Chapter 5

Summary & Conclusion
The present study was meant on the impacts of effluents on water environment from Tirupur textile industries situated on bank of Noyyal River. This study focuses on the general characterization of the quality of effluent before and after conventional and MBR treatment systems and a long term spatial and temporal impact of non-treated and treated effluent discharge on river water and groundwater quality around Noyyal River. In order to achieve that, the hydro-geochemical, statistical analysis and hydro-chemical modelling techniques were used. The field data, effluent characterization, surface water and groundwater, hydro-geochemical process were integrated with microbial diversity to get an insight into contamination of textile effluent on water resources besides its effectiveness on water treatment facilities as a countermeasure. Findings of preceding chapters are summarised as follows:

Comparison of conventional and MBR based CETPs has been carried out of before treatment (BT) and after treatment (AT). In the conventional CETPs the pH, SO₄²⁻ and almost all the heavy metals fall well within the regulatory limits. However, TDS and Cl⁻ in all plants and Pb and SO₄²⁻ in Raipuram CETP were found to be beyond the permissible limit. The values of BOD and COD are variable. The value of Na % undergoes enrichment in AT effluent of this treatment system. In the MBR based CETP, the values of pH, BOD, COD, SO₄²⁻ and heavy metals fall well within the regulatory limit. Total Dissolved Solids (TDS) and Cl⁻ fall beyond the permissible limit, while Na % value shows enrichment. The overall results show that the conventional CETPs are quite efficient in treating such parameters like TDS, HCO₃⁻ total major cations and the MBR treatment system is comparatively more efficient in some of the parameters like BOD, COD, SO₄²⁻ and for some metals like Zn, Pb and Cr. So, it is very difficult to articulate which treatment system is most suitable even though worldwide studies indicate that the MBR treatment system is more advanced and efficient in treating textile effluent that are having high organic and inorganic load. The MBR based CETP thus shows comparatively better textile effluent treatment potential than conventional systems, but in Tirupur it has been recently installed and yet not standardized. So, long term study of MBR treatment system is needed to establish its efficiency in treating the textile effluent.

The impact of the textile effluent on river water quality of Noyyal of two successive years i.e. 2008-09 was compared with the earlier reports of 2002-03 collected from different secondary sources, indicate that the pollution load is gently less in upstream of the Tirupur industrial hub (Siruvani) in comparison to two different downstream sites.
i.e. the industrial hubs at Kasipalayam and Anaipalayam. EC, TDS, Cl, SO$_4^{2-}$ were found to be very high in river water in the stretch of industrial site in the downstream of the industrial site. Over the years from 2002-03 to 2008 to 2009 the concentration of all the anions i.e. HCO$_3^-$, NO$_3^-$, PO$_4^{3-}$, F$^-$ shows the decreasing trend, showing clearly the temporal variation. The Na % content increases from Siruvani to Kasipalayam to Anaipalayam in a single year 2008 as well as 2009 and are site specific. But yearly data shows that the Na % content decreases from 2008 to 2009 which may be due to improvisation in Treatment technologies. The concentration of metals is in the following order: Fe > Cu > Zn > Mn > Ni > Pb > Cd > Cr at Kasipalayam and Anaipalayam in the year of 2008 and 2009. All the metals were found to be under the tolerance limit prescribed for effluent discharge except for Fe that is high at Kasipalayam in 2008. As far as the long term impact of non-treated and treated effluent on river water quality is concerned the implementation of conventional CETPs and MBR CETP have lead to the decrease in low concentration of different ions and metals in effluent discharge over the years i.e. for 2002-03 to 2009 onwards the river water quality has shown signs of significant improvement.

The impact of effluent on the groundwater quality of the Noynal River basin for the year 2008-09 was compared with earlier reports (2002-03) from different secondary sources. Pollution level is less in groundwater in upstream of the Tirupur industrial hub (Perur) as compared to two different sites i.e. the industrial hub (Kasipalayam) itself and downstream of the industrial hub (Anaipalayam) follow the trend of river water quality. The groundwater is highly alkaline in nature at Kasipalayam and Anaipalayam due to textile effluent percolation. The TDS at all the three sites are above the permissible limit, barring Perur. The major cations were found to be very high at Kasipalayam and Anaipalayam and are attributed to the impact of effluent discharge which is having high salt content over the years. All the anions at the study sites: were found to have high concentration in the groundwater except at Perur which is well within the permissible limit. Hence, Perur being in the upstream of the Tirupur industrial hub is found to be less contaminated than the other two sites in terms of cations, anions and heavy metals such as Cd, Pb, Mn, Ni and Fe while Cr, Zn and Cu. Among the two sites, Kasipalayam was found to be most contaminated due to incessant industrial discharge till 2008. But with the advent of new treatment technologies like CETPs having zero liquid discharge system and MBR
based CETP there has been slight decline in the concentration of different physicochemical parameters and metals from 2002-03 to 2008 to 2009.

The hydro-geochemical study revealed that the dominance of Mg-Cl and Na-HCO$_3$ groundwater type in the upstream region. Na-Cl groundwater type was found increasing in Kasipalayam and Anaipalayam sites. The dominance of Na-Cl type of water is mainly due to the impact of salts like NaCl, Na$_2$SO$_4$ etc used in textile processing, which after discharge, percolate and accumulate in the aquifers. Seasonal groundwater quality of Tirupur region as a whole showed the dominance of Ca-HCO$_3$-, Na-HCO$_3$- and Na-Cl water types. The PHREEQC modelling output indicates that nearly all the groundwater samples were oversaturated with respect to calcite and dolomite and undersaturated with respect to gypsum and halite. This indicates that the water is likely to precipitate calcite and dolomite and dissolve gypsum and halite.

The results were also integrated with the microbial diversity. The microbial density and diversity were high in the river water at the industrial site (Kasipalayam) as compared to non-industrial site (Perur). Similarly, the microbial populations were found to be high in the BT effluent as compared to AT effluent in the conventional treatment systems and similar trend is observed for MBR treatment systems as well. The MBR treated effluent found to have some bacterial as well as fungal growth may be due to under operational phase of the plant. The microbial stock in BT effluent is higher than microbial stock of river water even at Tirupur site may be due to the dilution effect of river and accumulative toxicity of textile effluent in river water. The bacterial diversity at river site near industry and non-industrial site have similar biological diversity In addition Pseudomonas sp., and Achromobacter sp. (bacterial diversity) and Aspergillus fumigates (fungal diversity), which reported to have decolourization potential of dye effluent. The bacterial and fungal diversity in the BT was found to be high as compared to the AT effluent.

The present study thus gives a better insight and understanding into the textile effluent physico-chemical character, treatment plant efficiencies of existing plants and their implications to the surface and groundwater quality around the Tirupur region. The observation is supported by the hydro-geochemical, hydro-chemical and microbial diversity studies carried out here. The study also reveals that, with the advent of zero liquid discharge technology through the various treatment systems. After strict implementation of Supreme Court order there is a positive improvement in the surface and groundwater
quality. The information obtained in this study can be utilised in better management of effluent generated from textile industries.

**Recommendations for Future Study**

Over the years even though large number of studies have been undertaken in the region to understand the implications of textile industries on the surface and groundwater quality of the region, no systematic and scientific documentation of the data on water and effluent quality is available, even though they are existing mostly as unpublished reports. Hence a systematic continuous monitoring of water quality is needed for better management of water resources in this region.

Future water quality studies may include cluster analysis to substantiate the exchange processes between surface water bodies and groundwater. Moreover, it may opt for strong tracers like stable isotope analysis of contamination, flow modelling like MODFLOW, NETPATH etc. Further examination of extent of surface-ground water interaction in relation to reaction kinetics using large number of samples must be promoted for obtaining long term and futuristic assessment of contamination. Though there are a number of conventional CETPs in operation there is a great need to introduce the zero discharge technology and treatment systems like MBR in large numbers so as to minimize the harmful impacts of the textile effluents on water resources.

There is a need to understand the systematic variation in microbial diversity that comes with the accumulation of pollution load through monitoring. There is also a scope for the evolution of microbial species which will naturally treat the dye effluent i.e. dyes and dye residues. Thus, there is a need to quantify such microbes in water and sediments of river. In this study only chemical and microbial indicators were taken into account. However, such industrial effluents are bound to have impact on several other aquatic species including fish, through which metal can enter into food chain. Future, study should be focused on the bio-accumulation of toxic contaminants like heavy metals and its impact on human being. Only a holistic multidisciplinary intense continuous study at different industrial hubs will throw more light on the system level approach which is adopted with sustainable technology. This will lead to evolve a better policy to have a sustainable economic growth without affecting the environment as well as it helps the deteriorated environment to revive back to its pristine condition. A routine monitoring of the water bodies around the industrial area for regulatory purpose can be very effective in restricting release of untreated effluents and enforcing the strict water regulations.