CHAPTER 9
CONCLUSION

9.1 General

In this chapter, the findings of the research works carried out in this thesis are summarized and the conclusions emerging from the study presented. The scope for further research in this direction is also outlined.

9.2 Summary and Conclusions

The major conclusions derived from the hydro-geochemical studies, water quality trends and water quality prediction modeling of DCM Industrial Area, Kota (Rajasthan), India are outlined below:

1. The interpretation of hydro-geochemical analysis reveals that the groundwater in DCM Industrial Area, Kota is fresh to brackish and alkaline in nature, which is permissible in water for drinking and agricultural purpose. The major cations (Ca$^{2+}$, Na$^+$, Mg$^{2+}$ and K$^+$) and major anions (Cl$^-$, HCO$_3^-$, SO$_4^{2+}$ and CO$_3^{2-}$) of the study area are well within the permissible limits for the entire area.

2. In major places, total hardness is exceeding the limits in the groundwater, which makes the groundwater of the study area unsuitable for drinking from this angle.

3. In general the quality of groundwater in DCM Industrial Area, Kota is good and moderate in most of the observations for ground water sources. Saline pockets are observed in certain areas. The main reason for the presence of larger amount of dissolved solids may be due to geological formation or seepage from fertilizers or local contamination. This may be the cause salinity.

4. Generally the pH of the water has a small variation due to buffering action of water with Carbon-di-oxide. Regarding the study area the pH value range lies within the permissible limit except in few places. The higher pH observed in this basin is found to be above 8 in Soorsagar, Dhakerkhari, Dakniya Talav. This may be due of to Calcium carbonate bearing rock formations.
5. The Chloride concentrations in all the ground water sources of this study are found to be within the limit. When the salt concentration is increased, it is difficult for plants to extract water. Chlorides are more toxic to some plants.

6. The quality of ground water depends on the different types of rocks encountered. Major portion of the study area is covered with sandstone. Sand stone is a buff to Red coloured, hard compact and quartzitic. Hardness is due to presence of Calcium, Magnesium, Bicarbonate and Chloride ions.

7. The concentrations of Nitrate in most of the wells are within the acceptable limit except in some places like Soorsagar, Dhakerkheri, Raipura, Daddavi, Indra colony, Prem Nagar. The increased concentration of Nitrate may be due to excessive application of nitrogen fertilizers or decay of plants and animals’ residue or sewage or by increased cultivation of leguminous plants. The toxicity of Nitrate leads to cardiovascular effects at higher dose level and Methemoglobinemia at lower dosage limits.

8. The concentration of Fluoride is found to be within the permissible limit in most of the areas. When the intake of Fluoride is above the permissible limit, it leads to skeletal and dental fluorosis.

9. The groundwater of Soorsagar, Dhakerkhaeri, Raipura, Shri Ram Nagar and Prem Nagar are identified as the most polluted in all the seasons. Government may give priority to these places while implementing groundwater improvement measures. Based on the present study, Kansua is identified as a potable source for the entire year. Bombay Yogena, Dakniya talav, Sanjay Nagar are identified as less contaminated areas from this study. Hence, developmental activities in terms of agriculture or water resources development can be carried out in the above places.

10. Pre monsoon and post monsoon analysis of samples indicate significant changes. Electrical conductivity is high in all seasons in most of areas while some of them lie in doubtful category. Only one sample was found in excellent category and is of Bombay yogena (S1) during Post-monsoon period.

11. During pre monsoon period TDS content is above desirable limits and during Monsoon and Post-monsoon period TDS content is low in some locations. It can be assumed to be due to addition of rainwater into the groundwater regime through infiltration. The locations Bombay yogena (S1), Raipura (A1), Daddavi (A2), Soorsagar (A3), Dhakerkhari (A4) with low TDS point out that water is potable in these areas. In other locations TDS exceeds the desirable limit and water is non-potable.
12. The Water quality study on this area by the help of Aqva chem shows that most of the water (90% of the water sources) can be used for different purposes. The calcium, TDS, and hardness, alkalinity and electrical conductivity are the major parameters which account for water sources unfit for potable purposes.

13. Total Coli form is also found very high in most of the areas especially in Bombay Yogena, Kansua, Near Dakniya Talav, Sanjay Nagar, Raipura, and Daddavi. Bacteriological study reveals that may be due to seepage from fertilizers or local contamination and sewage pollution.

14. Hierarchical Cluster analysis also shows conductivity, TDS and Coli form in Group C alone formed a group with highest Euclidian distance as compared to other cluster groups and appears to be highly polluted, marginally free from major point and nonpoint pollution sources.

15. The detailed statistical study on water quality reveals that chloride, hardness, sulphate, potassic and sodium show a good correlation with TDS.

16. The water quality monitoring of DCM Industrial area has been simplified by constructing GIS-based Contours water quality maps. These models are capable of determining parameters such as TDS, chloride, sulphate, phosphate, conductivity and hardness etc on the basis of colour interpolation map.

17. The study reveals that quality of ground water changes in post monsoon period may be due to infiltration and seepage of rainwater in groundwater sources. As such, groundwater quality and its suitability is an area of concern in near future also.

18. Decision makers and relative authorities associated with DCM Industrial area will do well to use the findings of as a decision support tool. It has been concluded that DCM Industrial area is not yet polluted with industrial effluents compared to sewage waste. The primary factors contributing to the present situation are presence of small number of industries and Sewage waste.

19. Since the GIS based map is purely based on the exiting data, the methodology may be used for the other area, based on the availability of the data.
9.3 Suggestive Measures

The following measures are suggested after analyzing the various data and also by considering the realities of the ground conditions:

- Water should be used after prior treatment like Ion exchange method for hardness removal in study area especially in Prem Nagar, Soorsagar, and Raipura area.
- Water conservation structures and harvesting structures can be promoted especially in the eastern area of the study area. Less water consuming crops can be irrigated in the summer period and in the low rainfall period.Judicious utilization of water resources is the prime need of the hour in the entire basin area.
- Renovating old tanks and ponds, canals, desilting of supply channels and constructing water harvest structures to improve irrigation potential appear to be potential woks, which need to be carried out. Planning for rainwater harvesting and saving surface water has to be done in fast mode.
- Large scale extraction should be avoided especially in the industrial region due to high pollution contamination.
- Environmental Act and regulations should be followed by industries.
- Groundwater extraction can be restricted so as to fix the horse power of motor within a desired limit.
- Popularize the awareness programs among the public, especially farmers at various levels, which should be made effective so as to attain self sufficiency in the sustainable water resources development.
- Measures to zero down presence of E Coli should be initiated.
- Further studies should be commissioned in the region to properly identify the source of pollution.
- Further strict compliance of BIS, CPCB and CGWB/CGWA are required to be implemented and regular checks need to be made.
- Since the area is near to industries and groundwater is getting contaminated with industrial pollutant, desalination plants must be installed as first priority.
- The parameters TDS, TH, EC, Na\(^+\), NO\(_3\)- and Total coli have high mean rank value and have significant spatial variability and put larger impact on the GQI, so GQI must be carefully and accurately mapped.
- Water quality indexes should be used in automated or manual way to understand the
overall water quality.

➢ Study of inter relationship between various chemical species present in the water is the most important aspect of hydrochemistry. Statistical relationships like correlation between various ions present in the waters of the study area shall be studied using Minitab 15 version. It would be interesting and useful to look at the relationship of HCO\textsubscript{3}--Ca\textsuperscript{2+} and HCO\textsubscript{3}--Mg\textsuperscript{2+}, Na\textsuperscript{+} C, Ca\textsuperscript{2+}--Mg\textsuperscript{2+}, Fe-Pb and Fe-Zn etc.

➢ It is highly recommended to use GIS tools and their applications to produce maps for better and fast remedy in improving groundwater quality of DCM industrial area and its adjoining areas.

➢ It would be interesting to look at the impact of climate change on the quality of groundwater however this would require long term data but may also give very useful results.

This work has demonstrated that hydro-geochemical studies, water quality trends and water quality prediction modeling helps in better evaluation of the study area. The above results can be used for future sustainable development of the study area by the Kota authorities and decision makers.

**9.4 Scope for Future Works**

- The modeling study can be extended for other water quality parameters.
- A study on groundwater quality movement can be carried out.
- A detailed study on consumptive use of ground water can be carried out.
- The surface ground water interaction needs to be studied using various surface water and ground water models like MODFLOW and MT3DMS.