# CESS NEWS

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# The Quaternary Period: Climate, Sea level oscillations and Kerala's mineral wealth

Throughout the geologic history, the earth has been subjected to changes in its environment. The changes were most striking in the Quaternary period - the time span representing the last two million years of earth history. The Quaternary period was associated with waxing and waning of the gigantic continental ice sheets that have covered a considerable part of the northern hemisphere. Continental ice sheet began to develop at about 3.5 million YBP (years before present) and attained enormous volume in the beginning of the Quaternary period. The oscillations between glacial and interglacials during the Quaternary are characterized by the transfer of immense volumes of water between the continents and the oceans. The numbers of glacial and interglacial cycles were the highest during the Quaternary than in any other period in the history of the Earth. The mid and low latitude glaciation, low latitude aridity and lower sea levels are characteristic of the Quaternary period. These changes have strongly influenced the geomorphic evolution, sedimentation rate and the history of biological world including that of mankind. Further, movement of the plates of the earth's crust was so rapid and is of the order of several centimeters a year in some areas. Volcanism and seismicity have also become strong in many parts of the earth. The marked changes in Quaternary climate have led to the extinction of many life forms in the Biosphere. If the changes were slow, the biological system could have had some possibility to adapt to the new environmental conditions either by genetic modifications or by moving themselves to favourable areas.

The Quaternary period comprises two epochs-the Pleistocene epoch (2 million YBP to 10 kilo YBP) and the Holocene epoch (<10 kilo YBP). The Pleistocene comprises at least four principal glacial episodes separated by warmer interglacials. Each major glacial episode itself is complicated by many minor warmer periods or interstadial events. During the interglacials, glaciers had shrunk and the sea rose approximately to the present level. Rivers have transported vast amounts of suspended mud and bed load sand from their catchments to the coastal area of the oceans and seas. During glacial periods, sea level began to lower and the rivers could no longer shift from their courses because of reactivated down cutting of older sedimentary formations in consonance with the lowering of the sea level. In the final glacial episode in the Last Glacial Maximum (LGM), between 30 kilo YBP and 18 kilo YBP, approximately 50 million $km^3$ of ice has melted from the continental ice sheets, raising the global sea level in regions distant from the major glacial centers by 120 - 130m. During the rising spells of the sea, rivers began to meander within their incised valleys and, point bar sand bodies and over bank mud were deposited. The deeply incised lower reaches of the valleys filled slowly with brackish to marine water as the sea level rose and sedimentation took place under transgressive regimes.

Studies reveal that the sea level rise in Quaternary (especially in Late Quaternary) period was not monotonic; rather, it was at varying rates

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## Prof. C. Karunakaran Endowment Lecture Series: Our Changing View of the Cosmos

*Prof. T Padmanabhan, Dean, Core Academic Programmes, Inter-University Centre for Astronomy & Astrophysics, Pune delivering the nineth Prof. C.Karunakaran Endowment Lecture on 13 August 2010*

The Prof. C. Karunakaran Endowment Lecture, the nineth in the series was delivered by Prof. Tanu Padmanabhan, an internationally acclaimed Theoretical Physicist and Cosmologist whose research spans a wide variety of topics in Gravitation, Structure formation in the Universe and Quantum Gravity, on August 13, 2010. The topic of his lecture was 'Our Changing View of the Cosmos'.Prof. Padmanabhan spoke on the discovries about the Universe and elaborated on the current research in cosmology. Sri. S. Singanenjam, Director, GSI, Trivandrum paid tributes to Prof. C.Karunakaran. Dr. R. Krishnan, Associate Director, IIST, Dr. V. Unnikrishnan Nayar, Emeritus Professor, IISER and Dr. Chithra Karunakaran, daughter of Prof. C. Karunakaran spoke on the occasion. Dr. T. Radhakrishna, Director in Charge welcomed the gathering and Sri. G. Balasubramanian proposed the vote of thanks.

## Director Speaks

Kerala is a thickly populated state that is undergoing fast urbanization. This has resulted in severe environmental degradation in all its major cities. Conversion of vast agricultural lands and rural areas to urban conglomerations causes negative impacts on the environment. Saline water intrusion into aquifers, pollution due to dumping of solid and liquid wastes to land and water bodies, air and noise pollution due to increased vehicles and industrialization, encroachment on coastal plains, dispersion of toxic elements into the environment and neglect of sites of cultural heritage and natural beauty are some of the ill effects of unplanned urbanization. The major handicap in the assessment of environmental deterioration due to urbanization is the lack of adequate data and information on air quality, surface and ground water quality, health of land mass, etc. of the affected area.

In order to deal with this situation CESS has carried out a study to assess the impact of urbanization on surface and ground water quality, soil and aquatic sediment in the three most urbanized regions of Kerala, viz. Thiruvananthapuram, Kochi and Kozhikode. Data on the hydro-chemical and bacteriological characteristics of water, nutrient status in soil, contamination level in lake sediments were measrued in these three cities and its immediate neighborhoods. Groundwater from wells and surface water from different sources like river, lakes, ponds, canals, temple ponds and coastal marine regions were collected and analyzed.

The study revealed that ground water quality of urban areas is considerably poor with respect to its adjoining non-urban areas and within an urban area, the degree of deterioration is directly related to density of population, soil texture, land use pattern, elevation of land, etc. The overall impact was most severe in Kochi followed by Thiruvananthapuram and Kozhikode. In Thiruvananthapuram, the groundwater quality showed greater contamination in urban areas. Both Akkulam Lake and Parvathiputhanar received wastes of complex nature from several sources. The water and sediment characteristics of Akkulam lake reflected the alarming state of this lake. Vellayani - a fresh water lake - in comparison was relatively less contaminated. The water quality of upstream and downstream stretches of the Karamana River showed high contamination with very high pollution in the lower stretches due to unprecedented urbanization.

As compared to Thiruvananthapuram, all well samples of Kochi showed high concentration of nutrients and depletion of dissolved oxygen. Regionally, both well-water and bore-well water from the highly urbanized zones of Kochi revealed greater enrichment of nutrients and depletion of dissolved oxygen. The surface water sources of Kochi city indicated high concentration of nutrients with low DO values while soil samples from agricultural regions had low nutrient levels.

The study has brought to light the need to devise strategies and management action plans for minimizing the impacts of urbanization on aquatic environment and soil/sediment systems. As an initial step, discharge of highly contaminated and potentially toxic wastes from hospitals and manufacturing units into the water bodies and the discharge of raw sewage and effluents into the river/estuarine systems should be made punishable.

*Dr. N. P. Kurian*

*Continued from page 1*

## The Quaternary period.....

and with several pauses, resulting from fluctuations in glacial activity. Pauses and minor reversals of sea level rise are evidenced by terraces in the continental shelf and also submerged shoreline sands that occur on the shelf far from the present shoreline. In the post LGM, the rise was marked by two intervals of extreme rapid sea level rise of 24 m in less than 1000 radiocarbon years. The rate of rise was minimal at 11 kilo YBP and remained low until 10.5 kilo YBP. The sea level reached its maximum during the mid-Holocene. At about 6 kilo YBP, the sea level was almost same as that of the present. But in the subsequent periods, a further rise of 3-4 m is indicated. Since about 2.5 kilo YBP, the coastal zone has generally evolved to its present condition by erosion, deposition and, compaction and subsidence- the processes are still important and operating today.

In recent years, the planners and policy makers all over the world are becoming increasingly aware of the relevance of Quaternary studies owing to its immense applications in the fields of agriculture and natural resources management. Further, increased concern about the adverse effect of global climatic change demands in-depth studies on past geological and climatic changes. Though the effects of global warming and related climatic changes would affect many countries like India, the Quaternary studies have not been taken seriously by most of the countries until recently. But it is now widely accepted that a better understanding of Quaternary geological events is utmost important especially in the coastal states where a major proportion of the population and economic activity are centered. Further, the people in the coastal lands of such areas depend on Quaternary aquifers for their fresh water requirements and any rise in sea level could adversely affect the fragile fresh water lenses in that area. In addition to these, the sedimentary archives of Quaternary period preserve records of sea level and climate changes, the information of which will be useful for fine tuning the climate prediction systems developed from measurements of the actual climate/weather parameters.

*Significance of Quaternary studies in Kerala*

Kerala is a coastal state with a long coastline of 590 km. The coastal land constitutes about 10% of the land area of the state and sustain a high density of population. Almost all the major developmental centres are in the coastal land which are built up essentially by Late Quaternary sedimentation. Out of the three major geologic provinces of the state, the Quaternary deposits are of extreme importance as it

*Glass sand deposit of Alappuzha district*

hosts certain economically viable and strategically significant mineral resources compared to the other two provinces viz., the Pre-Cambrian crystallines and the Tertiary (Neogene) sediments. The major economic minerals associated with the Late Quaternary sediments of Kerala include heavy mineral sands, silica (glass) sands

*Ilmenite rich heavy mineral sands of Kollam district*

and limeshells. Further, the building materials like river sand, floodplain (ordinary) sand and

*Lime shell deposits at Kannur (top) and Vembanad Lake Alappuzha (above)*

tile/brick clay are also associated with the Late Quaternary deposits.

The most important heavy minerals in the beach sands of Kerala are ilmenite, sillimanite, zircon, rutile and monazite. Studies reveal that palaeo-oceanographic conditions coupled with sea level oscillations in the Holocene Climatic Optimum (HCO) were responsible for the segregation of heavy minerals in the Kollam coast and silica rich sands in the Alappuzha coast, which were later modified by the aeolian activity in the subsequent aridity event. Limeshell, a deposit of biogenic origin found associated with the major lagoons and their overbank areas, is also believed to be a product of the Late Quaternary period. In addition to these, the thick deposit of fine aggregate grade sand that occur in the storage zones of the rivers and adjoining floodplains, organic rich sticky clays used in the brick and tile industries etc., also have Late Quaternary age.

All these stress the imminent need for better understanding of the Quaternary geology and records of sea level and climate changes in the sedimentary archives of the coastal areas of Kerala. This is very essential not only for predicting the near-term future of human kind and estimating the effects of human activities on the environment but also for laying down strategies for the economic well being of the people of the area.

*Dr. D. Padmalal*

## Publications

*Papers published in Journals*


Vishnu R, Murali Das S, Sampath S and Mohan Kumar G (2010). Detection of possible thunderstorm formation inferred from weather element changes at ground level on a mountain slope, *Journal of Lightning Research*, II, pp. 12-24.

Mallia R J, Subhash N, Sebastian P, Kumar R, Shiny S T, Mathews A, and Madhavan J (2010). *In Vivo* temporal evolution of ALA-induced normalized fluorescence at different anatomical locations of oral cavity: Application to improve cancer diagnostic contrast and potential, photodiagnosis and photodynamic therapy, 7, pp.162-175 [DOI: 10. 1016/ j.pdpdt. 2010. 06. 006].

Rupananda Mallia, Narayanan Subhash, Jayaprakash Madhavan, Paul Sebastian, Rejnish Kumar, Anitha Mathews, Gigi Thomas and Jayakrishnan Radhakrishnan (2010). Diffuse reflectance spectroscopy: An adjunct to autofluorescence spectroscopy in tongue cancer detection, Applied Spectroscopy, 64(4), pp. 409-418 [DOI:10.1366/000 370 210 791 114 347].

Mahamaya Chattopadhyay and Chattopadhyay, S (2009). Water quality variations of headwater streams in the Western Ghats: A case of Kall Ar, Vamanapuram basin, Kerala. Geog. Review of India, V.71, No.3,pp.305-321.


*Papers published in proceedings*


Hamza Varikoden, Sampath S, Sasi Kumar V, Murali Das.S, Vishnu R and Mohan Kumar G, Measurements of cloud characteristics with a Ceilometer and supporting measurements with a water based Condensation Particle Counter: *Proc. 38th COSPAR Scientific Assembly*, Bremen, Germany, July-18-25, 2010.

Vishnu R, Sampath S, Mohan Kumar G and Murali Das S, A modified Electric Field Mill and measurements of cloud electric field with it at a tropical coastal station, *Proc. 38th COSPAR Scientific Assembly*, Bremen, Germany, July-18-25, 2010.

Hamza Varikoden , Harikumar R, Sampath S, Sasi Kumar V, R Vishnu, Murali Das S and Mohan Kumar G , Studies of cloud base height over a tropical station Trivandrum using a Laser Ceilometer: *Proc. 38th COSPAR Scientific Assembly*, Bremen, Germany, July-18-25, 2010.

Harikumar R, Mohan Kumar G and Sampath S, Simultaneous evidence for the origin of rain from stratiform or convective clouds from the Micro Rain Radar Bright Band Signature and the vertical profiles of Z-R empirical relation: *Proc. 38th COSPAR Scientific Assembly*, Bremen, Germany, July-18-25, 2010

Harikumar R, Hamza Varikoden, Gairola R M, Mohan Kumar G, Sampath S and Sasi Kumar V, Comparison of TRMM precipitation data with a K-Band Radar, Disdrometer and Manual Rain Gauge data during different monsoon seasons at coastal & high altitude tropical stations: *Proc. 38th COSPAR Scientific Assembly*, Bremen, Germany, July-18-25, 2010

Harikumar R, Mohan Kumar G and Sampath S, Evidence of the orographic effect on Rain from Rain Drop Size Distribution at coastal and high altitude tropical stations, *Proc. 38th COSPAR Scientific Assembly*, Bremen, Germany, July-18-25, 2010.

Zachariah E J and George Thomas, Methane discharges from a tropical estuary to coastal ocean, Proc. Int. Symp. Coastal Zones and Climate Change: Assessing the Impacts and Developing Adaptation Strategies, 12 – 13 April 2010, Monash University, Australia. pp.133-140.

Vishnu R, Murali Das S, Mohan Kumar G, and Sampath S, Investigations into cause of high lightning incidence and accidents by it in a region with relatively special characteristics', AGU Chapman Conference on Complexity and Extreme Events in Geosciences, National Geophysical Research Institute, Hyderbadad, India, 15-19 February 2010.

Sarath Krishnan K, Vishnu R, Subi Simon V N and Murali Das S, Sudden vertical motion of clouds in relation with pressure variation and wind direction, 48th Annual Convention of Indian Geophysical Union, 2010.

*Papers published in books*

E.J. Zachariah (2010). Methane Emission from Wetlands in Kerala, *In: Climate Change and Aquatic Ecosytem*, Aneykutty Joseph et al. (eds.). CUSAT, Kochi. pp. 130-139.

Chattopadhyay, S (2010): District plan: Revisiting methodological issues and recounting Kerala's experience in district. Planning Methodology and Agenda for Action, eds. M.A.Oommen & Mary George, Institute of Social Sciences, New Delhi, pp.23-44.

*Books*

Rupananda Mallia and Subhash Narayanan (2010), Photodiagnosis of Oral Malignancy – Basic, Translational and Clinical, Lap Lambert Academic Publishing GmbH, Germany, 175p.

## Honours/Awards

Dr. N. Subhash, Head, Atmospheric Sciences Division, was conferred as Senior Fellow of the Head and Neck Optical Diagnostic Society (HNODS) by the University College of London, UK, for his contributions in the field of biophotonics.

## National Green Corps Best Eco Club Award 2010

*Dr. R.V.G. Menon inaugurates the two day workshop to select best eco clubs at State and District levels on 5th August 2010 at CESS. Dr. C.T.S Nair, Dr. T.Radhakrsihna and Dr. Kamalakshan Kokkal are also seen*

A Two day work shop was held in CESS during 5-6 August 2010 to select the best performing Eco Club for the year 2010, under the National Green Corps (NGC) programme implemented by the Kerala State Council for Science, Technology and Environment in selected schools all over Kerala. Forty two schools, three schools from each district, which entered the final round of selection, made presentations before a panel of experts. The two day workshop was inaugurated by Dr. R.V.G Menon, noted scientist and science populist. Dr. C. T. S Nair, Executive Vice President, KSCSTE, Dr. T. Radhakrishna, Director-in-charge CESS, Dr. Kamalakshan Kokkal, Joint Director, KSCSTE and Dr. Harinarayanan, Scientific Officer, KSCSTE also spoke on the occasion. Sree Ramakrishna Mission High School, Kozhikode bagged the best Eco Club in the State for the year 2010 and has won a project worth Rs. 100000/-. The best clubs in each district were awarded with a project worth Rs. 50000/-.

*Dr. C.T.S Nair, Executive Vice President, KSCSTE, presenting the Best Eco Club award to the students of Ramakrishna High School, Kozhikode*

Ms. M. Vandana, Project Fellow, Resources Analysis Division has secured second position in the Prof. N.P.Ayyer Young Geographer Award for her research paper entitled 'Landform evolution of Kabani river basin, Wayanad district Kerala' conducted during the 32nd India Geography Congress held at the Punjab University, Chandigarh.

Mr. Vishnu R. ,Research Scholar, Atmospheric Sciences Division, presented two papers in the 38th Assembly of Committee on Space Research (COSPAR-2010) at Bremen, Germany.

Mr. George Thomas, Project Fellow, ASD, was endowed with the second best performer award by Department of Science and Technology & Indian Institute of Tropical Meteorology on successful completion of the 'SERC School on Global Warming and Climate Change'

## Ph.D Awarded

Dr. Shiny Sara Thomas has been awarded Ph.D Degree under the Faculty of Science, Cochin University of Science and Technology, Kochi for her thesis entitled 'Spectroscopic investigation of tooth caries and demineralization'. Dr. N. Subhash, Head, Atmospheric Sciences Division, was the supervisor for the PhD dissertation work of Dr. Shiny Sara Thomas.

## Invited Talks

Dr. N P Kurian delivered a lecture on Vulnerability of Kerala to Coastal Hazards in the Workshop on 'Hazards, Risks and Vulnerability Assessment' on 4th October 2010.

Dr. N. Subhash delivered a lecture at the Advanced Centre for Training, Research and Education in Cancer (ACTREC), DAE, Govt. of India, Khargar, Mumbai on 'Laser induced fluorescence in cancer detection' on 30th September 2010.

Dr. K K Ramachandran delivered a talk entitled 'Geo-informatics for the preparation of the thematic maps' in the training programme organized by Central Ground Water Board and Kerala Water Authority on 30th September 2010.

Dr. M Samsuddin delivered a talk entitled "Kerala Spatial Data Infrastructure" in a training programme on 27th September 2010 in IMG jointly organized by State Ground Water Department and Institute of Management in Government.

Shri. V N Neelakandan delivered a talk entitled 'Geo-informatics' in a training programme on 27th September 2010 in IMG jointly organized by State Ground Water Department and Institute of Management in Government.

Dr. K K Ramachandran delivered a talk entitled 'Geo informatics for micro mapping' in a training programme on 27th September 2010 in IMG jointly organized by State Ground Water Department and Institute of Management in Government.

Sri. B K Jayaprasad delivered a talk entitled "Geo informatics in urban areas in a training programme on 27th September 2010 in IMG jointly organized by State Ground Water Department and Institute of Management in Government.

Dr. K K Ramachandran delivered a talk on GPS at a workshop held for the Town planners of the Town Planning Department of GoK on 4th October , 2010.

## Papers Presented in Conferences

Sri. S S Praveen and V R Shamji attended and presented papers entitled 'Numerical modelling studies on Tsunami inundation along the Kerala coast' and 'Numerical modelling of beach erosion along Southwest coast of India during Southwest monsoon' respectively in the 9th International Conference on Hydro-Science and Engineering (ICHE-2010), a conference held at Indian Institute of Technology, Chennai during 2-5 August 2010.

Ms. Manju Stephen presented a paper entitled 'Diffuse reflectance spectral imaging: a non-invasive promising tool for early diagnosis of malignant changes in the oral cavity' in the Conference of the Indian Association of Oral and Maxillofacial Pathologists (IAOMP), November 2010.

Shri. B Sukumar attended 4th session of the IAG Working Group in Geomorphological hazards(IAGEOMHAZ) and International workshop in Geomorphological hazards held at Kanyakumari during July 2010 and presented two papers titled 'Geomorphic hazards due to anthropogenic processes-A study between Thrissur and Ernakulam districts of Kerala' and 'Hazard zonation mapping of Valapattanam river basin in Kannur district of Kerala using GIS and remoter sensing'.

Shri. B Sukumar attended the Working Group Meeting on 'Application of geomatics for disaster management' at Osmania University, Hyderabad during 8-12 December, 2010.

Dr. D Padmalal and Vishnu Mohan attended International Conference on Climate Change and Environment at Kochi and Lakshadweep and presented a paper 'EIA of sand mining from the small catchment rivers in the south west coast of India; A case study'.

Dr. K V Thomas attended a seminar on 'CRZ 2010 Draft Response and Challenges' organized by the International Centre Goa (ICG) and National Institute of Oceanography (NIO) and presented a paper 'Setback lines for Coastal Regulation Zone-Different approaches and implications'.

## Nomination

Dr. Srikumar Chattopadhyay has been nominated as a member of the advisory committee to start an Inter University Centre for Social Sciences Research and Extension at M.G. University, Kottayam.

## Exhibition

CESS Participated in the Santhigiri Expo-2010 held at Santhigiri Ashramam, Pothencode during 06-15 September, 2010.

## Distinguished Visitor

Dr. Tad S. Murty, University of Ottawa, Canada was in CESS during October 25 to 30,2010. Dr. Murty delivered the following lectures. (i) Early warning systems for oceanic natural hazards-the fundamentals (ii) Practical applications of long gravity waves in the Ocean.

## New Arrivals in CESS Library


Popsescue, Gabriel(ed.). Nanobiophotonics. Mc-Graw Hill, New York, 2010.

Kresic, Neven and Stevanovic, Zoran(eds.). Ground water hydrology of springs. Elsevier, Amsterdam, 2010.

Nayar, T.S [et al.]. Flowering plants of Kerala: a handbook. TBGRI, Palode. 2006.

Narayan B. Office management. APH Publishing Corporation, New Delhi, 2010.

Chopra, R.K and Ankita Bhatia. Office management. Himlaya Publishing House, Mumbai, 2010.

Mathur, M.N. A textbook of office management. Wisdom Press, New Delhi, 2011.

Indian Tide Tables 2011. Surveyor General of India, 2010.

Pavesi, Lorenzo and Fauchet, Philippe M(eds.). Biophotonics. Springer, Heidelberg, 2008.

Varma, O.P, Rajamanickam, G.V. And Wilson, Eugene(eds.). Coastal hazards. Indian Geological Congress, Roorkee, 2010.


## New Projects

**Sediment budgeting studies for the mining sites of KMML, Chavara**

The Kerala Minerals and Metals Ltd (KMML), a Kerala Government Undertaking engaged in mining and processing of beach heavy minerals, approached the Centre for Earth Science Studies to carry out sediment budgeting studies for the block III of the Chavara coast allotted to them for beach sand mining. The CESS with its expertise in this field with a pioneering study during 1999-2001for the Indian Rare Earths Ltd. has taken up the project with the following objectives:

- Study the hydrodynamic and sedimentologic characteristics in the innershelf of Chavara coast.
- Carry out numerical model studies to understand the innershelf sediment transport processes of the region.
- Estimate the beach sediment budget for the coast.
- Recommend the quantity of mineral sand accretions that can be removed without affecting the beach stability.

The proposed work components are deployment of wave gauges, current meters and other equipments at different locations in the model domain and recording of data during different seasons, monthly beach profile measurements, collection and analysis of surficial sediment samples from different locations in the beach and offshore of the study area, setting up of numerical models for simulating the circulation and sediment transport pattern in the study area, computation of sediment transport and working out beach sediment budget. The project with an outlay of Rs.39.5 lakh and tenure of 18 months was initiated in July 2010.

### Establishment of Wave Gauge Stations in the Coastal Waters of the SW coast of India

Information on the state of the ocean is vital for coastal community especially the fishermen. The Centre for Earth Science Studies in collaboration with the Indian National Centre for Ocean Information Services (INCOIS) has taken up a new project to establish a couple of wave, current and tide measurement stations along the SW coast of India to provide this essential information. In the first phase of the project which is initiated during the current Plan period, waverider buoys will be deployed in the inner shelf at depths of around 15-20m off Trivandrum and Kozhikode. Satellite assisted data transmission will be done at an interval of 30 minutes. The real time data from the system will be then used for the validation of the Sea State Forecast System for the Kerala coast provided by INCOIS at regular intervals. The forecast system which gives vital information like site specific sea condition (which includes wind and wave data), location of potential fishing zones, etc. would be made available to the local fishermen through Electronic Display Boards installed at important harbours like Vizinjam near Thiruvananthapuram and Beypore in Calicut. It is also envisaged to disseminate the data to the user communities particularly to the fishermen and coastal community by organising workshops and also by employing other methods of mass communication like television, radio and newspaper.
During the 12th Plan period the programme will be enhanced by adding one more station off central Kerala so that the entire coastal community of Kerala can be benefitted by this service. The peformance of the stations will be improved by augmenting their capacity with automatic weather stations, tide gauges and current meters.

## Retirements

*Sri. V. N. Neelakandan*

Sri. V. N. Neelakandan, Scientist F and Head, Central Geomatics Laboratory retired on 31st December 2010

*Sri. M.P. Sivakrishnan*

Sri. M. P. Sivakrishnan, Deputy Registrar (Accounts) retired on 31st August 2010

*Sri. K. Sreedharan*

Sri. K. Sreedharan, Deputy Registrar, Administration, retired on 31st December 2010

*Sri. A. Abdunnasar*

Sri. A. Abdunnasar relinquished his post of Librarian CESS to take up the post of Librarian in the Indian Institute of Space Science and Technology, Valiamala, Trivandrum

*Sri. G. Krishnan Nair*

Sri. G. Krishnan Nair, Driver Grade I, attached to the Director's Office, retired on 31st August 2010

*Sri. P. C Sasikumar*

Sri. P. C Sasikumar, Helper attached to the Resources Analysis Division, retired on 31st October 2010

*Pictures taken during the Onam Celebrations organized by CESS Recreation Club. Film actor Sajan Surya was the Chief Guest of the event.*

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