CHAPTER 7

SUMMARY AND CONCLUSION

7.1 SUMMARY

Estuaries are important coastal ecosystems and play a significant role in the overall economy of coastal zone. It serves as a shelter for flora and fauna and in-turn helps to increase the biodiversity. The nature and distribution of the flora and fauna in an estuary is controlled by the fluctuations in the physico-chemical characteristics of water. The rapid urbanization and industrialization in the coastal zone are closely coupled for the adverse environmental impacts, which have compromised the ecological integrity of many estuaries such as Uppanar estuary located in Cuddalore, East Coast of India.

The present study is aimed at developing a two dimensional numerical hydrodynamic and advection dispersion modeling of Uppanar estuary using MIKE 21. The study area has an ancient port called Cuddalore port. This is an important minor port of Tamilnadu in the East coast of India, located on Gadilam river of Uppanar estuary. On the banks of the estuary State Industries Promotion Corporation of Tamilnadu (SIPCOT) is located. The disposal from the SIPCOT industries in estuary causes major environmental degradation of water quality in estuary and nearby coastal zone.

In order to address the above issue various literatures have been reviewed and formulated a methodology to arrive at the hydrodynamic and advection dispersion model using MIKE 21. The parameters considered for the numerical hydrodynamic model inputs are Bathymetry, Bed resistance, Wind
velocities and Hydrographic boundary conditions. Similar, components, initial concentration of the components, source and sinks, boundary concentration, deposition concentration and dispersion co-efficient are considered for advection dispersion model. The model is simulated for four different seasons namely Summer (April - May), South West (SW) monsoon (June - September), North East (NE) monsoon (October - December) and post monsoon (January - March) along with spring/neap high and low tide conditions. The simulation model results are validated with the 2011 observed water quality data in estuary and sea coast. The parameters considered for water quality are water quality parameters viz., pH, Temperature, Salinity, Dissolved Oxygen, Bio-Chemical Oxygen Demand, Nitrate (NO₂), Nitrite (NO₃), Ammonia (NH₃), Total Nitrogen (TN), Total phosphorus (TP) and Heavy metals (Zn, Cr, Cu, Pb and Ni).

Five sampling stations were selected to represent the estuary and coastal water quality. Samples were collected monthly between April 2004 and March 2005 during spring tide and neap tide periods at high and low tide condition. Also, the WQI is developed for Uppanar estuary to classify the quality in-terms of excellent, good, medium and poor. This WQI has been arrived for different seasons with extreme tidal condition.

The results obtained from the water quality analysis indicate that the pH values of stations in Gadilam river and Uppanar river are higher than other stations. The BOD in Uppanar river is always high compared to other locations. Also, the nitrate and nitrite values are relatively high during flood tide and low during ebb tide at all stations and seasons. The total phosphorus values are mostly high in sea south due to the marine outfall. The heavy metal analysis reveals that presence of Zn, Cr, Cu, Cd, and Pb are in high concentration during all the seasons. The results of present (2011) WQI analysis reveal that, the concentration level of various pollutants is in an increasing trend compared to 2004. The overall WQI of all locations fall under the medium class category.
The result of simulation model MIKE 21 indicates that the ocean currents are generally towards north from February - October and towards south from November – January. Pollutants from marine outfall are entering into the estuary during flood tide when ocean current is towards north. Pollution in sea north is mainly due to dispersion of pollutants from river mouth and marine outfall. The pollutants from marine outfall are not entering the estuary during November – January because of ocean current towards south.

7.2 CONCLUSIONS

The following are the conclusions deduced from the water quality analysis and simulation model:

1. In the present study, maximum pH of 9.4 was recorded in November 2004 at station 2 representing Uppanar estuary and a minimum pH of 7.6 was observed in June at station 3 representing river mouth. Higher pH concentration during November at station 2 could be due to the effluent discharge from the SIPCOT industrial complex.

2. A maximum of 34.9 °C and a minimum of 27.5 °C of surface water temperatures were recorded during summer and northeast monsoon respectively. The surface water temperature shows a seasonal pattern of monsoonal minimum and summer maximum.

3. Relatively high saline values from February to September with significant lowering of salinity during northeast monsoon were observed in the study area. Minimum salinity at the station in Uppanar River was recorded. Thus, salinity variations along this coastal region vary seasonally depending
upon mixing of high saline seawater, with the varying quantity of fresh water discharges from Uppanar and Gadilam rivers. Salinity shifts were observed clearly during the tidal periods which were mainly influenced by tidal action on monsoonal variation.

4. DO values in Uppanar River are less in contrast to other stations which indicate organic pollution in the river.

5. The BOD recorded in the study area clearly indicates that the Uppanar river is very much affected by the SIPCOT industrial effluent discharges. A Maximum concentration of 18.9 mg/l of BOD was recorded at Uppanar river during August 2004. High values of BOD are indicative of excessive organic matter contained in the raw domestic and industrial effluents. Maximum concentrations during this period could be due to runoff influenced by the northeast monsoon 2004.

6. Higher concentration of nitrate could be due to runoff from the nearby areas by conventional rainfall during that period. Minimum concentration of nitrate was registered during southwest monsoon 2004 (1.7 µmol/l) at station 5 which could be attributed to the utilization of nitrate by phytoplankton. Low concentrations could also be due to dilution with the open sea water a few kilometres offshore.

7. The ammonia concentration changes with respect to the tide. Since there is no difference in ammonia concentration between the spring high and neap high tide and for the same to spring low and neap low tide. During high tide the concentration was low. But as the tide recedes the
concentration increases and reaches the peak during low tide. This obviously demonstrated the dilution effect by the tide.

8. Maximum concentration of Total Nitrogen (60.5 µmol/l) at station 3 was observed during the study period. High value observed at estuary mouth might have been due to terrestrial runoff from domestic and industrial effluents influenced by conventional rainfall at summer 2004. Minimum concentration of total nitrogen (13.2 µmol/l) was observed at station 5 in May 2004. Low value of total nitrogen could be due to the utilization of inorganic nitrogen species by phytoplankton for photosynthetic activity. Low concentrations could also be due to dilution with the open sea water a few kilometres offshore.

9. In river stations the metal concentration has been always higher in Uppanar River because of the influence of SIPCOT industrial complex located on the bank of the river. The behaviour of heavy metals in the aquatic environment is strongly influenced by adsorption to organic and inorganic particles (Wen et al 2007). Compared to other seasons, the concentrations of all heavy metals in all stations are less during post monsoon season. This is due to December 2004 tsunami wave. The pollutants might have been transported to shore line or deep sea by tsunami waves.

10. In Water quality index it is inferred that the WQI of Uppanar River comes under poor class and Gadilam River is classified as medium class. The WQI of Uppanar estuary for all months is less than 50. During the spring high tide, WQI of Gadilam
river varied from 52 to 63 and for spring low tide condition, it ranged from 54 to 62.

11. It can be inferred that, the WQI of five different locations with respect to SH and NL always fall under the medium class (i.e. 50% to 70%).

12. The 2004 WQI was compared with 2011 WQI for Gadilam River, Uppanar River and River mouth. It is inferred that the pollution level increased considerably in the rivers and estuary. The pollution level shows an increasing trend (in all location WQI is classified as medium/poor class). This might be due to the increase in industrialization over the period.

13. The hydrodynamics of the estuary was analysed for four scenarios like spring high tide, spring low tide, neap high tide and neap low tide. In the model, the maximum and minimum depth of water in the model area was observed as 15.28 m and 0.4 m respectively. The surface elevation of the model for all the scenarios varied from 0.12 m to 1.2 m and the velocity varied from 0.55 m/s to 1.4 m/s. The velocity (V) is higher than the velocity (U) and the difference was around 0.32 m/s. The flux observed from the model varied from 0.525 to 2.4 m$^3$/s/m.

14. From the AD model it is observed that, the heavy metals like Zinc, Copper, Arsenic and Chromium have high concentration in all the seasons, namely, summer, southwest, and northeast and post monsoon. The variations of Zn, Cu and Cr ranged from 0.01 to 1.5mg/l respectively.
15. Ocean current in the model is towards north during February to October and it is towards south during the months of November, December and January. During most of the months, due to the ocean current the pollutants from the marine outfall moved towards mouth of estuary and northern side of marine outfall. This might be due to the location of the marine outfall which is located south of river mouth.

16. It is concluded that the Uppanar estuary river system is under critical stage (medium class/poor class), and if the same trend continues for a longer duration, the migration of flora and fauna will takes place, affecting the Uppanar eco system. It is suggested that a suitable alternate location for the marine outfall could reduce the movement of pollutant towards the estuary.

7.3 **SCOPE FOR FUTURE STUDIES**

This research has established the foundation for estimating the water quality index and simulation of the hydrodynamic and advection dispersion characteristics. Identifying the optimal location of marine outfall and its impact on the coastal ecosystem may be studied.