GIS LINKED MODELING OF NITRATE CONTAMINATION IN THE URBAN COASTAL AQUIFER OF EASTERN GODAVARI DELTA

by

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to the

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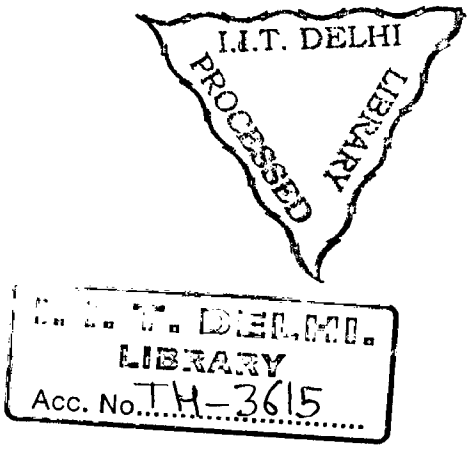
1. Septic tanks

2. Nitrate Contamination



Dedicated to My Parents

(Sri Y. Sundara Rao and Smt Janaki)

CERTIFICATE

This is to certify that the thesis entitled "**GIS Linked Modeling of Nitrate Contamination in the Urban Coastal Aquifer of Eastern Godavari Delta**" being submitted by **Yellamelli Ramji Satyaji Rao** to the Indian Institute of Technology, Delhi for the degree of Doctor of Philosophy is a bonafide record of research work carried out by him under my supervision and guidance. The thesis work, in our option, has reached the requisite standard, fulfilling the requirements of the said degree. The results contained in the thesis have not been submitted, in part or full, to any other University or Institute for the award of any degree or diploma.

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ABSTRACT

The use of septic tank-soak pit system is a common practice in India due to non-availability of sewer lines especially in the towns and cities. High density of septic systems is one of the major sources of groundwater nitrate contamination in coastal areas. Therefore, there is a need for a comprehensive understanding of nitrate contamination from septic systems for better management of groundwater quality and public health. The main objectives of the study are to develop an integrated methodology involving characterization of shallow groundwater quality, mapping of nitrogen load from septic system and NO_3^--N leaching estimation into groundwater by combining unsaturated and saturated zones.

Groundwater quality characterization was carried out by monitoring groundwater quality seasonally and analyzing quality data using multivariate geostatistical analysis. Results obtained revealed that the ion concentrations are in the order of $HCO_3^- > Cl^- > SO_4^{2-} > NO_3^-$ (anions) and $Na^+ > Ca^{2+} > K^+ > Mg^{2+}$ (cations) in the study area. The Piper classification indicated that most of the groundwater samples collected from the study area are Na^+- HCO_3 type. Results of multivariate analysis (PCA) showed that salinity and nutrients are major contaminants in the study area. As the maximum observed Cl^-/HCO_3^- ratio is limited to 7.37 in the shallow groundwater, the present salinity is due to marine environment of coastal aquifer and present land use practices and not from the seawater intrusion. Among nutrients, nitrates are high in groundwater (up to 421 mg/l) in the study area. It was also observed that there was significant seasonal change in the shallow groundwater quality due to temporal variations in shallow water table. Village/town wise nitrogen load map from septic

systems has been prepared for the years 1991 and 2004, and these two loading patterns were used to classify study area into high, medium and low nitrogen zones using 2-D Fuzzy c Means clustering technique. The comparison between these three zones and its average groundwater quality (NO_3^-, PO_4^{3-}, EC and K^+) indicated that the shallow groundwater nitrate contamination is influenced by septic system and unsewered conditions in the study area. RISK-N model was used to estimate monthly NO_3^--N concentration (July 2002 to June 2003) from septic systems at three different population density zones (Lb nagar, Madav nagar and Suresh nagar) within high nitrogen zone (polygon index 12) and compared with measured groundwater NO_3^--N concentrations.

RISK-N model results indicated that the % of septic systems NO_3^--N contribution into groundwater is mostly dependent on groundwater table condition and population density. The empirical equation is also used to estimate groundwater NO_3^--N concentrations from septic system at three locations in the study area. Results obtained from RISK-N model and the empirical equation suggest that these two tools together can provide complete range of groundwater NO_3^--N fluctuations from septic systems. The sensitivity analysis of RISK-N model indicated that intermediate vadose zone thickness, seepage from septic tank-soak pit systems, saturated zone denitrification rate, and average plot size are most influential factors in estimation of NO_3^--N from septic systems. Results of present study can be used effectively to carry out modeling studies pertaining to nitrate contamination in the coastal aquifers that can help in addressing groundwater quality problems and in decision making for better groundwater quality management and public health.

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