SUMMARY

River resource in Kerala are under a continuous threat of pollution because of the insufficient levels of sewage treatment and diffuse contamination from agriculture and industrial effluents. Rivers all over the world have suffered since more than 100 years from anthropogenic pollution, mainly untreated wastewater or effluents. The lack of good quality water hinders economic development and the potential for long term sustainability. One of the most harmful effects of human activities on surface waters is nutrient pollution, caused mainly by nitrogen (N) and phosphorus (P), with several undesirable effects, most of which are related to the increased growth of phytoplankton and other aquatic plants. This leads to a shift in the biological structure, and in severe cases even to oxygen depletion, production of toxins, and the collapse of entire aquatic ecosystems. However, in spite of its importance, not many studies have been done on the Chalakudy river on transport of nutrients and organic material to the estuary. Therefore, both scientific interest and environmental concerns dictated the need to investigate distribution, movement and deposition of nutrients mobilized and transported within the river and its estuary. Chalakudy riverine ecosystem is undergoing anthropogenic stress from large increases in population and urbanization. In many regions, changes in freshwater and material inputs to the rivers are altering the biogeochemical capacities of ecosystems. Here is considered the nature and relative importance of riverine inputs of nitrogen and phosphorus.

The qualitative and quantitative determination of nutrients (i.e. concentrations and loads) in Chalakudy river characterised and predicted...
the system responses and as a consequence, accurate estimates of nutrient levels were obtained. An effort was made to identify the main factors that can potentially control the terrestrial landscape contribution towards nutrients. Riparian vegetation are undoubtedly one of the most important parameter related to varying riverine nutrients defining the aquatic ecosystem as well as acting as the boundary between aquatic and terrestrial ecosystems. The moist and often wet soils and high water tables associated with riparian areas make them one of the most important and diverse parts of a river ecosystem. These systems vary considerably in their size, vegetation, species abundance, and diversity in the Chalakudy riverine ecosystem. Nutrient loading during the study appeared to be substantially impacted by rainfall, as ambient concentrations of all measured nutrients increased following significant rain events. A period of profound environmental change occurred in the river regions during the transition from monsoon to nonmonsoon. Changes in various species had been noted in association with seasonal variations in the waterway, especially following enhanced river runoff during the monsoon. Nutrient inputs showed a strong temporal variation linked to heavy precipitation events. A detailed analysis of the variation among hydrochemical parameters revealed significant relation with various nitrogen and phosphorus species in the dissolved, particulate and sedimented stages. The specificity of the river water included intensive chemical interaction of water and sediment, significant influences of rainfall and surface run-off, highly wind-dependent turbulence and turbidity of the waterbody, high particulate nitrogen concentrations and uneven distribution of particulate nitrogen and phosphorus within the waterbody. Thus, a higher number of important variables as well as of chaotic events make it practically more difficult to
follow the seasonally dependent course of N and P concentrations and the studies were a helpful completion of the standard geochemical mapping in order to characterize the river. Sediment, under certain conditions, acts as a source or becomes the sink in the exchange of nitrogen and phosphorus between overlying water and suspended particles. The analyses carried out have indicated that the annual survey give a very important information on the latent factors influencing the quality of Chalakudy river and reveal a specific information concerning the river water quality.

The growing concern about agricultural and other anthropogenic nutrients entering water bodies and causing deterioration in water quality, has however resulted in the need for nutrient transport models. An integrated GIS water quality modeling was performed and was found to be the most suitable. The model assisted the collation and interpretation of information, upon which decisions can be made for the management of water resources. Nutrient transport within a watershed depends almost entirely upon hydrology. Nutrient modelling has been much successful.

The river water is characterized by high concentrations of chlorophyll $a$. During seaward transport, the phytoplankton appeared from the river water concomitantly with the elements of N and P, indicating that an increased retention of these elements leads to increase in primary productivity. Although a linear rise of nutrient loads with increasing river flow was measured in some cases, this does not give a clear indication as to whether the inflowing freshwater is the ultimate source of particulate nutrients to the estuary since estuarine concentrations were lower. Increase in salinity actually decreased the dissolved nutrient loads. The concentrations of N species did reveal a clear trend and it could be realized that monsoon
concentrations were slightly higher. The likely effects on peak ammonia and nitrate at certain locations are especially of interest because of the effects of nitrogen on the biological diversity of streams. Soluble ammonia and nitrate increased in the mid reaches of the river because of local input and because of mineralization. Pronounced differences were present with regard to the concentrations of NH₃, NO₂⁻ and NO₃⁻ and urea. The concentrations exhibited a decreasing trend after the end of the wet season. The nitrate was the major contributor of total-N in all the regions. The percentage of nitrate-N was found to be between 62% and 87% in all stations, except the estuarine region which decreased this to 55 to 57% during monsoon. The percentage composition of nitrite during both monsoon and nonmonsoon seasons amounted to only ≤ 3%, pointing to water column nitrate and ammonia regeneration and uptake, N sinks (i.e. denitrification), and water column versus benthic N cycling, as marked factors related to water quality. The ferry station presented very high concentrations of all N species, substantiating the introduction of more inorganic as well as organic components mainly of anthropogenic origin through fertilizer utilization and factory effluents into the vicinity of this station. Phosphate was high in midstream during monsoon, whereas the concentration increased towards estuary in nonmonsoon. High concentrations of total and soluble reactive phosphorus were measured during the period of rising water in all sites, which displayed only mild consistent differences. Compared to nitrate, phosphorus was less variable over time and less divergent between sites. The percentage composition of this dissolved inorganic phosphorus was very high and ringed around 95% of total phosphate as compared to residual phosphorus, which is mainly organic form. The seasonal N:P ratios of dissolved phase were very high.
for riverine stations, whereas the ratio remained low for estuarine stations owing to chemo-estuarine fluctuations.

In the Chalakudy riverine system, the suspended solid is found to be a phase affected by processes such as denitrification and mineralization of organic matter. The degradation process occurs within the uppermost and lowermost water layers, where bioturbation, advection and diffusion cause rapid exchange of solutes and particles with the overlying water. Particulate nitrogen and phosphorus nutrient profiles provide hints on the intensity of mineralization and decomposition pathways along the river. Results indicated that nitrite-N was very low in percent (2 to 4%) and nitrate-N was the predominant form which ranged in composition from 50% to 68%. The total inorganic P was appreciable owing to comparatively high percentage of Fe/Al bound P, polyphosphates and Ca bound P even though, the other P fractions were low. The N:P ratios of suspended impurities ranged from 1.8 to 6.6 during both seasons and these low ratios was attributed to the increase of particulate P relative to N. The estuarine particulate matter was found to be richer in Ca bound P.

The results primarily indicate the monsoonal build-up of the nutrient loads in the sedimentary environment of this tropical fluvial system. Nitrate-N is the predominant form of total nitrogen and accounts about 50%–74%. Residual-N which denotes mainly the organic-N (excluding urea-N) preserved as organic reserve, is considerable and occupies 6%–30% of total nitrogen and it has a massive role in the riverine productivity. The sediments show a broad variability in N content and in the distribution of its different oxidation forms, which has a direct relation with processes controlling geochemistry in a system contributed by both natural and
anthropogenic inputs. Values of various species of phosphorus showed an oscillating trend with no distinct seasonal variation. But it could be seen that stations 7 and 8 having mixing with seawater are specific in their low composition of loosely bound P, and the very high percentage of Ca bound P, polyphosphates and Fe/Al bound P. Residual-P is the predominant form among the various P fractions quantified and it accounts for more than 30% of total phosphorus. Fe/Al bound P and polyphosphates also contribute appreciably towards total phosphorus. Comparatively low values of N:P ratios signifies the benthic enrichment of P nutrient in relation to N, and also the variability in the dynamicity of their recycling processes.

The relationships among N components in all the three phases showed that these originated from the same source. Nutrient concentrations were similar in reservoir and midstream sites during the rainy season when interchange between the mainstem and land was greatest, and the concentrations diverged during the period of falling water level. Nitrogen and phosphorus fractions were markedly lower in the waterfalls, during the period of high as well as low water levels. The study showed that nitrogen is mainly present as nitrate in all the three phases. Total nitrogen concentrations were very high at all sites except waterfalls. Sediment phosphorus concentrations were also lower during high/low water levels at both reservoir and midstream sites. In the mainstem as well as estuary, higher values were observed at the beginning of the rainy season. Dissolved organic nitrogen represented 10%, and particulate and sedimentary organic nitrogen upto 30%. Almost half of the phosphate is particulate phosphate, the largest part of which is calcium bound phosphate. The concentration of nutrients at all
stations sank rapidly to a minimum in the waterfalls. Thus, the course of the measured N and P concentrations were mainly characterized.

Options to reduce pollution due to nutrients included reducing nitrogen and phosphorus fertilizers by reducing application rates, and recreating vegetation along the river banks to enhance natural denitrification processes and also to reduce detritus entering the riverine system. Integrating climate change and land use change is particularly challenging because of numerous process interactions and different effects of all the driving variables. It can be said that the quality of receiving waters with respect to nutrients in the river examined is a function of different sources of nutrients and the amount of riverine constituents as well as the morphology of each area and the circulation of waters. It can also be concluded that all stations of Chalakudy river are polluted with various nitrogen and phosphorus components of anthropogenic origin. Generally analyses suggested that the nutrient limitation patterns of the river are spatially and seasonally variable, and demonstrate the importance of not only N, but also P, as the main agent for the biogeochemical processes. The findings of this study reinforce the concept that management of point and non-point sources should be integrated as the combination of both sources connected with land use results in deleterious effects on water quality. The enrichment of nutrients in the samples clearly suggested that these can affect significantly the trophic status of the Chalakudy river. It is emphasized that river quality monitoring is a helpful tool not only to evaluate the impacts of pollution sources but also to ensure an efficient management of riverine resources and the protection of aquatic life as well as humanity.

**********