iJRASET
International Journal For Research in Applied Science and Engineering Technology



INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 10 **Issue:** V **Month of publication:** May 2022

DOI: https://doi.org/10.22214/ijraset.2022.42309

www.ijraset.com

Call: 08813907089 | E-mail ID: ijraset@gmail.com

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 10 Issue V May 2022- Available at www.ijraset.com

"Modeling of Saline Water Intrusion using MODFLOW in Una Coastal Aquifer of Gujarat, India."

Aman Timaniya[1], Nayankumar Soni[2]
[1]*P.G. Scholar, Department of Civil Engineering, Shantilal Shah Engineering College, Bhavnagar, Gujarat, India*
[2]*Assistant Professor, Department of Civil Engineering, Shantilal Shah Engineering College, Bhavnagar, Gujarat, India*

Abstract: ***Groundwater is the most valuable and extensively dispersed resource on the planet, and unlike any other mineral resource, it is replenished annually by meteoric precipitation. The present study would include simulation and modelling of the problem of seawater intrusion in the Una coastal area of Gujarat. The interrelationships of two miscible fluids in porous media have been widely explored both theoretically and experimentally. Because of the extreme salinity, many agricultural wells are no longer used. This high salinity is a sign of a process known as saltwater intrusion, which occurs mostly in coastal aquifers due to excessive pumping. Modelling software has also been utilized to analyze the behavior of groundwater flow models. Numerical models may simulate diverse groundwater scenarios and link them to groundwater management. To simulate seawater intrusion, MODFLOW-2005, a grid-based variable density-dependent flow model, is used. Water balance research reveals that rainwater recharge is the aquifer's primary input. To compute the water level in the area and estimate the position of the seawater intrusion barrier, the saltwater intrusion phenomena were simulated using the MODFLOW software combined with the SWI2 package. The model was used to visualize the salinity levels of the coastal aquifer's groundwater and their fluctuation over time and space from May 2004 to October 2014. The model was developed for a 10-year stress period with 100-time steps, which included a 5-year steady state and 5 years transient state stress period using the previous 10 years of pre-monsoon and post-monsoon data. This research would assist to describe Pumping's impact on groundwater levels and seawater intrusion was studied.***

Keywords: MODFLOW, Saltwater Intrusion, Modelling, Numerical Model, Coastal aquifer

I. INTRODUCTION

Human activity is the most common cause of seawater intrusion into fresh groundwater creation. The majority of large sources of fresh groundwater are near the sea, where the groundwater is naturally more in salts content, or in coastal areas w here the groundwater has been released by fluctuating tides. Groundwater is the primary, if not the only, source of natural fresh water in dry and semi-arid environments. Because of the direct hydraulic interaction between freshwater in aquifers and seawater, many aquifers across the world are subject to the seawater intrusion phenomenon [5]. The purpose of this research is to determine the effect of pumping on the water level along the coastline. To that end, a groundwater flow model for the coastal strip was created using MODFLOW-2005 and data from the Gujarat Water Resource Development Corporation (GWRDC) [1]. MODFLOW was used for groundwater flow, while SWI2 in conjunction with MODFLOW was used for seawater intrusion. It is found that rainfall and recharge events have a substantial impact on groundwater flow patterns and, as a result, the saltwater intrusion problem [5]. Following calibration using available data, the models are said to perform pretty well in projecting water levels and salinity concentrations [6]. In this instance, MODFLOW was utilized to simulate groundwater flow, whereas SWI2 was employed in combination with MODFLOW to simulate seawater intrusion. The models are believed to perform well in forecasting water levels and salinity concentrations after calibration using available data [3].

II. STUDY AREA

The studied region in this paper is the Una coastal region which is part of the Gujarat State districts of Gir Somnath. Una is located in the Gir Somnath district, between latitude 20.8235° N and longitude 71.0409° E. Its headquarters are in the city of Somnath, which is located on the southern tip of the Kathiawad peninsula.

©IJRASET: All Rights are Reserved

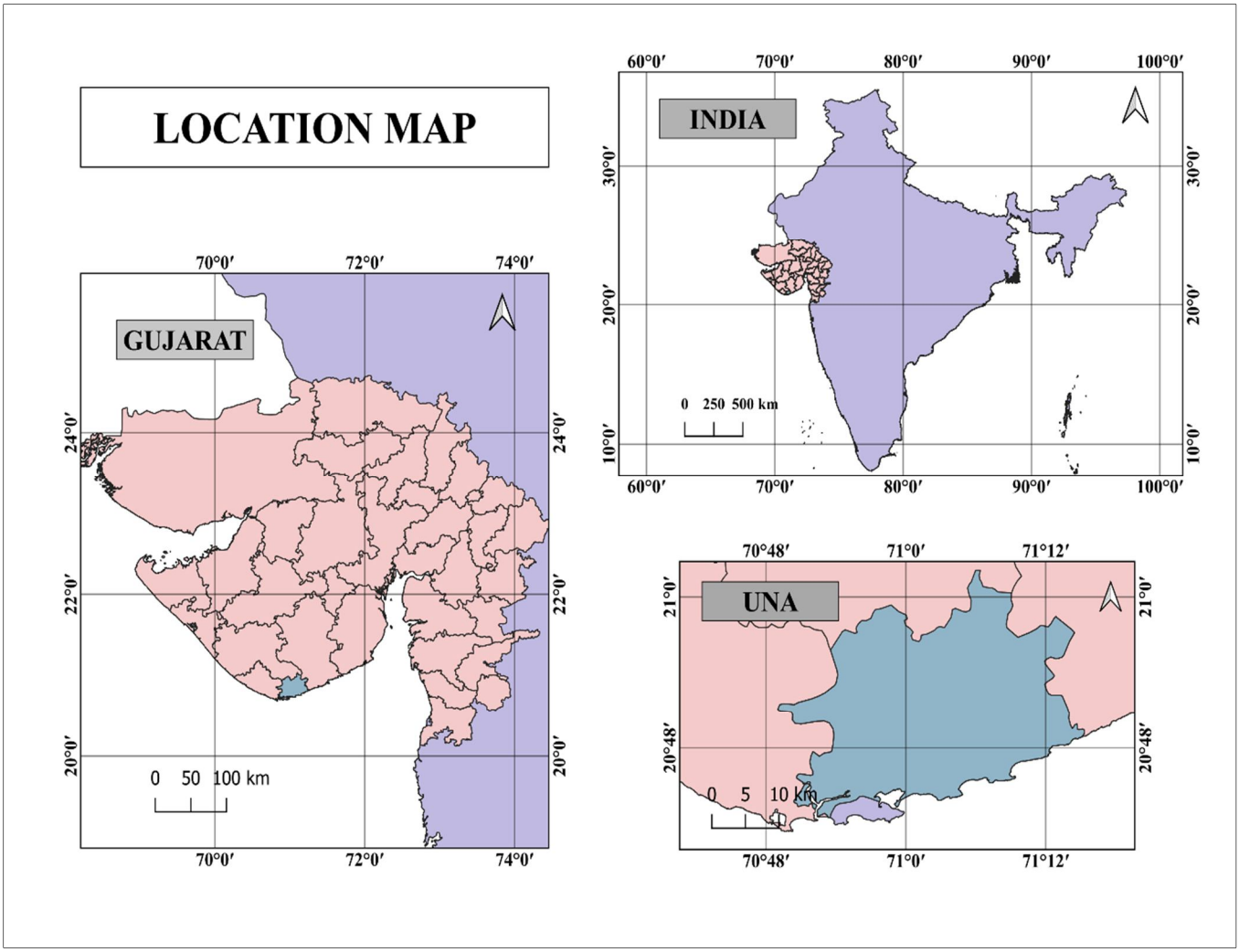


Figure 1.1 – Study Area Map

The normal annual rainfall is 500-800mm which varies in Una according to past year data sets. Medium black soil is typical and may be found across the area. In Una, the average maximum temperature is 43.82°C and the average lowest temperature is 9.83°C. The average specific humidity in town is 13 g/kg, and the average relative humidity is 58.69%. In Una, the average maximum wind speed is 19.97 m/s while the average lowest wind speed is 0.01 m/s. The soil in this location is saline, making it less productive. Groundnuts, wheat, grams, cotton, sugar cane, bajri, jowar, and pluses are the principal crops grown in this region. Groundnuts are the most important crop in the region, accounting for approximately 61 percent of the total crop area. Wheat is the district's second most significant crop. It is grown on around 30% of the farmed land. Guava and pomegranate are two well-known plants that flourish in the area.

III. DATA COLLECTION

Water samples were collected from 19 different wells. CGWB (Central Ground Water Board) monitors 5 wells, whereas GWRDC monitors 14 wells (Gujarat Water Resources Development Corporation). Water samples of 250ml are gathered from each well, in a polyethylene plastic bag, as well as farm information such as water level in the dug well, quality of water, the quantity of water accessible in different seasons, and whether the water is portable or not, and so on. Some information concerning seawater infiltration nearer the sea region or beach border has been gathered as a result of this survey. A total of 19 well samples were collected for groundwater analysis. The specifics of water sample collection are depicted in table 1. Specific yield and Transmissivity data are taken from GWRDC and hydraulic conductivity data were taken from relevant research papers due to the lack of availability of data.

Table-1 Location of well and Static Water Level (S.W.L.)

Well No.	District	Taluka	Village	Latitude	Longitude	S.W.l
37	Gir Somnath	Una	Siloj	20.81	71.01389	9.34
38	Gir Somnath	Una	Tad	20.75389	70.93972	5.86
39	Gir Somnath	Una	Delwada	20.78389	71.02361	8.86
40	Gir Somnath	Una	Khan	20.785	71.07667	7.45
41	Gir Somnath	Una	Dandi	20.78528	71.09083	6.71
42	Gir Somnath	Una	Khajudra	20.79444	71.11139	5.63
43	Gir Somnath	Una	Simar	20.78583	71.15889	3.61
44	Gir Somnath	Una	Gangda	20.86194	71.17	11.41
45	Gir Somnath	Una	timba	20.86538	71.1819	9.4
67	Gir Somnath	Una	Manekpur	20.81139	71.20833	4.77
68	Gir Somnath	Una	Sondardi	20.86083	71.20278	6.97
69	Gir Somnath	Una	Sondarda	20.86833	71.19889	6.64
72	Gir Somnath	Una	Motha	20.82861	71.13222	14.42
73	Gir Somnath	Una	Rameshvar	20.845	71.13417	9.32
74	Gir Somnath	Una	Kalapan	20.77	71.0675	6.4
75	Gir Somnath	Una	Anjar	20.78944	71.06444	14
76	Gir Somnath	Una	Una	20.8225	71.05667	9.8
77	Gir Somnath	Una	Mota Desar	20.78944	71.00139	8.21
78	Gir Somnath	Una	Delwada	20.77139	71.04417	9.66

IV. METHODOLOGY

The ModelMuse main window contains a top, front, and side view of the model for editing, as well as a 3D view of the model for presenting model characteristics. ModelMuse contains tools for building and changing the model grid. It also contains a number of interpolation methods and geographic functions that may be used to help define the model's geographical variability. The purpose of this analysis is to determine the existing salinity status of groundwater in the study region. The present groundwater model assesses the necessary development in the research region. A groundwater model is a simplified depiction of the natural flow system of groundwater. In numerical modelling, variable input parameters are utilized to create the model. The model will run based on the input parameters. There are other packages and boundary conditions available in MODFLOW software, however, the following programs are employed in this study.

A. Preparing Shapefiles

To gain access to the India spatial data, visit the DIVA-GIS website and download a free shapefile. Launch Google Earth Pro and import the shapefile of Gujarat, including its states and districts. The new templates were created and a polygon from the measurements was selected. The limits of research region was drawn and in properties edit them to reflect according to requirement. Polygons should be measured and saved in KML format. Because it is not possible to simply import a KML file from the Google Earth Pro program, one has to first open Q – GIS software and create a new project, then proceed to add layer and add vector layer. So, now the KML file to a shapefile was converted. To do so, right-click on the vector layer and select Save Vector Layer as giving required name. Then pick ESRI Shapefile as the file format. Modified geometry types based on availability, such as lines, points, polygons, and so on... Click OK to save the file as an ESRI Shapefile. Shapefiles may be simply imported into any version of Model Muse.

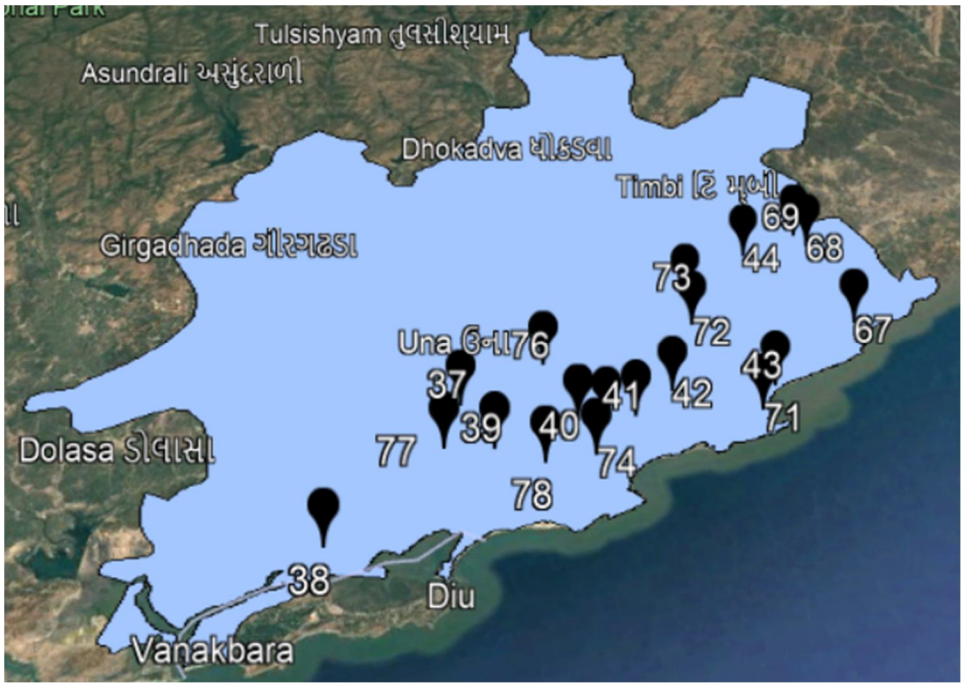


Figure 1.2-Well Location with Study Area

Table-2 MODFLOW Packages and Programme

Sr. No.	Boundary Condition	Name	Application
1	Time-variant specified-head	CHD	The user can define the head in the model cells using this package. Specific-Head might change over time. It is multiplied by factors that the user specifies.
2	Seawater intrusion package 2	SWI2	Variable density flow is being simulated. Each model cell is examined for two or more zones of density fluctuation.
3	Drainage Package	DRN	The drain package causes water to escape the groundwater system when the head in a cell with drain borders increases over the elevation of the drain boundary.
4	River Package	RIV	This package is used to define borders where the flow into or out of the groundwater system is determined by the head. River conductance is also necessary for this package.

B. Input Parameters

Several input parameters are required to run the MODFLOW model. The input parameters include initial circumstances, groundwater recharge, evapotranspiration, and hydrological data such as specific yield, specific storage, well latitude, longitude, and static water level (S.W.L). The conductivity of the river's border condition is 0.001 m2/day. The values for specific yield and Transmissivity were 0.2 and 150 m2/day, respectively. The groundwater recharge rate was set at 14 liters per second, and the evapotranspiration surface model top was used when the depth was about 0.9 m. Choose among a variety of interpolation methods, such as nearest point, inverse distance square, fitted surface, average point, and so on. Based on the specifications of this model, the inverse distance square method was best suitable. Modflow_Intital_Head set as a model top. There were two zones present in the seawater intrusion: normal freshwater and saline water, with densities of 0 and 0.025, respectively.

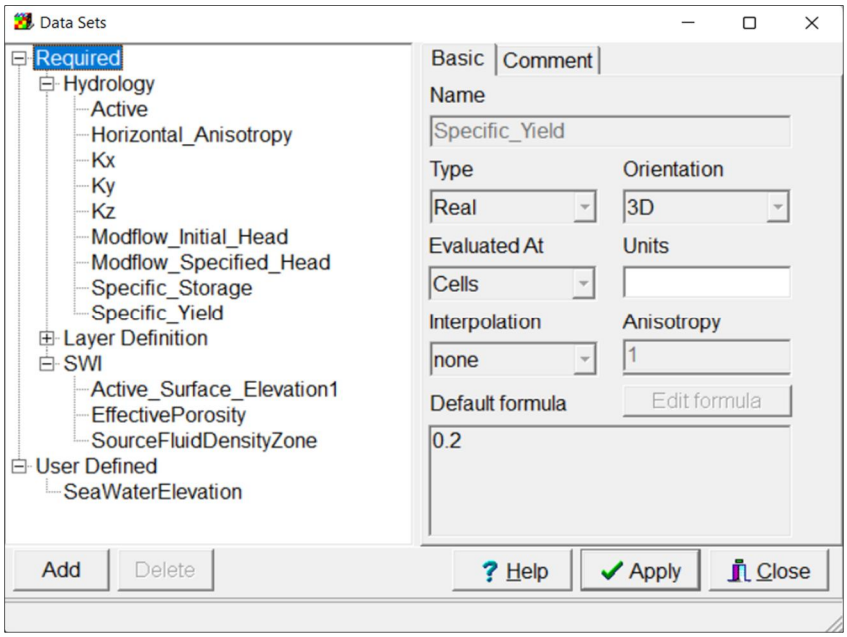


Figure 1.3 – Input Data Sets

C. Grid Generation

The entire range is divided into cells with 45 columns and 30 rows. The total number of cells is 1350, with each cell having 1350 cells. Figure 5 shows how active and inactive cells are applied based on the study boundaries. Well represents the blue cell in the study area map grid generation. Furthermore, the elevation information is constructed in three distinct layers based on geological formation in 19 observation well sites. The digital elevations of each section are saved as shapefiles, which are then loaded into the MODFLOW-2005 program to calculate the aquifer's three-layer thickness, as -15, -20, and -25 respectively. According to the illustration, each layer has a distinct thickness value over the whole cross-section.

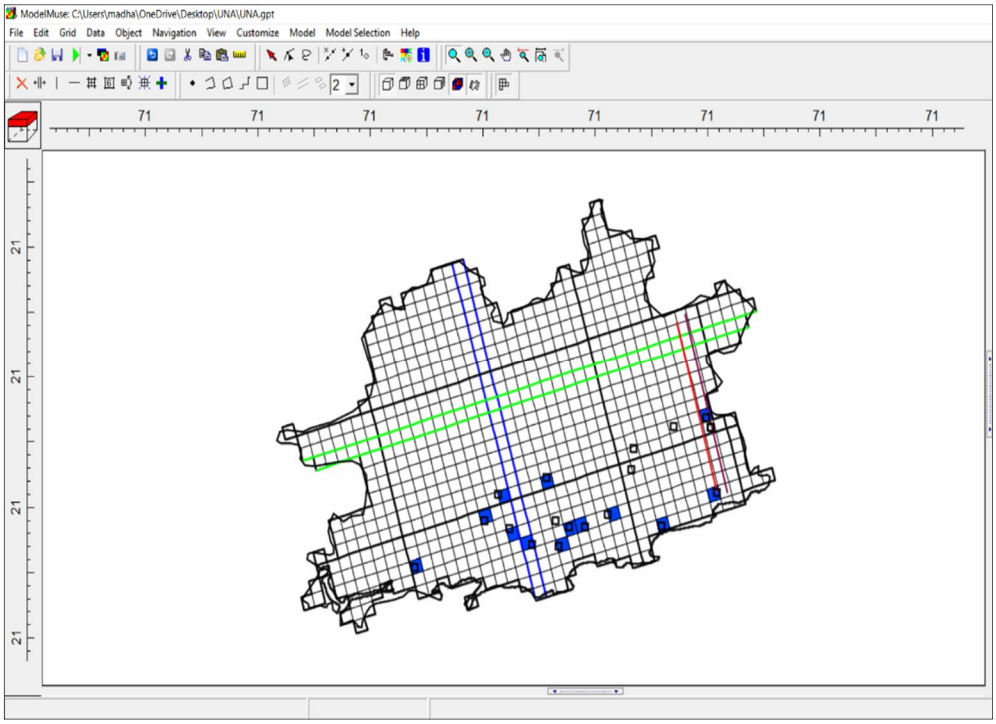


Figure 1.4 – Grid Generation for study area map

ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 10 Issue V May 2022- Available at www.ijraset.com

V. RESULTS

After the simulation of the model, the Model monitoring tab will be open that results show a discrepancy in the model. At the end of the successful run of the model, the first three-year from 2004 to 2007 pumping effect has been shown in figure 1.5, and simultaneously next three years i.e. from 2007 to 2010 have been shown in figure 1.6. Light blue to dark red colour gradations is visualized below figure. Light blue colour shows a lesser affected area compared to a dark red cell by seawater intrusion.

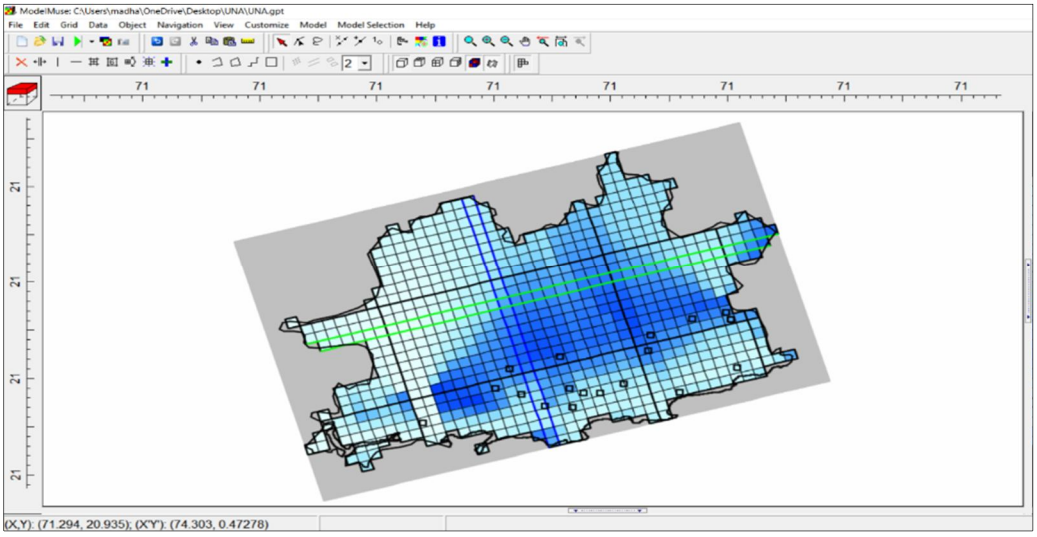


Figure 1.5 – Effect of Pumping during 2004-2007

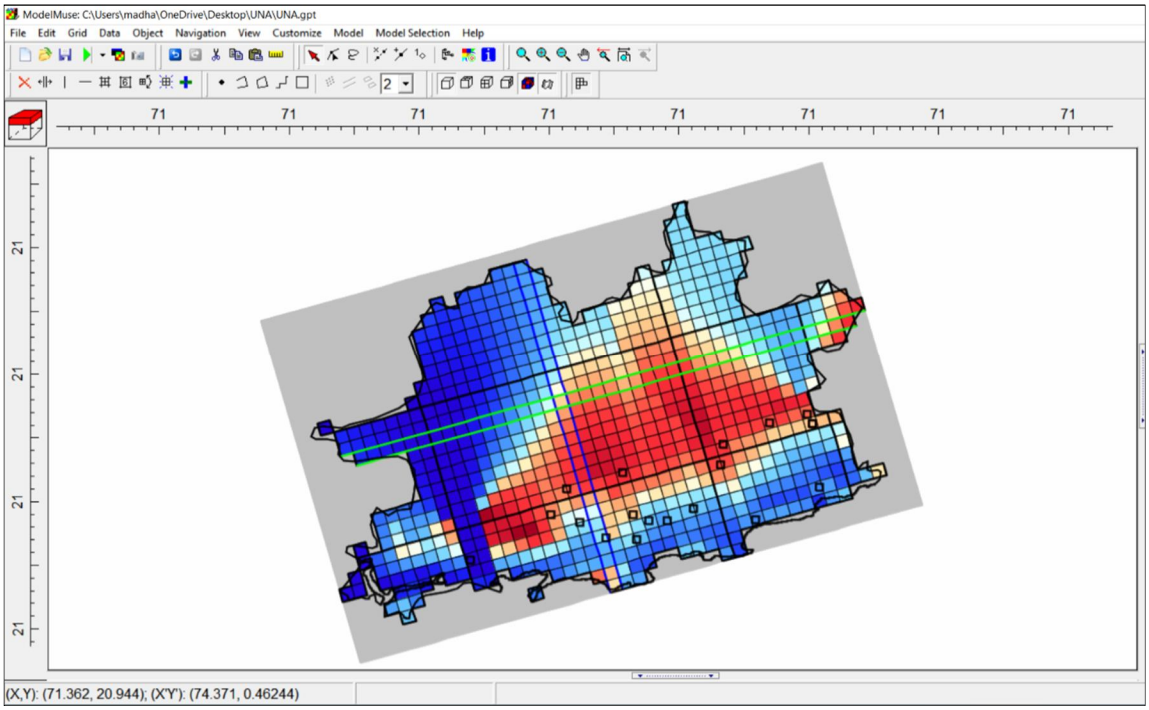


Figure 1.5 – Effect of Pumping during 2007-2010

Calibration period for last four years contour from 2010 to 2014 shows a greater concentration of seawater intrusion. Pumping's impacts on groundwater levels and seawater intrusion were examined. The results revealed that lowering of pumping from the wells in the Una region will result in lowering of saltwater intrusion into the south-eastern region of the aquifer. Under present groundwater pumping rates, seawater will continue to move inland which can be seen below figure.

©IJRASET: All Rights are Reserved

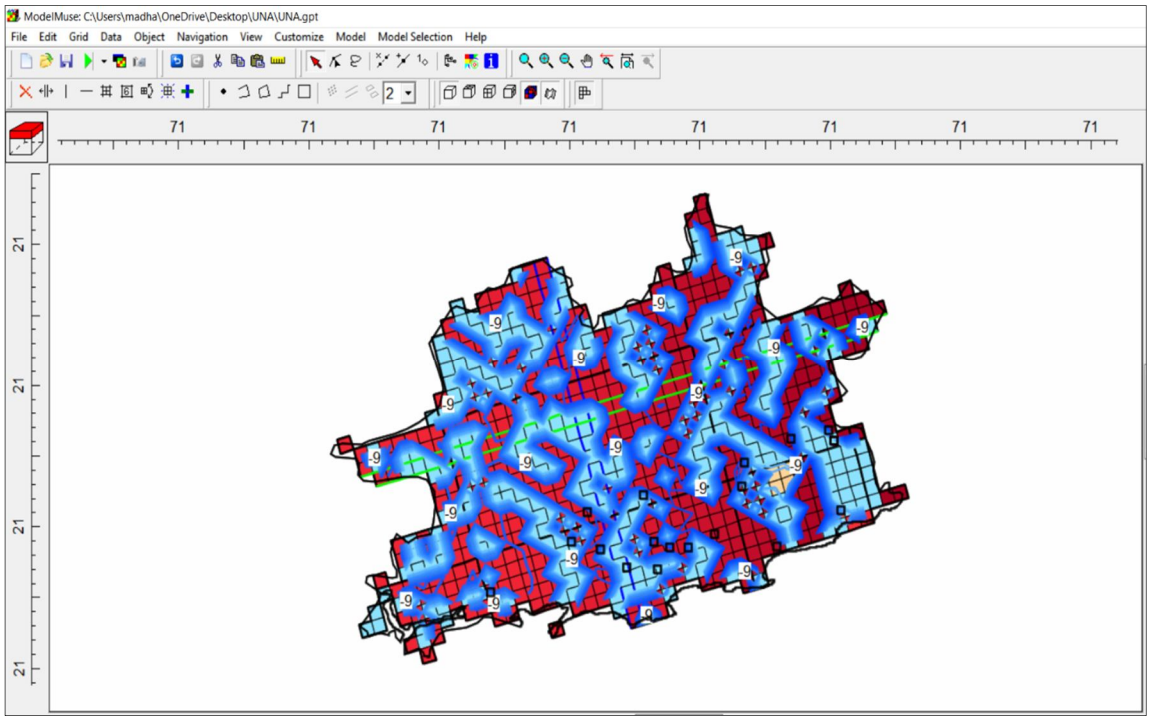


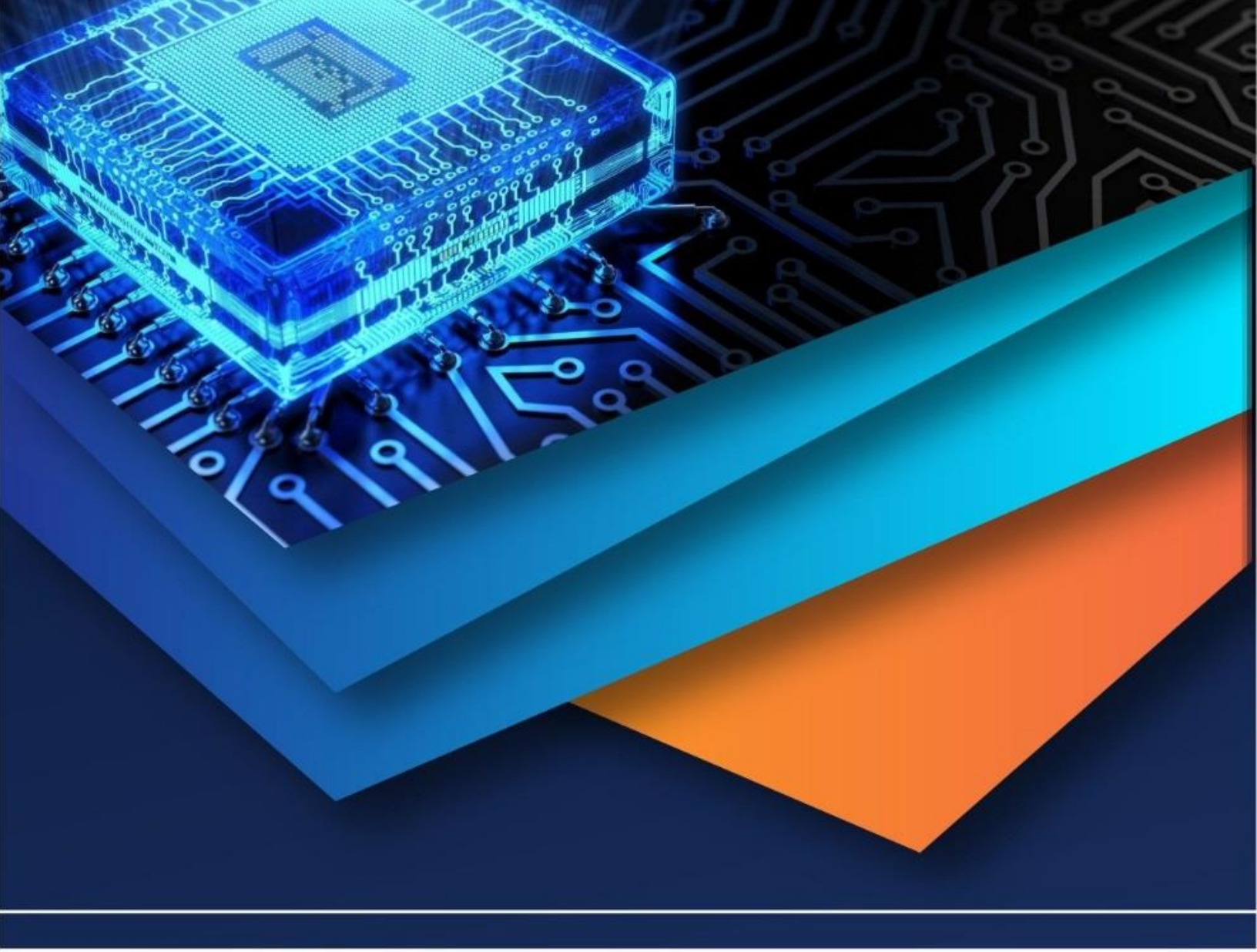
Figure 1.6 – Contour of Pumping during 2010-2014

VI. CONCLUSION

There are various numerical modelling tools accessible, however, for studying seawater intrusion, MODFLOW is a particularly useful tool that includes several significant packages and programs. This utility is also freely available in the public domain. The results suggest that the parameters in the seawater impacted region do not fall below permitted limits. The rate of seawater intrusion in the Bhavnagar coastal region has been increasing at a rate of 4000-4600 cm^2/day. Drainage in the Bhavnagar coastal area is 0.6587 m^2/day at the conclusion of the stress periods. Evapotranspiration occurs at a rate of 0.1945 mm/sec from the top layer of soil strata at a depth of 0.9 meters in the study region. The model predicts seawater intrusion in the aquifer system's coastal sections. According to the study, overall withdrawal from this aquifer must be restricted to 32.75 million cubic meters (mcm) in order to prevent saltwater intrusion. Annual recharge needs to increase from 39.78 million cubic meters (mcm). The model results revealed that saltwater intrusion has an impact on the south-western section of the Pondicherry area, which extends 13 kilometres north.

REFERENCES

[1] Abdelhaleem Ibraheem Abdelhaleem Saleh: - IMPACT OF PUMPING ON SALTWATER INTRUSION IN GAZA COASTAL AQUIFER, PALESTINE
[2] Beatrice M.S. Giambastiani - Saltwater intrusion in the unconfined coastal aquifer of Ravenna (Italy): A numerical model
[3] CP Kumar: - "Numerical modelling of groundwater flow using MODFLOW" Indian Journal of Science, Volume 2, Number 4, February (2013).
[4] KARLA'S MARIOS: - SIMULATION OF GROUNDWATER FLOW USING THE MODFLOW CODE IN THE ALLUVIAL AQUIFER OF KORISOS BASIN, NW GREECE.
[5] M. I. Shammas & G. Jacks: - Seawater intrusion in the Salalah plain aquifer, Oman.
[6] M. R. Janardhana:- Simulation of seawater intrusion in coastal aquifers: a case study on the Amol Ghaemshahr coastal aquifer system, Northern Iran.
[7] Mohamed El Mokhtar: - Modeling of the Groundwater Flow and Saltwater Intrusion in the Coastal Aquifer of Fum Al Wad, Province of Laayoune, Morocco.
[8] MOHSEN SHERIF1 & ANVAR KACIMOV2:- Seawater intrusion in the coastal aquifer of Wadi Ham, UAE
[9] Prajapati B.S., Soni N. P.:- Assessment of Seawater Intrusion in Coastal Aquifer of Bhavnagar District using MODFLOW and Hydro-Chemical Analysis.
[10] Sana A. and Al-Shibli S. H: - "Modelling of Seawater Intrusion into a Coastal Aquifer in the Sultanate of Oman" XXX IAHR Congress (2003).



10.22214/IJRASET

45.98

IMPACT FACTOR: 7.129

IMPACT FACTOR: 7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Call : 08813907089 (24*7 Support on Whatsapp)