CHAPTER 8

SUMMARY AND CONCLUSION

8.1 CONCLUSION

The Krishnagiri Reservoir is no exception to the general water quality problem of eutrophication and its impacts, although it has had a very useful life span of half a century, as is the case of many other Lakes and Reservoirs in our country (Reddy and Char 2006).

The present study reveals that the sediment load entering the Reservoir is dominated by fine grained clay particles. Among the different methods tested, the Gill method predicted the trap efficiency as 64.99 to 95.31 %, which is found to be closer to the actual sedimentation rates in Krishnagiri Reservoir. The rate of sedimentation has been assessed as 0.445 % and the useful life span of the Reservoir as 101 years.

The decreasing storage capacity of the Krishnagiri Reservoir directly impacts the intended benefits / purposes for which it was designed and affects the livelihood of the local inhabitants. The fishermen are the part of local community who were directly affected by the decline of the culture fisheries in the Reservoir (Ravichandran 2010) due to sedimentation and consequent decline in water quality.

The loss of capacity has been assessed as 41.7 % in Krishnagiri Reservoir (IHH, 2007) and points to the changing land use and soil conditions in the watershed that needs to be addressed. The ongoing programs of soil
and water conservation needs to be focussed and intensified in areas of severe soil erosion (Karunakaran and Ravichandran 2006) in the watershed which may help reduce the watershed sediment delivery into the Krishnagiri Reservoir.

The water quality is strongly influenced by the south west and north east monsoon rainfall and seasonal inflows into the reservoir. In this study, the EC of the Krishnagiri Reservoir responds to the monsoon inflows, especially during the SWM season by wider fluctuations in EC values. In addition, the concentration profiles of major ions, nitrates and phosphates displayed close correlation with the monsoon rainfall pattern and the consequent hydrological conditions of the Reservoir. This is supported by a statistical comparison of water quality variables (Table 6.4) indicating that the differences among seasonal mean concentrations are significant, while the spatial locations of sampling in the reservoir as non significant.

Further, the EC showed an inverse relationship to the monsoon inflows and was high in the inflows to the Reservoir compared to other locations in the reservoir. This indicates that the watershed delivery of major ions and nutrients forms a significant component of input solute load into the Reservoir. When compared with the TDS values recorded in Krishnagiri Reservoir during 1960’s (Mohanakrishnan, 1988) of 487 ppm and the average values recorded in the present study (660 ppm), an increase of 172 ppm has been noticed in a span of 40 years. These values are very high compared to the world average for Lakes and Reservoirs (105 ppm) and Asian average of 126 ppm (Wetzel, 2006). The probable reasons are the high erosion in parts of the catchment area and the accelerated expansion of agriculture and urbanisation (Jasmin and Ravichandran 2008) in the catchment areas.

The dynamics of phosphate, the key nutrient in eutrophication was analysed in Krishnagiri Reservoir, based on the data collected for a period of
nine years (2001 – 2009) by several investigators. The application of eight
different mass balance models proposed in literature to the Krishnagiri
Reservoir indicated similar responses to the influence of monsoon season with
increased $R$ values and decreasing $\sigma$ values by all the methods. When the
sedimentation coefficient from these eight methods were used for the
prediction of phosphate in the inflow, reservoir and out flows, the results
show different levels of success. The modification suggested by Hejzlar et al
(2006) and a method proposed in the present study gave comparatively better
results.

When the $\text{TP}_{\text{in}}$, $\text{TP}_{\text{res}}$ and $\text{TP}_{\text{out}}$ measured in the Krishnagiri
Reservoir is compared with the estimated respective TP values, a better fit of
data is obtained ($R^2 = 0.70$) in the case of TP in outflow from the Reservoir,
moderate fit in the case of TP in inflow ($R^2 = 0.42$) and average in the case of
Reservoir ($R^2 = 0.24$). The main causes for the prediction errors could be due
to inadequate TP input budgets and many factors involved in the TP losses to
Lake sediments.

8.2 RESEARCH CONTRIBUTION

The present study reports the rate of sedimentation, the trap
efficiency, the useful life span and water quality of the Krishnagiri Reservoir,
important for management of eutrophication of water bodies. A modification
proposed to the Gill method with coefficients calibrated based on the present
study gave better estimates of trap efficiency than all other methods and can
be used for monitoring sedimentation in Krishnagiri Reservoir.

The significant role of the monsoon seasons on water quality and
its dynamics on nutrient delivery from the catchment area, adds important
field information, wanting especially from tropical regions. Further, the role
hydrological regime (with seasonal inflows and controlled outflows) in
imposing alternate conditions (stable conditions during winter and summer and transient during south west and northeast monsoon) in the Krishnagiri Reservoir and its effect on water quality responses have been analysed.

The mass balance modelling of phosphate dynamics in the Krishnagiri Reservoir, though with limited data, is a pioneering attempt. The review of literature also suggests modelling attempts for eutrophication management from tropical regions are very limited. This study proposed a modification of Vollenweider model for TP prediction based on data from Krishnagiri Reservoir that also validates the Retention coefficient for Phosphorus estimation in tropical reservoirs by Hezjlar et al (2006).

8.3 ASSUMPTIONS AND LIMITATIONS

The mass balance models basically assume uniform (continuously stirred tank reactor) conditions to prevail in the system. Since Krishnagiri Reservoir is shallow in nature (mean depth 2.77 m) and the role of wind is significant during most part of the year, I presumed the reservoir does not have any stratification and behave in the same way. The other limitation of the study is that the role of sediments in release/deposition has not been considered.

The limited data available for the Krishnagiri Reservoir did not permit the application of dynamic / process based models. Since empirical models have been used widely in literature (Ahlgren 1988; Frisk 1992; Brett and Benjamin 2008) because of their simplicity and less demand on data requirements, they are considered for application in Krishnagiri Reservoir. The paucity of data from tropical regions, especially from Reservoirs encouraged the assessing of existing models, their application and suitability under tropical conditions.
8.4 **SCOPE FOR FUTURE WORK**

The sediment trap efficiency may be dependant not only on the catchment area characteristics, the runoff volume, but also the size, shape and outlet structure of the reservoir. In some reservoirs, the trap efficiency is found to have direct relationship with sediment flushing rate and the operation of the bottom sluice gates (White 1990; Richardson 1996). In Krishnagiri Reservoir also, the sluice gates of the RMC and the LMC have a difference in elevation of 3.6 m (Mohanakrishnan, 1988). The release of water through the low level sluice LMC may remove more suspended sediment load than RMC sluice. This aspect needs more study and collection of data on suspended sediment release through various outlets in Krishnagiri Reservoir to assess the role of reservoir and for managing the problem of sedimentation.

The sediments accumulated in the reservoir, in addition to the watershed inputs, appear to be responsible for the eutrophication in the Reservoir. The release of phosphate from the sediments into the overlying water, the key nutrient responsible for eutrophication, may be significant in this process. The concentration of phosphate recorded in the LMC and RMC (Table 6.3) showed a range of variation from 7.89 to 20.5 µg / L (significant p < 0.05). The increased concentration of phosphate in LMC is attributed to the depth of the water column and prevailing anoxic conditions that released the phosphate bound to the sediments into the water column. The role of sediments accumulated in the Krishnagiri Reservoir need to be assessed for their role in release of Phosphate, which may affect the present and future status of eutrophication.

The watershed delivery of Total Suspended Solids and TDS is still a major factor affecting the water quality of Krishnagiri Reservoir and emphasise the need to intensify the existing soil and water conservation
programs initiated in the catchment area of the Krishnagiri Reservoir by various agencies.

The modification to the Vollenweider model suggested in the present study, starting with an equation defined by Canfield and Bachmann (1981) gave similar values for coefficients proposed by Hejzlar et al (2006) for Reservoirs and also gave a better fit of data for the Krishnagiri Reservoir. The application to more case studies using the equations proposed in this study, may throw more light on the applicability and use of these equations for predicting the TP concentration in Reservoirs from tropical regions.

The results of investigation of this thesis have clearly brought out the need for accounting of the temporal hydrological variability in modelling of Reservoirs for phosphate dynamics. The method used in this study of partitioning of annual hydrological series into monsoon and post monsoon gives an improved prediction of phosphate concentration. Further research to account for the effect of monsoons is necessary to build better predictive models for Reservoirs in monsoon regions.

This thesis also points to the need for more studies, comprehensive in nature from tropical regions to improve the paucity of data and information on the mechanisms controlling the interaction between hydrological, hydraulic and hydro chemical aspects of the reservoirs. This would then lead to the development of more general models that could better predict TP dynamics in tropical Reservoirs.