variables with the help of Kaiser-Meyer-Olkin (KMO) and Bartlett's Test. The KMO value for combination of parameters like Ca, Na, k, Mg, Cl, and SO_4 has given the KMO value of 0.749, which was in between the acceptable range. It is evident that sulphate is one of the major parameter which is coming from the tannery effluent, because without Sulphate the KMO value of other parameters range between 0.522 to 0.610, the combination of Sulphate with other parameters will give the more KMO value 0.749.

From the GROUNDWATER MODELLING SYSTEM outputs, a study of simulated potentiometric surface of the study area indicates that the highest heads are found on the southern side of the study area which is general reflection of the topography. The regional groundwater flow direction is towards the southeast (Bay of Bengal). The RMS error value between the observed and measure the water level head is 0.8089. So in this study area aquifer is stable with projected pumping rate During calibration, horizontal and vertical hydraulic conductivities and recharge values were adjusted in sequential model runs to match the simulated heads and measured head.

SEAWAT for simulation of advection, dispersion and chemical reactions of soluble contaminants in three-dimensional groundwater flow systems. The population data is projected by the "decrease growth rate" method. The projected population data is used to determine the pumping rate for the future years from 2012. Those projected pumping values are given as input to the model while running. From the output of SEAWAT, it is found that the major regions in north, east and west is degraded by the salt water intrusion. Its found out that the salt water has started intruding from the region of Bay Of Bengal towards the inner area where the head level is low and has spreaded exponentially with increase in time Its also seen that the southern region (Muttukadu) and the western region (beyond Buckingham canal) is not affected majorly by salt water intrusion. Hence the region nearby **Padur, Siruseri, Kalipathur, and Kannathur Reddy Kuppam** has a good potential zone for artificial recharge.
The validation is done by taking the values of salt concentration which is obtained from the model and it is compared with the values got from CPWD department of Taramani, Chennai, for the same year. It is found that about 87.7% result is getting correlated which shows that the GMS software model is well suited for predicting the sea water intrusion.

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