International Journal of Engineering and Advanced Technology (IJEAT)
ISSN: 2249-8958 (Online), Volume-9 Issue-2, December, 2019

Simulation of Saltwater Intrusion in a Coastal Aquifer – Chennai, India.

B. Krishnakumari, RM. Narayanan

Abstract: ***SEAWAT-2000 is employed to reproduce groundwater movement and migration for a coastal stretch in the Chennai city, India. SEAWAT coupled interpretation of MODFLOW and MT3DMS can recreate 3-D model, variable thickness, groundwater flow and multi-layer transport. The variable thickness flow strategy uses the MODFLOW framework to decide the variable thickness flow condition. The aquifer considered for the present investigation is ~ 75 km coastal area from southern Thiruvanmiyur to northern Thiruvottiyur. The analysis considers about managing the available data most capably to create an intense and complex propagation model. The game plan parameters are quantifiable by altering the model for multi-year outputs with consistent time step. The idea is to recharge the unconfined strata using wise groundwater potential of the aquifer with progression of transmissivity and unambiguous yield for weathered, fractured aquifer alluvium and Gondwana formations starting from 2 to 143.2 m^2/day along and 0.00075 to 0.2 independently. The model evaluates the extent of above mentioned study area with the targeted accuracy by segregating the data. From this, the model is perceived to be tentatively steady for any groundwater applications and associated with foreseeing the water incursion in beach front aquifers for various strategy and overall water level rising.***

Keywords— Coastal aquifer, Flow and transport; MODFLOW; Saltwater intrusion

I. INTRODUCTION

Spontaneous misuse of freshwater aquifers has prompted extreme groundwater quality issues around the world. This issue is overwhelming in the beachfront aquifer framework, as the waterfront groundwater frameworks are touchy to effects, for example, diminished revive, tainting from conventional and synthetic sources and over-abuse (Essink. 2001) thinking about the danger of seawater interruption and ecosystem variations (Dharanirajan *et al.*, 2010). Under normal conditions, there exists harmony among saltwater and freshwater because of toward the freshwater ocean slope bringing about ostensible saltwater interruption into the freshwater aquifer. Because of unreasonable siphoning exercises, toward the freshwater ocean slope gets decreased and even some of the time might be turned around to landward heading. This outcome in forceful water interruption from the sea defiling inside crisp aquifers to a large degree which can take numerous years to inclination remediated. To report this issue adequately, thickness assisted groundwater model is required to follow the development of dissolved salts in beachfront aquifers (Lin et al. 2009). 3-D groundwater stream and solute transport models in particular FEFLOW, 3DFEMFAT, HST3D, AQUA3D, FEMWATER, SEAWAT, and MOCDENS3D are being used around the world. The focus of this work is to use SEAWAT code to build solute transport model for a waterfront aquifer in Chennai, India. The present examination may shape the starter information for investigating the conceivable outcomes of further groundwater advancement for the Chennai metropolis.

A.STUDY AREA

The basin considered for the investigation lies between 13° 4' 2.7804" N and 80° 14' 15.4212" E. covering a spatial degree of about 426 km^2 (Fig. 1). Chennai has three principal streams – the Kosasthalaiyar (covers 3.240 km^2) toward the north, the Adyar waterway (covers 763 km^2) toward the south, and the Cooum (682 km^2) streaming between them crosswise over focal Chennai. The Buckingham channel associates the three waterways worked in the nineteenth century for navigational purposes. It is limited by Andhra Pradesh state in the north; Palar River aquifer framework in the west and south and the Bay of Bengal ocean on the east. The upper east storm during October, November, and December mostly contributes the precipitation for the locale. The southwest storm precipitation is profoundly inconsistent, and summer downpours are unimportant. The average yearly precipitation of the locale is 1200 mm. The aquifer transmissivity and explicit yield range from 6.94 to 3974.16 m^2/day and 5.7 X 10-5 to 0.2 separately. Adding to this, the (VES) vertical electrical sounding review directed in the region demonstrates that the aquifer profundity in the locale differs between1 to76 m.

II. METHODOLOGY

A. Conceptual model development

Seawat2000 a numerical model is being used in the present study towards simulating the variable thickness consequences for transient groundwater flow which is further coupled with MODFLOW and MT3DMS to produce 3D groundwater flow and multi parameters contaminant transport (Lakshmi and Narayanan, 2015). The variable thickness is proposed to utilize the enhanced MODFLOW strategy towards groundwater flow condition. The integrated MT3DMS module tackles and address the contaminant transport along the beachfront for saltwater intrusion.
The model grids are drawn by keeping 13.022° N and 80.27 °E which is reprojected to WGS1984 to have UTM coordinates.

Revised Manuscript Received on December 30, 2019.
* Correspondence Author
B.Krishnakumari, Research Scholar, Department Of Civil Engineering, Dr. M.G.R. Educational And Research Institute, Chennai, India & (Assistant Professor, Panimalar Engineering College, Chennai, India).
Dr.Narayanan.Rm, Professor, Department Of Civil Engineering Dr. M.G.R. Educational And Research Institute, Chennai, India

The study area includes 2587 rows and columns with 100m intervals. The elevation details are assigned to create the topography for each lithology which varies from 0 along east – 595 m above MSL in the west. The bottom height is assigned as 1m contour for the study region.

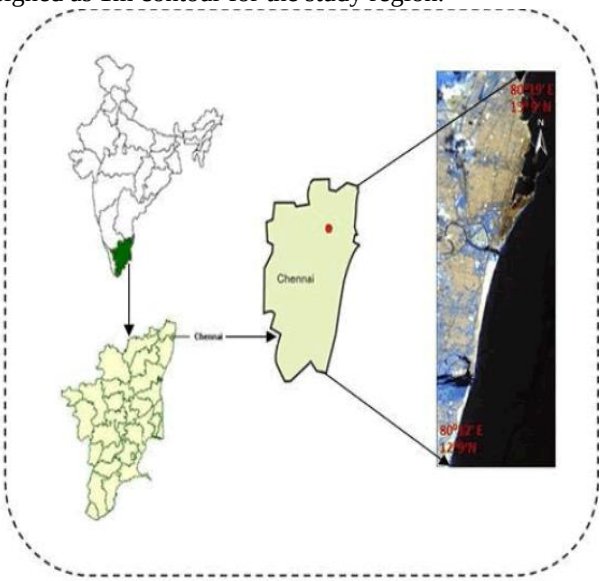

Figure 1.Study area

B. Input parameters and boundary conditions

The model is constructed based on the available and gathered information for the study area. Along the Bay of Bengal the constant head boundary value is assigned as 0 in the model domain further the tedious concentration along the oceanic region is assigned as 35000 ppm i.e.35kg/m^3. The waterways in the study area are assigned the appropriate boundary conditions in the model domain based on the field data such as layer thickness, discharge characters, conductivity etc., Near the coastal region and along the river boundaries, the TDS values are assigned as 0. Based on the precipitation data the average rainfall for the study area is assigned as 1200mm for deriving the recharge co-eff which varied from 15 to 25% due to urbanization and less rate of infiltration. From July to December the values are assigned as 0. based on 5 years data the average rainfall (Krishnakumari and Narayanan, 2019) the study region is estimated as 1200mm which is further used in deriving recharge coefficient for the study area which varied from 25% - 35% because of urbanization and less infiltration.

The total of 20 wells is utilized in the model domain on the gathered information. The rate of withdrawal is determined based on the demand, and the study area is divided into 7 regions based on the following factors. 1. The decrease in Groundwater Level and low manageability. (Figure.2) 2. Risk of Seawater Intrusion. 3. Groundwater Mining for Chennai city. 4. Groundwater Contamination because of Landfill destinations 5. Groundwater Contamination by Industries (Petrochemicals, Tanning, and Electro-plating) 6. Urbanization and enormous interest for groundwater to provide food developing Chennai City Population. 7. Low yielding aquifer units.

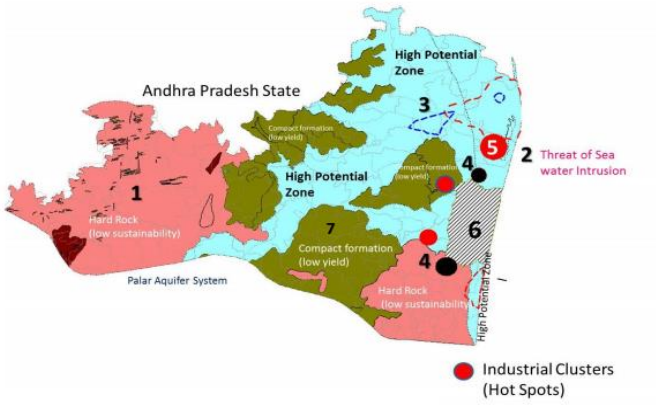

Figure.2. Issues pertaining to the Chennai Aquifer system

C. Model Simulation

Alignment is made in the model for hydraulic driven conductivity, explicit yield, groundwater recharge coefficient, porosity and dispersivity under the steady-state condition with randomly assigned aquifer parameters by trial and error method (Lathashri and Mahesha, 2015). The model is kept running under relentless state condition for the period of November 2018. The aquifer parameters are arbitrarily relegated at first and adjusted by experimentation methodology until an adequate coordinate between the watched and aligned heads are acquired. The water level data of two recognition wells under the custody of Central Ground Water Board and Mines and Geology department, Govt. of Tamilnadu are utilized to verify the consistency of the modelling. The head acquired from this reenactment is utilized as the underlying head condition for a moderate groundwater stream recreation. The moderate reproduction is completed for the multi-year duration (May 2017 to September 2019) with day by day time step. The reasonable modification is carried out until a decent match among watched and recreated TDS and groundwater head are procured. For this reason, information from four wells are used, which were observed by Honnanagoudar (2012) during the adjustment time frame.

III. RESULT

The moderate alignment within the model is done for each season towards improving the efficiency of calibrated model. The scatter plots are derived during the transient run between observed and reenacted groundwater heads and total dissolved solids demonstrating the corresponding R^2 values of November (Post-monsoon), December (Winter), May (Summer) and September (Monsoon) months are displayed in fig.3. The outcomes demonstrate that the model is experimentally stable with R^2 extending from 0.59 to 0.88 and can be utilized for new applications. The model resulted with 74% accuracy for various seasons and having an acceptable error of less than 30% which is owing to the model limitation and lack observed data. Further the SEAWAT-2000 documentation details (Langevin et al. 2003), the impediments of the appropriateness of the model are expressed plainly.

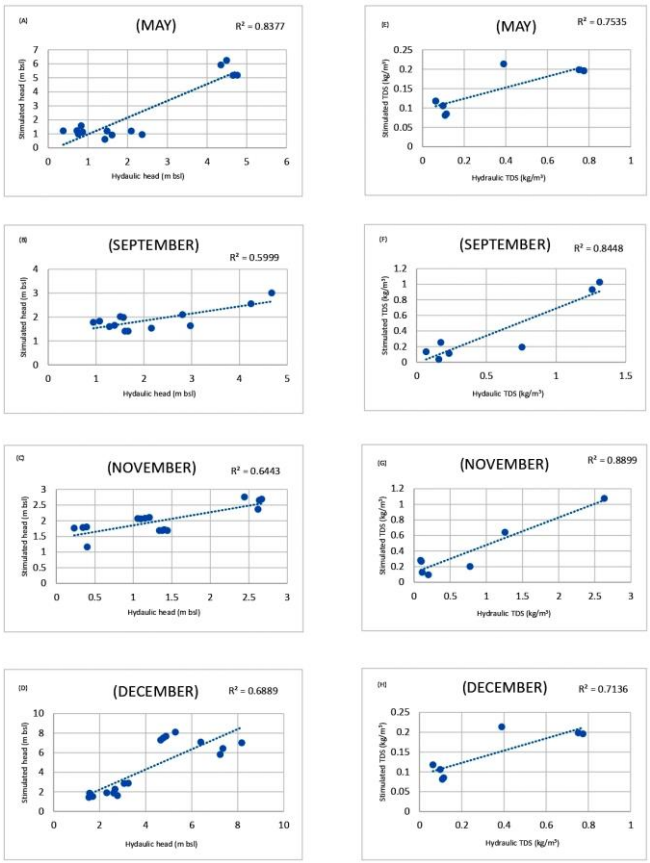

Figure 3. The scatter plots of the watched versus reproduced groundwater head and TDS intensity

The model is verified for the period May 2017 to September 2019, and the factual assessment consequences are presented in the scatter plots with the acceptable R^2 value ranging from (0.59 to 0.88). The simulated stream flow results demonstrate that, the pressure-driven hydraulic head during the long stretch of September month ranges from 0 and 25m and that during the period of May varied between 0 and -8m. The shape demonstrates an increasing sloping pattern from the shoreline (Kunte and Wagle, 1993) (0m -low-lying territory), towards the high raised zone towards the west. The transient simulation with the MODFLOW software demonstrates TDS isoline of 1600g/m^3 to 2800g/m^3 infringing the terrestrial territory about 500m from the shoreline throughout the dry season when contrasted with that of the monsoon time frame. This is additionally demonstrated by the overall inflow and outflow along the no flow region or constant head boundaries. The sensitivity analysis of TDS investigation for the study area show that pressure-driven conductivity of zones 1,2,3,4,5 and 7 are highly sensitive and specific yield of zones 6 and 7 are less sensitive from the outcome of the model execution. There is potential for seawater intrusion along the coastal aquifer if the over pumping of ground water exceeds 4.2 million gallons per day (Elango and Ganasunda, 2006) because of the expansion in longitudinal dispersivity.

IV. CONCLUSION

The critical sources of freshwater for the coastal population is significantly examined in this study towards a sustainable and scientific assessment for the coastal region using hydrodynamic modelling capabilities. The SEAWAT code is one of the advanced technology to understand the extent of the damage caused by seawater interference in the geospatial region. The precise model results with the output and the R^2 values extending from 0.59 to 0.88.The hydraulic conductivity for the study region varied between 25 to 75m/day. Similarly the specific yield for the study region varied from 0.17 to 0.22. The present study investigates two-layered model because the information pertaining to shallow and deep water aquifer formation. Further the study results with transient simulation run shown with field data are well correlated with lateral movement of the seawater intrusion among the coastal aquifers further exposed to environmental impacts and coastal hazards.

ACKNOWLEDGEMENT

The authors convey their sincere thanks **to Er. A.C.S Arunkumar**, President, Dr M.G.R Educational and Research Institute and the Central Ground Water Board and Public Works Department Chennai for providing the permissions and necessary data for this study. Authors are also grateful to the anonymous reviewers for their comments and feedback, which are useful for improving the content of this paper.

REFERENCES

1. Essink, G.O., 2001. Improving fresh groundwater supply: problems and solutions. Ocean Coast Management 44, 429–449.
2. Lin, J., Snodsmith, J.B., Zheng,C., and Wu,J., 2009. A modeling study of seawater intrusion in Alabama Gulf Coast, USA. Environmental Geology 57, 119–130.
3. Dharanirajan, K. *et al.* (2010) 'Remote sensing and GIS for the Study of coastal ecosystem changes and its conservation', *International Journal of Earth Sciences and Engineering*, 3(4), pp. 512–524.
4. Elango, L. and Ganasunda, D. (2006) 'Numerical modelling of groundwater flow in south Chennai coastal aquifer', *Defense*, (January 2006).
5. Krishnakumari, B. and Narayanan, R. M. (2019) 'Managed Aquifer Recharge for Seawater Intrusion', (9), pp. 573–578.
6. Kunte, P. D. and Wagle, B. G. (1993) 'Remote sensing approach to determine net shore drift direction - a case study along the central east coast of India', *Journal of Coastal Research*, 9(3), pp. 663–672.
7. Lakshmi, C. and Narayanan, R. M. (2015) 'Study on Groundwater Modeling of Aquifers Using Visual Modflow', *International Research Journal of Engineering and Technology (IRJET)*, 2(2), pp. 23–26.
8. Lathashri, U. A. and Mahesha, A. (2015) 'Simulation of Saltwater Intrusion in a Coastal Aquifer in Karnataka, India', *Aquatic Procedia*, 4, pp. 700–705. doi: 10.1016/j.aqpro.2015.02.090.
9. Harbaugh, A.W., Banta.E.R .,Hill.M.C., McDonald.M.G., 2000. MODFLOW-2000, the U.S. Geological Survey Modular Ground-Water Model—User guide to modularization concepts and the ground-water flow process, U.S. Geological Survey Open-File Report 00-92, pp.121.
10. Honnanagoudar, S.S., Reddy.D.V., Mahesha.A., 2012. Terrain analysis and hydrogeochemical environment of aquifers of the southern West Coast of Chennai, India. International Journal of Earth Sciences and Engineering 05, 1619-1629.
11. Langevin, C.D., Shoemaker, W.B., Guo, W., 2003. MODFLOW-2000, the U.S. Geological Survey modular groundwater model: Documentation of the SEAWAT-2000 version with the variable-density flow processes (VDF) and the integratedMT3DMS Transport Processes (IMT). U.S. Geological Survey Open-File Report 03–426.

AUTHORS PROFILE

B.Krishnakumari, Research scholar, Dr.MGR Educational & Research Institute, Chennai, India. Member of Indian Society of Technical Education. Area of interest Groundwater modelling and researching seawater intrusion-Managed aquifer recharge.

Dr.Narayanan.Rm Professor, Department Of Civil Engineering Dr. M.G.R. Educational And Research Institute (Deemed To Be University), Chennai, India. Dr Rm. Narayanan Has Published ~43 Articles In International, National Journals, Book Chapters And Various Conferences Proceedings Of International And National Importance. He Has Guided/Guiding Several Ug, Pg And Ph.D. Research Scholars. His Research Interest Is Focused On Remote Sensing, Gis, Gps, Water Resources Management, Numerical Modeling Of Pollutants And Coastal Environmental Management. He Is Presently An Expert Panel Member In Serb Dst (N-Pdf Scheme) For Scrutinizing The Proposal Submitted In The Field Of Water Resources And Environment. He Too Serves As The Scrutinizing Expert Panel Member In Mhrd & Dst Joint Program Imprints In The Fields Of Advanced Materials. He Is Presently A Member Of Ocean Color Forum (Ocf), Goddard Space Flight Center, Nasa, Usa And International Ocean Color Coordination Group (Ioccg), Dartmouth, Nova Scotia, Canada. He Was One Of The Editors Of American Journal Of Remote Sensing (Science Publishing Group) And Also Reviewers Of Journal "Geomatics, Natural Hazards And Risk" (Taylor & Francis Group), Current Science, International Journal Of Civil Engineering, Etc...