Chapter - VII

SUMMARY AND CONCLUSION

7.1 BACKGROUND

River water pollution from both point and non-point sources based on population, livestock, agricultural inputs etc., was evaluated in the basin in order to assess the river water quality of the river system. In addition, river water samples at different locations were collected and analysed to monitor the present status of source pollution indicative parameters. Of all the planet's renewable resources, water has a unique place. It is essential for sustaining all forms of life, food production, economic development, and for general well being. It is impossible to substitute for most of its uses, difficult to de-pollute, expensive to transport, and it is truly a unique gift to mankind from nature. Water is also one of the most manageable of the natural resources as it is capable of diversion, transport, storage, and recycling. All these properties impart to water its great utility for human beings. The surface water and groundwater resources of the country play a major role in agriculture, hydropower generation, livestock production, industrial activities, forestry, fisheries, navigation, recreational activities, etc. A systematic study has been carried out to monitor assessment and quantify the spatial and temporal variations of physiochemical parameters, pathogen indicator microorganisms and organochlorine pesticide residues in both water and sediment of the Tamiraparani river basin. In the present study, a multidisciplinary approach towards the understanding of various processes (natural and anthropogenic) that control the environmental biogeochemistry and microbiology of the river basin has been attempted.

7.2 APPROACHES TO MONITORING

These goals are determination of natural freshwater qualities in the absence of significant direct human impact, determination of long term trends in the levels of critical water quality indicators in freshwater resources and determination of the fluxes of organic matter, nutrients, toxic chemicals, pathogenic microbes and other pollutants from river basins to the seawater/coastal water interfaces. To meet the objectives and goals, highly selective network of strategically located monitoring stations is created. The samples were collected from 21 locations on mainstreams and coastal region of the Tamiraparani river and their tributaries. Water samples are being analysed for 30 parameters consisting of physicochemical parameters, pathogen indicator organisms and OCPs for water samples apart from the field observations. Besides this, 17 pesticides (HCH and its isomers, HCB, heptachlor, aldrin, trans-Chlordane, o,p´-DDE, cis-Chlordane, dieldrin, p,p´-DDE, o,p´-DDD, endrin, o,p´-DDT, p,p´-DDT, p,p´-DDD and mirex were analysed in twelve selected samples. The enumeration of pathogen indicator organisms was carried out on all the sampling locations once in two month period. In view of limited resources, limited numbers of organic pollution related parameters are chosen for frequent monitoring i.e. monthly and quarterly and major cations, anions, other inorganic ions and micro pollutants (POP's) are analysed short term period of a year to keep a track of water quality over small period of time. The procedures and methods have been followed APHA (2001); Ramesh and Anbu (1996); Veeraiah and Durga Prasad (1996) and USEPA Method 3630C (1996) for the analyses of water quality and pesticides. On the basis of media manufacturers guide and on the knowledge of innumerable previous analyses, typical colony morphology characteristics of different bacterial groups were recognized and initial enumeration of pollution indicator and pathogenic bacteria was completed. Typical colony characteristics of each group are listed below: McConkey Agar: all colonies grown on the medium counted as total coliforms. Typical, pink 2–3 mm dia colonies counted as *Escherichia coli* like organisms. All colonies on M Enterococcus agar counted as

S*treptococci*. Those typically pink enumerated as *Streptococcus faecalis* like organisms. XLD Agar: reddish, small, round, convex colonies with black centers counted as *Salmonella spp.* (SA) and reddish, small colonies without black centers as *Shigella spp*. Cetrimide Agar: green colonies on Cetrimide Agar counted as *Pseudomonas aeruginosa* (Mohandass et al 2000; Nagvenkar and Ramaiah 2009).

7.3 SIGNIFICANT RESULTS

7.3.1 Chemical composition of the Tamiraparani river

- The surface water of the Tamiraparani river is alkaline in nature. However, in the upstream region due to the presence of humic substances and high organic content the river water acidic in nature (pH 6.3).
- Seasonal variations in the total dissolved solids shows that the average TDS is higher during post-monsoon (1178.6 mg l^{-1}) and lower during summer (60 mg l^{-1}).
- The river water is predominantly controlled by rock water interactions and weathering process. About 1.7% of silicate and 27% of carbonate weathering contributes to the HCO_3 concentration in the river basin.
- The average silica concentration (5.4 mg l^{-1}) is lower than Indian rivers (7.0 mg l^{-1}).The temperature, lithology and precipitation control the silicate weathering in the river basin.
- The dominant anions and cations in the river water is in the order of HCO_3 > SO_4 > Cl > Na > K > Ca > H_4SiO_4 > Mg, respectively.
- The concentration of nutrients (N and P) in the river water is higher during summer and lower during post-monsoon season indicating that municipal untreated sewage directly mixing, agricultural and also damming activities to the river.
- The higher concentration of NO_2-N (47.1µg l^{-1}) in the upstream region is due to the higher rates of nitrification in the forest ecosystem.

- During the post-monsoon season the damming effect reduces the considerably the nitrite (0.02 µg l^{-1}) concentration in the upstream whereas additional input from anthropogenic/agricultural sources NO_2-N (3.25 µg l^{-1}) causes higher concentration in the downstream.

7.3.2 Impact of pesticides on water and sediments

- In the river water and sediments ΣOCPs residues ranged between 2.5 to 79.9 ng l^{-1} and 1534.4 to 3839.7 ng g^{-1} –dw, respectively. The results, further, suggested that source of DDT contamination is from the aged and weathered agricultural soils with signature of recently used DDT in the catchments.
- The average dieldrin concentration (6.3 ng g^{-1}) in the river is higher than other OCPs in the water samples indicating the impact of extensive agricultural practices in areas near the river basin.
- Although, during the study period different spatial and temporal trend could be observed the river comportment, however, the overall seasonal average of ΣOCPs residues (across the sites) in water and sediments were higher during the monsoon and summer seasons respectively. In the river water, individual pesticide highest concentration was observed at Papanasam (58.0 ng l^{-1}); however in case of the sediments, it was at Athoor (1693 µg g^{-1}).
- In river water, aldrin and dieldrin ranged from BDL - 1.5µg l^{-1} and and BDL - 7.5 µg l^{-1} and sediments ranged from BDL - 562.4 µg g^{-1} and BDL -1693 µg g^{-1}, respectively.
- The average composition of DDT isomers measured in the sediment samples in four sampling seasons are o,p′-DDE: 32.7%, o,p′-DDD: 19.3%, p,p′-DDD: 19.3%, p,p′-DDE: 17.2%, p,p′-DDT: 7.13%, o,p′-DDT: 4.23% with dominance of p,p′DDE. The dominance of the parent compound over their degradation products (metabolites) in the sediments suggests for the previous use of DDT along with degradation of DDT used earlier.

- Other OCPs was detected in most of the water and sediments samples from Tamiraparani river basin (including endrin, cis-Chloridane, trans-Chloridane, aldrin, diedrin, endrin, heptachlor and mirex) indicates present usage in large amount for agricultural purposes.

7.3.3 Pathogen indicator organisms counts

- Total viable counts (TVC) in water samples were the highest during month of November and the least during March for both water and sediment. In water, the mean TVC ranged from 1.1-14.2 [$\times 10^4$] m l^{-1} during November and 3.5-85.0 [$\times 10^3$] m l^{-1} during March. In sediments, the mean TVC ranged from 2.4- 94.0 [$\times 10^4$] m l^{-1} during November and 0.83-61.0 [$\times 10^4$] m l^{-1} during March. Variations in total viable counts (TVC) were large in both month and stretch wise. In water, the overall TVC were more during November 9.7-14.2 [$\times 10^4$] m l^{-1}, and were lower in middle 2.3-12.7 [$\times 10^4$] m l^{-1} and upper (1.1– 13.9 [$\times 10^4$] m l^{-1}).
- Commonly, the total coliform count was relatively higher in November month than other months**,** except Kuttralam (S6) and Tenkasi (S7). Lower counts of total coliforms were obtained during March and July months. In downstream region, high values of TC were obtained during November month mainly in Eral (S17), Athoor (S18) and Punnakayal (S21). Because S16, S17 are populated area and S19 is a fishing harbor. So these contribute high level of pollution in lower stretch. Similar, midstream region, higher counts obtained in Tirunelveli (S13), Srivaikundam (S15) and Alwarthirunagari (S16). These are holy and dense populated area. Whereas, in upper region, high values were counted in Kuttralam (S6) and Tenkasi (S7) in the month of July, predicts more tourist intake dense populated places which got higher values in throughout year.
- However, in upper stretch TC, TS and VLO counts were highest in November as compared to other months. Especially S6 and S7 are major sites in upper

region which contributes very high load of TC, TS and VLO in July months followed by November, May, September, January and March. During July, other sites of upper region does not observed high amount of bacterial load.

- The values for TS were also found higher in the rainy season, which were similar to the findings of TC. On the other hand, in the upper region counts for TS were low in most the months. In the middle and lower regions, higher values were obtained especially S13, S14, S15, 16, S19 and S20. Interestingly, TS count was nil in some sites of upper region Karaiyar (S1), Servalar (S2) and Manimuthar (S5) in March, July and January.
- The Vibrio like organisms (VLO) of lower stretch was higher in most of the months especially Sangam (S21) and Punnakayal (S22), compared to November the VLO was higher in May. Similar to TS, the VLO range was nil in some sites of upstream region such as S1, S2, S3, S4, S5, S8 and S9 during March, July and January. In the midstream region sites such as Tirunelveli (S13), Srivaikundam (S15) and Alwarthirunagari (S16) giving to increase the surveillance of VLO.
- In water sample, among the pollution indicator bacterial groups, such as TC, TS and VLO counts were the highest during 0.3–16.6 [$\times10^3$] m l^{-1}, 0.4–14.0 [$\times10^2$] m l^{-1} and 0–13.0 [$\times10^2$] m l^{-1} in November and the least during 0.5 – 88.0[$\times10^2$] m l^{-1}, 0–7.6[$\times10^2$] m l^{-1} and 0–7.8 [$\times10^2$] m l^{-1} in March, respectively.
- In the sediment samples, there were large variations in the abundance of different pathogenic bacterial types were evident in sediment samples. In November, counts of EC, SA, SF and PA were in the range of 200–19000 m l^{-1}, 0 -1800 m l^{-1}, 0 – 1100 m l^{-1} and 0 – 500 m l^{-1} respectively. But, VC was high during May (0 – 5300 m l^{-1}).

7.4 RECOMMENDATIONS FOR PATHOGENIC INDICATOR ORGANISMS

Tamil Nadu accounts for 4 % of the land area and 6 % of the population, but only 3 % of the water resources of the country. Most of Tamil Nadu is located in the rain shadow region of the Western Ghats and hence receives limited rainfall from the south-west monsoon (TNDR 2005). From a conservation perspective essentially, it is the management of land, river and the environment as one ecological unit. Land, forest and water within a river basin are intricately linked. Thus, environmental management is a link between land and the river where it emphasizes ecosystem approaches. Industries cannot be set up within 1 km of a river or water body. However, the effluents often flow through nallahs or open drains and reach the rivers, lakes, etc. Since the river water is used downstream for irrigation or drinking by people/livestock, contamination of the river has increasingly become a serious problem in many of the river basins of the State. River basins like Palar, Tamiraparani, Cauvery, Noyyal, Bhavani and Amaravathy face serious pollution problems due to industrial effluents. Sewage and sullage from municipalities and settlements has also increased tremendously due to piped water supply and is contaminating rivers, lakes, tanks, and ground water (TNDR 2005).

Municipal waste management: Numerous conservation strategies may be taken to minimize waste inputs into the Tamiraparani river basin. Domestic effluents cause as much as 90% of the pollution of river water. The remaining 10% is due to industrial discharge. The presence of hazardous substance and disease bearing bacteria in domestic wastewater underlines the urgent need for treatment before discharge into rivers. The 1974 Water (prevention and control of pollution) act prohibits or restricts the release of industrial effluents in streams, wells, and on land. The water safety plan described in the WHO Guidelines for drinking water quality (WHO 2008) provides a common framework for applying risk management techniques in the water industry. The procedure has three main components:

- System assessment to determine whether the drinking water supply chain as a whole (up to the point of consumption) can deliver water of a quality that meets identified targets. It includes assessment of design criteria for new systems.
- Identification of control measures in a drinking water system that will collectively control identified risks and ensure that the health based targets are met. For each control measure identified, an appropriate means of process control 83 monitoring should be defined, to ensure that any deviation from required performance is rapidly detected.
- Management plans describing actions to be taken during normal operation or incident conditions, and documenting the system assessment (including upgrade and improvement), monitoring and communication plans, and supporting programmes.

This common framework quantifies hazards or risks within the whole treatment process, and identifies important monitoring and remedial actions at designated hazard control points. Thus, in the Tamiraparani river basin, pollution loads of the river can be mitigated through the following management practices:

- Improved agricultural management
- Improved treatment of municipal waste water
- Pollution abatement and prevention in industry
- Improved river management

It is evident that a balance between industrial, agricultural and domestic use coupled with environmental sustainability are critical aspects for such a perennial and extensively used river basin like the Tamiraparani. There is an urgent need for research into the feasibility and practical applications of monitoring water quality in natural watercourses by means of microbiological determinations.

Environmental impact assessment is an effective management tool which needs to be executed by recognizing project proponents with good environmental practices; strengthening institutional networking for proper implementation of EIA, emphasizing on information dissemination, education, communication, and training activities, and enforcing the EIA requirements strictly. The EIA process, by and large, has remained very subjective. There should be an increased stress on the development and incorporation of objective and quantitative techniques in EIA which would contribute to the decision- making process. Screening and scoping, the most important parts of EIA, need to be certainly and effectively carried out to identify the environmental parameters that will be affected by development projects, and initiate dialogues with affected people for appraising the positive and negative features of the projects for effective public participation. It would facilitate to minimize future conflicts. The EIA process could be simplified by improving the systems and procedures for processing documents, defining the appropriate methodology, introducing the component such as risk assessment, developing guidelines for various stages, it's providing guidelines for environmentally- critical areas, and strengthening the coordination among central and state agencies, regional offices, and local governments in the implementation of EIA.

7.5 CONCLUSION

The river basin is one of the most important perennial river basins in Tamil Nadu, South India. The conversion of forests to agricultural land has had an impact on the biogeochemical cycles of C, N and P. In this study focuses on nutrient biogeochemistry; irrigational quality; Pathogenic bacterial loads; OCPs and its transport characteristics within the river and its flux to the Bay of Bengal. Spatial and seasonal variations of dissolved major ions and inorganic nutrients (Ca^{2+}, Mg^{2+}, Na^{+},

K^+, SO_4^{2-}, NO_2^-, PO_4-P, TDP and H_4SiO_4) were measured from the samples collected from the entire basin, for premonsoon, monsoon, postmonsoon and summer seasons. Distinct seasonal variability in nutrients especially N and P was obvious. In general, the nutrient concentrations were high in the upstream region but distinct changes were observed four different seasons. The very high nutrient levels observed in the headwaters during wet season rapidly decreases with increasing river order. In the mid-stream, the effect of dam plays a vital role in the temporary storage of nutrients during dry season. However, when discharge is high during monsoon, the effect of floodwater is felt far below, giving rise to very small spatial changes in nutrient levels in the downstream region. Thus, a clear stratification in nutrient content between the upstream and downstream reaches has been observed and is represented as: forest watershed (upstream), agricultural inputs (downstream) damming (midstream). It is also clear that in the downstream region, excessive runoff from agricultural areas has significantly elevated N and P content at the point of confluence with the Bay of Bengal.

The most dominant river basin change in land use in this river basin has been the clearing for forests for agriculture. Because of this, non-point sources of pollution (viz., agricultural runoff) have increased considerably over the recent past. Intensive agricultural practices in this basin have led to the additional input of fertilizers which again is a significant N and P source to the river basin. The vast differences in spatial distribution of nutrients through the course of the river is due to the confluence of several tributaries, channels and canals entering the main river at different points. In addition, the presence of large dams across the river plays a vital role in trapping the nutrients particularly during summer. Hence, we have observed a non-linear distribution of nutrients and other elements through the entire course of the river. Our results show that agricultural activities have caused a two-fold increase in nutrient level in the surface water during dry season, in comparison to the wet season. In the upstream region, the natural forest ecosystem enhances storage of N while the presence of reservoirs reduces nutrient concentration in the midstream significantly.

In the study, the presence of OCPs in both water and sediments indicate previous usages for agriculture, pest control and household activities of pesticides in the river basin. Dieldrin and DDTs are the dominant OCPs present in water and sediment samples and it reflects the previous and recent uses for agriculture. Higher concentration of DDT metabolites in the study area indicates earlier as well as continuous use of DDT in the catchments. The parent DDTs depict that OCPs contamination was mainly from the aged and weathered agricultural soils, and was retained under anaerobic conditions in the sediment. The hydrological characteristic of the river basin, such as seasonal variation of flow and damming activities, can influence the spatial and temporal distribution of OCPs in water and sediments. Assessment of the freshwater contamination using the MRL of the FAO/WHO permissible limits for water quality criteria reflects that water is contaminated with OCPs and toxic effects may occur to the biota in the river. The results indicate that there is an existence of certain potential health hazards for drinking water consumers and organisms in the river water and further work is needed to assess the bioaccumulation of POPs in the food web and associated risks to the ecosystems and human health.

The assessment of pathogen indicators of the river system with respect to bacteriological pollution is of immense significance for improving living standard and quality of life in this region. Monitoring of microbial contamination in the runoff of river should be an essential component of the protection strategy in river area. Our studies on microbial ecology in the runoff of the Tamiraparani in relation to pollution have clearly revealed that there is significant presence of bacterial indicators of faecal pollution, safeguarding the ecosystem from adding undesirable microbial population calls for evolving appropriate policies and regulations. The base line data generated on bacteriological water quality of runoff of the river may serve as biomonitoring standard and comparisons for other rivers and may be useful for all scientists, decision makers and resource managers working with environmental planning and management of such areas. Therefore, monitoring of microbial contamination on periodic basis should be an important component of the protection strategy in this area. Every effort leading to reduction in pollution indicating bacteria and microbes of human health concern has to be promoted and implemented. Based on the results obtained in this study, there is a clear need to improve the water quality of this river. Thus, a balance between industrial, agricultural and domestic use coupled with environmental sustainability is a critical aspect for such perennial and extensively used river basin.