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'International Conference on Biogeochemistry of Estuaries - Mangroves and the Coastal Zone Management'

Book of Abstracts

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ENVIS Centre in Biogeochemistry

NEWSLETTER

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EDITORIAL

Coastal ecosystem includes a large variety of wetland habitats, including estuaries, mangroves and coastal waters and lagoons in tropical and subtropical regions. The coastal biogeochemistry has strong process and modeling links with the river, ground water and hydrodynamics components. It provides outputs to the ecology component through the understanding of the dynamics of the autotrophic – heterotrophic balance in the system domains and how it responds to river derived fluxes. Study of biogeochemical processes in estuaries-mangroves is of particular significance in understanding the role of marginal filter in global cycles of carbon and many other nutrients. Hence this conference aims at getting insight to understand the coastal biogeochemical aspects.

This International conference is sponsored by DOD and partially by ENVIS Centre, INCOH and other agencies. This conference has attracted ate attention the attention of various researchers working in this area from all over the India and abroad. The organizations participating in this conference includes: AIMS, Australian, University of France, France, Khulana University Bangladesh, JICA, Japan, Institute of Fundamental Sciences-RRCK-University of Ruhuna all from Sri Lanka , Kenyata University, Kenya from abroad and NIO, Anna University, CGWA, CGWB, Annamalai University, Madras University, Jadavpur University, IIT Mumbai, IIT Delhi, University of Mumbai, Orissa State Wild Life Dept. Gujarat Ecology Commission, CEREM, JNU, DCE, NGRI, DST, MOEn and F, University of Kerala and RRL and other organization from India.

The papers will cover the wide aspects of the coastal ecosystem including estuaries, mangroves, coastal waters and the interaction of coastal aquifers. The authors will discuss the various case studies to give the audience better understanding of the recent advances in the coastal biogeochemical processes.

So the conference will have the benefit of experienced national and international delegates who will certainly bring with them their several decade experiences in this coastal biogeochemical field and related activities. This will surely give a wide opportunity for the young scientists who will be benefited from this two day deliberations. The full volume of the paper will be brought in due course. I hope the conference will be useful for those who are working in the aquatic ecosystems and coastal environments.

AL. Ramanathan

SES, JNU

Organiser and Guest Editor

Funding from the following Agencies has supported holding of this Workshop

1. Department of Ocean Development, Govt. of India, New Delhi

2. ENVIS Centre, SES, JNU

3. INCOH, Roorkee

List of Contents

Present status and future of the world's mangrove forests

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This paper summarises an assessment of the present status and future of mangrove forests to the year 2025.Mangroves, the only woody halophytes living at the confluence of land and sea, have been heavily used traditionally for food, timber, fuel and medicine, and presently occupy about 181,000 km^2 of tropical and subtropical coastline. Over the past 50 yrs, approximately one-third of the world's mangrove forests have been lost, but most data show very variable loss rates and there is considerable margin of error in most estimates. Mangroves are a valuable ecological and economic resource, being important nursery grounds for birds, fish, crustaceans, shellfish, reptiles and mammals; a renewable resource of wood; accumulation sites for sediment, contaminants, carbon and nutrients; and offer protection against coastal erosion. The destruction of mangroves is positively related to human population density. Major reasons for destruction are urban development, aquaculture, mining and overexploitation for timber, fish, crustaceans and shellfish. Over the next 25 years, unrestricted clear felling, aquaculture and overexploitation of fisheries will be the greatest threats, with lesser problems being alteration of hydrology, pollution and global warming. Loss of biodiversity is, and will continue to be, a severe problem as even pristine mangroves are species-poor compared with other tropical ecosystems.

The future is not entirely bleak. The number of rehabilitation and restoration projects is increasing worldwide with some countries showing increases in total mangrove area. The intensity of coastal aquaculture appears to have levelled off in some parts of the world. Some commercial projects and economic models indicate that mangroves can be used as a sustainable resource, especially for wood. At present there is a worldwide shortage of tropical timber, and this may be somewhat alleviated by increased recycling and sustainable use of mangroves.

The brightest note is that the rate of population growth is projected to slow during the next 50 years, with a gradual decline thereafter to the end of the century. Mangrove forests will continue to be exploited at current rates to 2025, unless they are seen as a valuable resource to be managed on a sustainable basis. After 2025, the future of mangroves will depend on technological and ecological advances in multi-species silviculture, genetics, and forestry modelling, but the greatest hope for their future is for a reduction in human population growth.

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Biogeochemistry of mangrove-estuarine ecosystems: Nutrient fluxes via seven river systems in Sri Lanka

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Although surrounded by the Indian Ocean, lagoons and estuaries are not numerous in number on Sri Lanka's 1760 km long coastline but they are heterogeneous in nature, processes and functions. Heterogeneous nature of lagoons and estuaries is primarily determined by climate and weather, tidal fluxes and river input, and cohesive interactions with land based activities. However, present knowledge on biogeochemistry, ecosystem processes and dynamics of mangrove-estuarine ecosystems in Sri Lanka is trivial although they play a vital role in the island's ecology and nation's economy. Total dissolved salts (TDS), and primary nutrients (Nitrate-N, total phosphorus and dissolved silica) fluxes into mangrove-estuarine systems via seven river systems with different catchment geochemistry, drainage patterns and land use in Sri Lanka were determined using standard methods and compared with the rivers in the tropical latitude.

Mahaweli river with the largest discharge (11.016 km^3 yr^{-1}) empties 2.24 x 10^6 tons of TDS compared to the lowest TDS load of 0.20 x 10^6 t yr^{-1} by Mi Oya, which has 3% discharge volume of the Mahaweli. A more or les similar trend with highly significant linear relationships was found with respect to fluxes of nitrate-N, total phosphorus and DSi into respective mangrove-estuarine systems. In contrast, the yields of nitrate-N (252 kg km^{-2} yr^{-1}), total phosphorus (62 kg km^{-2} yr^{-1}) and DSi (5527 kg km^{-2} yr^{-1}) were highest in the Maha Oya watershed, which has 14.6% discharge volume of the Mahaweli. The results clearly indicate that material flux into mangrove-estuarine systems is a function of discharge volume, however, catchment geochemistry, land use and stream flow regulation play important roles with respect to yields of respective watersheds. Further, fluxes of Sri Lankan rivers are relative low compared to other rivers in the tropical latitude, but yields fall within the tropical range.

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Nutrient Dynamics in Pichavaram Mangroves

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The natural systems of coastal zone are recognized in the scientific arena and across much of the wider community. The entire structure of the coastal zone – mangroves, tropical wet lands, estuaries – is subjected to pressure from human and natural changes. They are widely exploited for various activities which will alter its biogeochemical processes. This study aims to study the biogeochemical changes taking place in these ecosystems.

Water and sediment samples has been collected from various locations and analyzed for major nutrients. Concentration of major nutrients DIC, DIN and DIP in water ranges from 93 mg l^{-1} - 250 mg l^{-1} , 17.5 µ g l^{1} – 22.3 µ g l^{1-} and 0.9 µ g l^{1} – 2.95µ g l^{1} respectively. Salinity is an important chemical factor which has direct impact on the distribution of nutrients in the saline environment. The salinity ranges from 11.2 - 34 g/l. The tropic state of the ecosystem is depends upon the DIN : DIP ratio i.e. 7.68 – 19.44. This suggests that, the mangrove system is autotrophic in nature. The phosphorus limitation may be due to rapid assimilation of phosphorus by the biological systems and deposition in the sediments. DOC concentration varies from 1.85 – 4.85 mg/l. The availability of nutrients to the biological systems in any ecosystem depends upon the chemical nature and retention capacity of the surfacial and core sediment. TC, TN and TN in the sediments of the Pichavaram mangroves varies from 63-106 gm^{-2}, 2.5-2.35 gm^{-2} and 0.39-1.62 gm^{-2} respectively. Core sediments were also collected from Rhizophora dominated zone and Avecinia dominated zone. There is no much variation in phosphorus distribution in these two zones, but there is a significant variation in carbon and nitrogen distribution in these two zones. High concentration of carbon and nitrogen in Rhizophora dominated zone is found. The vertical distribution of nutrients in the core sediments shows the significant variation from in the top 60 cm in the ground level. The grain size distribution controls the nutrient concentrations. From the data it is clear that 0.067 mm and 0.032 mm grains controlling the distribution and mobility of nutrients in both zones.

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Hydrobiological investigation on the coral reef environs of the Gulf of Mannar Biosphere Reserve

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Environmental (meteorological and physical-chemical) conditions play a major role in governing the ecology, distribution, productivity and health of the organisms of any ecosystem including the coral reef ecosystems. Having this in mind, hydrological features of the coral reef islands (Manoli and Krusadai island) of the Gulf of Mannar were studied for a period of two years. The ranges recorded for different parameters

were as follows: air temperature (25 - 33^0 C), surface water temperatures (23 - 33^0 C), salinity (27 - 36.5 ‰), pH (7.5 - 8.6), DO (3.9 - 7.2 ml/lit), particulate organic carbon (7.5 - 65.2 ìgC/lit), total phosphorus (0.06 - 4.6 ìM), inorganic phosphate (0.06 - 2.3 ìM), total nitrogen (6.4 - 44.2 ìM), nitrite (0.12 - 1.32 ìM), nitrate (1.3 - 13.3 ìM), reactive silicate (0.09 - 12.3 ìM), calcium (130 - 810 mg/lit) and magnesium (1060 - 1710 mg/lit). Interactions between these parameters and the spatial differences between the two stations have been studied through statistical interpretations.

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Mangrove Swamps of the Krishna and Godavari Deltas: A Tell-Tale Sedimentatary Response to Anthropogenic Onslaught

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The Krishna and Godavari deltas (KGD) of India constitute major sedimentary systems next only to those of Ganges and Mahanadi deltas. The KGD also constitutes enormous spread of fragile ecosystem represented by estuarine-mangrove swamps. Systematic analyses of mangrove swamps of KGD in terms of areal extent, sedimentation history and processes, land-use pattern and sedimentary geochemistry were attempted to asses the status of ecosystem. As these regions host reserve forests that support diverse and ecologically sensitive fauna and flora forming a vital link to estuarine-coastal-marine food chain. The results of this study indicates that

(1). The mangrove swamps are being destructed at an enormous rate along the coastal regions owing to rising sea level, diminishing riverine discharge, neotectonic subsidence and ongoing shifting of active lobes. The magnitude could be gauged from the simple fact that, at places the mangrove swamps previously located at or above spring tide are now under neap tide and intertidal regions.

(2). The coastal eco-systems are under threat due to a variety of causes, primarily aggravated by human intervention of natural sedimentary processes.

(3). The ever growing spread of urbanization, aquaculture along coastal tracts at the expense of mangrove swamps and marsh lands, mixing of untreated effluents of coastal industries and aquaculture ponds into tidal channels and estuaries that crisscross mangrove swamps pose immediate threat to the well being of reserve forests.

(4). The pollutant assimilation capacities of Krishna and Godavari estuaries are far below the quantum of pollutants released by urban, aquaculture and coastal industrial sources.

Detailed discussions on each of the ongoing sedimentary processes, land-use dynamics, adsorption-desorption reactions on mangrove swamp sediments, and anthropogenic intervention are made in this paper. The study has also suggests few plausible remedial measures to halt ecological deterioration with site and process specifications.

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Fluxes of inorganic nutrients in Chaliyar river estuary (West coast of India)

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The Chaliyar river estuary is a positive coastal plain estuary with total drainage of 2923 km2. The estuary's functions as sinks and transformers to nutrients and the dynamics of nutrient uptake and release,

retaining and recycling of nutrients within estuary and relative contribution of external nutrient supply, nutrient budget, geo-chemical and biochemical pathways were investigated. The studies revealed that the major source of nitrogen in the estuary is the river discharge. During pre monsoon period, the percentage of inorganic nitrogen to total nitrogen pool is at the minimum and the major form is organic nitrogen. During the post monsoon period, the contributions from both these components are almost equal, with a predominance of inorganic form. The dissolved nitrogen components are present in one form or other through out the estuary in all seasons and so nitrogen is not a limiting nutrient for primary production. The urea-N fraction remains < 7% with the lowest levels in pre monsoon. The contribution of Ammonia-N to total nitrogen pool is < 10% during monsoon and pre monsoon seasons. The maximum contribution > 25% is in the post monsoon season. When the monsoon discharges are maximum, 80 –90% contribution to the total nitrogen pool is by nitrate-N alone and in the pre-monsoon months, 75-85% of total nitrogen pool is from the organic –N. The net fluxes of inorganic nutrients in monsoon and post monsoon season are very large- with very small positive or negative fluxes for the pre-monsoon months. The average net fluxes are 4.97 mg/m^2/s to 9.61 mg/m^2/s for the monsoon months and are 7.22 mg/m^2/s to 8.01 mg/m^2/s for the post monsoon months. During pre monsoon period, ammonia is transported towards the river (–0.47 mg/m^2/s to 0.03 mg/m^2/s). The net fluxes of nitrite-N are very small and directed upstream during the pre monsoon months. The average flux of nitrate is of the order of 81.09 mg/m^2s to 134 mg/m^2/s for the monsoon months and 4.87 mg/m^2/s to 33.23 mg/m^2/s in the post monsoon months. During the pre monsoon months, –ve net flux is towards the river and the magnitude decreases towards upstream. The net flux of phosphate increases from marine end towards riverine end with the monsoon month's net flux of 3.52 mg/m^2/s to 4.63 mg/m^2/s. During the post monsoon months, fluxes vary from 1.87 mg/m^2/s to 2.82 mg/m^2/s. The net fluxes are very small and directed towards the river in pre monsoon months. Except in the pre monsoon, there is net transfer of nutrients to sea. The mean annual fluxes for nitrate-N, Ammonia-N and phosphate-P are 31.01 mg/m^2/s, +3.9 mg/m^2/s, and +2.39 mg/m^2/s respectively. The average peak southwest monsoon transport of nitrate, ammonia and phosphate to sea are 13.7 tons/day, 1.2 tons/day and 0.61 tons /day respectively.

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Characterization and Modeling of Groundwater Flow Regime of an Artesian Aquifer System in the Coastal belt of Cuddalore District (South India)

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The Neyveli basin lies in the coastal sedimentary belt of Cuddalore District in Tamilnadu. It is one of the extremely complex multi-layer groundwater systems in India having a sequence of highly productive unconfined, semi-confined and confined aquifers. Large deposits of lignite, in excess of 3000 million tons, occur at the Neyveli Lignite field. For safe mining of lignite, a continuous groundwater pumping at the rate of 6800 m^3/hr was started in the year 1961 to reduce the hydrostatic pressure exerted by the artesian aquifer below the lignite seam. The groundwater pumping in the two mines during nineties was about 20000 m^3/hr. The studies carried out so far indicate that the total pumping for domestic, industries and irrigation from the basin exceeds the total input to the aquifer system. This imbalance has been resulting in to a regional lowering of groundwater levels and creating an artificial recharge mound between the Mines and the East coast, which is moving slowly towards the coast.

A preliminary regional model was prepared by NGRI during 1985 by making use of only the available data and the aquifer was characterized as the bottom of aquifer with syncline nature at that time with the idea postulated by GSI during sixties. It was further characterized as the bottom of Cuddalore sandstone aquifer with flat bottom during 1990 and again re-characterized during 1998 based on the

ONGC borehole data at that point of time that the bottom of aquifer is dipping towards the coast and groundwater modeling study was carried out accordingly.

The study helped to arrive at a better understanding of the complex hydrodynamics of the system. We could evolve clear-cut boundary conditions in the complex aquifer system as well to quantify the characteristic parameters of the multi aquifer system. We have progressed from whatever the data and the modeling technique available initially and then progressed to get more information regarding the aquifer condition and parameters as well improved version of the computer codes. We could simulate a multilayer aquifer system with the advent of fast computing machines, improvised software to simulate multi-layer system with additional data required to model such a complex system. This is to illustrate how that modeling process is a dynamic one and one has to up date the model with more information on aquifer system and by utilizing the up dated modeling techniques.

The model study has revealed that the artificial recharge mound created due to heavy pumping in Neyveli basin is continuously moving towards the coast. There is fear among public that if this mound touches the seawater front near the coast, there is likelihood of reversal gradient of groundwater flow towards the aquifer system and thereby converting the freshwater into saltwater zone. This is another form of groundwater contamination. The paper also deals with the remedial measures to contain seawater intrusion due to over exploitation of coastal aquifers.

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Groundwater Modelling for Environmental Management of Coastal Regions

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Groundwater modelling of coastal aquifers has been widely used as an environmental tool, since the development of digital computers and appropriate numerical models. These models solve the basic partial differential equations that govern the flow of groundwater and solute transport through the saturated and unsaturated porous medium. Models solve the equations of more complex hydrogeological problems involving aquifer heterogeneties, anisotropic aquifer properties and complicated boundary conditions. Groundwater models of several categories are developed for specific purposes. Flow and solute transport problems vary in 2 or 3 dimensions. Groundwater flow and solute transport model have widely been used by many researchers to solve numerous problems related to groundwater. Groundwater modelling is an effective management tool to sustainably manage the groundwater resources of coastal regions.

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Groundwater Quality Assessment in Shallow Aquifer of Chennai City, Tamil Nadu, India

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Chennai being one of the coastal metropolitan cities of India and is situated in south eastern coast. The water need of the city is increased by many folds due to the increase in population and industrialisation in and around the city. The surface resources are not able to cater the present day demand. Hence they are going for groundwater exploration. Due to the overexploitation of ground water, the water quality is deteriorating. For the present study, a part of Chennai city have been selected and 30 groundwater samples have been collected in a systematic manner from the existing open wells of shallow depths for both pre monsoon and post monsoon seasons. The water samples have been analysed for major cations and anions. With the analysed results, the water has been classified using HYCH programme. The following thematic maps have been prepared viz., total dissolved solids, total hardness, corrosivity ratio and chloride vs.

bicarbonate ratio using GIS. From the above study, it is understood that the groundwater (open well), of Chennai city, is of moderate quality. The dilution and quality enhancement in post monsoon season indicate recharge phenomena through rainwater. Only a very few fresh water pockets have been identified in the study area. It is inferred that the groundwater of Chennai city is under going quality deterioration. The existing fresh water resources have to be utilized to minimum extent and managed properly. The existing groundwater quality can be improved through roof rainwater harvesting structures. The other artificial recharge methods are not possible since the area having high settlements.

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An overview of Ground water Resource in coastal parts of India

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Ground water play a significant role in socio economic development of coastal population in India. However, advent of phenomenal population growth coupled with developmental activities over the years has led to severe stress on sustainability of ground water resources in the coastal areas. The over development of ground water resources to meet the growing water demands is attributed to be the primary cause of sea water intrusion in many coastal areas of the country.

In the present paper the ground water resource availability scenario and issues associated with its over development and sustainability in coastal areas in India have been discussed. The management options for protection of coastal aquifer have also been suggested.

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Management o Ground Water in Coastal Orissa

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The management of the coastal aquifers of Orissa aims at sustainable development of the prolific fresh water resources and maintaining the delicate hydrochemical balance of salt and fresh water. The complex and fluctuating depositional environments and tectonic history in the geological past created such varying hydrochemical situations as freshwater overlying, underlying or alternating with saline water. Reduction in freshwater flow through manmade or natural causes offsets this hydrochemical balance resulting in environmental hazards. Management of these aquifers therefore needs proper understanding of the coastal groundwater regime through scientific investigations and periodic groundwater monitoring.

Surveys and exploration conducted by Central Ground Water Board (CGWB) in the coastal areas of Orissa have revealed that the sand and gravel layers in the thick pile of sediments form prolific aquifers. The salinity problems are most pronounced between the main Mahanadi river course and Brahnmani-Baitrani rivers with varying vertical depth, as tidal effects and salt water ingress are observed even 60 km upstream from the coast. The near-surface groundwater occurs under water table condition with depth to water table within 4 metres below ground (bgl). The deeper confined aquifers occur in the coastal areas underlying thick confining clay layers. The Piezometric heads lie within < 1 - 7.4 m. bgl. The quality of ground water shows a gradual deterioration towards sea.

The basic principle in management of coastal aquifers is to ensure a fresh water flow towards the sea or a seaward hydraulic gradient. As per Ghyben Herzberg principle changes in Piezometric heads of

aquifers due to overexploitation or due to low rainfall and recharge alter freshwater- saltwater interface. Hence groundwater monitoring is of vital importance in the management of coastal aquifers. Ground water monitoring in the area is carried out through a network of hydrograph observation wells and piezometers established by CGWB since 1969. While well hydrographs of aquifers occurring within 135 metres depth fairly match, hydrographs of piezometers of deeper aquifers are distinctly different in nature showing thereby two different ground water regimes – unconfined or near unconfined condition down to 135 meters depth and confined condition in deeper aquifers. Also the deeper aquifers are less affected by drought than the shallower aquifers occurring within 100m depth, which may be due excessive withdrawal of ground water through shallow tube wells during the drought period. Further declining waterlevels has also been recorded in parts of Balasore district due to excessive groundwater extraction threatening seawater ingress if the situation persists. Updation of knowledge about these aquifers through reappraisal surveys and monitoring is essential for their proper management.

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Hydrochemistry of coastal aquifers

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The quality of groundwater in the coastal aquifers often gets deteriorated due to several factors.

The most common factor is the intrusion of seawater into the aquifers. Low flow rates, excess draft and high tides are some of the factors that control seawater intrusion. The seawater-fresh water interface fluctuation in such area is controlled by the water table fluctuation and is governed by Ghyben-Herzberg principle of seawater intrusion. This principle need not be invoked in all the cases wherever salinity problem occurs. A careful examination of the chemical constituents in the affected waters renders meaningful explanation for such causes.

The second factor that governs the quality is the saltpan activity. A typical example of this kind is seen around Vasi-Palghar coastal zone of northern Mumbai. The Br/Cl ratio of the contaminated groundwater samples ($1.5x\ 10^{-2}$ to 1.4×10^{-2}) is far above the value recorded for the Arabian Sea ((3.14×10^{-3}). Such high concentration of Br in the water samples is attributed to the super saline brines from the saltpans.

Irrigation return waters also cause deterioration of groundwater quality. B/Cl ratio is the best indicator to identify this source. A typical example of this kind is recorded from the Vasi-Palghar region. The B/Cl of irrigation contaminated waters is $>15x10^{-4}$ and is far above the ratio of the Arabian Sea (1.7×10^{-4}).

Quality deterioration is also caused due to seawater intrusion into coastal aquifers. Here, as mentioned above, the intrusion mechanism is commonly envisaged to follow the Ghyben-Herzberg principle. But it is not always true that this mechanism operates in all the coastal aquifers. If the water table lies above the mean sea level, the interface between the fresh and saline water is controlled by the water table level fluctuation. However, if the water table levels fall below the mean sea level, then a negative gradient sets causing permanent mixing of saline water into the coastal aquifers. Wherever quality of groundwater in the coastal aquifers deteriorates, the above mechanism need not be invoked always. In certain cases, as is the case along the Malappuram coastal aquifers of Kerala, the quality deterioration is due to release of anions from the marginal basin sedimentary formations rather than due to the adjacent sea.

What it implies is, groundwater quality deterioration along the coastal aquifers is a site-specific problem and needs to be evaluated carefully using geochemical and geophysical techniques. Solution, which is applicable in one area, need not be applicable to other areas. Hydrogeochemical parameters play an important role in delineating such areas and seeking solution to such problems.

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Environmental Monitoring of Flat Bay Mangrove-Estuarine Ecosystem

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Estuaries being the interface between rivers and the sea are the sites of tremendous human development and biotic diversity. Estuaries receive large quantities of nutrients from their inflowing rivers and often estuaries widen into a bay having higher salt concentration due to its proximity to the ocean. These bays many times face human interventions for various purposes such as navigational and water supply infrastructure schemes, and thus ecological regimes are affected. The dynamics of interaction between the bay and subsurface is of paramount significance because of dominant role of sediment and subsurface in controlling the groundwater recharge, fate of contaminants and ecologically important substances, and impact on the stream as well as groundwater system in terms of their quality and quantity. The biogeochemical processes within the upper few centimeters of sediment beneath surface water bodies, termed as hyporheic zone, have a profound effect on the chemistry of the water exchange. The flow patterns within the aquifer are significantly influenced by the flow conditions in the bay because of the bank flow dynamics. Thereby the exchange of water and contaminant fluxes at the interface becomes determinative factor while assessing the quantity of bank and bay storages and their quality, which in turn influences the groundwater quality of shallow aquifers and water quality of bay.

The exchanges of water and chemical species into various components of ecosystem are affected by human interventions such as damming the bay fully or partially for the intended uses. These interventions do affect the marine ecosystem as well. The mangroves may reduce drastically because of impoundment and backwater effect, which in turn affect the estuarine ecosystem as they are halophytes and thus have ability not only to endure high concentration of certain ions in their water supply but also to absorb water with ease under these conditions.

This paper presents in situ monitoring of various physical, chemical and biological parameters to assess the environmental status of Flat bay estuarine system, which has significant amount of mangrove plants. The Flat bay estuarine system is located in Port Blair, Andaman and Nicobar Islands, India. The productivity of bay aquatic system is also obtained, which provides a comprehensive assessment of the trophic status, whether a given water body is oligotrophic, mesotrophic or eutrophic. It reveals the changes in the physiological status of aquatic ecosystem resulting from the pollutants. The mangrove in the bay area is approximately 10% of high water area. The gross primary productivity ranges between 90-160 $mgC/m^2/hr$, and the net production efficiency varies between 29-42%. These results are based on the depth integrated marine water samples taken from four sampling locations in the Flat bay during the first week of March 2001. The temperature of bay water varies from 26-34^oC during the day periods of measurements. This study together with the mathematical modeling of bank flow and storage dynamics describing the quantification of interaction between banks of river mouths and bay in terms of both quantity and quality under human intervention to the flow system for the intended use can enable to assess the impact of human intervention on the biodiversity and marine ecology of the Flat bay estuarine system that may accrue because of such developmental human interventions. The results reported are significant in the developmental project context as the bay is intended to be dammed for the development of a freshwater lake by natural desalination process and harvesting water from rain and creeks to augment the water supply to the Port Blair city.

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Nutrient and Heavy Metal Contaminants in the Ganges Estuary

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Dissolved silica and phosphorus shows a highly non-conservative behavior in the Ganges Estuary. In addition, phosphorus also shows seasonal variation, with winter levels higher than the levels in the monsoon. Mineral composition indicates enrichment of coarse quartz grains due to selective removal of finer clays in the estuary, either due to flocculation or due to dredging effects of the Port of Calcutta. Particulate P and Si show strong opposite trends, possibly indicating the presence of P in predominantly nondetrial fractions in the sediments. Certain trace contaminants such as, Fe, Mn, Cu, Pb and Zn shows seasonal variability as well as enrichment in suspended particulate material relative to bed sediments. Levels of all these contaminants are still well below those reported for rivers such as the Rhine and other highly man – influenced systems.

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The Impact of Prawn Farm Effluent on Coastal Waterways

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The findings from a 3 year project that investigated the behaviour and impact of prawn farm effluent on aspects of mangrove coastal physical and biological processes will be described.

Computer models were generated describing the fate of prawn farm effluent in farm discharge creeks. These models, in the form of video simulations, show creek flushing characteristics under different scenarios of tide, pond loading and discharge volume.

Nutrient rich particulates from farm effluent displayed high settling velocities and accumulated during periods of low currents. Fluxes of C and N between the water column and these sediments will be described. Preliminary estimates for C and N nutrient budgets indicate the rate of supply from the prawn farm exceeded the assimilative capacity of the upper reaches of the creeks. High sedimentation rates of particulate material combined with rapid burial to prevent the release of C. Rates of C and N transformation represented a small fraction of the farm supply rate. Despite the assimilative capacity of the upper reaches of the discharge creeks being exceeded during harvesting periods, farm effluent did not appear to result in eutrophication due to a variety of mechanisms. These are a combination of physical and biological processes operating within the creek waters which will be described.

A companion presentation by D.McKinnon will describe the dynamics of the pelagic communities where very high rates of primary production, bacterial growth and zooplankton grazing were observed during discharge periods.

This research was supported by AIMS, FRDC, Aquaculture CRC, the prawn farming industry (APFA) and individual farms (Sea Ranch, Seafarm).

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Membrane Processes: Water Pollution Control and Management

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Water is an essential element of the evolution of life and its sustainment, but its quantity on our planet is constant. Hence, water must be properly used, conserved and recycled after the removal of pollutants.

Rapid advances and demographic increase during the next thirty years around the world will lead to a great demand of drinking water and hence for efficient and economic ways to manage water resources, disposal and its treatment.

Water quality management problem is acute in India. It is not from the quantity of water available but from its quality standards, in particular, for drinking purposes. The drinking water treatment is mostly done by sedimentation and chlorination; norms for pesticides, arsenic, fluoride, bacteria, parasites, and viruses are not very well known and applied. Another problem is from sewage systems, they are very poorly maintained causing leakage to ground water. The water quality has also deteriorated with the increased discharge of industrial wastewaters, natural wash and contamination of aquifers. Biologicals, organelles, ions, synthetic organic chemicals, etc all pose danger to human and livestock health.
Trends to use inline measurement devices are emerging and the development of reliable systems remain a challenge for the scientific and engineering community. Membranes can play an important role in drinking water processing and in designing analytical water quality monitoring systems. In this presentation, we discuss the use of membranes in water and wastewater treatment and in the construction of monitoring and measurement devices.

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Possible recovery from economic loss induced by decadal changes in two lagoon ecosystems of Sri Lanka, through a newly patented mangrove product.

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Kahandamodara and Kalametiya are two estuarine lagoons situated about 12 km apart, along the Southern coast of Sri Lanka. According to a socio-economic survey, both lagoons were moderately or highly saline water bodies, sustaining an important center of prawn fishery until the late 1960s. Two irrigation projects upstream, namely the Udawalawe irrigation scheme and the Murutawela tank, came into operation in 1967 and 1968 respectively, increasing fresh water inflows to these two lagoons. The flora, fauna, and water quality subsequently changed and lagoon fishery has severely declined since then.

A study on the changes of mangrove cover of each lagoon from 1956 to 1994 was carried out within a GIS, based on airborne remote sensing and ground verification. It revealed that the mangrove cover of each lagoon increased during the period concerned and percentage increases of Kahandamodara and Kalametiya were 25% and 50% respectively. These increased areas of each mangrove are dominated by low saline species, particularly by mangrove apples (i.e. Sonneratia caseolaris). These changes were spontaneous and not due to (re)planting programs or reduction of anthropogenic pressure on mangrove cover. Further analysis revealed that changes of the mangrove cover could also be attributed to the upstream irrigation schemes.

The pulp of the fruit of mangrove apples is tasty and can be used to prepare a fruit drink. However, earlier it had not been commercialized or consumed widely, even at home. This is mainly due to the fact that numerous small seeds in the fruit release some phenolic compounds when they are damaged, giving a bad color and an astringent taste to the pulp. A method was developed to extract fruit pulp from mangrove apple with minimal release of phenolic compounds. This fruit pulp has been used to produce ice cream and fruit drinks, and the whole procedure is now patented in Sri Lanka. Apparently, this is a novel mangrove product reported for the first time in mangrove Ethanobotany. Analysis of the fruit pulp of mangrove apple for nutritional composition revealed that it is very rich in Vitamin C and dietary fiber, indicating that these new products may have a higher potential as a supplementary food. It could thus be considered a health food as well as an eco product.

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Technological and Environmental Impact Assessment on Oil and Gas Exploration at the Sundarbans coastal regions

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The Sundarbans largest single tract block of mangrove forest in the World, is under the risk of severe biodiversity loss and possible extinction of many species (Chowdhury, 2003).

The EIA document for oil and gas exploration and production at the Sundarbans consists of the sectors covering impacted communities, technical details and environmental impacts. From the Leopold's (1971) environmental ranking system, it has found that the development stages of oil and gas exploration on field and pipeline operation and termination stage might have a mammoth impact on the Sundarbans ecosystem. However the geophysical surveys, drilling and production facilities construction are showing moderate impact ranks as the project says the exploration could be held out of 20 km range from the impact zone of the Sundarbans.

The World Rain-forest Movement (WRM) has already declared the anti oil and gas exploration movement as 'war-fare' (WRM, 2003). However, the Bangladesh government recently completed initial Production Sharing Contract (PSC) with Shell Oil Company and Cairn Energy PLC to begin oil and gas exploration in the periphery of the Sundarbans at 20 km away from impact zone. However the incidences in Nigerian belt always remind us the potential impact of the hydrocarbon exploration in mangrove forest. Mangrove forests are very much sensitive and fragile and responsive to any kind of ecosystem changes. So there is an urgent need to conduct an EIA in the Sundarbans for possible impacts of hydrocarbon exploration. Environmental organizations in Bangladesh vigorously oppose all exploration activity adjacent to the Sundarbans coastal regions. Shell's brutal devastation of Niger Delta mangroves and villages is a grim warning that oil and mangroves don't mix (EII, 2003).

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Effects of Human Activities on Mangroves Ecosystem

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Mangroves are salt tolerant plant communities occurring in sheltered coastline areas such as bays, estuaries, lagoons and creeks. Mangroves represent an interphase between terrestrial and marine and constitute a dynamic ecosystem with a complex association of species of floras and fauna of terrestrial and aquatic systems. Mangroves enhance the productivity of the ecosystem. In India, the Mangroves comprises of 69 species excluding salt marshes and other associated species, under 42 genera and 27 families. In recent decades, the Mangroves forests have been affected mainly due to human activities resulting into the impact of climate on ecosystem. There are indirect relationships between climate change and the Mangrove ecosystem through changes in sea level. Human activities are likely to prove as major long term influences on sea level, as is the global environmental problem of climate change caused by greenhouse gas emissions. As sea level rises, coastal erosion and the severity of coastal flooding increases and coastlines will recede unless they are stabilized through sand nourishment. Coastal currents and upwelling patterns are likely to

shift geographically and change in intensity. All of these Sea changes are affecting the Biodiversity in coastal zones. In India, the Mangroves experts have found that of 52 species of marine fish, 9 are vulnerable and 2 are endangered, and that of 41 invertebrates, 4 are endangered, 4 are vulnerable and only one species is critically endangered. Taking into consideration ecological and economic significance of Mangroves and threats faced by them due to Human activities, the Ministry of Environment and Forest, Government of India, launched a scheme on Conservation and Management of mangroves. It has been reveled that there has been a significant increase of 615 Sq. Km. of mangroves areas in the country during the last one decade. Fifteen additional mangrove areas in the country have been identified for intensive Conservation and Management.

In India, the studies carried out indicate that Mangroves face serious problems due to Urbanization, Human settlement, Industrial and Sewage pollution. The Central Government has notified the Coastal Regulation Zone to protect the marine water quality and aquatic life in accordance with the mandate given in Section 3 (2) (v) of the Environment (Protection) Act, 1986. The Environmental Guidelines indicate that the Industrial development, Housing & Human settlement including Urbanization must be at least ½ Km away the from coastal areas. However, the increasing population and Human settlement in the city like Mumbai has crossed the boundary of the Coastal regulations. The Housings Societies are still constructing the Buildings, in some areas, with in the boundary of ½ Km distance from the coastal regions. In Kerala, embankments are constructed to prevent the entry of seawater, and then for raising coconut trees. This has resulted in destruction of Mangroves. Shrimp culture has been developed after clearing Mangroves in some places of Andhra Pradesh, Tamil Nadu and Orissa. Heavy exploitation of Mangroves in the country for firewood and animal fodder has also depleted the resources significantly. The studies on the effects of Human activities on the Ecosystem of mangroves will be of great significance for deciding the strategies for Conservation and Management of Mangroves in the Country.

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Management of Mangrove Forests within and Adjacent to Kiunga Marine Protected Area, Lamu, Kenya: An Application of Remote Sensing

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The present study reveals that the existing mangrove forests within and adjacent to iunga Marine Protected Area (MPA) covers an area of 16,035.94 ha. The status of mangrove is assessed through aerial photographs and satellite imagery and fieldwork. Vegetation map (1:25,000) is produced on GIS environment making it possible to store, retrieve and analyze various types of information. The maps together with the digitized information provide important tools to the management of mangroves of Kiunga MPA.

There are eight species of mangrove trees, of which Rhizophora mucronata and Ceriops tamale are dominant. The standing volume ranges between 6.85 to 710.0m^3 ha^{-1}, for stem with diameter above 5.0cm. The average volume of the entire study area was 145.88m^3 ha^{-1}, which corresponds to a stocking rate of 1,736 stems per ha. Given its high potential productivity and regeneration, mangroves within and adjacent to Kiunga MPA have excellent prospects for sustainable exploitation. Management strategies the mangrove forests are also suggested in this paper.

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Trace gas emissions from the Coastal Ecosystems

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Carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) together account for nearly 75% of enhanced greenhouse forcing. Atmospheric inventories of N_2O and CH_4 are increasing by ~25% year^{-1} and ~0.3% year^{-1} and together they account for ~18% of enhanced greenhouse forcing. Wetlands are the most prominent single source of methane to the atmosphere. Concern about the steadily increasing atmospheric CH_4 concentration from terrestrial and aquatic environments has stimulated research to quantify their sources and sinks. Tropical natural wetlands in recent times have been of great environmental concern due to human intervention such as urbanization, intensification of agriculture etc. The CH_4 emissions from diverse coastal wetlands have been measured. Annual emission rates varied widely (3.1 mg m^{-1} ha^{-1} to 21.56 mg m^{-1} ha^{-1}) based on nature of perturbance to each of the ecosystem studied. Distinct seasonality in CH_4 emission was noticed in an unpolluted ecosystem and over a two-fold increase was evident in the ecosystem that was disturbed by human activities. The wide ranges in estimate suggest that methanogenesis occurs by both natural and anthropogenic activities in these wetlands.

Several physico-chemical factors such as salinity, sulfate, O_2, and organic matter content influence methanogenesis to larger degree in each of these ecosystems in addition to individual responses to human induced stress. For example, there was a clear negative correlation between O_2 availability, SO_4 and salinity with CH_4 emission in the Adyar River. Although similar results were obtained for the other wetland ecosystems, CH_4 emission was largely influenced by tidal fluctuations resulting in a concomitant increase in methanogenesis with high SO_4^{2-} concentrations. This study demonstrates that coastal wetlands are potentially significant sources of atmospheric CH_4.

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Distribution of heavy metals in the mangrove soils and plants of Pitchavaram

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Distribution of heavy metals (Mn, Fe, Co, Ni, Cu, Zn, Hg) in soils and mangrove plants viz. Bruguiera cylindrica, Ceriops decandra, Rhizophora apiculata, R. lamarckii and R. mucronata was studied from Pitchavaram, southeast coast of India. It revealed that the concentrations of some of the heavy metals (Co, Ni and Cu) in Pitchavaram mangrove environment are relatively higher than those recorded from other coastal marine environs of the southeast coast of India. The order of metal abundance based on the total mean values varied widely. In B. cylindrica and C. decandra, it was as follows: Fe > Mn > Zn > Cu> Ni > Co > Hg, in the case of R. apiculata, R. lamarckii and R. mucronata, the order of abundance was Mn > Fe > Zn > Ni > Cu > Co > Hg while the order differed in the soil (Fe > Mn > Ni > Cu > Zn > Co > Hg). This would indicate that there are clear inter and intra specific variations in the accumulation of different heavy metals by the plants from the habitat soil. Based on the concentration factors, B. cylindrica (for Fe, Co, Ni, Cu and Zn) and R. apiculata (for Mn & Hg) were identified as the active up-takers of the heavy metals. From the present study, it is also inferred that there is a need to prevent the increasing heavy metals pollution in the Pitcharvarm mangrove area in order to protect this fragile ecosystem and safeguard its biodiversity.

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Status of Aquaculture Farms in Bhitarkanika Wildlife Sanctuary Orissa, India.

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Bhitarkanika Wildlife Sanctuary is located in the North -Eastern part of coastal state Orissa in Eastern India.It harbours one of the richest mangrove eco-system in the country and is known for it's species diversity, both flora and fauna. The core area of wildlife sanctuary has been declared as a National Park in 1998 covering pristine mangrove forest of 145 sq. kms. The periphery of NP is dotted with around 90 villages covering 6 gram Panchayats. Most of these villagers are very poor who have settled in these areas during 1950's and 60's from neighbouring states and countries. Since the productivity of agricultural land in this area is low, the poor villagers are increasingly converting their fields into aquaculture farms for immediate economic gain. A study reveals that most of the aquaculture farms have been constructed during 1998-2000. The supercyclone in 1999 made their fields even more unproductive due to salinity ingression, hence their preference for aquaculture farms.

Forest Department has taken a number of initiatives to involve the people in management of the Sanctuary and to reduce their dependence on mangrove resources.

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Mangrove Swamps of the Krishna and Godavari Deltas: A Tell-Tale Sedimentatary Response to Anthropogenic Onslaught

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The Krishna and Godavari deltas (KGD) of India constitute major sedimentary systems next only to those of Ganges and Mahanadi deltas. The KGD also constitute enormous spread of fragile ecosystem represented by estuarine-mangrove swamps. Systematic analyses of mangrove swamps of KGD in terms of areal extent, sedimentation history and processes, land-use pattern and sedimentary geochemistry were attempted to asses the status of ecosystem. As these regions host reserve forests that support diverse and ecologically sensitive fauna and flora forming a vital link to estuarine-coastal-marine food chain. The results of this study indicate that

The mangrove swamps are being destructed at an enormous rate along the coastal regions owing to rising sea level, diminishing riverine discharge, neotectonic subsidence and ongoing shifting of active lobes. The magnitude could be gauged from the simple fact that, at places the mangrove swamps previously located at or above spring tide are now under neap tide and intertidal regions.

The coastal eco-systems are under threat due to a variety of causes, primarily aggravated by human intervention of natural sedimentary processes.

The ever growing spread of urbanization, aquaculture along coastal tracts at the expense of mangrove swamps and marsh lands, mixing of untreated effluents of coastal industries and aquaculture ponds into tidal channels and estuaries that crisscross mangrove swamps pose immediate threat to the well being of reserve forests.

The pollutant assimilation capacities of Krishna and Godavari estuaries are far below the quantum of pollutants released by urban, aquaculture and coastal industrial sources.

Detailed discussions on each of the ongoing sedimentary processes, land-use dynamics, adsorption-desorption reactions on mangrove swamp sediments, and anthropogenic intervention are made in this paper. The study has also suggests few plausible remedial measures to halt ecological deterioration with site and process specifications.

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Mangrove Restoration in Gujarat, India

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Degradation of mangroves in Gujarat coast is obvious for various reasons like livelihood requirements such as fodder and fuel and industrial establishments, ports and jetties. Gujarat Ecology Commission addresses the degradation of mangroves by restoring 5000ha through the Indo Canada Environment facilitated project. The paper projects the experiences gained through the project in Gulf of Kachchh and Gulf of Khambhat.

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Analytical Chemistry for the conservation of Mangroves

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Mangroves are inter tidal zones, highly productive and self-sustaining. They hold a wide variety of flora and fauna. They regulate pH, scavenge heavy metals and pesticides. Further they play a significant role in biochemical cycling of nutrients. However, the mangroves are facing threat due to continued anthropogenic intervention. It is in this context, that analytical measurements of the mangrove ecosystem are important. These pose a unique set of challenges as the composition of the water body is subjected to both saline and fresh water incursions.

The flow of chemicals through the mangrove system is closely linked to its ability to sustain the growth of flora and fauna and also to its capacity to purify many of the waste products. To a certain extent, it also provides a sink for the Carbon dioxide, which is fixed by the alkaline nature of the water in combination with the presence of phytoplankton. The natural cycles of many chemicals are characterized by temporal changes. Daily variability is the result of photosynthesis, respiration, photochemical reaction and inter tidal mixing. Similarly, variations also occur over spatial scales. The challenge to the analytical chemist is to develop methodologies with the necessary sensitivity to determine a wide variety of chemicals over temporal and spatial scales.

Many trace elements as Fe, Mn, Cu, and Zn occur in the mangrove environment as a result of natural processes. These act as micronutrients for the phytoplankton growth and thus control the secondary and tertiary stages. Very often there is a strong correlation between them and the macronutrients as phosphate, nitrate and silicate. The trace elements are present at low levels of nanomolar or picomolar concentrations. The analytical methods involve preconcentraton by solvent extraction, chelation ion exchange and modified solid phases. Even with preconcentration highly sensitive analytical measurements GF-AAS or ICP-MS are needed. It is necessary not only to measure the total concentrations but, more important, the concentration of the chemical species. IC alone or coupled to ICP-MS has been successfully used towards this goal. DPASV is also a useful technique for evaluating the different chemical species.

The water in the mangroves holds a number of organic compounds, as Flavanoids, Tannic acids etc. as result of the decomposition of fallen leaves. However, there is still a large gap in our knowledge of the dissolved organic compounds. For example, the presence of dimethyl sulphide is expected to throw light on the sulphur cycle. Similarly the different alkenones are synthesized by phytoplanktons and stored in the cell membranes can be related to surface temperature.

A study in the above areas can lead to a better understanding of our knowledge as to the mechanisms by which mangroves are able to sustain and thus help in their conservation.

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The monsoon water chemistry in and around the Sundarbans - the largest single tract mangrove forest globally

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The water quality of the Sudarbans mangrove is alkaline in nature. The TDS and EC are very high in the area near the coast. The interior channels are also showing a very high EC and TDS. The SO_4^{2-} and Cl^- follow the similar trend. The other anions are relatively lower due to dilution effect. Na^+ and Ca^{2+} are very high compared to Mg^{2+} And Ca^{2+}. The water chemistry indicates that there is around 30% dilution effect during the monsoon period.

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How does macro algea affect the two major seagrass species Halophila and Halodule productivity in Negombo lagoon, Sri Lanka?

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Seagrass beds are ecologically important habitats, providing ecological benefits such as sediment stabilization and nursery grounds for many important aquatic fauna in fisheries industry. Seagrasses of Negombo lagoon cover approximately 20% of the total area and have to bear the pressure of many anthropogenic activities such as pollutants inputs, conversion of wetlands for other development activities. Macroalgal proliferation on seagrass beds are a result of nutrient loading to the water column and cause reduction of light availability which is one propose mechanism of seagrass bed decline. Aim of the study was to investigate the effect of macro algea on the productivity of two seagrass species. Clear inverse relationship is observed with the % cover of seagrass and algae. Increased macroalgal blooms in the 70-100m away from the shore could reduce available PPDF to below the minimum required for survival. It was reveled that Taxon of algae is significant factor for light interception. Eighty (60%) of the surface of the area is covered with those algae mats. Height of water column also a factor for the attenuation for light to bottom dwellers. The % light reaching to surface of the macro algae canopy was reduced by 96% after penetration thorough a 42cm deep macroalgal canopy.

H. pinifolia showed a high photoadoptation and it showed more tolerance to the shade than H.ovalis .The Ic& Ik of shaded plants were increased than non shaded plants. The shade levels given in this study was not sufficient for Halodule pinifolia to effect the saturating irradience levels. This shows the well photoadoptation of the species.

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Biogeochemical Cycling of Carbon (C) in Mangrove Forest Soils: A mini review

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Mangrove forests in the coastal landscape are known for their various economic and ecological services with unique biodiversity both in aboveground and belowground components. Belowground carbon

storage, which has links to climate change research, is one such ecological service has received circumstantial research attention. The depth distribution of C stores and stability of C sequestered in the different zonation level may vary, which has the linkages to biotransformations process operating concurrently in the predominantly anaerobic sediments. However, a clear knowledge on spatial variability in relation to aboveground plant diversity and composition (biochemical quality of litter) and associated microorganisms mediating the transformations of C is yet to be established. Evidence suggest that the complex interactive linkages exist between plant-nutrient cycling-microbial controls on the stocks and biotic-fluxes of C. Few studies suggest active involvement of aerobic and anaerobic functional groups of microorganisms in cycling of C resulting both in loss and retention mechanisms. However, relative dominance and activity of bacteria and fungal functional diversity with eventual accretion in their biomass (microbial byproducts-primary and secondary) is of relevance to C cycling warrants research. There may also exist myriads of unexplored microorganisms mediating C cycle in sediments, which cannot be cultured on synthetic media. Recent microbial ecological techniques like compound specific stable isotope analysis on microbial biomarkers (PLFA-dominant microbial cell residues) coupled with ^{13}C in the depth profiles of sediment will provide an idea about the type of C sequestered (origin), age and bimolecular stability. Limited effort has been made in this direction except to analyze the ^{13}C signatures in some mangrove sediments elsewhere. To date research reported on C cycle in mangroves has looked at quantitative analyses with lesser importance paid to cycling in relation to microbial controls on loss and retention mechanisms. Present review examines mechanisms, microbial controls and process level linkages to C cycle in mangroves with implications for restoration/stabilization of ecological service like C sequestration in mangrove forests at coastal landscape.

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Remote sensing based landuse/landcover analysis for groundwater studies: A case study of Coastal Maharashtra

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The study area lies between latitudes 17° 51¢ to 19° 08¢ N and longitudes 72° 51¢ to 73° 40¢ E, covering an area of 7148 km^2. It is surrounded by Thane district in the north, Ratnagiri district in the south, Pune district in the east and Satara district in the southeast. The study revealed that the groundwater potential is higher in the northern part of the district where structural control is higher than the land use / land cover control. Lineament density and intersection and fractured nature of the coastal basalt hold the key to the groundwater prospect and its quality. A detailed land use/ land cover change analysis of the district has also been carried out in order to assess and evaluate the pattern of land use/ land cover changes which plays a key role in formulating a suitable land use planning. Basaltic hills are present in this area, which are flat-topped and descend to the plain in terraces. The main natural recharge to the groundwater is from precipitation, influent seepage from streams and small tanks during rainy season and horizontal seepage from the sea.

The chemical composition of groundwater samples collected from 67 administrative units of the district were analysed for pH, EC, TDS, TH, Na, K, Ca, Mg, CO_3, HCO_3, Cl, F, SO_4 and NO_3 to assess the suitability of groundwater in the area for drinking as well as irrigation purposes. It was observed from the correlation coefficient matrix that TH, EC, Na, Ca, Mg and Cl have strong correlation with each other. It was also observed that the quality of groundwater is suitable for domestic uses with few exceptions. The subsurface water chemistry of the area is dominated by sodium, calcium and bicarbonate. High values of Fluoride and nitrate at some locations have made it unsafe for drinking and demands detailed groundwater investigation in the area. High values of SAR, Na% and RSC in the groundwater at many sites restrict its

suitability for irrigation. The groundwater falls under class – I/II at almost all locations in the district as per classification of Doneen's permeability index and can be treated as good for irrigation. An attempt has also been made to classify the groundwater of the study area on the basis of Wilcox and U.S. Salinity Laboratory classification.

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Factors controlling the water chemistry along the coastal aquifers from Puduchattiram to Chidambaram, East coast of India.

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The coastal aquifer is a fragile system. Higher concentration of dissolved ions affects the portability of the water. The concentrations of these ions determine the quality and utility of water. Hydrogeochemical studies carried out in the study area in premonsoon and post monsoon season reveals the dominance of the ions in the following order: $Cl<SO_4<HCO_3$ and $Na<Mg<Ca<K$. The abnormal concentrations of CL, SO_4 and Na are observed in the entire study area in both seasons and in both aquifers.

The spatial distribution of hydrogeochemical facies indicates the predominance of Cl and SO_4 in salinity groundwater also in both the seasons. The predominant geochemical water type is Na-Cl and Na+K- SO_4. The ground water in these regions were classified using the SAR, RSC, SAR, Na% and C.I. The weathering, leaching process fertilizer and anthropogenic influence was also noted to control the chemistry of groundwater. Nutrient levels are within the limits and increasing in the post monsoon season. Salt-water intrusion is suspected to have partial influence in the groundwater chemistry in the aquifer system.

So it is essential to evolve a suitable precautionary method to avoid further deterioration of water quality in future.

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Hydrogeochemical Evaluation of Layered Aquifers of Tiruvadanai, Tamil Nadu

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Tiruvadanai is situated in southeastern coast of Tamil Nadu. Geologically this area encounters from Archaean crystalline basement to Recent alluvium. There are nearly 900 naturally formed rainfed tanks exist in this region. This area experiences 850 mm of annual rainfall, which is slightly lower than the state average rainfall. Hydrogeologically it is interesting to note that there are two aquifer sequences exist in this area namely shallow water table aquifer and deeper confined aquifer. In shallow aquifer open wells exist with the depth range below 25 m. The deeper aquifer has the bore wells of depth ranging from 75 to 400 m. The deeper aquifer depth increases towards the coast. To evaluate the water qualities of different aquifers 20 samples from each aquifer have been collected and analysed for major cations and anions for pre monsoon and post monsoon period. The analysed results have been processed using a computer program HYCH. By adopting this program, the quality assessment can be done at a faster rate without resorting to tedious manual graphical procedures. From the output following thematic maps have been prepared: TDS, Hardness, Corrosivity Ratio, Ground water classification and $Cl / (CO_3+HCO_3)$ ratio for both seasons. From these maps, it is understood that during post monsoon period quality enhancement takes place due to monsoon recharge. From $Cl / (CO_3+HCO_3)$ ratio studies, it has been inferred that shallow aquifer has been encroached by saline water to some extent whereas the deeper aquifer has not been invaded by saline water at present. Raising the banks (Bunds) of larger tanks and desilting the other tanks would be the ideal

recharge structures for this region to improve the water quality and quantity. Designing the check dam in the catchment area of the deeper aquifer would improve the quality.

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Distribution of heavy metals in the mangrove soils and plants of Pitchavaram

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Distribution of heavy metals (Mn, Fe, Co, Ni, Cu, Zn, Hg) in soils and mangrove plants viz. Bruguiera cylindrica, Ceriops decandra, Rhizophora apiculata, R. lamarckii and R. mucronata was studied from Pitchavaram, southeast coast of India. It revealed that the concentrations of some of the heavy metals (Co, Ni and Cu) in Pitchavaram mangrove environment are relatively higher than those recorded from other coastal marine environs of the southeast coast of India. The order of metal abundance based on the total mean values varied widely. In B. cylindrica and C. decandra, it was as follows: Fe > Mn > Zn > Cu> Ni > Co > Hg, in the case of R. apiculata, R. lamarckii and R. mucronata, the order of abundance was Mn > Fe > Zn > Ni > Cu > Co > Hg while the order differed in the soil (Fe > Mn > Ni > Cu > Zn > Co > Hg). This would indicate that there are clear inter and intra specific variations in the accumulation of different heavy metals by the plants from the habitat soil. Based on the concentration factors, B. cylindrica (for Fe, Co, Ni, Cu and Zn) and R. apiculata (for Mn & Hg) were identified as the active up-takers of the heavy metals. From the present study, it is also inferred that there is a need to prevent the increasing heavy metals pollution in the Pitcharvarm mangrove area in order to protect this fragile ecosystem and safeguard its biodiversity.

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Modelling the Circulation and Mixing in a Lagoon – Chilika Lagoon: A Case Study

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Chilika Lake, ($19^0$28'N and $19^0$54'N and $85^0$06'E and $85^0$36'E) on the Orissa coast, India, is one of the unique ecospheres in the world. It is the largest brackish water lagoon with estuarine character. Based on the physical and dynamical characteristics of the lake, the lake is divided into four sectors. The northern sector receives discharge of the floodwaters from the tributaries of the river Mahanadi. The southern sector is relatively smaller and does not show much seasonal variation in salinity. The central sector has features intermediate of the other sectors. The eastern sector, which is a narrow and constricted outer channel, connects the lagoon with the Bay of Bengal and the tidal effects are important in that area. Due to its complicated geomorphology, circulation in the lake corresponding to the different sectors is very complex. Interest in detailed analysis of the circulation, biotic and abiotic factors affecting the lake and its limnology is due to the opening of the new mouth to resolve the threat to the lake from various factors – Eutrophication, weed proliferation, siltation, industrial pollution and depletion of bio resources. This paper describes the development of a two – dimensional depth averaged hydrodynamic model for Chilika Lake and is used for the simulation of currents and salinity for the Southwest and Northeast monsoon seasons. Results for

seasonal circulation and salinity profiles are obtained, which are then validated against the observed data. A comparison between the circulation and salinity patterns from Southwest to Northeast monsoons is also done, which shows an average increase of 60% in salinity values throughout the lake area with the old tidal opening and an increase of around 70% with both the old and the new tidal inlets.

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Physico-chemical characteristics of Muthupettai Mangrove environment, southeast coast of India

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Mangrove ecosystem provides with a series of benefits for coastal populations as a result of its rich biodiversity and high productivity. It plays an important role in maintaining the ecological balance between the coastal and marine systems. Such an important ecosystem is under serious threat due to natural and demographic pressures, which differs in time and space. It is true in the case of Muthupettai mangroves also. The present study, therefore, aims at to characterize the physico-chemical features of the Muthupettai mangrove ecosystem as a mean to monitor the water quality of this fragile ecosystem. Physico-chemical characters viz. temperature (atmospheric and surface water), salinity, pH, dissolved oxygen, nitrate (NO_3-N), nitrite (NO_2-N), silicate (SiO_3-Si) phosphate (PO_4-P), and Particulate Organic Carbon (POC) were recorded for a period of two years from July 1997 to June 1999.

In the present study, ranges noticed in the atmospheric temperature (27-35^{O}C), surface water temperature (26-33 ^{O}C), salinity (20-38‰), pH (7.1-8.7), Dissolved oxygen (3.1-6.35 mg O_2 l^{-1}), NO_3-N (0.15-14.17µM), NO_2-N (0.09-3.58µM), SiO_3-Si (0.6-19.86µM), PO_4-P (0.07-10.3µM) and POC (1.46-85.43 mg1^{-1}) indicate these parameters are within the carrying capacity of the mangrove environment. However, if the natural and demographic pressures continue in a larger scale, it will definitely affect the mangroves of Muthupettai.

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Variations in certain biochemical parameters during the leaf litter decomposition of Excoecaria agallocha under different salinity gradients

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Excoecaria agallocha is one of the abundant mangroves in the Ayiramthengu mangroves (Kollam District, Kerala, India). This plant contributes large quantities of leaf litter to the ecosystem. Yellow senescent leaves of E. agallocha collected from Ayiramthengu mangroves were allowed to decompose on laboratory conditions under three selected salinities for 12 weeks. The salinities selected were 0.2ppt, 10ppt and 30ppt representing fresh water, estuarine and seawater respectively. At weekly intervals, samples of leaf litter from each series were withdrawn. The litter was analyzed quantitatively for Total Nitrogen, Total Protein, Lipid, Water-Soluble Carbohydrate and Organic Carbon. ANCOVA (Analysis of Covariance) technique was applied to statistically analyze whether any significant relationship exists by the parameters and days of decomposition in different salinity gradients by the leaf litter.

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Mangrove distribution study using Remote Sensing techniques, at Bhitarkanika National Park, Orissa

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The Satellite remote sensing has already proved its efficacy in the fields of reconnaissance survey for vegetative cover or distribution of forest species. Satellite Remote Sensing with bands in visible range (Red) and near Infrared spectrum (IR) has been found to be most useful in assessment of forest cover or vegetation health. The comparative assessment between the reflectance values in VR and IR bands from the regions of vegetative growth, known as Normalized Difference Vegetative Index (NDVI) is a universally accepted method for studying the vegetative health of any area.

The present study has been conducted over the Bhitarkanika National Park of Orissa, which is the second largest mangrove patch of India at the estuary of Bramhini and Baitarani river and extended within 20º33'50''N & 20º48'N latitude, and 86º46'50''E & 87º05'E longitudinal extent under administrative jurisdiction of Rajnagar Community block of Kendrapara district.

The study of different mangrove and non-mangrove community distributions on the basis of supervised classification technique followed by the NDVI value calculation over LISS III imagery, revealed presence of mixed vegetation patches within dense mangroves distribution. As mangroves have been found to have distinctly higher NDVI values compared to other terrestrial plant communities, proper demarcation could be done among mangrove communities and mixed vegetations or mesophytic woodlots of the area.

Earlier study of landuse change detection reported transformation of forest or swamp, either to agricultural land, or fallow grazing land with occasional orchard vegetation in last few years. The present observation strengthened the earlier finding, as higher distribution of such mixed vegetation within the mangrove forest has been observed mostly near the forest edges, reflecting a tendency of further forest transformation.

In this paper, the distribution of mangroves and non-mangroves within the demarcated forest area has been discussed on the basis of NDVI values of different vegetation signature.

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Remote Sensing Application in the Assessment of Changes in Pichavaram Mangrove Forest, Tamil Nadu, East Coast of India.

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The total area of mangrove in India is approximately 6740 sq. km., which comprises about 7% of the world total mangrove area. Mangroves are considered as a bridge between terrestrial and coastal aquatic ecosystem. The mangrove development may be pursued by integrating developmental concerns in coastal zones, sea beach vegetation such as sea grasses, coral reefs and coastal fisheries.

The North-eastern part of the Cauvery delta formed by Vellar and Colerron river ends its way in an estuarine ecosystem of Pichavaram before finally merging into the Bay of Bengal. Variation in the composition, extinction and displacement in the coastal wetland plant species functions as clue elements for understanding the degree of transgressive / regressive sea water phases. The magnitude, duration and direction during the past is also revealed by this ecosystem. This event may be directly or indirectly related to Neotectonic activity on a local / regional scale.

In this paper an attempt has been made to study the status of mangrove wetlands of Pichavaram by using Remote Sensing and GIS technique. The changes in the mangrove forest were studied over different periods of times (1970, 1986 and 2002). The study is shows that the mangrove forest keeps reducing between 1970 to 1986. Increased luxuriant growth of mangroves, about 90% (293ha.) was noted in the period between 1986 and 2002 because of the restoration measures.

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Weekly observations on dispersal and sink pathways of the terrigenous flux of the Ganga – Brahmaputra in the Bay of Bengal during NE monsoon

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Analyses of 64 sequential satellite images (October 1999- March 2001) of Indian Remote Sensing Satellite IRS - P4 Ocean Color Monitor OCM (bands around 490, 555, and 670 nm) for Total suspended Matter (TSM), synchronous sea truth data acquisition, and salinity variations have been used to construct dispersal pathways of the surficial fluvial flux in the northern Bay of Bengal during the NE monsoon. From the spatial extent of the plumes of TSM (160-120 km), during the months of October of 1999 and 2000, off the mouth of the Himalayan Rivers the Ganga and the Brahmaputra (G-B), it is deduced that fluvial flux does not dwindle concurrent with the Southwest monsoon, as observed in time series trap in the northern bay. During the NE monsoon, influx of the G-B moves N-S initially, off the mouth, and thereafter advects southwest alongshore in the form of coastal sediment plumes, reducing the salinity of the coastal waters along the entire northern bay during October-December. We have observed a strong relation between enhanced episodic discharges of the Ganga-Brahmaputra and augmented coastal turbidity during weekly events. It is also observed that during short (weekly) events of very high pulse of TSM discharge by the G-B system, the fluvial fluxes do not advect offshorewards into the deeper offshore regions of the north-central bay, but are transported alongshore and distributed along the shelf. The influx of the terrigenous sediment during the NE monsoon therefore has altogether different pathways, then here to before deduce for the G-B system. These observations have implications for a possible different sink pathway, and associated biogenic processes during Heinrich events characterized by a stronger NE monsoon.

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Mathematical modeling for the solute transport

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The field of ground water flow and transport modeling has grown tremendously over past fifteen years. This is mostly due to the need for quantitative estimates of flow and mass transport in the substances. A ground water model is a toll to represent a simplified version of real field site. It is an attempt to take our understanding of the physical, chemical, and biological processes and translate them into mathematical terms. The goal of modeling is to predict the value of an unknown variable such as head in an aquifer system or concentration distribution of given chemical in the aquifer in time and space. This paper represents the various steps involving in the development of ground water flow or solute transport model and it convert into a mathematical model and finally solution of equations using the analytical and numerical methods. Since analytical solutions can be used only for geometrics, homogeneous aquifer and simple boundary conditions, so a computer program is prepared to find solution for a collection of partial differential equation and auxiliary conditions, are also a part of discussion.

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Identification of Ground Water Resources Using Remote Sensing-A Case Study From Coastal Cuddalore, Kurinjipadi, Porto Nova Blocks Cuddalore District, Tamilnadu

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Ground water resources with its potential concealed below the surface expresses itself in the form of anomalous surface manifestations. The advent of remote sensing techniques has opened a new vistas in the ground water identification.

Thus an attempt has been made to identify ground water resources for the development of coastal Cuddalore, Kurinjipadi and Portnova blocks of Cuddalore district Tamilnadu. The study area includes 150 villages. The topography of the area is generally a plain terrain with maximum elevation in the south western region and slopes towards northeast. The Vellar, the Gadilam and Ponnair rivers drain the study area. The geology of the area comprises of Archean Charnockites, Creteaceous fossiliferous limestone formations, Tertiary sandstones and sub-recent to recent soil and sand formations. The geocoded remotely sensed data on 1:50,000 scale corresponding to the Survey of India toposheet 58 M/10 and 58 M/14(IRS1b) has been used for preparing geomorphological map. The features were observed and identified by the tonal variation in shades of red brown and yellow from the imagery. The geomorphologic map shows the different units on the basis of land form expressions and dissection patterns which are Delineated as Shallow high ground (35%), Flood plains (20%) and the Shallow pediments (20%). Among the various land forms identified in this area the most favorable geomorphic unit for ground water is flood plains while unfavorable landform is coastal plain.

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Quantifying Uncertainties in Runoff Estimation for Landuse Units: A Fuzzy Logic Approach

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A fuzzy logic approach is presented to quantify the uncertainties in runoff estimation for land use units namely urban residential areas, parks, commercial and industrial areas, asphalt and concrete roads, and forest areas. The runoff is calculated by considering runoff coefficient and annual maximum 24 hr rainfall as fuzzy imprecise parameters. Membership functions for annual maximum 24 hr rainfall and runoff coefficients of urban residential areas (single apartments and garden apartments), parks, forest areas, commercial and industrial areas, asphalt and concrete roads are developed. A plotting position formula is used to develop the membership function for the annual maximum 24 hr rainfall for a station. Trapezoidal, convex and asymmetric membership functions for the runoff coefficients of urban residential areas, parks and forest areas are developed. The membership functions for commercial and industrial areas and asphalt and concrete roads are considered to have a constant value. A hypothetical dataset for annual maximum 24 hr rainfall at a station for twenty-two years is used for the study. California plotting position formula is used for developing the membership function for annual maximum 24 hr rainfall. A fuzzy arithmetic and interval analysis approach is used to quantify the uncertainties in runoff estimation at different alpha-cut levels. Results reveal that the annual maximum 24 hr rainfall with alpha-cut level of 1 is 6 mm. The runoff with alpha-cut level of 1 at upper bound for the urban residential areas is 3 mm, parks 1.8 mm, forest areas 1.2 mm, commercial and industrial areas 5.4 mm and asphalt and concrete roads 5.1 mm. At alpha-cut level of 0.5, the annual maximum 24 hr rainfall is 9.5 mm and the corresponding runoff at upper bound for the urban residential areas is 5 mm, parks 3 mm, forest areas 2 mm, commercial and industrial areas 8.5

mm and asphalt and concrete roads as 8 mm. This approach can be further extended to a regional scale by integrating remote sensing data, GIS and fuzzy logic for runoff estimation in the mangrove and estuary regions.

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Nutrient Budget in Pichavaram Mangroves.

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The Pichavaram mangroves in south east coast of India is a saline ecosystem with salinity varying from 17-19%. We collected water samples from different locations in order to study the nutrient in put to and out put from the mangrove system and analyzed for major nutrients i.e. DIN & DIP. We collected secondary data from different agencies to study the nutrient budget. DIN and DIP concentration varying from 17.5 μ g l^1 – 22.3 μ g l^{1-} and 0.9 μ g l^1 – 2.95μ g l^1 respectively.

We developed LOICZ model to study the nutrient budget of DIN and DIP and tropic status of the system. The data indicate that the mangrove ecosystem currently oligotropic in state, its Dissolved Inorganic Nitrogen : Dissolved Inorganic Nitrogen (DIN : DIP) ratio ranges from 7.68 – 19.44. The major loss of phosphorus is apparently driven by biological uptake and diagenic reactions in sediment. Phosphorus retention in the sediment and saline state of the system may prevent changes in the autotrophic communities and formation of entropic conditions in the mangrove system.

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International Co-operation in water and Environmental Sector including Coastal Environment between India and Japan.

Iijiama Daisuka
Japan International Co-Operation Agency, Japan

He will be discussing ongoing projects on water and environment between India and Japan. He will give an over view on the Indo-Japanese program over the years in the above aspect.

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Arsenic Speciation in marine algae and seafood products

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Arsenic is metabolized quite differently in foods and water and also in animal species depending on the chemical species administered. The most toxic species being arsenite (As^{III}) and arsenate (As^{V}), which represent main forms of arsenic, present in soils, sediments and water. High concentration of organic form, in a typical range of 1-100 mg Kg^{-1} are reported in algae and marine animals due to accumulation and bio transformation process. The less toxic compounds, such as monomethylarsonate (MMA), dimethyl arsonate (DMA) are sometimes detected in trace amounts in seafood products. The non-toxic organic forms are generally arsenocholine (AsC), arsenobetaine (AsB) and arsenosugars. Latter two are the major biosynthesis products in marine animals. To evaluate the risks associated with the presence of arsenic, the identification and quantification of different species of this element in the complex environment is necessary. In the present study, two independent procedures are described for separation of arsenic species based on liquid

chromatography in combination of ICP-MS detection. These methods are optimized for better selectivity, sensitivity and applicability. The typical chromatogram of HPLC-ICPMS for ion exchange separation. The developed procedures were used for the analysis of arsenic species in two different marine algae and variety of seafood products. In addition, these methods were validated by analysis of reference materials for which, total arsenic, AsB, DMA concentrations are certified.

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Identification of Sources of Salinity in Groundwater in the Coastal Aquifers: A Case Study in Krishna Delta, Andhra Pradesh

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The Krishna district of the Andhra Pradesh covering an area of 4600 sq. km has a flourishing agricultural production. The area lies within North Lattitude 15°44'-16°40' and East Longitude 80°20'-81°30'. The river Krishna flows in SSE direction from Vijaywada to a distance of 65 km and then branches itself before discharging into the Bay of Bengal. Most of the delta area is having canal network originated from the Prakasam Barage located at Vijaywada. The unlined canals flow along the paleo-channels. The demand of groundwater is rapidly increasing because of increasing population and increase in gross area under agricultural and reduction in the canal water supply.

In a recent study, the Andhra Pradesh Ground Water Department (APGWD) on the basis of water quality data obtained from Public Water Supply wells has reported that the salinity front in groundwater is moving landwards (APGWD, 1999). This led a concern regarding the sustainability of the valuable groundwater resources. In order to take any remedial measures to curb salinity it is necessary to know the origin of salinity. With this objective, in the present study, the salinity problem in the Krishna Delta region is investigated using an integrated hydrogeological, hydrochemical and isotopic approaches.

The results obtained for groundwater age using tritium and radiocarbon analyses show an increase in groundwater age along the direction from Prakasam reservoir to the coast. Similarly, the results show an increase in age trend with the groundwater depth. The salinity also follows a trend similar to the groundwater age i.e., an increase in salinity with the depth and in the direction towards the coast. These results along with the stable isotope data indicate that fresh water is mainly recharged at Prakasam Barrage and along the Krishna canal network. The apparent old radiocarbon age for saline deep aquifer attributes to the paleosalinity. The recharge from canal water irrigation is freshening the paleo-salinity. The results obtained at few sites near the coast indicated an active groundwater-seawater interconnection. The radiocarbon ages of the trapped marine water corresponds to the sea-level change in this region.

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Author Index