CHAPTER 7

SUMMARY AND CONCLUSIONS

7.1 GENERAL

This chapter summarises and appraises the conclusions arrived at as a result of the present study on aquifer vulnerability and also restates the major results which are described in chapter six. The chapter is organised into three major sections covering the summary of study and results, conclusions and suggestions for future study.

7.2 SUMMARY OF STUDY AND RESULTS

The primary objective of this study is to develop a methodology for regional scale aquifer vulnerability assessment using DRASTIC model and modifying it to improve its utility in vulnerability assessment. The incorporated modifications to DRASTIC model were intended to reduce the subjectivity in the model application and to aid in better representation of local hydrogeologic settings.

As stated earlier in section 1.4, the study area comprising of Ambur and Vaniyambadi municipalities located in the banks of Palar river, is facing rampant pollution from excess use of fertilizers in agricultural lands and from the disposal of effluents from tannery industries. It is in this context specific vulnerability assessment was carried out with regard to the contaminants viz. nitrate and chromium in the study area, and the major results obtained in the present study are presented below:
• **Specific aquifer vulnerability assessment**: Specific aquifer vulnerability assessment was carried out based on the hydrogeologic settings of the study area using DRASTIC model and GIS with regard to the contaminants nitrate and chromium. The primary result of the aquifer vulnerability assessment was identification of areas, which are more likely to be contaminated than others on a regional scale to focus attention in the form of specific vulnerability index maps, which are of social and economic relevance.

• **Prioritisation of aquifer vulnerability**: Prioritisation of specific vulnerability index maps into low, moderate and high vulnerability categories was attempted for implementation of landuse regulation policies and ground water protection strategies. Major portion of the alluvial aquifer is found to be highly vulnerable to contamination both with regard to nitrate and chromium. These high vulnerability areas are identified as zones wherein strict landuse regulation policies and ground water protection strategies have to be focussed upon.

• **Reducing subjectivity in ratings for impact of vadose zone parameter**: A methodology for reducing subjectivity in ratings for impact of vadose zone parameter was developed using sub-surface characterization of vadose zone based on travel distance and travel time of the contaminant. Results from this study have shown that the developed methodology enables spatial characterization of impact of vadose zone parameter on vulnerability without any subjectivity.

• **Modifications of ranges and ratings of DRASTIC model**: Modifications of ranges and ratings of DRASTIC model parameters for a
refined representation of local hydrogeologic settings show improved results than with the conventional ranges and ratings of DRASTIC model.

- **GUI for AHP-DRASTIC model**: The study has demonstrated that the development of GUI for AHP-DRASTIC model and its integration with GIS facilitates easier implementation and automation of the modification of model parameters.

- **Model Performance**: In case of both the contaminants viz. nitrate and chromium, the AHP-DRASTIC model has shown better results than the modified DRASTIC model.

- **Non-point versus point source pollution**: The results with regard to both contingency table and correlation analysis have shown that DRASTIC model vulnerability assessment is better in case of non-point source contamination than for point source contamination.

- **Spatial database and GIS**: Spatial database of the parameters for aquifer vulnerability assessment was created using GIS. The study has demonstrated the utility of GIS in sub-surface characterization, in handling voluminous data required for aquifer vulnerability studies and in converting them into few meaningful maps.

### 7.3 CONCLUSIONS

The conclusions drawn from this study on 'specific vulnerability assessment using GIS and modified DRASTIC model' is discussed below based
on whether the purposes of intended objectives of this study were met and the practical utility of such studies.

7.3.1 Conclusions Based on Intended Objectives

- This study has clearly demonstrated that regional scale assessment of aquifer vulnerability using DRASTIC model and GIS could be used to depict areas, which are more likely to be contaminated than others in relation to one another. As detailed site-specific analysis are costly, these cost-effective regional vulnerability assessments can be used as tools which identifies the zones of concern and as a tool which decides the need for detailed assessment in such zones of concern.

- Subjectivity in the assignment of ratings in the original DRASTIC model with regard to impact of vadose zone parameter could be reduced by characterization of vadose zone in terms of travel distance and travel time of the contaminant.

- Modifications of ranges, ratings and weights of DRASTIC model parameters for adaptation or refined representation of local hydrogeologic settings has shown to perform well for vulnerability assessments. The development of user-friendly GUI in seamless integration with GIS facilitates its implementation simple.

- Specific vulnerability assessment results for point source contaminant using DRASTIC model could be improved if additional data with reference to contaminant mobility in different soils and the potential for the contaminant to get fixed by soil are available.
7.3.2 Practical Use of Results

- With regard to the study area, the high vulnerability zones in the alluvial aquifer need to be protected. The farmers in these zones need to be educated that the excessive use of fertilizers will worsen the situation rather than improving the yield.

- As the alluvial aquifer of Palar river is highly vulnerable the disposal of treated effluents into palar riverbed shall be avoided. And also, the conveyance of raw effluents from tanneries to CETPs by open drains shall be prohibited.

- Specific vulnerability assessment maps derived as products of this study is a cost-effective planning or screening tool to overcome problems of haphazard, uncontrolled development of land and of undesirable activities having an impact on ground water quality. However, the SVI maps are to be used as screening tools to focus efforts and not as a replacement for detailed site-specific analysis.

- In the hands of a resource manager, these vulnerability maps provide a valuable guidance for implementation of landuse regulation policies and in planning ground water protection strategies. This enables the resource managers, planners, and policy regulators alike, to make environmentally sound decisions regarding landuse and protection of ground water quality. However, the resource manager shall be aware of the limitations of the maps. For example, low vulnerability category does not indicate uncontrolled landuse practices.
• The vulnerability categories themselves serve as pointers to protection strategies in terms of identifying the level and type of protective actions that may be required and also to emphasis the need for detailed site-specific assessment in areas of highest priority.

• Central Pollution Control Board (CPCB), Government of India, prepares industrial atlas for siting of industries. Vulnerability assessment maps are a valuable tool for CPCB in decision-making with regard to siting of water polluting industries in respect of indicating the relative degree of concern in establishing a particular type of industry at a given location.

• Wherever contamination could not be avoided, vulnerability assessment maps can play the role of identifying areas where contamination to the environment is minimal or within tolerable limits.

7.4 SUGGESTIONS FOR FUTURE STUDIES

Based on the experience and results of this study, the following research recommendations are made for future studies in vulnerability assessments:

• Model validation of vulnerability assessment based on contaminant concentrations from field data shall incorporate exclusion of naturally occurring concentration of such contaminant in order to unambiguously attribute elevated concentrations to human impacts alone.

• It is suggested that data which describe the fate and mobility of contaminant along with its soil attenuation characteristics shall be
included for specific vulnerability assessments. This will enable improved representation of anthropogenic impact parameter rating.

- Suitable methods for spatial characterization of point source contaminant that would help defining the contaminant loading and contaminant mobility shall be included in specific vulnerability assessment studies.