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Ministry of Earth Sciences, Govt. of India
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NCESS Annual Report 2014 - '15

ANNUAL REPORT 2014 - '15

National Centre for Earth Science Studies
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(ESSO, Ministry of Earth Sciences, Govt. of India)
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Committed to our Earth our Future
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ANNUAL REPORT
वार्षिक प्रतिवेदन

2014 - 2015

National Centre for Earth Science Studies

राष्ट्रीय पृथ्वी विज्ञान अध्ययन केन्द्र

(ESSO, Ministry of Earth Sciences, Govt. of India)

(ई एस एस ओ,पृथ्वी विज्ञान मंत्राालय, भारत सरकार)

Akkulam, Thiruvananthapuram-695011, India

आक्कुलम, तिरुवनंतपुरम–695011, भारत

वार्षिक प्रतिवेदन 2014–15

प्रकाशित

निदेशक,
राष्ट्रीय पृथ्वी विज्ञान अध्ययन केंद्र (एनसीईएसएस)

संपादकीय समिति

डॉ. डी. पद्मलाल
डॉ. एल. शीला नायर
डॉ. डी. एस. सुरेश बाबू

सचिवीय सहायता

श्री. डी. श्रीकांत पाई
श्रीमती एस. आर. रीजा राज
श्रीमती आर. पि रेजानी

Contents

From the Director's Desk

The MoES takeover of CESS gave great vigour and enthusiasm among the research community of the centre in pursuing an integrated approach to the earth system science studies. NCESS recognises the vast potential and promise of research opportunities in implementing major research programmes in the frontier areas of basic and applied aspects of Earth Sciences. Goal for the coming decade will be to achieve and maintain research efforts at internationally competitive level.

The reporting period is another creditable year for NCESS in its efforts to grow as a leading R & D centre of the country in the field of Earth System Sciences. NCESS continued to undertake R&D activities for the improved knowledge of earth's processes and for sustainable development of our natural resources, conservation of environment and mitigation of natural hazards in accordance with its stated objectives.The R&D activities of NCESS is centered on four major spheres of research viz., Crustal Processes, Coastal Processes, Cloud Microphysics & Lightning and Natural Resources & Environmental Management. In addition to the implementation of core project "Earth system dynamics", notable are the implementation of 32 external grant-in-aid projects and 25 consultancy projects for several public/ private sector undertakings and agencies in different parts of our country.

The activities of the Crustal Processes group were focussed mainly on the petrological studies of southern granulite belt, geochemistry and palaeo-magnetism of mafic dykes, formation of palaeo-fluids in petroliferous basins, Quaternary geology and geo-hazards. A collaborative project between NCESS and the Bundelkhand University was undertaken to study the mafic dykes in the Dharwar and Bundelkhand cratons and to identify linkages between the igneous units occurring within the basins. Detailed studies on palaeo-magnetic, major and trace element geochemistry of the Palaeoproterozoic mafic dykes in the Indian shield was also carried out so as to understand the petrogenesis of continental magmatism. Demagnetization experiments, petrological and geochemical studies have been initiated during this period.

A non-destructive methodology was developed to determine the API gravity of oil in hydrocarbon fluid inclusions based on photoluminescence emission to determine the quality of oil. Patent has been filed for the methodology. From the studies on land subsidence in the highlands of Kerala taken up since 2012, a database of the affected sites is created and laboratory-scale mitigation trials are experimented using chemical amelioration techniques. Studies on Quaternary geology, land disturbances, micro-seismicity, neo and active tectonics, electrical resistivity surveys, and geochemical and mineralogical studies were continued in selected localities in SW India. A National Workshop on continental crust and cover sequences in the evolution of the Indian sub-continent was conducted during January 20-21, 2015.

The Coastal Processes Group is continuing its multidisciplinary studies on the coastal land, estuaries, surf zone, nearshore and inner-shelfregions of the west coast. With better instrumentation and numerical modelling capabilities, the group is examining nearshore dynamics, beach-surf zone morphology, coastal hydrogeology, mudbank and estuarine dynamics on a micro scale in order to decipher the complex processes at work in the land-sea interface. Study of near bed sediment dynamics in the surf zone, mapping of sediment thickness and its distribution in the innershelf, measuring submarine ground water discharge, estimation of sediment flux in tidal inlet system and coastal zone management are the major thrust areas of the Coastal Processes Group.

As part of developing methodology to use video imaging for monitoring beach-surf zone morphodynamics and measurement of near shore waves, a long term program has been initiated by the Group. The project in collaboration with ESSO-INCOIS for collection of site-specific, real-time wave data for validation of the daily Ocean State Forecast (OSF) is being continued in the reporting period as well. Site specific OSF information is being disseminated through e-mails and news bulletin of the All India Radio. As instructed by the Hon'ble Supreme Court of India, Integrated Island Management Plans for all the inhabited islands and 3 uninhabited islands of Lakshadweep has been accomplished in record time. Preparation of Coastal Zone Management Plans (CZMPs) of coastal districts of Kerala in 1:25000 and 1:4000 scales are in the final stages of completion.

Studies on intensity, duration, frequency analysis of precipitation micro-physical parameters of south-west monsoon rain has been the thrust areas of the Atmospheric Processes Group. As part of this studies, measurement of cloud and atmospheric parameters from the three stations established at Thiruvananthapuram,Braemore and Agumbeare is being continued. Additionaly, real-time collection of data from AWS as well as data collection from Atmospheric electric field mill and Ceilometer were carried out. The pollutants and weather parameters are also being monitored, as part of MAPAN project of IITM.

In an experimental study to reduce the toxicity of Municipal Solid Waste (MSW) landfill pollutants like dissolved organics, inorganics and heavy metals in leachate and methane, an *in-situ* bioremediation technique has been initiated using a consortium of micro-organisms. The results are highly encouraging. This technique does not require costly installations for recovery and purification of LFG or for leachate treatment units.

Small rivers being one of the most sensitive ecosystems and perhaps the first to be hit by negative impacts of developmental pressures, as part of the Natural Resources and Environmental Management Group's activities, it is planned to conduct an integrated river basin analysis of the two twin- river basins in the western flanks of the Western Ghats, the Periyar- Chalakudi river systems (Kerala state) draining the granulite belt and Netravathi-Gurupur river systems (Karnataka state) draining the Dharwar Craton.

As part of the Sea water Quality Monitoring Programme of MoES, hydrochemical, biological and microbiological parametes are being monitored off Kochi and off Mangalore offshore and Lakshadweep on a regular basis. In order to ensure the drinking water potential of springs, physic-chemical and biological parameters in 200 highland springs in the central Kerala were monitored. The study on water quality parameters and sediment characteristics has been continued in the Cochin backwaters. Analysis of water and sediment quality of the Ashtamudi Wetland System revealed that the Wetland is contaminated moderately with chromium, iron, nickel, and copper. By integrating the thematic layers and attribute data of societal importance, web based user-friendly customized information systems has been designed and developed in open source platform.

With the takeover of Ministry of Earth Sciences, the centre has continued its effort to enhance its infrastructural facilities in a full swing. This year saw setting up of a National Facility for Micro Laser Raman Spectrometer, revitalizing the chemical lab to modern analytical facility, initiating the SEM facility, modular data centre, upgradation of LAN facility with WiFi campus, purchase of various oceanographic equipment etc. By initiating action to set up the paperless office and introduce e-tendering and e-attendance system, we have made major strides in the e-governance also. In pursuit of adopting e-library services, Web of Science and Scopus LAN based online public access catalogue (OPAC) facilities are made available. NCESS continued to extend consultancy services to government departments and public and private sector undertakings on earth science related issues. The Coastal Regulation Zone (CRZ) maps prepared by the Centre for different parts of the Indian coast have enabled decision makers at various levels to arrive at appropriate management action plans and decisions on development projects.

Submission of 30 project reports stands to the testimony of earnest effort of the scientific community of NCESS in achieving the target of completing the sponsored projects. NCESS publication record was moderate with 25 papers in peer reviewed national and international journals, 6 papers/chapters in proceedings/books. In the academic activities also NCESS continued its vibrant activities with 29 Ph. D. students and 1 Ph. D. award during the year. Besides, 25 students completed their B.Tech./M. Tech./ M. Sc. dissertations.

I would like to place on record our appreciation and gratitude to all the members of the NCESS family for their hard work and co-operation. Special thanks are also due to the senior scientists, who superannuated this year, for their invaluable contribution and support in achieving the goals set forth by this institute. I greatly appreciate the unstinted co-operation and support received from the President and members of the NCESS Society, the Chairman and members of the Governing Council, Research Advisory Committee, Finance Committee of NCESS and the Ministry of Earth Sciences.

On behalf of NCESS, I acknowledge with appreciation the relentless service and the commitment of Dr. N. P. Kurian, who superannuated this year. His earnest effort in accomplishing the takeover of CESS by MoES and his contribution in the scientific endeavours of this centre once deeply acknowledged.

Dr. M. Samsuddin
Director, NCESS

1.1 Mafic Volcanic Flows / Sills in the Gwalior, Bijawar Sedimentary Basins

Gwalior, Bijawar and Cuddapah Basins constitute the large Palaeoproterozoic sedimentary basins in India with occurrences of volcanic flows and/or sills in the lower stratigraphic horizons. The igneous activity is generally linked to the dyke magmatism in the adjoining cratons and to the geodynamic development of these marginal basins. A collaborative project between the NCESS and the Bundelkhand University has been initiated with funding from the Department of Science and Technology, Government of India to study petrology, geochemistry and palaeomagnetism coupled with isotope dating of the igneous units occurring within these basins. The project is aimed at integrating and comparing the data with the results produced on mafic dykes in the adjoining Dharwar and Bundelkhand cratons to identify linkages, if any, between them. The results along with own and other published data will summarize and constrain the Palaeoproterozoic igneous activity in India in terms of large igneous provinces across the Archaean cratons of the world and will test different Palaeoproterozoic supercontinental reconstruction models tracing the position of Indian landmass within the reconstruction model.

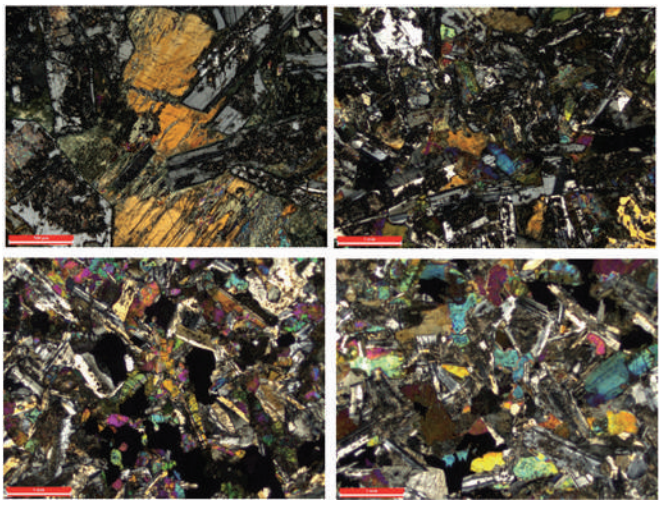

Fig.1.1.1 Photomicrographs of Gwalior and Bijawar igneous units

A fieldwork was carried out during the previous year in the Gwalior and Bijawar Basins. Oriented cores of 2-3 inch long and 1 inch dia were drilled from igneous units at six sites in Bijawar Basin and at eight sites in the Gwalior Basin for palaeomagnetic study and fifteen block samples were collected for major and trace element analysis. During this year thin sections were made and petrography of these

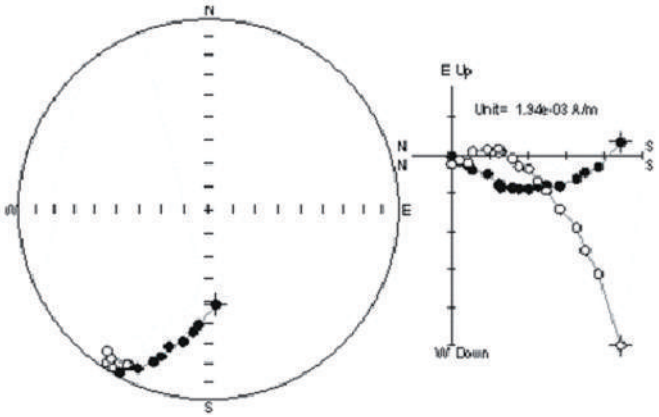

Fig. 1.1.2 Examples of Equal area and orthogonal projections of alternate field demagnetization results from Gwalior traps. In the equal area plot the open and closed symbols indicate projections in the lower and upper hemisphere; in the orthogonal projections, closed symbols are in horizontal plane and open symbols are in the vertical plane.

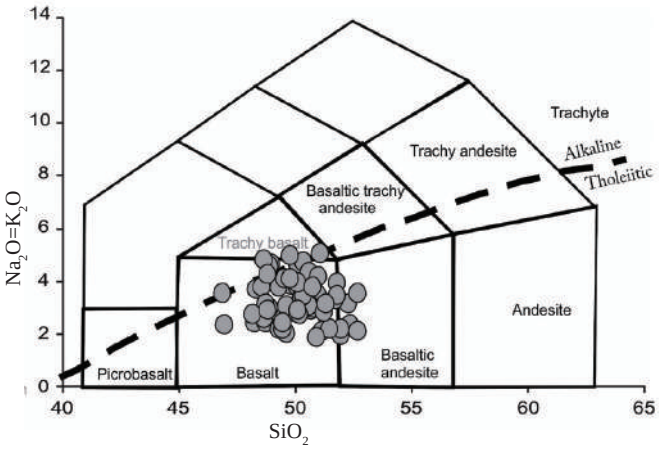

Fig. 1.1.3 Tholeiitic basalt composition of the Gwalior and Bijawar igneous units depicted in total alkali-silica (TAS) diagram by Le maître (2002)

samples was documented. The samples are found to be relatively fresh and are only sparsely altered without any trace of deformation (Fig. 1.1.1). The samples were crushed and pulverised for major and trace element geochemistry. Major oxides were determined by XRF methods. The LOI of all samples were <1 % attesting no major hydrothermal alterations except in one sample for which the LOI was ~3%. Trace elements, including rare earth elements were determined by the ICP-MS.

All the oriented core samples were made into 1 inch dia and long specimens for detailed palaeomagnetic study. Stepwise incremental alternating field demagnetization experiments have been initiated. Natural Remanent Magnetisation (NRM) was determined for 50 samples and demagnetisations attempted at 2.5 mT increments initially up to 40 mT, then 10 mT steps up to 60 mT. Selected

samples where sizable magnetization still retain, were demagnetized at 20 mT steps up to 100 mT. The data were analysed following the standard methods of stereographic projections, orthogonal projections and principal component analysis. A typical demagnetization behavior during alternating field demagnetization experiments is presented in Fig. 1.1.2.

Preliminary analyses of both geochemical and palaeomagnetic data (Fig. 1.1.3) have been carried out by taking into account the field and petrographic details to submit progress report to DST for a mid-term review and also presented in a Group Monitoring Workshop of the PAC-DST at the IIT, Kharagpur.

T. Radhakrishna, Tomson J. Kallukalam & Ram Chandra
Funding: DST, GoI

1.2 Proterozoic Mafic Dykes

Palaeoproterozoic mafic dykes have become the focus of recent research because of their potential in unraveling global continental reconstructions in the early history of the Earth and also in understanding petrogenesis of continental magmatism. The Indian shield comprises one of the five oldest cratons of the world with profuse dyke intrusions of Palaeoproterozoic era. During the previous years, our focus was on the analysis of palaeomagnetic results for testing various continental reconstructions. During this year, thrust has been given detailed analysis of the major and trace element geochemistry of mafic dykes in the Bundelkhand craton. Major and trace element data of 60 dolerite samples have been critically analysed. The samples are all tholeiitic basalts in composition and are the products of variable degrees of fractionation. The Mg numbers typically vary between 0.62 and 0.36. Some of the less fractionated samples appear to have witnessed only limited fractionation of olivine. However, majority of samples show evidences of gabbro fractionation in the latter stages of magmatic evolution. More detailed work on identifying mantle source characteristics is in progress.

The main palaeomagnetic investigations on mafic dykes during this year has focused on reassessing the palaeopole data reported on 1460 Ma dykes on the Eastern Ghat mobile front in the eastern Bastar craton. The palaeopole data were carefully examined in the light of our recent results on Palaeoproterozoic dykes in the Indian shield. Eliminating the pole data comparable to the Palaeoproterozoic poles, a robust pole of Mesoproterozoic has been estimated. Interpretations of the results are in progress.

T. Radhakrishna & Ram Chandra
Funding: DST, GoI

1.3 Late Neoproterozoic Anorthosites in South India

Petrogenesis and emplacement of Proterozoic anorthosites are highly controversial and considered to have important bearing on supercontinent assembly and dispersal. South India is marked by numerous anorthosite-gabbro plutons whose age of emplacement and petrogenesis are relatively unknown. In this background detailed field, petrology, geochemistry and palaeomagnetic investigations on Oddanchatram and Kadavur anorthosites (Fig. 1.3.1 & Fig. 1.3.2) in Dindigal district, Tamilnadu have been initiated.

Fig. 1.3.1 Anorthosite-gabbro layering within Oddanchatram anorthosite.; variation in the thickness ranging to subcentimeter scale is seen.

Fig. 1.3.2 Outcrop of Kadavur anorthosite near Kadavur town

A field work has been carried out to record their physical characteristics and also the geological relationships with the adjoining lithological units. Seventy oriented core

samples for palaeomagnetic investigations and twenty block samples for detailed petrological work were collected. Field observations indicate significant differences in disposition and physical characters of these plutons. The Oddanchatram anorthosite (Fig. 1.3.3) is better exposed as an elongated north east-south west oval shaped body comprising *sensuo stricto* anorthosite in the central region. Towards the southern and northern margins, it becomes more layered with gabbroic assemblages ranging from sub-centimeter to meter scale in width. In contrast to Oddanchatram anorthosite, the Kadavur anorthosite (Fig. 1.3.4) is rarely exposed. Most of the available exposures are deeply weathered and restricted to drainage channels. It is devoid of mafic layering and surrounded by massive gabbro on the margins. The anorthosite and gabbro units are confined to circular ridges of quartzite.

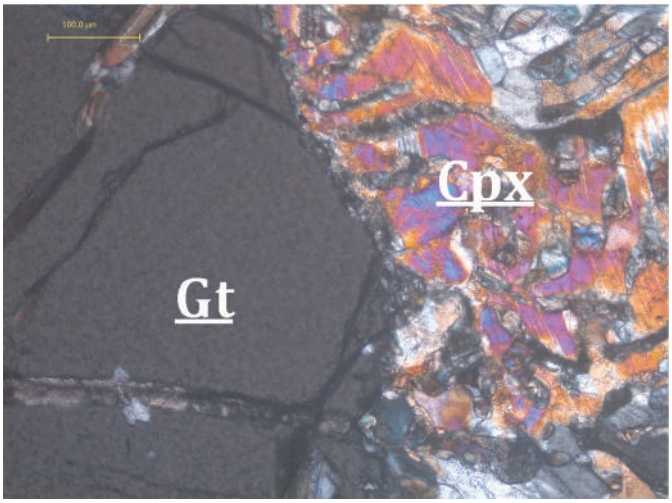

Fig. 1.3.3 Large garnet (Gt) crystals within Oddanchatram anorthosite; clinopyroxene(Cpx) is seen along the margin of the garnet

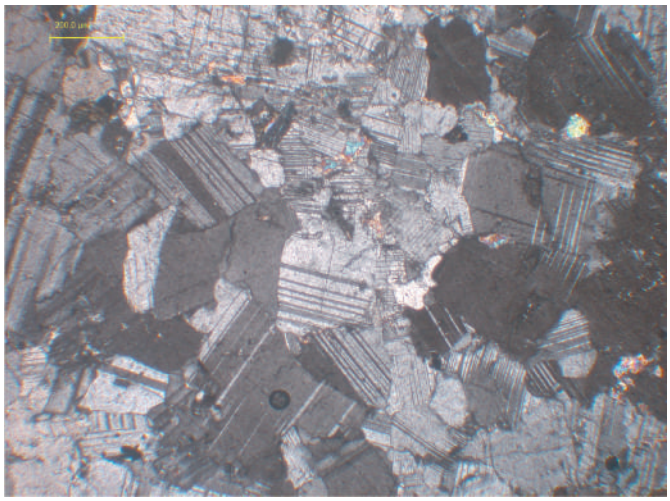

Fig. 1.3.4 Anorthosite from Kadavur comprising plagioclase and fine grained minor mafic minerals

Preliminary petrographic studies reveal that both Oddanchatram and Kadavur anorthosites are comprised of >90% plagioclase and common accessory phases are pyroxene, hornblende, biotite and iron oxides. Primary hornblende in Oddanchatram anorthosite implies presence of water content in the magma. Occasionally the plagioclase is granulated in Kadavur anorthosite.

Electron probe microanalysis (EPMA) has been done for two thin sections of Oddanchatram anorthosites. All the collected oriented core samples have been made into 1 inch dia and long specimens for NRM and demagnetization experiments. Detailed petrological, geochemical and palaeomagnetic studies are in progress.

G. Soumya, Tomson J. Kallukalam & T. Radhakrishna

1.4 Paleao Fluids in the Petroliferous Basins of Western Offshore, India

The potential of Laser Raman Micro Spectroscopy (LRMS) in photoluminescence emission studies on oil inclusions was explored in detail. A non-contact, non-destructive methodology was developed to determine the API gravity of oil in hydrocarbon fluid inclusions (HCFIs) based on photoluminescence emission studies. Using the emission profile of oil in inclusions, the quality of oil such as high or low API gravity could be assessed and further studies on the emission ratio could tell the actual API gravity. It has been observed that the API gravity values obtained for oil in the RV-1 well samples (Fig. 1.4.1) are between 35 and 55 and are commercially viable oils. The developed methodology could be used in real time drilling site to determine the quality of oil and is a quick and convenient technique in petroleum quality assay. *Patent application filed* for the methodology developed with filing *No. 1559/CHE/ 2015 dated March 26, 2015.*

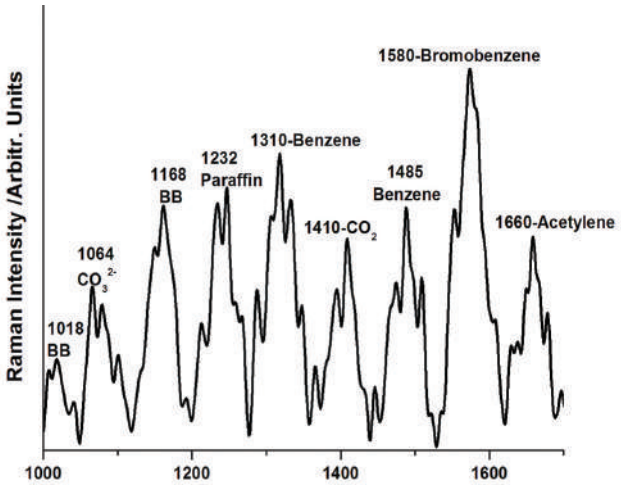

Fig. 1.4.1 Raman spectrum in the middle frequency region of natural HCFIs in the RV-1 well (3495-3500m)

The utility of Raman spectroscopy as a tool for fingerprinting hydrocarbons and also for identifying the major functional groups within oil inclusions/ hydrocarbon bearing fluid inclusions (HCFIs) were also explored. A laser wavelength of 785nm was used for Raman studies since longer wavelength excites less fluorescence. Peaks correspond to cyclohexane (863, 2660, 2938 cm^{-1}), benzene and its derivatives (309, 464, 703, 999, 1310, 1018, 1168 , 1485, 1580cm^{-1}), methane/methylene (2905, 2924, 2848, 2945 cm^{-1}), carbonyl group (1064, 1650 cm^{-1}), paraffin (1232, 2560 cm^{-1}), perchlorate ion (645 cm^{-1}), propane (940, 2740 cm^{-1}), acetylene (1662 cm^{-1}), i-butane (800 cm^{-1}) were identified in HCFIs along with the presence of CO_2 peaks at 1410, 2350 cm^{-1} . Fig. 1.4.1 shows the Raman spectra obtained for oil inclusions in the mid frequency region for RV-1 well. This could be a significant step in the petroleum exploration industry where characterization of HCFIs could be decisive in the development of a well.

Table 1.4.1 Micro thermometric data from KK-4C-A-1 well.

Sample No.	Depth /horizon (m)	Lithology	T_{FM} (°C)	T_{LM} (°C)	T_H (°C)	Salinity (eq. wt% NaCl)	System
1	3215-3220	Claystone, Sandstone, Limestone	-181	-4.5	-80	7.17	CH_4-CO_2-H_2O-NaCl (N_2)
2	3235-3240	Claystone, Sandstone	-64.3	-31.2	15	1.40	CO_2-H_2O-NaCl (CH_4,N_2)
3	3885-3890	Claystone, Sandstone, Limestone	-58.3	-2.2	21	3.71	CO_2-H_2O-NaCl

A total of 619 samples from KK-4C- A-1 well (offshore to Kerala) were obtained from the Regional Geological Laboratory, Panvel. Samples from horizons with claystone and shale were excluded from the study. Representative samples from other lithologies of interest from different depths were selected for the study. A preliminary scanning on the specially prepared 285 wafer samples from 3025-6190 m depth were subjected to petrographic (93 Nos.), micro thermometric (80 Nos.) and Raman Spectroscopic (42 Nos.) studies. Micro thermometry data were used to study the P-V-T-X properties of the entrapped fluids along with the determination of oil window using heating-freezing stage and Bakker program at the Geo-Fluids Research Laboratory (GFRL) of NCESS. Laser Raman Micro Spectrometer (LRMS) at the National Facility for Fluid Inclusion Research (NFFIR) at NCESS was used for the photoluminescence (PL) and Raman spectroscopic studies.

In KK-4C- A-1 well, micro thermometric studies were performed for 80 samples and mostly aqueous phase inclusions that were seen in secondary fractures and cements mostly from quartz and feldspars. Systems such as CO_2-H_2O, CO_2 (l)- CO_2 (g) – NaCl, NaCl-H_2O and H_2O-CO_2-CH_4–N_2 were identified based on the first melting and last melting temperature using heating-freezing stage.

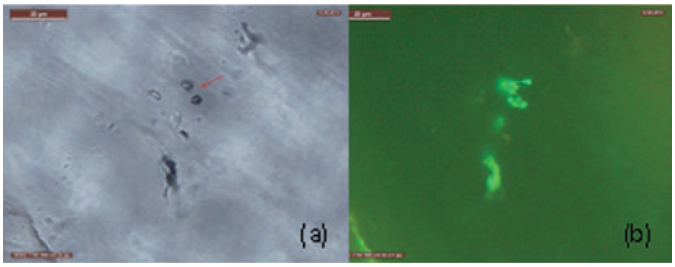

Fig. 1.4.2 Bright field (a) and fluorescent (b) images from the oil inclusion in KK-4C-A-1 well (depth 3950-3955m)

Table 1.4.1 shows the micro thermometer data obtained from the well.

Presence of hydrocarbons were observed at the horizon depths 3890-3895, 4020-4025, 3950-3955 m while doing petrography (Fig. 1.4.2 & Fig. 1.4.3). The first two horizons are of sandstone- claystone lithologies and the latter one is of claystone- limestone lithology (Table 1.4.2). Inclusion sample at a depth of 4020-4025m and a coevial inclusion showed a temperature of homogenization at 155°C, which is indicative of overheating for oil with medium to high API gravities.

The API gravity of oil from the HCFIs of the KK-4C-A-1 well were determined using the recently developed technique.The values arrived at are between 20 and 30 that indicating the entrapment of heavy grade oil which are of low commercial viability.

Table 1.4.2 Oil inclusions in KK-4C-A-1 well with horizon depth and lithology

Sl. No.	Depth /horizon (m)	Lithology
Oil inclusion 1	3890-3895	Sandstone, claystone
Oil inclusion 2	3950-3955	Claystone, limestone
Oil inclusion 3	4020-4025	Claystone, sandstone

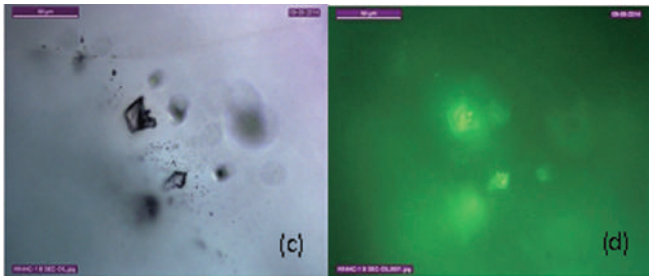

Fig. 1.4.3 Bright field (c) and fluorescent (d) images from the oil inclusion in KK-4C-A-1 well (depth 3890-3895m)

Raman Spectroscopic studies were performed on non-HCFIs too and the species present were identified (Fig. 1.4.4). Peaks corresponds to species such as CO_3^{2-}(1064 cm^{-1}), calcite (1081 cm^{-1}), SiO_2 (1160 cm^{-1}), CO_2(l) and CO_2(g) (1281, 1385 cm^{-1}), N_2 (2330 cm^{-1}) and CH_4 (2926 cm^{-1}) were present in the fluid inclusions of samples of KK-4C- A-1 well. Presence of water in liquid form shows

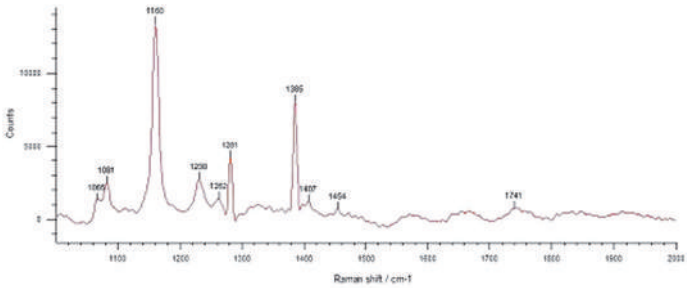

Fig. 1.4.4 Raman peaks for non-HCFI from KK-4C-A-1 well (3940-39455 m)

a broad peak around 3000 - 3500 cm^{-1}. More specialized fluid inclusion wafers are to be prepared to ascertain the availability, API gravity and extent of hydrocarbons in different horizons in the KK-4C- A-1 well from the already available samples. Raman Spectroscopic studies are in progress for both RV-1 and KK-4C- A-1 well samples.

V. Nandakumar
Funding: MoES, GoI

1.5 Graphitization Process in Kollam district, Kerala, India

Graphite and graphite bearing rocks having different mineral assemblages occur in khondalite suite of rocks, like quartzo feldspathic gneiss, garnet-biobite gneiss, and granetiferrous biotite gneiss. In some sampling locations graphite occurs as coarse grains/flakes, hosted in laterite or weathered khondalite. Associated minerals could not be identified as the rock is in weathered condition. Graphite samples from almost all the localities are flaky in nature. The flaky nature is indicative of the good quality nature of graphite. 10 representative samples were collected from 3 taluks of Kollam district.

The compiled X-Ray Diffraction (XRD) data reveals highly crystalline and highly ordered nature of the graphite as evidenced by the sharp and well defined peaks at 2Ø values 26.61°, 26.35° and 54.45° having inter-planar spacing $d_{(002)}$ values (3.35A° to 3.38A° and (1.68A°) respectively.The Scanning Electron Microscopic (SEM) data of the graphite samples from all the study area was compiled. The photomicrographs of the samples from Nilamel, Azhanthakuzhy and Cherukara display triangular markings on the base. Arrangement of well-formed, platy individual layers of flakes is exhibited by SEM photos of Ottumala and Karalikonam. The SEM photos representing graphite from Chithara, Eyyappacha and Boundaa rymukku, show hexagonal outline with prominent basal plane having perfect micaceous cleavage. The graphite samples from Manjappara, Ottumala and Arayil are arranged in a book type stacking sequence.

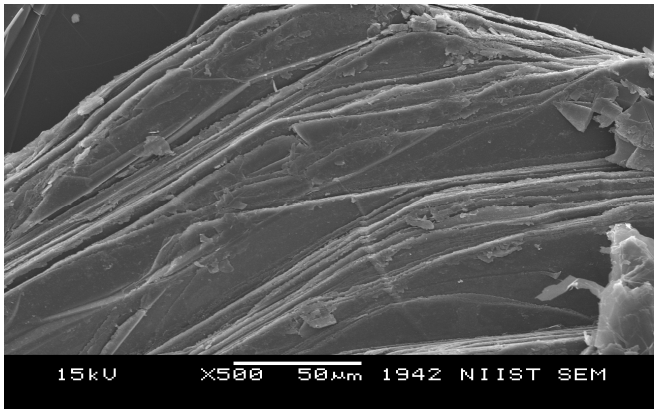

Fig. 1.5.1 SEM photograph of the graphite

The unique morphology and textural pattern displayed by SEM photomicrographs (Fig. 1.5.1) correlate well with the high degree of crystallinity and slow cooling rate as proved by the well-defined and sharp peaks in the X-Ray Diffractograms. Through these studies important clues are obtained in the mineralization history as well as the formation environment (high pressure, temperature metamorphic) of the flaky graphite.

The graphite occurrence in Kollam district is found to be of high grade with more than 85% carbon. The stable isotopic values of carbon ($\delta^{13}C$) vary significantly indicating difference in the origin of graphite from different sources. Manjappara and Ottumala graphite show sedimentary origin and/or showing tendency towards sedimentary origin with ($\delta^{13}C$) value of 18.7 ‰ and 22.4 ‰ respectively. Arayil and Eyyappacha graphite indicate remobilization origin and have ($\delta^{13}C$) values of -6.4 ‰ and -7.9 ‰ respectively.

Ansom Sebastian

1.6 Late Quaternary Geology of the Coastal lands of Southern Kerala, India with special reference to Palaeoclimate and coastal evolution

Earth has been subjected to dramatic changes in environment throughout its geologic history. The changes were most striking in the Quaternary period - the time span representing the last two million years of earth's history. The Quaternary period comprises two epochs- the Pleistocene epoch (2 million yrs BP to 10 kilo yrs BP) and the Holocene epoch (<10 kilo yrs BP). The Pleistocene epoch comprises four principal glacial episodes separated by warmer interglacial periods. During glacial period, sea level began to lower and the rivers could no longer shift their courses, instead cut its own valley to deeper level rather than widening its valley. The Last Glacial Maximum (LGM), occurred around 18 kilo yrs BP, witnessed lowering of sea level to about 120 m with respect to the present Mean Sea

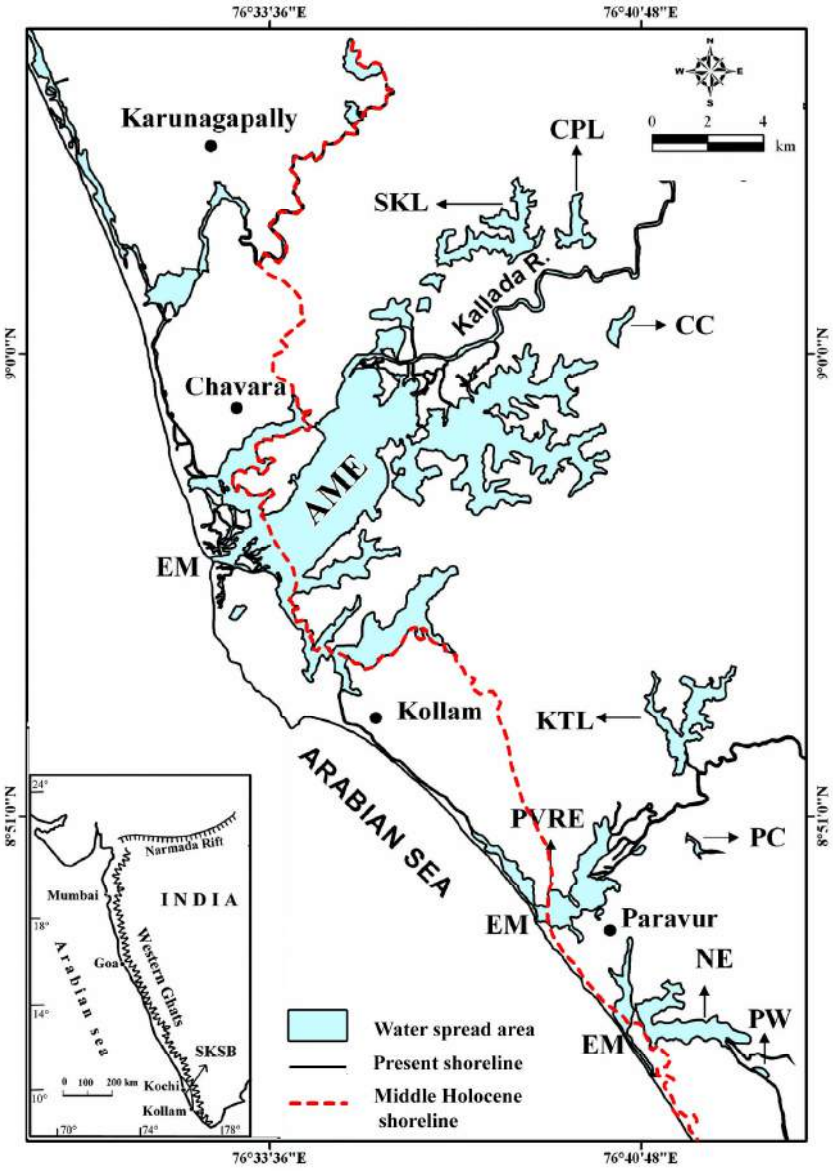

Fig. 1.6.1 Study area showing the present and Middle Holocene shoreline positions; AME Ashtamudi estuary; SKL Sasthamkotta lake; CPL Chelupola lake; CC Chittumala chira; PVRE Paravur estuary; KTL Kota lake; PC Polachira; NE Nadayara estuary; PW Poovankal wetland; EM Estuarine mouth; SKSB (inset) South Kerala Sedimentary Basin

Level. This was followed by a sea level rise in the interglacial period. During the rising spells of the sea, rivers began to meander within their incised valleys, depositing its load in the form of point bar and / or over bank deposits. Like many other tropical coasts, the south western coast of India, especially the coastal lands of Kerala also responded remarkably to Late Quaternary climate and sea level changes. A better understanding of the same receives special significance as a major proportion of the State's population and economic activity are centered on the coastal lands. In addition to this, many of the economically viable mineral resources like heavy mineral sands, lime shells, glass sands, tile/ brick earths etc., are also associated with the Quaternary sedimentary deposits in the coastal lands. Further, the sedimentary archives of Late Quaternary age preserve reliable records of sea level and climate changes which in turn have a strong bearing on human settlements/migration history of the area. In the light of this, a study has been undertaken in the Late Quaternary sediments of the Cenozoic belt of southern Kerala, i.e. south of Achankovil Shear Zone (ASZ), with special reference to palaeoclimate and coastal evolution. The entire area selected for the present study (Fig. 1.6.1) lies between North latitudes 8°40' - 9°30' and East longitudes 76°20' - 77°00', and falls within the Trivandrum block of Peninsular India.

The study area hosts a series of estuarine basins – coast parallel and coast perpendicular. The coast perpendicular estuaries are seen entrenched over the uplifted Neogene sedimentary formations. The size of these estuarine basins shows a progressive decrease towards south. The average width of these estuaries is many times higher than that of the rivers joining these estuaries. These estuarine basins enfold a full record of Holocene transgressive-regressive events in the 30-40m thick sediment fill. Borehole cores collected from the fluvial end of the estuarine basins reveal a coarsening upward sequence with high organic input in the lower silt and clay dominated sediments. A multi-proxy analysis of the bore hole cores shows that sedimentation in these basins took place under fluctuating climate and sea level conditions of Holocene. Similarity in the radiocarbon ages of uprooted, buried riparian plant remains (7490 ± 90 yrs BP) with that of the embedding sediments (7480 ± 80 yrs BP) indicates rapid sedimentation in the river confluence zones during Early Holocene. The progradation of sediments in the form of a bay head delta during Early Holocene and fast deposition of sediments under the rising spells of sea were responsible for the separation of some of the prominent arms of the pre-estuarine basins into fresh water lakes. Among the fresh water lakes of this kind, the Lake Sasthamkotta evolved from the cut-off of a prominent arm of the pre-Ashtamudi basin due to progradation of the Kallada Bay Head Delta is the largest one in the southwest coast of India. The upper part of the deltaic plains of the estuaries is blanketed by 2-3m thick yellowish brown, mud dominated sediments with higher $\delta^{13}C$(-19.56‰) and $\delta^{15}N$ (8.85‰) values than the lower part ($\delta^{13}C$-28.17‰; $\delta^{15}N$ 3.92‰). This is indicative of marine origin

of the sediment blanket which is later subjected to sub-aerial weathering and degradation of organic matter and iron containing minerals imparting yellow or yellowish brown coloration to the sediments. The colouration of the exposed sediments, occurrence of calcareous nodules in the sediment cores retrieved from the marginal areas of the estuarine basins etc., are indicative of dry phase at around 5-4 kyrs BP. This was followed again by a high rainfall period before stabilizing the climate to the present. The coastal lands north of the Ashtamudi estuary have been subjected to severe coastal erosion from Late Pleistocene onwards. As a result, the entire area has been leveled down leaving a chain of wetlands on its east as a mark of the once existed coastal plain rivers. At the same time coastal erosion and cliff retreat is now aggressive in areas south of the Ashtamudi estuary.

S. Vishnu Mohan, D. Padmalal & K. Sajan
Funding: CSIR

1.7 Palaeoclimate and Sea Level Records in the Late Quaternary Sediments of the Coastal Wetlands of Pallikkal and Achankovil River Basins, Kerala

The discrete array of wetlands that are seen incised over the lateritic terrains in the lowlands of the Pallikkal and Achankovil river basins enfold a fairly thick blanket of Late Quaternary sediments whose radiocarbon dates vary between 46570±3480 and 2460± 120yrs BP. The oldest date is recorded for the sediment sample at a depth of 5m below ground level (bgl) of the Valummel Punja borehole core and the youngest for the vegetative material at a depth of 3m bgl of the Ramapuram borehole core. Most of the Late Pleistocene sediments are confined mainly to the eastern side of the study area and also seen underlying the Holocene sands and clays in the western side. Sediments in the younger coastal plains in the west and also some of the wood samples in the eastern wetlands exhibit Holocene age. Among the Holocene dates, the oldest date was recorded for a wood sample collected from Vatta *kayal,* one of the important wetlands in the eastern periphery. This indicates that the eastern wetlands that existed during late Pleistocene and supported marine brackish water fauna and flora were later transformed to fresh water swamps during Holocene.

It is reported that the Muthukulam borehole core retrieved from the younger coastal plains in the west showed C^{14} dates 3662 ± 114 yrs BP (depth 1.27-1.35 m bgl), 6276 ± 112 yrs BP (2.07-2.12 m bgl) and 7176 ± 82 yrs BP (3.0-3.10 m bgl). The sediment sample at a depth of 20.4 mbgl of the Ayiramthengu borehole was ^{14}C dated 40000yrs BP. However, a shell sample at a depth of 4.75 mbgl in the same borehole core gave Late Holocene date (2580±110 yrs BP). Two carbonaceous clay samples of Pathiyur borehole from 5.0 m (40,000 yrs BP) and 9.0 m (28830 ± 2330 yrs BP) levels gave Late Pleistocene age. Almost similar date has been obtained for a peat sample at 1.0 m level (20600 ± 1030 yrs BP) and organic matter rich sediment at 10.0 m level (43738 ± 574 yrs BP) of the Komallur borehole core. The geological section of the study area (Fig. 1.7.1) reveals records of two transgressive events - one corresponds to the NNE-SSW trending beach ridge and the other to NNWE-SSE trending beach ridge. The heavy rainfall during periods of lowered sea level around 40-30 kyrs BP might have resulted in carving wide and deep channels and wetlands in the eastern side.

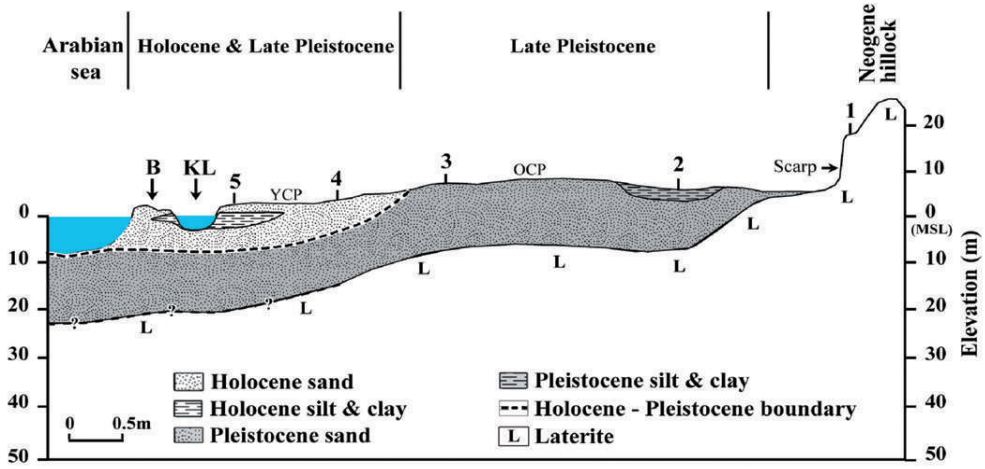

Fig. 1.7.1 A transect along Vayyankara chira (1) – Komallur (2) – Pathiyur (3) – Ramapuram (4) – Muthukulam borehole locations. KL Kayamkulam Lagoon; B Beach; YCP Young Coastal Plain; OCP Old Coastal Plain.

However, the events in 10-7kyrs BP have affected only half of the coastal area as evidenced from the coast parallel beach ridges. In short, the observed geochronology and landform features of the study area unveil the effects of Late Pleistocene - Early Holocene geological events in giving rise to the observed features in the coastal lowlands of Pallikkal and Achankovil river basins.

D. Padmalal, K. Maya & S. Vishnu Mohan

1.8 Quaternary Geology, Paleoclimate and Geomorphic Evolution of Central Kerala, SW India (MoES Plan)

The study of Quaternary sediments has attained great importance in recent years as it is now generally accepted that the present day landscape and environment are essentially the products of various processes that operated during the Quaternary period. Further, the Quaternary sediments are expected to contain records of past sea level and climate changes, information of which is very essential for developing high resolution predictive models of future climate and sea level changes. The coastal areas of Indian subcontinent contain Late Quaternary sediments in its estuaries, lagoons and nearby coastal lowlands. Therefore, a systematic study has been undertaken in the SW coast of India, especially the coastal lowlands between Periyar and Kadaludi rivers of Central Kerala, to unfold the palaeoclimate and sea level records in its coastal sedimentary archives, using multiproxy analysis of a series of borehole cores retrived from the area. In connection with this investigation, reconnaissance field surveys were conducted in the area to collect representative samples from different landforms. Also, identified 10 sites for borehole drilling from the coastal segment between Periyar and Karuvannur rivers. A survey of published studies reveals that the region is blanketed by a maximum of 30-50m thick Late Quaternary sediments whose age ranges from 1828±520 yrs BP to 40000 yrs BP. Out of the total 42 ^{14}C dates available from the secondary records, about 83% of the dates are of Holocene and the remaining (17%) are of Late Pleistocene. The Late Pleistocene sediments, occur as pockets within the Holocene dominated sediment blanket. This reiterates that greater land modifications had occurred during Holocene rather than Late Pleistocene. The floodplains of the Periyar, Chalakudy and the Karuvannur rivers contain a fairly complete record of Holocene sediments - carbonaceous clays, peat and yellowish brown silty clays. The peat is ^{14}C dated 6630±120 yrs BP. Sedimentological, palaeontological and stable isotope ($\delta^{15}N$ and $\delta^{13}C$) analysis of the sediments are in progress.

D. Padmalal & K. Maya

1.9 Monitoring Indian Shield Seismicity with 10 BBS to understand Seismotectonics of the region using Vsat connectivity

Broadband seismic observatory at Peechi, being operated by CESS (present NCESS) in the campus of the Kerala Forest Research Institute (KFRI) was established in 1999, as a part of strengthening earthquake monitoring in the peninsular India and for improving the detection and identification of location capabilities of earthquakes in the shield region. Major objectives of the project are to maintain and operate the Seismic Observatory at Peechi to produce high resolution seismic data.

A total of 2018 local events were recorded during the period March 2014 - February 2015. In addition, there were records of 1856 global events, 15 events from other parts of India and 55 from the Andaman-Nicobar region. Among the regional events, 7 events are from the neighboring areas of Karnataka and Andhra. Andhra tremors were mainly from Guntur and Prakasam Districts whereas the Karnataka tremor was from Sakaleshpur-Mudigere border. Seismic activity in India was relatively low this year. Indian events are mainly from Koyna, Assam, Manipur, Mizoram, and Arunachalpradesh-Myanmar border. The 8.2 magnitude Chile, 7.6 magnitude earthquake of Solomon Islands, 7.9 near Alaska and 7.1 near Fiji were some of the major teleseismic earthquakes recorded in the observatory during the period.

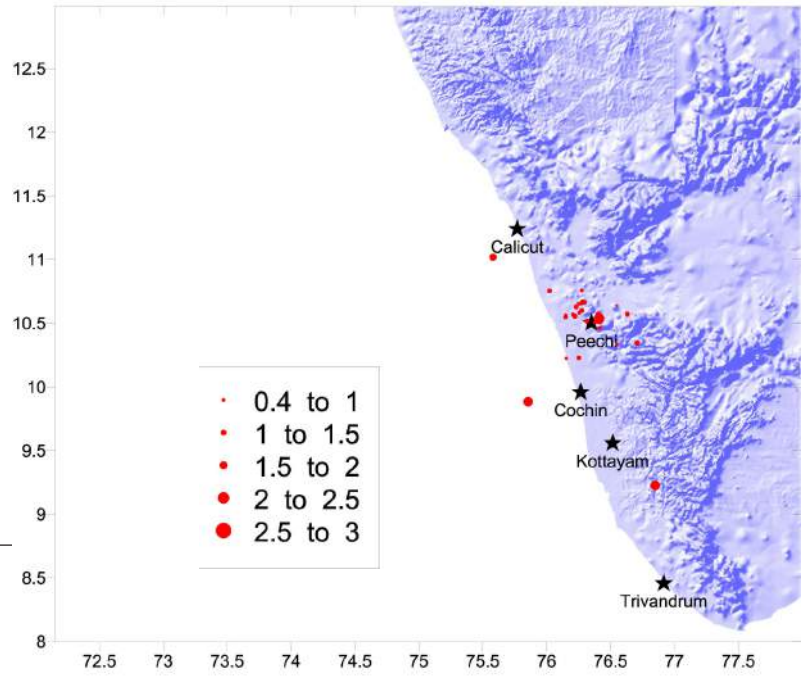

Fig. 1.9.1 Location of tremors recorded from Kerala During March 2014-February 2015.

Table 1.9.1 List of tremors recorded at Peechi in March 2014-February 2015

Sl. No.	Date	Lattitude	Logitude	Magnitude	O. time (UTC)	Region
1	05/03/2014				05:01:49	~184 km from Peechi, Thrissur
2	06/03/2014	10.525	76.413	0.9	12:34:18.63	Peechi Dam Area, Thrissur
3	12/03/2014	10.555	76.411	1.6	22:52:07.34	Peechi Dam Area, Thrissur
4	15/03/2014	10.537	76.409	1.6	04:48:28.01	Peechi Dam Area, Thrissur
5	19/03/2014	10.225	76.154	1.0	12:01:03.32	Near Sreenarayanpuram, Thrissur
6	23/03/2014	09.227	76.849	2.8	22:23:26.38	Konni, Pathanamthitta
7	30/03/2014	10.542	76.380	1.3	05:44:31.00	Peechi Dam Area, Thrissur
8	01/04/2014	10.534	76.405	1.3	17:25:50.07	Peechi Dam Area, Thrissur
9	01/04/2014	10.755	76.023	1.7	22:01:45.18	Alamcode,Malappuram
10	09/04/2014	10.666	76.294	1.2	06:22:52.68	Attur, Thrissur
11	10/04/2014	10.473	76.423	0.9	14:45:15.64	Peechi Dam Area, Thrissur
12	19/04/2014	10.543	76.410	1.0	07:22:35.00	Peechi Dam Area, Thrissur
13	20/04/2014	10.648	76.255	0.9	07:27:36.00	Panagattukara, 2.6 km SE Wadakanchery, Palakkad
14	28/04/2014	10.537	76.410	1.5	03:04:05.40	Peechi Dam Area, Thrissur
15	01/05/2014	11.020	75.580	2.1	12:46:25.65	100 km , NW of Peechi in the sea
16	04/05/2014	09.884	75.855	2.6	20:23:07.93	44 km W of Kannamaly in the Sea
17	09/05/2014	10.524	76.414	0.9	04:16:04.60	Peechi Dam Area, Thrissur
18	14/05/2014	10.539	76.410	0.4	07:53:56.55	PeechiDam Area, Thrissur
19	18/05/2014	10.667	76.287	0.9	19:48:05.12	Attur, Thrissur
20	18/05/2014	10.669	76.287	1.0	20:01:48.27	Attur, Thrissur
21	22/06/2014	10.229	76.252	1.5	18:15:25.15	SW Mala, Thrissur
22	26/06/2014	10.655	76.270	1.3	11:27:27.53	3.3 km West of Attur, Thrissur
23	26/06/2014	10.665	76.293	1.9	13:33:54.12	Attur,Thrissur
24	26/06/2014	10.665	76.295	1.8	12:59:02.46	Attur, Thrissur
25	26/06/2014	10.664	76.289	1.1	12:59:32.27	Attur, Thrissur
26	26/06/2014	10.665	76.291	1.1	13:03:41.21	Attur, Thrissur
27	26/06/2014	10.666	76.296	1.0	13:04:50.74	Attur, Thrissur
28	30/06/2014	10.516	76.314	1.6	14:18:42.73	Cherumkuzhy, near Kannara, Peechi
29	03/07/2014	10.670	76.281	1.6	18:24:00.56	Near Attur, Chittanda reserve forest
30	03/07/2014	10.627	76.237	0.9	18:28:33.29	Near Attur, Chittanda reserve forest
31	04/07/2014	10.640	76.551	0.9	15:35:38.26	Near Alattur,Palakkad
32	19/07/2014	10.524	76.321	1.2	12:17:27.00	Cherumkuzhy, near Kannara, Thrissur
33	26/07/2014	10.462	76.412	1.1	22:02:51.00	5.8 km NW Chimmony dam, Forest area, Thrissur
34	11/08/2014	10.551	76.149	1.6	05:56:46.95	Adattu, Thrissur
35	11/08/2014	10.563	76.149	1.3	10:09:41.63	Adattu, Thrissur
36	25/08/2014	10.630	76.231	1.7	23:15:15.33	Kuranchery, Thrissur
37	26/08/2014	10.337	76.549	1.2	20:40:30.96	Pariyaram, Thrissur
38	30/08/2014	10.534	76.408	0.9	18:40:02.83	Peechi Dam Area, Thrissur
39	30/08/2014	10.536	76.409	1.2	22:52:49.76	Peechi Dam Area, Thrissur
40	30/08/2014	10.536	76.407	1.4	22:56:07.27	Peechi Dam Area, Thrissur
41	02/09/2014	10.532	76.408	0.4	00:33:02.47	Peechi Dam Area, Thrissur
42	05/09/2014	10.532	76.410	2.0	01:57:06.84	Peechi Dam Area, Thrissur
43	05/09/2014	10.535	76.412	1.6	02:01:47.93	Peechi Dam Area, Thrissur
44	05/09/2014	10.537	76.411	1.6	05:31:29.35	Peechi Dam Area, Thrissur
45	05/09/2014	10.556	76.220	1.7	20:07:41.69	Ramavarmapuram, Thrissur
46	06/09/2014	10.656	76.269	0.7	18:10:58.58	Karumathara, Thrissur

47	07/09/2014	10.530	76.407	0.7	08:15:32.06	Peechi Dam Area, Thrissur
48	07/09/2014	10.537	76.413	2.7	17:02:19.64	Peechi Dam Area, Thrissur
49	07/09/2014	10.537	76.411	1.2	17:10:48.47	Peechi Dam Area, Thrissur
50	07/09/2014	10.538	76.412	2.3	18:21:14.41	Peechi Dam Area, Thrissur
51	07/09/2014	10.535	76.411	1.7	19:50:20.13	Peechi Dam Area, Thrissur
52	07/09/2014	10.530	76.409	0.8	20:07:06.82	Peechi Dam Area, Thrissur
53	08/09/2014	10.539	76.411	1.1	00:29:57.04	Peechi Dam Area, Thrissur
54	11/09/2014	10.534	76.406	1.1	01:24:06.63	Peechi Dam Area, Thrissur
55	11/09/2014	10.539	76.409	1.3	11:07:31.18	Peechi Dam Area, Thrissur
56	11/09/2014	10.535	76.410	1.7	11:08:41.55	Peechi Dam Area, Thrissur
57	11/09/2014	10.532	76.410	2.2	11:12:18.50	Peechi Dam Area, Thrissur
58	11/09/2014	10.532	76.411	2.7	11:12:04.12	Peechi Dam Area, Thrissur
59	15/09/2014	10.504	76.378	1.3	02:13:42.10	Anakuzhy, 5 km SE Peechi station
60	25/09/2014	10.570	76.206	1.3	01:02:16.68	Kolazhy, Thrissur
61	17/10/2014	10.560	76.407	2.1	02:55:29.19	Near Kuthiran, Thrissur
62	19/10/2014	10.539	76.410	2.4	04:04:02.54	Peechi Dam Area, Thrissur
63	23/10/2014	10.551	76.414	2.1	05:03:07.99	Near Kuthiran, Thrissur
64	23/10/2014	10.550	76.410	0.9	13:42:33.95	Near Kuthiran, Thrissur
65	26/10/2014	10.345	76.708	1.8	01:26:16.66	Near Sholayar, Thrissur
66	27/10/2014	10.530	76.411	1.2	10:50:05.07	Peechi Dam Area, Thrissur
67	03/11/2014	10.663	76.283	1.3	11:14:02	Near Attur, Thrissur
68	03/11/2014	10.541	76.420	2.2	13:50:52.62	Peechi Dam Area, Thrissur
69	06/11/2014	10.668	76.308	0.8	23:16:52.34	Attur, Thrissur
70	06/11/2014	10.669	76.299	0.7	23:18:52.3	Attur, Thrissur
71	14/11/2014	10.537	76.413	1.5	01:54:50	Peechi Dam Area, Thrissur
72	25/11/2014	10.534	76.408	0.9	18:58:55.92	Peechi Dam Area, Thrissur
73	25/11/2014	10.543	76.412	1.1	21:40:15.92	Peechi Dam Area, Thrissur
74	27/11/2014	10.543	76.408	1.6	14:38:41.17	Peechi Dam Area, Thrissur
75	30/11/2014	10.552	76.414	1.3	01:42:29.42	Peechi Dam Area, Thrissur
76	28/12/2014	10.557	76.416	1.4	09:24:30.10	Peechi Dam Area, Thrissur
77	12/01/2015	10.572	76.632	1.8	23:52:50.43	Near Poothundy dam, Palakkad
78	17/01/2015	10.658	76.245	0.5	23:06:29	Wadakkanchery, Palakkad
79	18/01/2015	10.759	76.275	1.3	02:03:09	Shoranur, Palakkad
80	27/01/2015	10.518	76.410	1.8	03:00:42.93	Peechi Dam Area, Thrissur
81	04/02/2015	10.550	76.415	2.0	03:13:18.89	Peechi Dam Area, Thrissur
82	04/02/2015	10.539	76.413	1.5	03:13:5032	Peechi Dam Area, Thrissur
83	06/02/2015	10.556	76.409	1.3	06:47:47.30	Peechi Dam Area, Thrissur
84	15/02/2015	10.601	76.275	1.5	04:03:29.79	Kundukad, Thrissur
85	15/02/2015	10.582	76.257	1.0	04:25:54.78	Thannikudam, Thrissur

Sreekumari Kesavan
Funding: MoES, GoI

1.10 Land Subsidence in the Highlands of Kerala

During high rains, especially during monsoons, land subsidence and landslides occur in many parts of Western Ghats. Eventhough landslides are very common in highlands, the incidences of land subsidence were noticed only recently. The first major occurrence was reported in 2005 from Chattivayal in the Thirumeni village of Kannur district, Kerala. Since then from many parts of the state land subsidences were reported. Other than Trivandrum, Kollam and Alappuazha almost all the districts in the state have reported incidence of land subsidence.

The studies carried out indicated that the land subsidences are caused by the internal soil erosion called tunnel erosion or soil piping. The cavities and pipes developed below the ground grow with respect to time. The development of subsurface tunnels will result in weakening the overburden. Subsidence of the overburden occurs over a period of time. The soil piping affected soils are not suitable for cultivation or any development purposes. Infact the soil piping affected land converts a fertile land to a totally a waste land. Systematic investigations were taken up since 2012 to create a data base of the affected sites, to study the processes

responsible for those destructive events and to contain the adversities of soil piping.

Data base on soil piping : A data base was created on the soil piping affected regions in the southern Western Ghats. The data base is being updated by incorporating

Fig. 1.10.1 Inside the tunnel, Niranganpara, Iritty taluk, Kannur district

Fig. 1.10.2 Failed roof of tunnel inside the well, Niranganpara, Iritty taluk, Kannur district

new incidences. A new incident which occurred in July 2014 in the Niranganpara locality (Fig. 1.10.1 and Fig. 1.10.2) in Ayyankunnu panchayath, Thalasseri taluk in the Kannur district evoked lot of public attention. A subsidence has occurred inside a well (N12°02'09.4", E75°45'07.2"). The affected locality is in the foot hills and surrounded by hilly area. Piping has affected the saprolite clay below the laterite. The piping outlet is located at 120m north of this area. The soil is 1.5m thick and overlying the well-developed laterite. The slope of the terrain as well as the orientation of the tunnel were Northwest direction. The underground tunnels formed are found to be affected by the ground water storage of the wells in this area.

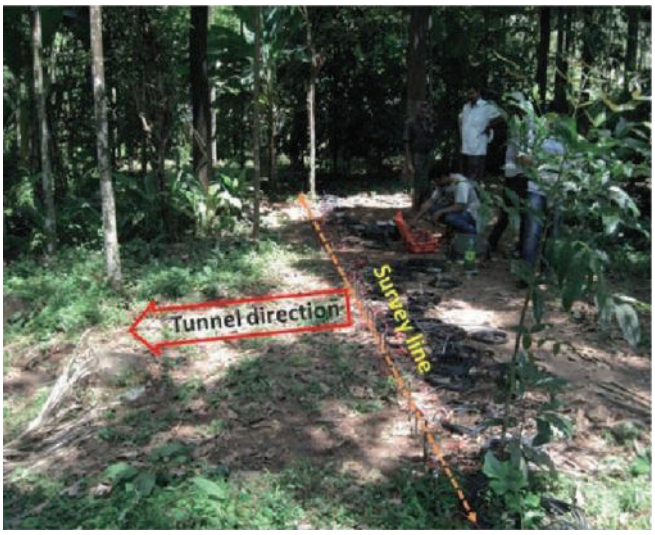

Fig. 1.10.3 Electrical resistivity survey at Kottathalachimala, Kannur

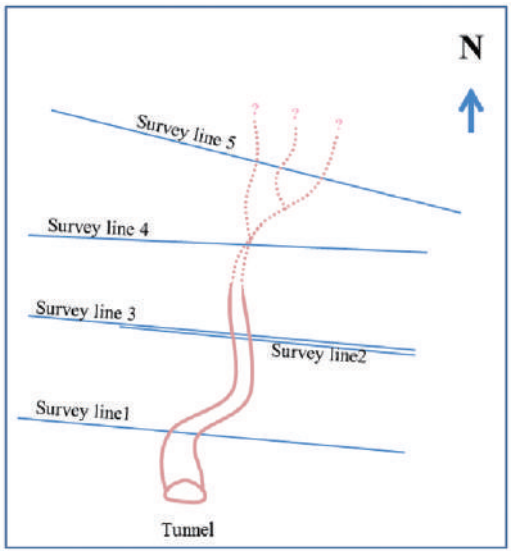

Fig. 1.10.4 The layout of Electrical Resistivity survey line (figure not to scale)

Field Surveys : Field surveys were conducted in Niranganpara locality in Ayyankunnu panchayath,, Kannur district, Kuttikol in Kasargod and Peringassery and

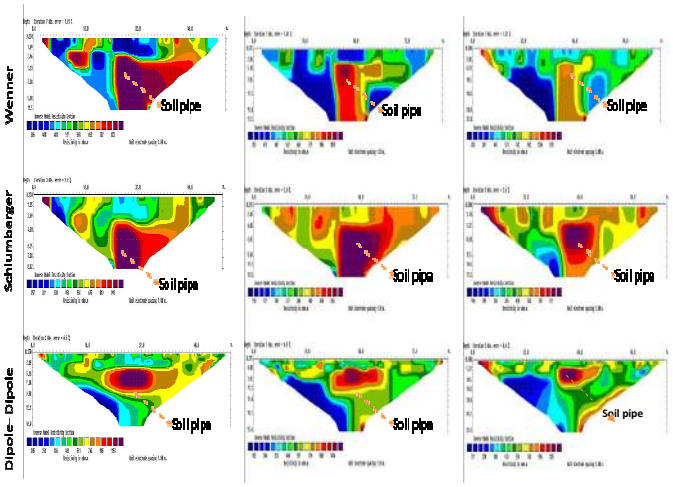

Fig. 1.10.5 Electrical Resistivity Tomographic section in different electrode spacing

Tattekanni, in the Udumbanoor and Kanjikuzhi village in the Thodupuzha taluk of the Idukki district.

Electrical Resistivity Surveys (Geophysical surveys): The 2D Electrical Resistivity imaging experiments using Electrical Resistivity survey techniques were used at Kottathalachimala near Cherupuzha, Kannur district across the alignment of a known soil pipe by using the WGMD-4 Multi-function instrument. Electrical resistivity tomography has been carried out over five mutually parallel profiles using a 60 electrode-setup (Fig. 1.10.3). A minimum of 0.25m to a maximum of 2.0m spacing has been used as electrode configuration. Use of larger electrode spacing has been constrained due to the nature of the terrain.

The five survey profiles were laid in the West-East direction (Fig. 1.10.3). Profiles are laid above an established soil pipe. The terrain gently slopes towards north hence the elevation gradually decreases from profile 1 to profile 5. ERT at profile 1 is carried out using five different electrode spacing. Profile 1a,1b,1c,1d and 1e correspond to ERT at profile 1 with electrode spacing equal to 0.25m, 0.50m, 1.00m, 1.50m and 2.00m respectively.

Profiles 2 and 3 are laid almost parallel (Fig. 1.10.4) to profile 1 at a distance of about 27m north of it. The central electrode for profile 2 is about 8m east of central electrode for profile 3. Profile 2a and 2b correspond to electrode spacing of 0.50m and 1.00m respectively. Profiles 3a and 3b correspond to electrode spacing of 1.50m and 2.00m respectively. Profile 4 is laid further towards north at a distance of about 18m from profiles 2 and 3. The electrode spacing used for profiles 4a and 4b are 1.00m and 1.50m respectively. Profile 5 is laid in the NW-SE direction with the first electrode towards north-west. Electrode spacing of 1.00m and 1.50 m has been used for profiles 5a and 5b respectively.

Another experiment was conducted with profile with different electrode separation were laid parallel to the pipe in north south direction (Fig. 1.10.6 - Fig. 1.10.8) mid-point of survey is 30m north of the pipe entrance on the down slope side oriented in the North to South direction. at Kottathalachimala in Kannur district.

The dipole-dipole configuration has the highest investigation depth and a highly resistive region can be observed for this array just below the surface. This high resistive region can be attributed to the roof of the tunnel. From the earlier analyzed data we are concluded that the dipole-dipole configuration has the highest investigation depth; this array configuration clearly brings out the entire

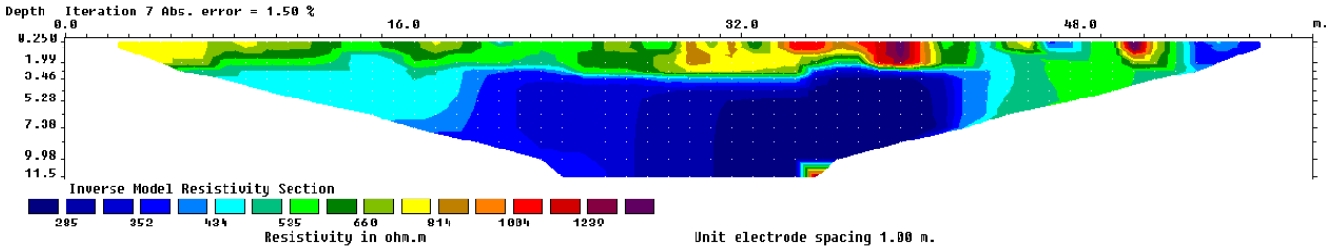

Fig. 1.10.6 Electrical Resistivity Tomographic section of Schlumberger array at 1m electrode spacing

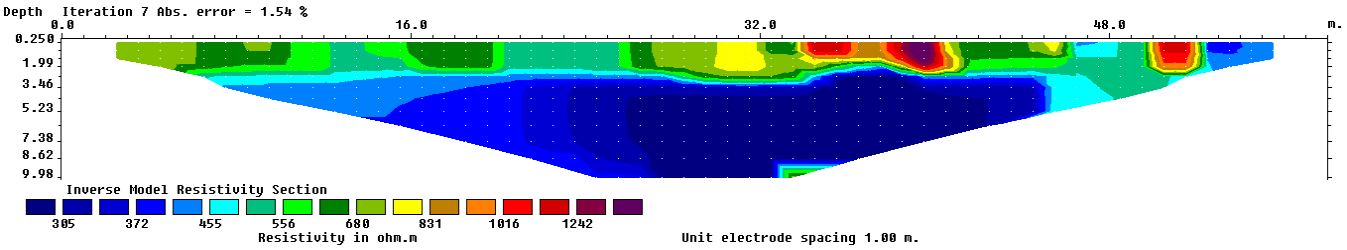

Fig. 1.10.7 Electrical Resistivity Tomographic section of Wenner array at 1m electrode spacing

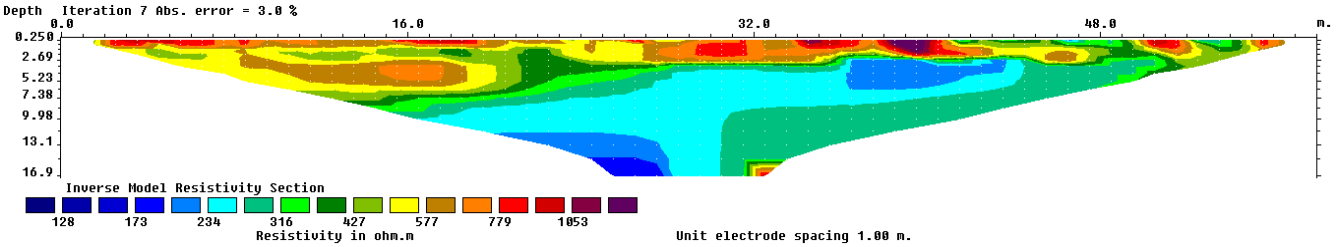

Fig. *1.10.8 Electrical Resistivity Tomographic section of Dipole-Dipole array at 1m electrode spacing*

tunnel cross-section. Wenner and Schlumberger array fails to map the vertical extent of the soil pipe but it can be used for differentiating piping from the rock boulders. Across all the qualitative interpretation of the resistivity section indicates that the technique could delineate the conductive zones where the soil pipes are present. For detailed investigation need more electrical resistivity surveys data information from the other piping location.

Investigations with Push camera:

The underground tunnels formed by the soil piping process have many branching small tunnels. Often they are either small or water filled making it impossible for further investigations. Push Cameras are highly useful in under water operations and small tunnel investigations. One such Camera was used (Fig. 1.10.9) for visual investigation of tunnel branches at Chattivayal in Kannur district for studying sediment deposition and branching. The camera has a cable length of 100meters enabling to cover deeper levels. The information from camera was recorded in both video and picture modes (Fig. 1.10.10).

Geochemical studies: Nine samples (Table 1.10.1) were collected for analysis from Idukki district. The six soil samples were collected from the premises of the non-piping area, by using hand auger at different depths and thickness from the surface. The three samples (I-23, I-24 and I-25) were taken from the piping affected area in Peringassery and Venniyanimala of the Idukki district.

Analysis of samples (Table 1.10.2) indicate that the sample I-21 shows an organic carbon percentage of 3.40 %. The soil sample was collected from a depth of 50 cm at a location with an elevation of 877m. The sample I-25 shows relatively low organic carbon content (0.48%). This sample was collected from a piping affected locality with an elevation of 492m. In general, vertical distribution of organic carbon in soil is decreasing with depth. By comparing samples of the piping and non piping areas, organic carbon is rich in non-piping area and low in piping area.

Table 1.10.3 shows pH, EC and TDS of nine samples collected from both piping and non piping areas. In non-piping areas (I-17, I-18, I-19, I-20, I-21, I-22) the samples show variation in pH, EC and TDS. The pH of the sample ranges from 5.63 to 6.02, EC from3.84µs/m to 13.22 µs/m and TDS from 2.72ppm to 9.38 ppm in non-piping area. In piping affected area (I-23, I-24, I-25) pH value ranges from 5 to 5.91, EC from 5.49µs/m to 21.52µs/m and TDS from 3.95 to 15.29 ppm.

Sedimentalogical and geochemical analyses were carried out on the samples collected from the affected sites. 12 soil samples were collected from Kottathalachi mala during 04-

Fig. 1.10.9 Experimenting with Push Camera inside the Tunnel in Chattivayal, Kannur

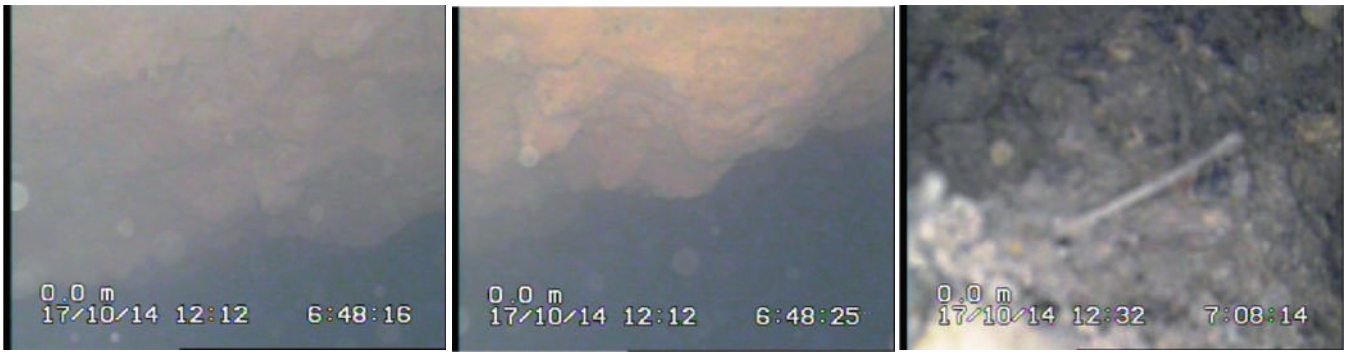

Fig. 1.10.10 The images taken by Push Camera from inside the pipes (filled with water)

Table 1.10.1 Location and other relevant details of samples

Sl. No.	Sample number	Location	Latitude	Longitude	Type of Sample
1	I 17	Nalaam Mile	N 9°39'34.0"	E 765°59'29.4"	Soil (Non piping area)
2	I 18	NalaamMile			Soil (Non piping area)
3	I 19	Nalaam Mile			Soil (Non piping area)
4	I 20	Nalaam Mile	N 9°39'37.4"	E 765°59'28.5"	Soil (Non piping area)
5	I 21	Nalaam Mile			Soil (Non piping area)
6	I 22	Nalaam Mile			Soil (Non piping area)
7	I 23	Peringassery	N $9^0$52'2.9"	E $76^0$51'28.4"	Soil Piping area
8	I 24	Peringassery	N $9^0$52'2.9"	E $76^0$51'28.4"	Soil Piping area
9	I 25	Venniyanimala	N$9^0$51'39.3"	E $76^0$51'16.8"	Soil Piping area

Table 1.10.3 Analytical results of soil samples collected from Idukki

Sl. No.	Sample code	pH	E C (µs/m)	TDS (ppm)
1	I-17	5.63	10.85	7.70
2	I-18	5.74	13.22	9.38
3	I-19	5.96	5.22	3.70
4	I-20	6.02	10.16	7.21
5	I-21	5.71	6.66	4.72
6	I-22	6.00	3.84	2.72
7	I-23	5.85	7.33	5.22
8	I-24	5.00	21.52	15.29
9	I-25	5.91	5.49	3.95

Table 1.10.2 Organic carbon and organic matter percentage of samples

Sl. No.	Sample code	Organic carbon (%)	Organic matter (%)
1	I-17	2.49	4.30
2	I-18	2.04	3.52
3	I-19	0.97	1.67
4	I-20	2.98	5.14
5	I-21	3.40	5.87
6	I-22	2.49	4.30
7	I-23	0.75	1.29
8	I-24	0.69	1.18
9	I-25	0.48	0.82

03-2014 and 05-03-2014 and 1 rock sample from Kottathalachi mala on 19-03-2014 for further laboratory examinations.

The textural analysis of the samples from the affected area shows (Table 1.10.4) a high percentage of sand. The maximum percentage was shown by 6-WAY-(68.96%) and minimum by K-42 (23.75%). The maximum percentage of silt (46.82) was shown by K-40 and minimum (4.58%) by 6-WAY. Higher values of clay 54.86% was indicated by K42 and a lower value of clay (12.25%) was shown by K45. XRD analysis was carried out on 5 samples collected from Kasaragod (KSD), Kannur (KTM) and Wayanad (WAY) soil samples. The XRD studies reveled that, gibbsite, zeolite and kaolinite are more dominant followed by quartz. Presence of gibbsite and other clay minerals enhance the absorption capacity of soil. This indicates prominent leaching material which confirms the erosional activity in that region.

Mitigation: Management of surface and subsurface hydrology is the one of the methods adopted to arrest the soil piping process. Diverting water to the nearest naturally occuring drains for rapid discharge will considerably reduce the erosive power of the subsurface flow. However chemical amelioration techniques are found to be one of the effective methods to contain the erosion.

Labaratoray scale mitigation trials were experimented using chemical amelioration techniques: Chemical amelioration by adding gypsum ($CaSO_4 2H_2O$) to improves physical properties of sodic soils such as infiltration rate and hydraulic conductivity in addition to decreasing excess Na+ levels was studied. For this five soil sample of 20g each collect from different piping location were tested by adding gypsum at different amount (0.5g, 1g, 1.5g, 2g and one free of gypsum); treated for 15hr. These trials showed positive indications of slowing down of the dispersion tendency. More tests are needed to calculate the rate of change with addition of gypsum. Hydrated lime (calcium hydroxide) has also been widely used to prevent piping. Rates of application have varied depending on soils and degree of compaction used in construction. Laboratory testing usually indicates that only around 0.5 –1.0% hydrated lime is required to prevent dispersion.

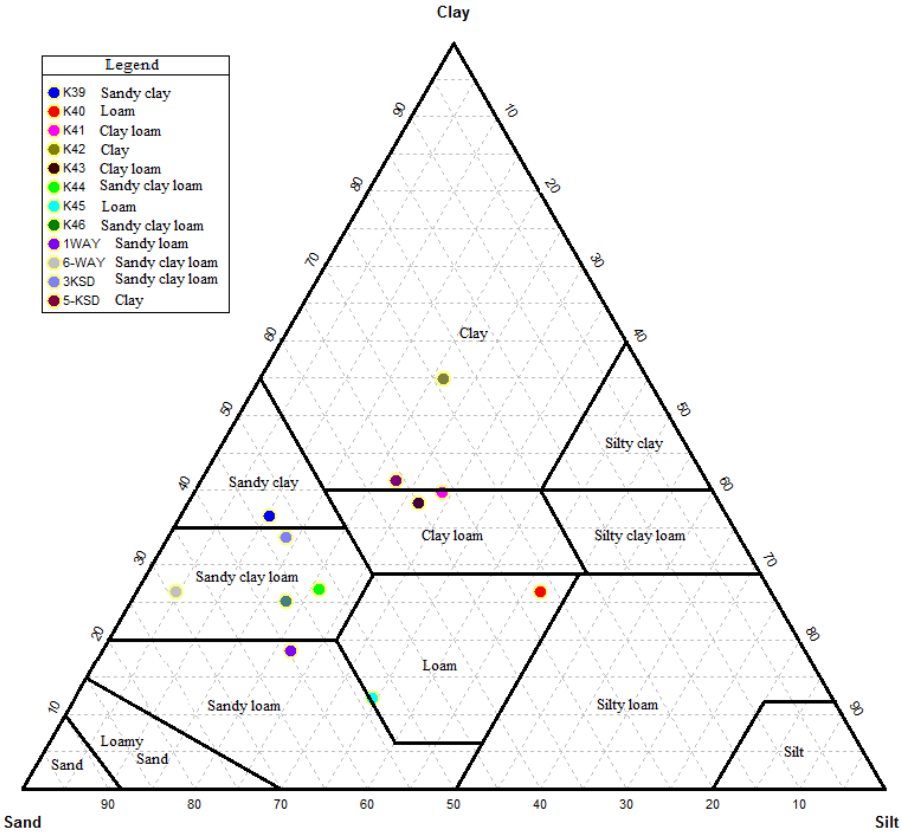

Table 1.10.4 Ternary diagram for classification of soil texture (USDA)

processes and forms. In this context reconnaissance surveys were carried out in the Sahyadris and adjacent regions falling in Karnataka and Maharashtra to select few areas prone to landslides and to elucidate geomorphology and structural geology imprints along suspected faults and lineaments.

Reconnaissance surveys: Traverses in the Coorg region indicates the presence of slope instability along the road sections especially in Medikeri-Sullya sector (Fig. 1.11.1), Subramania-Kudrasthe sector and in the Shiradi Ghat sector. Cutting and levelling of steep hill facets in the northern part of Medikeri town can trigger instability in critical segments. The presence of fresh down dip slickenslides on the foliation planes in finely laminated gneisses near Subrah mania, sheared metadolerites filled with assymmetrically folded quartz veins near Enjira on Bangalore-Mangalore Highway and the presence of deep valley fill deposits with terraces at different levels near Bhagmandla

G. Sankar
Funding: NDMA, GoI

1.11 Surficial Earth Processes-Studies in the Sahyadris

Evaluation of landforms having close relation to regions of active tectonics provide basic data for long-term prediction of natural hazards especially landslides and earthquakes. This is mainly due to the fact that tectonic rates are reflected in rates and patterns of geomorphic

Fig. 1.11.1 A distant view of slope failure intiated in the lithomargic clay at the base of a deep laterite profile at Kadwad near Karwar.

Fig. 1.11.2 Road section near Medikeri shows the presence of a crack in steep road cutting that can develop as a potential surface of failure

are indicative of continuing tectonic activity in this region. Critical segments of instability were noted in the Agumbe Ghats and on the way from Jog falls to Honnavar and Bhatkal in Karnataka, Ambe Ghat near Kolhapur, Patan Ghats and Mahabaleswar in Satara district, Ingaloon, Ambegaon and Khandala ghat areas in Pune district of Maharashtra. The pattern of weathering and erosion in the Deccan basalt region leading to the formation of flat bottom valleys flanked by long and steep side slopes with terraces at different levels and the presence of active lineaments are significant in defining locales of possible landslides.

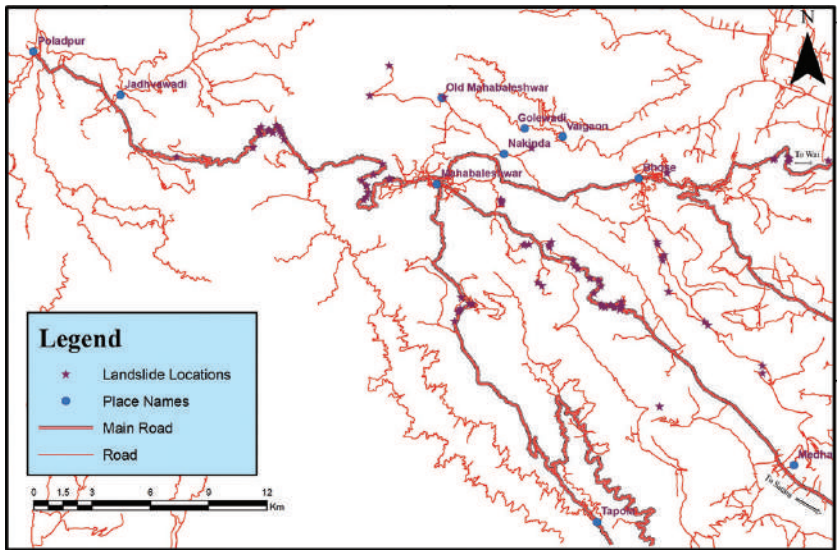

Fig. 1.11.3 Landslides occure in Mahabaleswar region

Landslide at Malin: Investigation of the landslide affected Malin site shows that the failed surface is a rectilinear slope of over 150 m height and >32^0 slope with an ill defined hollow in the centre. The slope is moderately vegetated and terraced cultivation is practised at least at two levels on the slope. The overburden of 2-3 m thick is underlain by blocky basaltic rock with N-S, E-W and subhorizontal joints. Deep weathering along E-W planes is evident from the profile. The crown region where the slip has been initiated merges with the floor of an ephemeral drainage channel that conducts water from a wide flat topped crestal portion to the valley. Diversion of the overland flow from the flat upper crestal portion into the drainage channel has resulted in the channel exceeding its normal capacity leading to oversaturation of the adjacent hollow portion and its failure. The location of the dwelling units directly in the path of the debris flow has resulted in the large number of casualties. Another minor debris flow is seen on the eastern side.

Landslide occurrence in Mahabaleswar region: Detailed studies were carried out in the Mahabaleswar region -mainly along the road sections- to document the recent occurrence of landslides (Fig. 1.11.3) and to elucidate the broad causative terrain factors to the region. Over sixty landslide affected locations have been identified in the study area. Most of the failed surfaces are the steep slopes of road cuttings with little vegetation cover (Fig. 1.11.4). The traverse from Mahabaleswar to Poladpur, Satara, Tapola and Wai reveals the presence of many failures. Some of the villages have also suffered by landslides.

Fig. 1.11.4 Failed surfaces are the steep slopes of road cuttings with little vegetation cover.

The annual average rainfall in this region is 600 cm making it one of the wettest regions in the country. Bulk of this rain is received in the month of July and August (430 cm), when large number of landslide events are reported. Though intense rainfall is a causative factor, the common association of the affected sites to certain lithology, landform and a higher level of human intervention was noticed. Deccan basalt with multiple flows of Mahabaleswar, Ambenali and Poladpur formations form

Fig.1.11.5 Sub-horizontal flows in nature

Fig. 1.11.6 Distinct flow with red coloured weathered zone

the dominant lithology of the region. The flows are mostly sub-horizontal in nature (Fig. 1.11.5). The upper most part of a flow is distinct with a red coloured weathered zone (Fig.1.11.6), underlain by an extremely vescicular layer. The lower most part of the flow is often massive but with subvertical arcuate joints mostly oriented NNW-SSE and NNE-SSW.

The dominant landform of the region is nearly flat topped hills flanked by very steep slopes interrupted with terraces of limited width at lower elevations (Fig. 1.11.5). The terraces are the locations of the upper weathered part of a flow that support vegetation while the steep slopes depict massive basalts of the lower part of the flow that is either barren or with sparse vegetation. The flat topped crestal portions in Mahabaleswar region is characterised by luxuriant vegetation that holds the soil and adds stability to the upper surface. Landslide occurrences are more common in areas where the red clay rich weathered zone is exposed in a steeply sloping man made cutting with little vegetation cover. In periods of intense rain, the water that percolates through the joints are arrested by the weathered red coloured clay rich zone that act as an impervious layer.

Fig. 1.11.7 Circular cracks have developed with creep damage in buildings and cemented road, Bhekavali Village, Mahabaleswar, Satara, Maharashtra

When the cohesive strength of this clay rich layer exceeds the pore water pressure, failure takes place. The presence of vegetation cover adds to the strength resisting pore pressure.

Some of the localities with settlement have been inferred to be affected by landslides. In Bhekavali Village (17^0 54' 58" N, 73^0 41' 31" E) circular cracks have developed with creep damaging four buildings and a cemented road (Fig. 1.11.7). The event initiated on 13th July, 2014 and continued for eight days. The area with terraces at different levels, mainly for cultivation, is being converted for settlement and would require intervention for the stabilisation of the region. Similalry past occurrence of landslides were noted in Navli, Machutar, Tekavli, Erandal, Dhardev, Adhal, Dhanavli, Rajni, Umbari, Par, Chikhali, Ghavri and Yermukh Village all these areas need a detailed investigations to delineate critical land failures.

John Mathai & G. Sankar

1.12 Impact of Human activities in the generation of land disturbances in Humid tropical highland areas - a study in Idukki district, Kerala

This study aims to investigate the role of human activities in the generation of land disturbances mainly in the form of landslides in Idukki district, Kerala. The district is characterized by dynamic land use changes due to population pressure mostly in the form of migration. This is one of the areas in Kerala where maximum deforestation of tropical rainforests, with the consequent replacement by plantation and settlement has taken place. Settlements and cultivation have been extended even in the hazardous slopes which in turn increased the risk factor of landslides.

As part of this study extensive fieldwork was carried out the Idukki district and also collected secondary level data from various village/panchayat/ taluk offices. Based on the field observations and the inferences from the secondary data, five panchayats having habitual occurrence of landslide phenomena are identified for comprehensive study. Analysis of spatial distribution and growth pattern of population and analysis scope based Young's formulae are progressing.

C. Ganapathy & K. Raju
Funding: Post -metric scholarship of the Scheduled Caste Development Dept., Govt. of Kerala

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1.13 Analysis of Natural Hazards along a Tropical Highland basin with special emphasis on Flood and Landslides: Panamaram Watershed, Wayanad district, Kerala

Broad objectives of the study are to identify and assess the physical factors that causes natural hazards, to analyse the impact of landslides and flood on the environment, to arrive at vulnerability of people living at hazard prone areas and to evolve recommendations for the mitigation hazard induced problems in the study area.

A reconnaissance survey was conducted in the study area and visited various taluk/ panchayat offices, research institutions and agriculture offices for collection of secondary level data on the subject.

N. P. Ragi & K. Raju
Funding: UGC / JRF

2.1 Integrated study on estuary, beach and innershelf dynamics of west coast of India (Core program-I of CoP)

The integrated study on Estuary-Beach-Innershelf Dynamics pertaining to the southwest coast of India between Koyilandy and Puthiyapa in northern Kerala was initiated in July 2014. The coast has a complex morphology consisting of tidal inlets at Kadalundi, Beypore, Kallayi and Elathur; coastal plains along the Beypore – Kozhikode sector; promontories at Elathur and Kollam; seawalls along Beypore-Kozhikode and Elathur-Koyilandi sectors; groins at Kallayi and Kappad and harbor breakwaters at Beypore, Vellayil, Puthiyapa and Koyilandi. Occurrence of mudbanks was also observed along the Koyilandi-Kappad sector (Fig. 2.1.1).

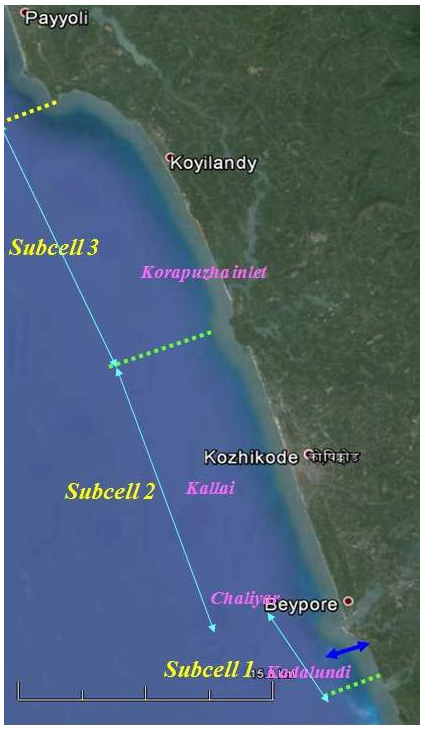

Fig. 2.1.1 Location Map

During the reconnoiter surveys, 16 beach monitoring stations were identified for regular beach profile measurements and LEO observations. Two major morphological sediment cells and three sub-cells have been identified in the study area (Fig. 2.1.1). Mapping of shoreline and other geomorphological features, sediment and water sampling and their analysis for suspended sediment load, texture, clay minerals, etc.,were carried out. Sediment and water samples were collected from 8 locations along two transects from the innershelf with depth ranging from 4 to 13 m to understand the sediment characteristics and distribution in the study area. Two sediment cores were also collected. All the collected samples were analyzed for suspended sediment concentration (SSC), texture and clay minerals. (Table 2.1.1). Collected samples were also prepared for chemical analysis. The process of procurement of the same has been initiated. Based on the reconnoiter study and suggestions of NCESS, in the last RAC some of the envisaged objectives were fine tuned within the core theme of the coastal processes group.

Tran -sect	Sample No.	Water Depth (m)	Sediment Type	Sediment Size (microns)	Heavy mineral (%)	Water Samples SSC (g/lt.)	Clay Minerals
I	1	4	Medium silt	13.12	7	0.01469	Kaolinite is dominant mineral with illite, gibbsite and chlorite as minor minerals
	2	6.5	Coarse silt	16.90	1.02	0.02963	
	3	10	Medium silt	14.35	-	0.035319	
	4	12	Coarse silt	17.56	0.12	0.01469	
II	5	13	Medium silt	13.10	4.54	0.018089	
	6	9.5	Very coarse silt	33.65	4.50	0.02297	
	7	7	Medium silt	12.06	7.33	0.035539	
	8	8	Fine sand	83.84	1.34	0.0408842	

Table 2.1.1 Characteristics of surficial sediments and suspended sediment contents in the water samples off Kozhikode during July 2014

The major objectives of the project are:

- Developing a reliable methodology to use video imaging for monitoring of beach-surf zone morphodynamics and nearshore waves including breaker wave-surf zone processes. Formulation of methodologies to collect reliable real time data on nearshore waves, wave breaking, surf zone waves, rip currents, longshore currents, longshore bar, rhythmic morphology and sediment characteristics for beach-surf zone system.
- Developing prediction capabilities for nearshore processes, nearshore sea state, wind-wave set up, etc.
- Study of near bed sediment dynamics in the surf zone and enhancing the prediction capabilities of nearshore sediment transport due to surf zone currents.
- Mapping of sediment thickness and distribution in the innershelf to obtain stratigraphic structure and nature of bottom sediments.
- Measuring submarine ground water discharge through field mapping to understand the fresh and saline water interaction and mud suspension and its role in the formation, cessation and dissipation of mudbank.

- Estimation of sediment flux in tidal inlet system to develop hydrodynamic model for the system.

Measurement of Submarine Groundwater Discharge (SGD) was carried out through field mapping and resistivity surveys to understand the fresh and saline water interaction and mud suspension in the nearshore waters. Normally the ground water either fresh, saline or both that escapes or recirculates from coastal margins into the marine environment; it commonly occurs as seepage, submarine springs, and tidally controlled groundwater discharge from unconfined as well as artesian aquifers. The flow may be driven by terrestrial hydraulic gradient, water level differences across a permeable barrier, along with different marine processes such as wave set up, tidally driven oscillations, density-driven convections and thermal convection. It acts as a pathway for material transport to marine environment. Different processes that cause significant impact on the hydrochemistry of surface and subsurface discharges to marine environment can be human use of surface water and groundwater for agricultural, industrial and domestic purposes and subsequent waste water treatment, reuse and disposal practices. The study on SGD focuses particularly on discharge rate and also on an amount of pollution loads into ocean.

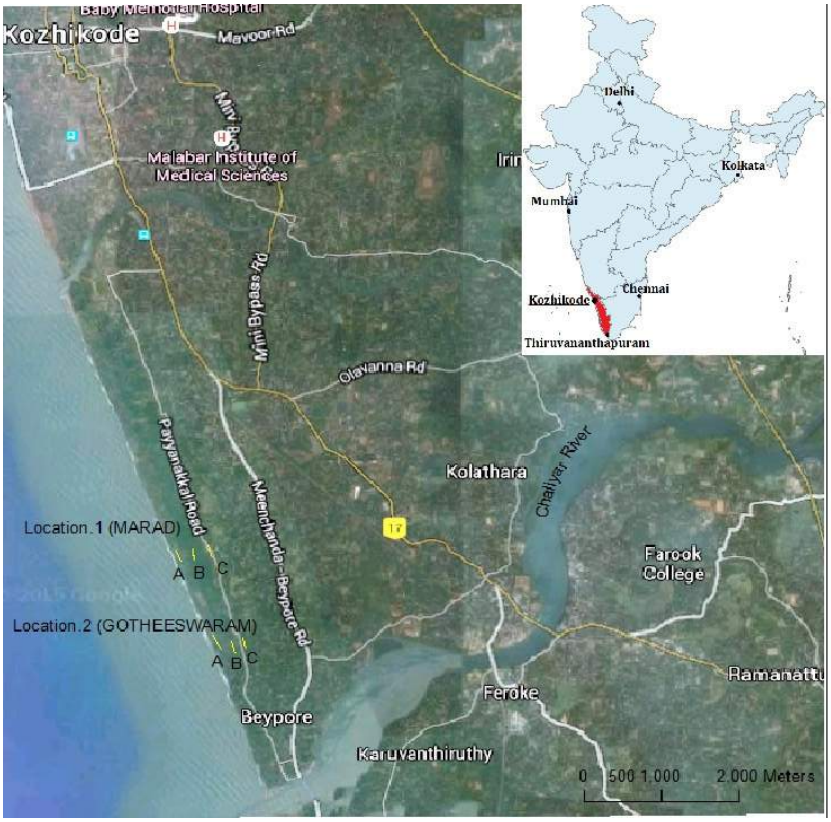

Fig. 2.1.2 Map Showing the study area

The significance of understanding SGD in the Indian context involves estimation of maximum pumping possibilities and defining the limit of seawater intrusion in the fresh-seawater interference zone. In short, such studies help in assessing the optimum exploitation levels of coastal fresh groundwater, locating feasible waste disposal sites in coastal zone and estimating seaward pollution transport levels. The objectives of study are (a) mapping the horizontal and vertical extent of coastal aquifer in the area between Koyilandi and Kadalundi, (b) demarcation of hydrochemical facies and (c) determining temporal changes in the dynamism of freshwater-salt water wedge.

Methodology adopted for the study includes direct measurements using seepage meters and piezometers, modeling, natural tracers using ^{222}Rn, ^{226}Ra, salinity, and temperature, isotopes, and conventional hydrochemical methods. In addition, water-balance approaches, hydrograph separation techniques, and numerical simulations have been widely applied for basin-scale estimates of groundwater flow into the ocean. The methods adopted for the present study are (i) digital analysis of satellite data, (ii) EC measurements in coastal wells, (iii) Resistivity sounding, SP and resistivity cross section profile surveys in the interface zone, (iv) hydrochemical analyses, (v) water table elevation surveys with respect to msl, and (vi) groundwater modeling.

During the reporting period, we have downloaded thermal band satellite images for image processing, procured GMS groundwater modelling software and received training and conducted resistivity surveys in the study area to understand the hydrological layers and the nature of the shallow aquifer. It was observed that the sediment thickness in the area is more than 35m and the depth to water table is around 2m. Inspection of open wells in the coastal zone under consideration indicated that the area releases fresh groundwater to sea during a considerable period of the year. Two cross section profiles showing the nature of aquifer along the beach as well as at about 500m inland are provided in the following figure (Fig. 2.1.2 & Fig. 2.1.3).

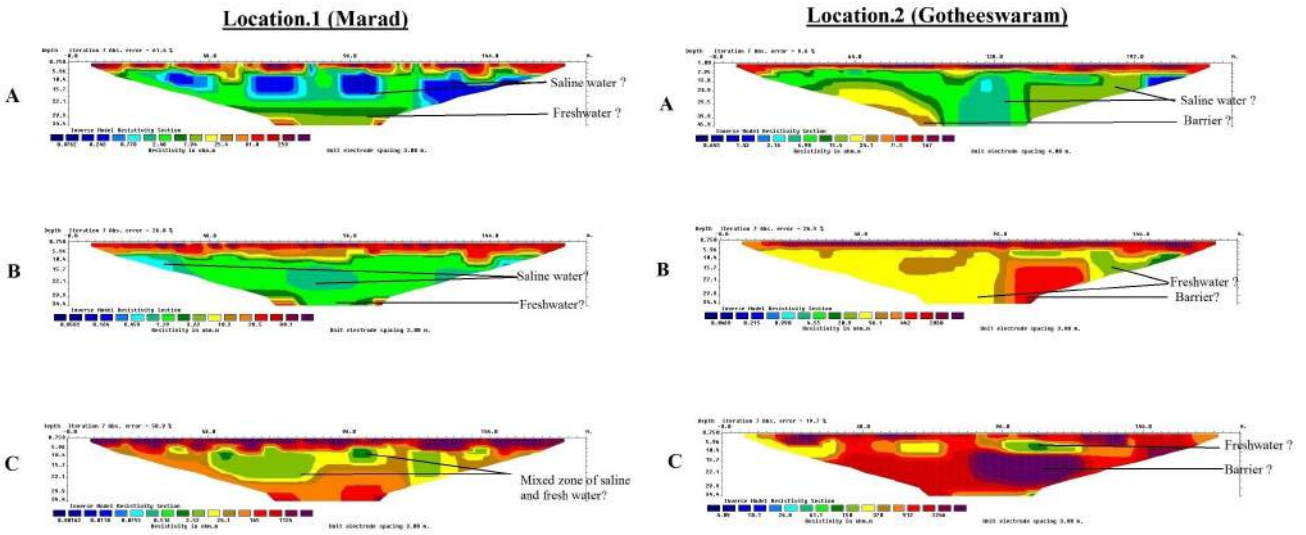

Fig. 2.1.3 Cross section profiles of coastal aquifer at two location in study area

T. N. Prakash (Co-ordinator), P. John Paul, L. Sheela Nair, D. S. Suresh Babu, K. Raju, Reji Srinivas, D. Raju, M. Ramesh Kumar, S. Mohanan, M. K. Rafeeque & M. K. Sreeraj
Funding: MoES, GoI

2.2 Shoreline Mapping and Monitoring along west coast of India

This project utilizes the satellite data of IRS P6 LISS IV for period 2004-2006 and LISS III for 2011 for the shoreline mapping of the west coast. The extracted shoreline is rectified using sufficient ground control points from the field observation and also using Google Earth imageries. Erosion hotspots are identified by conducting field surveys and the location cross checked withthose obtained from satellite imageries (Fig. 2.2.1).

The field data indicated that erosion mostly occurs at the downdrift side of the harbor breakwater/groins, seawall end, mining sites, fishing gaps and also downdrift side of mudbanks. Some of the coastal stretches where coastal protective measures have not worked effectively were also identified. High resolution World View image was pansharpened in ERDAS Imagine to get 0.5 m spatial resolution in multispectral mode. This image was re-rectified using ground control points and shoreline of Alapuzha and Thrissur districts were compared with IRS P6 LISS-4 images. Wide beaches were observed at Puthuvype sector along the Kerala coast. Due to the construction of LNG terminal along this coast the accretion has shifted further north. Mudbank formation

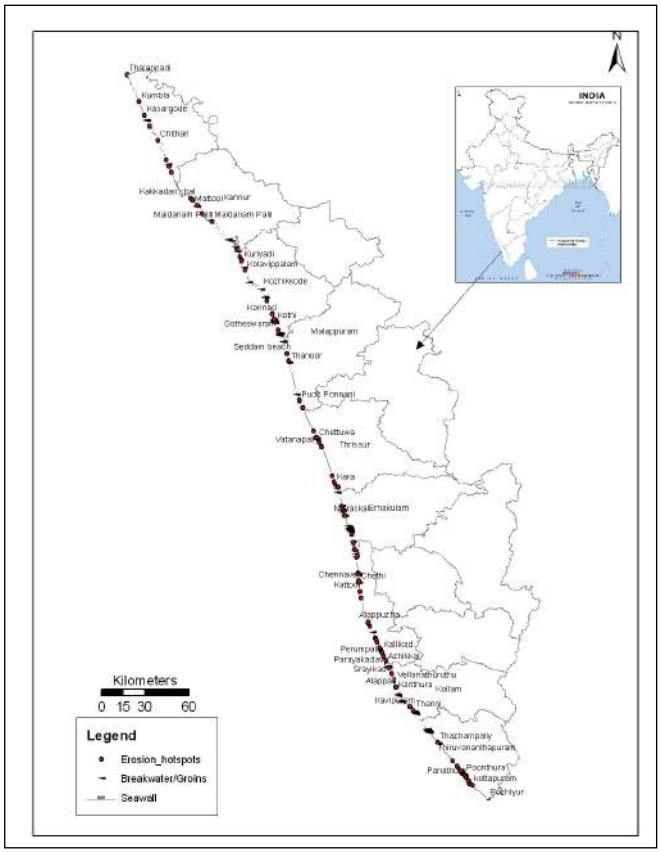

Fig. 2.2.1 Erosion Hotspots along with Kerala Coast

has also been reported along this coast during the SW monsoon where the beaches are stable.

K. V. Thomas & L. Sheela Nair
Funding: MoES through ICMAM P. D., Chennai

2.3 Establishment and Maintenance of Wave Gauge Stations in the Coastal Waters of the SW coast of India

The project was taken up in collaboration with the ESSO-INCOIS, Hyderabad. The main objective of this project is to establish and maintain wave gauges at selected locations along the Kerala coast for the collection of site specific real time wave data for validation of the daily Ocean State Forecast (OSF). As part of this programme, the first Wave Rider Buoy (WRB) was deployed off Valiathura coast in Trivandrum during May 2011 and this was later shifted to Kollam in May 2012. The second station was established off Kozhikode coast in northern Kerala on 26th April, 2013. At both the locations, shore stations have been set up for the reception of HF data from the WRB.

The methods currently being adopted for the dissemination to the coastal community includes providing site specific OSF through e-mails to the user and also through news bulletin of the All India Radio (AIR). At present the AIR broadcasts site specific OSF for five important coastal locations of Kerala viz. Trivandrum, Kollam, Aleppey, Cochin and Kozhikode is being continued twice a day both in the morning and evening. The mobile phone based OSF-SMS facility (text as well as voice message in Malayalam) for the coastal community of Kozhikode is also continuing.

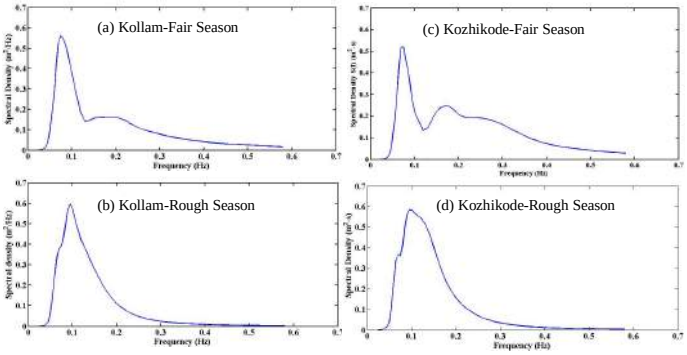

Fig. 2.3.1 Average spectral energy density for (a & b) Kollam and (c & d) Kozhikode for the fair and rough seasons during 2014

The real time wave data from the WRB's off Kollam and Kozhikode are also being used for validation of the site specific daily forecast. The statistical error estimates are computed at regular intervals by comparing the forecast data with the measured values. The data set will also be used for the core programme of Integrated study on Estuary Beach and Innershelf Dynamics of the west coast of India carried out by the Coastal Processes Group of NCESS.

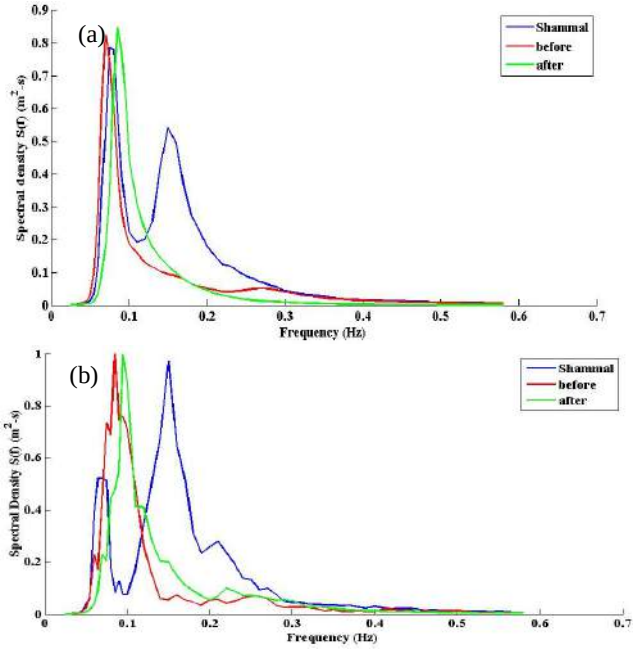

Fig. 2.3.2 Spectral energy density showing the effect of Shamal wind off (a) Kollam and (b) Kozhikode during 2014

On comparison of the wave climate off Kollam and Kozhikode it can be seen that during the rough season the sea condition at both the locations is dominated by the westerly swell waves. But the influence of locally generated wind waves was more pronounced for the Kozhikode coast compared to that of Kollam (Fig. 2.3.1). The total energy level at both the locations was found to be more or less of the same magnitude. This study also provides the observational evidence of Shamal waves along the Kerala coast (Fig. 2.3.2). The effect was found to be more pronounced for the north Kerala coast compared to south Kerala. During the Shamal event mixed sea condition was observed indicating the co-existence of locally generated wind waves from the northwest direction and southerly swells. Even though a reduction in the peak wave period was observed during the event, the total energy more or less remained the same as the spectrum became broader due to the effect of local wind waves.

L. Sheela Nair

Funding: MoES, GoI

2.4 Study of Impact of Sea Level Rise along Kerala coast

The study on 'Impact of sea level rise along Kerala coast' sponsored by the Department of Environment and Climate Change (DECC), Govt. of Kerala addresses the following major objectives.

1. Assessment of areas of probable inundation due to projected SLR along the coast and including overbank areas and backwaters

2. Identification of impact zones in the form of salinity ingress, vulnerable ecosystems and infrastructure including possible damages to coastal protection measures
3. Assessment of damages to flora, fauna and habitats and impacts on livelihood requirements and activities due to changes in physical parameters like salinity
4. Assessment of economic implications of impacts such as loss of land and infrastructure, livelihood activities, modifications to wetland systems, groundwater contamination due to salinity, etc.
5. Assessment of financial implications to adaptation strategies and mitigation measures

Realistic assessment of possible inundation of the coastal areas due to the projected SLR is dependent on the accuracy of the contour maps of the coastal zone. The MoEF & CC is in the process of generating Digital Elevation Maps (DEM) of 0.5 m accuracy through Survey of India. The accuracy of 0.5 m is proposed for hazard line mapping by MoEF. This will be cross-checked with available elevation data including SRTM elevation data and updated with primary DGPS surveys. Maximum inundation limits will be arrived with the help of GIS computation. Shoreline data, land use, landform/morphology and assets/ infrastructure will be derived from high resolution satellite imageries and toposheets which will be fine-tuned with GPS-based field observations. Some of the archival data available with different organizations including NCESS, PWD, Town Planning Dept., etc., will also be utilized.

Coastal land has multiple and competing uses. All the economic activities in the affected zone will be listed and extent of damage in each case including tourism will be worked out. Socio-economic activities in the coastal zone are performed by people living *in-situ* and also *ex-situ*. The coastal zone acts as main thorough fare by housing NH and Railways to link the Kerala State with outside. The study will capture all aspects like fisheries, agriculture, aquaculture, tourism, ports, etc., to create respective impact scenario and compute socio-economic impacts. These data will be projected on a GIS platform which will make it easy to transfer the data to inundation maps. Once these are projected on inundation maps, the strategies for action plans for adaptation and mitigation could be evolved. Financial implications for loss, mitigation and adaptation would form the final deliverables.

Regarding the progress of the work during the reporting period, the study area was subjected to microlevel geomorphological mapping in terms of (a) coastal plains, barrier beaches and spits ; (b) sandy beaches ; (c) tidal inlets, estuaries and backwaters ; (d) sea walls ; (e) headlands and pocket beaches ; (f) vegetated coasts and (g) backwater islands. Subsequently, morphological hotspots of SLR and coastal landuse distribution patterns were identified. Detailed DGPS surveys are being conducted to generate contour lines of elevation along the coastline as well as along the backwater banks. The mapping of already affected zones of salt water ingress are also planned during these GPS campaigns.

The work plan is as follows: Digital Elevation Model (DEM) of the land area will be generated using elevation values of contours and spot heights and primarily surveyed Ground Control Points (GCPs) using DGPS. Tide contours will be generated with high water level values to map the maximum area of inundation, pertaining to the current spring tide position and will be represented on map. Georeferenced topographic maps and high resolution satellite images will be used as spatial references to plot the present land-sea interface at high spring tide as well as the probable inundation areas with respect to sea level rise (high tide) of 0.5m, 1m and 1.5m. The predicted inundation area in km^2 at different SLR will be calculated using GIS.

P. John Paul & D. S. Suresh Babu
Funding: Department of Environment and Climate Change, GoK

2.5 Coastal Zone Management Plan for Kerala

The coastal policy of the Government of India and the coastal states is to develop the coastal regions of the country within the framework of Integrated Coastal Management Plans (ICMP). This will ensure the utilisation of coastal resources to its optimum potential and to sustain the functional integrity of coastal ecosystems. This approach will also help to contain, to a certain extent, the impact of coastal hazards to coastal communities and properties. The CRZ notifications intend to achieve the above objective through providing a framework for ICZMP. Regulating high impact activities in the coastal zone through CRZ is one of the effective tools in this endeavour. It was with this objective the Coastal Regulation Zone (CRZ) Notification (MoEF, 2011; 1991) was introduced in the country. The Coastal Regulation Zone (CRZ) notification of 2011 has made it mandatory for the State to prepare Coastal Zone Management Plan (CZMP) as per the guidelines in the notification and get it approved by the Govt of India. Accordingly the preparation of the CZMP has been entrusted with the National Centre for Earth Science

Table 2.5.1 Coastal Zone Management Plan for Kerala in differnt stages of progress

District	World View Image Rectification	HTL Delineation	Morphology Delineation	HTL buffering and CRZ categorization	Proposed Work
Kottayam	Completed	Completed	Completed	Completed	Field Verification of HTLcompleted.
Ernakulam	Completed	Completed	In Progress	In Progress	
Trissur	Completed	Completed	Completed	Completed	
Malappuram	Completed	Completed	Completed	Completed	
Kozhikkode	Completed	Completed	Completed	Completed	
Kannur	Completed	Completed	Completed	Completed	
Kasaragod	Completed	Completed	Completed	Completed	
Alappuzha	Draft CZMP in 1:25000 scale submitted KSCSTE				
Kollam	Draft CZMP in 1:25000 scale submitted KSCSTE				
Thiruvananthapuram	Draft CZMP in 1:25000 scale submitted KSCSTE				

Studies (vide reference STED S.O (M.S) No. 02/2014/ STED dt. 10.03.14 and Council (P) Order No. 356/2014/ KSCSTE dt.30.04.2014).

During the reporting period CZMP of three districts viz., Thiruvanathapuram, Kollam and Alleppey in 1:25000 scale were finalized and submitted to KSCSTE, Government of Kerala. The CZMP maps for the other six districts viz., Kasargod, Kannur, Kozhikode, Malappuram, Thrissur and Kottayam are in different stages of progress (Table 2.5.1). The first draft of CZMP map of 6 districts will be submitted to KSCSTE in July/August, 2015. The cadastral data base of all the districts are also being generated simultaneously along with the 25,000 scale map.

T. N. Prakash (Co-ordinator), P. John Paul, L. Sheela Nair, D. S. Suresh Babu, K. Raju, Reji Srinivas, D. Raju, M. Ramesh Kumar, S. Mohanan, M. K. Rafeeque & M. K. Sreeraj

Funding: KSCSTE, GoK

3.1 Intensity, Duration, Frequency Analysis of Precipitation Microphysical Parameters of South-west Monsoon Rain, 2014 at a High Altitude Station on the Western Ghats

Intensity, duration and frequency analysis of rain in 2014 South West monsoon season was conducted. A laser optical disdrometer (PARSIVEL) along with a manual rain gauge is used for the present study. Rain intensity was classified as per the norms of World Meteorological Organisation (WMO) and further analysis was carried out in these classified intensity ranges (Table 3.1.1). One minute average data from a high altitude station (Braemore, Lat. 8.76 Long.77.07 600 ASL) on western slopes of the Western Ghats is used for the present work. For validation and cross comparison daily rain water intensity is compared with a manual rain gauge observation.

Table 3.1.1 World Meterological Organisation's (WMO) classification of rain intensity.

Rain Type	Range	Intensity class
Drizzle	RI < 0.1 mm/h	Light
	0.1 ≤ RI < 0.5 mm/h	Moderate
	RI ≥ 0.5mm/h	Heavy
Rain	RI < 2.5 mm/h Light	Light
	2.5 ≤ RI < 10.0 mm/h	Moderate
	10.0 ≤ RI < 50.0 mm/h	Heavy
	RI ≥ 50.0 mm/h	Violent

Being a tropical region in a heavy rain prone area we introduced two more intensity ranges 50 d" RI < 100 mm/h and RI e" 100 mm/h for the present study and each intensity bins are designated as *R1, R2, R3, R4, R5, R6* & *R7*. Mean drop diameter, Dm is also divided into equaly spaced 20 bins of width range 0.25-Dm20. Regarding rain drop number, Nt is classified as follows. Ranges 10 d" Nt < 100 and 100 d" Nt < 500 are designated as N1 & N2 respectively. Then from 500 upto 5000 Nt is equally divided into 9 bins of bin width 500. So there are 11 Nt bins in total.

Daily rain fall data from optical laser disdrometer is cross checked with manual rain gauge observation and found to be reliable (Fig. 3.1.1). The frequency of occurance of rain is decreasing more or less linearly from lower range bins to higher range (Fig. 3.1.4).

So maximum number of occurances of Rain Intensity (RI), Drop mean Diameter (Dm) and Number of drops (Nt) are in lower bins during the study period (Southwest Monsoon, 2014). A notable difference from the other two graphs, histogram of Dm shows maximum frequency is in the second bin of range 0.5-0.75 mm.

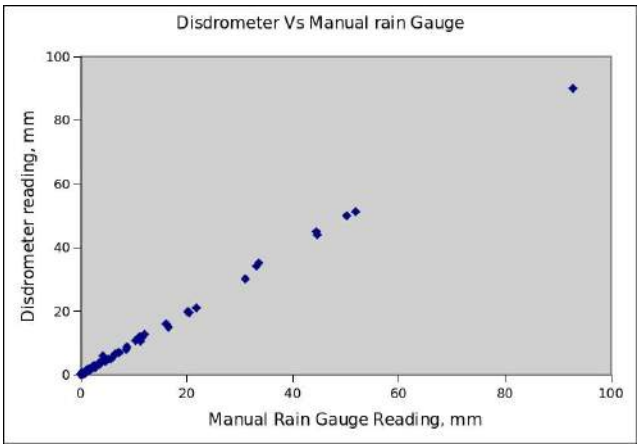

Fig. 3.1.1 Cross comparison of Disdrometer reading with Manual Rain Gauge

Average values of rain intensity, drop diameter and drop number in each of the intensity bins are calculated and ploted in Fig. 3.1.2. Average values increase linearly from low range bins to higher bins. So for higher rain intensity durations number and size of rain drops are also.

Contribution of accumulated water from RI, Dm and Nt bins are calculated and ploted in Fig. 3.1.3. About 45% (300mm out of 693 mm) of total rain water is contributed by the intensity range R5 (5-10 mm/h, heavy rain as per WMO norms). Another 40% is jointly contributed by ranges R4 & R6 mm/h. Eventhough the frequency of occurance is higher in the low intensity ranges, contribution of accumulated water is high from middle order ranges and not from high and low range intensity ranges. Even R4 and R5 are contributing equally, contribution fron R5

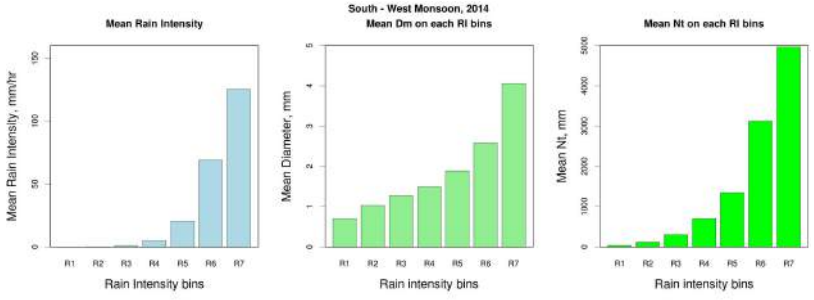

Fig. 3.1.2 Mean RI, Dm and Nt in each intensity bins

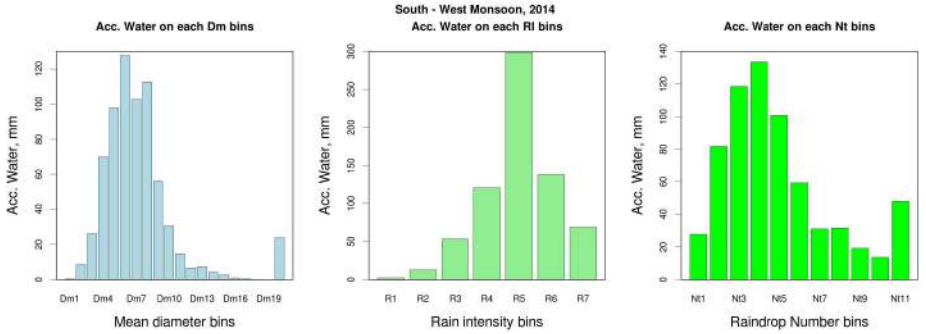

Fig. 3.1.3 Accumulated rain water from Dm, RI and Nt bins

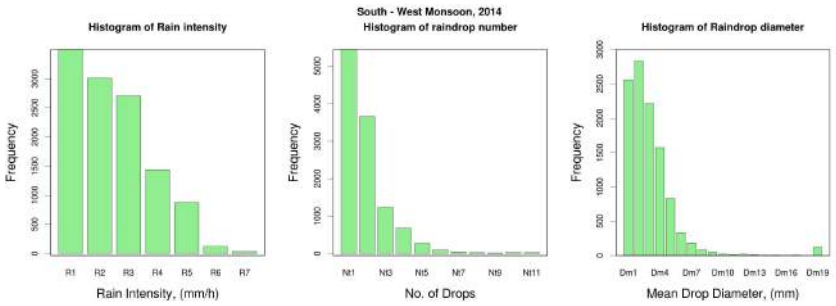

Fig. 3.1.4 Frequency of rain occurance in RI, Nt and Dm bins

is from a shorter time period since it is a higher intensity range.

Total water contribution from mean diameter bins revealed that about 65% of total rain water is from Dm bins Dm5, Dm6, Dm7 and Dm8 covering 1.25 mm to 2.25 mm drop diameter. Last bin Dm > 5 also contributed 20 mm rain to the total. Here also the major contribution to total rain from Dm bins is from middle order bins and not from low and higher ranges.

Regarding number of drops (Nt), about 55% of rain water is from ranges Nt3, Nt4 and Nt5 covering 500-2000 drops. i. e. during 55% of total rain number of rain drops is varying between 500 and 2000. Last Nt bin Nt11 (Nt > 5000) also contributed 47 mm (7%) to the total rain water. With these collective information of rain intensity, raindrop number and drop diameter, we can conclude nature of rain in a rainy seaon. Present work is confined to 2014 Southwest monsoon season and can be extended to other seaons also.

R. Ajayakumar Varma
Funding: MoES,GoI

3.2 Modelling Atmospheric Pollution and Networking (MAPAN)

The Indian Institute of Tropical Meteorology (IITM),Pune has initiated an air quality monitoring and atmospheric pollution modelling project with the objectives of setting up air pollution monitoring stations at selected strategic locations in India to continuously monitor pollutants and weather parameters to address question related short term climate change and its impact. As a part of this, a station has been established in NCESS campus at Thiruvananthapuram in 2013 with NCESS as a collaborator. The entire instrumental set up has been provided by IITM. Monitoring of the parameters has commenced from March 2014. The station monitors 18 air pollution and weather parameters and the data is shared online with IITM. The station is equipped with all the necessary analysers such as Beta Attenuation Monitor for Suspended Particulate Matter (PM_{10}& $PM_{2.5}$), Serinus-10 Ozone Analyzer, Serinus-30 CO Analyzer, Serinus-40 NOxAnalyzer, Alpha 115 Hydro Carbon Analyzer, Black Carbon Analyzer required for Ambient Air Quality monitoring; calibration equipment - Hydrogen Generator and Zero Air Generator, Gas Calibration System; data acquisition hardware and software with complete power backup; Met Sensor for monitoring Ambient Temperature, Relative Humidity, Barometric Pressure, Solar Radiation, Rain Gauge, Wind Speed, Wind Direction.

The station continuouly records Particulate Matters (PM_{10}&$PM_{2.5}$), Carbon Monoxide(CO), Carbon Dioxide (CO_2), Surface Ozone (O3),Oxides of Nitrogen (NO,NO_2,NO_x),Methane (CH_4),Non methane Hydro Carbon (NMHC), Black carbon (BC) Ambient Temperature, Relative Humidity, Barometric Pressure, Solar Radiation, Rain Gauge, Wind Speed and Wind Direction.

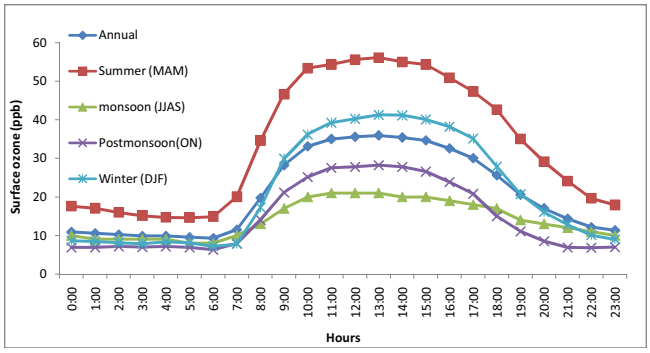

Fig. 3.2.1 Diurnal and seasonal variation of surface ozone during March 2014 – February2015

Diurnal, seasonal and annual variability in surface ozone (O_3) concentrations over NCESS have been studied from March 2014-February 2015 in the light of changes in

meteorological parameters like solar radiation, temperature, and relative humidity (RH). The annual average diurnal profile of O_3 showed (Fig. 3.2.1) a peak (35.92 ppb) at 13.00 hrs afternoon and minimum of (9.31ppb) in the early morning. Surface ozone exhibits a distinct seasonal variation over this site. Among the maximum concentration, the highest value of O_3 was found in summer (56.09 ppb) and lowest during monsoon (8 ppb). The correlation coefficient of O_3 concentration with relative humidity, wind speed and temperature were 0.98, 0.96 and 0.97respectively during the period of observation. It is evident that O_3 variation is directly correlated to temperature and solar radiation and is inversely related to relative humidity.

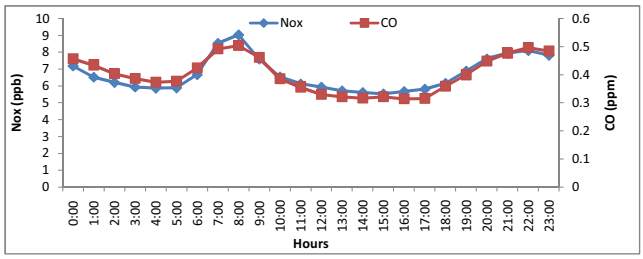

Fig. 3.2.2 Diurnal variation of CO and NO_x during March 2014 – February 2015

The ozone precursors, NO_x and CO, show (Fig. 3.2.2) an almost opposite diurnal variation to Ozone characterized by high concentrations during night and morning and low concentrations during day time, especially noon and afternoon. Each pollutant has two main peak concentration levels; the first peak appears in the morning rush hours (6:00 - 9:00); the second one appears around late night (22:00 - 2:00), but for CO, the second one, appears around midnight (21:00 - 1:00).

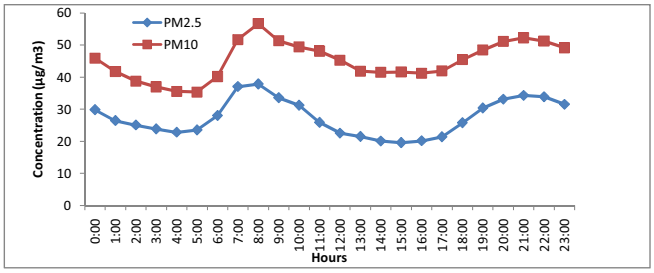

Fig. 3.2.3 .Diurnal variation of PM_{10} and $PM_{2.5}$ during March 2014– February 2015

Diurnal variation of PM_{10} and $PM_{2.5}$ shows similar pattern of variation (Fig. 3.2.3). Both the particulate matter concentration gradually increase just an hour after sun rise in the morning.The build-up of local anthropogenic activities associated with higher traffic density is responsible for this peak. The morning high concentration, low concentration at mid-afternoon hours and nocturnal peak

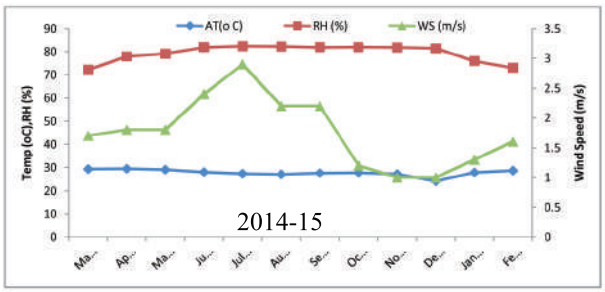

Fig. 3.2.4 Monthly variation of temperature, relative humidity and wind speed

value also attributed with atmospheric boundary layer (ABL) dynamics. In the evening, the concentration of both particulates matter increased gradually due to local anthropogenic activities and increased traffic density. The diurnal variation of PM_{10} and $PM_{2.5}$ with wind speed shows an inverse relationship. The monthly variations of PM_{10} and $PM_{2.5}$ show that high value occurs in summer and low values during the monsoon months. This is due to the wet removal of aerosols by extensive monsoon rains and stronger monsoon winds.

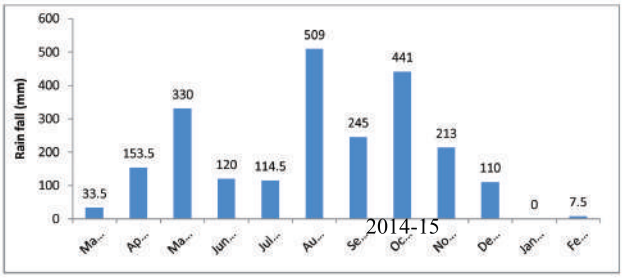

Fig. 3.2.5 Monthly variation of rainfall

Concentration of particulate matter shows an inverse relationship with wind speed. During night the mean wind speed has been generally slow (1-2.5 m/s) and nocturnal boundary layer has been shallow resulting low ventilation coefficient (defined as product of boundary layer height and horizontal wind speed).This had caused confinement of particle and increase in concentration during early night period. As day progresses ,the wind speed increases and also release of solar heating of land. This results in increased convective activity leading to an increase in

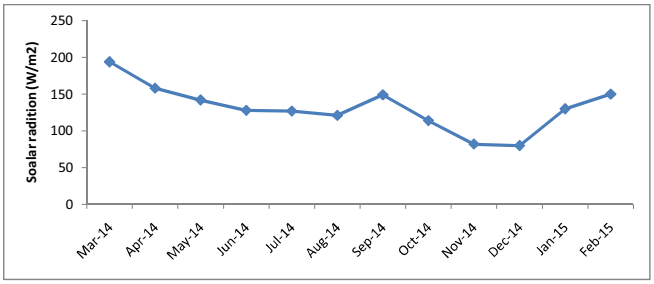

Fig. 3.2.6 Monthly variation of solar radiation

boundary height and faster dispersion of particulate matters.

The average weather parameters like relative temperature, humidity, wind speed, rainfall and solar radiation during observation period are depicted in (Fig. 3.2.4 - Fig. 3.2.6).

R. Ajayakumar Varma
Funding: MoES, GoI

Natural Resources and Environmental Management

4.1 Water Resources

4.1.1 Appraisal of drinking water potential of springs in Pathanamthitta, Kottayam and Idukki districts of Kerala

The programme involves seasonal monitoring of water quality parameters (physico-chemical and biological) of highland springs in the central Kerala (Pathanamthitta, Kottayam and Idukki districts). A total of 64 springs was identified and studied. The study area lies between 90°3' & 10°23' North Latitudes and 76°37' & 77°30' East Longitudes and covers nearly 9995 km^2 in Central Kerala. The area falls within the western flanks of Southern Western Ghats Region covering Pathanamthitta, Kottayam and Idukki districts.

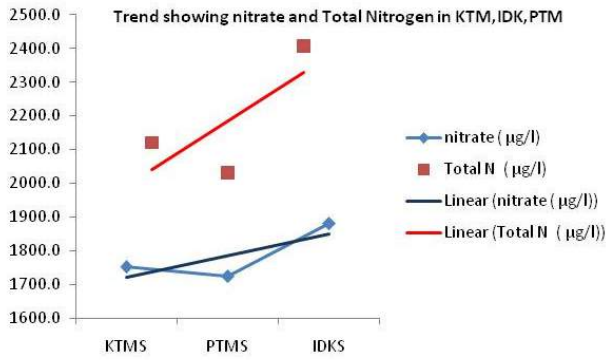

Fig. 4.1.1.1 Trend showing the total nitrogen concentration

Conventional water resources are at the verge of destruction due to various anthropogenic activities. Agricultural activities have an important role in the deterioration of ground water quality. The areas of Idukki nourished with plenty of perennial spring water resources which are remained relatively untapped to its full potential. Majority of the springs falls under perennial category. Springs of both flow type and pond type are identified in the area. Selected spring water samples from Kottayam, Idukki and Pathanamthitta were studied for microbiological and hydrogeochemical characteristics. The chemical quality of water satisfies BIS/WHO drinking water specifications except pH, which showed acidic characteristics in certain springs of Idukki region. In general the springs have conductivity values less than 100µS/cm indicating low range of dissolved salts in water. The major ion concentrations are in the order of Ca (03-3.97mg/l), Mg (0.5-1.84mg/l), Na (1.3-1.79mg/l), Fe (60.0-67.88 µg/l)Cl (22.22-31.70mg/l), and NO_3 (1752.10-1879.52 µg/l (Fig. 4.1.1.1). All the values are well below the permissible limits.

Presence of pathogenic coliforms noticed in certain spring waters in three clusters where unhealthy human interaction exists. In Idukki the spring water near the spices cultivation areas shows coliforms populations. The spring and ground water especially in the areas of Erumeli, and Pampa are polluted due to pilgrim activities. In the present study, 20% of the observed spring resources are on verge of deterioration. The average microbial health Indicator population is given in Fig. 4.1.1.2.

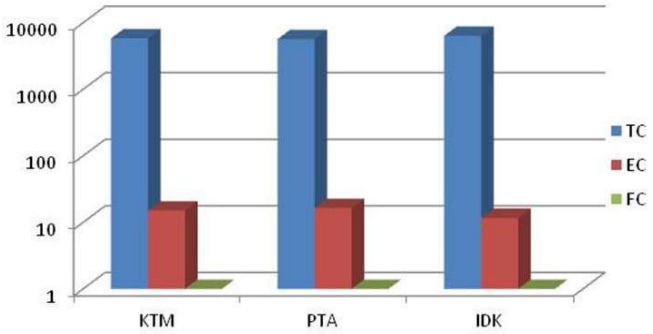

Fig. 4.1.1.2 Average Microbial health indicator population

Most of the spring water resources remain unutilized/ under-utilized. A scientific water resource management is highly needed for effectively using these precious spring resources. The present study revealed that the quality of spring waters in the three districts and importance of rejuvenation of traditional ground water resources for the sustainability of the ecosystem. Throughout the study area, it has been observed that people's participation is inevitable in preserving the spring resources. So far, the end users are not aware about the quality as well as the ways of protection of these resources.

K. Anoop Krishnan

Funding: KSCSTE, GoK

4.1.2 Hydrological modelling of Greater Cochin urban agglomerate in the context of Sustainable Urban Water Resource Development

The study area comprises of Cochin (Kochi) as well as all the major towns towards north of Cochin within Ernakulam district along the national highway (NH47). This study envisages providing insights in to the amount of alteration due to urbanization in the hydrologic system.

Even though the district receives very good rainfall of about 3400 mm annually it is paradoxical that acute water scarcity is felt in certain areas. Another important problem is salt water intrusion.

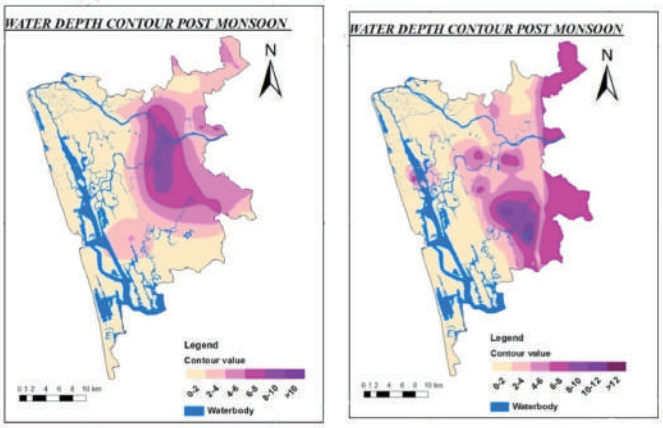

Fig. 4.1.2.1 Water depth contour fluctuation of post monsoon season in 1981 and 2014 (CGWB data)

Monthly monitoring of ground water table in selected wells is carried out for determine changes with respect to time and rainfall rate. The effect of fast growing urban life in the ground water recharge will clearly understood through this method.

Water samples were collected from 60 selected locations including dug wells and surface water bodies. The *insitu* physical parameters like pH, mV, TDs, resistivity, conductivity, DO and temperature were measured during sampling. The chemical analysis for carbonate, sulphate, phosphate, chlorite, nitrate, calcium, magnesium and hardness are carried out. Hydrogen- ion concentration (pH) of the collected water samples of coastal area ranges from 5.68 to 7.14. In most of the areas the pH level goes beneath the standard quality especially in midland areas where it varies from 3 to 5.87 showing the water is more acidic. The pH of Surface water samples are between 3.96 and 8.4.

TDS values are high in coastal areas are varing from 2 to 847 mg/l. But in midland areas the values chang from 45 to 301 mg/l, and in NH side it varies from 69 to644 mg/l. The major sources for nitrate in the ground water are atmosphere, legumes, plant debris, and animal excrement. Maximum concentration for nitrate in the coastal area is 39.54mg/l (Fig: 4.1.2.2). Some locations in the NH side and midland areas show values above the standard limit, but in surface water bodies the nitrate concentration is below specified standard values.

Chloride occurs to only a limited extent under normal conditions. The important sources of chloride, however, are from sewage, connate water, and intruded sea water. In the study area chloride is showing a highest value of 128mg/l in the Thattapalli river sample. In the coastal ponds because of the sea water influence, chloride shows a higher value with respect to other surface water bodies.

Hardness results from the presence of divalent metallic cations, of which calcium and magnesium are the most abundant in ground water. Low pH condition leads to the solution of insoluble carbonates in the soil soluble bicarbonates. Contents of limestone, such as sulfates, chlorides, and silicates are dissolved and the hard water is originated in areas where thick topsoil overlie limestone formations. In the present study the dug well and surface water samples are soft to moderately hard, though river sample hardness is falls near to very hard water class. Phosphate is a minor constituent as a dissolved solid in potable water. Phosphate is commonly seen as 0.0001 – 0.1 mg/l and is within the desirable limit.

Reji Srinivas

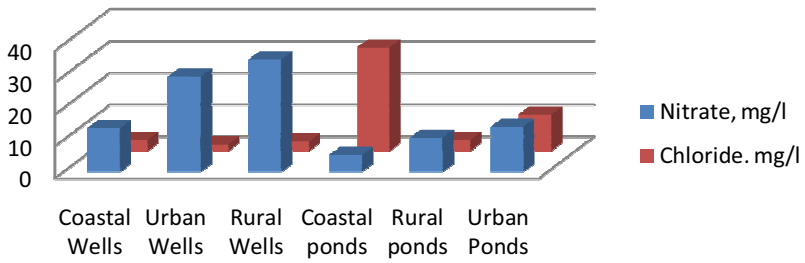

Fig. 4.1.2.2 Concentration of nitrate and chloride in wells and ponds of the study area.

4.2 Environmental Assessment

4.2.1 Sand Audit of the Rivers of Idukki District

River sand auditing is a procedure to evaluate the process of sand mining in a river or a portion of a river after a specific period of sand mining. This exercise has to be undertaken to know how far the mining process and its execution in a river or a part of a river perform to minimize the negative effects of sand mining on one side and to maximize the positive effects on the other. In line with the provisions of sand auditing of Kerala rivers within the ambit of the legislation "The Kerala Protection of Rivers and Regulation of Removal of Sand Act, 2001" an ideal methodology has been evolved by the Centre and sand audit reports were prepared for a few rivers of Kerala including the rivers draining Idukki district.

Fig. 4.2.1.1 Instream sand mining from the Periyar river, Vellathooval grama Panchayat, Idukki district.

The important rivers of Idukki district are Periyar, Muvattupuzha, Pambar and Manimala. However river sand mining is practiced at present only in Periyar river draining through the district (Fig. 4.2.1.1).

The study revealed that the Periyar river stretch of the Idukki district between Neriyamangalam and Karimanal contains mineable sand resource of about 404800 tonnes. Sand occurs as sporadic patches all along the river channel. Two mineable areas are identified in the river stretch and recommended to extract an amount of 3600 tonnes of sand per year. Further an amount of 525 tonnes per year is recommended to be extracted from the tributaries of Periyar river. The mining activity is to be allowed only under certain conditions suggested in the report. The other rivers such as Muvattupuzha, Manimala and Pambar draining through the district do not hold mineable sand in their channel environment and therefore recommended to continue the sand mining holiday enforced by the district administration for one more audit period of 3 years.

D. Padmalal & K. Maya

4.2.2 Study on the Environmental Effects of Mining and Quarrying in the Periyar River Basin, Central Kerala

Kerala state in the southwest India has undergone dramatic changes in resource exploitation over the past 4-5 decades due to rapid economic developments and rise in foreign remittances. Although Kerala is a state with low percapita land and resource availability, the natural resource extraction is not in tune with the principles of sustainable development. As a result, many of the highly populated areas in the state are affected severely by the adverse impacts of resource extraction. In fact, the negative impacts of the activity are a continuing challenge to the existing regulatory systems. If the current trend of mineral extraction continues, many life sustaining systems run the risk of environmental degradation in the near future.

The present study in the Periyar river basin, that spreads over a greater part of central Kerala, reveals that rampant and unscientific extraction of resources is a major threat to the very existence of the river and its biological environment. Mining and quarrying activities are rampant in all the three physiographic regions (lowlands <8m above MSL; midlands 8 – 75m above MSL and highlands >75m above MSL) of the river basin environment. Indiscriminate quarrying of hard rock, excavation of soil from hillocks, extraction of sand from instream and floodplain areas, tile and brick clay mining from floodplains/wetlands, laterite cutting, etc., are some of the activities that could be noticed in the basin. Spatial distribution of mining/quarrying locations reveals that midlands and highlands are the most affected than the lowlands. The major driving force behind indiscriminate mining and quarrying is the rising demand of building materials for the mega developmental projects in Kochi City, one of the fast developing urban-cum-industrial centres in South India. Most of the local bodies that fall partially or completely within the Periyar river basin are engaged in mining/quarrying activities.

Hard rock quarrying has become widespread in recent years, as the activity contribute both coarse and fine aggregates, and also foundation stones for building sector. The study reveales that even the highly Ecological Sensitive Areas (ESA) of the Western Ghats are also not free from indiscriminate mining and quarrying (Fig. 4.2.2.1). The present study shows that in Idukki district alone, a total

of 449 mining/ quarrying locations of hard rock, soil, and sand exist in its Ecologically Sensitive Zones that are to be protected with high priority. Unplanned and haphazard mining not only imposes marked environmental impacts on land, water and atmosphere but also adversely affect the socio economic conditions of the people of the area in the long run. Indiscriminate hard rock quarrying in the Western Ghats has disrupted many first and second order tributary channels of the Periyar river and is a major threat to the hydro-geological setting of the basin. The rampant floodplain and instream mining activities, over the last few decades, have led to severe river bank erosion, channel incision, lowering of water table in the adjacent areas of mining and depletion of river sources of sand. A time-series analysis of a river section at CWC gauging station reveals that riverbed of Periyar has lowered markedly (av. 18 cmy^{-1}) over the years. Ground water level in some of the watersheds has gone down by about one meter in the last two decades. Widespread soil quarrying/ levelling of hillocks is another activity that threatens the environmental integrity and ecosystem structure and functions of the region. Water quality analysis of the pitlakes resulted from hard rock quarrying reveals that almost all the water quality parameters are well within the WHO and BIS drinking water standards. If quarrying is integrated with the regional development plan and regulated scientifically, these pitlakes can offer an alternate source of freshwater to the developmental centres of the area.

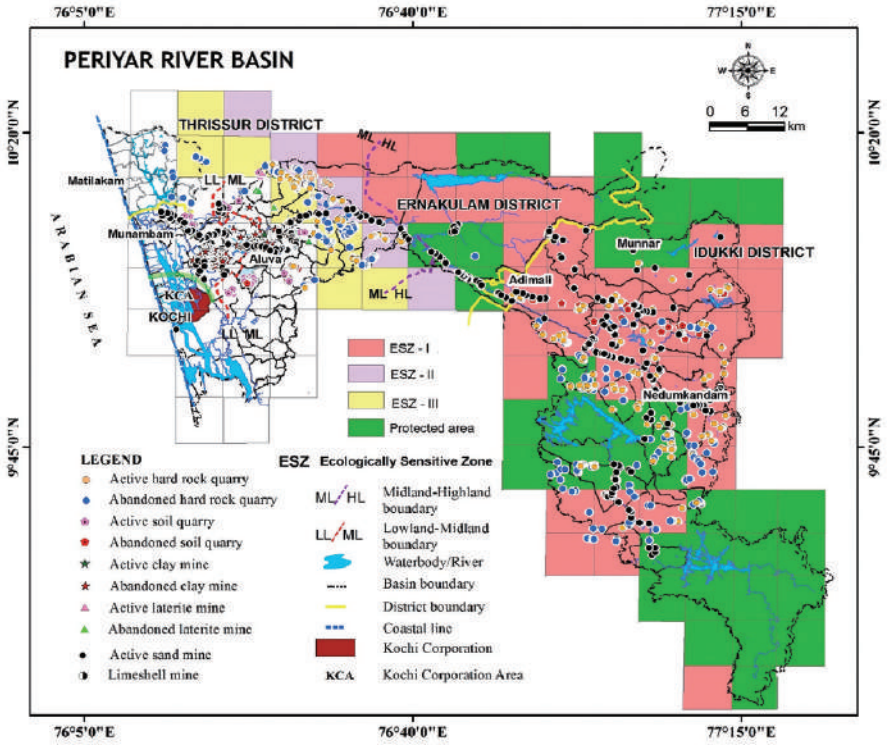

Fig. 4.2.2.1 Locations of mining and quarrying with Periyar rive basin Note: Even the protected zones (eg. ecologicaly sensitive zones) are not free from rampant mining activities.

Some of the major recommendations of the study are: a) Strictly enforce the existing rules and regulations in mining and quarrying; b) Environmental clearance for mining and quarrying should be given only based on Environmental Impact Assessment by a competent scientific agency; c) Evolve a policy containing guiding principles especially to do with compliances, impact assessment and management, and other activities associated with mining operations within the umbrella of a Sustainable Development Framework; d) Mining has to be in accordance with the regional developmental plan; e) Discourage random/ haphazard mining operations; f) Mining and distribution of building materials, and environmental restoration have to be brought under the direct control of the State Government; g) Strategies are to be formulated to deal with illegal mining by the active involvement of all stakeholders with a strong focus on enforcement.

K. Maya & D. Padmalal

4.2.3 Environmental Monitoring of Water and Sediment Quality Parameters in the Backwaters of Cochin Port Trust

Kochi, the industrial capital of Kerala hosts over 200 medium and large scale industries and about 2000 small scale industries, handling diverse organic and inorganic products. Most of the industries discharge their effluents either directly or indirectly into the water bodies liquid and solid as wastes. Apart from this, indiscriminate use of fertilizers, insecticides/ fungicide and other consumables causes considerable damage to the water quality of Riverine, estuarine and marine ecosystems posing serious threat to biotic community including man.The work involves monthly collection and analysis of water and sediment samples for various marine/estuarine pollution parameters at seven locations in the Cochin Harbour.

Water and sediment quality in terms of physico-chemical parameters in the backwaters around Cochin Port was monitored from April 2014 to March 2015. The surface water temperature from 27.8^{0}C to 32.4^{0}C and bottom water temperature varied from 27.1^{0}C to 31.9^{0}C. Dissolved Oxygen varied from 4.52 mg/l to 7.39 mg/l in

surface water and 4.08 mg/l to 7.05 mg/l in bottom water. The salinity of surface water was minimum during November and January and maximum during August. Bottom water recorded prominent values in salinity, which may be due to the saline water intrusion. The pH of water showed fluctuations in surface and bottom waters due to the icobined effects of saline water ingression and rainwater inflow. Inorganic phosphate showed the highest values during the month of August and November. Surface water recorded high values than bottom water. Nitrate Nitrogen ranges from low values in January (0.86 µmol/l to 2.86 µmol/l) to high values in August (1.59 µmol/l to 7.65 µmol/l). The concentration of nitrite was maximum of during August and ammonia nitrogen during September and October, total nitrogen and total phosphorous do not exhibit marked change when compared with the results of the previous year. In surface water, Petroleum Hydrocarbon (oil and grease) varied from 0.2 mg/l to 25.63 mg/l during the study period.

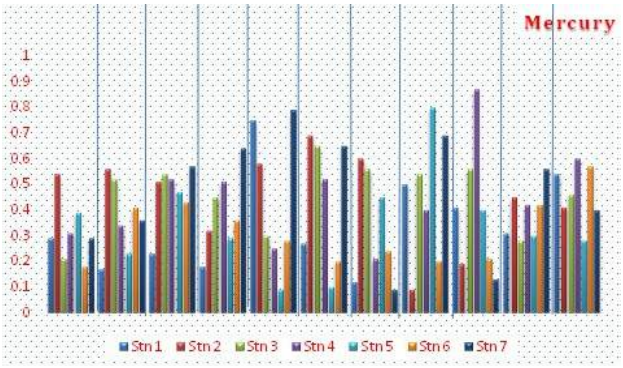

Fig.4.2.3.1 Concentration of mercury in sediments of the study area

Petroleum hydrocarbon (PHC) in bottom water varied from 0.2 mg/l to 10.94 mg/l. Surface water always showed higher values for petroleum hydrocarbon. Station 4 reported the high values of PHC (32.4 mg/l) both in surface and bottom waters which may be due to oil shipment activities carried out in this area. Turbidity was low in surface water compared to the bottom water. In surface water, Gross Production showed higher value upto 104.6 mgC/m^3/hr and bottom water showed upto 20.54 mgC/m^3/hr.

As regards sediment quality parameters, pH showed marked variation from 7.68 to 9.04 during the study period. The concentration range of cadmium (Cd), lead (Pb) and mercury (Hg; Fig. 4.2.3.1) in the sediment any environs around Cochin Port Trust were 0.31 to 1.54 ppm; 18.24 to 48.35 ppm; and 0.09 to 0.87 ppm respectively during the study period. The river Periyar brings heavy metals in the form of fine grade suspended particulates matter from effluent discharge points of various industries. The sediment quality parameters are indicative of industrial pollution in the study area.

K. Anoop Krishnan
Funding: Cochin Port Trust (CPT)

4.2.4 In-situ Bioremediation of Landfill Pollutants: Maximizing the Remediation Potential of Select Indigenous and Exogenous Microorganisms

The safe disposal of Municipal Solid Waste (MSW) is a critical issue worldwide. Although different waste management strategies have been in use like recycling, composting, incineration etc, this sector still remains is one of the most poorly managed sectors in India. Sanitary landfilling is the predominant waste disposal alternative, but raises environmental concerns in the form of generation of landfill gas (LFG) with methane as a major component and leachate as an obnoxious effluent with its toxic compound overloading. Moreover, the issue of fugitive and residual methane emissions has still not been resolved fully.

Fig. 4.2.4.1 Experimental Setup

The present study consists of using the technique of *in-situ* bioremediation to reduce the toxicity of Municipal Solid Waste (MSW) landfill pollutants like dissolved organics, inorganics and heavy metals in leachate and methane in landfill gas. Landfill is proposed to be considered as a bioreactor in the study in which the stabilisation of waste is accelerated by incorporating various interventions. Combined methane oxidation and *in-situ* treatment of leachate is proposed to be conducted using a consortium of microorganisms. The methane from the landfill soils is to be oxidised using methanotrophic bacteria. The organics, inorganics and heavy metals in leachate are proposed to be reduced using select chemoautotrophic bacteria as well as fungal species. The technique does not require costly

installations for recovery and purification of LFG or for leachate treatment units.

The study will estimate the quantity and quality of landfill gas and leachate produced from each of the landfill models; the oxygen/air requirement for optimal remediation of landfill pollutants; the growth rate of select indigenous and exogenous microorganisms in the system; the correlation of bacterial growth rate with the treatment efficiency; the bacterial kinetics of select species and the group performance of the exogenous bacteria with the indigenous bacteria. The physical models to suite the purpose of landfill simulation and fitted with the installations for aeration, inoculation of microorganisms, recirculation of leachate, collection of landfill gas from various locations and collection of leachate. Indigenous microorganisms in the models have been identified. The exogenous microorganisms were selected based on their source, prospective remediation capability and growth conditions and were procured from Microbial Type Culture Centre, Chandigarh. These microorganisms have been cultured in the lab and inoculated into the two of the landfill models for enhanced bioremediation and accelerated waste stabilization.

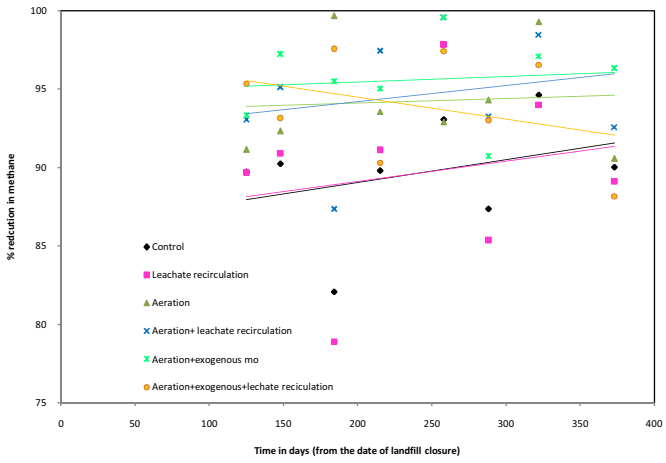

Fig. 4.2.4.2 Percentage reduction in Methane

The study aims to develop a comprehensive procedure to reduce the toxicity of landfill pollutants and design of a landfill system to cater to municipal solid wastes based on the remediation efficiency of the interventions. LFG is being monitored once in every two weeks from October 2013 and leachate every month from January 2014. The parameters estimated from LFG include CH_4 and CO_2. Aeration started in 4 among the 6 landfill models. The results (Fig. 4.2.4.2) show a decreased production of methane as well as enhanced bioxidation of generated methane in the aerated models. The model with methanotrophic microorganism inoculation without leachate recirculation shows much lower methane generation and a higher bioxidation than the other aerated models.

K. Deepa Nair
Funding: DST, GoI

4.2.5 Sea Water Quality Monitoring

The littoral ecosystem and nearby areas of our country, particularly the south west coast of India, are facing unprecedented threats from rampant population growth, growing urbanization, declining fisheries and multiple impacts from climate change. In order to assess the seasonal variations of chemical, biological and microbiological aspects of coastal milieu, the Ministry of Earth Sciences, Govt. of India initiated a project "Sea Water Quality Monitoring (SWQM)", the prime objective of which is to assess the sources, levels, pathways and effects of various pollutants in identified hot spots along the coastal areas of Kerala, Mangalore and Lakshadweep islands.

Kochi

Silicate shows relatively higher values (31.93 ± 8.66 µ mol/ L; Fig. 4.2.5.1) among the nutrients in coastal waters of Kochi during post monsoon season. In Coastal sediments Lead (Pb) is reported in higher concentration (22.47 µg/ g). In a positive correlation with silicate values diatom population dominates in the Kochi coastal waters.

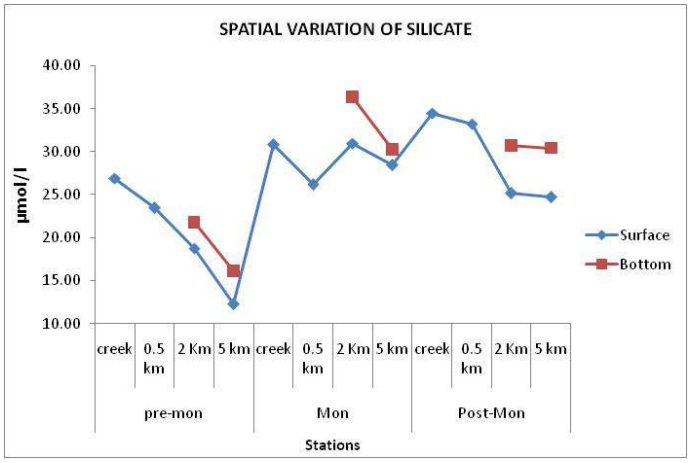

Fig. 4.2.5.1 Spatial variation of Silicate in Kochi

Among the phytoplanktons populations, *Chaetoceroslorenzianus*, *Cosinodiscusgigas* and *Skeletonemacostatum* dominate in Kochi estuary during monsoon and post monsoon seasons. Dinoflagellates like *Ceratiumfurca* dominate throughout the pre-monsoon period (24200 Cells/L). Crustaceans like *Evadnaetergestina* and copepods namely *Acrocalanus gibber* and *Lucifer hanseinii* contribute a

major share among the zooplankton population during pre-monsoon (21.4%) and post monsoon seasons (23.7%). During monsoon season, more than fifty percent of zooplankton density was composed of fish eggs as the season is breeding time for fishes. Zoobenthos of Kochi consist mainly of foraminifera like *Ammoniatepida* and *Ammonia beccari*. *Capitellacapitata* is one of the common benthic species which indicates bioaccumulation in deep waters. Though, not in large numbers, these species are encountered round the year irrespective of seasons.

Annual mean chlorophyll values of Kochi estuary ranged from 1.6 to 3.1 mg/m^3.Nutrient entrainment along with presence of plant matters like *Eichornia* sp. contributed higher values in the estuary as compared to open sea. No Harmful Algal Blooms (HABs) were reported from the station.The highest mean value for Total Viable Bacterial load (TVC) in Estuary is reported in post-monsoon season(20615.38 CFU/mL), While highest mean population of *E.coli* and Faecal coliforms are reported in pre-monsoon season (359.2 CFU/mL and 2693.8 CFU/mL). In Kochi coastal waters post monsoon studies show highest mean viable bacterial load (TVC) is 24807.69 CFU/mL but the mean population of *E.coli* reported as 630.8 CFU/mL and Feacal coliforms reported as 5033.08 bursting the contamination limits.

Mangalore

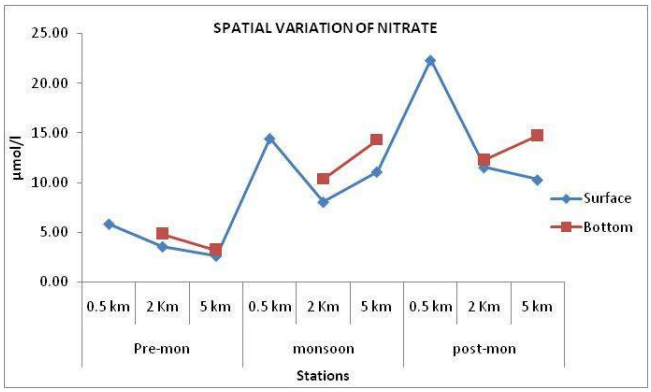

Fig. 4.2.5.2 Spatial variation of Nitrate in Mangalore

In post monsoon season, the nitrate (NO_3; Fig. 4.2.5.2) and silicate (SiO_4) reported higher values (25.48±3.16 µ mol/L and 26.12±2.95 µ mol/L ,Fig. 4.2.5.2). In sediment the heavy metal Pb shows high value of 22.47 µg/g during the post monsoon seasons. Mangalore recorded comparatively lower values of chlorophyll ranging from 0.15 to 2.7 mg/m^3. Cells of *Chaetocerosdydymus*, *Coscinodiscusgigas*, *Pleurosigma sp.*, and *Leptocylindrusminimus* are found in large numbers at Mangalore during monsoon and postmonsoon seasons. In premonsoon season, dinoflagellates like *Prorocentrummicans*, *Peridinium sp.* were become dominant. Among zooplanktons, calanoid copepods, fish eggs and larvaes like mysis and nauplius are found in large numbers at Mangalore during premonsoon and postmonsoon. However no HABs were reported.

During monsoon, Fish eggs considerable the major zooplankton populations. Zooplankton abundance in Mangalore is governed by vertical migration due to upwelling of the sea. Gastropods and bivalves are the major macro benthos which constitutes 80 percent of biomass. The major meiobenthos recorded include *Ammonia beccari* and *Oxystomina species*. The benthic diversity was found to be low in all the seasons. The highest mean value for Total Viable Bacterial load (TVC) in the coastal waters reported in premonsoon(18269 CFU/mL). The mean population of *E.coli* and Faecal coliforms is reported as 165.4 CFU/mL and 2752.3 CFU/mL.

Kavaratti

In Kavaratti coastal waters the summer values of SiO_4 from 5.24 µmol/L to 10.33 µmol/L, Total nitrate ranges from 5.21 µmol/L to 9.65 µmol/L and Total phosphate from 1.25 µmol/L to 2.40 µmol/L (Fig. 4.2.5.3). Chlorophyll value of Kavaratti lagoon ranges from 0.078 to 0.71 mg/m^3, which indicates the oligotrophic nature of lagoon. Major phytoplanktons include coralloid algaes like *Bellerochea malleus*. Zooplankton composition was primarily governed by the abundance of larvaes like mysis, polychate larvae, fish eggs and nauplius. Zoobenthos commonly constitutes gastropods and bivalves like *Meritrixmeritrix, Desmodora sp., Pernaviridis*etc. *E. coli* has not detected in the summer samples but hourly studies shows that Mean viable count of *Faecal streptococci* in the lagoon water is 75 CFU/mL. However Vibrio sps. show their presence in the coastal and lagoon waters (Mean viable count – 311 CFU/mL).

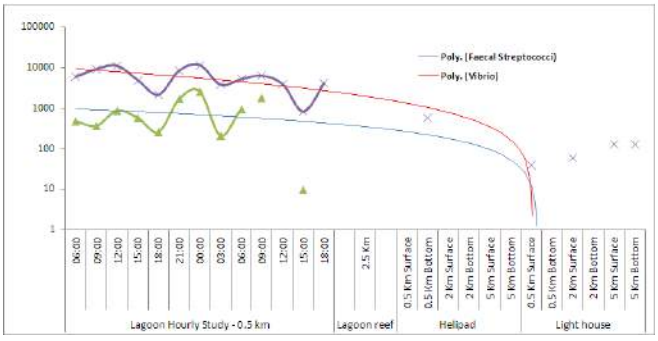

Fig. 4.2.5.3 Microbiology in Kavaratti coastal waters

R. Ajayakumar Varma & K. Anoop Krishnan
Funding: MoES, GoI

4.2.6 Environmental Studies of the Kollam - Neendakara Wetland System and Associated Inlands

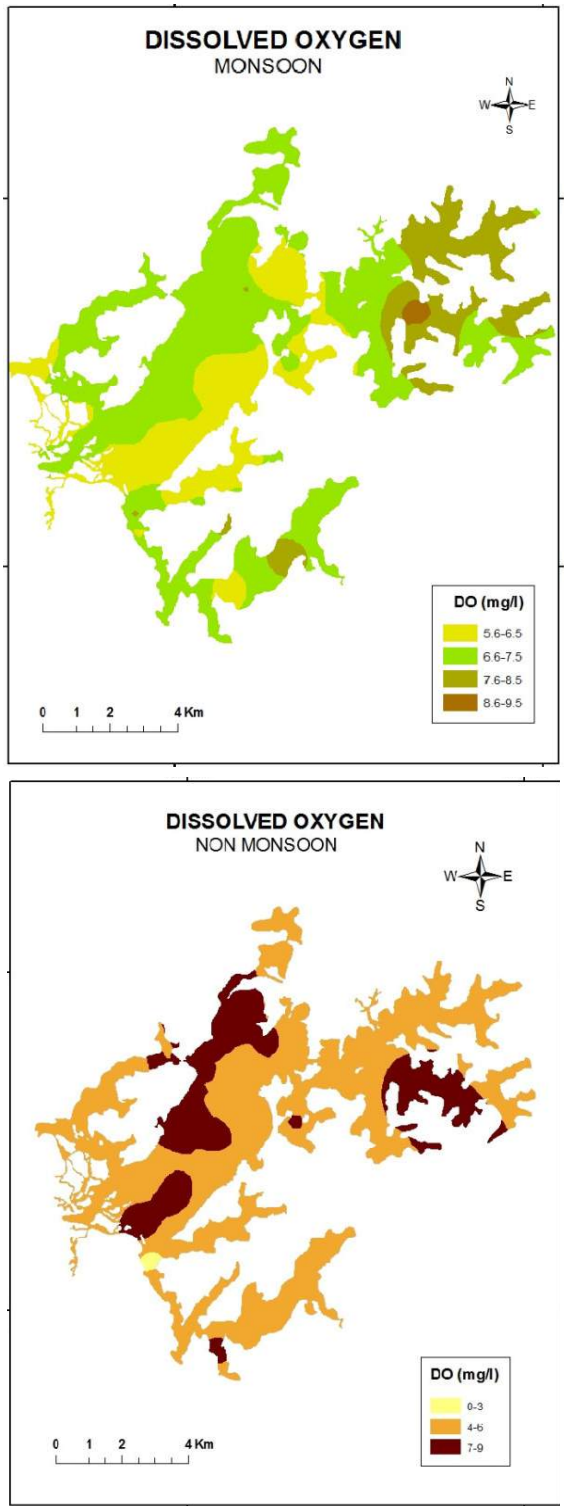

Fig. 4.2.6.1 Spatial distribution of Dissolved oxygen in surface waters of Ashtamudi Wetland Systems

The Ashtamudi wetland system (AWS), a Ramsar Site designated as "Wetland of International Importance", is a major estuarine wetland in SW India. The present study evaluates the extent of water pollution and accumulation of heavy/trace metals in the recent sediments of AWS. The analysis of water and sediment quality of AWS revealed the degree of impacts of human activities in this estuarine wetland. The contamination factor worked out for beach sediments indicates that AWS is moderately contaminated with chromium, iron, nickel, and copper.

The hydrochemical quality of the AWS has been controlled by the freshwater input from Kallada River and marine water inflow from the nearly coastal waters. Comparatively lesser inputs from riverine source is noticed in non-monsoon season while high inputs from sources like coconut husk retting yards, fish-processing centres, urban sewages and industries located near the system (Table 4.2.6.1). Comparing with the monsoon period, a different situation is noted during nonmonsoon period in AWS due to reduced fresh water inflow to the sytem together with the addition of contaminants in large quantities and thereby depleting the level of DO and subsequent non-oxidation of organic matter. The spatial distribution of DO during the different seasons are depicted in Fig. 4.2.6.1

Table 4.2.6.1 Ranges of water Quality Parameters of Ashtamudi Wetland System (AWS) during Monsoon and Non-Monsoon seasons

Parameter	Units	Monsoon	Non-monsoon
pH		5.86 - 8.38	4 - 8.04
TDS	mg/l	83 - 838	464 - 2720
TSS	mg/l	11.7 - 135.6	53.2 - 125.6
EC	mS/cm	3.07 - 32.45	30.9 - 47.4
Total Hardness	mg/l	96 - 1620	4000 - 7400
Calcium	mg/l	60.12 - 400.80	320.64 - 721.44
Magnesium	mg/l	2.44 - 299.02	729 - 1552.2
Total Alkalinity	mg/l	100 - 300	500 - 900
Salinity	0/00	18.68 - 21.25	20.96 - 72.72
Sodium	mg/l	123.10 - 558.6	624 - 839.7
Potassium	mg/l	26.20 - 1094	114.2 - 145
DO	mg/l	5.12 - 9.07	1.69 - 6.78
BOD	mg/l	0.11 - 5.85	0.089 - 6.79
Total Phosphorus	mg/l	0.05 - 0.58	0.07 - 1.60
PO_4	mg/l	0.001 - 0.08	0.05 - 0.20
Total Nitrogen	mg/l	0.07 - 1.75	1.11 - 2.77
Nitrate, NO_3^-	mg/l	0.64 - 5.20	0.01 - 1.14
Nitrite, NO_2^-	mg/l	0.002 - 1.30	0.003 - 0.05
Ammonia	mg/l	3.03 - 3.67	0.87 - 1.72

The study emphasizes the need of sustainable management measures of this Ramsar wetland. Continuous monitoring of sediment and water quality of different sub-environments of the AWS is suggested for deriving location specific management options for the conservation of the health of the important backwater system.

A. Krishnakumar

Funding: Department of port & Fisheries, GoK

4.2.7 Environmental studies on the Netravathi-Gurupur river basins of Karnataka and Periyar-Chalakudy river basins of Kerala

Reconnaissance field work was conducted in the Periyar - Chalakkudi River basin for primary and secondary data collection. A few sediment and water samples were also were analysed for various physico-chemical and microbiological parameters using standard procedures. Analysis of nitrates and heavy metal contents in the water and sediment samples are progressing. The spatial distribution of nitrite, phosphate and silicate is shown in Fig. 4.2.7.1

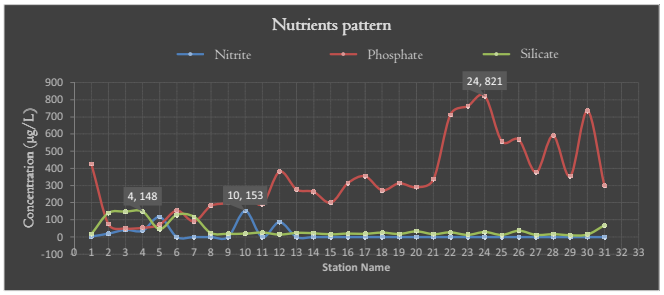

Fig. 4.2.7.1 Spatial distribution of nitrite, phosphate and silicate contents in the water samples of the Periyar-Chalakudy river

Water level fluctuations with respect to the ground level has been worked out. The hydro-chemical quality of the observations wells of Periyar River basin for the period 2003 - 2012 has been compiled. The salient features of the drainage characteristics and neo-tectonic activities of the Periyar and Chalakudy river basins has been compiled from published work and detailed analysis of drainage features are in progress. Rainfall data from 1916 to 2005 has been analysed and its trend has been worked out (Fig. 4.2.7.2).

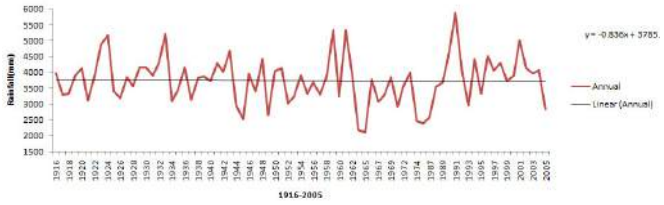

Fig. 4.2.7.2 Annual average rainfall in the Munnar area for the period 1916-2005

Existing data sets are being transformed with reference to OSM in UTM Zone-43 coordinate system and WGS-84 datum. Vectorization of drainage network of Chalakkudi River basin has been completed based on Strahler's method using ArcGIS 10.3 in Window's platform.

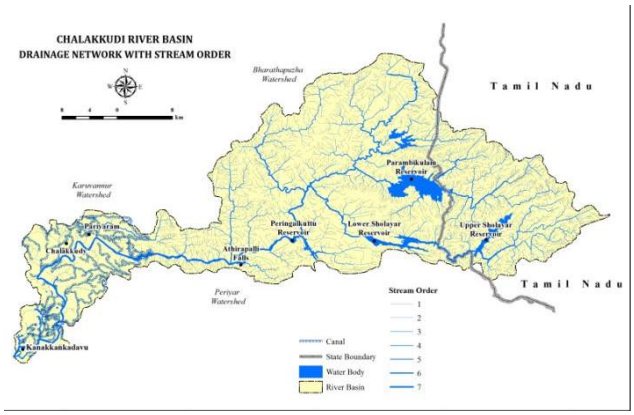

Fig. 4.2.7.3 Drainage network of the Chalakkudi River Basin

The drainage network in Chalakkudi river basin is given Fig. 4.2.7.3. A rapid morphometric analysis has been carried out for the basin. The study is in progres.

R. Ajayakumar Varma, D. Padmalal, B. K. Jayaprasad, Ansom Sebastian, K. Maya, K. Anoop Krishnan & A. Krishnakumar

4.2.8 Monitoring Global Change Impacts in Sahyadri (Western Ghats)

As part of monitoring climate change and its impacts on Sahyadri (Western Ghats), 4 major themes in a cross-section of area south of Palghat gap and the Achenkovil shear zone is monitored. In connection with this program, installed two Automatic Weather Stations (AWS) one in Periyar river Basin and the other in Netravathi River Basin for collecting weather data. The daily weather data on air temperature, wind speed, wind direction, relative humidity, rainfall, pressure, solar radiation, sun rise and sunset are being collected from March 2015 onwards.

The major objectives are (i) Setting up a high altitude Green house gas Observatory at Rajamalai near Munnar around 2000m elevation and Automatic Weather stations at Rajamalai, Chinnar and Mankulam; (ii) Ecological studies along altitudinal gradients and in associated headwater basins, (iii) Monitoring and analysis of indicators of systemic and cumulative environmental changes in mountain regions and (iv) Integrated model based studies of environmental changes in mountains through scenario building and modeling. The transect study selected the Eravikulam National Park (ENP), the highest plateau in Western Ghats with mountain cloud forests as the undisturbed core area and moist forests of Idamala-Puyankutty valleys in the western slope and the dry deciduous Muthirpuzha –Chinnar valleys in the eastern slopes.

Sl. No.	Sampling Station	pH	Conductivity	TSS	Turbidity	Alkalinity	Total Hardness	Ca Hardness	Mg hardness	Chloride	Sulphate	Iron	Silicate	Nitrite	Nitrate	Ammonia	T.N	Phosphate	T.P	Escherichia coli	Other Coliforms
			ms/cm	mg/L	(NTU)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(µ g/l)	(µ g/l)	(µ g/l)	(µ g/l)	(µ g/l)	(µ g/l)	(µ g/l)	(µ g/l)	(µ g/l)	CFU/mL	
1	Nallathanni	6.38	35.39	0.0036	5.2	12	11	3.607	0.49	26.67	0.03	1.94	40.09	0.05	1.78	17.94	2.73	0.33	13.16	NIL	300
2	Nallathanni Bridge	6.66	137	0.0072	0.42	24	63	24.850	0.24	45.72	0.17	11.40	54.59	0.38	3.36	7.80	1.44	0.39	15.71	NIL	620
3	Vellathooval	6.06	41.51	0.0058	0.55	8	8	2.004	0.73	45.72	0.01	0.78	28.40	0.02	3.44	8.76	2.38	0.15	5.91	NIL	80
4	Anayirankal Dam	6.12	31.84	0.0042	< 0.19	8	14	2.004	2.19	38.10	0.02	1.27	45.96	0.01	1.96	8.68	0.38	0.19	7.52	NIL	70
5	Pooppara	4.75	71.3	0.0044	0.9	8	24	4.810	2.92	68.57	0.03	2.31	48.44	0.12	5.56	10.08	4.21	0.45	18.26	240	610
6	panniyar	4.8	30.82	0.0006	0.16	8	15	1.603	2.67	38.10	0.01	0.83	43.84	BDL	3.03	8.53	1.21	0.18	7.12	NIL	380
7	Ponmudi Dam	4.72	39.56	0.0028	0.09	8	15	3.206	1.70	49.52	0.01	0.98	27.09	BDL	3.75	8.73	1.86	0.26	10.34	NIL	20
8	Vimala City	4.75	40.96	0.003	0.55	4	15	2.004	2.43	38.10	0.01	1.00	30.97	0.01	4.02	10.23	0.97	0.11	4.56	NIL	1830
9	Senkulam Reservoir	5.06	43	0.0022	0.19	8	15	3.607	1.46	41.91	0.01	0.50	40.70	0.03	3.74	7.28	1.64	0.30	12.08	NIL	50
10	Kallarkutty Bridge	5.13	30.69	0.0048	0.33	8	15	2.806	1.94	38.10	0.00	0.00	72.84	0.00	0.66	8.24	0.67	0.33	13.43	NIL	90
11	Neryamangalam	5.62	38.65	0.0038	0.18	12	17	4.409	1.46	41.91	0.02	1.57	47.08	0.02	2.84	7.98	0.51	0.50	20.27	10	90
12	Neendapara East	5.15	26.9	0.0066	0.88	12	13	2.806	1.46	34.29	0.00	0.00	55.33	BDL	0.98	9.12	0.38	0.29	11.81	NIL	540
13	Pambla Dam	5.4	32.27	0.0034	0.18	8	20	4.409	2.19	34.29	0.04	2.56	67.24	0.02	3.39	6.99	0.47	0.53	21.35	NIL	60
14	Kallarkutty	5.3	24.8	0.0126	0.88	8	7	3.206	-0.24	38.10	0.00	0.33	47.34	BDL	4.08	9.16	1.12	0.23	9.13	NIL	440
15	Panamkutty	6.45	223.8	0.0022	0.18	60	118	28.056	11.67	53.33	0.53	35.65	119.33	0.13	1.31	8.16	0.63	0.47	18.80	NIL	190
16	Kallarkutty Dam	5.91	62.57	0.037	0.63	16	28	10.822	0.24	34.29	0.12	7.95	40.47	0.06	3.77	8.27	1.14	0.56	22.69	NIL	60

Table 4.2.8.1 Water quality data of the upstream regions of the study area in Periyar river

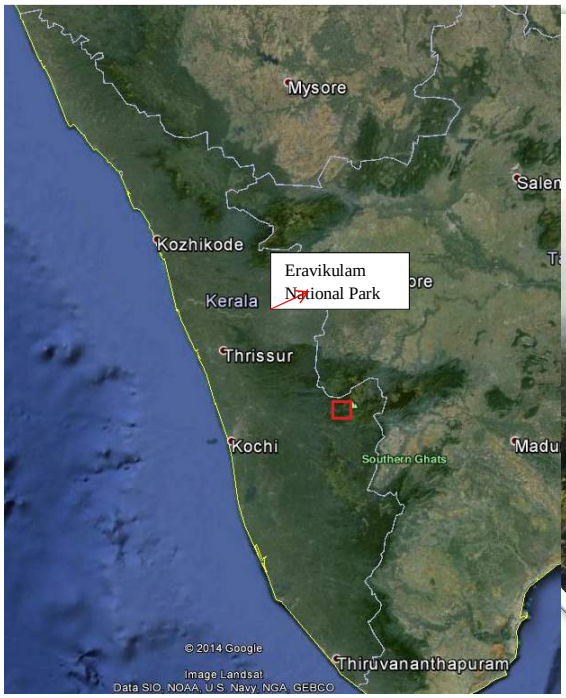

Fig. 4.2.8.1 The Automatic Weather Station in Munnar

A suitable site at 2000m elevation at Rajamalai in Eravikulam National Park has been identified for setting up the Green house gas observatory.

The programme mainly covers two watersheds (Periyar and Chinnar) for modeling purposes. Data on water quality and quantity of the streams originating from Eravikulam National Park area and its downstream, were used to study the aquatic and terrestrial community, the population of rare and endangered species and pollution in indicator species like lichens and mosses. Accordingly, water samples (premonsoon) were collected from upstream reaches of Periyar river and analysed for physico-chemical and microbiological parameters. The result is presented in Table 4.2.8.1

A. Krishnakumar

4.2.9 Preparation of Management Action Plan for Eco-restoration of Vembanad Lake Ecosystem

Vembanad lake is one of the three Ramsar sites in Kerala and greatly influences the social, economic and environmental aspects of the state. However, the wetland is increasingly under stress due to various anthropogenic and environmental pressures. Though there are various studies and reports highlighting the internal and external factors impinging upon the very existence of Vembanad Lake and its inflowing rivers, there is no holistic management action plan exists that could be implemented for eco-restoration of the lake and its catchments. Therefore, a project has been conceived for preparing an implementable action plan for restoring the Vembanad lake and its river catchments drained by Achankoil, Pamba, Manimala, Meenachil and Muvattupuzha rivers in line with the guidelines of National Lake and River Conservation Plan (NLRCP).

Detailed inventory has been carried out on various studies pertaining to the environmental aspects of Vembanad Lake and rivers, field level information gathered for assessing the state of environment of the ecosystems and environmental evaluation carried out for delineating the environmental issues, causative factors, resultant pressure, present state, impact and stakeholder responses. Based on this, position papers on the five rivers and lake have been prepared. Detailed watershed analysis has been carried out for the five river catchments and catchment area conservation plans have been prepared. Comprehensive plan for waste management has been prepared taking into consideration the urban and rural local bodies in each of the river basin and also considering the requirement for solid and liquid waste management including septage and fecal sludge. An overflow management system has been adopted for both solid and liquid waste management. The conservation and development plans will be integrated to prepare a Management Action Plan for Vembanad Lake Ecosystem.

R. Ajayakumar Varma

Funding: 13th Finance Commission Award, Govt. of Kerala

4.2.10 EIA of Municipal Solid Waste Management Project of Thiruvananthapuram Municipal Corporation

An environmental impact assessment study has been carried out on the project 'Municipal Solid Waste Management (MSW) of Thiruvananthapuram Municipal Corporation (TMC)' which has been designed to expand and upgrade the MSW management system of the TMC. The proposed project includes modernization of process and procedures in the collection, transportation and treatment of MSW and disposal of the final rejects. As a first step, detailed baseline environmental study has been carried out in the impact zone comprising the entire TMC domain and the neighborhood of the composting yard at Vilappilsala. Based on this, the existing environmental scenario has been elucidated and the environmental hotspots delineated. The major environmental issues identified have been the leachate generation, breeding of flies, emission of green-house gases (GHGs) and possibility of health hazards. As required, additional studies have been carried out to ascertain the composting capacity of the plant at Vilappilsala, its performance efficiency, environmental issues and environmental cost due to the operational deficiencies of the plant, environmental, health and social safeguards for MSW collectors, alternative management options etc.

Based on the impacts predicted, mitigation plans derived and the additional studies carried out, a detailed environmental management plan has been evolved. In the background of these, an alternative management option has been examined in conformity with reduce-reuse-recycle principle for MSW management. Based on this, 10 recommendations are put forward for implementation by the TMC to improve the MSW management system. The prime recommendation is to adopt Overflow Management Option for MSW management. This is a concept based on reduction and management of biodegradable waste at source using the most appropriate technology and social engineering and centralization of non-biodegradable waste for appropriate reuse and recycle considering the commercial viability.

R. Ajayakumar Varma

Funding: Corporation of Thiruvananthapuram

4.2.11 Mining and quarrying in the river catchments of Central Kerala around Kochi city, SW India-Consequences and sustainable development strategies

Expanding human requirements and economic developments impose immense pressure on our natural resource base. Economic growth will continue to depend on the extractive industry as it supplies most of the raw materials for developments. Kerala state with an area of 38,863 sq km is one of the densely populated regions of the world having limited land and natural resources availability. The scenario of resource utilization in the state has changed drastically over the past 4-5 decades due to

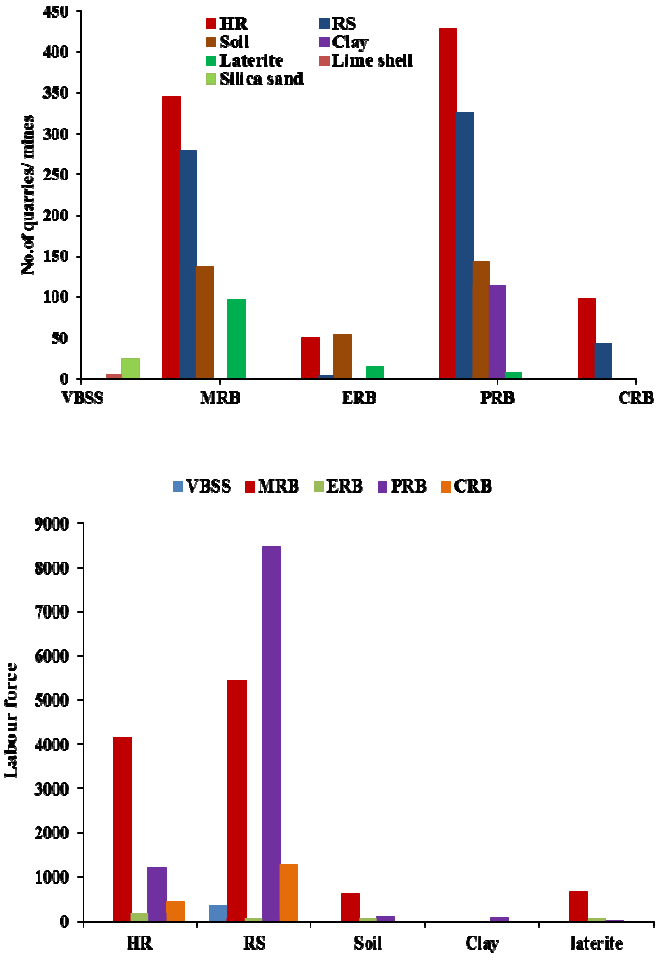

Fig. 4.2.11.1 Resource extraction and associated labour force in mining/ quarrying sectors of the study area. HR Hard rock; RS river sand; VBSS Vembanad Beach Strandline System; MRB Muvattupuzha River Basin; ERB Edappally River Basin; PRB Periyar River Basin; CRB Chalakudy River Basin

the exponential rise in foreign remittance and subsequent economic developments. Most of the highly populated areas even in the midlands and highlands are affected severely by the mining and quarrying activities. Construction of infrastructure is of prime importance in sustaining the pace of developments that are under taken with an intention to enhance the quality of life of the people in the state. As the demand for minerals increase, the extent and magnitude of mining also grows. Resource extraction in its wake causes serious environmental problems which need to be tackled judiciously by striking a balance between the degree and need for development, and the extent of environmental hazards based on scientific studies.

In view of the severity of environmental degradation caused by indiscriminate mining and quarrying, and also considering its potential impacts on the developmental initiatives of the state, a study has been made in the river catchments of Muvattupuzha, Periyar and Chalakudy rivers in Central Kerala as an example.

The study area falls within Alappuzha, Kottayam, Ernakulam, Idukki, Palakkad and Thrissur districts of Kerala. Spatial analysis of mining and quarrying activities in the area reveals that the activities are rampant in the midlands compared to highlands and lowlands (Fig. 4.2.11.1). The mining and quarrying activities in the study area include hard rock quarrying, alluvial sand mining, soil and laterite quarrying, clay mining, lime shell mining and silica sand mining. A total of 209 local bodies fall partially or completely within the study area; comprising Vembanad Beach Strandline System (42), Muvattupuzha basin (63), Edappally river basin (11), Periyar river basin (80) and Chalakudy river basin (13). Hard rock quarrying is the most widespread extractive activity in the midland and highland regions. It is surprising that the Ecologically Sensitive Areas of the Western Ghats are also not free from this destructive activity. It is estimated that an amount of 16.657 x 10^6 ty^{-1} of hard rock is being extracted from the study area for various purposes. An overall analysis shows that among the three physiographic zones, the midlands contribute the bulk of hard rock (85%) to the construction sector. Hard rock quarrying is widespread in the midlands of Periyar river basin (6.872 x 10^6 ty^{-1}). Although small in river length and catchment area compared to the river Periyar (244 km / 5398 km^2), the river Muvattupuzha (121 km / 1554 km^2) is also subjected to indiscriminate rock quarrying (4.635 x 10^6 ty^{-1}). A total of 5995 labourers (5190 in midlands and 805 in lowlands) are employed in hard rock quarrying sector of the study area. The midland areas falling in Ernakulam district is likely to become a potential hotspot in terms of resource extraction, as the demand for building materials is expected to rise exponentially on account of the rapid developmental activities in the region. Soil quarries noticed in about 60 local bodies of the study area. About 800 labourers are engaged in the activity. The maximum quantity of soil is extracted from the midlands (85%) followed by lowlands (14%) and highlands (<1%). About 3.012 x 10^6 ty^{-1} of soil is extracted from the 77 soil quarries in the study area; out of which maximum quantity of extraction is from Muvattupuzha river basin (2.105 x 10^6 ty^{-1}). Apart from soil quarrying, mining for brick clays was also widespread in the lowlands and midlands. At present, there are only a few active tile and brick clay mines in the basin. A major part of the highland in the Idukki district is categorized under Ecologically Sensitive Zones (MoEF 2011). Mining and quarrying activities are widespread even in these local bodies as well. The consequences of haphazard mining will have severe long term impacts that in turn can threaten the ecological integrity of the region.

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4.2.12 Integrated geoenvironmenal studies of the Lacustrine wetlands of Kerala in climate change paradigms for conservation and management

Freshwater resources act as pioneers for nation's wealth and they play a pivotal role in the socio-environmental frame of its holding expanse.The studies on the quality of fresh water resources have received considerable attention worldwide in order to protect them for present and future generations. In this context, the three fresh water lakes of Kerala viz: Sasthamkotta, Vellayani and Pookot lakes (Fig. 4.2.12.1) have been taken for the present study.

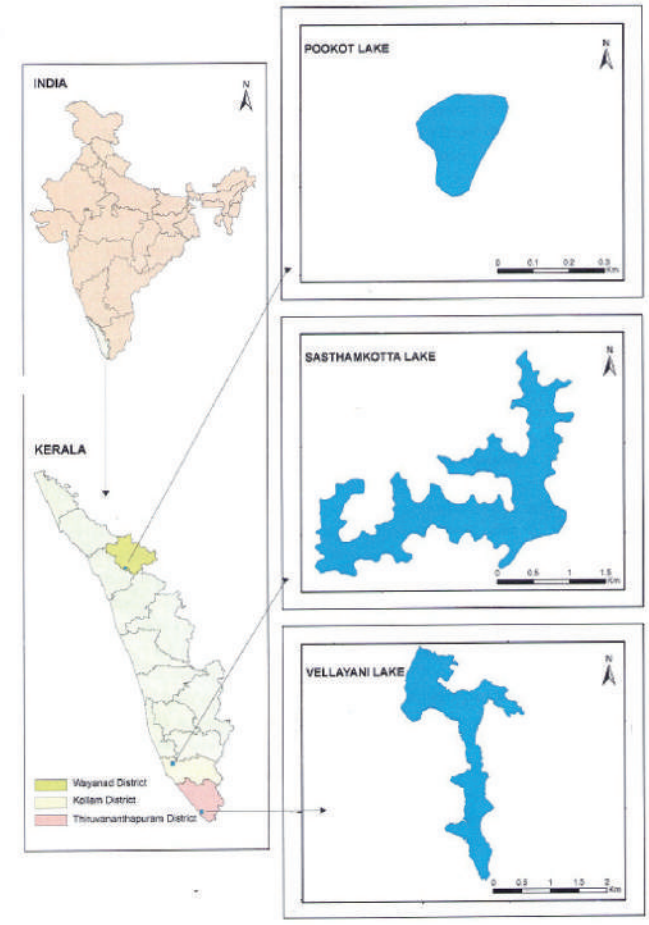

Fig. 4.2.12.1 Location Map

Sasthamkotta lake which lies between North latitudes 9^{0}00'40" -9^{0}4'05" and East longitudes76^{0}36.2' 30" -76^{0}39.2'55.3" is located in the outskirts of Kollam town.Vellayani lake (second largest lake) situated at the outskirts of Thiruvananthapuram city, is located between North latitudes 8^{0}24'90"-8^{0}26'30" and East longitudes 76^{0}59'08"-76^{0}59' 47". Pookot lake, located in the high ranges of the Wayanad district, lies between North latitudes 11^{0}30' 20" -11^{0}45'30" and East longitudes 76^{0}4'10" -76^{0}10'00'. The hydro geochemistry of these three lakes during monsoon

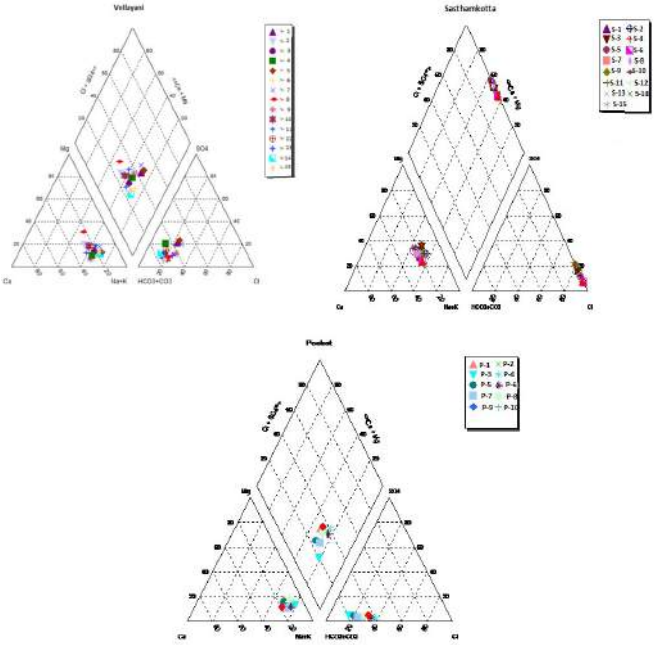

Fig.4.2.12.2 Piper Diagram for the relative concentration of anions and cations in Vellayani,Sasthamkotta and Pookot Lake waters

season was studied, and their drinking water potential was evaluated against WHO (2011) drinking standards. The piper trilinear diagram worked out showed that Na-HCO_3 with subordinates of sulphates in Vellayani, Na-HCO_3 type in Pookot and Na-Cl with subordinates of Ca & Mg in Sasthamkotta Lake (Fig. 4.2.12.2).

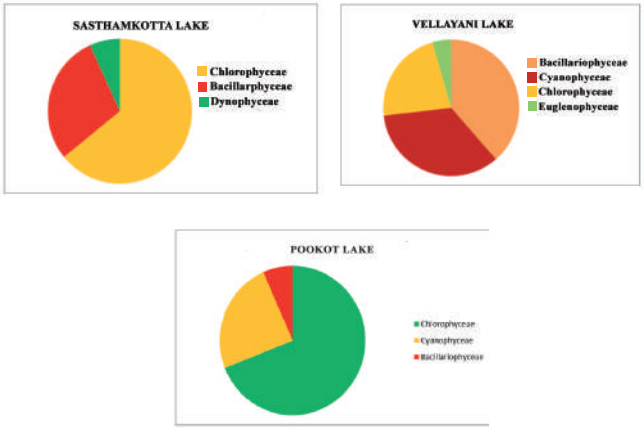

Fig. 4.2.12.3 Phytoplankton Diversity in Sasthamkotta, Vellayani, and Pookot Lake waters

The Water Quality Index (WQI) calculated for evaluating the infuence of natural and anthropogenic activities based on several key parameters (pH, EC, TDS, HCO_3, Cl, SO_4, NO_3, Ca^{2+}, Mg^{2+}, Na^+, K^+) of surface water chemistry and based on the WQI, majority of the samples in the three lakes falls under excellent to good category indicating its suitability for drinking water. Increased concentration of nitrates and phospates were observed in the water samples

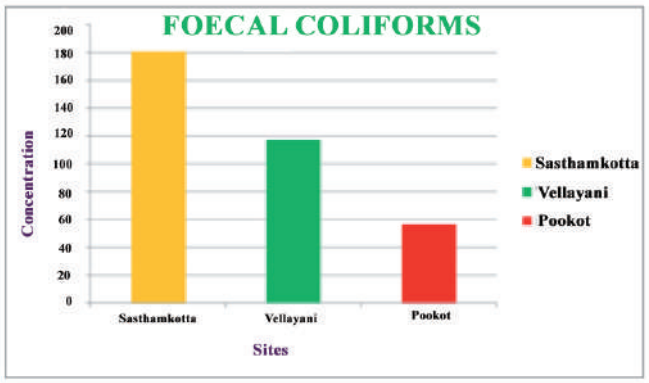

Fig .4.2.12.4 Average concentrations of Faecal Coliforms in Sasthamkotta, Vellayani, and Pookot lake waters

of the three lakes compared to the previous data (2006) reported from the region.This may be due to the intensive agricultural activities around the lake ecosystems. The textural facies were also worked out for the substratum sediments. Sasthamkotta Lake sediments show predominance of silt and clay with very subtle quantities of sand. The surface sediments of the Vellayani Lake blanketed mainly by silty sediments. But in Pookot Lake, sediments show dominance of silt and clay. The high percentage of C-org and TN recorded in the surface sediments of Pookot Lake, which surrounded by thick forest plantations. The research also includes understanding of greenhouse gas dynamics and effective ways to reduce greenhouse gas emissions in the area inorder to improve its ecological health.

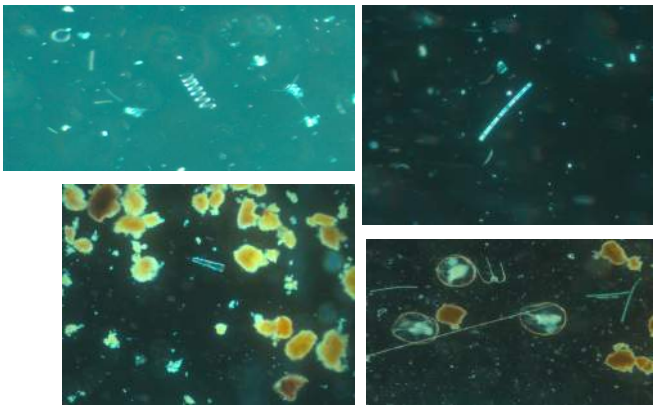

Fig. 4.2.12.5 Dominant phytoplankton species (Arthospirasps, Aulacioseira. sp, Gomphonemasps, Ceratium sps) observed in Vellayani, Sasthamkotta and Pookot lake waters.

Detailed microscopic investigation revealed that 4 families consisting of 40 genera of phytoplankton in the order Baciilariophyceae>Cyanophyceaae>Chlorophyceae> Euglenophyceae in Vellayani Lake. Sasthamkotta Lake, showed the presence of 3 families consisting of 27genera in the order Chlorophyceae>Bacillariophyceae> Dynophyceae. But in Pookot Lake, a diversity of 22 genera observed consisting of Chlorophyceae>Cyanophyceae> Bacillariophyceae (Fig. 4.2.12.3). Faecal Coliforms showed an average concentration of 159CFU/ml in Sasthamkotta Lake, 136 CFU/ml in Vellayani Lake and 98 CFU/ml in Pookot Lake (Fig. 4.2.12.4). Although all physico-chemical parameters are falling under the prescribed limits of drinking waterquality standards, microbial population of faecal origin was noticed in all lakes due to the unhealthy waste management practices in the catchments.

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4.2.13 Adsorptive potential of surface modified clays and chitosan for the Recovery of certain inorganic toxic Metal ions from Aqueous media using Batch and Column studies: Kinetics and Thermodynamic profile

Adsorption is a most promising technology for effluent treatment in terms of cost, operation, application at very low concentrations and possibility of regeneration and reuse. Present study makes use of adsorption technique for the removal of cationic as well as anionic pollutants from aqueous phase. Heavy metals have been indicated as a prominent component of industrial effluents, causing of environmental pollution problems because of their bioaccumulation tendencies and toxicity to life. A quality adsorbent at the solid/solution interface can lead to adsorption process more easily and effectively.

Chitosan, a linear polysaccharide is one among the suitable adsorbents used for recovery of toxic metals. It can have exceptional ways of modification as they are composed of randomly distributed β-(1-4)-linked D-glucosamine (deacetylated unit) and N-acetyl-D-glucosamine (acetylated unit). It is prepared by treating exoskeliton of shrimps and other crustaceans with alkali sodium hydroxide. The chemical modification of chitosan is of interest because the modification would not change the fundamental skeleton of chitosan, similarly these derivatives conforms new or improved adsorption properties.

Methodology includes a novel organic synthesis propagating through a free radical chain reaction mechanism leads to the formation of a highly active graft co-polymer possessing improved adsorption properties. The effects of pH, contact time, initial concentration, adsorbent dose, and adsorption isotherm on removal

process were evaluated using batch adsorption technique for chitosan and the chitosan derivatives. The proposed reaction mechanism for the organic synthesis of chitosan based co-polymer is shown in Fig. 4.2.13.1.

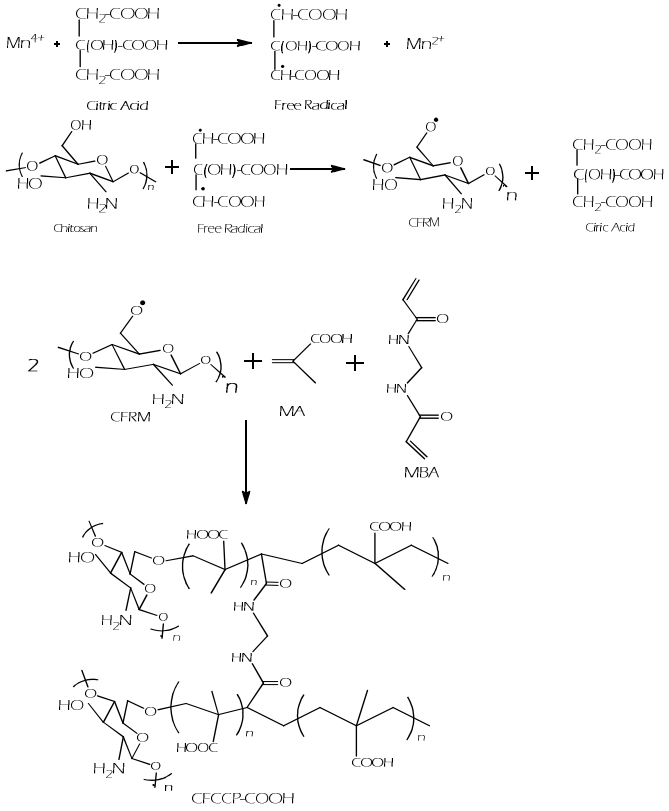

Fig. 4.2.13.1 The Mechanism involved in the preparation of CFCCP-COOH

The carboxylate functionalized chitosan co-polymer (CFCCP-COOH) was prepared by reacting chitosan free radical (CFRM) and a monomer methacrylic acid (MA) in the presence of a cross linker N, N'-methylenebisacrylamide (MBA), Mn IV/citric acid as initiator. Studies on adsorption behavior of newly synthesized chitosan based graft co polymer CFCCP-COOH are pursuing and the properties of Chitosan as an adsorbent for the removal of lead (Pb) are well studied and the results were summarized (Fig. 4.2.13.2).

The performance of chitosan on the adsorption of Pb is maximum at the pH range 4.5– 5, 99.1% and 91.2%. Pb is removed from the solution of initial concentrations 10 mg/L and 25mg/L of lead respectively at pH 5. The percentage of adsorption decreases with increase in pH may be due to the formation of $Pb(OH)_2$ species having less tendency for complexation with chitosan. The equilibrium contact time for adsorption is 30 minutes, beyond that it is almost saturated and the amount adsorbed are 0.97, 3.17, 7.7 and 14.84 mg/L, respectively for 5, 10, 25, 50 mg/L of initial concentrations of Pb(II). This is due to the availability of large number of adsorption sites initially for adsorption. The influence of initial concentration was studied by varying the concentration of adsorbate from 5 mg/l to 125 mg/l. The adsorption efficiency was consistent up to 25 mg/l suggests unavailability of adsorption sites beyond the mono layer capacity.

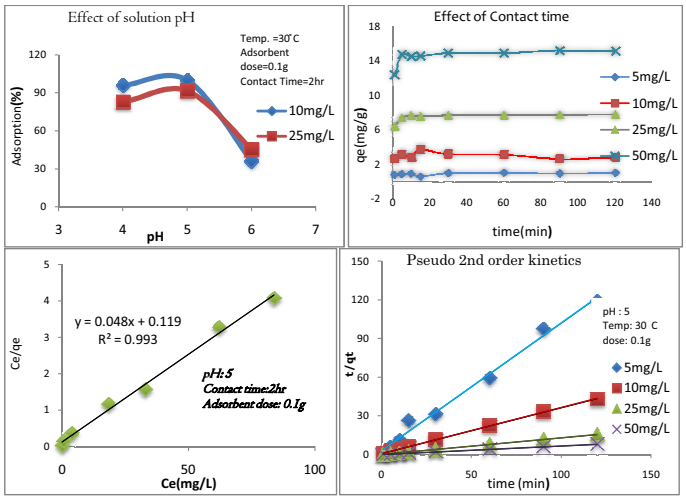

Fig. 4.2.13.2 The adsorption behavior of newly synthesized chitosan

For determining the adsorption capacity Langmuir and Freundlich isotherms were introduced for the process and the isotherm constants were calculated. Langmuir isotherm gives the best fit for the entire range of concentration with R^2 value 0.993. There for the adsorption of Pb(II) on chitosan is mono molecular layer.

The adsorption potential of chitosan was investigated in batch technique. The parameters like pH, contact time, initial concentration and temperature were optimized and the isotherm models are introduced in the results. The maximum adsorption of Pb(II) was observed at pH 5 and the removal of Pb(II) is highly efficient up to 30 minutes of contact time. Kinetics of adsorption indicates that the process follows a pseudo second order rate equation. Adsorption process is well described by Langmuir isotherm model and suggests entire process attains equilibrium after the formation of a mono molecular layer. The adsorption capacity of chitosan for the adsorption of Pb(II) was found to be 25 mg/l at 30^0C. For higher adsorbate concentrations beyond 25 mg/l chitosan skeleton need modification. The newly synthesized CFCCP-COOH can be a better option and the adsorption studies are pursuing to introduce better results.

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4.2.14 Studies on Hydrogeochemical and Biological aspects of various streams of Karamana river near Sree Parasurama Swami Temple, Thiruvananthapuram district, Southern India

The present study entitled "Studies on hydrogeochemical and biological aspects of various streams of Karamana River near Sree Parasurama Swami Temple, Thiruvananthapuram District, Southern India" focuses on the pollution aspect of the selected localies. The downstream of Karamana river near the Parasurama Swamy Temple is widely utilized by people in various walks of life - pilgrims, students, fishermen, merchants, swimming youths, etc. The region has high socio-economic, cultural and spiritual importance. The main objective of this work is to develop a spatial and temporal model for representing the area under study and the nearby areas to understand the factors contributing to pollution of water bodies. This study also aims to propose reliable remedial measures to improve socio-economic, cultural and spiritual aspects of the study area inorder to improve its overall environmental quality. Moreover, the study focuses on the pollutant distribution pattern in terms of solution chemistry and also the speciation of chemical constituts as well as bilogical components with in the water/sediment interfaces. Awareness creation on environmental degradation including pollution of water resources form another aim of the study.

Methodology of research programme is streamlined well in advance. Initially, water and sediment samples are collected for analysis from seven stations in Karamana River and nearby canals/streams which are located near Sree Parasurama Swami Temple, Thiruvallam, Thiruvananthapuram District. Chemical analysis includes tests for alkalinity, dissolved oxygen, BOD, ammonia, nitrites, nitrates, phosphates, chlorides, sulphates , Iron, etc. based on APHA. Sediment analysis is done for texture analysis, heavy metals, nutrients and major ions. The estimated physico-chemical data is summerised in Table 4.2.14.1.

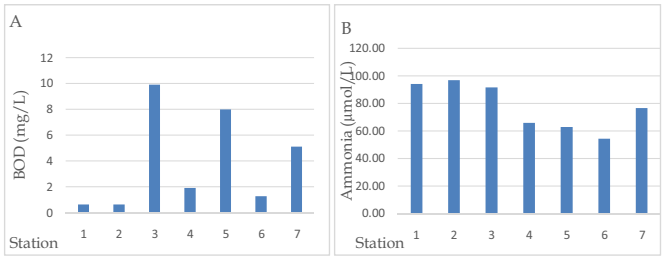

Fig. 4.2.14.1 (A)Variation of BOD and (B) ammonia at different stations

Among the nutrients, phosphate concentration ranges from 1.96 to 11.52 µmol/l, while the range of nitrite, nitrate, ammonia and silicate were found to be 2.04-6.02, 54.36-96.91, 0.46-9.91 and 84.65-119.83 µmol/l, respectively. The higher values of nutrient concentration is indication of uncontrolled sewage disposal into the riverine system. A holistic approach is to be implemented to prevent the water pollution in and around the Temple premises. The evaluation of sediment characteristics along with heavy metal analysis is progressing.

Table 4.2.14.1 The physico-chemical data for the field programme

Stn	Alkalinity (mg/l)	DO (mg/l)	BOD (mg/l)	Ammonia (µmol/l)	Nitrite (µmol/l)	Nitrate (µmol/l)	Phosphate (µmol/l)	Chloride (mg/l)	Silicate (µmol/l)	TP (µmol/l)	TN µmol/l	Sulphate µmol/l)	Iron (µmol/l)
1	224	0.64	0.64	0.70	2.83	94.16	2.64	15.49	105.93	9.93	96.82	0.05	1.23
2	116	4.80	0.64	0.46	3.61	96.91	4.06	13.10	115.29	12.02	102.43	0.14	1.08
3	180	4.84	9.92	1.85	2.04	91.78	11.31	12.33	114.52	8.12	96.69	0.22	0.72
4	172	2.56	1.92	0.82	2.29	65.99	11.52	14.21	107.54	2.50	90.64	0.17	3.87
5	196	7.56	8.00	7.66	2.11	62.89	7.06	13.78	112.29	0.91	92.12	0.05	4.59
6	160	1.60	1.28	6.41	6.02	54.36	8.64	0.51	84.65	0.73	89.64	0.15	1.87
7	180	1.92	5.12	9.91	4.65	76.71	1.96	0.26	119.83	0. 96	91.89	0.08	5.78

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4.2.15 Assessment of Nutrient flux in Urban Drainage Systems: Identification of Sources, Pathways and Remedial Measures

The objective of this research is to assess the nutrient flux in urban drainage systems, with an emphasis on phosphates in Karamana River Basin, Thiruvananthapuram, Kerala. Phosphorous is an essential nutrient for micro and macro organisms. Its presence beyond 1.0 ppm leads to eutrophication and therefore its removal from water and wastewaters is highly warranted. Among the various methods adopted for phosphate removal, adsorption is found to be one of the excellent technique for their removal from aqueous solution. Here a preliminary study has been initiated to focus on the removal of phosphate by adsorption technique. Prior to that one field programme has been conducted to collect water/sediment samples from selected points in Karamana River, Killiyar, Aamayizhanjanthodu and Parvathy Puthanar. Collected

water/sediment samples from selected points in the drainage systems. Analysis of physico-chemical as well as micro-biological parameters is carried out using APHA. Temperature, pH, DO, BOD, nutrients, major ions and heavy metals were also analysed. Batch adsorption experiments (operational conditions such as pH, initial concentration, agitation speed, contact time and temp) were conducted to remove phosphate from simulated as well as real samples. Initially the focus of the work was to seasonally monitor the water/sediment quality of four riverine systems (Karamana, Killiyar, Aamayizhanjanthodu and Parvathy Puthanar) which are flowing through the Trivandrum urban area. Secondly to evaluate the physico-chemical and biological parameters for assessing the health of the watershed regions. Finally, to develop an effective adsorbent material using clays and clay minerals for effective removal of phosphate from simulated as well as real systems. The range of physico-chemical parameters is presented in Table 4.2.15.1.

A series of batch adsorption experiments were carried out to optimize the operational conditions for effective removal of phosphate from water and wastewaters using bentonite-alum system. The effect of contact time on the adsorption of phosphate from aqueous phase onto bentonite clay was determined (Fig. 4.2.15.1A). Equilibrium studies revealed that the adsorption process can be best described by Langmuir isotherm model rather than Freundlich model (Fig. 4.2.15.1B). The equilibrium data for the adsorption processes and thermodynamic parameters were presented in Table 4.2.15.2 & 4.2.15.3 respectively.

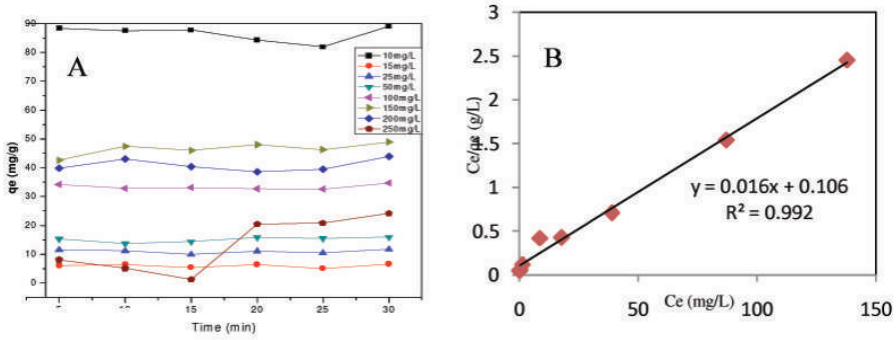

Fig. 4.2.15.1 (A) Effect of contact time (contact time: 30 min, pH=4, adsorbant dosage=0.1g) and (B) Langmuir isotherm plot for 40°c the adsorption of phosphate on to bentonite-alum system.

Thermodynamic parameters such as change in free energy (ΔG°), enthalpy (ΔH°) and entropy (ΔS°) were also calculated using the following equation,

$$\Delta G^{O} = -RT\ln K_{O}$$

$$\ln K_{O} = \frac{\Delta S^{O}}{R} - \frac{\Delta H^{O}}{RT}$$

where K_o is the equilibrium constant. The values of K_o were determined from the intercepts obtained by plotting ln q_e/C_e versus q_e and extrapolating to zero q_e at various temperatures ranging from 10-40°C. The plots of ln K_o versus 1/T for phosphate was found to be linear. The values of ΔH° and ΔS° were obtained from the slope and intercept of the plots and were found to be 40.46 kJ/mol and 14.28 J/mol/K respectively. The positive value of ΔH° indicates that the adsorption process is endothermic and temperature dependent. The values of ΔG° were found to be -1.43, -0.02 and -0.04kJ/mol for the adsorption of phosphate from aqueous solution at 10, 20 and 40°C respectively. The negative values of

Table 4.2.15.1 Range of physico-chemical parameters observed in the study area

Parameter	Samples collected from four rivers			
	Karamana	Killiyar	Aamayizhanjanthodu	ParvathyPuthanar
pH	6.34-6.57	6.46-6.76	6.56-6.71	6.75-6.9
TDS (mg/L)	125.7-159.7	135-180	332.5-413.5	638.3-88
Phosphate (mg/L)	5.05-8.34	4.43-17.7	0.68-1.12	1.09-1.63
Nitrite (µg/L)	0.02-2.3	0.08-16.28	0.87-6.18	2.03-174.03
Ca hardness (mg/L)	10.42-12.02	11.22-14.42	33.66-40.08	38.47-62.52
Mg hardness (mg/L)	2.43-6.82	3.41-8.77	2.92-9.75	3.9-22.9
Total hardness (mg/L)	36-56	48-72	68-136	172-208

Table 4.2.15.2 The equilibrium data for the adsorption process

Adsorbent	Temperature (°C)	Langmuir isotherm			Freundlich isotherm		
		Q^0 (mg/g)	b (L/mg)	r^2	K_F (mg/g)	n(L/mg)	r^2
Bentonite clay in presence of alum	10	58.82	0.0442	0.952	3.999	1.8281	0.952
	20	50.00	0.0877	0.974	7.0631	2.4807	0.931
	30	38.46	0.1485	0.911	4.3853	1.9230	0.776
	40	26.53	0.1509	0.992	9.8627	2.2573	0.962

Table 4.2.15.3 Thermodynamic parameters for the adsorption process

Adsorbent	Temperature (°C)	K_0	ΔG^0 (KJ/mol)	ΔH^0 (KJ/mol)	ΔS^0 (J/mol)
Bentonite clay in presence of alum	10	0.049	-1.4258	40.46	14.28
	20	2.159	-0.0217		
	40	4.741	-0.0414		

ΔG° show the spontaneous adsorption of phosphate on the adsorbent. The positive value of ΔS° suggested some structural changes in adsorbent and adsorbate and also reflects the affinity of the adsorbent material under consideration towards phosphate ions.

The probable mechanism of phosphate adsorption onto bentonite clay in presence of alum can be summarised as follows:

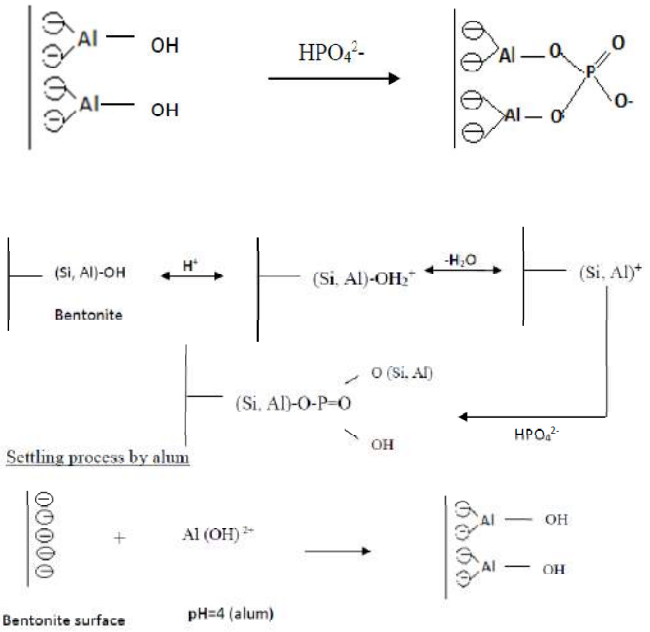

Table 4.2.15.4 Adsorption of phosphate from riverine water samples

Waste water system	Concentration (mg/L)	q_e (mg/g)
Simulated system	25mg/l	11.25 (90.0%)
Water sample collected from Parvathy Puthanar	17mg/L (phosphate present in real system) + 8mg/L (spiking)	11.00 (88.0%)
Water sample collected from Aamayizhanjanthodu	10mg/L (phosphate present in real system) + 15mg/L (spiking)	9.81 (78.5%)

Pre-monsoon sampling was successfully conducted in selected locations at Karamana River, Killiyar, Aamayizhanjanthodu and Parvathy Puthanar in Trivandrum urban area. Physico-chemical and biological parameters were analysed and evaluated. Batch adsorption studies were conducted and found that bentonite in presence of alum is an effective adsorbent for the removal of phosphate from water and wastewaters. The maximum adsorption was found to be at pH 4.0 and equilibrium attained at 30 min. Equilibrium studies revealed that adsorption follows the Langmuir isotherm model. Application of bentonite clay into riverine water samples is shown in Table 4.2.15.4.

Water samples containing phosphate were analysed by usual procedure and found that about 17mg/L and 10mg/L of phosphate was present in Parvathy Puthanar and Aamayizhanjanthodu respectively. In our experiments, maximum phosphate adsorption was found to be for 25 mg/L and therefore we made the real water sample concentration into 25mg/L through spiking and by applying suitable operational conditions (contact time 30 min & pH 4.0). The water samples from Parvathy Puthanar and Aamayizhanjanthodu showed a q_e value of 11mg/g (90.0%) and 9.81mg/g (78.5%) respectively. This finding explains the suitability of the adsorbent in real system for phosphate removal.

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4.2.16 Appraisal of Marine Ecosystem of Kavarathi Island in Kochi in South West coast of India with special reference to Lagoon system

The present study deals with the hydrochemical, marine biological and geochemical characteristics of the lagoon environment of the Lakshadweep Archipelago. As a consequence of indiscriminative exploitation of water resources and population explosion, the quality of well water and nearby lagoon waters is constantly deteriorating especially around the Kavaratti Island. Detailed hydrogeological, geophysical and hydrochemical studies have been carried out to characterise the ground water resources and identify the vulnerable areas of Kavaratti. Biological processes also impart considerable influence in the composition of coastal waters and lagoon systems. At the same time chemical characteristics have an important role in the productivity between oligotrophic and eutrophic waters and life sustaining processes between aerobic and anoxic waters. In the lagoon system of Kavaratti, the composition of sea water is closely related to the temporal and spacial variation of marine biological resources. Pollution of Kavaratti is mainly due to microbial means, as the industrial development was almost nil in the region and the island has little or no suitable sewage treatment in the coral reef area. The small oceanic islands differ from the mainland and the major islands in their aquifer geometry and hydrochemistry. In these small oceanic islands, fresh groundwater occurs as a lens floating over the saline water,and the freshwater lens is in hydraulic continuity with seawater. The variation in quality ismore pronounced in themargins of the freshwater lens than at its centre .The coral islands are composed of calcareous sand and the materials derived from coral atoll, which are

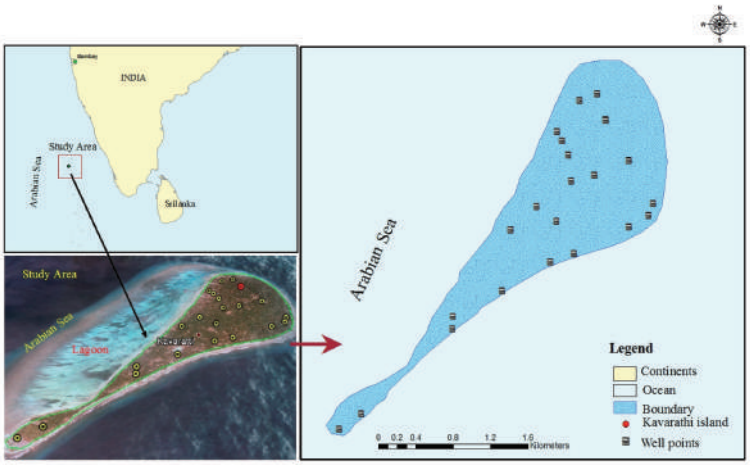

Fig.4.2.16.1 Map showing the sampling sites in Kavarathi island

of very high purity and chemical grade, with 87 percent $CaCO_3$. The present study aims to identify, and quantify anthropogenic influences over time with repect to the natural base line data. The seasonal monitoring concentrate towards physico-chemical and biological changes in hydrogeology of ground water and geological attributes of sediments and distribution of heavy metals. The periodic study also aims to identify the threads in marine ecosystem (marine biological and microbiological aspects) with special reference to lagoon system in Kavaratti.

Seasonal monitoring was conducted for the study. Twenty wells were selected for the ground water monitoring and geochemical study (Fig. 4.2.16.1). Off shore sampling was carried out by cruise ORV Sagar Manjusha. Parameters were analysed following by Standard Methods.

The groundwater exists in the form of a thin freshwater lens over saltwater, having restricted lateral movements. The influence exerted by the shape of these tiny islands on the stability of the water in the lenses and the tendency of this water to mix with seawater are elucidated. The factors which influence the chemical evolution of groundwater in these islands are the geochemistry of the coral aquifer, mixing of sea water, and dissolution of $CaCO_3$.The nutrient profile in this coral aquifer system reflect the general hydrochemical scenario and are presented in Fig. 4.2.16.2. Mean value of NH_4 recorded higher value (3.88µmol/L) than NO_2 (1.84 µmol/L) IP (1.45µmol/L) and TP (1.78µmol/L). Oligotrophic condition prevailed in Kavaratti lagoon where chlorophyll a was found to be low (< 2mg/m^3). Phytoplankton and zooplankton density were very low as there is low entrainment of nutrients. In the present study sediment samples of Kavaratti was undertaken to evaluate the distribution of heavy metals in various clusters. Concentration of zinc varies from 2.92ppm to 0.26ppm. Considering the distribution of lead maximum concentration recorded was 2.5 ppm and minimum 0.28 ppm.Ni ranges from 0.21-0.95 ppm, Cd from 0.14 to 0.29 p pm, Co from 0.05 to 0.20 ppm and Cu from 0.14ppm to 0.91 ppm. The graphical representation of distribution of heavy metal among difficult sampling is shown in Fig. 4.2.16.2.

The chemical evolution of groundwater in the coral islands of Lakshadweep is due to the combined effect of various processes such as mixing of waters, contributions by marine aerosols, cation exchange, and dissolution of $CaCO_3$. Physico-chemical and biological studies are going on with the reference of lagoon system in Kavaratti. Relatively low concentrations of trace elements were recorded in sediments (Zn- 2.92-0.26 ppm), Pb(2.5-0.28 ppm), Ni(0.21-0.95 ppm), Cd(0.14-0.29 ppm), Co (0.05-0.20 ppm), and Cu (0.14-0.91 ppm).

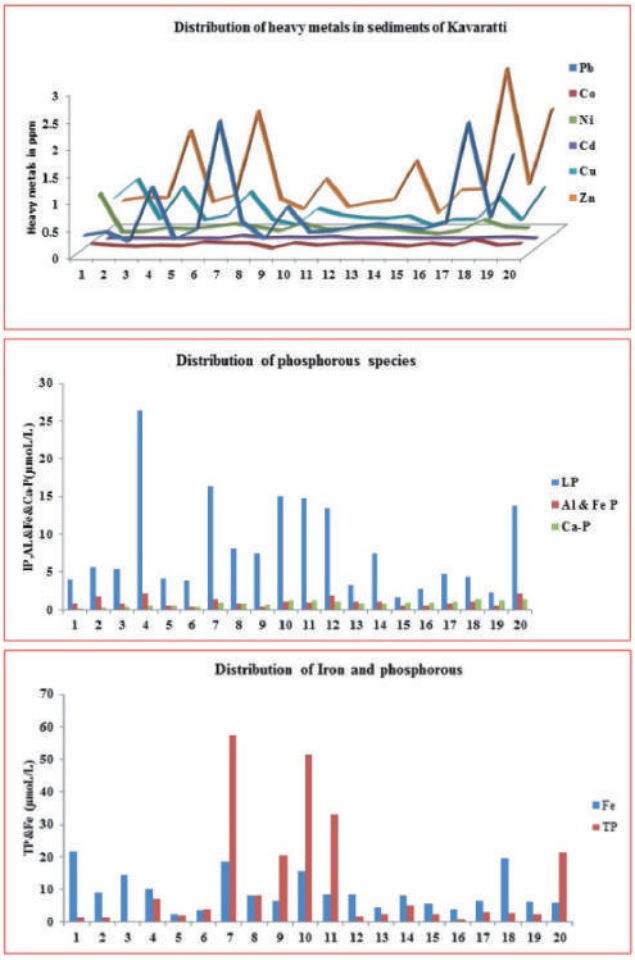

Fig. 4.2.16.2 Distribution of heavy metals and nutrients in the study area

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4.3 Coastal Zone Management (CZM)

4.3.1 Integrated Island Management Plan (IIMP) for Lakshawdeep islands

The preparation of Integrated Island Management Plan (IIMP) for all the inhabited islands of Lakshadweep has been accomplished in accordance with the guidelines provided in the Island Protection Zone Notification of MoEF, 2011. The plan preparation was supervised by a Technical Committee constituted by the Supreme Court of India in 2012 under Chairmanship of Justice R.V. Raveendran, Supreme Court Judge(Rtd). The entire island zone including the aquatic area were considered for the preparation of IIMP plan. The digital data base on 1:4000 scale was utilized for mapping different physical characteristics of the island. Areas indicating the dwelling units including the infrastructure projects such as schools, markets, hospitals, public facilities, road net work were brought into the digital map with all their characteristics. The conservation and preservation schemes were mapped separately. The data on the coral ecosystems which were mapped utilizing the satellite imageries of 2007 were also incorporated. Vulnerability map showing the elevation of the island with respect to the MSL has been worked out. This map will be utilized to assess the vulnerability to human life and property. This will also help to indicate suitable areas that are safe for locating dwelling units, infrastructure and appropriate safeguard measures to protect the life and property of the local communities. Mapping of HTL and No Development Zone in the island has also been completed. An approach for identification of Buffer zone/Setback line for Conservation/ Preservation in the islands has been worked out keeping the natural threats such as high waves storm surges, horizontal shoreline displacement and sea level changes in the islands.

The final report and IIMP plan in respect of 10 inhabited islands viz., Agatti, Amini, Androth, Bitra, Chetlet, Kavaratti, Kadamat, Kalpeni, Kiltan and Minicoy were completed and submitted to the UT Lakshadweep Administration. The public interaction and field visits to the related representative islands were also completed. The draft IIMP for 3 uninhabited islands were also completed and submitted to UTL.

T. N. Prakash

Funding: DST, UT of Lakshawdeep

4.4 GIS and Remote Sensing Applications in Natural Resources Management

4.4.1 Setting up of modular data centre

Main purpose of this infrastructure is to organize and share the available geospatial data in inter-operable and open standard format. Based on the comprehensive request for proposal tender was released to supply, instal and commissioning of server and storage in a virtual environment. As depicted in the Fig. 4.4.1.1, the proposed infrastructure comprises of modular rack, physical servers, SAN switches, SAN storage and tape library. The three physical servers will act as three VMware hosts. The vSphere hypervisor shall be installed on these 3 physical servers in order to virtualize them.

The cluster shall be configured in such a way it is capable of High availability and Distributed Resource Scheduling (DRS). SAN Storage comprises of dual controllers and an enclosure module and disks will be grouped using appropriate RAID, thus ensuring high availability for controllers and disks respectively. The servers and data storage will be hosted at the Central Geomatics Lab of NCESS.

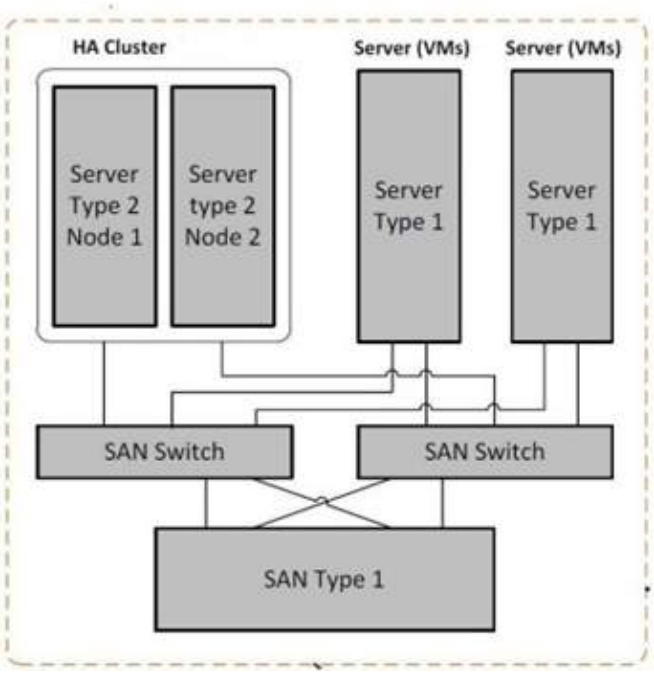

Fig. 4.4.1.1 Logical schematic diagram of the proposed of hardware architecture of modular data centre.

M. Samsuddin & B. K. Jayaprasad

4.4.2 Spatial Urban Information System using open source software

Main focus of the programme is to generate and disseminate spatial/non spatial digital database including socio economic data in the Malappuram municipal area through a customized information system with thrust on planning, management and decentralized governance.World view 2 satellite data (with spatial resolution of 0.50m Mx and 2 m PAN) was used in conjunction with Global Positioning System (GPS) and field survey data for preparing the database. WV02 satellite data was precisely geo-corrected using Differential Global Positioning System values. Various thematic layers such as land use/land cover, road network, water bodies, settlements, building foot prints, assets, utilities, services, religious institutions and amenities etc, were derived in 1:4000 scale.The thematic layers were integrated with socio-economic database and were reproduced in WGS-84 Datum and UTM Projection.

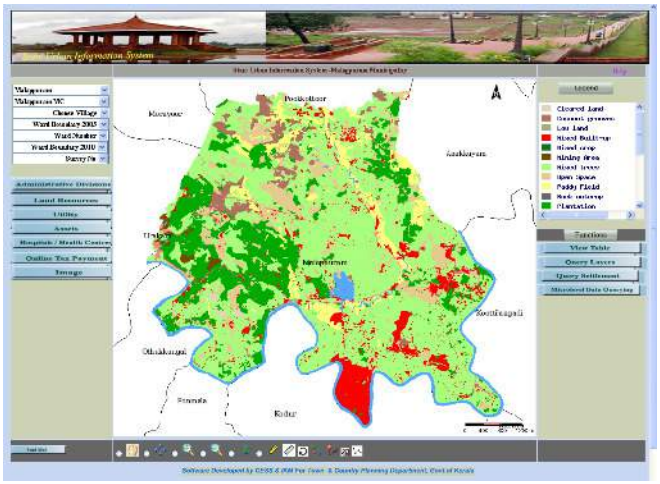

Fig. 4.4.2.1 Customized Urban Information System

Individual village level cadastral sheets were Geo-Referenced with respect to the DGPS coordinate values. Cadastre was vectorized and linked to the survey parcels. Attribute data with respect to the location, resource database including socio-economic data collected from the field has also been linked in a GIS platform.

By integrating the thematic layers and attribute data of societal importance, a web based user-friendly customized information system (Fig. 4.4.2.1) has been designed and developed in open source platform. The decision support modules provide flexible environment for data handling, resource query, update analysis and provide inputs into the master/zonal planning and utilities management.

The user can explore, update and extract reliable cadastre level spatial database according to their requirement.The application has been modified to incorporate all the .jpg images of buildings/properties along with building details collected through the socio-economic survey. After modification of application with spatial search module and application tools the customized application has been hosted.

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Funding: Information Kerala Mission, LSG Department, Govt. of Kerala

4.4.3 A Customized OSSGIS Application for Vegetable and Fruit Promotion Council Keralam (VFPCK) for Management of Soil Nutrients

Vegetables and Fruit Promotion Council Keralam (VFPCK), the successor of Kerala Horticulture Development Programme(KHDP) is a Kerala Government Public Sector Undertaking. VFPCK has awarded a project to this centre for developing a Open Source GIS customized application software for the management of soil nutrients in 162 Grama Panchayats covering fourteen districts of Kerala using Open source Mapserver and PostgreSQL. The objective of the project is to build application software using the existing thematic digital database of land use/land cover, geomorphology, soil etc. and updating with the data pertaining to the soil (macro & micro) nutrients of the panchayat to help farmers engaged in the horticulture development program for the application of proper manures on need basis in their farms.

Thus customized GIS application software has been developed using open source software to show the GPS coordinates of soil sample locations collected and provided by VFPCK for selected 162 panchayats of Kerala. Open source software used for the development of Customized GIS application are Map Server 4 Windows 2.2.3, Web server (Apache-HTTP), PHP 5.2, JavaScript, PostGIS enabled Postgre SQL8.4 and Quantum GIS 0.11.0 . The software shall be hosted in intra-net/internet and there is no license required for any deployment.

The application has a menu comprising pan, zoom-in, zoom-out, recenter, measure, display current extent and map legend. It has the facility to identify the attributes of a thematic layer by using a mouse click. The application has the provision to add the coordinates of latitude/ longitude values in Degrees, Minutes and Seconds (DMS) for inserting a point shape in the appropriate location based on the graticule (latitude & longitude) values. Apart from that, functions such as "Query", "View data", "View legend", "Export attributes in .xls format", "add point", "import excel", "delete excel", "remove point" are also

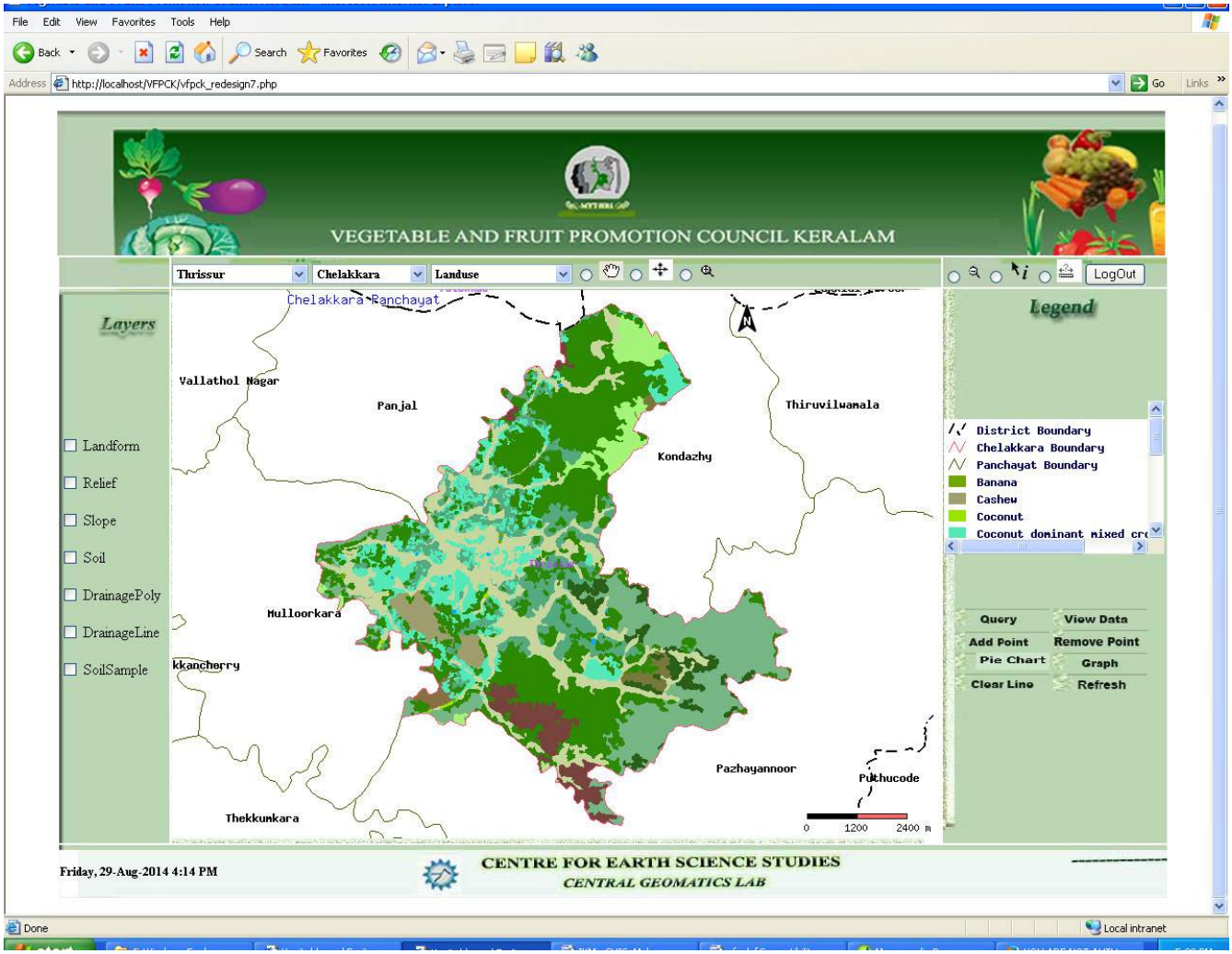


Fig 4.4.3.1 Soil sample sites in land use of Chelakkara Panchayat

available. The variation of micro and macro nutrients distribution of the soil parameters are also displayed in graphs and charts. The customized application has been hosted in the site address **http://14.139.171.147/VFPCK**

B. K. Jayaprasad

Funding: Vegetable and Fruit Promotion Council, Govt. of Kerala

4.4.4 Geographic Information System of the Particularly Vulnerable Tribal Groups of Kerala

The tribal communities of the state are at varying degrees of socio-economic educational and political advancements. A few of them are very much adapted to the mainstream life and are living as part of it. However, there are certain communities who are still leading more or less an isolated life either within the rural society or away from it in the forest terrain. Eight among the 36 Scheduled Tribe communities of the state are categorized as Particularly Vulnerable Tribal Groups (PTG) since they are the most vulnerable sections amidst the ST's of the State. The present work is an outcome of the study undertaken jointly by NCESS and KIRTADS for generation of a digital database pertaining to the hamlets of the Particularly Vulnerable Tribal Groups (PTG's) spread across six districts of the state in order to accelerate the development process among the tribal communities. Main objective of the project is to develop a customized information system for the PTGs by integrating the existing digital resource database and updating the information with the data pertaining to the spatial location of the house hold of these tribal groups. Both primary and secondary data were used in the study.

The point data such as spatial location of the PTGs, as provided by KIRTADS in standard geographic reference datum and projection viz., WGS 84 datum & UTM Zone 43 projection. The spatial location of amenities like hospitals/Primary Health Centers, Government Officers, etc., were integrated to the existing digital database such as drainage, road network (Fig. 4.4.4.1), landuse/land cover and soil pattern in 1:250,000 scale generated by NCESS. A

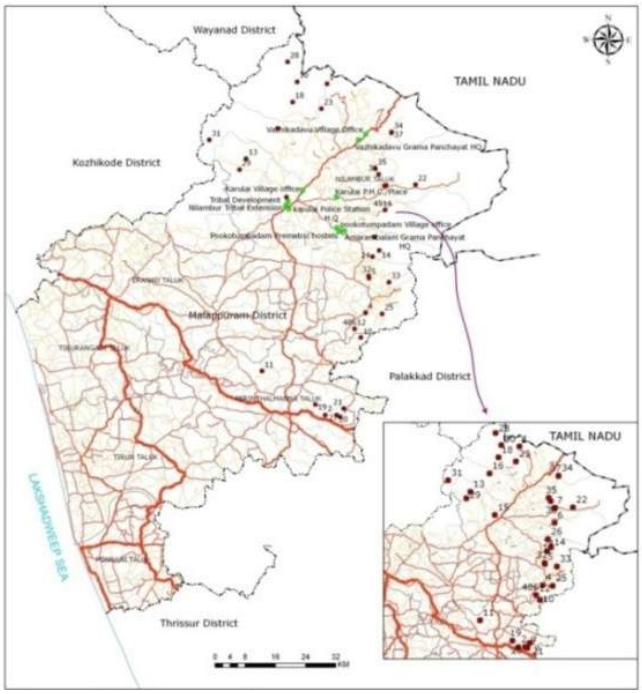


Fig. 4.4.4.1 Spatial distribution tribal population in Malappuram District

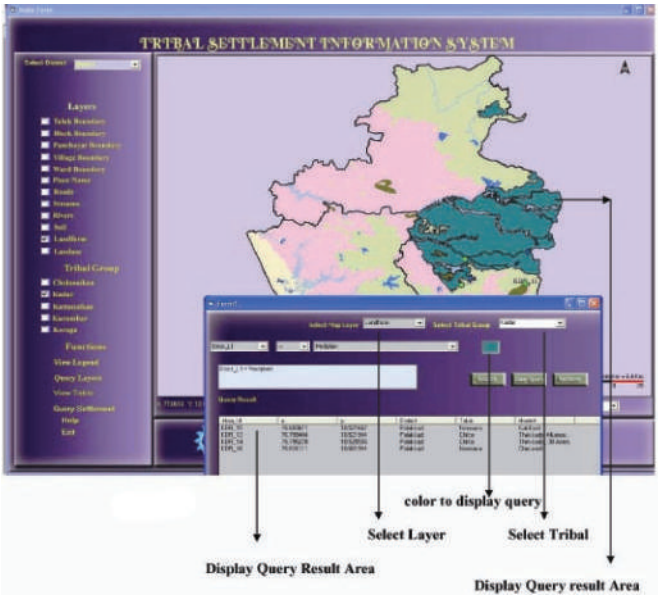


Fig. 4.4.4.2 The tribal information system

user - friendly Tribal Settlement Information System (TSIS) has been developed with all basic functionalities customized for viewing, analyzing, editing, updating and retrieving and analyzing the information pertaining to the selected particularly vulnerable tribal groups of Kerala (Fig. 4.4.4.2) Attribute data with respect to the location of PTG household and resource database including socio-economic data has been linked in a GIS platform, so that desired information can be retrieved based on user query.

Archana M. Nair & B. K. Jayaprasad

Funding: KIRTADS, Govt. of Kerala

बाह्य और परामर्श परियोजनाएं

5.1 बाह्य अनुदान सहायता परियोजनाएं

क्र. सं.	परियोजना का शीर्षक	निधिकरण एजेंसी	प्रधान अन्वेषक	प्रभाग	सह अन्वेषक	परियोजना की अवधि	कुल परिव्यय (लाख रुपए में)	वर्ष के दौरान प्राप्ति निधि (लाख रुपए में)
1	कुट्टनाड डेवलपमेंट – स्टडी फॉर प्रिपरेशन ऑफ मैनेजमेंट एक्शन प्लान फॉर इको–रेस्टोरेशन ऑफ वेम्बानद लेक (एजीआरआई 4)	कृषि विभाग	डॉ. आर. अजय कुमार वर्मा	प्राकृतिक संसाधन और पर्यावरण प्रबंधन	डॉ. के. वी. थॉमस, डॉ. डी. एस. सुरेश बाबू, श्री बी. के. जया प्रसाद	2013–15	47.43	0.00
2	सी वॉटर क्वालिटी मॉनिटरिंग (सीओएमएपीएस 4)	पृथ्वी विज्ञान मंत्रालय, भारत सरकार (आईसीएमएएम के माध्यम से)	डॉ. आर. अजय कुमार वर्मा	प्राकृतिक संसाधन और पर्यावरण प्रबंधन	डॉ. के. अनूप कृष्णन	–	323.00	0.84
3	मॉनिटरिंग ऑफ वॉटर सेडीमेंट क्वालिटी पैरामीटर्स इन द बैक वॉटर्स ऑफ कोचीन पोर्ट ट्रस्ट (सीपीटी 3)	कोचीन पत्तन न्यास	डॉ पी. के. ओमना	प्राकृतिक संसाधन और पर्यावरण प्रबंधन	डॉ. के. अनूप कृष्णन	2012–17	25.20	6.89
4	इम्पैक्ट ऑफ सी लेवल राइज इन केरल कॉस्ट (डीईसीसी 2)	पर्यावरण और जलवायु परिवर्तन निदेशालय	डॉ. टी. एस शाहुल हमीद श्री. पी. जॉन पॉल (01.02.2015 के बाद से)	तटीय प्रक्रियाएं	डॉ. के. वी. थॉमस (समन्वयक) डॉ श्रीकुमार चट्टोपाध्याय, डॉ. टी. एन. प्रकाश, डॉ. डी. एस. सुरेश बाबू, डॉ. एल शीला नायर	2013–16	67.80	1.62
5	कोस्टल हैजर्ड मॉनिटरिंग एंड अर्ली वार्निंग (डीएमडी 1)	एचवीआरए	डॉ. के. वी. थॉमस श्री. जी. शंकर (26.11.2014 के बाद से)	तटीय प्रक्रियाएं	–	–	23.22	0.00
6	इन–सीटू बायोरेमीडिएशन ऑफ लैंड फील पोल्यूटेंट्स : मक्सीमीज़िंग द रेमीडिएशन पोटेंशियल ऑफ सेलेक्ट इंडजीनस एंड एक्सोजीनस माइक्रोनेजियम (डीएसटी 79)	डीएसटी	श्रीमती के. दीपा नायर	वायुमंडलीय प्रक्रियाएं	–	2013–16	20.00	0.00
7	जियोकेमेस्ट्री पेलियोमैग्नेटिस्म एंड आइसोटोप स्टडीज ऑफ माफिक बॉडीज इन द ग्वालियर, बिजवास एंड कुडप्पा बेसिनंस : ए सिंथेसिस ऑफ पेलियोप्रोटेरो–ज़ोइक लार्ज इनौस प्रोविन्सेस इन इंडिया डीएसटी 80)	विज्ञान और अभियांत्रिकी अनुसंधान बोर्ड	डॉ. टी. राधाकृष्ण	क्रस्टल प्रक्रियाएं	डॉ. टोमसन जे. कुल्लुकुलम	2013–16	34.20	5.00

8	एनवायर्नमेंटल स्टडीज ऑफ द वेटलैंड सिस्टम ऑफ कोल्लम–नींदकारा एन्ड एसोसिटेड इलैंड्स (एफपीडी 1)	मत्स्य पालन और पत्तन विभाग	डॉ. ए. कृष्णकुमार	प्राकृतिक संसाधन और पर्यावरण प्रबंधन	डॉ. रेजी श्रीनिवास डॉ. के. अनूप कृष्णन, डॉ. टोमसन जे. कुल्लुकुलम	2013–15	8.18	0.00
9	हैजर्ड वल्नेरेबिलिटी एंड रिस्क असेसमेंट ऑफ द स्टेट एज़ पार्ट ऑफ प्रेपेरिंग डिजास्टर मैनेजमेंट प्लान फॉर द स्टेट (एचवीआरए)	राजस्व विभाग	श्री. जी. शंकर	क्रस्टल प्रक्रियाएं	–	2011–15	4.56	0.00
10	केडेस्टरल स्केल सीआरज़ेड मैप्स फॉर अर्बन एरियाज इन केरल; फेज 1 – कोज़हीकोडे, कोल्लम एंड त्रिवेंद्रम कॉर्पोरेशंस एंड वरकला युनिसिपेलिटी(केएससीएस 6)	केएससीएसटीई	डॉ. के. वी. ॉमस	क्रस्टल प्रक्रियाएं	श्री डी राजू, श्री एस मोहनन, श्री एम रमेश कुमार	2006–15	6.99	0.00
11	केडेस्टरल स्केल सीआरज़ेड मैप्स फॉर अर्बन एरियाज इन केरल : फेज 2–कोच्ची कॉरपोरेशन, मरदु एंड कान्हानगड़ युनिसिपैलिटी (केएससीएस 17)	केएससीएसटीई	डॉ. रेजी श्रीनिवास	क्रस्टल प्रक्रियाएं	श्री डी राजू, श्री एस मोहनन, श्री एम रमेश कुमार श्री श्री एम. के. श्रीराज श्री एम. के. रफीक	2011–15	25.00	0.00
12	सी लेवल चेंज एंड इट्स इ पैक्ट्स (केएससीएस 18)	केएससीएसटीई	डॉ. के. वी. ॉमस	क्रस्टल प्रक्रियाएं	डॉ. टी. एस. शाहुल हमीद	2011–16	81.54	0.00
13	मॉनिटरिंग ग्लोबल चेंज इ पैक्ट्सइन सह्याद्रि (वेस्टर्न घाट्स) (केएससीएस 21)	केएससीएसटीई	डॉ. ए कृष्ण कुमार	प्राकृतिक संसाधन और पर्यावरण प्रबंधन	श्री बी. के. जयाप्रसाद	2011–15	63.46	0.00
14	पेलियोक्लाइमेट एंड सी लेवल रिकार्ड्स इन द लेट क्वाटर्नरी सेडीमेंट्स ऑफ कॉस्टल वेटलैंड्स ऑफ पल्लिकाल एंड अचानकोविल रिवर बेसिनंस, केरल–इट्स इ ि प्लकेशन्सऑन कॉस्टल इवोलूशन (केएससीएस 24)	केएससीएसटीई	डॉ. डी पदमलाल	प्राकृतिक संसाधन और पर्यावरण प्रबंधन	डॉ. के. माया	2011–15	10.54	0.00
15	एनवायर्नमेंट मैनेजमेंट ट्रेनिंग (केएससीएस 28)	केएससीएसटीई	डॉ. के. वी ॉमस डॉ. डी. सुरेश बाबू (26.11.2014 के बाद से)	क्रस्टल प्रक्रियाएं	डॉ. डी. एस. सुरेश बाबू	2014–15	4.00	4.00
16	कोस्टल जोन मैनेजमेंट प्लान ऑफ केरल विद् रिस्पेक्ट टु कोस्टल रेगुलेशन जोन (केएससीएस 29)	केएससीएसटीई	डॉ. के. वी ॉमस डॉ. टी. एन. प्रकाश (26.11.2014 के बाद से)	क्रस्टल प्रक्रियाएं	डॉ. डी. एस. सुरेश बाबू, डॉ. के. राजू, श्री बी. के. जयाप्रसाद, डॉ. रेजी श्रीनिवास	2014–15	299.75	45.00
17	इनवेस्टीगेशन अंडरग्राउंड स्ट्रक्चर्स एट ओवर – ब्रिज टु एसएल ि एटर स्ट्रेच ऑफ रोड यूजिंग इमेजिंग रेजिस्टिविटी वॉटर (केएसयूडीपी 2)	केरल स ायी शहरी विकास परियोजना,	डॉ. आर. अजयकुमार वर्मा	प्राकृतिक संसाधन और पर्यावरण प्रबंधन	–	2014–15	1.15	0.69

		स्थानीय स्वशासन विभाग, केरल सरकार						
18	मॉडलिंग एटमोस्फेरिक पॉल्यूशन एंड नेटवर्किंग (एमएपीएन)	भारतीय उष्णकटिबंधीय मौसम विज्ञान संस्थान	डॉ. आर. अजय कुमार वर्मा	वायुमंडलीय प्रक्रियाएं	–	2013–17	20.32	2.77
19	मॉनिटरिंग इंडियन शील्ड सेसमीसिटी विथ 10 बीबीएस टू अंडरस्टैंड सिस्मोटेक्टॉनिक्स ऑफ द रीजन यूसिंग वी–सेट कनेक्टिविटी (एमओईएस5)	पृथ्वी विज्ञान मंत्रालय, भारत सरकार	श्रीकुमारी केशवन	क्रस्टल प्रक्रियाएं	–	2010–15	13.93	0.00
20	पेलियो फ्लुइड्स इन द पेट्रोलिफेरोस बेसिनंस ऑफ वेस्टर्न ऑफशोर इंडिया (एमओईएस 7)	पृथ्वी विज्ञान मंत्रालय, भारत सरकार	डॉ. वी. नंदकुमार	क्रस्टल प्रक्रियाएं	डॉ. के. नरेन्द्र बाबू	2011–15	265.67	0.00
21	हैवी मिनरल केमिस्ट्री इन डिफरेंट सोर्स रॉक्स एंड कॉस्टल सेडीमेंट्स ऑफ एसडब्ल्यू कॉस्ट ऑफ इंडिया : अंडरस्टैंडिंग प्रोवेनन्स एंड प्रोसेसेज इन प्लेसर डिपॉजिट फार्मेशन (एमओईएस 8)	पृथ्वी विज्ञान मंत्रालय, भारत सरकार	डॉ. जी. आर. रवींद्र कुमार	क्रस्टल प्रक्रियाएं	डॉ. टी. एन. प्रकाश	2012–15	18.36	0.00
22	एस्टैब्लिशमेंट एंड मेंटेनेंस ऑफ वेव गेज स्टेशन्स अलॉन्ग द साउथवेस्ट कॉस्ट ऑफ इंडिया (एमओईएस 9)	आईएनसीओआईएस, एमओईएसए, भारत सरकार	डॉ. एल. शीला नायर	क्रस्टल प्रक्रियाएं	डॉ. रेजी श्रीनिवास डॉ. टी. एस. शाहुल हमीद	2013–17	98.49	15.84
23	शोरलाइन मैपिंग फॉर वेस्ट कॉस्ट ऑफ इंडिया (एमओईएस 10)	आईसीएमएएम, एमओईएस, भारत सरकार	डॉ. के. वी. थॉमस डॉ. टी. एस. शाहुल हमीद (26.11.2014 के बाद से) डॉ. एल. शीला नायर (01.02.2015 के बाद से)	क्रस्टल प्रक्रियाएं	–	2013–17	190.00	0.00
24	पेलियोमैग्नेटिक इनवेस्टीगेशन एक्रॉस द वन कि.मी. लॉन्ग कोयना ड्रिल कोर (एमओईएस 11)	पृथ्वी विज्ञान मंत्रालय, भारत सरकार	डॉ. टी. राधाकृष्ण	क्रस्टल प्रक्रियाएं	–	2014–17	9.25	4.63
25	मॉनिटरिंग इंडियन शील्ड सेइमिसिटी विद् 10 बीबीएस टू अंडरस्टैंड साइस्मोटेक्टोनिक्स ऑफ द रिजन यूजिंग वीएसएटी कनेक्टिविटी – कंटिन्यूड	पृथ्वी विज्ञान मंत्रालय, भारत सरकार	श्रीकुमारी केशवन	क्रस्टल प्रक्रियाएं	डॉ. सी. के. सोमन (केएफआरआई)	2014–17	13.04	4.15

	ऑपरेशन ऑफ द ब्रॉडबैंड स्टेशन एट पीची – केरल (एमओईएस 12)							
26	रिसर्च ऑन सॉइल पाइपिंग इन द हाई–लैंड्स एंड फुट–हिल ऑफ केरल टू अवॉयड द डिजास्टर (एनडीएमए 1)	राष्ट्रीय आपदा प्रबंधन प्राधिकरण	श्री जी. शंकर	क्रस्टल प्रक्रियाएं	डॉ. आर अजय कुमार वर्मा, डॉ. शेखर एल. कुरिएकोस (एचवीआरए प्रकोष्ठ), के. एलहौज़	2012–15	49.73	4.00
27	एप्लीकेशन ऑफ स्पेस टेक्नोलॉजी फॉर द डेवलपमेंट ऑफ केरल (पीएलजी 13)	केरल राज्य योजना बोर्ड	श्री. बी. के. जयाप्रसाद	प्राकृतिक संसाधन और पर्यावरण प्रबंधन	–	2008–15	12.62	0.00
28	सॉइल बेस्ड प्लांट न्युट्रिएंट मैनेजमेंट प्लान फॉर एग्रो इकोलॉजिकल ज़ोन्स (एसपीबी 2)	राज्य योजना बोर्ड	श्री बी. के. जया प्रसाद	प्राकृतिक संसाधन और पर्यावरण प्रबंधन	–	2010–15	13.6	0. 00
29	अपडेटिंग नेचुरल रिसोर्स एंड एनवायरनमेंट डेटा बेस कवरिंग कोस्टल एईजेड (एसपीबी – 3)	राज्य योजना बोर्ड, केरल सरकार	श्री बी. के. जया प्रसाद	प्राकृतिक संसाधन और पर्यावरण प्रबंधन	–	2012–15	8.00	0.00
30	फिजिकल, केमिकल एंड बायोलॉजिकल मॉनिटरिंग स्टडी एट ड्रेजिंग साइट इन वेम्बानद लेक (टीसीएल 2)	त्रावणकोर सीमेंट लिमिटेड	डॉ. पी. के. ओमना	प्राकृतिक संसाधन और पर्यावरण प्रबंधन	–	2008–15	1.15	0.29
31	प्रिपरेशन ऑफ इंटीग्रेटेड आइस्लैंड मैनेजमेंट प्लैंस फॉर अगत्ती एंड चेतलात आइस्लैंडस यू. टी. ऑफ लक्षद्वीप (यूटीएल – 6)	लक्षद्वीप संघ राज्य क्षेत्र	डॉ. टी. एन. प्रकाश	क्रस्टल प्रक्रियाएं	डॉ. के. वी. थॉमस डॉ. डी. राजू	2011–15	45.33	0.00
32	जीपीएस फैसिलिटेशन, जीआईएस मैपिंग एंड कस्टमाइजेशन फॉर सॉइल मैपिंग एण्ड सॉइल न्यूट्रिशन मैनेजमेंट प्लान प्रिपरेशन (वीएफपीसीके)	सब्जी और फल संवर्धन परिषद केरल	श्री. बी. के. जयाप्रसाद	प्राकृतिक संसाधन और पर्यावरण प्रबंधन	डॉ. अर्चना एम. नायर	2011–15	11.08	0.00

5.2 परामर्श परियोजनाएं : तटीय विनियमन क्षेत्र के लिए एचटीएल और एलटीएल का सीमांकन

एचटीएल, एलटीएल और सीआरजेड विनियमन लाइनों का सीमांकन किया गया है और 2014–15 के दौरान निम्नलिखित परियोजनाओं के लिए तैयार सीआरजेड मानचित्र। सीआरजेड स्थिति रिपोर्ट अलग अलग क्लाइंटों के लिए तैयार और जमा भी की गई। 2014–15 के दौरान पूरी की गई सीआरजेड रिपोर्टों की सूची तालिका 5.2.1 में दी गई है।

तालिका 5.2.1 : 2014–15 की अवधि के दौरान तैयार सीआरजेड रिपोर्टों की सूची

क्र. सं.	संस्थान / एजेंसी	परियोजना	स्थान
1	मे. जनक वासवानी मुंबई (अलीबाग, रायगढ़ में नवेदर – नवगांव)	प्रस्तावित स्थल	नवेदर – नवगांव, रायगढ़, महाराष्ट्र
2	मे. जनक वासवानी मुंबई (अलीबाग, रायगढ़ में मिलकटखार)	प्रस्तावित स्थल	अलीगढ़, रायगढ़, महाराष्ट्र मिलकटखार
3	मे. यूकेएन प्रॉप्र्टीज, फेरोके, कोझिकोड़े	अपार्टमेंट का निर्माण	फेरोके, कोझिकोड़े, केरल
4	अलापाड, कोल्लाम, केरल में इंडियन रेयर अर्थस लिमिटेड (आईआरईएल) माइनिंग ब्लॉक्स, 'एनके 4' एंड 'एनके 4 ईई'	खनन ब्लॉक	अलापाड, कोल्लाम, केरल
5	कोचीन पोर्ट ट्रस्ट, विलिंगटन द्वीप, कोची	विकास स्थल	विलिंगटन द्वीप, कोची, केरल
6	हार्बर इंजीनियरिंग केरल विभाग (चिलकूर, वरकला में मिनी फिशरी हार्बर)	मिनी फिशरी हार्बर का निर्माण	वरकला, तिरुवनंतपुरम, केरल
7	मे. श्रीववाला इस्टेट डेवलपर्स प्रा. लि., महाराष्ट्र	विकास स्थल	निलजे गांव, कल्याण तालुका
8	मे. आई – राइज बिल्डर्स – डेवलपर्स लि., थालास्सेरी, कन्नूर	रेजीडेंशियल अपार्टमेंट परियोजना	थालास्सेरी, कन्नूर, केरल
9	चिथरामलिका, थॉमस डोमिनिक, एर्नाकुलाम	भवन का निर्माण	थेवरा, कोची, केरल
10	मे. अंसल बिल्डवेल लि., वेचूर	रिज़ॉर्ट डेवलपमेंट	वेचूर, कोट्टायम, केरल
11	विजन वरकला इंफ्रास्ट्रक्चर डेवलपमेंट कॉर्पोरेशन	कला प्रदर्शन के लिए केंद्र की स्थापना	वर्कला, तिरुवनंतपुरम, केरल
12	मे. अलमास आयुर्वेदिक रिज़ॉर्ट, पुरथुर, मलप्पुरम	रिज़ॉर्ट डेवलपमेंट	पुरथुर, मलप्पुरम, केरल
13	श्री श्रीपद् उपाध्या, वोदेहोबली गांव, उदुपी जिला, कर्नाटक	प्लॉट सि. सं. 194 के एचटीएल और एलटीएल सीमांकन के साथ सीआरजेड मानचित्र	वोदेहोबली गांव, कुंडपुर, कर्नाटक
14	मे. चॉइस सीसाइड होटल, कन्नूर	होटल अपार्टमेंट का निर्माण	कन्नूर, केरल
15	कोचीन पोर्ट ट्रस्ट, कोची (एमयूएलटी)	मल्टी यूजर क्लिविड टर्मिनल का विकास	पुथुवपीन, कोची, केरल
16	मे. एजिस लॉजिस्टिक्स, मुंबई (हल्दिया में एलपीजी टर्मिनल)	एलपीजी टर्मिनल	हल्दिया, पश्चिम बंगाल

तालिका 5.2.2 जारी परामर्श परियोजनाएं

क्र. सं.	परियोजना का शीर्षक	निधिकरण एजेंसी	प्रभाग	परियोजना की अवधि	कुल परिव्यय (लाख रुपए में)	वर्ष के दौरान प्राप्त निधि (लाख रुपए में)
1	डिलाइनेएशन ऑफ एसटीएल / एलटीएल एण्ड प्रीपेशन ऑफ एसआरजेड स्टेट्स रिपोर्ट	के. टी. निकोलस, अलांगी कन्याकुमार, रिज़ॉर्ट डेवलपमेंट	तटीय प्रक्रियाएं	2014–15	2.06	0.26
2	– तदैव –	सीजेडएमपी वसाई – विरार नगर निगम	तटीय प्रक्रियाएं	2014–15	117.48	45.39
3	– तदैव –	माइटी ग्रूप, मोंटाना डेवलपर्स प्रा. लि., मुंबई	तटीय प्रक्रियाएं	2014–15	8.40	0.00
4	– तदैव –	कोचीन पोर्ट ट्रस्ट, कोचीन	तटीय प्रक्रियाएं	2014–15	15.00	7.50
5	– तदैव –	महानगर गैस लि., मुंबई	तटीय प्रक्रियाएं	2014–15	7.65	0.77
6	– तदैव –	हजीरा इंफ्रास्ट्रक्चर, अदानी हाउस	तटीय प्रक्रियाएं	2014–15	8.10	0.00
7	– तदैव –	अदानी पेट्रोनेट (दहेज)	तटीय प्रक्रियाएं	2014–15	20.25	0.00
8	– तदैव –	जोशू जनरेशन मंत्रालय, एर्नाकुलम	तटीय प्रक्रियाएं	2014–15	3.45	0.00
9	– तदैव –	हार्बर इंजीनियरिंग विभाग, केरल	तटीय प्रक्रियाएं	2014–15	1.05	1.05
10	– तदैव –	एनएचएआई – वडोदरा, मुंबई एक्सप्रेस मार्ग	तटीय प्रक्रियाएं	2014–15	6.18	2.75
11	– तदैव –	हाय–राइज़ बिल्डर्स डेवलपर्स थालास्सेरी, कन्नूर, केरल	तटीय प्रक्रियाएं	2014–15	3.15	3.15
12	– तदैव –	विजन वर्कला इंफ्रास्ट्रक्चर डेवलपमेंट कॉर्पोरेशन लि. त्रिवेंद्रम	तटीय प्रक्रियाएं	2014–15	1.05	1.05
13	– तदैव –	चॉइस सीसाइड होटल, कन्नूर	तटीय प्रक्रियाएं	2014–15	3.15	3.15
14	– तदैव –	श्रीवाला एस्टेट डेवलपर्स लिमिटेड, थाणे	तटीय प्रक्रियाएं	2014–15	4.05	4.05
15	– तदैव –	थॉमस डोमिनिक, चित्रमलिका, एर्नाकुलम	तटीय प्रक्रियाएं	2014–15	3.15	3.15
16	– तदैव –	अलमास रिज़ॉर्ट / होटल, मलप्पुरम, केरल	तटीय प्रक्रियाएं	2014–15	3.15	3.15
17	– तदैव –	श्रीपद उपाध्याय, कोंदापुरा	तटीय प्रक्रियाएं	2014–15	4.05	4.05
18	– तदैव –	यंत्र आयुर्वेदिक रिज़ॉर्ट प्रा. लि.	तटीय प्रक्रियाएं	2014–15	3.15	3.15
19	– तदैव –	मेरित्रा होम्स प्रा. लि. कोचीन	तटीय प्रक्रियाएं	2014–15	0.26	0.26
20	– तदैव –	भारत पेट्रोलियम कॉर्पोरेशन लि. कोची	तटीय प्रक्रियाएं	2014–15	3.15	3.15
21	– तदैव –	एजिस लॉजिस्टक्स, मुंबई	तटीय प्रक्रियाएं	2014–15	5.25	5.25
22	– तदैव –	कोचीन पोर्ट ट्रस्ट, एर्नाकुलम	तटीय प्रक्रियाएं	2014–15	3.15	3.15
23	– तदैव –	वाईईएम सीईई इंफ्रास्ट्रक्चर, कन्नूर, केरल	तटीय प्रक्रियाएं	2014–15	3.15	3.15
24	– तदैव –	रवींद्रन, एर्नाकुलम	तटीय प्रक्रियाएं	2014–15	0.75	0.67
25	– तदैव –	भारत पेट्रोलियम कॉर्पोरेशन लि. कोची	तटीय प्रक्रियाएं	2014–15	3.15	3.15

Honours, Awards & Academic Activities

6.1 Honours & Awards

Mrs. L. Sheela Nair, Scientist-E, Coastal Processes (CoP) has been awarded Ph. D. Degree under the faculty of Coastal Engineering from IIT, Madras for her thesis "Sediment dynamics along the coast of Kerala, India" in July 2014.

Dr. D. Padmalal, Scientist-F, Natural Resources and Environmental Management (NREM) has been awarded 'Cetificate of Merit Award-2014' by the Ministry of Earth Science Studies, Govt. of India.

Ms. T. R. Rajimol, Research Scientist, Natural Resources and Environmetal Mangement (NREM) has been awarded best paper award on 'Coastal Plain Rivers of Thiruvananthapuram district, Kerala-River Characteristics, Human Interventions and Management Strategies' in the Environmetal Science session of the 23rd Swadeshi Science Congress organized by Swadeshi Science Movement, Kerala and Mahatma Gandhi University, Kottayam during 6-8, November 2013 at Mahatma Gandhi University.

Smt. K. Viswabharathy, Deputy Manager, Administrative Section has been awarded 'Cetificate of Merit Award-2014' by the Ministry of Earth Science Studies, Govt. of India.

Shri. K. Eldhose, Technician Grade-B, Crustal Processes Group (CrP) has been awarded 'Cetificate of Merit Award-2014' by the Ministry of Earth Science Studies, Govt. of India.

Shri. P. Saseendran Nair, MTS, Administrative section has been awarded Cetificate of Merit Award-2014' by the Ministry of Earth Science Studies, Govt. of India.

6.2 Membership in Committees outside NCESS

Dr. N. P. Kurian

Member, Project Review Board, Coastal Engineering Division, National Institute of Ocean Technology, Ministry of Earth Sciences, Govt. of India.

Member, Board of Studies in Physical Oceanography and Member, Faculty of Marine Sciences, Cochin University of Science and Technology, Kochi.

Member, Kerala Dam Safety Authority, Water Resources (Inter State Water Cell) Department, Govt. of Kerala.

Member of the State High Level Committee, Kerala Protection of River Banks of Regulation of Removal of Sand Rules 2002- for River Management Fund by Revenue (P) Department, Govt. of Kerala.

Member, Kerala Coastal Zone Management Authority constituted by the Ministry of Environment & Forests, Govt. of India.

Member, Project Appraisal and Monitoring Committee on Ocean Sciences and Resources of the Ministry of Earth Sciences, Govt. of India.

Vice-Chairperson (Research), Hazard Vulnerability and Risk Assessment Cell, ILDM, Thiruvananthapuram.

Chairman, Independent Expert Committee to evaluate the progress of work carried out during the 11th Plan period for the "Studies on Cobalt Crust', constituted by the Ministry of Earth Sciences, Govt. of India.

Member, Task force on Coastal Erosion, Narmada Water Resources, Water Supply and Kalpsar Department, Govt. of Gujarat.

Dr. K. V. Thomas

Member, Project Advisory Committee of INCOIS, Hyderabad.

Invited Member of the Expert Committee, constituted by the Hon'ble Supreme Court of India under the chairmanship of Justice R. V. Raveendran, Former Judge, Supreme

Court for the preparation of Integrated Island Management Plan (IIMPs) for Lakshadweep.

Member, Kerala Coastal Zone Management Authority (KCZMA) Sub-committees to look into various CRZ issues implementation, policies, violations and reports.

Member, Lakshadweep Coastal Zone Management Authority.

Member, Project Advisory Committee of the ICZMP project of Odisha.

Dr. R. Ajayakumar Varma

Chairman, Committee for assessing the damages to the properties of local people due to the blasting operations in a 7 km long tunnel of Sengulam Augmentation Scheme.

Member, Committee for preparing Project Report for modernization of the Department of Mining and Geology, Govt. of Kerala.

Chairman, Expert Committee to assess the impact of blasting operations in the tunnel of Thottiyar Hydro Electric Project, Kerala State Electricity Board.

Member, Expert Committee for Drafting guidelines for the preparation of District Development Plan, Kerala State Planning Board.

Member, Task Force on Greening Rural Development constituted by the Ministry of Rural Development, Govt. of India.

Member, Management Committee of Centre State Technology Transfer Institute.

Member, Technical Support Group of Solid Waste Management by Govt. of Tamilnadu.

Dr. T. Radhakrishna

Member, Evaluation of the UGC-Kothari PDF applications.

Member, MoES representative for a JRF interview at PSG Institute Coimbatore.

Member, Selection Committee for the post of Associate Professor of the Indian Institute of Geomagnetism, Mumbai.

Member, UNESCO-IGCP 597 National Working Group.

Member, Assessment Committee of Scientific and Technical personnel of Indian Institute of Geomagnetism, Mumbai.

Shri. John Mathai

Member, State Expert Appraisal Committee, Government of Kerala, under the State Level Environment Impact Assessment Authority (SEIAA), Kerala.

Member, Expert committee for the formulation of Scientific Mining Policy of Kerala State.

Member, Technical Committee, Disaster Management-Mullaperiyar Dam, Govt. of Kerala.

Dr. T. N. Prakash

Invited Member, Expert Committee, constituted by the Hon'ble Supreme Court of India under the chairmanship of Justice R. V. Raveendran, Former Judge, Supreme Court for the preparation of Integrated Island Management Plan (IIMPs) for Lakshadweep.

Convenor of the Research Committee of CUSAT, Member of the Permanent Doctoral Committee of Geography, constituted by the University of Kerala.

Expert Member, Technical Review Committee on Mineral Mapping of Indian Coasts, National Centre for Sustainable Coastal Management (NCSCM), MoEF, Chennai.

Shri. G. Sankar

Member, Technical Committee for validation of security schemes at Sree Padmanabha Swami Temple constituted by the Govt. of Kerala.

Member, Ecologically Fragile Land (EFL-CDRC), Chalakudy division, Govt. of Kerala.

Member, Expert Committe for making recommendations in the modernisation of Kerala Forest Department, Govt. of Kerala.

Member, Research and Management Committee of HVRA Cell, Department of Revenue, Govt. of Kerala.

Member, Expert Committee constituted by the State government as well as the Ministry of Earth Sciences to suggest immediate mitigation measures to Varkala Cliff Vulnerability.

Shri. P. Sudeep

Member, Board of Studies under the Faculty of Social Sciences (social work), University of Kerala.

Dr. E. J. Zachariah

Member, Research Advisory Committe of Sophisticated Test & Instrumentation Centre, Kochi.

Dr. G. R. Ravindra Kumar

Member, Programme Advisory Committee on Earth Sciences (PAC-ES), Department of Science & Technology, Govt. of India, New Delhi (2012-2015).

Dr. D. Padmalal

Member, Editorial Board, Journal of Geoscience Research, Journal of the Gondwana Geological Society, India.

Shri. B. K. Jayaprasad

Member, Technical Committee of Kerala State Remote Sensing and Environment Centre (KSREC) for the procurement of Servers.

Member, Technical Advisory Committee for the procurement of GIS software and hardware for the Kerala State Forest Department

Dr. D. S. Suresh Babu

Member, PG (Geology) Board of Studies by the University of Kerala under the Faculty of Science for three years.

Member, Assessment Committee for Scientific staff, Kerala State Remote Sensing and Environment Centre (KSREC), Govt. of Kerala.

Member, Committee constituted for framing Confidential Report and work report for Scientific staff of Kerala State Remote Sensing and Environment Centre (KSREC), Govt. of Kerala.

Member, 13th Committee for Society for All Round Development (SARD), Kerala State Council for Science, Technology and Environment (KSCSTE), Govt. of Kerala.

Dr. A. Krishnakumar

Member, Expert Committee for the scientific study of Athani Quarry, constituted by the District Collector, Wayanad.

Member, Expert Committee constituted by the District Collector, Malppuram for studies on environment and water flow in the site proposed for the construction of hospital in the Kottakkal village, Tirur taluk, Malappuram district.

Dr. K. Anoop Krishnan

Member, Advisory Committee of International Conference on 'Emerging Frontiers and Challenges in Chemistry (ICEFCC-2014) at Department of Chemistry, All Saint's College, Trivandrum

6.3 Visits Abroad

Dr. A. Krishna Kumar, Scientist-C, Natural Resources and Environmetal Management (NREM) represented MoES in the training programme on Integrated Coastal area and River Basin Management organised by the SAARC Coastal Zone Management Centre (SCZMC) in academic collaboration with the University of Colombo, Sri Lanka during 13-17th October, 2014.

Ms. Dhanya Vijayan (UGC-SRF), Natural Resources and Environmental Management (NREM) visited Germany in connection with the selection meeting of German Chancellor Fellowship of Alexander von Humboldt Foundation, Germany. The selection meeting was held at the Gustav-Stresemann-Institut in Bonn, Germany from 5-8th May, 2014.

6.4 Internship / Summer Training

Sl. No	Name of Student	Affiliation	Name of Supervising Scientist
1.	Gopikarani G.	Indian Institute of Technology, Kharagpur	Dr. R. Ajayakumar Varma
2.	Ebna V. Mohan	Indian Institute of Information Technology & Management, Kerala, Thiruvananthapuram	Dr. L. Sheela Nair
3.	Shilpa V. S.	Indian Institute of Information Technology & Management, Kerala, Thiruvananthapuram	
4.	Neeraja	NITK, Suratkal	
5.	Jibisha K. P.	Centre for Applied Geology, Gandhigram Rural Institute, Tamil Nadu	Shri. B. K. Jayaprasad
6.	Paulsy K. Poly	Centre for Applied Geology, Gandhigram Rural Institute, Tamil Nadu	
7.	Nithu Raj	Centre for Applied Geology, Gandhigram Rural Institute, Tamil Nadu	

6.5 M.Sc. / B. Tech / M. Tech Dissertaion Programmes

Sl. No.	Name of Student	College / Affiliation	Topic of Dissertation	Supervising Guide
1.	Austin T. Sabu	St. Josephs College of Engineering & Technology, Palai	Sustainable Coastal Protection Methods.	Dr. K. V. Thomas
2.	Elza Mathew			
3.	Justin Jayan			
4.	Thrishna N.			
5.	Deepak Babu	Government College, Kasaragod	Texture and heavy mineralogy of the coastal sediments of Thruvananthapuram district.	Dr. D. Padmalal
6.	Sudharma Mohan	CUSAT	Estimation of Longshore sediment transport along the Beypore-Puthuvypene coastal sector	Dr. L. Sheela Nair
7.	Suresh Thatikonda	IITM, Pune	Wave climate studies along the SW cost of India	
8.	Akhil Shaji	Kerala University	SEAM-GIS	Shri. B. K. Jayaprasad
9.	Jasmin			
10.	Akhila C. K.			
11.	Monica Praisy	Regional Centre, Anna University	Impacts of digital elevation model in land degradation assessment-A case study in Munnar	
12.	Sujitha		Slope stability analysis for identifying landslide prone areas using remote sensing and GIS techniques in Munnar	
13.	Suresh D.		Morphometric analysis for the identification of artificial recharge sites in Neyyar river basin	
14.	Shalini		Identification of groundwater potential zone using remote sensing and GIS in Kabani river basin	
15.	Ancy Abraham	Mar Ivanios College, Trivandrum	Adsorption of phosphate from water and waste waters using Bentonite clay	Dr. K. Anoop Krishnan
16.	Elizabeth T. Vargheese		Hydrogeochemical modeling to assess the nature of highland springs in the PRB and analysis	
17.	Nithya T. M.		Chemical hydrology of cochin estuary around Willington island, South India	
18.	Sruthy S. L.	SN College, Varkala	Hydrochemical and biological profiling of well water resources at Kadakkavur grama Panchayath, Thiruvananthapuram, India	
19.	Praveena Prasad		Adsorptive removal of Pb (II) from aqeous phase using surface modified chitosan	
20.	Ayishath Nabeela	CUSAT	Study of ground water recharge ability in the context of urbanization, using remote sensing and GIS	Dr. Reji Srinivas
21.	Likhil		Surface texture of quartz grain from a high energy coast, Thiruvananthapuram, SW coast of India	
22.	Neethu		Heavy mineral assemblage of a high energy coast Thiruvananthapuram, SW coast of India.	
23.	Mithun P. M.	Mangalore University, Mangalagangotri	Beach morphological and sedimetological study along Calicut coast, Kerala	Dr. T. N. Prakash
24.	Sooraj P.			
25.	Meenu V.	Sree Sankara University		Dr. Archana M. Nair

6.6 Ph. D Students

Sl. No.	Research Scholar / Sponsorship	Title of the thesis	Guide	University / Registration Date
1.	Tiju I Varghese / MACIS	Beach and estuarine evolution of Kollam coast during holocene	Dr. T. N. Prakash	CUSAT / 29.12.2008
2.	Sreekanth T. S. / Project C	Characterization of tropical rain fall in terms of drop size distribution at surface, its variation with altitude and comparison of rain rates with satellite measurements	Dr. G. Mohan Kumar	Kerala / 17.08.2009
3.	Raji S. Nair / Plan 111	Multi Spectral Imaging	Dr. N. Subhash	Kerala / 29.04.2010
4.	Divya V. / KSCSTE	Ecological Studies along Elevational Gradients in a Transect in Southern Western Ghats, with special reference to Forest Soil	Dr. C. N. Mohanan	Kerala / 04.11.2010
5.	Prasad R. / MoES 9	Sediment Dynamics in Coastal Waters	Dr. N. P. Kurian	CUSAT / 18.11.2010
6.	Vishnu Mohan S. / CSIR	Quaternary Geology of the Coastal Lowlands of Southern Kerala, SW India	Dr. D. Padmalal	CUSAT / 22.11.2010
7.	Hema C. Nair	Water quality and drinking water potential of the ground water resources of Kallada and Ithikkara river basin, Kerala, SW India	Dr. D. Padmalal	CUSAT / 04.08.2011
8.	Unnikrishnan U.	Common Property Resource (CPR) Management in the lowlands of Thiruvananthapuram district with special reference to surface water resource	Dr. Srikumar Chattopadhyay	Kerala / 06.03.2012
9.	Shaji J.	Coastal Zone Management: A case study of Thiruvananthapuram coast	Dr. Srikumar Chattopadhyay	Kerala / 06.03.2012
10.	Ganapathy C. / SC/ST Department	Impact of Human Activities in the generation of Land Disturbances in Humid Tropical Highland Areas- A case study in Idukki district, Kerala	Dr. K. Raju	Kerala / 04.05.2012
11.	Ragi N. P. / UGC	Causes and Impacts of landslides in Panamaram and Mananthavadi watersheds of Kabani river basin, Kerala	Dr. K. Raju	Kerala / 15.07.2012
12.	Soumya G.S. / UGC	Lithosperic Processes (Neoproterozoic Anthrosites in South India, a comparative study to delineste petrogenesis and India's position in Rodinia Assembly)	Dr. T. Radhakrishna	Kerala / 19.07.2012
13.	Sheikha E. John / Plan 103	Mining and quarrying in the river catchments of Central Kerala around Kochi city, SW India-Consequences and sustainable development strategies	Dr. K. Maya	Kerala / 06.03.2013
14.	Jayalekshmy S. S.	Urbanization trend of Kerala over a period of 1961-2011.	Dr. Srikumar Chattopadyay	Kerala / 19.08.2013
15.	Revathy Das / UGC	Integrated geoenvironmental studies of the locustrine wetlands of Kerala in climate change paradigms for conservation and management.	Dr. A. Krishnakumar	Kerala / 25.11.2013
16.	Arun T. J. / MACIS	Studies on selected rivers in different climatic regimes, southern India.	Dr. Reji Srinivas	CUSAT / 13.12.2013
17.	Aneesh T. D. / Project D	Hydrological Studies of an Urban agglomerate, Ernakulam district, Kerala	Dr. Reji Srinivas	CUSAT / 13.12.2013
18.	Krishna R. Prasad / KSCSTE	Wetland Studies of Akathumuri-Anchuthengu-Kadinamkulam Esturine System, Southwest coast of India.	Dr. Reji Srinivas	CUSAT / 13.12.2013
19.	Viswadas V.	Studies on hydrogeological & biological aspects of various streams of Karamana river near Sree Parasuramaswamy Temple, Thiruvallam, Thiruvananthapuram district, Southern India.	Dr. K. Anoop Krishnan	Kerala / 15.01.2014

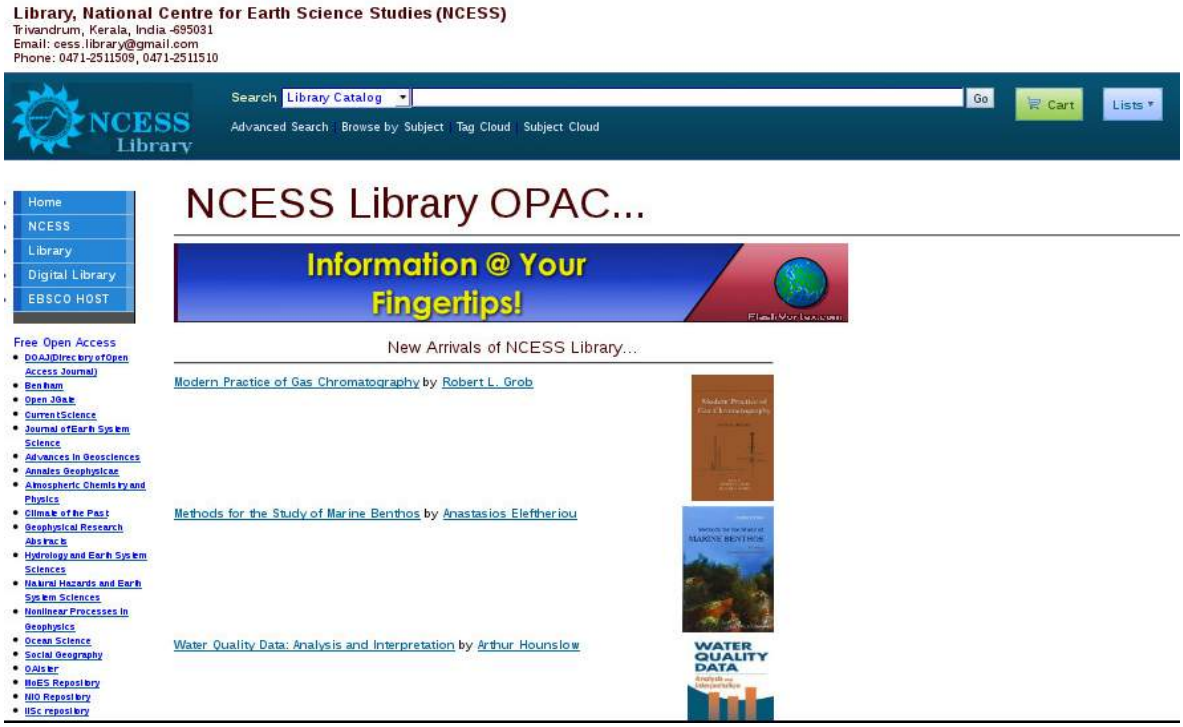
20.	Mereena C. S / DST	Inland waterways of Kerala: A geographical and economical analysis of west coast canal	Dr. Srikumar Chattopadhyay/ Dr. K. Raju (Co-Guide)	Kerala / 17.03.2014
21.	Jobish E. A. / SC/ST Department	Coastal Zone Management: A case study of Eranakulam coast	Dr. K. Raju	Kerala / 28.03.2014
22.	Parvathy K. Nair / KSCSTE	Development of Vembanad Management action plan through a geological perspective	Dr. D. S. Suresh Babu	Kerala / 30.04.2014
23.	Sibin Antony / COMAPS 4	Appraisal of marine ecosystem of Kavarathi island in southwest coast of Kerala in the special reference to lagoon system	Dr. K. AnoopKrishnan	Kerala / 23.05.2014
24.	Vinu V. Dev / CPT-3	Adsoptive potential of surface modified ceramics, clays and chitosan for the removal of toxic heavy metals from aqeous media using batch and column studies: kinetic and thermodynamic profile	Dr. K. AnoopKrishnan	Kerala / 09.06.2014
25.	Praseetha B. S. / KSCSTE	Geochemistry estuarine and innershelf sediment	Dr. T. N. Prakash	CUSAT / 18.12.2014
26.	Praveen M. N. / (part time)	Geological aspects of the eastern part of betal belt, Central Indian Tectonic Zone	Dr. G. R. Ravindra Kumar	CUSAT
27.	Kunhambu V. / CGWB (part time)	Characterisation and evaluation of the aquifer system of Kuttanad area, Kerala for Sustainable Groundwater Development	Dr. D. S. Suresh Babu	Kerala / 05.01.2015
28.	Shiny R. / KSCSTE	Geo-environmetal appraisal and water quality assessment of low land and coastal plain rivers of southern Kerala, India-A GIS based study.	Dr. K. Maya	Kerala / 02.03.2015
29.	Harsha Mahadevan	Assessment of Nutrient Flux in Urban Drainage Systems: Identification of Sources, Pathways and Remedial Measures	Dr. K. Anoop Krishnan	Kerala / 01.05.2015

Library and Publications

7.1 Library

The Library of ESSO-NCESS is one of the key reference and information centre for researchers in the field of Earth Sciences in terms of its collection and services. It has a unique and rare collection of books, journals, back volumes, maps, atlas, theses, project reports, reference books, CDs, VCDs, CD ROM Databases etc. The Library subscribes a good number of foreign as well as Indian periodicals and journals. Apart from this 129 full text E-journal of Science Direct, SCOPUS and Web of Science are available through the MoES E-Journal Consortium .

The Library offers Reference Service, Document Delivery Service, Selective Dissemination of Information, Current Awareness Service, Internet access to electronic full-text journals etc. An e-mail alert is sent to the scientists who request new arrival of books and publications related to their fields. Library provides Inter Library Resource Sharing facilities with a number of major R&D and Academic institutional Libraries. In addition, a list of new additions of NCESS publications, useful article, fellowship information, forthcoming conferences, seminars are displayed in the library. A separate computer lab provided to students and staff for surfing internet. Books are arranged according to the Dewey Decimal Classification (DDC) system.



Online Public Access Catalogue(OPAC) software customised by NCESS Library Team.

All functions of the library have been automated with KOHA Library management software and library documents are bar-coded. The library catalogue OPAC (On-line Public Access Catalogue) can be accessed through the on campus wide Intranet.

7.2 Research Papers

7.2.1 In Journals

Anoop Krishnan, K., Ajmal, K., Faisal, A. K., Liji, T. M. (2014). Kinetic and isotherm modeling of methylene blue adsorption on to kaolinite clay at the solid-liquid interface, Separation Science and Technology, DOI: 10.1080/01496395.2014.965832.

Badarudeen, A., Sajan, K., Reji Srinivas, Maya, K. and Padmalal, D. (2014). Environmental significance of heavy metals in leaves and stems of Kerala Mangroves, southwest coast of India, Indian Journal of Geo-Marine Science, Vol. 43 (6), pp. 1021-1029.

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Kumaran, K. P. N., Padmalal, D., Nair, K. M., Limaye, R. B., Guleria, J. S., Srivasathava, R. and Shukla, A. (2014). Vegetation response and landscape dynamics of Indian summer monsoon variations during Holocene: An eco-geomorphological appraisal tropical evergreen forest subfossil logs, PLOS ONE, Vol 9 (4), pp. 1-24.

Linto Alappat, Manfred Frechen, Sree Kumar, S., Suresh Babu, D. S., Rajan Ravur and Sumiko T. Sukamoto (2015). Evidence of Late Holocene shoreline progradation in the coast of Kerala, South India obtained from OSL dating of palaeo-beach ridges, Journal of Geomorphology, Vol. 245, pp. 73-86.

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Ratheesh Kumar, M., Vishnu, S. Raj, Sudhanandh, V. S., Faisal, A. K., Shibu, R., Vimexen, V., Ajmal, K., Aneesh, K. S., Sibin Antony and Anoop Krishnan, K. (2014). Proliferation of dinoflagellates during pre monsoon season in Kochi bar mouth, Kerala, Journal of Environmental Biology, Vol. 35, pp. 877-882.

Ria Mukherjee, Sisir, K. Mondal, Hong Zhong, Zhong-Jie Bai, Vysetti Balaram and Ravindra Kumar, G. R. (2014). Platinum group element geochemistry of komatiite-derived 3.1 ga ultramafic-mafic rocks and chromitites from the Nuggihalli greenstone belt, Western Dharwar craton (India), Chemical Geology, Vol. 386, pp. 190-208.

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Vimexen, V., Aneesh, K. S., Sheena, A. S., Faisal, A. K., Ajmal, K., Anoop Krishnan, K. and Ajayakumar Varma, R. (2014). Geochemical aspects and uptale mechanism of Pb(II) onto nano sized clay fractions of lithoral sediments in Kochi, South-west of India, Journal of Research in Science, ISSN: 2278-9.73, pp. 115-119.

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7.2.2 In Conference proceedings

Anoop Krishnan, K. (2015). Ocean Acidification: Chemistry and impacts, Proc. of National workshop on Ocean Acidification Research, NWOAR, Department of Marine and Coastal Studies, School of Energy, Environmental and Natural Resources, Madurai Kamraj University, pp. 17-22.

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Krishnankumar, A. (2015). Evaluation of seasonal fluctuation of water quality in Ashtamudi Wetland System, India, Proc. of National Seminar on Recent and Emerging Advances in Chemical Science (REACS-2015), Department of Chemistry, All Saints' College, Trivandrum, pp. 50-55.

Krishnankumar, A. (2015). Recent hydrochemical characterisation of two tropical Lacustrine Ecosystems of Kerala, Proc. of National Seminar on Recent and Emerging Advances in Chemical Science (REACS-2015), Department of Chemistry, All Saints' College, Trivandrum, pp. 55-59.

Krishnankumar, A. (2015). Groundwater chemistry of Neyyar and Karamana Basins, Kerala with special refernce to salinity intrusion problems in the coastal urban environment, Proc. of National Seminar on Recent and Emerging Advances in Chemical Science (REACS-2015), Department of Chemistry, All Saints' College, Trivandrum, pp. 12-16.

Vinu, V. Dev, Sachin, S. R., Faisal, A. K., Arya, S., Liji, T. M. and Anoop Krishnan, K. (2015). Aqueous nutrient flux and sediment heavy metal contaminaton in Cochin Backwaters: A systematic spatial pattern study on monthly basis, Proc. of National Seminar on Recent and Emerging Advances in Chemical Science (REACS-2015), Department of Chemistry, All Saints' College, Trivandrum, p. 69.

7.3 Project Reports

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Ajayakumar Varma, R., Jayaprasad, B. K., Suresh Babu, D. S., Shiny, R. Ragi, M. S., Kalaraj, Krishnapriya, S. and Anila, M. T. (2015). An integrated management action plan for ecological restoration of Vembanad lake and its inflowing river systems- Meenachil river basin, Project report submitted to Department of Agriculture, Govt. of Kerala, 56 p.

Ajayakumar Varma, R., Padmalal, D., Maya, K., Suresh Babu, D. S., Jayaprasad, B. K., Shiny, R., Ragi, M. S., Kalaraj, Krishnapriya, S., Kiran, S. J. and Anila, M. T. (2015). An integrated management action plan for ecological restoration of Vembanad lake and its inflowing river systems- Muvattupuzha river basin, Project report submitted to Department of Agriculture, Govt. of Kerala, 57 p.

Ajayakumar Varma, R., Shiny, R. and Ragi, M. S. (2014). EIA study of Municipal solid waste Management project of Thiruvananthapuram Municipal Corporation.

Ajayakumar Varma, R. and Anoop Krishnan, K. (2014). Coastal Ocean Monitoring and Prediction System, Project report submitted to ICMAM, PD., Ministry of Earth Science, Govt. of India, 54 p.

Anoop Krishnan, K., Krishnakumar, A., Liji, T. M., Baiju, R. S., Arya, S., Sibin Antony, Noufal, K. N. and Arunima, R. (2015). Appraisal of drinking water potential in Pathanamthitta, Kottayam and Idukki districts of Kerala, Project report submitted to the Kerala State Science, Technology and Environment, Thiruvananthapuram, 118 p.

Anoop Krishnan, K., Liji, T. M., Vinu, V. Dev, Faisal, A. K., Mohind, M. and Suraj Krishna, R. (2015). Environmental monitoring of water and sediment quality parameters in the backwaters around Cochin Port Trust (Half yearly), Project report submitted to the Chief Engineer, Cochin Port Trust, 77 p.

Archana, M. Nair and Jayaprasad, B. K. (2014). Generation of Geographic Information system of five particularly vulnerable tribal groups (PTG's), Project report submitted to KIRTADS, 95 p.

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Jayaprasad, B. K. (2014). Creation of a model GIS database for Malappuram Municipality under Saptial Urban Information Sytem, Project report submitted to Information Kerala Mission, Department of Local Self Governmet, Govt. of Kerala, 146 p.

John Paul, P. (2014). Quaternary evolution of the Coastal Plains of Southern Kerala, Project report, National Centre for Earth Science Studies, Thiruvananthapuram, 66p.

Mahamaya Chattopadhyay (2014). Land system analysis of Kabani river basin Wayanad district, Kerala, Project report, National Centre for Earth Science Studies, 96 p.

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Mahamaya Chattopadhyay and Raju, K. (2014). Geomorphic evolution and terrain characteristics: A case study of the Achankovil river, Project report, National Centre for Earth Science Studies, 87 p.

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Maya, K., Padmalal, D., Baburaj, B., Sheika, E. John and Rajimol, T. R. (2015). Study on the environmental effects of minning and quarrying in the Periyar river basin, Central Kerala, Project report, National Centre for Earth Science Studies, 115 p.

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Padmalal, D., Maya, K., Baburaj, B., Aswathy, K. A., Sheika, E. John and Rajimol, T. R. (2014). Environmental degradation of Paravur kayal, Kollam district, Kerala, project report submitted to the Additional Chief Secretary, Water Resources Department, Govt. of Kerala.

Padmalal, D. and Maya, K. (2014). Sand auditing of rivers (Manimala, Periyar and Muvattupuzha) in the Idukki district, Project report submitted to the Department of Revenue, Govt. of Kerala, 37 p.

Padmalal, D., Maya, K., Baburaj, B. and Shiekha, E. John (2015). Feasibility of sand mining in Muvattupuzha , Manimala and Pambar rivers flowing through Idukki district (Kerala) using the methodology of Sand Auditing, Project report submitted to the district Collector, Idukki, 22 p.

Prakash, T. N., Thomas, K. V., Raju, D., Sreeraj, M. K., Rafeeque, M. K., Anish, S. Anand, Sreejith, S., Nadee Bin Haneef, Kiran, S. J. and Muhammad Asif, M. (2014). Preparation of Integrated Island Management plan for Lakshadweep

Islands, Project report submitted to Department of Science and Technology, UT of Lakshadweep, Govt. of India, 100 p.

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Thomas, K. V. (2014). Conservation and nourishment of beaches of selected tourism locations of Kerala, Project report submitted to the Department of Tourism, Govt. of Kerala, 23 p.

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Zachariah, E. J., Ouseph, P. P., Narendrababu, K., George Thomas and Iyer, C. S. P. (2014). Nitrous Oxide and Methane in coastal ocean and estuaries, Project report submitted to Ministry of Earth Sciences, 54 p.

Zachariya, E. J. and Sasidharan, C. K., Deepa Nair, K., Sherin, A.P. and Pravinkumar, C. S. (2014). Greenhouse gases monitoring, Project report submitted to the Kerala State Council for Science, Technology and Environment, Thiruvananthapuram, 26 p.

Zachariya, E. J. and Vinayak, P. V. S. S. K., George Thomas, Shareekul Ansar and Sherin, A. P. (2014). Effect of urbanization on the buildup of urban heat island in Kochi, Project report, National Centre for Earth Science Studies, Thiruvananthapuram, 22 p.

7.4 Books / Edited Volumes /Monographs

Padmalal, D. and Maya, K. (2014). Sand Mining- Environmental Problems and Selected Case Studies, Springer, London, 162 p.

Prakash, T. N., Sheela Nair, L. and Shahul Hameed, T. S. (2015). Geomorphology and Physical Oceanography of the Lakshadweep Coral Islands in the Indian Ocean, Springer Briefs in Earth Sciences, Springer Cham Heidelberg, New York, Dordrecht London, 111 p. (DOI 10.1007/978-3-319-12367-7).

8.1 Continental Crust and Cover Sequences in the Evolution of the Indian Sub-Continent

Dr. Shailesh Nayak, Honorable Secretary, MoES delivered the keynote lecture on the workshop on " Continental Crust and Cover Sequences in the Evolution of the Indian Sub-Continent" was organized in NCESS on January 20-21, 2015 to commemorate the one year completion of takeover of CESS by MoES. Dr. N.P. Kurian, Director, NCESS , Shri. T.M. Mahadevan, Former Director, AMD, Dr. T. Radhakrishna, Chairman, Organising Committee and Group Head, Crustal Processes are also seen on the dias.

A National Workshop on "Continental Crust and Cover Sequences in the Evolution of the Indian Sub-Continent" was conducted in NCESS during January 20-21, 2015 to commemorate the one year completion of takeover of CESS by MoES. The workshop was inaugurated by Dr. Shailesh Nayak, Honorable Secretary, MoES and presided by Sri. T.M. Mahadevan, Former Director, AMD. Dr. N.P. Kurian, Director, NCESS welcomed the participants and Dr. T. Radhakrishna, Chairman, Organising Committee offered vote of thanks. The workshop included twenty special invited lectures on various themes by eminent geoscientists from different organisations and Universities in India who have made significant contributions in the field of geology and geophysics. The talks covered a wide spectrum of topics related to the crustal processes in the development of Solid Earth involving studies on basement complexes as well as sedimentary cover sequences ranging in age from Archaean to Quaternary. The lectures also focused on inferences on early crustal growth, paleoclimate changes, neotectonics, present day seismicity and land disturbances in the Indian shield. In addition to the special lectures, a poster session was also included in the workshop on topics related to the theme of the workshop. Thirty-four posters were presented and the workshop was attended by nearly hundred young researchers and students both within and outside Kerala.

8.2 Invited Lectures / Chairing of Technical Sessions

Dr. N. P. Kurian

Attended and delivered an invited talk entitled "propogation and inundation of the 2004 tsunami along the Lakshadweep and SW coast of India" at the International conference on a decade after the Indian Ocean Tsunami: Statement Experiences, Pondicherry during 10-13th December 2014.

Inaugurated and delivered a talk entitled "Coastal Hazards and Management" at the National Workshop on Disaster Mitigation Measures, Kothamangalam during 16-18th December 2014.

Delivered a talk entitled "Technologies for coastal disaster risk reduction-Indian context"at the 102nd Indian Science Congress, Mumbai during 4-8th January 2014.

Dr. K. V. Thomas

As a resource person gave a lecture on "Coastal Erosion and Prevention Measures in Kerala Coast" for the training programme for Engineers, Irrigation Department, Govt. of Kerala, August 2014.

Dr. R. Ajayakumar Varma

Delivered a lecture on "Technology options for sustainable municipal solid waste management" in summer school for Architects organized by the Laurie Baker Centre for habitat studies, Nopoliyode on 26th May 2014.

Attended and delivered a lecture the workshop on "Drinking water" organized by the State Planning Board, Thiruvananthapuram on 23rd July 2014.

Delivered a lecture on "Sanitation in Kerala – Yesterday, Today and Tomorrow" at the training on sanitation for senior officials from Rajasthan, Bihar, Jharkhand and Assam organized by the World Bank at Kozhikode on 2nd August 2014.

Delivered a talk on "Overflow management technique for waste management" during the training on development perspective for participants from the Third World Countries organized by Kanthari, an NGO at Vellayani, Thiruvananthapuram on 25th August 2014.

Delivered an invited talk on "Urban environmental issues during the training programme on urban design: oppourtunities and challenges-India" organized by the Department of Architecture, College of Engineering, Thiruvananthapuram during 17-19th November 2014.

Shri. John Mathai

Attended the pre-workshop meeting on "Water resources" convened by the State Planning Board and made a presentation of "Different techniques of rain water harvesting and ground water recharge implememted in Chadayamangalam block as part of Hariyali project and in other parts of the state" on July 2014.

Dr. D. Padmalal

Delivered a keynote address on "Impact of mining and quarrying on the Western Ghat environment" at the National seminar conducted by Government college Kottayam on March 2015.

Dr. L. Sheela Nair

Delivered an invited talk on "Sediment deposit in pattern at selected inlets along the SW coast of India" at the INDO_ JAPAN workshop on River mouths, Tidal Flats and Lagoons, IIT Madras during 15-16th September 2014.

Delivered an invited talk on "Oil spill trajectory modeling off the coast of Kiltan in the Lakshadweep group of Islands" at the Oil Spill India International Conference, Goa during 18-20th September 2014.

Shri. B. K. Jayaprasad

Delivered a lecture on "GIS and Remote sensing Applications for Irrigation Management" at IMG, Thiruvananthapuram in connection with the training programme for the Engineers and Officers of the Irrigation Department, Govt. of Kerala on 15th November 2014.

Dr. Mahamaya Chattopadhay

Delivered a lecture on "Terrain analysis of Kerala: Concepts and methodology" during the training programme at Kerala State Landuse Board, Thrissur as part of a pilot project on Eco restoration plan through land cover information management system at agro ecological unit level on 22nd April 2014.

Dr. K. Anoop Krishnan

Delivered a lecture on the "Ocean Chemistry: Impacts of Ocean Acidificatin on Phosphorus and Silicon Speciation" at the UGC sponsored National Workshop on Ocean Acidificatin Research (NWOAR-2015), Department of Marine & Coastal studies, Madurai Kamaraj University,

Madurai during 25-27th February 2015

Delivered a lecture on "Seawater quality monitoring: Ocean acidification as a case study of impact of climate change on marine ecosystem" at the World Environment Day Celebrations on 'Impact of Climate Change on Environment', Department of Environmental Science, St. John's College, Anchal, Kollam during 17-18th June 2014.

8.3 Papers presented in Conference / Workshop / Symposium / Seminar

Name	Conference / Symposium / Seminar	Title of the Paper
Krishnakumar A.	National Conference on 'Sedimentation and Stratigraphy' and XXXI Convention of Indian Association of Sedimentologists, University of Pune during 12-14 November,2014.	Geochemical signatures of Anthropocene in the sediments of the tropical Ashtamudi wetland system, Kerala, SW Coast of India.
Padmalal D.	5th Indian National Conference on Harbour and Ocean Engineering (INCHOE-2014), CSIR-NIO, Goa, during 5-7th February 2014.	Holocene land-sea interactions and landform changes in the coastal lands of Vembanad lagoon, Kerala, SW India
Padmalal D.	Regional workshop on 'Water conservation in Kerala-Impacts and challenges', Central ground water board, Trivandrum on 27th March 2014.	Chemical quality of fresh water sources in Kerala, SW India-an overview
Raju K.	36th Indian Geography Congress on urban systems rural livelihoods, security and resource management organized by Jaipur University, Rajasthan, 2014.	Morphometric and TRP Analysis of a highland Tropical river basin: A case study of Panamaram River, Wayanad, Kerala
Suresh Babu D. S.	Regional workshop on 'Water conservation in Kerala-Impacts and challenges', Central ground water board, Trivandrum on 27th March 2014.	Can we conserve part of portable ground water that regularly discharges to sea across the Kerala coast.
Thomas K. V.	Seminar on 'Climate Change' organized by Malayala Manorama in July 2014.	Sea level rise and its impact on Kerala coast.
Thomas K. V.	Workshop on 'Coastal Zone Management in South Asia' organized by the Centre for Science and Environment (CSE) on January 2014.	Climate Change and coastal vulnerability.

9.1 Observance of Rashtriya Ekta Diwas

31st October 2014, the birth anniversary of Late Sardar Vallabhai Patel was be observed as "RASHTRIYA EKTA DIWAS" (National Unity day). As part of the observance, all the employees of NCESS assembled at the Foyer of the Administrative block at 10.55 am to take the pledge which was read out by the Director.

9.2 Observance of Vigilance Awareness Week:

Vigilance awareness week was observed at NCESS from 27th October 2014 to 1st November 2014 with the theme'Combating Corruption- Technology as an anabler".

9.3 Swachch Bharat Mission

The 150th Birth Anniversary of Mahatma Gandhi on 2nd October 2014, every Government servant take part of swachch Bharat Mission programme. As part of this programme, the employees of NCESS has assembled at the Foyer of the Administrative block at 09.45 am and take the pledge which was read out by the Director. Further all officers and officials take part in the cleaning of the office and its premises, which was coordinated by the Campus Green Committee.

9.4 Observance of Communal Harmony Campaign Week

Communal Harmony Campaign Week during 19-25 November, 2014 and the Flag Day on 25th November, 2014 of the National Foundation for Communal Harmony were observed at NCESS. NCESS Employees contributed to augment the resources of the National Foundation for Communal Harmony (NFCH) to carry on its activities on various schemes and projects. The donation was sent to NFCH. During the campaign week flags and stickers were distributed and posters displayed.

9.5 Visit to NCESS Seismic Observatory at Peechi

64 students and 5 teachers of Santa Higher Seconddary school, Avannur, Thrissur visited the observatory on 23rd September 2014.

Deputy Director General, Department of Forest Research and Survey, Katmandu, Nepal and his five colleagues visited the observatory on 11th July 2014.

9.6 Earth Science Forum

The Earth Science Forum organized two invited lectures and four in house pre synopsis submission presentations during 2014-15. Dr. M A Atmanand, Director, NIOT, Govt. of India delivered an invited lecture on the topic: "*Glimpses of NIOT Activities*". Dr. Mohan Menon, Senior Operations Manager, CB&I, Baton Rouge, Louisiana, USA delivered an invited lecture on the following topic: "*Louisiana Coastal Restoration and Protection: Sediment Conveyance- A Tool?*". As part of the NCESS Research Scholar's pre-synopsis submission of the PhD thesis to CUSAT, Smt. P. V. Anu Baburaj presented "*An investigation on coral fluorescence and the effect of elevated temperature in corals using laser induced point monitoring and multi-spectral imaging.*", Shri. Tiju I Varghese presented "*Sedimentology and Geochemsitry of core sediments from the Asthamudi estuary and the adjoining coastal plain, Central Kerala.*"., Shri. Noujas V., presented "*Coastal Hydrodynamics and Sediment Transport Regime of the Central Kerala coast in comparison to Southern Kerala*" and Shri. Vishnu Mohan S presented "*Late Quaternary Geology of the Coastal Lands of Southern Kerala, SW India with Special Reference to Palaeoclimate and Coastal Evolution*".

9.7 Campus Development & Green Committe (CD & GC)

As part of value addition for recyclable materials especially waste papers that are otherwise disposed off, 3 paper shredders have been installed. Branches of certain trees have been pruned for protecting the buildings. The logs that have been felled were assessed cost wise by the Department of Forests, Government of Kerala and were sold and cost remitted to NCESS. Roofing provided for the basin in between the RAD & GSD blocks. Renovated the 2 artificial ponds in the campus. New carpet grass laid in the courtyard of the scientific block. All routine activities like cleaning the campus, procurement of garbage bags, and pruning of trees, connected with CGC were undertaken.

NCESS observed Swatch Bharat Abhiyan on 02 October, 2014. A consultant was engaged to oversee the civil works that are being undertaken in NCESS. Prepared the layout and design of the Guest House, Hostel, Security Complex, and Compound Wall.

9.8 Recreation Club: Onam Celebration

The activities of the Recreation Club of CESS continued to be vibrant. Onam and New Year Eve were celebrated with great fanfare with participation of staff members, students and family members.

10.1 Statutory Committees

10.1.1 Governing Body (GB)

Dr. Shailesh R. Nayak *Secretary, Ministry of Earth Sciences, Government of India* *Prithvi Bhavan, Lodhi Road, New Delhi*	*President*
Dr. (Mrs.) Swati Basu *Scientific Secretary & Advisor* *Ministry of Earth Sciences, Government of India* *Prithvi Bhavan, Lodhi Road, New Delhi*	*Member*
Mrs. Anuradha Mitra *JS&FA, Ministry of Earth Sciences, Government of India* *Prithvi Bhavan, Lodhi Road, New Delhi*	*Member*
Shri. Anand S. Khati *JS, Ministry of Earth Sciences, Government of India* *Prithvi Bhavan, Lodhi Road, New Delhi*	*Member*
Dr. B. K. Bansal *Scientist-G & Advisor* *Ministry of Earth Sciences, Government of India* *Prithvi Bhavan, Lodhi Road, New Delhi*	*Member*
Director, *National Centre for Antartic & Ocean Research (NCAOR)* *Ministry of Earth Sciences, Government of India* *Headland Sada, Vasco-da-Gama, Goa*	*Member*
Director, *National Institute of Ocean Technology (NIOT)* *Velacherry-Tambaram Main Road, Narayanapuram* *Pallikaranai, Chennai*	*Member*
Dr. M. Samsuddin *Director, National Centre for Earth Science Studies* *Akkulam, Thiruvanathapuram*	*Member Secretary*

10.1.2 Governing Council (GC)

Dr. Shailesh R. Nayak *Secretary, Ministry of Earth Sciences, Government of India* *Prithvi Bhavan, Lodhi Road, New Delhi*	*Chairman*

Dr. Somnath Dasgupta — *Member*
Vice Chancellor, Assam University, Silchar, Assam
Professor,
Indian Institute of Science Education and Research (IISER)
Kolkatta

Mrs. Anuradha Mitra — *Member*
JS&FA, Ministry of Earth Sciences, Government of India
Prithvi Bhavan, Lodhi Road, New Delhi

Shri. B. N. Satpathy — *Member*
Sr. Adviser (E & F & S & T)
Planning Commission, New Delhi

Shri. Anand S. Khati — *Member*
JS, Ministry of Earth Sciences, Government of India
Prithvi Bhavan, Lodhi Road, New Delhi

Dr. (Mrs.) Swati Basu — *Member*
Scientific Secretary & Advisor,
Ministry of Earth Sciences, Government of India
Prithvi Bhavan, Lodhi Road, New Delhi

Dr. Suresh Das — *Member*
Executive Vice President
Kerala State Council for Science, Technology & Environment
Sasthra Bhavan, Pattom
Thiruvananthapuram

Director, — *Member*
National Centre for Antartic & Ocean Research (NCAOR)
Ministry of Earth Sciences, Government of India
Headland Sada, Vasco-da-Gama, Goa

Dr. M. Samsuddin — *Member Secretary*
Director, National Centre for Earth Science Studies
Akkulam, Thiruvanathapuram

10.1.3 Finance Committee (FC)

Mrs. Anuradha Mitra — *Chairman*
JS&FA, Ministry of Earth Sciences, Government of India
Prithvi Bhavan, Lodhi Road, New Delhi

Shri. Anand S. Khati — *Member*
JS, Ministry of Earth Sciences, Government of India
Prithvi Bhavan, Lodhi Road, New Delhi

Dr. B. K. Bansal — *Member*
Scientist G & Advisor
Programme Officer, ESSO-NCESS
Ministry of Earth Sciences, Government of India
Prithvi Bhavan, Lodhi Road, New Delhi

Dr. M. Samsuddin *Director, National Centre for Earth Sceince Studies* *Akkulam, Thiruvananthapuram*	*Member*
Shri. P. Sudeep *Chief Manager* *National Centre for Earth Science Studies* *Akkulam, Thiruvananthapuram*	*Member*
Shri. M. A. K. H. Rasheed *Manager (Finance)* *National Centre for Earth Science Studies* *Akkulam, Thiruvananthapuram*	*Member*
Dr. D. S. Suresh Babu *Head, Projects, Training & Documentation* *National Centre for Earth Science Studies* *Akkulam, Thiruvananthapuram*	*Member Secretary*

10.1.4 Research Advisory Committee (RAC)

Dr. Somnath Dasgupta *Vice Chancellor, Assam University, Silchar, Assam* *Professor,* *Indian Institute of Science Education and Research (IISER)* *Kolkotta*	*Chairman*
Director, NIOT/ Nominee *National Institute of Ocean Technology* *Velacherry-Tambaran Main Road, Narayanapuram* *Pallikaranai, Chennai*	*Member*
Director, NGRI/ Nominee *National Geophysical Research Institute* *Uppal Road, Habsiguda, Uppal* *Hyderabad, Andra Pradesh*	*Member*
Prof. A. D. Rao *Centre for Atmospheric Sciences,* *Indian Institute of Technology* *New Delhi*	*Member*
Dr. M. V. Ramanamurthy *ICMAM Project Directorate* *NIOT Campus* *Velacherry-Tambaram Main Road* *Pallikkaranai, Chennai*	*Member*
Dr. V. Nandakumar *Scientist-F, Crustal Processes (CrP)* *National Centre for Earth Science Studies* *Akkulam, Thiruvananthapuram*	*Member Secretary*

10.2 Internal Committees

10.2.1 Group Heads

Director, NCESS	*Chairman*
Dr. T. Radhakrishna	*Member*
Crustal Processes	
Dr. T. N. Prakash	*Member*
Coastal Processes	
Dr. R. Ajayakumar Varma	*Member*
Atmospheric Processes	
Dr. M. Samsuddin	*Member*
Natural Resources & Environmental Management	
Shri. P. Sudeep	*Member*
Chief Manager	
Dr. D. S. Suresh Babu	*Convenor*
Head, Project, Training & Documentation	

10.2.2 Material Purchase

Dr. E. J. Zachariah	*Chairman (till April 2014)*
Shri. John Mathai	*Chairman (since May 2014)*
Dr. T. N. Prakash	*Member*
Shri. M. A. K. H. Rasheed	*Member (till October 2014)*
Dr. L. Sheela Nair	*Member (till January 2015)*
Shri. P. Sudeep	*Member (since January 2015)*

10.2.3 Library Management

Director	*Chairman*
All Group Heads	*Members*
Manager, Accounts	*Member*
Head, PT&D	*Member*
Librarian (i/c)	*Convenor*

10.2.4 Canteen

Dr. T. S. Shahul Hameed	*Chairman (till January 2015)*
Dr. D. S. Suresh Babu	*Member*
Shri. M. Mohammed Ismail	*Member*
Shri. G. Lavanya	*Member*

10.2.5 Campus Development and Green Committee

Dr. V. Nandakumar	*Chairman*
Shri. G. Sankar	*Member*
Shri. John Paul	*Member*
Shri. S. Krishnakumar	*Member*
Dr. K. Raju	*Member*
Dr. L. Sheela Nair	*Member*
Dr. Tomson J. Kallukalam	*Member*
Shri. S. Mohanan	*Member*
Shri. M. Ramesh Kumar	*Member*
Smt. K. V. Padmaja Kumari	*Convenor*
Shri. D. Raju	*Convenor*
Shri. N. Nishanth	*Member*
Smt. Indu Janardanan	*Member*
Smt. P. C. Rasi	*Member*

10.2.6 Complaints Committee to combat Sexual harassment at work place

Dr. L. Sheela Nair	*Chairperson*
Smt. G. Lavanya	*Member*
Dr. J. K. Tomson	*Member*
Dr. Susha Janardhanan	*External Member*

10.2.7 Website Maintenance

Dr. D. S. Suresh Babu	*Chairman*
Shri. N. Nishanth	*Member*
Shri. S. S. Salaj	*Member*

Staff Details

11.1 Directors office

Dr. M. Samsuddin	Director (Since February 2015)
Dr. N. P. Kurian	Director (Since August 2014) (till January 2015)
Dr. K. Somasunder	Director-in-Charge (till July 2014)
Dr. D. S. Suresh Babu	Scientist-E & Head PT&D
Smt. T. Remani	Helper (Gr. 1)

11.2 Crustal Processes (CrP)

Dr. T. Radhakrishna	Scientist-G & Head
Shri. John Mathai	Scientist-G
Dr. C. P. Rajendran	Scientist-G (on long leave)
Shri. G. Sankar	Scientist-G
Dr. V. Nandakumar	Scientist-F
Smt. Sreekumari Kesavan	Scientist-D
Dr. Tomson J. Kallukalam	Scientist-C
Shri. N. Nishanth	Scientific Asst. (Gr. B)
Shri. K. Eldhose	Technician (Gr. B)

11.3 Coastal Processes (CoP)

Dr. K. V. Thomas	Scientist-G & Head (till November 2014)
Dr. T. N. Prakash	Scientist-G & Head (Since December 2014)
Dr. T. S. Shahul Hameed	Scientist-G (till January 2015)
Dr. L. Sheela Nair	Scientist-E
Shri. P. John Paul	Scientist-E & Librarian (i/c)
Dr. D. S. Suresh Babu	Scientist-E
Dr. K. Raju	Scientist-E
Dr. Reji Srinivas	Scientist-C
Shri. D. Raju	Scientific Officer (Gr. 3)
Shri. S. Mohanan	Scientific Officer (Gr. 2)
Shri. A. Vijayakumaran Nair	Scientific Officer (Gr. 2) (till November 2014)
Shri. M. Ajith Kumar	Scientific Officer (Gr. 2)
Shri. M. Ramesh Kumar	Scientific Officer (Gr. 2)
Shri. S. S. Salaj	Scientific Asst. (Gr. B)
Shri. M. K. Rafeeque	Scientific Asst. (Gr. A)
Shri. M. K. Sreeraj	Scientific Asst. (Gr. A)
Shri. Louis William	MTS

11.4 Atmospheric Processes (AtP)

Dr. E. J. Zachariah	Scientist-F & Head (till April 2014)
Dr. R. Ajayakumar Varma	Scientist-G & Head (since May 2014)
Shri. Mohammed Ismail	Technical Officer (Gr. 4)
Smt. Nita Sukumar	Technical Officer (Gr. 1)

11.5 Natural Resources and Environmental Management (NREM)

Dr. M. Samsuddin	Scientist-G & Head (on deputation) (till January 2015)
Dr. R. Ajayakumar Varma	Scientist-G & Head (till December 2014)
Dr. K. K. Ramachandran	Scientist-F (on deputation)
Dr. P. K. Omana	Scientist-F (till July 2014)
Dr. D. Padmalal	Scientist-F
Dr. Mahamaya Chattopadhyay	Scientist-E (till June 2014)
Dr. K. Maya	Scientist-E
Dr. Ansom Sebastian	Scientist-E
Shri. B. K. Jayaprasad	Scientist-E
Dr. K. Anoop Krishnan	Scientist-C
Dr. A. Krishnakumar	Scientist-C
Dr. Archana M . Nair	Scientist-C (on leave)
Smt. C. Sakunthala	Technical Officer (Gr. 5)
Shri. K. Surendran	Co-Ordinator (Gr. 4)
Smt. S. Najumunniza	Technician (Gr. E) (till December 2014)
Smt. T. M. Liji	Scientific Asst. (Gr. B)
Shri. P. B. Vibin	Scientific Asst. (Gr. A)

11.6 Projects, Training & Documentation (PT&D)

Dr. D. S. Suresh Babu	Scientist-E & Head
Dr. K. Raju	Scientist-E
Shri. S. S. Salaj	Scientific Asst. (Gr. B)
Smt. K. Reshma	Scientific Asst. (Gr. A)
Shri. P. M. Gopakumar	Junior Executive

11.7 Administration

Shri. P. Sudeep	Chief Manager (since January 2015)
Dr. L. Sheela Nair	Chief Manager (i/c) (till January 2015)
Shri. M. A. K. H. Rasheed	Chief Manager (i/c) (till October 2014)
Shri. M. A. K. H. Rasheed	Manger (finance) (since November 2014)
Shri. M. Philip	Internal Auditor (on deputation)
Smt. K. V. Padmaja Kumari	Joint Manager

Shri. T. D. Bashardeen	*Co-rdinator (Gr. 4)*
Shri. R. Haridas	*Deputy Manager*
Smt. K. Viswabharathy	*Deputy Manager (on long leave)*
Shri. C. M. Youseph	*Deputy Manager (on deputation)*
Shri. M. Madhu Madhavan	*Deputy Manager*
Smt. R. Jaya	*Deputy Manager*
Smt. G. Lavanya	*Deputy Manager*
Shri. S. Krishnakumar	*Senior Executive*
Smt. Femi R. Sreenivasan	*Executive*
Shri. P. Rajesh	*Executive*
Smt. P. C. Rasi	*Executive*
Shri. N. Jayapal	*Executive*
Smt. Smitha Vijayan	*Junior Executive*
Smt. K. S. Anju	*Junior Executive*
Shri. P. H. Shinaj	*Junior Executive*
Smt. D. Shimla	*Junior Executive*
Smt. V. Sajitha Kumari	*Junior Executive*
Smt. Seeja Vijayan	*Junior Executive*
Shri. K. R. Satheesan	*Junior Executive (till April 2014)*
Smt. Indu Janardanan	*Scientif Asst. (Gr. A)*
Smt. P. Prabhavathy	*Co-Ordinator (Gr.4)*
Smt. N. J. Saramma	*Senior Executive*
Smt. K. Prasanna	*Senior Executive*
Smt. M. K. Radha	*Senior Executive (till November 2014)*
Shri. M. Parameswaran Nair	*Technician (Gr. E)*
Shri. N. Unni	*MTS*
Smt. S. Vimala Kumari	*MTS (till October 2014)*
Shri. P. S. Anoop	*MTS*
Smt. P. S. Divya	*MTS*
Shri. B. Rajendran Nair	*MTS*
Shri. P. Saseendran Nair	*MTS*
Shri P. Rajendra Babu	*MTS*
Shri. K. Sudeerkumar	*MTS (Driver)*
Shri V. Chandran Nair	*MTS (till May 2014)*

11.8 Retirements

Dr. N. P. Kurian
Director
Superannuated on
31st January 2015

Dr. K. V. Thomas
Scientist-G
Coastal Processes
Superannuated on
31st November 2014

Dr. T. S. Shahul Hameed
Scientist-G
Coastal Processes
Superannuated on
31st January 2015

Dr. E. J. Zachariah
Scientist-F
Atmospheric Processes
Superannuated on
30th April 2014

Dr. P. K. Omana
Scientist-F
Natural Resources & Environmental Management
Superannuated on
31st July 2014

Dr. Mahamaya Chattopadhyay
Scientist-E
Natural Resources & Environmental Management
Superannuated on
30th June 2014

Shri. A. Vijayakumaran Nair
Scientific Officer Gr.2
Coastal Processes
Superannuated on
30th November 2014

Smt. S. Nujumunniza
Technician Gr. E
Natural Resources & Environmental Management
Superannuated on
31st December 2014

Smt. M. K. Radha
Senior Executive
Administration
Superannauated on
30th November 2014

Shri. K. R. Satheesan
Junior Executive
Administration
Superannauated on
30th April 2014

Shri. V. Chandran Nair
MTS
Administration
Superannuated on
31st May 2014

Smt. S. Vimalakumari
MTS
Administration
Superannuated on
31st October 2014

11.9 Obituary

Dr. K. M. Nair, former Director of CESS (04.11.1992 – 16.04.1998), expired on the 7th July 2014 at Amrutha Hospital, Ernakulam. He joined CESS after an illustrious career in ONGC (India), University of Illorin (Nigeria) and United Nations Programme at Belize (Central America). At ONGC, he has made extensive studies on the Western Offshore Sedimentary Basins of India. His tenure in CESS was instrumental in initiating/strengthening many new areas of research like Sand Mining Studies, Landslide Hazard Zonation, Water harvesting, Carrying Capacity Studies, Palaeo Seismicity and Natural Resources Evaluation at local level. After his retirement from CESS he undertook many projects on Quaternary studies of Kerala funded by State and Central Government Agencies. He has published many bench mark papers on the Cenozoic Sedimentary Formations of India. On superannuation from CESS, he was also associated with many NGO's in awareness creation on various environmental issues of the State. He is survived by wife Saraswathi Amma and their sons Ayyappan and Ashok, who always stood by Dr. Nair in the Geological pursuits. In his passing, the geoscientific community lost a very brilliant and dedicated earth scientist of our country.

Manoj & Sajeev
CHARTERED ACCOUNTANTS

AUDITORS' REPORT

To,

The Director
National Centre for Earth Science Studies,
Thiruvananthapuram

REPORT ON THE FINANCIAL STATEMENTS

We have audited the accompanying financial statements of **National Centre for Earth Science Studies, Thiruvananthapuram** which comprise the Balance Sheet as at 31st March 2015, Income and Expenditure Account, Receipts and Payments Accounts for the year ended and a summary of significant accounting policies and other explanatory information.

MANAGEMENT'S RESPONSIBILITY FOR THE FINANCIAL STATEMENTS

The Society's Management is responsible for the preparation of these financial statements that give a true and fair view of the financial position and financial performance of the Society in accordance with the Accounting Standards notified and in accordance with the accounting principles generally accepted in India. This responsibility includes the design, implementation and maintenance of internal control relevant to the preparation and presentation of the financial statements that give a true and fair view and are free from material misstatement, whether due to fraud or error.

AUDITORS' RESPONSIBILITY

Our responsibility is to express an opinion on these financial statements based on our audit. We conducted our audit in accordance with the Standards on Auditing issued by the Institute of Chartered Accountants of India. Those Standards require that we comply with ethical requirements and plan and perform the audit to obtain reasonable assurance about whether the financial statements are free from material misstatement.

An audit involves performing procedures to obtain audit evidence about the amounts and disclosures in the financial statements. The procedures selected depend on the auditor's judgment, including the assessment of the risks of material misstatement of the financial statements, whether due to fraud or error. In making those risk assessments, the auditor considers internal control relevant to the Society's preparation and fair presentation of the financial statements in order to design audit procedures that are appropriate in the circumstances, but not for the purpose of expressing an opinion on the effectiveness of the Society's internal control. An audit also includes evaluating the appropriateness of accounting policies used and the reasonableness of the accounting estimates made by management, as well as evaluating the overall presentation of the financial statements.

T C 9/1444 (2), TRRAW D 18B, Moolayil Lane, Sasthamangalam, Trivandrum - 695 010
Tel: 0471 2721444, 91 90615 77668, E-mail: manojandsajeev@gmail.com

We believe that the audit evidence we have obtained is sufficient and appropriate to provide a basis for our audit opinion.

OPINION

In our opinion and to the best of our information and according to the explanations given to us, financial statements give the information required by is in the, manner so required and give a true and fair view in conformity with the accounting principles generally accepted in India:

(a) In the case of the Balance Sheet, of the state of affairs of the Society as at 31st March 2015;

(b) In the case of Income & Expenditure Account, of the Excess of expenditure over income of the Society for the year ended on that date.

(c) The Receipts and Payments Account is in agreement with the Books of Accounts.

For Manoj & Sajeev
Chartered Accountants
FRN. 008024 S

R. Sajeev, FCA
(Partner)
M.No. 206626

Place: Trivandrum
Date :09.10.2015

National Centre for Earth Science Studies
Ministry of Earth Science, Government of India

Balance Sheet as on 31st March, 2015

Particulars	Sch No.	2014-15	2013-14
		₹	₹
Liabilities			
Capital Reserve	1	10,64,56,544.00	7,98,02,697.00
General Reserve	2	(1,91,56,822)	(96,26,472)
Unspent Balance GOI - MoES	3	8,58,79,874.00	1,30,66,365.00
Unspent Balance of Projects	4	7,17,50,149.00	8,68,59,105.00
Corpus Fund	5	7,16,42,995.00	5,84,21,083.00
Current Liabilities	6	28,03,204.00	16,41,197.00
Total		**31,93,75,944.00**	**23,01,63,975.00**
Assets			
Fixed Assets	7	10,64,56,544.00	7,98,02,697.00
Current Assets, Loans & Advances	8	21,29,19,400.00	15,03,61,278.00
Total		**31,93,75,944.00**	**23,01,63,975.00**
Notes forming part of Accounts	15		

AUDITORS' REPORT

As per our report of even date attached

Manoj & Sajeev
Chartered Accountants
(FRN. 008024 S)

R. Sajeev, FCA
(Partner)
M No. 206626

MANOJ & SAJEEV * THIVANDRUM * CHARTERED ACCOUNTANTS

Manager (F&A) **Chief Manager** **Director**

राष्ट्रीय पृथ्वी विज्ञान अध्ययन केंद्र National Centre for Earth Science Studies तिरुवनन्तपुरम Thiruvananthapuram 695 011 भारत सरकार Govt. of India

October 09,2015
Thiruvananthapuram

National Centre for Earth Science Studies

Ministry of Earth Science, Government of India

Income & Expenditure for the year ended 31st March, 2015

Particulars		Sch No.	2014-15	2013-14
			₹	₹
Income				
Operation and Maintenance Grant		9	9,43,46,695	4,00,00,000
Grant Received	10,15,34,000			
Less Capital Expenditure	71,87,305			
Interest from Bank / Other Income		10	15,64,805	30,90,467
Depreciation Written Back			2,11,19,207	47,86,269
Total - A			**11,70,30,707**	**4,78,76,736**
Expenditure				
Staff Salary & Benefits		11	9,49,59,211	2,67,07,173
Other Institutional Expenses		12	1,77,21,267	33,16,929
Total of Other Institutional Expenses	2,49,08,572			
Less Capital Expenditure	71,87,305			
Depreciation			2,11,19,207	47,86,269
Total - B			**13,37,99,685**	**3,48,10,371**
Excess of Income over expenditure (A-B)			**(1,67,68,978)**	**1,30,66,365**
Excess of Income over expenditure of Prev. Year			**1,30,66,365**	
Total of Excess of Income over expenditure			**(37,02,613)**	
Notes forming part of Accounts		15		

AUDITORS' REPORT

As per our report of even date attached

Manoj & Sajeev
Chartered Accountants
(FRN. 008024 S)

R. Sajeev, FCA
(Partner)
M No. ~~208826~~

MANOJ & SAJEEV CHARTERED ACCOUNTANTS TRIVANDRUM

Manager (F&A)

Chief Manager

Director

राष्ट्रीय पृथ्वी विज्ञान अध्ययन केंद्र National Centre for Earth Science Studies तिरुवनन्तपुरम Thiruvananthapuram 695 011 भारत सरकार Govt. of India

October 09,2015
Thiruvananthapuram

National Centre for Earth Science Studies
Minstry of Earth Science, Government of India

Receipts & Payments Account for the year ended 31st March,2015

Receipts	Amount R	Amount R	Payments	Amount R	Amount R
Opening Balance:			**Staff Salary & Benefits:**		
State Bank of Travancore	99,75,898.00		Staff Salary	7,72,67,051.00	
Other Income	30,90,467.00	1,30,66,365.00	Bonus & Festival Allowance	1,62,338.00	
Grant Received during the year:			Contribution to EPF/EPS	64,24,648.00	
Operations & Maintenance	10,15,34,000.00		LIC GG Scheme for Staff	1,00,72,926.00	
R&D Programes	11,00,00,000.00	21,15,34,000.00	Children Education Allowance	3,52,136.00	
Other Receipts:			Professional Update Allowance	27,774.00	
Interest from Bank	5,62,157.00		Incentives to Staff	10,000.00	
Security Deposit	10,000.00		Medical Expenses Reimbursement	2,02,414.00	
EMD	12,30,500.00		LTC	4,39,924.00	9,49,59,211.00
Miscellaneous Receipts	5,52,325.00		**Other Institutional Expenses:**		
Receipts from Other Projects	4,79,453.00	28,34,435.00	Advertisement	2,30,432.00	
Other Receipts- Payable			Assessment Committee Expenses	18,081.00	
TDS- Contractors	37,636.00		Audit Fee/ legal Charges	2,16,961.00	
TDS- Staff	3,95,500.00	4,33,136.00	Electricity Charges	21,66,331.00	
			Water Charges	47,807.00	
			Hospitality Expenses	40,836.00	
			Printing & Stationery	4,37,870.00	
			Postage & Communication	4,00,696.00	
			Repairs & Maintenance	8,82,072.00	
			Consumables	4,24,206.00	
			Remuneration to Contingent Staff	20,58,848.00	
			Books & Journals	43,42,279.00	
			Building	28,45,026.00	
			Prior Period Expenses	3,00,000.00	
			Travelling Expences	18,46,500.00	
			Vehicle Hire Charges	2,11,545.00	
			Research Council Expenses/ Honorarium	3,66,676.00	
			Contingency	44,43,439.00	
			Expenses for CESS R&D	5,38,500.00	
			Previous Year Adjustments	30,90,467.00	
			Advance Payments	2,900.00	2,49,11,472.00

Receipts	Amount R	Amount R	Payments	Amount R	Amount R
			Payment against R & D Funds:		
			a. Crustal Processes		
			Equipments/Softwares	13,67,329.00	
			Manpower	6,95,781.00	
			Travel & Field Da	3,43,675.00	
			Consumables	2,57,113.00	
			Vehicle Hire	2,67,665.00	
			Repairs & Maintenance	4,21,323.00	
			Contingency	12,65,859.00	
			Margin Money on LC	15,50,000.00	
			Advance Payments	2,921.00	61,71,666.00
			b. Coastal Processes		
			Equipments/Softwares	26,70,739.00	
			Manpower	1,42,716.00	
			Travel	4,92,928.00	
			Consumables	9,09,064.00	
			Other Contractual Services	72,997.00	
			Repairs, Maintenance, Amc, Insurance	10,66,018.00	
			Contingency	3,08,261.00	
			Margin Money on LC	70,97,000.00	
			Advance Payments	80,013.00	1,28,39,736.00
			c. Atmospheric Processes		
			Equipments/Softwares	6,79,483.00	
			Manpower	3,69,742.00	
			Travel & Field Da	93,514.00	
			Consumables	1,86,074.00	
			Vehicle Hire	51,889.00	
			Repairs & Maintenance	11,555.00	
			Contingency	1,36,841.00	15,29,098.00
			d. Natural Resources & Environmental Management		
			Equipments/Softwares	53,26,362.00	
			Manpower	11,92,347.00	
			Travel	3,96,424.00	
			Consumables	7,83,274.00	

MANOJ & SREEJITH CHARTERED ACCOUNTANTS TRIVANDRUM

Receipts	Amount R	Amount R	Payments	Amount R	Amount R
			Vehicle Hire	2,30,505.00	
			Repairs & Maintenance	4,75,863.00	
			Contingency	2,31,301.00	
			Margin Money on LC	35,00,000.00	
			Advance Payments	20,316.00	1,21,56,392.00
			Other Payments/ Receivables		
			EPF to Staff	10.00	
			Advance for Purchase	12,70,351.00	
			Service Tax Receivable	63,036.00	
			TDS Receivable	10,31,778.00	23,65,175.00
			Closing Balance		
			SBT-E-tax	4,34,136.00	
			State Bank of Travancore	7,25,01,050.00	7,29,35,186.00
Total	**22,78,67,936.00**	**22,78,67,936.00**	**Total**	**22,78,67,936.00**	**22,78,67,936.00**

For National Centre for Earth Science Studies
Akkulam Trivandrum

Manager (F&A) **Chief Manager** **Director**

Thiruvananthapuram
Dated: October 09,2015

राष्ट्रीय पृथ्वी विज्ञान अध्ययन केन्द्र
National Centre for Earth Science Studies
तिरुवनन्तपुरम
Thiruvananthapuram
695 011
भारत सरकार
Govt. of India

Manoj & Sajeev
Chartered Accountants
FRN. 008024 S

R. Sajeev, FCA
(Partner)
M.No. 206626

MANOJ & SAJEEV CHARTERED ACCOUNTANTS TRIVANDRUM

Schedule No.15- Notes forming part of Accounts

Organizational Information

National Centre for Earth Science Studies is a Society taken over by the Ministry of Earth Sciences, Government of India on 1st of January 2014 for perusing and promoting basic and applied advanced research in the frontier areas of Earth Sciences. The Centre has been registered under Travancore Cochin Literary, Scientific and Charitable Societies Registration Act, 1955 as an autonomous institution under the Ministry of Earth Sciences, Government of India.

Significant Accounting Policies:

1. Basis of Accounting:

   The Society had followed mercantile system of accounting till the conclusion of financial year 2013-14. Financial year 2014-15 onwards, Society has changed their accounting system to cash basis. So it recognizes income and expenditure on cash basis.

   The effect of change in Accounting Policy for the financial year (from 01.01.2014 to 31.03.2014) is negligible.

2. Income Recognition

   The Grant-in-aid is received by the Society from the Ministry of Earth Sciences as Research Program Grant and Operations and Maintenance Grant.

   In addition, the society also under takes other R&D Projects sponsored by Ministries/Department of GOI/GOK, Consolidated Service Projects and Consultancy Projects which amounts to ₹.344.43 Lakhs. The Grant-in-aid unutilized at the end of the period is as disclosed in Schedule 4.

3. Fixed Assets and Depreciation:

   a. All the Fixed assets of Centre for Earth Science Studies (CESS) as on 31.12.2013 have been taken over by National Centre for Earth Science Studies (NCESS) other than the land owned by the Government of Kerala. As per G.O (Ms) No.468/2013/RD dated 24/10/2013, the Government of Kerala has accorded sanction in principle for leasing out an extent of 13.95 acres of land possessed by Centre for Earth Science Studies (CESS) to the Ministry of Earth Sciences, GOI for 99 years @ of Re.1/- per acre per year for the operation of the Society.

   b. The additions of fixed assets during the period are stated at cost. Fixed assets of the Centre are acquired out of grants received. Assets acquired for the sponsored projects (Grant in Aid) are capitalized on completion of the project/receipt of permission from the concerned Government Departments. Funds utilized for acquiring fixed assets from Grants received are transferred to Capital reserve.

c. Depreciation is charged to the fixed assets on Written Down Value basis as per the rates prescribed under the Income Tax Rules. Depreciation has also been charged on fixed assets on written down value method for assets transferred from the externally funded projects on closure of the projects or on receipt of permission from concerned Government Departments/ Ministries.

4. Current Assets

Cash and bank balances represent the balances with the Society, grant in aid projects and consultancy projects accounts.

Closing stock of chemicals, glassware, consumables and stationery items are at cost as certified by the management. Cash equivalents like term deposits and margin money in letter of credit are as per the confirmations provided.

5. Loans and Advances

Advances to staff represent the balance with them for meeting the expenses in connection with the conduct of research projects and are considered good and secured.

Advances and deposits with the suppliers and creditors are as certified by the management and are considered good.

6. Capital Reserve

The amount received from the Ministry of Earth Sciences and other institutions utilized for acquiring Fixed Asset is credited to the Capital Reserve and the depreciation charged in the Income & Expenditure statement is written back by debiting the Capital Reserve. The Capital reserve as on the date of taking over is carried forward after deducting the value of the land not taken over.

7. General Reserve

The unspent/overspent balance of the grant received from the Government of Kerala has been stated under General Reserve which will be closed once the projects stated under the schemes of CESS or overspent balance amount is received from the Kerala State Council for Science Technology and Environment. The detail of the said workings is as stated in Schedule No 2.

8. Research Program Funds

The balance of the grant for the research programs remaining unspent is stated as Research Program fund under Unspent Balance GOI - MoES. During the year, the Society has received ₹.1100.00 lakhs funds towards Research Program Grant from the Ministry of Earth Sciences (MoES). Unspent balance as on 31st March, 2015 is ₹.895.82 lakhs.

9. Unspent Balance of Projects

The unspent balances of the grant received for the conduct of sponsored R&D projects sanctioned by the Ministries/ Departments of Government of India /Government of Kerala, Consolidated Service Projects/ Consultancy Projects from various agencies are carried forward as Unspent Balance of Projects. During the year the Society received an amount ₹.344.43 lakhs and unspent balance as at the end of the period amounts to ₹.717.50 lakhs. Detailed list of project wise unspent balance is as in Sub-Schedule A & B.

10. Operations and Maintenance Fund

a. Unspent balance of Grant received from the Ministry of Earth Sciences (MoES) for Operations and Maintenance expenditure is stated as the balance of Operations and Maintenance Fund. The excess of income over expenditure or deficit of income over expenditure in the Statement of Income and Expenditure is credited or debited in the account. Overspent balance as on 31st March,2015 ₹.37.02 lakhs.

b. The interest and other income for the financial year 2013-14 amounts to ₹.30,90,467/- relates to grant received from Government of Kerala was erroneously credited to Government of India Operations and Maintenance Fund. This was rectified during this year by debiting Operations and Maintenance Fund and crediting unspent balance of Grant, Government of Kerala.

11. Projects

The Committees consisting the heads of respective projects and other technical personnel are monitoring the status of the various projects, including the financial budgets etc., and noting the minutes of the output of such meeting.

The various assets of the projects, purchased by NCESS are located at such projects.

Income and Expense of the External/ Consultancy projects are accounted on cash basis. Balance of unutilized grant in aid and other receipts as on the date of Balance Sheet has been shown as Schedule 4. The unspent amount on the completion of consultancy projects is transferred to Corpus Fund.

12. Retirement Benefits

Liability towards Gratuity is provided through a Group Gratuity Scheme of LIC. The gratuity amount is limited to ₹.10,00,000/-.

Leave Encashment is accounted on Cash basis. No provision for leave encashment is made in the accounts. The terminal encashment is limited to 300 days and the amount paid is considered as the expense in the year of payment itself.

13. Income and Expenditure Account & Receipts and Payments Account

Income and expenses and Receipts and Payments Account of the Society are accounted on cash basis.

14. Interest Received

The Society parks funds in Short Term Deposit with bank and also in Savings Bank accounts. The interest received in the said accounts is the income of the Society. Interest earned on corpus fund is added to the corpus fund itself and not included in the Income of the Society.

Manoj & Sajeev
Chartered Accountants

(FRN. 008024 S)

R. Sajeev, FCA
(Partner)
M No. 206626

October 09,2015
Thiruvananthapuram

Manager (F&A) **Chief Manager**
~~**Director**~~

DIRECTOR

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