5.0. SUMMARY

The present study suggests the need for periodic monitoring of physicochemical parameters of water and sediment samples of temple tanks as well as adoption of proper water quality management practices in order to protect the temple tanks of Kanyakumari district. The present investigation comprises of the following chapters.

Chapter I represent an introduction to the problem that was identified.

Chapter II deals with the methodology related to selection of sampling locations, sampling frequency and the analytical techniques employed to study the physicochemical and bacteriological parameters. The study area includes ten important temple tanks in Kanyakumari district. The selected temple tanks (sampling sites) were named as site 1 to site 10. The water and the sediment samples were collected from each sampling station once in a month for a period of two years (January 2009 to December 2010).

Chapter III deals with the results on monthly variation of physicochemical parameters such as temperature, pH, electrical conductivity, dissolved oxygen, biological oxygen demand, carbon dioxide, hardness, calcium, magnesium, bicarbonate, chloride, sodium, potassium, phosphate, nitrate, total dissolved solids, total suspended solids, iron, copper, zinc, manganese and lead. The bacteriological parameters such as total coliform and faecal coliform counts in the collected water samples were also analysed.
The water temperature recorded was maximum in May 2009 at site 9 and minimum in October 2010 at site 5. The pH value observed was high in May 2009 at site 1 and low in November 2010 at site 2. The increase in pH may be due to the reduced rate of photosynthetic activities which reduces the assimilation of carbon dioxide and bicarbonates, which are ultimately responsible for increase in pH. Electrical conductivity of water samples was high at site 6 in March 2010, while low content was observed at site 4 in April 2010. The recorded electrical conductivity was due to higher total dissolved solids and less water movement.

Dissolved oxygen content in the sampled water contained maximum value at site 4 (July 2009, January 2010 and December 2010) and at site 9 (October 2010). Minimum content of dissolved oxygen was observed at site 6 (August 2009). Low DO indicates higher organic input and stagnancy of water. The biological oxygen demand during this study was maximum at site 8 in May 2009. Site 3 (March 2009) and site 7 (May 2010) exhibited low content of biological oxygen demand throughout the study. Carbon dioxide content in the water samples was maximum at site 5 in May 2009. Site 1 (November 2009) had minimum content of carbon dioxide during the study period. Increase in carbon dioxide may be due to very low photosynthetic activity.

Site 6 had maximum amount of hardness (August 2010), calcium (January 2009), magnesium (November 2010) and bicarbonate (February 2010) in the water samples. The reason behind high value of hardness, calcium, magnesium and bicarbonate was due to large scale of human activities such as using detergents for washing. Abishekam with milk and turmeric was another reason
for the increase in hardness, calcium and magnesium. Minimum amount of hardness (June 2010) and calcium (September 2010) was noted at site 4. But site 5 showed minimum concentration of magnesium in November 2010 and site 7 had low concentration of bicarbonate in August 2009.

The chloride content was high and low at site 6 (October 2009) and site 7 (April 2009) respectively. Accumulation of polluting substances may be the reason for the increase in chloride content. Concentration of sodium in the water samples was high at site 6 during the study period 2009 (April), but it was minimum at site 5 during January 2010. Potassium concentration in the water samples was maximum at site 2 in July 2010. Its concentration was minimum at site 7 in February 2010. Increase in the concentration of potassium may be attributed to the leaching of potassium through rain water from the surrounded fields, which contains potash in the form of fertilizer.

The content of phosphate was found to be maximum at site 1 (February 2009), while minimum value was accounted at site 4 in January 2009 and at site 3 in January 2010. Run-off from agricultural fields was responsible for high phosphate content. Concentration of nitrate was maximum at site 1 in April 2009. Minimum value of nitrate was recorded at site 7 (July 2009), site 4 (August 2010) and site 5 (May 2010). Usage of nitrogenous fertilizers for nearby agriculture field is the reason for increase in nitrate concentration.

The total dissolved solids showed maximum value at site 6 in March 2010. Minimum concentration of total dissolved solids was found at site 4 in February 2010. Increase in total dissolved solids concentration was due to a lot of
holy rituals like Abishekam with milk and turmeric. In this study, site 7 showed low concentration of total suspended solids in the year 2009 (January and December). Site 8 contained higher concentration in June 2009. Degradation of organic matters through the presence of bacteria may be the reason for the increase in TSS content in water.

The cationic sequence of the temple tanks water samples was found to be $\text{Na}^+ > \text{K}^+ > \text{Ca}^{2+} > \text{Mg}^{2+}$ and the anionic sequence was found to be $\text{Cl}^- > \text{HCO}_3^- > \text{NO}_3^- > \text{PO}_4^{3-}$. Through the course of this study it has clearly become evident that Nagercoil Arulmigu Nagaraja temple tank water (site 6) was the highly polluted.

Iron content in the water samples was high at site 1 in 2010 (March). Minimum content of iron was at site 5 in January 2009. The content of copper in the water samples was maximum at site 7 in the year 2010 (July). But the minimum content was recorded at site 1 in May 2009. This high level of copper may be attributed to domestic sewage and run-off from extensive farmfields. The zinc content in the water samples was maximum at site 9 in April 2010 and minimum at site 10 in April 2009. High concentration of zinc in water is due to mixing of agricultural wastes from nearby fields. The concentration of manganese was maximum at site 5 in April 2010. Minimum concentration of manganese was reported at site 4 in May 2009. Lead concentration in the water samples was maximum at site 10 in August 2010. Minimum concentration of lead was shown by site 3 during December 2009. High concentration of lead resulted due to direct release of domestic waste containing lead from human activities and vehicular exhaust.
The order of abundance of heavy metals in the temple tanks water samples during the study period was iron > lead > copper > manganese > zinc.

Total coliform count in the water samples was high at site 1 in 2009 (November). Minimum count of total coliform was exhibited by site 9 in April 2009. Throughout the study, faecal coliform count was maximum at site 1 in November 2009. Its count was minimum at site 5 in March 2010 and at site 2, site 6 and site 7 in April 2010. Site 9 also showed minimum count of faecal coliform in April 2009. Higher bacterial population during monsoon months was obviously due to transport of organic matter from various sources through surface run-off from catchment area.

Statistical analysis was made among different parameters of the water samples. They exhibited positive correlation among some parameters and possessed negative correlation among some other parameters. Two way ANOVA study was also conducted between sampling sites and seasons. A few of them were statistically significant and some were insignificant.

Chapter IV deals with the results on monthly variation in physicochemical characteristics such as pH, electrical conductivity, organic carbon, sodium, potassium, phosphorus, iron, copper, zinc, manganese and lead contents in the sediment samples collected from all the ten temple tanks.

In the sediment samples, the pH value recorded maximum at site 1 (April 2009), at site 6 (August 2009), at site 8 (January 2010) and at site 10 (October 2009). Minimum amount of pH was shown by site 4 (April 2009). Electrical conductivity exhibited higher value at site 10 in February 2009. Site 4 had lower
value of electrical conductivity in June 2010. Higher level of conductivity reflects the pollution status. Organic carbon content recorded maximum at site 10 in March 2009. Site 4 showed minimum content of organic carbon in October 2010. Maximum value of organic carbon content at site 10 is attributed to the flourishing of phytoplankton and zooplankton leading to high organic productivity.

The sodium content in sediment samples had maximum value at site 10 (January 2009 and December 2009), while minimum concentration of sodium was observed at site 9 in June 2009. High value of sodium content in sediment sample may be due to the mineralization in the sediments. Concentration of potassium was high at site 6 in May 2010; while minimum concentration of potassium was exhibited by site 4 in September 2009. Increase in the concentration of potassium may be due to the leaching of potassium through rain water from the surrounding fields, which contains potash in the form of fertilizer. The amount of phosphorus exhibited maximum value at site 10 in September 2009. Minimum content of phosphorus was reported at site 3 during December 2009. Higher concentration of phosphorus may be due to mineralization and regeneration from the biological material in the sediments especially during anoxic condition.

Concentration of iron in the sediment samples was maximum at site 7 in the year 2009 (February). Site 1 exhibited minimum content of iron in June 2010. The relative lower values of iron may be attributed to its absorption of large amount of dissolved organic matter. Copper concentration was maximum at site 8
in April 2009 and at site 2 in May 2009. But the minimum content was shown by site 5 in the year 2009 (October). The reason for higher content was deposition of metals in the sediments which come out during heavy rainfall and flow into the water system. The zinc content in the sediment samples was maximum at site 1 in April 2010. But it was minimum at site 4 in December 2010. The lower concentration of zinc and manganese may be due to their mobilization from sediment to overlying water due to microbial activity. The concentration of manganese in sediment samples possessed maximum value at site 5 in April 2009 and minimum concentration of manganese was reported at site 8 in December 2010. Lead concentration showed maximum value at site 10 in August 2010. Minimum content of lead was observed at site 3 during October 2010. Lead in the soil sediments results mainly from the dry and wet deposition of atmospheric lead.

Statistical analysis showed positive correlation among some parameters and negative correlation among some other parameters of sediment samples. Two way ANOVA test was conducted between sampling sites and seasons during the study period. Some results were statistically significant and a few others were insignificant.
Conclusion

In the present study it was found that most of the physicochemical parameters of the temple tank water samples crossed the maximum permissible limit prescribed by WHO (1993). Besides, the parameters such as the total alkalinity, electrical conductivity, chloride, total dissolved solids, hardness, calcium and magnesium have higher value; which make the ponds very harmful for the use of human beings.

Based on the analysis during the two years study period (January 2009 to December 2010), among the ten temple tanks, the Nagercoil Arulmigu Nagaraja temple tank (site 6) and Vadasery Sri Kasi Viswanathar temple tank (site 10) were the most polluted.

In water sample analysis, most of the parameters were found to be maximum at site 6 throughout the study period. This was mainly due to continuous anthropogenic activities, festival inputs, climatic changes, addition of ground water to surface water and lack of attention paid towards sanitation and cleanliness of the tank. Different types of Abishekham with milk and turmeric have been frequently done in this temple. Another reason for this polluted nature was due to the smaller size of the temple tank and blockages in inlet and outlet.

Sediment parameters such as electrical conductivity, organic carbon, sodium, phosphorus and lead were maximum at site 10. This was also due to the anthropogenic activities such as washing and bathing. Another reason for this polluted state is that this temple tank is located adjacent to the bus stand; therefore dust particles and vehicular emission accumulated in this tank. A part of
this temple tank is covered with algae which decompose and increase the organic carbon content.
Recommendations

To reduce the extent of pollution in these temple tanks, the following suggestions are made as recommendations.

- Awareness must be created among everyone concerned to clear encroachment of temple premises.

- Inlets and outlets of the temple tanks should be checked frequently to avoid blockages.

- Instruction boards should be kept in appropriate places to direct the pilgrims to upkeep the temple tanks clean and unpolluted.

- Using of detergents for washing clothes should be avoided.

- Natural dirt removing plants should be grown inside the temple tanks.

- Artificial manure containing phosphorus should not be used for the paddy fields around the temple tanks.

- The temple tanks water should be changed frequently.

- Non-biodegradable objects should not be thrown into the temple tanks.

- Chemical disinfection methods like ozone treatment, addition of disinfectant should be adopted in the temple tanks.

The selected temple tanks are the most popular ones in Kanyakumari district. These temple tanks should be protected from various polluting agents. It
is recommended to follow the above said preventive and protective measures to retain the holiness of these tanks. It is expected that, this report will be a baseline and anovel initiative to develop qualitative methods to protect the holy places particularly temple tanks in our holy land, India.