CHAPTER 9

DISCUSSION AND CONCLUSION

The South Bangalore Metropolitan region encompasses Cauvery and Krishna Basin. Eastern Part of Bangalore south and Anekal taluks fall under the catchment of Cauvery to Palar. Ramanagara, Kanakapura, Channapatna taluks and part of western portion of Bangalore south and Anekal falls under the catchment of Cauvery. Pennar River flowing towards Eastern side and Cauvery River flowing towards Southern side.

In the study area laterite formation in Cainozoic age, quartz vein, felsites, felsites porphyry, Lamphrophyre and Potassic rock, these are the younger intrusive formation in upper Proterozoic age, Basic dyke are the basic intrusive. Pink and Grey granite are the Closepet granite its formation under Lower Proterozoic in age. Gneiss / Migmatite / Granite this are Peninsular Gneissic Complex, Quartzite, Amphibolite / Homblende schist formation are Sargur group of schist belt and Charnockite formation in Charnockite group Rock, these group under the age of Archaean. In the study area Gneiss (68%), Pink and Grey Granite (28%) rocks are dominantly spread in the study area.

In the southern parts of Kanakapura taluk, a numerous small bodies of alkaline rocks of syenite affinity in the form of narrow dykes and tiny plugs rich in potassic feldspars and feldspathoids (ultra-potassic rocks) are emplaced in the gneisses and granites. These dykes carry essentially fine grained light coloured orthoclase and hence named felsites.

Thick blanket of laterite especially in the eastern parts extends over a depth of five m and more. Granitic rocks on sustained weathering produce a colluvium of coarse sandy material laid in the slopes and also lateritised at planar level surfaces. This type of soils are noticed in north eastern part of Bangalore taluk and eastern portion of the Anekal taluk.
The total area covered is about 30 %. Red loamy soils occur on hilly to undulating landscape on granites, this type of soils are noticed in south of Bangalore taluk and central portion of the Ramanagara taluk. The total area covered is about 20 %. Red sandy soil in the study area is derived from the residual products of granite and gneiss varying form sand or gravel to loams and are highly leached and light textured.

Morphometric analysis is an important in any hydrological study in urban areas like Bangalore city for development and management of drainage basin. Morphometric analysis of fourteen sub-watersheds comprising part of River Cauvery of Bangalore district have been carried out using Geographic Information System (GIS) and Topo-sheets. The parameters such as Rb, Dd, Fs, T, Lof and Ccm are calculated by using standard formula and prioritization has been done by using raster calculator option of spatial analyst. The stream orders varies from first order to sixth order in the basin and the total number of stream segments of all orders cumulated to 11,134. The maximum area covers under Dakshina Pinakini sub basin in about 892.70Sqkm and Minimum of 24.42Sqkm in Edakolada Halla. The Various Types of Geomorphological features were found pediments and Pediplain, Valley flat, Hills valleys Denudational Plateaus and Denudational Hills. Hills / Valleys (31%), Pediplain and Pediments (28%), Denudational Plateaus (28%) dominantly spreads in the study area Map (3.1). Pediplain and pediments are flat surface with good weathered profile covering thick vegetation. These types of thick vegetation are very helpful and acts as important role for ground water infiltration.

The minimum length of the sixth order is 120.50Km in Kanva Hole watershed, Maximum length is 186.05 km in Doddaguli Halla watershed and total length of the sixth order is 518 km. This has been calculated dividing the total stream length of the order (U) by the number of stream of segments in the order. The Total number of first to sixth order is 11,134,
mean stream length of the study area is 0.75 km. bifurcation ration ranges between 9.67 to 22.56, drainage density ranges between 1.942 to 136.57. The circularity ratio show in the study area part of Dakshina Pinakine River, Vrishabhavathi River, Arkavathi River and Kanva Hole showing low circularity ratio. Kutle and Antergange Hole is showing high circularity ratio value. In the present study the circularity ratio its shows 0.026 to 0.27. Elongation ratio shows Low in DoddaHalla, DoddaguliHalla Cauvery River and Kutle hole. High in DakshinaPinakini River, Arkavati River, Vrishabavati River and Part of Shimsha River. In the study area results indicate that 0.167 (<0.7) the basin is elongated area 0.2171 to 1.05.

Slope may be defined has the concept of the terrain parameters which is explained by horizontal spacing of the contour in the study area, nearly too very gentle slope 0-5 (73%), gentle to Moderate Slope 5-10 (10%), Strong Slope 10-15 (9%) covers in the study area. In the study area nearly too very gentle slope are covers 73 % these area considered good potential zone. Slope is measured by identification of maximum rate of changing value for each cell nearly too very gently slope. In the gently slope area the surface runoff less and rain water to percolate and consider as recharge good ground water potential zone.

Land use land cover features are dominant in the development of ground water resources Agricultural Land (59%), water bodies / Wetlands (16%), Forest (15%) and Built-up land (10%). lineament area digitized form Geological survey of India maps. The majority of area covers dendritic drainage pattern, Major and Minor lineaments are observed, Very high Lineament density observed around 81% of the study area.

Precipitation is the primary source of all surface water and groundwater in the basin. The annual precipitation of the study area is 866 mm. The map shows that low rainfall is restricted to the south part of study area ranges from 813 to 838 and high rainfall in North West of the
Channapatna area ranges from 890 to 921 the weighted averages have been calculated by Thiessen polygon method.

The data on number of days for the year 1981 to 2011 has been used to calculate the AE. The annual AE of the 266.14 mm. A rainy day means a day with a minimum rainfall of 2.5mm. To determine the number of rainy days in a month, rainfall data from 1984 to 2014 has been used. The contribution of southwest monsoon (Jun-Sept) is about 45 %. The study area receives fairly good amount of rainfall (30 %) during the post-monsoon season. (Oct-Dec). The study area receives about 866 mm of annual rainfall distributed over 52 rainy days. The computed results of actual and potential evapotranspiration are 266.14 and 915.55 mm respectively.

Ground water is the component of the hydrologic cycle to realize the benefits of remote sensing and GIS. Drainage, Drainage Density and slope maps have been derived using topo sheet in GIS environments. Geology, Soil and Lineament maps of Geological Survey of India have been prepared using GIS. Remote Sensing Technique has been used to obtain Geomorphology, Land use land cover. These standard thematic layers are proposed to determine the ground water potential zone Using RS and GIS Technique. These thematic layers integrated with one layers to another layer by overlay method in Arc GIS. Weight and Rank are given based on infiltration capacity of ground water. In the present study area Ground Water Potential Zone (GWPZ) grouped in to five classes VIZ., Good 33%, Excellent 27%, Moderate and Poor 18%, Very Poor 4%.

The GWPZ zone map derived using GIS technique has been validated by superposing the field data. Comparison of GWPZ and their respective yield has been verified. About 44% of bore well points matching with excellent to good, 36% matching with good to moderate and remaining 20% not matches with the respective zones. The Central portion comprises
of Good to Excellent Zone because of the Arkavathi River. The validation of the model using Well inventory shows that there exists a matching of zones obtained with a marginal error.

A comprehensive watershed management programme may have multiple objectives such as controlling and managing and utilizing for useful controlling Soil erosion. An attempt has been made to work on Soil erosion. A fourth order stream of Nelligudda watershed with a total length of the stream 133 km has been selected for the study. Rainfall erosivity factor (R) erosive force of specific rain prepared using average rainfall of the study area s is 300 mm, Soil erodibility factor (K) is 0.41, Slope length factor (L) is 0.59, Slope steepness factor (S) is 0.153, Crop management factor (C) is 0.52 and conservation practice factor (P) is constant 1. The elevation ranges between 682 to 914 meters above MSL. Moderate soil erosion grouped into five class Slight <5, Slight to Moderate 5 to 10, Moderate 11-25, Sever 26 to 50 and Very Sever > 50 T/ha/year. in the study area observed in central part Moderate 11-25 T/ha/year and Northern and South Eastern part of the study area Severe 26 to >50 T/ha/year dominantly distributed in the Nelligudde watershed. Soil erosion map was prepared using overlay method in Arc GIS (10.2.1).

The minimum water level observed is 4.9 m in Kodihalli village altitude of 622 meter above mean sea level over the observation well and the maximum water level observed is 21.7 m in Ramanagara observation well over the altitude of 685 meter above mean sea level.

The average water table during Pre-monsoon is about 16.9 m and its variation is 4.8 to 40 m. The ground water level is high in western and northern parts. Exploitation of groundwater seems to be very high in eastern part of the study area. The change in the value of discharge quotient indicates that the flow gradually improves after 30 lpm limit but in the process it shows sharp decline in its efficiency, but it is within
laminar flow as it has not crossed Q power beyond 2. It also indicates that there is decline in draw down in the fourth step indicating positive contribution to discharge.

Recharge and Discharge areas have been delineated. This may be used effectively to construct artificial recharge structures. Storage structures like form ponds, gokatte, kalyani may be constructed in the discharge areas. Check dams, gulli plugs and point recharge structures may be constructed in the recharge areas.

Resistivity Survey has been carried out in Matanahalli MWS. A total 54 VES were conducted using Schlumberger array and 128 number of profile survey were carried out using Wenner Configuration. These profiles were covered mainly to decipher the depth to soil layer, soil layer followed by weathered rock and weathered rock followed by basement rock to know the bed topography of the area. Fractured rock encountered in the depth of 18, 24, 30, 60, 78 and 150 meters respectively. The longitudinal conductance in the study area varies 0.10 to 0.38 mhos.

The spatial distribution maps for all the chemical constituents have been prepared with the help of Arc GIS (Version 10.1) software. The average value of Calcium (Ca) is 99.08 ppm, Magnesium (Mg) is a range of 29 to 269 ppm, Sodium (Na) is a range of 6 to 109 mg/ltr, Potassium (K) ranges from 1.26 to 75.5 mg/ltr, Nitrate (NO3) concentration is from 0.37 mg/ltr to 260 mg/ltr. Sulphate (SO4) is 2.7 mg/ltr to 276 mg/ltr, the total hardness (TH) value ranges from 30 mg/ltr to 980 mg/ltr, EC value ranges from 365 to 2565 - mhos/cm and pH value of the study basin is 7.64, with a range of 6.75 to 8.53 in the study area.

The mean Fluoride value in the study area is 0.029 mg/ltr and the value ranges from 0.029 to 1.74 mg/ltr. The spatial variation of Fluoride shows anomalous zones. Highest value showing in the north & south portion of Bangalore south taluk and Kanakapura taluk of the study area.
Discussion and Conclusion

and highest values showing in Thavarekere, Thimmanahalli and Sarjapur villages and lowest values showing in west of Channapatna taluk and central part of the study area. Lowest values showing in Chilur and Kempapur village of the study area.

The Hill Piper diagram is used to infer hydro geochemical facies. A trilinear diagram was created to classify the groundwater from different parts the study area and to reveal any groupings, indicate that most of the samples fall in no-dominant and carbonate types respectively. The central diamond field reveals that 10 samples fall in '1st' hydro-chemical facies (Ca, Mg - CO3, HCO3) and 35 samples fall in 'IIIrd' facies (Ca, Mg-Cl, SO4). Then remaining 1 and 4 samples fall in 'IIInd' (Na, K, Co3, HCO3 ) and ‘IV’ (Na, K, Cl, So4). Hydro-geochemical investigations were carried out with an objective to identify the processes affecting the chemistry of groundwater in BMRD Region Karnataka. The sodium or alkali hazard in the use of water for irrigation is determined by the absolute and relative concentration of cations and is expressed in terms of sodium adsorption ration (SAR). SAR is well within permissible limit with a small error. The USSL plot indicates that the total Samples are fall in the area of C2S2 (Medium salinity and Medium Sodium hazard) Class 17% covered followed by C3S2 (14%), C3S3 (12%), C2S1 (10%), C1S1, C3S4 (6%), C4S4 (4%), C4S3, C4S2, C2S4 and C3S1 shows (2%). C3s2, C3S3 and C2S1 types of water shows medium salinity to high Sodium hazard group and moderate amount of leaching for the most of crop respectively.

Bicarbonate concentration in water affects the suitability of water for irrigation purpose. The RSC values of the study area ranges from -13.13 to 2.68mg/ltr Maximum value is 35.35 in the eastern part of the study area and lowest value ranges is about 3.89 mg/ltr, Based on the classification 98 % of the samples of the basin fall in safe and are good for agricultural practices except one sample which is not suitable. The percent of sodium (% Na) in water is a parameter computed to evaluate the
suitability for irrigation. The mean of Na % 10.21 to 75 mg/ltr. High value range of 75.39 showing in the northwest potion of the study area of Channapatna taluk and eastern portion of Anekal taluk. Lowest value ranges of 10.21 mg/ltr in South of Ramanagara taluk however some water samples are classified under permissible to doubtful and doubtful to unsuitable classes.

**Conclusions:**

- The study area covers about 4,125 Sqkms of South Bangalore Metropolitan Region.
- Archean Gneisses and Pink & Grey Granites are the dominant lithological units.
- Pediments, Pediplains, Valley flat, Hills valleys Denudational Plateaus and Denudational Hills are the landforms.
- Sandy Soil, Clayey Soil and Laterites are prominent in the area.
- The annual rainfall in the study area 4332.61 mm & maximum annual rainfall of 922.25 mm and minimum rainfall 813.46 mm.
- Ground water potential zones have been delineated by integration of thematic layers and validated using well inventory data. Majority of the area comprises of Good and Excellent zones of Groundwater potentiality.
- Soil Erosion map of Nelligudde watershed, part of the study area has been prepared to quantified Central portion shows Moderate erosion with 11-25 T/ha/year and Northern and South Eastern part of the study area Severe with 26 to >50 T/ha/year dominantly distributed.
- Flow net analysis used to delineate the Recharge and Discharge areas of the study area. Water storage structures form ponds, gokatte, kalyani may be constructed in the discharge areas. Check dams, gulli
plugs and point recharge structures may be constructed in the recharge areas.

- Resistivity Survey of part of a MWS with a total 54 VES and 128 number of profile survey has been carried out. Fractured rock encountered in the depth of 18, 24, 30, 60, 78 and 150 meters respectively. The longitudinal conductance in the study area varies 0.10 to 0.38 mhos.

- Chemical concentration is well within the permissible limits with an exception of Ca at two location; Fe at one location; NO3 at two location and F at one location crossing marginally the permissible limit.

- SAR, RSC, %Na and PI values are within permissible limit with a negligible error.

- The Hill Piper diagram is used to infer hydrogeochemical facies. 10 samples fall in 'Ist' hydro-chemical facies (Ca, Mg - CO3, HCO3) and 35 samples fall in 'IIIrd' facies (Ca, Mg-Cl, SO4). Then remaining 1 and 4 samples fall in 'IInd' (Na, K, Co3, HCO3) and ‘IV’ (Na, K, Cl, So4).

- The results obtained indicates the necessity of using both surface and Groundwater in a sustainable method as Bangalore City is one of the fast growing cities.