वार्षिक प्रतिवेदन
ANNUAL REPORT

2020-2021

एम ओ ई एस – राष्ट्रीय पृथ्वी विज्ञान अध्ययन केन्द्र
MoES - National Centre for Earth Science Studies
(पृथ्वी विज्ञान मंत्रालय, भारत सरकार)
(Ministry of Earth Sciences, Govt. of India)
आक्कुलम, तिरुवनंतपुरम – 695011, भारत
Akkulam, Thiruvananthapuram – 695011, India

ANNUAL REPORT 2020 – 2021

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Shri. S. R. Unnikrishnan

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From the Director's Desk

The year 2020-2021 was an extraordinary year for the entire world, and NCESS was no exception. While our country was struggling with the pandemic spread and resulting economic hardship, I took over as the Director of NCESS on September 24, 2020. Although most staff and scholars were back at work, they had already adapted to the new normal. Because of prior lockdowns and stringent COVID protocols still in place, the progress during the first quarter of the year was sluggish. However, our scientists did publish a good number of papers during this time taking advantage of working remotely. Most of the official meetings were turned up online including the 14th Governing Council (GC) Meeting of the NCESS that took place soon after assuming charge, on 28th September 2020, which approved the constitution of a new Research Advisory Committee (RAC) under the chairmanship of Prof. S.K. Tandon. NCESS has already been in the path of creating a research environment at par with national institutes and all efforts have been made to improve the ambience during 2020-21 with the support of the RAC.

The year 2020 witnessed significant research planning activities by the scientists of the institute to formulate, discuss and defend the research proposals intended for implementation during the new plan period 2021-2026. Following several rounds of internal deliberations within the institute, the proposals were reviewed by the RAC during two of its meetings with NCESS scientists on January 22 and March 25, 2021, and subsequent individual interactions. A total of 15 research proposals, under the theme "Geodynamics and Surface Processes (GSP)" were submitted to the Ministry of Earth Sciences (MoES) for consideration. The proposals were successfully defended in the Standing Finance Committee (SFC) and the Expenditure Finance Committee (EFC) meetings as part of the umbrella scheme "Seismology and Geosciences (SAGE) of the Ministry. We look forward to the successful implementation of these projects in the coming years.

The year 2020-21 was one of the most productive years for NCESS. Our scientists and researchers had published 45 peer-reviewed journal papers, in comparison to 28 during the previous year. Many of these papers appeared in leading journals of the respective disciplines. Other research outputs include 14 book chapters, 14 articles in conference proceedings and one patent. During the year, three research scholars successfully completed their Ph.D. programs. As for the development of research facilities, a High-Altitude Cloud Physics Observatory (HACPO) was established at Rajamallay (Munnar) at an altitude of 1820 meters, all the three Critical Zone Observatories (CZO) were made operational, and the work on the class 10000 clean chemistry laboratory was completed. The Phase-I of the national network project on Submarine Groundwater Discharge (SGD) involving fourteen institutes of the country was successfully coordinated by NCESS in its final year. The project received appreciation from many quarters and NCESS is looking forward to implement the Phase-II of this program with novel objectives and new partners.

With a view to reorient research activities of the institute, to maximise utilization of available research facilities, and for the betterment of scientific administration, the number of research groups was

increased to six from four and renamed appropriately. Currently the research groups of NCESS are known as Solid Earth Research Group (SERG), Crustal Dynamics Group (CDG), Marine Geoscience Group (MGG), Hydrology Group (HyG), Biogeochemistry Group (BgG) and Atmospheric Science Group (ASG). Although researchers are listed in various groups for administrative purposes, they are encouraged to pursue intergroup research collaborations and make use of all available facilities irrespective of their administrative controls.

In the organizational front, several goals were achieved during 2020-21. Because of the continued efforts of our Administration, NCESS was issued the final lease document from the Government of Kerala, duly approved by its cabinet, after resolving all land border disputes. The institute got its new entrance gate, a paved approach road and a new boundary wall/fence.

In spite of the fact that the year 2020-21 was one of the most turbulent years, NCESS as a national institute has risen to a greater height in terms of scientific research. We have proudly contributed to the nation building by sharing our knowledge and resources. Every member of NCESS is proud to be part of the institute in helping the state of Kerala and the country during this unusual year. I am extremely happy to place this Annual Report before all the well-wishers of this unique institute.

Dr. Jyotiranjan S. Ray
Director, NCESS

Committees

Statutory Committees

1. General Body (GB)

Secretary Ministry of Earth Sciences, Government of India Prithvi Bhavan, New Delhi	President
Advisor Ministry of Earth Sciences, Government of India Prithvi Bhavan, New Delhi	Member
Additional Secretary & Finance Advisor Ministry of Earth Sciences, Government of India Prithvi Bhavan, New Delhi	Member
Joint Secretary (Admin) Ministry of Earth Sciences, Government of India Prithvi Bhavan, New Delhi	Member
Programme Head (NCESS) Ministry of Earth Sciences, Government of India Prithvi Bhavan, New Delhi	Member
Director National Centre for Polar & Ocean Research Vasco-da-Gama, Goa	Member
Director National Institute of Ocean Technology Pallikaranai, Chennai	Member
Director National Centre for Earth Science Studies Akkulam, Thiruvananthapuram	Member Secretary

2. Governing Council (GC)

Secretary Ministry of Earth Sciences, Government of India Prithvi Bhavan, New Delhi	Chairman
Additional Secretary & Finance Advisor Ministry of Earth Sciences, Government of India Prithvi Bhavan, New Delhi	Member

Joint Secretary (Admin) Ministry of Earth Sciences, Government of India Prithvi Bhavan, New Delhi	Member
Chairman, RAC National Centre for Earth Science Studies Akkulam, Thiruvananthapuram	Member
Dr. Suresh Das Emeritus Professor Indian Institute of Science Education and Research Thiruvananthapuram	Member
Dr. Anil Bhardwaj Director Physical Research Laboratory, Ahmedabad	Member
Director National Centre for Polar and Ocean Research Vasco-da-Gama, Goa	Member
Dr. Radhika Ramachandran Former Director Space Physics Laboratory, Thiruvananthapuram	Member
Director National Center for Seismology Lodhi Road, New Delhi	Member
Programme Head (NCESS) Ministry of Earth Sciences, Government of India Prithvi Bhavan, New Delhi	Permanent Invitee
Representative, NITI Aayog	Invitee
Director National Centre for Earth Science Studies Akkulam, Thiruvananthapuram	Member Secretary

3. Finance Committee (FC)

Additional Secretary & Finance Advisor Ministry of Earth Sciences, Government of India Prithvi Bhavan, New Delhi	Chairman
Joint Secretary (Admin) Ministry of Earth Sciences, Government of India Prithvi Bhavan, New Delhi	Member

Programme Head (NCESS) Ministry of Earth Sciences, Government of India Prithvi Bhavan, New Delhi	Member
Director (Finance) Ministry of Earth Sciences, Government of India Prithvi Bhavan, New Delhi	Member
Director National Centre for Earth Science Studies Akkulam, Thiruvananthapuram	Member
Manager (F&A) National Centre for Earth Science Studies Akkulam, Thiruvananthapuram	Member
Senior Manager National Centre for Earth Science Studies Akkulam, Thiruvananthapuram	Member Secretary

4. Research Advisory Committee (RAC)

Dr. S. K. Tandon Professor Emeritus University of Delhi Delhi	Chairman
Dr. P. P. Mujumdar Professor Indian Institute of Science Bengaluru	Member
Dr. S. Balakrishnan Professor Pondicherry University Puducherry	Member
Dr. Kanchan Pande Professor Indian Institute of Technology Mumbai	Member
Dr. N. P. Kurian Former Director National Centre for Earth Science Studies Thiruvananthapuram	Member

Dr. S. K. Satheesh Professor Indian Institute of Science Bengaluru	Member
Dr. V. K. Gahalaut Chief Scientist National Geophysical Research Institute Hyderabad	Member
Dr. Rajiv Sinha Professor Indian Institute of Technology Kanpur	Member
Director National Centre for Earth Science Studies Thiruvananthapuram	Member
Dr. Tomson J. Kallukalam Scientist-D National Centre for Earth Science Studies Thiruvananthapuram	Member Secretary

Preface

The research activities of NCESS are carried out under the theme "Geodynamics and Surface Processes (GSP)", which focusses on Geodynamical Evolution of Peninsular India, Complexities of Coastal Processes, Surface and Groundwater Hydrology, Critical Zone Processes and Natural Hazards. Fifteen sub-schemes or projects have been formulated under GSP for 2021-26 plan period, which are being implemented by the six Research Groups of the Centre namely; Solid Earth Research Group (SERG), Crustal Dynamics Group (CDG), Hydrology Group (HyG), Biogeochemistry Group (BgG), Marine Geoscience Group (MGG), and Atmospheric Science Group (ASG).

The projects under "Geodynamics and Surface Processes" are:

1. Geodynamic evolution of Archean cratons, Proterozoic mobile belts, Western Ghats & Andaman Subduction Zone
2. Internal structure of volcanic eruptive centers by Muon Tomography
3. Deep lithospheric and Asthenospheric structures; Insights into Indian Ocean Geoid Low & Origin of shear zones
4. Early Earth Differentiation Processes
5. Hydrocarbon Fluid Inclusions in Sedimentary Basins of India
6. Slope Stability and Landslide
7. Coastal ocean dynamics and boundary exchanges, their role on climate regulations
8. Origin, evolution and paleoclimatic implications of estuarine-continental margin sediments
9. Submarine Groundwater Discharge
10. Critical zone studies of Peninsular India
11. River and Groundwater hydrology of Peninsular India
12. Evolution and water potential of natural springs of India
13. Bio-geochemistry and nutrient fluxes of rivers and coastal environments
14. Thermodynamical and microphysical processes of Clouds & Cloud-aerosol feedback processes and its influence on weather systems
15. Dynamics of thunderstorms and lightning

Solid Earth Research Group (SERG): The main research goal of the Solid Earth Research Group is to comprehend the origin and evolution of the planet Earth and its various reservoirs such as the crust, mantle and the core. To achieve this the group focuses on deciphering the timescales and understanding the processes of geodynamic evolution of Archean cratons, Proterozoic mobile belts and Western Ghats of India. In addition, the research of the group aims at understanding the chemical evolution of the Earth's mantle since the earliest differentiation events by studying mantle derived rocks at different tectonic setting, including active subduction zones. Other activities of the group include delineating lithospheric structures under various Indian crustal blocks and shear zones/active faults, evolution of the Andaman subduction zone and evolution of Quaternary landscapes.

Crustal Dynamics Group (CDG): This Group addresses scientific issues related to near surface dynamic processes. The focus has been understanding the cause and effect of slope failures. With the help of satellite imagery, field studies and geochemical characterization of soil/rock the group attempts to help predict landslides and suggest mitigation. The activities of the group also include understanding of hydrocarbon fluid movements in the crust leading to mineralization.

Hydrology Group (HyG): The Hydrology Group focuses on basic and applied aspects of research in hydrology and water resources with specific reference to Earth's Critical Zone. Earth's Critical Zone is a complex natural reactor where inputs of solar energy and, atmospheric deposition and gases interact with biota and rock masses of the continents to maintain soil, nourish ecosystems and yield clear water. The Critical Zone is experiencing ever increasing pressure from rapid economic developments. A better understanding of the processes taking place from tree to the aquifer bottom is very essential in the context of India's rapid economic developments and global climate change scenario.

Biogeochemistry Group (BgG): Biogeochemistry Group focuses on the study of physico-chemical, geological and biological processes and reactions that governs the characteristics of natural environment. The Group also studies the biogeochemical cycles of elements and their dynamics/fate with respect to the changing climate and environment together with signatures of paleoclimate proxies. We employ geochemical and microbiological modeling along with species/isotopic level studies to interpret the environmental processes and their effects on the global biogeochemical cycles. The thrust areas of research include biogeochemical studies of water environs including estuarine, coastal, springs and fresh waters in main land/island systems with emphasis on solute fluxes/dynamics and speciation, pesticide/organics fragmentation and degradation, water quality monitoring, pollution assessment and mitigation strategies.

Marine Geoscience Group (MGG): The focus of the Marine Geoscience Group has been the understanding of waves, currents and sediment transport and their effects on beaches and nearshore including modelling of coastal processes of the west coast of India. The activities include setting up of high-resolution numerical models capable of simulating coastal ocean dynamics and boundary exchanges, establishing video based Coastal Monitoring network and investigating the evolution of the Alleppey Terrace and its role on economic mineral deposits. The national network project on Submarine Groundwater Discharge, aimed at quantifying the amount of fresh groundwater discharge to the Bay of Bengal as well as to the Arabian Sea through coastal aquifers, also forms a major activity of the group. The program on SGD is implemented by NCESS with the participation of twelve agencies in the country using multiple research methods such as remote sensing, hydrogeological modelling, hydrogeochemistry and isotope geochemistry and mathematical/numerical modelling techniques.

Atmospheric Science Group (ASG): The Atmospheric Science Group in NCESS is actively engaged in the basic and applied research on atmospheric clouds, aerosol-cloud interaction, thunderstorms, lightning and atmospheric electricity, and regional climate over Western Ghats to improve the forecasting of atmospheric natural hazards.

1. Research Highlights

1.1 Evolution of the Bundelkhand Craton

Major and trace element geochemistry of the Palaeoproterozoic mafic dykes of the Bundelkhand Craton, one of the earlies Indian crustal segments, suggest that in spite of having the identical structural trends the dykes belong to two distinct igneous events. The major element chemistry of least fractionated samples from both the groups suggest a mantle potential temperature of ~1600◦C. Such a high source temperature hint involvement of a mantle plume in the generation of these dykes.

1.2 Paleomagnetic field intensity during the End Cretaceous period

Experimental data for the Earth's geomagnetic field intensity from the successive Deccan basalt lava flows of end Cretaceous age (66-65 Ma), from a drill hole of the Koyna Deep Scientific Drilling Project, provide a reliable mean Virtual Dipole Moment value ($1.46\pm0.69 \times 10^{22}$ Am^2). The dipole moment is clearly time-averaged mean value as it was estimated using data from multiple cooling units of unaltered subaerial lava flows in a thick stratigraphic section.

1.3 Origin of the Indian Ocean Geoid Low (IOGL)

The IOGL is the most prominent geoid anomaly (~106 m) on the globe, whose origin remains elusive. In a study from NCESS, the mantle transition zone (MTZ) structure beneath the region using P receiver functions (PRFs) was investigated to examine its role in the genesis of IOGL. Results from 3-D time to depth migration of PRFs reveal a thin MTZ primarily due to an elevation of the 660 km discontinuity. This is suggestive of anomalously hot temperatures in the mid mantle beneath the IOGL region, possibly sourced from the African Large Low Shear Velocity Province (LLSVP). The combined effect of the hot (low-density) material in the MTZ proposed in this study and the (high-density) cold slab graves atop the core-mantle boundary, inferred by previous studies, is the likely reason for this geoid low.

1.4 Detection of soil pipes through remote sensing and electrical resistivity methods

The integrated data based on remote sensing techniques, geomorphological and geophysical studies provide a very lucid picture of subsurface pipes in the landslide prone areas. The resistivity survey results indicate that the density of pipes is more than the estimated through surface mapping and clear characteristics of pipes. Similarly, the length of the pipes is more than the mapped pipe through the surface mapping. The combined results suggest that these regions are rich in these kinds of pipe features. Our work underlines the importance of detailed study of soil piping phenomenon to minimize its threat to human habitation and to provide specific recommendations to prevent the recurrence.

1.5 NCESS Critical Zone Observatories

The surface and shallow surface zones of the earth undergo marked changes due to natural and anthropogenic stressors. A better understanding of these processes is required for framing sustainable developmental strategies for the ever-changing critical zone. NCESS has developed a network of Critical Zone Observatories (CZOs) under the theme 'TERRAIn' (Tropical Ecosystem Research ObservatoRies in PeninsulAr India) in Attappadi, Munnar and Aduthurai to act as test bed for furthering studies on the Critical Zone. Studies of water sources of Attappadi CZO reveal that the solute loading in streams and shallow aquifers is dependent largely on the incongruent dissolution of aluminosilicate minerals in the host rocks under the climatic gradients.

1.6 Origin of low temperature thermal springs of South Konkan

Hydrogeological and geochemical investigations Bandaru and Irde thermal springs, located in the Dakshina Kannada district of the Karnataka state show that the hydrochemical process of these springs are controlled mainly by the dissolution of silicate minerals. Thermal water

is being recharged by precipitation from an estimated elevation of ~570 m above msl in contrast to lower elevation recharge of the adjacent cold springs and river. Water from both the springs is found to be mildly alkaline, having a low TDS and moderate silica concentrations. The major and trace element contents, stable isotope (δD, $\delta^{18}O$) data and geologic settings suggest that these thermal springs belong to fault controlled shallow dilute hydrothermal systems. The δD and $\delta^{18}O$ compositions suggest that the thermal springs and adjacent surface/ground water are of meteoric origin. Estimates based on Na-K-Ca, K^2/Mg, quartz and chalcedony geothermometers suggest formation temperatures in the range of 55-86°C.

1.7 Hydro-biogeochemistry of tropical mountain rivers and estuaries of Kerala

An integrated monitoring and mitigation approach has been practiced to study the extent and abatement of pollution (in water & sediment) using hydro-biogeochemical characteristics in various aquatic regimes. Studies have been carried out in the Netravati / Periyar / Chalakudy river basins including the associated estuarine/marine systems. Acephate, an organophosphorus pesticide, has been reported in Periyar river, for the first time, by NCESS. Heavy metal-sediment organic interaction/ mechanism identified in the Cochin Estuary along with Hg speciation. A series of surface modified adsorbent materials prepared for the removal of nutrients/heavy metals from aqueous phase such as multi-metal aqueous system consisting of Zn(II), Cu(II), Pb(II) and Cd(II) removal using tailor made Zwitterion-chitosan bed; removal characteristics of Orange-G using low-cost and active formaldehyde modified ragi husk (FMRh).

1.8 Export of particulate organic carbon by tropical mountain rivers of Kerala

Seasonal measurements of particulate organic carbon (POC) in the tropical coastal rivers, draining the Western Ghats (WG), suggest that, the WG, exports 0.79 Tg of POC to Arabian sea, which constitutes ~1% of Asia's riverine POC flux to the oceans. The averaged value of organic carbon (OC) in the particulate samples is 3.24%, and the mean POC concentration is 2.86 mg/L. Among the total transports of POC, Litter/riparian (42.5%) pools are the largest source of organic matter, followed by autochthonous (36%) and soil (21.5%) for the WG region. The POC yield of this passive coastal region found to be 4 times higher than the global average.

1.9 Coastal Monitoring Network - Video Beach Monitoring System (VBMS)

NCESS is spearheading establishment of a Coastal Monitoring Network for India by installing Video based Beach Monitoring Systems (VBMS) at critical locations and adopting technologies like the CoastSnap, and CoastSat. The data collected which is mostly site specific, provide continuous information on the beach and nearshore processes to the scientists and coastal engineers which are vital for understanding the stability of the coast and also for adopting appropriate measures which include both disaster mitigation and management. During the period 2016-2021, NCESS had installed VBMS stations at four locations Valiyathura, Kozhikode, Varkala and Kovalam, along the southwest coast of India, out of which three are currently operational. The real time data recorded by the VBMS is primarily used for understanding the spatial and temporal changes in the beach-surfzone region which includes the hydrodynamics and the related shoreline changes.

1.10 Submarine Groundwater Discharge (SGD) along the south west coast of India (Phase-I)

Under the Working Group-4 of SGD national network project, NCESS has estimated SGD flux from three coastal catchments of southwest coastal zone of India through modelling the aquifer units. There are nine critical zones with total shore length of 106.5 km, out of 640km surveyed, in the SW coastal zone having SGD signatures. Average flux of groundwater per unit length of shoreline is determined to vary from 36 to 1213 m^3/y/m. In other words, 4 to 6% of rainfall has been computed as leakage to sea as SGD in a year. The cliff sections composed of

the Tertiary sedimentary formation discharges (700 $m^3/y/m$), which is marginally lower than that of the coastal alluvium, weathered overburden and fractured country rocks (~900 $m^3/y/m$). Neotectonism had apparently facilitated in generating conduits for SGD and also in maintaining higher hydraulic gradient.

1.11 Cloud microphysics and lightning

NCESS study reveals that the annual lightning activity in south India has been increasing in recent years. A spike in lightning activity just before an active monsoon spell is identified in Central India. The study indicates that the lightning observations will be useful to predict the upcoming active monsoon. Clouds in the region also show marked spatio-temporal variability. Since observations of tropical monsoon clouds are rare, long period in-situ observations of clouds are essential to understand the trends from coastal areas in the west to the mountain belts in the east. The boundary layer processes play an important role in pre-conditioning the atmosphere during dry to wet monsoon transitions periods. Study on boundary layer parameterization schemes in Weather Research and Forecasting (WRF) model highlights sensitivity of the boundary layer schemes in weather parameter forecasting. Although the boundary layer schemes simulate the diurnal patterns and the overall variations of weather parameters, surface fluxes, and boundary layer heights as noted in the observations, the errors in their magnitudes are significantly large.

2. Honours, Awards & Academic Activities

2.1 Honours & Awards

Dr. E. A. Resmi, Scientist-D, Atmospheric Science Group has been awarded 'Certificate of Merit Award - 2020' by the Ministry of Earth Sciences, Govt. of India.

Smt. T. M. Liji, Scientific Assistant Grade-B, Biogeochemistry Group has been awarded 'Best Employee Award - 2020' by the Ministry of Earth Sciences, Govt. of India.

Smt. P. C. Rasi, Executive, Finance & Accounts has been awarded 'Best Employee Award - 2020' by the Ministry of Earth Sciences, Govt. of India.

Shri. P. Rajendra Babu, MTS, Purchase & Stores has been awarded 'Best Employee Award – 2020' by the Ministry of Earth Sciences, Govt. of India.

Shri. Vinu V. Dev, has been awarded PhD degree under the Faculty of Science, University of Kerala for his thesis "Surface functionalized natural polymers for the adsorptive removal of metal ions at the solid-liquid interface: Kinetic and thermodynamic profile" on 17th July 2020. Dr. K. Anoop Krishnan, Scientist-D, Biogeochemistry Group was his supervising guide.

Shri. Sibin Antony, has been awarded PhD degree under the Faculty of Applied Sciences & Technology, University of Kerala for his thesis "Appraisal of marine ecosystem of Kavaratti island in South West coast of India with special reference to lagoon system" on 27th January 2021. Dr. K. Anoop Krishnan, Scientist-D, Biogeochemistry Group was his supervising guide.

Shri. T. D. Aneesh, has been awarded PhD degree under the Faculty of Marine Science, Cochin University of Science and Technology for his thesis "Hydro-geochemical, stable isotopic studies and modelling of groundwater reserves of Greater Kochi, India" on 20th March 2021. Dr. Reji Srinivas, Scientist-D, Marine Geoscience Group was his supervising guide

Dr. Alice Thomas, Research Associate, Hydrology Group received the 'Best Presentation Award' for the paper entitled "A review of evolutionary algorithms in inverse modelling for groundwater flow and transport parameter estimation" in the 25th International Conference on Hydraulics, Water Resources, and Coastal Engineering (HYDRO-2020), organized by the Department of

Civil Engineering, National Institute of Technology, Rourkela, India in association with the Indian Society for Hydraulics (ISH) held during 26-28 March 2021.

Dr. Tripti Muguli, DST-Inspire Faculty, Marine Geoscience Group won the first rank and best poster award under the Earth and Atmospheric Sciences category in SERB - American Chemical Society jointly organized NPDF Online Poster Competition 2020.

2.2 Membership in Committees outside NCESS

Dr. Jyotiranjan S. Ray

Member, Expert Committee in Earth and Atmospheric Sciences for NPDF, SRG and ECR scheme, Science and Engineering Research Board, Govt. of India.

Co-convener, CSIR NET Examination Committee for Earth and Planetary Sciences.

External Expert, Committee for Faculty Appointment in NISER, Bhubaneswar.

External Expert, Committee for Faculty Appointment in IIT Roorkee.

Member, Scientific Advisory Committee of IUAC Geochronology Facility, New Delhi

Dr. D. Padmalal

Member, Expert Committee for MoES - MRFP Scheme.

Member, Advisory Committee of the Project "Facilitating multi-level climate governance in Kerala" chaired by Shri. S. M. Vijayanand and implemented by The World Institute for Sustainable Energy (WISE), Pune, India.

Member, Project Evaluation Committee on "Preparation of Detailed Project Report (DPR) for rejuvenation of 5 rivers of Kerala, funded by Irrigation Design and Research Board (IDRB), Govt. of Kerala.

Dr. K. Maya

Member, Board of Studies of Geology, University of Kerala.

Member, Special committee constituted by State Environmental Impact Assessment Authority (SEIAA) as per the judgement by the Hon'ble High Court of Kerala, regarding the laterite mining in the Cheekkod village of Malappuram district.

Member, Ph.D. Oral Examination Board, Centre for Research, Anna University.

Dr. A. Krishnakumar

Member, Academic Committee, Sree Narayana Guru Open University.

Dr. K. Anoop Krishnan

Member, Academic Committee to design the syllabus for UG program in Environmental Sciences, Sree Narayana Guru Open University.

Dr. E. A. Resmi

Member, Board of Studies, Department of Atmospheric Sciences, Cochin University of Science and Technology.

Dr. S. Kaliraj

Member, International Society for Photogrammetry and Remote Sensing (ISPRS).

Coordinator, IIRS - ISRO outreach programme in NCESS.

Dr. Tripti Muguli

Member, American Chemical Society.

2.3 Invited Lectures / Chairing of Technical Sessions

Dr. Jyotiranjan S. Ray

Delivered an invited talk on "Unravelling mysteries in Vindhyan Geology" organized by Regional Training Division, Geological Survey of India, Lucknow on 17th October 2020.

Delivered an invited talk on "Third Rock from the Sun: the story of the Earth" organized by Vikram Sarabhai Science Foundation on 09th March 2021.

Delivered an invited talk on "Retracing Saraswati: the lost river of the Harappan Civilization" organized by Indian Institute of Science Education and Research, Pune on 13th March 2021.

Dr. V. Nandakumar

Delivered the 13th lecture titled 'Geoscience - Basics' in the MoES Webinar series on 18th June 2020. The webinar provided an overview on the basics of geology / geophysics starting from the origin of Earth, plate tectonics, magmatism, ore genesis, natural hazards, viz., volcanoes, earthquakes, tsunamis and landslides, economic benefits in terms of ore deposits, absolute and relative dating techniques used to build Earth time record, etc.

Dr. D. Padmalal

Delivered a talk on "Impact of River Sand Mining" on 26th July 2020 in an online meeting organized by 'Friends of Bharathapuzha', Vayali Folklore Group, Palakkad.

Delivered an invited talk on "Bharathapuzha river and its environmental problems" on 08th August 2020, organized by Nilavichara Vedi, Cheruthuruthi, Thrissur.

Delivered an invited lecture on "Rivers and river sand mining" on 24th August 2020 for the participants of UGC-HRDC, Osmania University, Hyderabad.

Dr. D. S. Suresh Babu

Delivered the 20th lecture titled 'Ground water science and societal implications' in the MoES Webinar series on 14th July 2020. The webinar focused on basic concepts of groundwater systems, data collection and analysis, aquifers, risks of pollution, sustainable water availability and societal issues related to groundwater management in the country.

Delivered a talk on "Submarine Groundwater Discharge (SGD): Experience from Indian coasts" in the Webinar-athon organized by Indian Meteorological Society, Pune Chapter during 25-26 March 2021.

Dr. L. Sheela Nair

Delivered a talk on "Coastal erosion along the Kerala coast and impact of anthropogenic activities on the coast" in the National Webinar on Coastal Erosion with emphasis on Kerala organized by the Department of Environmental Sciences, University of Kerala as part of their Silver Jubilee Celebrations, during 17-18 August 2020.

Participated as a panelist in the 'Coastal Protection' session of the Vaishvik Bhartiya Vaigyanik (VAIBHAV), a global virtual summit of Overseas Indian Researchers and Academicians, organized during 02-31 October 2020, and made a short presentation on "Littoral environment observations– reliable and cost-effective methods for shoreline monitoring in India" on 07th October 2020.

Delivered a talk on "Seasonal erosion and permanent erosion in shorelines in Thiruvananthapuram and Alappuzha" in the National Conference on Coastal Erosion and Indigenous Community of South-West Coast of India 2021 organized by Bring Back Green and School of Gandhian Thought, MG University, Kerala during 05-07 February 2021.

Dr. K. Anoop Krishnan

Delivered a talk on 'The need for integrated monitoring and mitigation practices in containing pollution – The NCESS initiative' in the MoES Webinar platform on 16th July 2020. The webinar provided an overview of the importance of integrated studies on monitoring and feasible mitigation strategies to contain pollution, and the initiatives undertaken by NCESS in this regard.

Dr. S. Kaliraj

Delivered an invited talk on "Application of Deep Learning Techniques in Remote sensing & GIS Technologies" as part of the AICTE - STTP course programme for students, scholars and faculties of Indian Universities held at Francis Xavier Engineering College, Tirunelveli, Tamil Nadu during 08-12 August 2020.

Delivered an invited talk on "Application of Deep Learning Techniques in Remote sensing & GIS Technologies" as part of the AICTE - STTP course programme for students, scholars and faculties of Indian Universities held at Sethu Institute of Technology, Tamil Nadu during 15-20 February 2021.

Dr. K. Sreelash

Delivered an invited talk on "Critical Zone Observatories: The NCESS initiatives" in the International Workshop on 'The Joy, Opportunities and Challenges in Field Hydrological Research' jointly organized by NIE, Mysore and IIT, Guwahati during 2-6 November 2020.

Dr. Poornima Unnikrishnan

Delivered an invited talk on "Applications of GIS in Hydrology" to the B.Tech students of the Department of Civil Engineering, TKM College of Engineering on 8th January 2021.

2.4 Ph.D. Students

NCESS provides opportunities to researchers to carry out Ph.D. under recognized research guides of the institute. A total of 47 researchers are pursuing research in different universities of India.

Sl. No.	Research Scholar	Title of Research	Guide	University / Registration Date
1	Arun T. J.	Studies on selected rivers of different climatic regimes, southern India.	Dr. Reji Srinivas	CUSAT / 13.12.2013
2	Krishna R. Prasad	Wetland Studies of Akathumuri – Anchuthengu - Kadinamkulam estuarine System, southwest coast of India.	Dr. Reji Srinivas	CUSAT / 13.12.2013
3	Viswadas V. (Part time)	Studies on hydrogeological and biological aspects of various streams of Karamana river near Sree Parasurama Swami Temple, Thiruvananthapuram district, southern India.	Dr. K. Anoop Krishnan	Kerala / 15.01.2014
4	Parvathy K. Nair	Development of Vembanad Management action plan through a geological perspective	Dr. D. S. Suresh Babu	Kerala / 30.04.2014
5	Praseetha B. S.	Geochemistry of estuarine and inner shelf sediments	Dr. T. N. Prakash	CUSAT / 18.12.2014
6	Kunhambu V. (Part time)	Characterization and evaluation of the aquifer system of Kuttanad area, Kerala for Sustainable Groundwater Development	Dr. D. S. Suresh Babu	Kerala / 05.01.2015
7	Harsha Mahadevan	Synthesis, characterization and application of surface tuned clays and activated carbons to control nutrients in urban drainages: focus on adsorptive kinetics and isotherm modelling	Dr. K. Anoop Krishnan	Kerala / 01.05.2015

8	Saranya P.	Stable isotope studies on moisture source variation and associated water cycle dynamics in Periyar river basin, southern Western Ghats	Dr. A. Krishnakumar	Kerala / 01.06.2015
9	Mintu Elezebath George	Assessment of submarine groundwater discharge from the Kozhikode coastal segment, Kerala, southwest India	Dr. D. S. Suresh Babu	CUSAT / 15.10.2015
10	Remya R.	Groundwater - seawater interactions along the coastal stretch of Thiruvananthapuram district, Kerala	Dr. D. S. Suresh Babu	Kerala / 17.11.2015
11	Sajna S.	Metamorphic and tectonic evolution of granulites from Nagercoil Block (NB), Southern India	Dr. Tomson J. Kallukalam	CUSAT / 15.06.2016
12	Ratheesh Kumar M. (Part time)	Seasonal investigation and evaluation of water quality parameters of Mangalore coast, Karnataka, India: Hydrochemical, marine biological and microbiological approach	Dr. K. Anoop Krishnan	Kerala / 05.09.2016
13	Vipin T. Raj	Solute dynamics and modelling in the river catchments of southern Western Ghats, India	Dr. D. Padmalal	CUSAT / 07.03.2017
14	Shiny Raj R.	Pesticide dynamics and associated biogeochemical processes in the cardamom plantations of Periyar river basin: Focus on speciation studies and mitigation strategies	Dr. K. Anoop Krishnan	CUSAT / 30.06.2017
15	Sandhya Sudhakaran	Speciation and transport characteristics of nutrients in the paddy fields of Netravati river basin: Focus on biogeochemical processes and adsorptive removal studies	Dr. K. Anoop Krishnan	Kerala / 03.10.2017
16	Gayathri J. A.	Groundwater resource assessment in selected watersheds of Cauvery River basin, India	Dr. D. Padmalal Dr. K. Maya (co-guide)	Kerala / 23.10.2017
17	Amal Dev J.	Petrology, geochemistry, geochronology and fabric analysis of selected lithologies from Kambam Ultrahigh temperature (UHT) Belt, Madurai Block, South India	Dr. Tomson J. Kallukalam	CUSAT / 13.11.2017

18	Sribin C.	Seismic structure of crust and upper mantle along the Western Ghats: Constraints on passive continental margin evolution	Dr. Tomson J. Kallukalam	CUSAT / 13.11.2017
19	Silpa S.	Seismic structure of mid-to-upper mantle beneath the Indian Ocean Geoid Low using ambient noise tomography	Dr. N. Purnachandra Rao	CUSAT / 03.04.2018
20	Silpa Thankan	A comparative study of palaeofluids in the petroliferous basins of western offshore, India	Dr. V. Nandakumar	Kerala / 28.05.2018
21	Jithu Shaji	Reconstruction of Late Quaternary climate of southern Western Ghats: A multi-proxy approach using sedimentary archives	Dr. D. Padmalal Dr. K. Maya (co-guide)	CUSAT / 30.06.2018
22	Dharmadas Jash	Thunderstorms with special emphasis on lightning over India	Dr. E. A. Resmi	CUSAT / 01.10.2018
23	Resmi R.	Analysis of contributory factors for environmental fitness of Chalakudy river basin, southern Western Ghats, India: A GIS based approach	Dr. A. Krishnakumar	Kerala / 10.10.2018
24	Ronia Andrews	Characterization of active tectonic deformation processes in the Indian Ocean lithosphere	Dr. N. Purnachandra Rao	CUSAT / 25.10.2018
25	Micky Mathew	Hydroclimatological alterations of Western Ghats: Causes and consequences	Dr. D. Padmalal	CUSAT / 26.10.2018
26	Aditya S. K.	Assessment of the impacts of global environmental change in Sahyadri: A study of Periyar river basin in southern Western Ghats, India	Dr. A. Krishnakumar	Kerala / 03.12.2018
27	Prasenjit Das	Hydrogeochemistry, geothermal characteristics and origin of thermal springs of western India.	Dr. K. Maya	CUSAT / 29.12.2018
28	Ramesh Madipally (Part time)	Understanding the coastal processes through high resolution video monitoring systems in India	Dr. L. Sheela Nair	CUSAT / 29.12.2018
29	Sreeraj M. K. (Part time)	Sedimentary evolution and depositional history of Aleppey terrace Indian continental margin	Dr. Reji Srinivas	CUSAT / 29.12.2018
30	Swathy Krishna P. S.	Coastal Flooding and related process along the south west coast of India	Dr. L. Sheela Nair	CUSAT / 29.12.2018

31	Uma Mohan	Geoenvironmental studies of the land and water systems in Kallada basin, southern Western Ghats, India	Dr. A. Krishnakumar	Kerala / 05.04.2019
32	Arun J. John	A petrological and geochronological study of spinel-bearing metapelites in tracing the metamorphic evolution of the khondalite belt in southern Kerala	Dr. V. Nandakumar	Kerala / 22.11.2019
33	Arun V.	Integrated approach on species level monitoring of heavy metals and mitigation strategies using adsorption technique	Dr. K. Anoop Krishnan	Kerala / 27.11.2019
34	Reghunadh K.	Environmental degradation due to aggregate mining and quarrying on Achenkovil river basin, south – Western Ghats, Kerala, India.	Dr. K. Anoop Krishnan	Kerala / 18.12.2019
35	Arka Roy	Variability of Sq (solar quiet) and EET (equatorial electrojet) from ground magnetometer observations and satellite data in connection with modelling of geomagnetically induced current (GIC) during magnetic of GIC	Dr. N. Purnachandra Rao	CUSAT/ 30.12.2019
36	Jeenu Jose	Geo-environmental studies of the coastal wetlands of Kollam-Neendakara areas, Kerala, SW India with special reference to urban geochemistry	Dr. A. Krishnakumar	CUSAT/ 30.12.2019
37	Muthyala Prasad	Deep lithospheric structure and characteristics of the shear zones, South India and their tectonic implications	Dr. N. Purnachandra Rao	CUSAT/ 30.12.2019
38	Sameer V. K.	Air – sea interactions at the southwestern continental shelf of India	Dr. L. Sheela Nair	CUSAT / 30.12.2019
39	Syam Sunny	Early diagenesis of sediments and nutrient exchange between sediments and overlying waters – selected case studies from SW India	Dr. K. Maya Dr. D. Padmalal (co-guide)	Kerala / 15.10.2020

40	Badimela Upendra	Hydro-biogeochemistry of the tropical mountain rivers in southern Western Ghats: Role of anthropogenic activities, controls on nutrient flux, chemical weathering and CO_2 consumption rates	Dr. K. Anoop Krishnan	CUSAT/ 31.12.2020
41	Nayana V. Haridas	Late Quaternary paleoclimate and paleoceanographic reconstruction from sediment cores of western Bay of Bengal, India	Dr. D. Padmalal Dr. K. Maya (co-guide)	CUSAT/ 08.01.2021
42	Sreelesh R.	Hydro-geochemistry of surface and sub-surface water sources of Idamalayar (Periyar) - Amaravati (Cauvery) watersheds in Munnar CZO, India	Dr. K. Maya	CUSAT/ 08.01.2021
43	Sumit Kumar	Cloud microphysics and precipitation studies over Indian region	Dr. E. A. Resmi	CUSAT/ 08.01.2021
44	Vivek V. R.	Hygrology and hydrogeochemistry of cold-water springs in Kerala and Karnataka states (India) with special reference to conservation and management	Dr. K. Maya	CUSAT/ 08.01.2021
45	Princy J. R.	Influence of coastal morphology and shore structures on shore dynamics along the primary sediment cell of Muttom to Thankasserry	Dr. L. Sheela Nair	CUSAT/ 08.01.2021
46	Sreejith N.	Influence of Alleppey Terrace on the dynamics of the southwestern shelf sea of India	Dr. L. Sheela Nair	CUSAT/ 08.01.2021
47	Himanshi Gupta	Hydrogeochemical and stable isotopic studies of Kabini river (Cauvery basin), India	Dr. A. Krishnakumar	CUSAT/ 24.03.2021

3. Research Activities

3.1 Solid Earth Research Group

3.1.1 Characterization of multiple episodes of melt generation from lower crust during Archaean using amphibole composition

Spatial association of tonalite trondhjemite granodiorites (TTGs) and high-K granitoids (anatectic and hybrid granites) from the Bundelkhand Craton (BC), Central India, is well known. Geochronological data indicates multiple episodes of formation of these high silica rocks showing a spread of ~1 Ga during Paleo to Neoarchaean. In the present study, we try to understand the evolution of TTGs and high-K granitoids (hybrid granites) from the BC using amphibole composition. The amphibole in both TTGs and high-K granitoids (hybrid granites) from the BC are characterised as magmatic, zoned (Fig. 3.1.1.1), and calcic in nature. We find that the amphibole composition of the studied rocks is dominated by magnesiohornblende along with less common occurrence of tschermakite, magnesiohastingsite and edenite. Overall variation in amphibole compositions in terms of exchange vectors show a well-defined linear trend (except for a late-stage low-grade metamorphic readjustment), which suggests melt control over crystallization and evolution of amphibole chemistry. Moreover, the geothermobarometric analysis points towards higher pressure formation of TTGs in comparison to that of high-K granitoids (hybrid granites), with nearly the same temperature conditions in both the cases. Combining all our findings, we propose the evolution of the two considered rock types through lower crustal melting under varying PH_2O conditions at different depths of emplacement

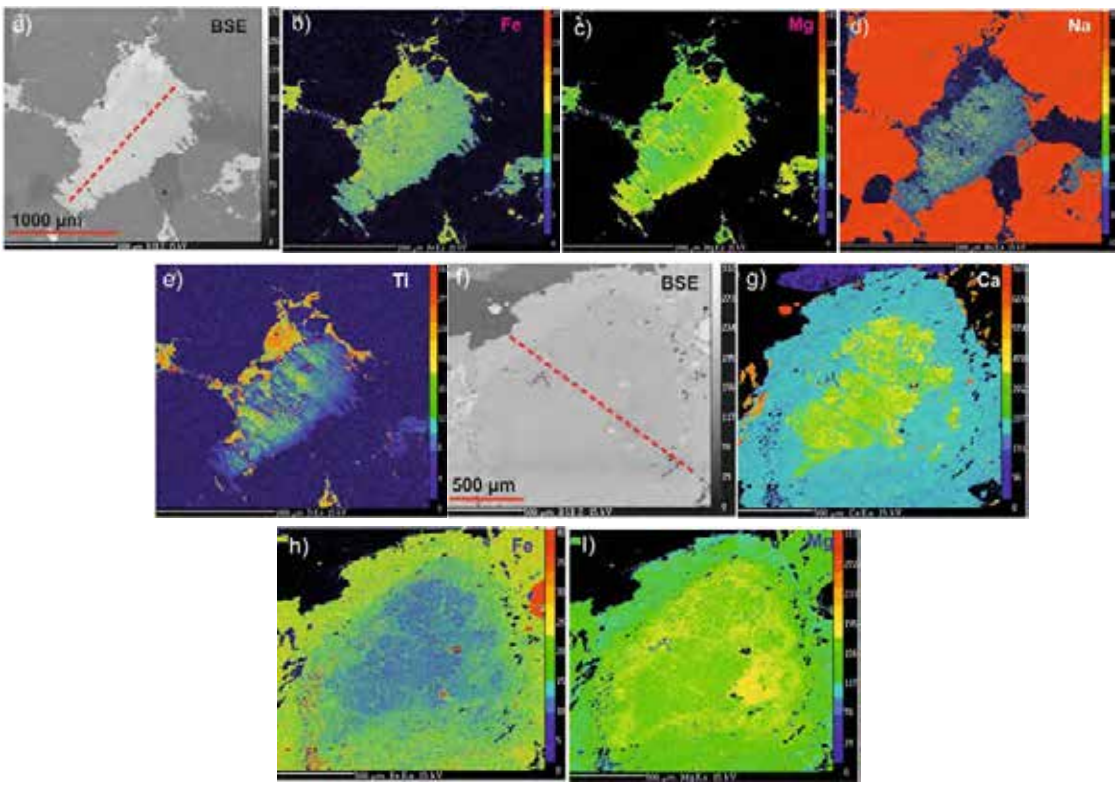

Fig. 3.1.1.1: BSE images and X-ray elemental maps of amphiboles from TTGs (a-e) and LSHM high-K grantoids (hybrid granites) (f-i) from BC. Measured rim to rim profile is marked as red dotted line in BSE images.

This work was done in collaboration with Prof. N. C. Pant of Department of Geology, University of Delhi, Delhi; Prof. Talat Ahmad, Vice Chancellors Office, University of Kashmir, Srinagar.

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Dr. Kumar Batuk Joshi, Dr. Nilanjana Sorcar, Dr. V. Nandakumar and Dr. J. K Tomson.

3.1.2 Geochemistry of NW-SE trending Palaeoproterozoic mafic dyke intrusions in the Bundelkhand Craton, India and subcontinental lithospheric mantle processes

NW-SE trending mafic dykes in the Bundelkhand Craton of the Indian shield manifest Palaeoproterozoic igneous activity. These dykes are Fe-rich tholeiitic basalts with compositions varying from near primary melts to more evolved magmas (Mg#: 0.64–0.35) and show enrichment of large-ion lithophile and light rare earth elements relative to primordial mantle values. Despite very subtle variations of elemental abundances and similar structural trend, at least two groups are identified, mainly based on incompatible element ratios and rare earth element patterns. Group 1 samples are characterized by relatively low Ti/Y (av. 222 ± 22) and Ti/Nb (av. 609 ± 108), high Zr/TiO2 (av. 117 ± 15), more light to heavy rare earth element fractionation (La/Yb)CN: 2.7–5.1) and mild negative Eu anomaly (Eu* = 0.77 ± 0.10). Group 2 samples possess high Ti/Y (av. 334 ± 46) and Ti/Nb (av. 1349 ± 198), low Zr/TiO2 (av. 70 ± 7) and minor light to heavy rare earth element fractionation ((La/Yb)CN: 1.5–2.7) without any Eu anomaly (Eu* = 0.97 ± 0.04). Both groups show relative depletions in Nb, Sr and P while the Group 1 also shows Ti depletion. A third group is apparent but is less certain. Group 2 dykes constitute the 1.98 Ga Jhansi swarm, whilst the Group 1 and unclassified samples are likely to be of older age (~2.18–2.20 Ga and ~2.37 Ga) based on available U-Pb ages and palaeomagnetic considerations. Despite the compositions indicate different batches of magma, the dykes have near similar petrogenetic evolutionary pattern as if the entire population constitutes a single clan. Samples of both groups (a) do not indicate significant crustal contamination (b) derived from two different batches of magmas formed by ~10–12% fractional melting of mantle near the spinel-garnet transition zone and (c) evolved through initial fractionation of olivine and thereafter clinopyroxene and plagioclase became important fractionation phases. The more primitive compositions of both groups indicate mantle potential temperatures of ~1550–1600 ◦C suggesting thermal anomaly. The dyke magmas inherited variably enriched compositions as a result of interaction of upwelling mantle melts with metasomatised subcontinental lithospheric mantle. Low H2O-CO2-rich silicate melts/ fluids are likely the dominant metasomatic agents to develop the Indian subcontinental lithosphere in the Archaean (c. 3.0 Ga).

Radhakrishna T., Tomson J. K., Chandra R., Ramakrishna Ch. This work was done in collaboration with Prof. R. Chandra of Centre of Excellence in Geology, Institute of Earth Science, Bundelkhand University, Jhansi and Ramakrishna Ch of GITAM University, Rushikonda, Visakhapatnam.

https://doi.org/10.1016/j.precamres.2020.105956

Dr. Tomson J. K.

3.1.3 Dipole field strength investigation on Koyna Deccan basalt drill hole (KBH-7)

Dipole field strength (Palaeointensity; PI) and various rock magnetic parameter's data were obtained from end-cretaceous Koyna Deccan basalt drill hole (KBH-7; Fig. 3.1.3.1) samples have been processed and interpreted during this period. The main dipole field strength result along with other high quality Cretaceous global data is aimed to understand the relationship between geomagnetic behavior, polarity reversals and deep mantle processes. Although the investigations were performed on 76 samples covering the 19 flows down to the basement, only 34 samples from nine flows were found successful in yielding PI data. A judicious selection, considering that: (i) at least there are successful determinations from three independent samples (ii) the samples show within flow consistency that is within limits of standard deviation (iii) the uncertainties over the mean value of the flow are less than 20% and

(iv) none of the flows represent transition field, eight lava flows (26 samples) provide a reliable mean PI of 7.30 ± 3.45μT. Using the remarkably well constrained Deccan palaeopole (37.8°N, 282.6°E) ~65 Ma palaeolatitude for the Koyna drill hole is estimated as 28.1°S to calculate the Virtual Dipole Moment (VDM), which is independent of the latitude. The calculated mean VDM is 1.46 ±0.69 $\times 10^{22}$ Am2 (range: 2.19–0.28 $\times 10^{22}$ Am^2; Fig. 3.1.3.2).

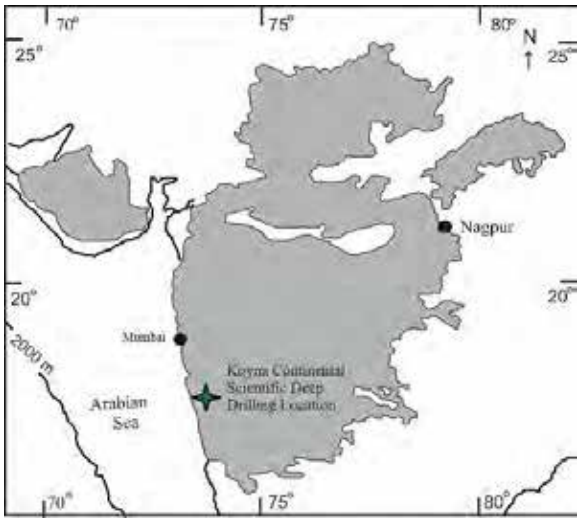


Fig. 3.1.3.1: Geological map showing areal spread of the Deccan flood basalt eruptions and location of the Koyna Continental Scientific Deep Drilling Project drill hole (KBH-7) of this study.

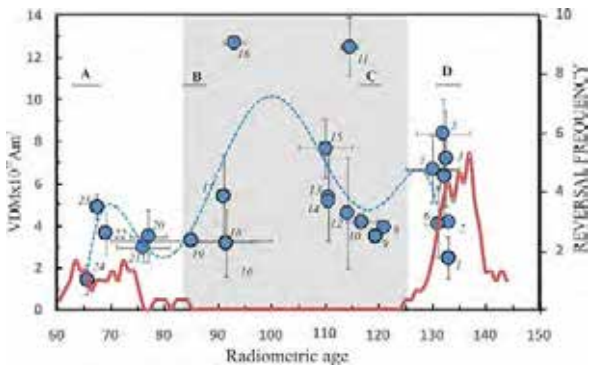


Fig. 3.1.3.2: Distribution of Virtual Dipole Moment (VDM) data during the Cretaceous period.

The main conclusion drawn from this study is as follows: (a) Dipole moment during the end Cretaceous Deccan eruption is the lowest in the whole of Cretaceous while dipole moment is generally lower at onset/termination of Cretaceous Normal Superchron relative to mid-superchron times (b) lack of perfect inverse relation between dipole moment and field reversal rate in contrast to many studies invoking coupling between the two and (c) a cause and effect relationship between CMB heat flux and the dipole low, supporting the predictions of the numerical models; large igneous provinces are shown as manifestations of this activity on the surface of earth.

https://doi.org/10.1038/s41598-020-67245-6

Shri. Mohamed Asanulla, R.

3.1.4 Seismic evidence for a hot mantle transition zone beneath the Indian Ocean Geoid Low

The Indian Ocean Geoid Low (IOGL), located to the south of the Indian continent, is the most prominent geoid anomaly (~106 m) on Earth, whose origin is still evasive. In the present study, we employ the P receiver function (PRF) technique to investigate the mantle transition zone (MTZ) beneath the IOGL and attempt to understand its bearing on the world's largest geoid anomaly. For this analysis, we collated data from 37 broadband seismological stations (BBS), selected in such a way that the piercing points of the P-S conversions lie in and around the IOGL region. Further, the waveforms of earthquakes in an epicentral distance range of 35° to 95°, magnitude ≥5, and signal-to-noise ratio (SNR) ≥ 2.5 are only considered for the analysis. Adopting these criteria, 20486 waveforms from 8148 events qualified for the computation of PRFs. We calculate the PRFs using the extended-time multitaper frequency domain cross-correlation receiver function (ET MTRF) technique.

Further, we bandpass filter the waveforms between 0.05 and 0.5 Hz and correct the PRFs for distance moveout to identify the low-frequency conversions from the upper mantle discontinuities. To select good quality PRFs, we visually examined them and discarded those which have significant energy prior to the zero-delay time and/or are reverberatory in nature. The exercise resulted in 16825 good quality PRFs. To map the lateral variations of

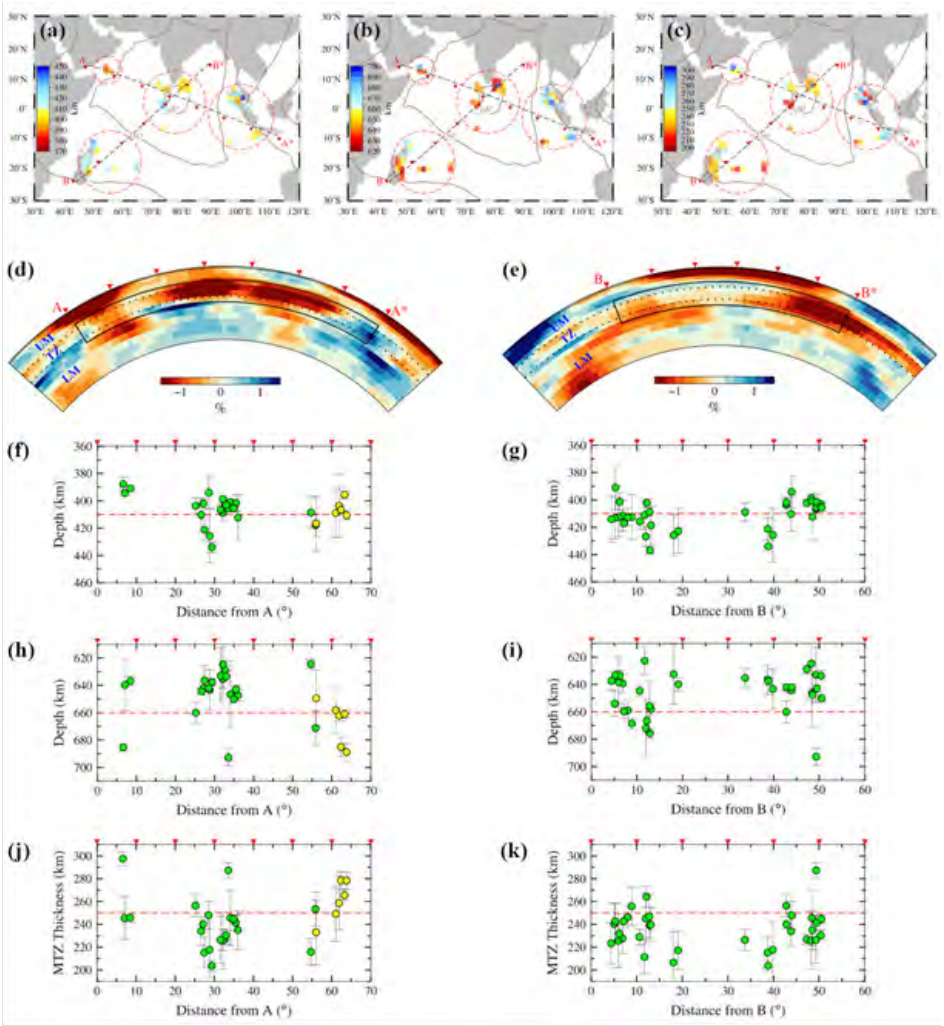


Fig. 3.1.4.1: Map showing the depths to the (a) 410 and (b) 660 km discontinuities, determined using the 3-D velocity model (GyPSuM) and (c) mantle transition zone thickness, along with the selected Profiles AA* and BB*. Light brown lines are the geoid anomaly contours. Red dotted circles indicate the observations which are projected onto the selected profiles. (d and e) Depth sections of the GyPSuM tomographic model (S wave velocity perturbations) from 0 to 1,600 km. (f and g) Depths to the 410 km discontinuity plotted along Profiles AA* and BB*. Dashed horizontal red line indicates the 410 km depth, and green and yellow circles indicate the observed 410 km discontinuity depths beneath IOGL and Sumatra-Java. (h and i) Depths to the 660 km discontinuity plotted along Profiles AA* and BB*. Dashed horizontal red line indicates the 660 km depth, and green and yellow circles indicate the observed 660 km discontinuity depths beneath IOGL and Sumatra-Java. (j and k) Observed mantle transition zone thickness plotted along Profiles AA* and BB*. Dashed horizontal red line indicates the global average of mantle transition zone thickness, and green and yellow circles indicate the observed mantle transition zone thickness beneath IOGL and Sumatra-Java. Vertical bars corresponding to each circle denote the one sigma error in the estimates.

upper mantle discontinuities beneath the IOGL region, the study region is divided into circular bins having 1° radius, in such a way that there is a 25% overlap between consecutive bins. Further, the bins having greater than or equal to 10 piercing points at 535 km depth are selected for the summation. The stacking process sums the in-phase signals and suppresses the out-of-phase data, thus enhancing the conversions from the upper mantle discontinuities. The depths to the transition zone discontinuities obtained using a velocity model may be affected by the existence of high/low-velocity anomalies in the Fresnel zone of the P-S ray paths. Thus, we utilized the 3-D velocity model constructed using both the P and S wave velocities, extracted

from the appropriate global tomography model, to migrate the PRFs to depth (3-D migration). The model GyPSuM is considered for this purpose, since this is one of the models that best explains the IOGL. Further, we also used the LLNL-G3D-JPS and MEAN2 models to compare the results. For a given grid, we applied the bootstrap resampling technique i.e., the PRFs are selected randomly, migrated to depth using the 3-D model, and stacked, and the Ps conversion depths of the 410 and 660 km discontinuities are picked from the summed trace. Further, the mean depth and the corresponding standard deviation of the 410 and 660 km discontinuities are estimated from the values of depth picked from 200 iterations. Results from 3-D time to depth migration of PRFs reveal a thin MTZ primarily due to an elevation of the 660 km discontinuity (Fig. 3.1.4.1). This is suggestive of anomalously hot temperatures in the mid mantle beneath the IOGL region, possibly sourced from the African Large Low Shear Velocity Province (LLSVP). The combined effect of the hot (low-density) material in the MTZ proposed in this study and the (high-density) cold slab graves atop the core-mantle boundary inferred from previous studies can possibly explain this geoid low.

This work was done in collaboration with Dr. M. Ravi Kumar of CSIR-National Geophysical Research Institute, Hyderabad, India and Dr. Dipankar Saikia of Indian National Centre for Ocean Information Services, Hyderabad, India.

https://doi.org/10.1029/2020GC009079

Dr. B. Padma Rao

3.1.5 Imprints of sunspot cycles on normal and abnormal geomagnetic fields: case study from equatorial and low-latitude sites of India

The quiet time characteristics of equatorial electrojet (EEJ), counter electrojet (CEJ), and solar quiet (Sq) day geomagnetic field over two decades (1980–2002) are established using Principal component analysis (PCA) from equatorial (Ettaiyapuram) and off-equatorial (Hyderabad) Magnetic Observatories, India, over sunspot cycles 21–23. The patterns of normal field shows that the diurnal amplitudes were strong during equinox compared to other seasons. Varying contributions of abnormal field in different Lloyd's seasons were evident in different phases of sunspot cycle. The diurnal amplitudes have reduced from the 21st to the 23rd sunspot maxima following the trend of weakening of sunspot cycle. Analysis of seasonal means shows evening CEJs were more pronounced when compared to morning and afternoon in different phases of sunspot cycle. The abnormal field variations have a strong correlation with the occurrence of afternoon CEJs during solar minima; a correlation of seasonal occurrences of CEJs with phases of sunspot cycles is revealed.

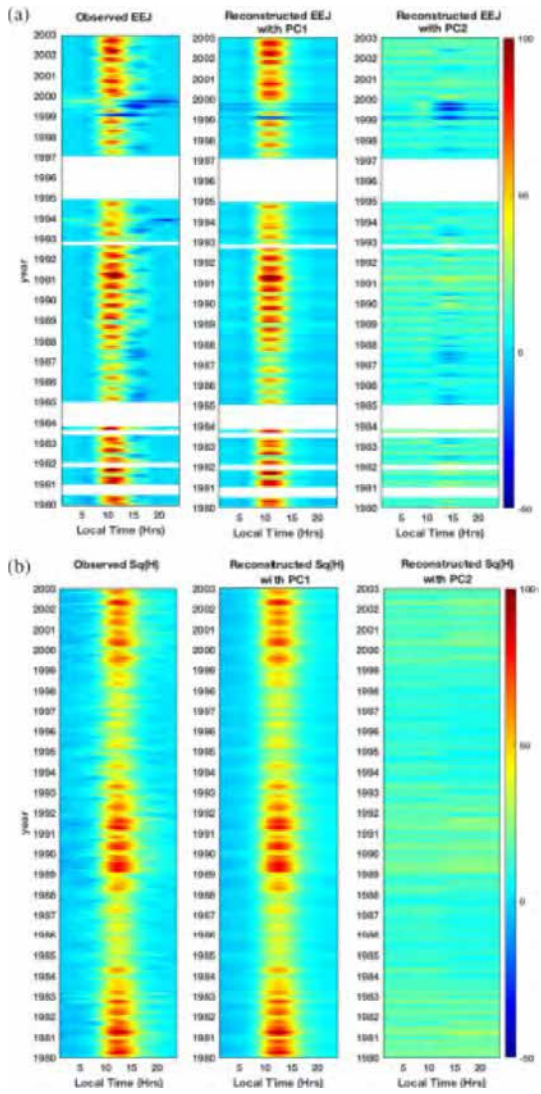


Fig. 3.1.5.1: Observed and reconstructed geomagnetic fields of (a) EEJ and (b) Sq, using first two principal components for ETT and HYB observatories.

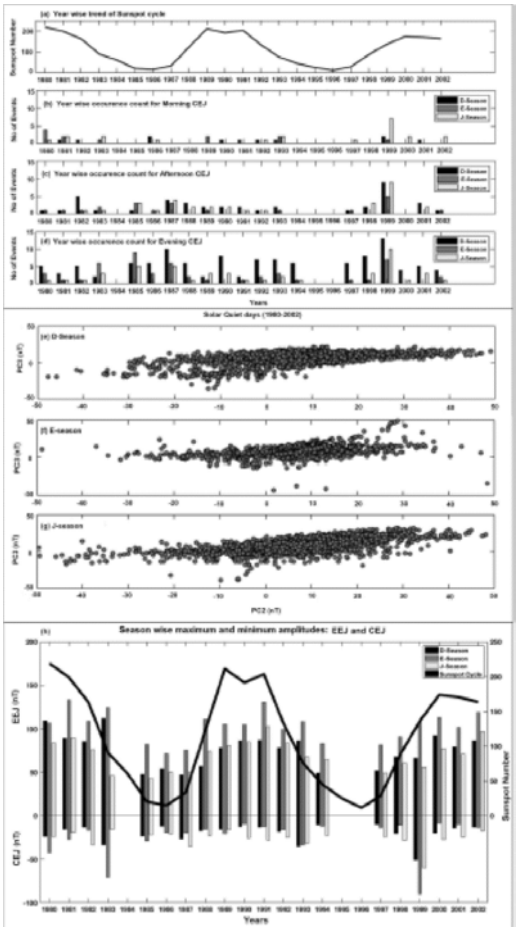


Fig. 3.1.5.2: (a) Yearly mean sunspot numbers showing maxima, minima, ascending, and descending phases of solar cycle 21–23 and seasonal characterization of occurrence of (b) MCEJ (c) ACEJ and (d) ECEJ. Distribution of PC2 and PC3 amplitudes during (e) D season (f) E season and (g) J season for the years 1980–2002, which have lower than average peak strength of ΔHEEJ (h) yearly mean of observed EEJ and CEJ amplitudes with reference to sunspot cycles 21–23.

This work was done in collaboration with N. Phani Chandrasekhar of National Geophysical Research Institute, Hyderabad.

https://doi.org/10.1029/2020JA028464

Shri. Arka Roy

3.2 Crustal Dynamics Group

3.2.1 Fluid inclusion studies to determine the paleotemperature and hydrocarbon quality in petroliferous basins

Hydrocarbon bearing fluid inclusions (HCFIs) along with the coeval aqueous inclusions could be utilized in petroleum exploration industry for determining the paleotemperature and American Petroleum Institute's (API) gravity of oils in a basin. The paleotemperature is a direct data that can be obtained through the temperature measurements only from fluid inclusions (Fig. 3.2.1.1).

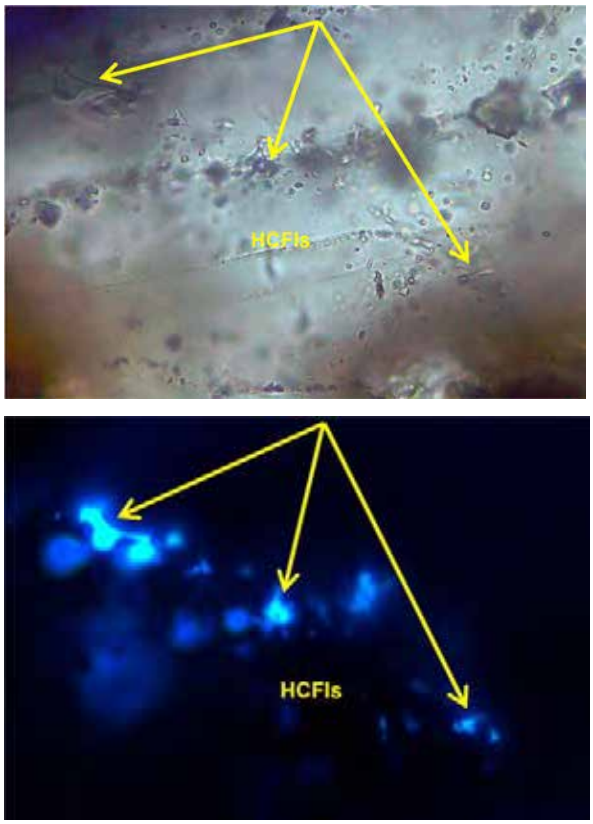


Fig. 3.2.1.1: Biphase HCFIs (marked with yellow arrows) at a depth 3495–3500 m depth with sandy siltstone and shale lithology in Panna Formation, Offshore basin, India. HCFIs are fluorescing; where vapour phase is not fluorescing. Scale 20 µm.

The determination of paleotemperature in a basin and hydrocarbon quality in terms of API gravity are the parameters that can indirectly yield a quick assessment on the hydrocarbon quality in a basin. We have used fluid inclusion data as a tool to study the paleotemperature and hydrocarbon quality of two offshore basins in India (dry wells from a proven basin and a non-proven basin). Towards this objective, temperature of homogenization (Th) of coeval aqueous fluid inclusion, assemblages seen associated with HCFIs and fluorescence emission features of oils in HCFIs were studied. Depth wise comparison of the fluid regimes in two basins were studied with the

micro-thermometrically obtained Th data and spectroscopically determined (fluorescence) API gravity values that give an estimation of the paleotemperature and hydrocarbon quality. The Th and, fluorescence emission features of oils in HCFIs (leads to API gravity) presented allow us to make a qualitative assessment of oils in these basins. This study brings out the potential of HCFIs/adjacent brine fluid inclusions, as a tool for determining the paleotemperature and API gravity of oils in petroliferous basins.

Microthermometric measurements provide additional insight into the fluid systems in a basin. In comparison with the theoretical Te (eutectic temperature), values and the measured values of fluid inclusion samples of Kerala-Konkan basin indicating that most of the primary fluid inclusions are aqueous carbonic (H2O-CO2) and secondary fluids belong to H2O-NaCl and H2O-KCl systems (Fig. 3.2.1.2). Temperature of homogenisation (Th) of coeval aqueous fluid inclusion assemblages (FIAs) associated with HCFIs fall in the oil window range (Th = 60–140 °C) (Fig. 3.2.1.3).

The total range in fluid salinity is 0.7–31 wt% of NaCl equivalent. Majority of the hydrocarbon bearing fluid inclusions are observed from Cannanore Formation, Calicut Formation and Kasaragod Formation with a dominant lithology of sandstone-claystone. Hydrocarbon fluid inclusions of Cannanore (Early Miocene) and Calicut (Early Oligocene) Formations of KK-4C-A1 well are in the form of blebs of bitumen like inclusions (monophase) with faint oil fluorescence and are show a migrating trend. At Kasaragod Formation (Palaeocene to Early Eocene) secondary fluid inclusions with monophase and biphase inclusions shows distinct oil fluorescence. HCFIs of Kerala-Konkan basin were observed in the healed fractures of minerals like quartz and feldspar grains of sandstone-claystone lithology indicating that majority of HCFIs in this basin originated due to post crystal fracture healing mechanism. Primary fluid inclusions (non-HCFIs) in the study area are rich in aqueous-carbonic inclusions and these fluids must have developed during the crystallization of detrital minerals like quartz and feldspar.H2O-NaCl and H2O-NaCl-KCl systems were identified mostly in the secondary trails typical of fluids in the sedimentary realm.

https://doi.org/10.1016/j.petrol.2020.108082

Dr. V. Nandakumar and Dr. J. L. Jayanthi

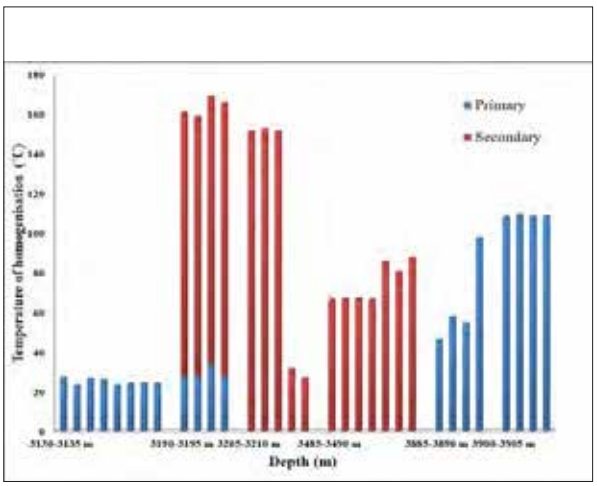


Fig. 3.2.1.2: Homogenisation temperature versus depth histogram for both primary and secondary fluid inclusions (non- HCFIs) from different formations of Kerala- Konkan basin.

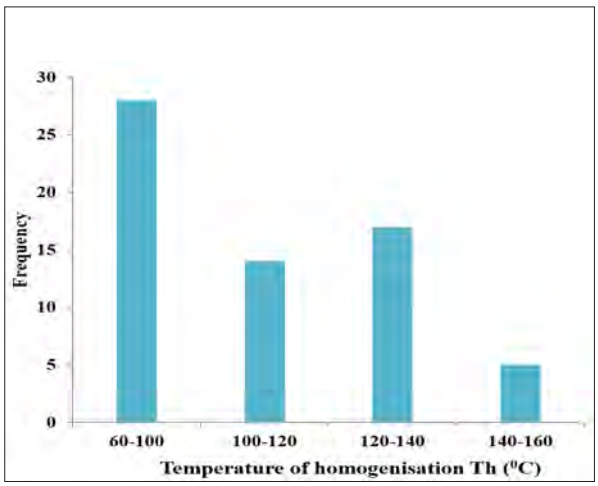


Fig. 3.2.1.3: Histogram showing coeval- biphase aqueous fluid inclusions associated with HCFIs falling in the oil window temperature range (Th) in KK-4C-A1 well of Kerala-Konkan basin.

3.2.2 Detection of soil pipes through remote sensing and electrical resistivity method: Insight from southern Western Ghats, India

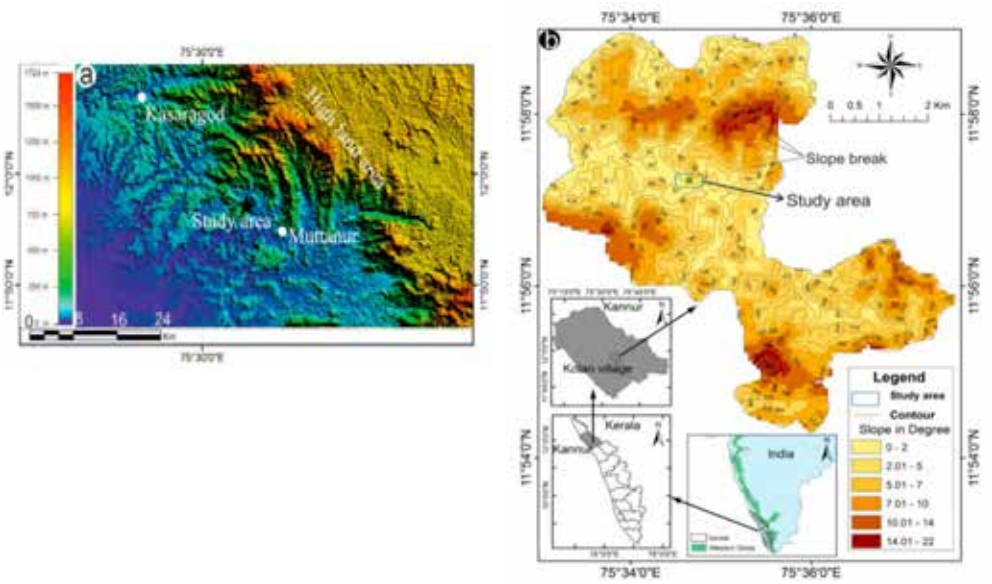


Fig. 3.2.2.1: (a) Digital Elevation Model, processed in GIS platform, of the Kannur area shows the elevation variation from west to east. Black star shows the location of the study area. (b) Slope map of Kolari village (study area) in Kannur district, Kerala prepared by Survey of India toposheet in ARC GIS 10.3 platform. Closed lines with number are the contour lines with corresponding elevation.

Fig. 3.2.2.2: (a) Inlet of younger pipe. Note the collapsed soil material near the mouth of pipe. (b) Newly formed juvenile pipe in the study area. Inset shows the close up of this. (c) Outlet of a pipe in the study area.

Every year, during the monsoon period (June–September), series of land subsidence incidences are reported from the southern Western Ghats in India. This land subsidence occurs primarily due to subsurface erosion, which leads to formation of soil pipes. These soil pipes are geo-morphologically an outcome of land degradation process that significantly influence the hill slope hydrology which makes the slopes susceptible to landslides and affect the human lives as well. However, detection of these subsurface pipes remains a serious challenge. Most of the previous studies were based on surface investigations, without considering the subsurface features. The reported study conducted in the Kannur district, southern Western Ghats (Fig. 3.2.2.1) aims to provide a more detailed account of these less-studied geomorphic features (soil pipes) using an integrated approach. The main purposes of the study are to: a**)** describe the characteristic of the soil pipes and b**)** to quantify the scale of piping activity; based on both surface and subsurface investigations in watershed scale. The remote sensing and GIS platforms were used to delineate watershed boundary, identify geo morphological setup of the terrain, detailed land use information and to bring out changes in land use, land cover pattern. The geomorphic mapping was carried out to identify the type of pipes, location of its inlet, outlet and other subsequent deformation features (Fig. 3.2.2.2). The resistivity survey was done to map geometry of the pipe, piping network, subsurface lithology, and get the water table depth. The resistivity survey results indicate that the density of pipes is more than the estimated through surface mapping. Resistivity profile (e.g., Fig. 3.2.2.3) shows three configurations Schlumberger, Wenner and Dipole-Dipole. Two subsurface high resistivity zones suggest two subsurface pipes Pi1 and Pi2. Pocket of low resistivity zones above the water table suggests perched water table**.** The integrated data based on remote sensing techniques, geomorphological and geophysical studies provide a very lucid picture of subsurface pipes in the study area. The remote sensing and resistivity survey are non-destructive processes and allows to examine extension and nature of a pipe. The field results shows that the Google Earth has an accuracy of ±3 m and if dimension of inlet/outlet is large (>3 m) then it can be easily picked up after comparing with the historical images. However, if the dimension of pipes is less, then very high-resolution remote sensing images from satellites or aerial sensors (Unmanned Aerial Vehicles or aircraft), which are very costly, is required. The surface measurement of a pipe could be less than the actual length. The study shows that in the recharge area, inlet and outlet of the pipe are in the same watershed. This leads to the recommendation for stopping water from percolation, reducing the subsurface erosion in turn, and minimising the soil pipe hazard.

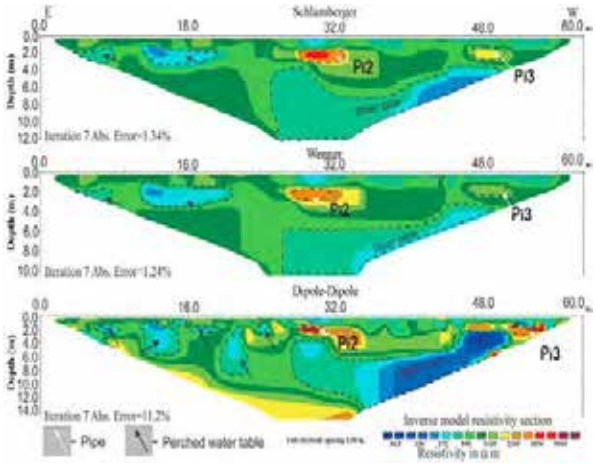


Fig. 3.2.2.3: Profile shows three configurations Schlumberger, Wenner and Dipole-Dipole. Two subsurface high resistivity zones suggest two subsurface pipes Pi1 and Pi2. Pocket of low resistivity zones above the water table suggest perched water table.

https://doi.org/10.1016/j.quaint.2020.08.021

Shri. Mayank Joshi, Ms. Alka Gond, Dr. B. Padma Rao, Dr. Tomson J. K., and Dr. V. Nandakumar.

3.2.3 Evaluating pedogenesis and soil Atterberg limits for inducing landslides in the Western Ghats, Idukki district of Kerala, South India

In the Western Ghats of India, the soil properties, particularly Atterberg limits, are of relevance to the landslides. Pedogenic processes in the Western Ghats and plateaus on it are regulated by parent materials, relief (topography), organisms, climate, and time. In this study, the five major soils found within

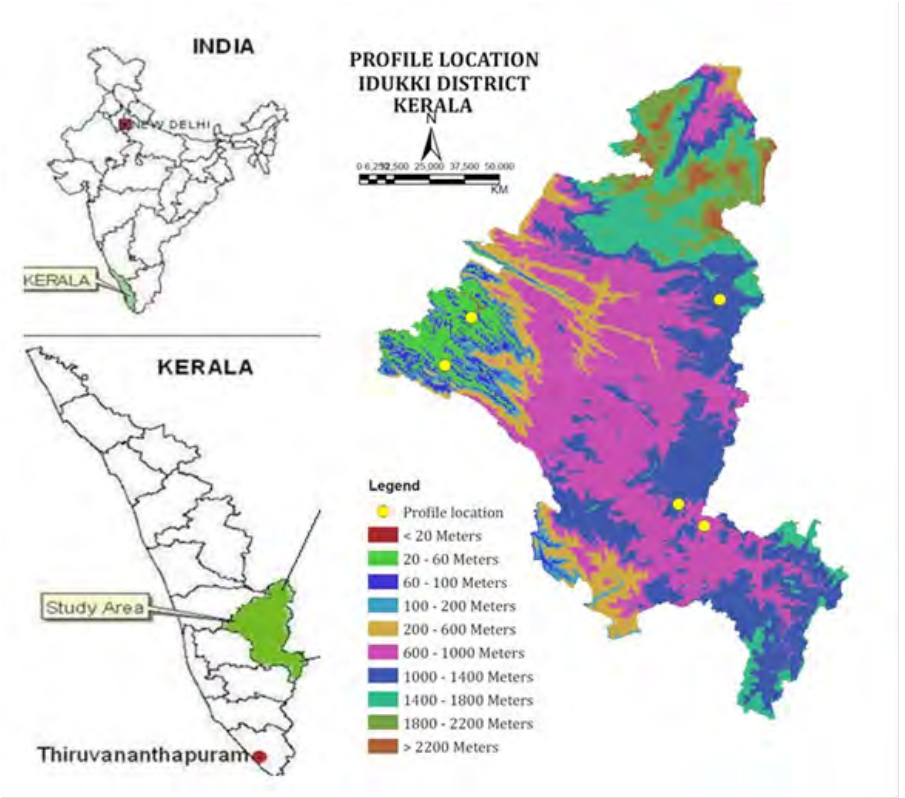


Fig.3.2.3.1: Location of pedogenesis and Atterberg studies in the Western Ghats of Idukki district, Kerala state, India.

the mid-part of the Western Ghats in the Idukki district of Kerala, Southern India was analysed for elucidating physical, chemical, and geotechnical properties (Atterberg limits) on landslides potentiality or slope failure processes. The result reveals that the highly weathered lateritic soils noted with lower KCl pH (3.6–4.6), low-cation exchange capacity (3.1 to 19.6 cmol (+) kg^{-1}), low-effective cation exchange capacity (0.8 to 10.7 cmol (+) kg^{-1}) and a negative ΔpH value indicate the presence of variable charge minerals such as amorphous sesquioxides. The variable ranking of random forest revealed that the soil Atterberg limits were significantly influenced by Citrate Bicarbonate Dithionite (CBD) iron, sand fractions, and organic carbon. The layer of porous sandy soils showed lower Atterberg limits due to accentuate with clay matter, whereas the illuvial layer (Bt) have noted as higher Atterberg limits that lead to potentially collapsing gullies or triggering mass movement during heavy rainfall followed by intensive runoff due to instability of soil mass within proxy of the steeply sloping surface. Soil geotechnical properties such as liquid limit, plastic limit, and plasticity index are the main characteristics that decide the slope stability and failure in various parts of the study area, whereas the soil profile morphometry has significantly associated with the occurrence of landslides with the plastic limit value between 28.01 and 40.48. It was noticed that the failed slopes have a higher value than stable slopes along with the hill-range topography, with soil particle sizes range of silt and clay (8.79 to 36.17 and 22.31 to 57.74%) with the measurement of liquid limit (40.05 to 68.4), plastic limit (24.2 to 43.94), and plasticity index (7.81 to 24.8). This indicates that the pedogenesis of the weathering profile of soils have significantly influenced the Atterberg limits that triggering slope failure or landslides along the gullies and weathered lateritic uplands.

This work was done in collaboration with Lalitha, M., Anil Kumar, K. S., Nair, K. M., Dharumarajan, S., Arti Koyal, Shivanand Khandal of ICAR-National Bureau of Soil Survey and Land Use Planning, Regional Centre, Bangalore, India.

https://doi.org/10.1007/s11069-020-04472-0
Dr. S. Kaliraj

3.2.4 Desertification and land degradation atlas of India – Assessment of Kerala and Tamil Nadu states

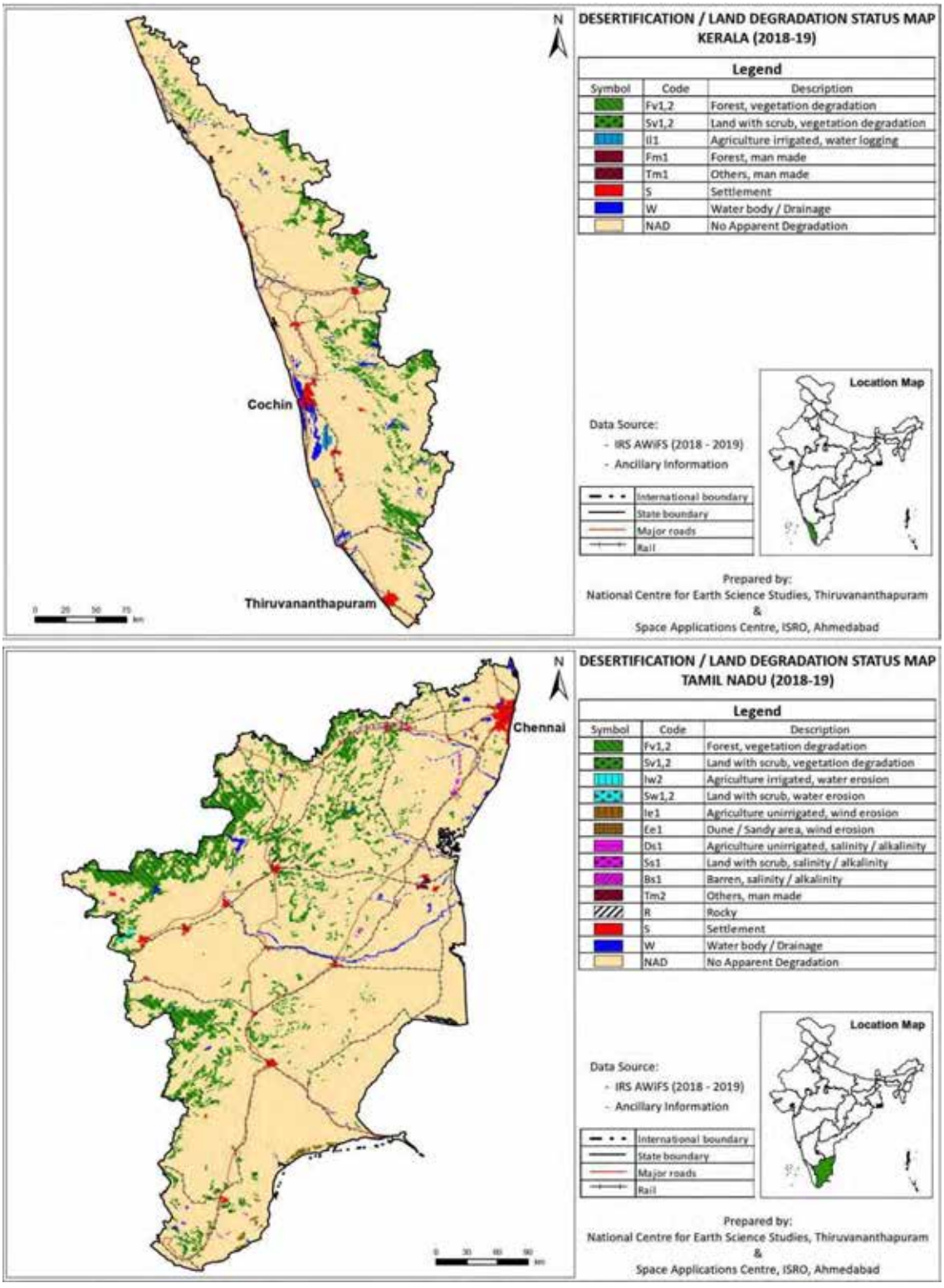


Fig. 3.2.4.1: Desertification and Land Degradation Atlas of India – Kerala and Tamil Nadu states in 2018 – 2019.

National Centre for Earth Science Studies (NCESS) signed as MOU with ISRO-SAC for National Network Project entitled "Desertification and Land Degradation: Monitoring, Vulnerability Assessment and Combating Plans 2018 – 2021 (Ref. No. EPSA/GHCAG/GSD/WP/3/2017). The NCESS is contributed to the National Atlas "Desertification and Land Degradation Atlas of India" for the two southern states - Kerala and Tamil Nadu. The statistical summary and analysis of Land Degradation in Kerala state reveal the area of 10.87% (4,22,299 ha) is undergoing Desertification/Land Degradation (DLD) during 2018-19. Whereas, the DLD during 2011-13 and 2003-05 is observed at 9.77% (3,79,587 ha) and 9.54% (3,70,512 ha) respectively. An increase of area at 1.10% (42,712 ha) is undergoing DLD from 2011-13 to 2018-19. During 2003-05 and 2011-13, the area of DLD has increased by 0.23% (9,075 ha). The most significant DLD in the state is Vegetation Degradation (9.24% in 2018-19, 8.69% in 2011-13 and 8.46% in 2003-05) mainly due to human-induced activities. In the Tamil Nadu state, the statistical summary and analysis reveal the area of 12.30% (1.59 million ha) is undergoing DLD during 2018-19. However, during 2011-13 and 2003-05, the area fall under DLD is about 11.87% (1.54 million ha) and 11.66% (1.51 million ha), respectively. An increase of the area at 0.43% (56,083 ha) is fall under DLD in 2011-13 and 2018-19. Whereas, DLD is increased by 0.21% (27,238 ha) during 2003-05 and 2011-13, due to soil erosion and surface runoff and human-induced activities. The most significant DLD process in the state is Vegetation Degradation (10.88% in 2018-19, 10.65% in 2011-13 and 10.52% in 2003-05), and it is gradually increased from 2003-05 to 2011-13 and 2018-19 in forest cover and agricultural across the state in 2018-2019.

This work was done in collaboration with Manish Parmar of Space Applications Centre (SAC), ISRO, Ahmedabad.

https://vedas.sac.gov.in/static/atlas/dsm/DLD_Atlas_SAC_2021.pdf

Dr. S. Kaliraj

3.3 Hydrology Group

3.3.1 TERRAIn: Tropical Ecosystem Research Observatories in Peninsular India – NCESS network of Critical Zone Observatories

Intense human activities in the earth in the post industrialization era is characterized by dramatic increase in environmental degradation and global changes questioning the capacity of the life sustaining systems to maintain their productivity. In the past two decades, this concern has fostered worldwide efforts to develop integrated studies of the "Critical Zone" (CZ), the thin layer of the Earth surface from the top of the canopy to the bottom of the aquifer, hosting the continental biosphere and providing the basic human needs such as water, food, energy and ecosystem services. The main challenge in advancing Critical Zone studies is to integrate effectively the multiple disciplines at stake, from geosciences and biological sciences to social sciences, working within a wide range of spatial and temporal scales.

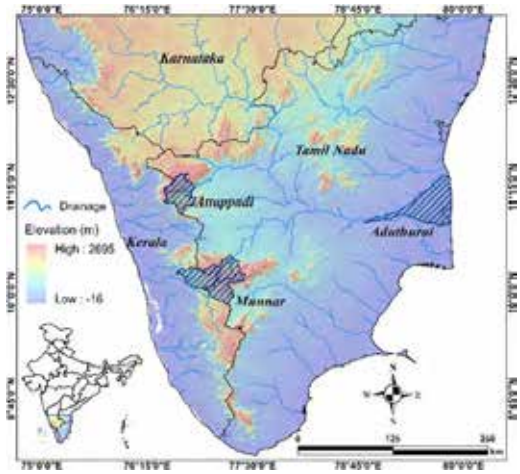


Fig. 3.3.1.1: Locations of Attappadi, Munnar and Aduthurai CZOs belonging to the TERRAIn network.

Critical Zone Science is based on Critical Zone Observatories (CZO), that are distributed in various climatic, geologic and human contexts. Currently, most of the CZOs are located in temperate regions. Tropical countries host only very few CZOs, even though the impact of global changes in the tropics is of utmost importance for climate feedbacks, food production and biodiversity changes. In this context NCESS has developed a network

of CZOs – TERRAIn (**T**ropical **E**cosystem **R**esearch Observato**R**ies in Peninsul**Ar In**dia) – with an aim to understand the relative influence of natural perturbations (climate variability) and anthropogenic activities on the hydrological and biogeochemical cycles in different agroclimatic regions of peninsular India and act as global test bed for furthering Critical Zone studies. Under this network of CZOs, a total of three CZOs has been established in southern peninsular India (Fig. 3.3.1.1) - (1) Attappadi CZO (Bhavani River), (2) Munnar CZO (Periyar/Amaravati River) and Aduthurai CZO (Cauvery Delta).

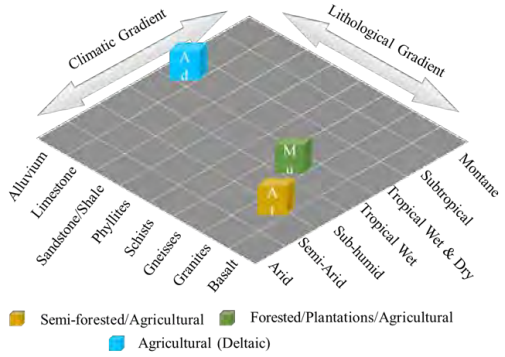


Fig. 3.3.1.2: NCESS CZOs (At: Attappadi, Mu: Munnar, Ad: Aduthurai) at different climatic, lithological and land-use gradients.

These regions are characterized by different climatic, tectonic, geomorphic setups and encompasses a complex aquifer system. These complexities demand a detailed study to understand the differences and commonalities in the behaviour of these systems, their resilience in the changing environment, the dynamics of feedback between the different systems etc., which will provide valuable insights into the functioning of the Critical Zone and provide fundamental understanding to achieve sustainability in the uncertain scenario of climate change and anthropogenic impacts. Each CZO is extensively characterized and a wide range of variables are monitored in the long term, to understand the processes involved in the response of CZ to changing external forcing and, creating opportunities for intercomparison and improving the generality of the findings among the CZO network. The NCESS CZOs are in the network of Indian CZOs spread across different agro-climatic and lithological gradients (Fig. 3.3.1.2).

NCESS CZO network is an integral part of the national initiative on Critical Zone Studies undertaken by the following Scientists/Institutes: Paras R. Pujari, S. Dhyani, P. Verma and R. Kumar (CSIR-National Environmental Engineering Research Institute, Nagpur); V. Jain (Indian Institute of Technology, Gandhinagar); V. Singh (Delhi University); M. Nema and S. Jain (National Institute of Hydrology, Roorkee) and M. Sekhar (Indian Institute of Sciences, Bengaluru).

Critical zone: An emerging research area for sustainability (2020). Current Science, Vol. 118 (10) - Opinion Paper in Current Science.

3.3.2 Groundwater studies of Chalakkudy basin, southern Western Ghats

Groundwater is an annually replenishable resource but its availability is non uniform in space and time. Therefore, conservation and management of these resources are very important to meet the increasing demands of quality potable water for different uses. The subsurface lithology is mainly controlling the chemistry of groundwater. The present study depicts the hydrochemical characterization and development of a Water Quality Index to assess groundwater quality of Chalakkudy River Basin (CRB) in Southern Western Ghats India during the pre-monsoon season of 2020. Due to unavailability of open wells in the upper catchments of CRB, this study is mainly concentrated in the mid and lowland stretches. Parameters like pH, Turbidity, EC, TDS, Total Alkalinity, Total Hardness, Nutrients, Na, K, Ca, Mg etc., were analysed for 20 wells. Based on the piper trilinear diagram the water type is estimated and is of $CaHCO_3$ type. The hydrochemical facies indicates that alkaline earth exceeds alkalis and weak acid dominates the chemical property of the groundwater. The Water Quality Index of about 95% of the well water samples is in excellent category and 5% is in good category. The Spatial variation map of major cations and anions were produced using IDW interpolation technique in GIS. At present the quality of well water in the area is quite good for consumption. The spatial variation map reveals that about 70% of the study area is dominated with the pH in the range 5.5 to 6 (Fig. 3.3.2.1).

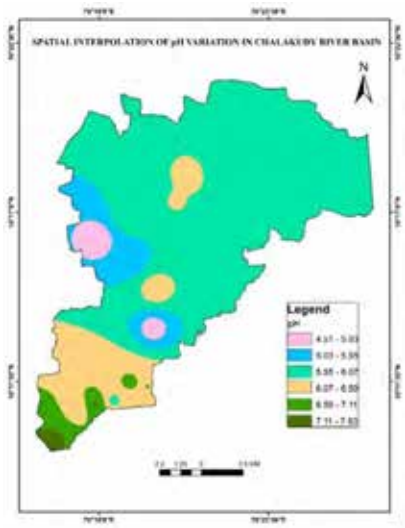


Fig. 3.3.2.1: Spatial variation map of pH in the mid-lowlands of the Chalakkudy river basin.

The highest pH is observed in the southern part of the study area. The low elevated regions of the study area show high values of EC. This is in the downstream stretches of Chalakkudy river basin and EC values are comparatively lower in the northern stretches. Majority of the study area has TDS values less than 500mg/L and falls in the fresh water group except certain areas in the eastern part. The solubility of minerals resulted in high value of EC and TDS in groundwater. Out of the twenty wells analysed for microbiology, no wells have been reported for microbiological contamination.

https://doi.org/10.1007/978-3-030-68124-1_18

Resmi R., Krishnakumar A. and Anoop Krishnan K.

3.3.3 Quality Index and drinking potential of groundwater resources of Kallada River Basin draining through southern Western Ghats

The drinking suitability of groundwater resources of Kallada basin was assessed during the three seasons using parameters like Water Quality Index (WQI), Pollution Index of Groundwater (PIG) and Entropy Weighted Water Quality Index (EWQI). Water quality index described the suitability of groundwater with different categories as 'Excellent', 'Good' and 'Poor'. During pre-monsoon season, about 75% of the samples fall in the Excellent to Good category and 25% in Poor category.

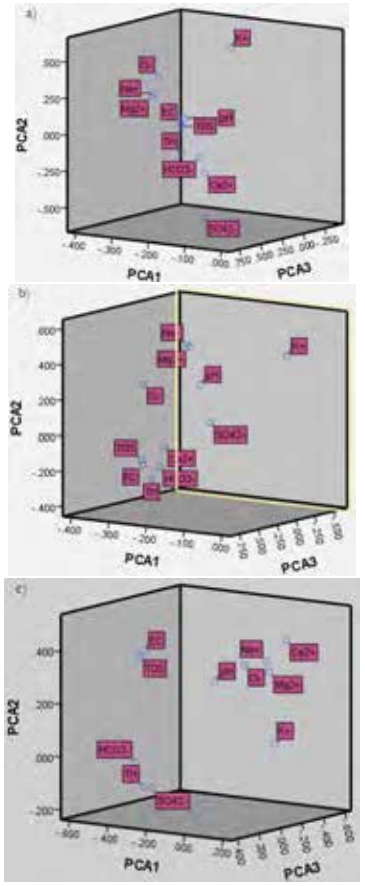


Fig. 3.3.3.1: Principal component analysis carried out for the samples of Kallada river basin. (a) Pre monsoon, (b) Monsoon and (c) Post monsoon.

In monsoon and post monsoon seasons, all the samples were in Excellent – Good category. The computed values of PIG varied from 0.12 to 0.49 and 0.10 to 0.88 respectively in monsoon and post-monsoon seasons, which indicated that the entire study area fall within insignificant pollution zone (PIG: < 1.0), whereas in pre-monsoon season the PIG value varied from 0.37 to 1.73, indicating that 75% of the area in insignificant pollution zone and the rest 25% in low pollution zone (PIG: 1.0 to 1.5) and the rest in moderate pollution zone (PIG: 1.5 to 2.0). Pearson correlation analysis and Principal Component Analysis (PCA) were applied using SPSS software to identify the seasonal variations of hydrochemical parameters of groundwater samples and their relationship among each other (Fig. 3.3.3.1). The Principal Component Analysis (PCA) extracted 3 factors and the obtained results show that Cl^-, TDS, Na^+ and Ca^{2+}ions contribute towards moderate pollution load in

groundwater. The first principal component (PC1) in pre monsoon season contains large negative loadings on bicarbonate, sulphate, total hardness, EC and TDS and lower positive loadings on pH, Ca^{2+} and Cl^-. In the same season, PC2 has moderate positive loadings on Na^+, Ca^{2+}, Cl^-, EC and TDS and PC3 explained strong to moderate negative loadings on Mg^{2+}, Ca^{2+}, Na^+ and K^+ (Fig. 3.3.3.1.a). In monsoon season, the second principal component (PC2) has moderate negative loadings on EC, TDS, TH, Cl^-, HCO_3^{2-}, Ca^{2+} and Mg^{2+} (Fig. 3.3.3.1.b). PC3 explains high positive loading on pH, which means that groundwater is slightly alkaline due to the dilution effect. Also, the low loading on HCO_3^{2-} with the negative loading on Mg^{2+}may be due to removal of Mg from the groundwater in the form of magnesium bicarbonate precipitate. In post monsoon season, PC1 shows low to moderate negative loadings on all the hydrochemical parameters. PC2 explains moderate negative loadings on Ca^{2+} and SO_4^{2-} and low negative loadings on EC and TDS. PC3 shows moderate to high positive loading on chloride and sulphate respectively (Fig. 3.3.3.1.c). This may be due to the groundwater contamination by industrial waste or domestic sewage. Ca^{2+}, K^+, EC, TDS and HCO_3^{2-} shows low negative loading on the third component.

Spatial distribution maps were prepared using ArcGIS 10.3 for the groundwater samples for the three seasons using Inverse Distance Weighted Interpolation (IDWI) technique. In this study, spatial distribution maps are prepared for pH, Total Dissolved Solids (TDS), Total Hardness (TH), bicarbonate (HCO_3^{2-}), chloride (Cl^-), sulphate (SO_4^{2-}), calcium (Ca^{2+}), magnesium (Mg^{2+}), sodium (Na^+) and potassium (K^+) of the groundwater to delineate the safe and unsafe zones. Spatial analysis of pH value of the groundwater samples indicates all of the water samples were within the permissible limits (6.5–8.5) of the BIS (2012) except at few sites in the western and central part of the study area during all seasons where the samples were slightly acidic in nature. The concentration of Cl^- was relatively high in the western part of the study area in the pre-monsoon season only. Spatial distribution maps of Ca^{2+} and Mg^{2+} shows that the northern part of the study area has slightly higher concentrations in post monsoon season comparing to southern, eastern and western parts but within the acceptable limits of drinking water as recommended by BIS and WHO.

https://doi.org/10.1007/978-3-030-68124-1_17

Uma Mohan and Krishnakumar A.

3.3.4 Geochemistry and suspended sediment concentration of Ashtamudi Wetland System

Remote sensing technology performs a vital role for measuring and monitoring Suspended Sediment Concentration (SSC) in water columns of large water bodies including that of coastal regions. Satellite images with multispectral characteristics employed for SSC quantitative measurement can be used as primary information to researchers and management authorities for understanding sediment transportation and coastal dynamic processes. In the Ashtamudi lake, a higher rate of SSC was found in the mouth of the lake (lake sea connecting area) during all seasons resulting from interactions of littoral current and tidal waves with the lake basin environment. Also, it was found that the SSC was spatially varying from place to place every month, indicating morphological landforms and ecosystems control as a primary factor for spreading heavy metals in water and sediment columns. In the lake-water column, the monthly variability of SSC is estimated in the range of 1.34-64.63 mg/L, wherein the maximum SSC found in two major sites includes (1) lake-Arabian Sea meeting point, and (2) lake-Kallada River meeting point (Fig. 3.3.4.1). Meanwhile, the river mouth (lake river connecting area) also received larger SSC during northeast monsoon through river discharge from the Western Ghats catchment area. It is noted that the larger quantity of suspended sediments settled within proximity of backwater and river mouth areas, whereas the lake's water physicochemical properties are frequently changing due to mixing of external materials. Moreover, in other parts of lake water, the SSC is found at a significant level due to shoaling effects and flowing water-current triggering the movement of suspended sediments toward different directions, especially the southern

side. In the mid-lake's water column, the SSC variations during different months depend on velocity of inflow from sea and river discharge.

Using sediment-sampling analysis, the assessment of pollution status is performed based on heavy metal concentration and shows the AWS environment is in a lower category for ecological risk. The CF, Cd, and mCd, analysed for monsoon and non-monsoon seasons suggested low to moderate contamination in all four subdivided locations, whereas Pollution Load Index (PLI) suggested 53% of samples as polluted (>1) This is due to the inflow of discharge from various sources that may carry and mix pollutants from point and nonpoint sources and their subsequent attachment to the finer particles of the sediments. The Hakanson Potential Ecological Risk Index (PERI) indicated a seasonal difference which can be attributed to the accumulation of sediments at different regions of AWS, which has altered the sediment water dynamics of AWS. It is also observed that the AWS environment denotes the spatiotemporal variability in potential ecological risk (RI) level, which depends on accumulation of sediments into the different parts of AWS, affecting growth and production of ecosystem in the AWS environment. Further, sediment dynamics and water quality in the lake-water column have been frequently affected by human-induced activities like dredging of river sand and deepening of harbours and fishing ports in the region.

Most areas of AWS during monsoon and non-monsoon seasons belong to the low-risk category (Fig. 3.3.4.2). The sediments deposited in the bottom of shelf and nearshore due to tidal waves and littoral currents contribute to stratification of sediments. This study proves that the integrated remote sensing and GIS techniques become essential for studying the environmental ecosystems in coastal and inland water bodies. Moreover, this study emphasizes the need for sustainable management measures and continuous monitoring of location-specific action plans for effective conservation and utilization of an important RAMSAR wetland system.

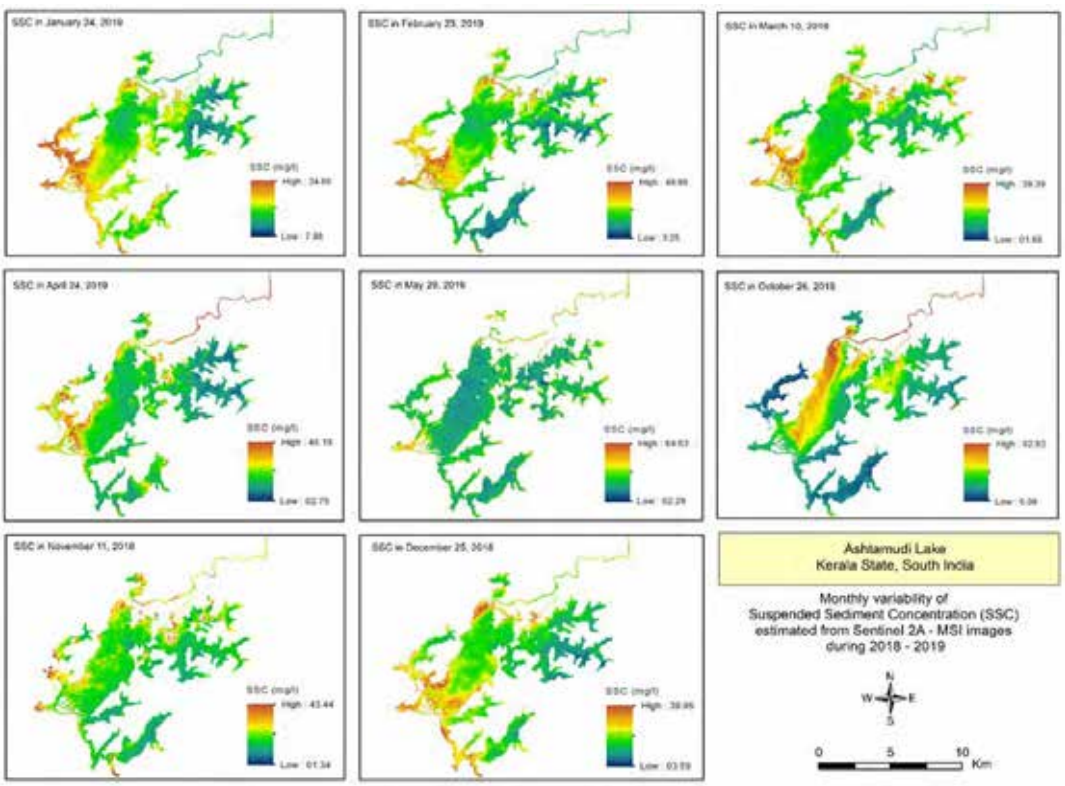


Fig. 3.3.4.1: Monthly variation of Suspended Sediment Concentration (SSC) in Ashtamudi lake.

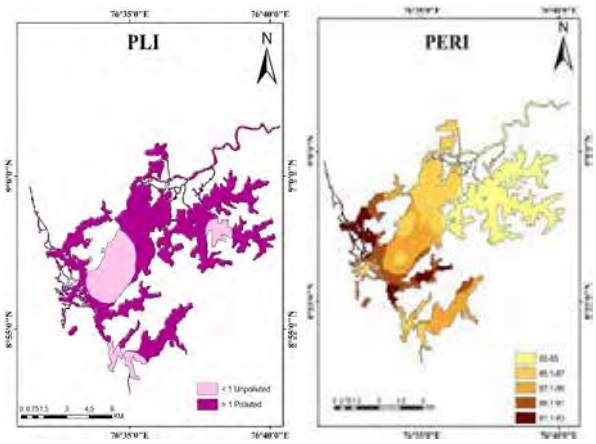


Fig. 3.3.4.2: Spatial variability of PLI and PERI in sampling locations of AWS.

https://doi.org/10.1016/B978-0-12-819604-5.00015-9

Krishnakumar A., Aditya S. K., Kaliraj S., Anoop Krishnan K. and Jeenu Jose

3.3.5 EIA of hard rock quarrying in Netravati – Gurpur river basin, Karnataka State

The increase in demand of building materials like foundation stones and construction-grade sand has resulted in aggressive quarrying for hard rocks in many parts of the world. The problems are severe in most of the countries undergoing rapid economic developments. The problems are to be assessed in detail for the judicious use of resources and also to ensure the health of the life sustaining ecosystems. The present study aims to assess the impact of hard rock quarrying in one of the important twin-river basins in southwest India - the Netravati–Gurpur river basin, which hosts the development centre, the Mangalore city. We mapped a total of 64 hard rock quarries (active 45, abandoned 19) in the basin. The total quantity of quarried stones in a year is about 6.75 million tonnes. The extracted rocks are used for direct uses and also for the production of coarse and fine aggregates and building blocks. An assessment of the environmental impacts using the Rapid Impact Assessment Matrix (RIAM) reveals marginal, short-term positive impacts in the economic-operational components but major negative impacts on all the other biophysical environmental components (Fig. 3.3.5.1). The study indicates that the current nature of quarrying is unsustainable (Sustainability Index -0.25) and hence the rock quarrying in the study area has to be strictly regulated for bringing down the river basin degradation due to rock quarrying to the barest minimum level and, at the same time, maximizing the ecosystem benefits to its full potential.

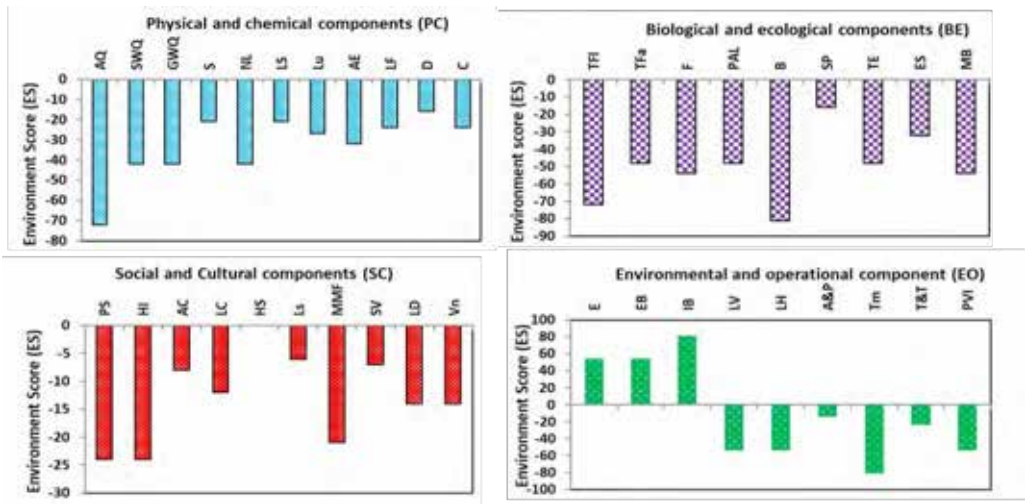


Fig. 3.3.5.1: Environmental scores computed for different components of the environment based on RIAM analysis. Physical and Chemical (PC) components: AQ-Air quality, SWQ-Surface water quality, GWQ-Groundwater quality, S-Soil, NL-Noise level, LS-Land stability, Lu-Land use, AE-Aesthetics, LF-Landform, D-Drainage, C-Climate; Biological and ecological (BE) components: TFl-Terrestrial flora, Tfa-Terrestrial fauna, F-Forest, PAL-Primary agriculture land, B-Biodiversity, SP-Soil productivity, TE-Terrestrial ecosystem, ES-Ecosystem services, MB-Migratory birds; Social and cultural (SC) components: PS-Public safety, HI-Health impairment, AC-Accidents, LC-Living conditions, HS-Heritage sites, Ls-Livelihoods, MMF-Man-made features, SV-Scenic views, LD-Landscape diversity, Vn-Vegetation; Economic and operational (EO) components: E-Employment, EB-Economic base, IB-Infrastructure built-up, LV-Land values, LH-Landholdings, A&P-Agriculture and plantations, Tm-Tourism, T&T-Traffic and transport, PVI-Property value impact.

This study has been made in collaboration with Dr. Shiekha E. John, Scientist, Ministry of Earth Sciences, Government of India.

https://doi.org/10.1007/s10661-020-08485-x

Dr. M. Vandana, Dr. K. Maya, Shri. Syam Sunny and Dr. D. Padmalal.

3.3.6 Monsoon variability and global linkage during the Roman Warm Period

The monsoon over the Indian landmass is a manifestation of lateral migration of the Inter Tropical Convergence Zone (ITCZ) which triggers the variability of the Indian Summer Monsoon (ISM) over India. The climate over the western India has been significantly influenced by the perturbations in the ISM and thus, provides a crucial platform to investigate the past variability of the monsoon intensities. Further, the mudflats of southern Saurashtra, western India being deprived of perennial rivers, receives terrestrial contribution exclusively during ISM due to the activation of ephemeral rivers and thus provides a unique platform to investigate the past monsoon variability during last two millennia. In view of this, a sediment core from the mudflats of southern Saurashtra coast (Fig. 3.3.6.1.a), western India, has been collected and analysed for several geochemical proxies supported by ^{14}C, ^{210}Pb and ^{137}Cs dating techniques. The study suggests ISM strengthening during Roman warm period (RWP: 2000-1800 cal yr BP) with intermittent marginal weakening of ISM during 1950-1970 cal yr BP and 1930-1890 cal yr BP associated with the reduced solar irradiance. Further, ISM weakening has been observed during Dark Age Cold period (DACP: 1800-1300 cal yr BP) and Little Ice Age (LIA: 800-200 cal yr BP) interrupted by a marginal ISM strengthening during Medieval Warm period (MWP), while the last two centuries witness climate warming (Fig. 3.3.6.1.b).

The reduction in TSI and the associated weakening within the RWP possibly caused by the volcanic event at ~1950 yr BP as indicated by the increased volcanic sulfate in GISP2 ice core of Greenland. The weak ISM during 1950-1970 cal y BP is further supported by reduced Titanium concentration (Ti) of Cariaco

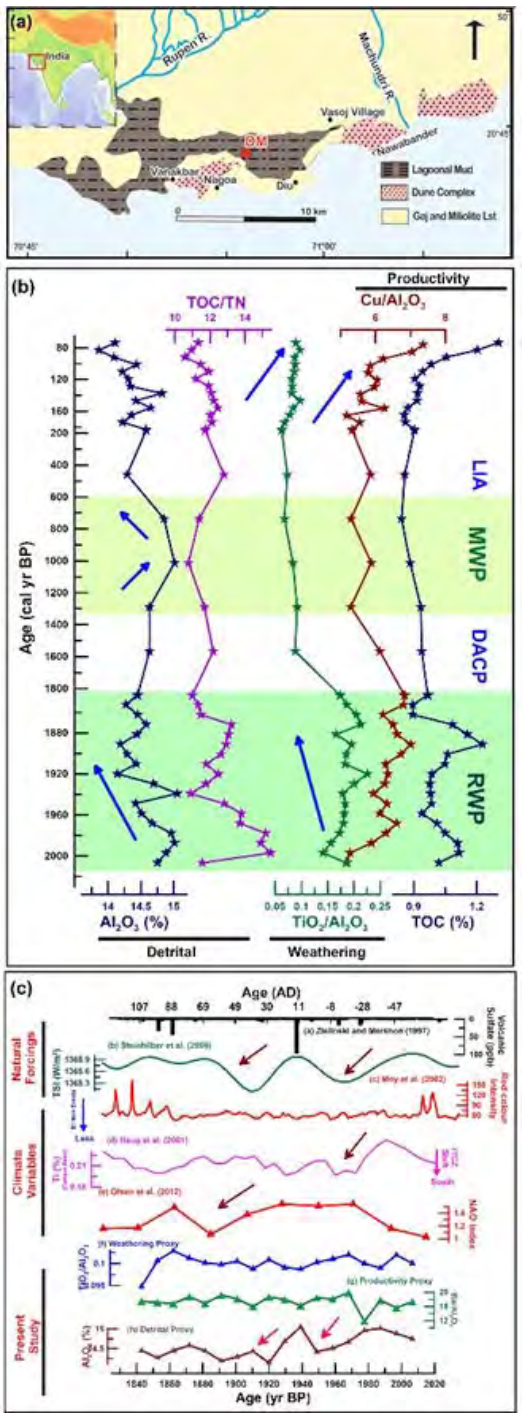


Fig. 3.3.6.1: (a) Core location and the nearby geology of the study area; (b) downcore variation of the geochemical proxies depicting detrital, weathering and productivity variations during last two millennia; (c) comparison of forcing factors and natural climate variables with the geochemical proxies of the study area.

basin which has been used to decipher ITCZ migration during Holocene (Fig. 3.3.6.1.c). Though the North Atlantic Oscillation (NAO)

index remained Positive (NAO+), but a gradual reduction of NAO index during 1930-1890 cal yr BP also supported ISM weakening, as low NAO values has been associated with weak ISM. Despite having intermittent reduced ISM, the climatic period between 1870 and 2000 cal yr BP remained destitute from significant El Nino events which could have caused severe reduction of ISM strength. Thus, within the time span of RWP a marginal reduction in ISM triggered by the low TSI but the change was so trivial that it mostly remained unnoticed compared to the overall strengthened ISM phase during the RWP.

This work was done in collaboration with Prof. Ravi Bhushan of Physical Research Laboratory; Ahmedabad, Gujarat; Prof. A. J. T. Jull of NSF Arizona AMS Laboratory, University of Arizona, Tucson, Arizona.

https://doi.org/10.1002/gj.4116

Dr. Upasana S. Banerji, Shri. Jithu Shaji and Dr. Kumar Batuk Joshi

3.3.7 Late Quaternary land-sea interactions and landform changes along southern Kerala coast, SW India

The Kerala coast displays a spectrum of varied geomorphic units that are evolved mainly as a result of Late Quaternary land-sea interactions. The Kerala coast displays a spectrum of varied geomorphic units that are evolved mainly as a result of Late Quaternary land-sea interactions. The southern Kerala coast, south of Achankovil Shear Zone (ASZ) is characterised by cliffed coasts with entrenched river channels and estuarine basins, pocket beaches, promontories, older and younger strand plains, coast parallel and perpendicular water bodies etc. These unique assemblages of geomorphic units have been evolved as a result of the transgressive-regressive phases to which the coast has been subjected during the late Quaternary Period. In spite of having diverse geomorphic features, lacuna in comprehending the evolutionary phases of the coastal landform features is the primary impediment that prompted us to unravel the Late Quaternary land-sea interactions and landform changes of the southern Kerala coast between Thottapally and Vizhinjam. Moreover, the last two centuries are known to have been witnessing many natural as well as human induced environmental perturbations in the area. The evidences based on geomorphic variations suggest that the area hosts two distinct paleo-coastlines - 1) coincides with the eastern boundary of the older strand plains (accreted during Late Pleistocene) and, 2) marks the boundary between older and younger strand plains (accreted during Early–Middle Holocene). A sector-wise analysis reveals that the northern half of the study area is characterised by many coasts perpendicular estuarine basins with well-developed Bay Head Deltas in its fluvial end, and Flood Tide Islands near the estuarine mouth. At the same time, the southern half is characterised by pocket beaches and coast parallel backwater bodies developed during the regressive phases of the sea. A high-resolution analysis of the shoreline changes during the period 1920-2018 reveals that the younger strandlines are vulnerable to severe coastal erosion compared to coastal accretion. The study stresses the imminent need for continuous monitoring and implementation of site-specific mitigation measures for the conservation and management of this coast known for its outstanding natural beauty and strategic beach placer deposits.

https://doi.org/10.1016/j.quaint.2020.05.011

Dr. P. Arulbalaji, Dr. Upasana S. Banerji; Dr. D. Padmalal and Dr. K. Maya.

3.4 Biogeochemistry Group

3.4.1 Hydrochemistry, geothermometry and origin of the low temperature thermal springs of South Konkan region, India

The west coast of India is one of the important geothermal provinces that hosts many thermal springs of varying discharge characteristics. A total of twenty thermal springs have been reported in this region falling into two different suites of geological formations. Two low temperature geothermal springs located in the south Konkan region were studied with the objectives: (1) to understand the geochemical evolution (2) to identify the recharge source and (3) to propose a reservoir temperature. The hydrogeological and geochemical investigations

were carried out on two geothermal springs, viz. Bandaru and Irde, both located in the Dakshina Kannada district of the Karnataka state, India. In this region, low-temperature geothermal activity has been reported in the form of the evolution of warm water from thermal spring systems with a notable presence of faults/ lineaments in the geological formation. These faults enable the upward flow of geothermally heated water. The hydrochemistry of water samples was analyzed to determine the dominant hydrogeochemical processes in the region. These thermal springs were categorized as Na-HCO_3 type facies and were moderately alkaline nature like other geothermal springs of the west coast of India. Based on the results for major and trace element concentrations it was found that the hydrochemical process was mainly controlled by the dissolution of silicate minerals with a marginal influence from anthropogenic activity. Evaluation of δD and δ^{18}O stable isotope data suggested that the thermal springs and adjacent surface and groundwater were of meteoric origin. Reservoir temperature was estimated with Na-K-Ca, K^2/Mg, quartz and chalcedony geothermometers (Fig. 3.4.1.1). The results suggest that the reservoir under consideration is a low enthalpy reservoir with temperatures ranging between 55 and 86 °C.

The perennial low temperature thermal springs of Bandaru and Irde seem to have no association with any volcanism in and around the area as no volcanic activity has been reported in peninsular India in the recent geological past. Moreover, the weakly mineralized character of the spring water, as revealed by analytical results and saturation indices of common minerals, does not support a magmatic origin. Hence, in the absence of valid geophysical evidence, the slightly high geothermal gradient of this area can be presumed to serve as the heat source for these geothermal springs. Furthermore, on the basis of the aforementioned structural setting and the results of hydrochemical analysis of the spring it is inferred that the thermal water emerged from the infiltration of meteoric water that was heated up (Fig. 3.4.1.2) and ascended to the surface through weak zones such as deep faults and/or fractures.

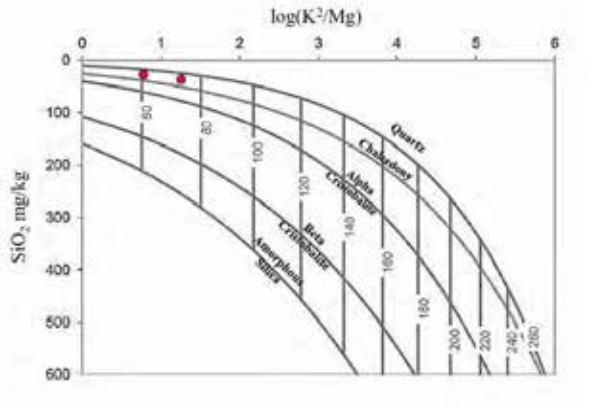


Fig. 3.4.1.1: The cross plot of silica versus K^2/Mg geothermometer for hot springs.

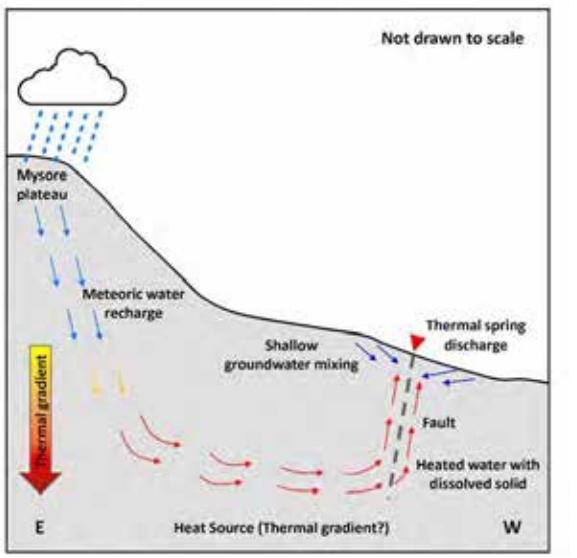


Fig. 3.4.1.2: Conceptual schematic model developed for the thermal springs of the study area.

https://doi.org/10.1016/j.geothermics.2020.101997

Shri. Prasenjith Das, Dr. K. Maya and Dr. D. Padmalal

3.4.2 A multivariate statistical approach in assessing the quality of potable and irrigation water environs of the Netravati River basin, India

One of the principal rivers of Western Ghats and rich in biodiversity, the Netravati river basin (Fig. 3.4.2.1), Karnataka state India was sampled to monitor the standards of the quality of the river and well water. The samples were collected from 16 major sampling sites during pre-monsoon (April), monsoon (August), and

post-monsoon (October) seasons in 2017 to ascertain its physicochemical parameters. The analytical results were compared with maximum permissible limits proposed by the World Health Organization (WHO) drinking water guidelines.

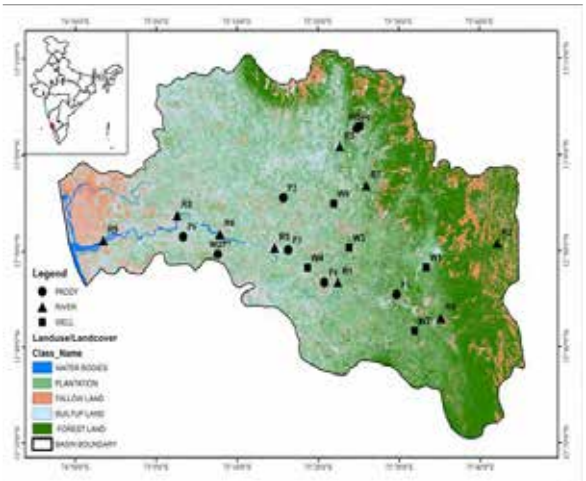
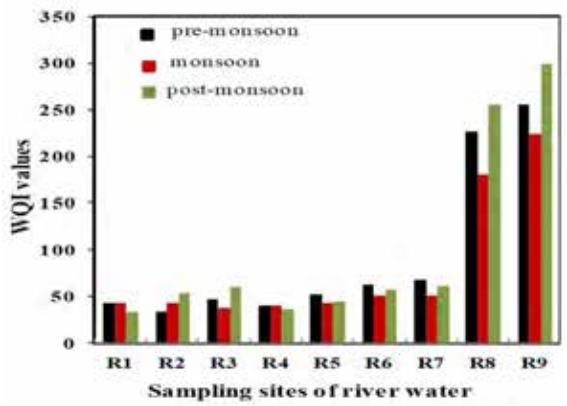


Fig. 3.4.2.1: Study area representing 23 different locations (Paddy, River, and Well) in the Netravati River basin, Karnataka.

To determine drinking and irrigational qualities, the Water quality index, Irrigational water quality index, multivariate statistical methods including PCA and Pearson correlation analysis have been employed. The results of the study were used to contemplate regulations to improve the water quality standard and help people living in and around the river basin to understand the current status of the water quality they use for various purposes. The results showed that certain parameters including Turbidity, EC, TDS, Cl^-, HCO_3^-, K^+, Ca^{2+}, and Na^+ values of water in the downstream regions of the basin exceed the permissible drinking limits of WHO (2011).



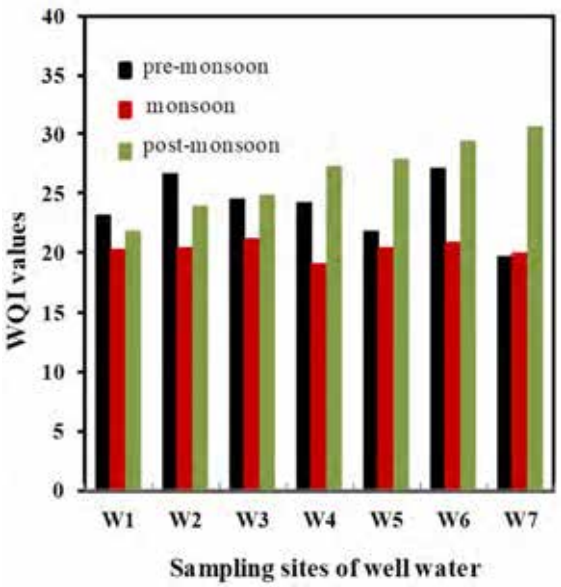


Fig. 3.4.2.2: Seasonal variations of WQI values indicating drinking water qualities in river water and well water.

The WQI and IWQI methods were regarded as an inexpensive and compatible ways to measure the quality of the water. The overall WQI values for drinking water from sampling sites (adjoining the Arabian Sea) were found to be very high. Salt deposits, sewage, industrial wastes and other anthropogenic inputs might be contributed to the high WQI values. The river water quality showed distinct seasonal variations (Fig. 3.4.2.2) with the highest WQI values in post-monsoon, followed by pre-monsoon and monsoon. Moreover, the WQI results of well waters showed excellent results and were not influenced by any seasonal variations. IWQI results showed excellent irrigation water quality based on SAR, RSC, Na%, MH, and PI. Na% and PI in specific sites depicted minor deviations due to excessive use of agrochemicals in the field areas. The outflow of paddy field water towards the river generated null changes in water quality during the three seasons (pre-monsoon, monsoon, and post-monsoon). The influence of sewage, domestic discharge, and industrial waste were major threats to water quality along the river basin.

https://doi.org/10.1016/j.gsd.2020.100462

Dr. A. Krishnakumar and Dr. K. Anoop Krishnan

3.4.3 Monitoring of heavy metal contamination in Netravati river basin: overview of pollution indices and risk assessment

The continuum fluctuations of river water quality and the metal contamination within the sediments of Netravati river basin were analysed using multivariate techniques and environmental indices. Water and sediment samples were collected from 10 locations along the flow path of the river basin and the hydrogeochemical features were investigated. The results were compared with maximum permissible limit values recommended by World Health Organization. A comprehensive Water Quality Index methodology was applied to come up with transparent understanding of overall excellence in water quality status. The dominant water cations and anions were within the order of $Na^+ > Mg^{2+} > Ca^{2+} > K^+$ and $HCO_3^- > Cl^- > SO_4^{2-} > NO_3^-$. The average abundance of sediment heavy metals was in the order of Pb > Mn > Ni > Zn > Cr > Cu > Co.

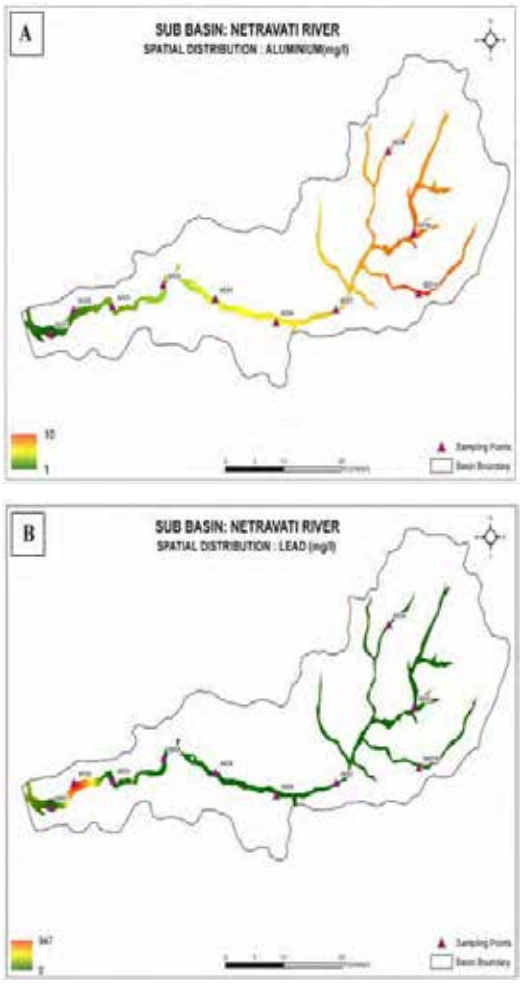


Fig. 3.4.3.1: Spatial Distribution of Aluminium and Lead.

An approach of exploiting environmental indices: enrichment factor, geo-accumulation index, contamination factor, degree of contamination, modified degree of contamination and pollution load index were accustomed to assess the pollutant level. Geochemical investigation and spatial distribution of heavy metals were represented by geographic information system-based maps (Fig. 3.4.3.1). The results indicate that lead contamination of surficial sediments might pose a significant threat to aquatic biota and the persistent exposure of pollutants even in low concentration causes changes in metabolic activities and alterations in the community structure of river biota.

https://doi.org/10.1007/s40899-021-00502-2

Dr. A. Krishnakumar and Dr. K. Anoop Krishnan

3.4.4 Multivariate statistical tools in assessing the quality of water resources in Netravati river basin, Karnataka, India

The study presents a general overview of hydrochemistry and water quality in Netravati river basin to understand the influence of geology, anthropogenic sources and variations in surface and groundwater chemistry. The results of the study showed that the analyzed physiochemical parameters were found within the permissible limits of WHO with few exceptions. Based on calculated WQI, the water samples were assessed into two groups of "excellent" and "good" for drinking purpose. The type of water that predominates in the study area is Na-Ca-HCO3-Cl and the Gibb's plot (Fig. 3.4.4.1) supports the influence of rock–water interaction followed by evaporation dominance. In surface and groundwater, the predominant cations were Na^+ and Ca^{2+} whereas HCO_3^{2-} and Cl^- were the dominant anions. Ion relations suggested that ion exchange, limestone dolomite weathering process yielding higher Na^+, Ca^{2+} and HCO_3^{2-} ion concentrations. To evaluate the groundwater and surface water of the basin for irrigation purposes %Na, SAR,

RSC, MH, PI and KR was determined. Irrigation water classified based on SAR and PI which classed all the water samples were excellent. As per the %Na and RSC surface water was more suitable for irrigation than groundwater, except few samples majority of water samples are suitable for drinking as well irrigation purpose. Results showed that, continuous monitoring and development of management strategies for surface and groundwater are required to preserve this resource from further pollution.

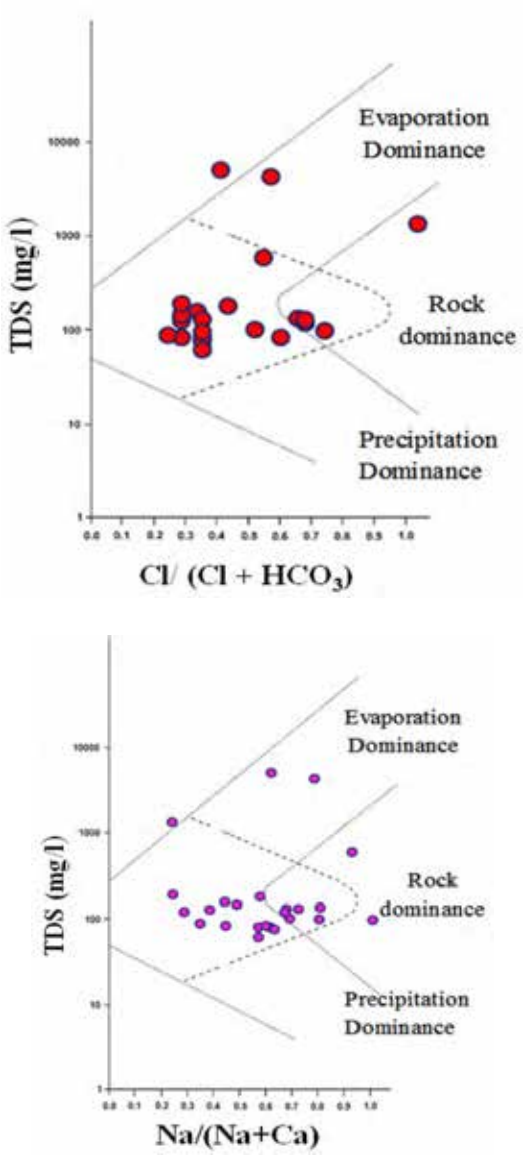


Fig. 3.4.4.1: Gibb's diagram showing the dominance of water-rock interaction on river water.

https://doi.org/10.1007/978-3-030-68124-1_16

Dr. A. Krishnakumar and Dr. K. Anoop Krishnan

3.4.5 Response surface modeling of Orange-G adsorption onto surface tuned ragi husk

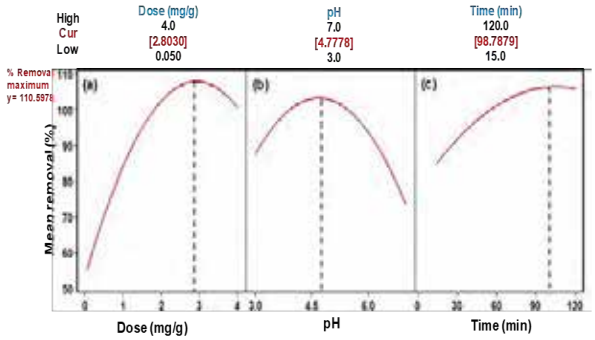


Fig. 3.4.5.1: Response optimization plots for the adsorption of Orange-G dye by FMRh.

The study describes a sustainable way of approach in containing dye pollution in surface water systems. An active formaldehyde modified ragi husk (FMRh), a bio-adsorbent was prepared and effectively managed to adsorb Orange-G from aqueous phase. Response surfaces were created to evaluate the adsorption process and the optimization of experimental data using ANOVA statistics to achieve 100 % removal efficiency of Orange-G with FMRh. The kinetic and equilibrium data were well fitted with pseudo-second-order and Langmuir isotherm models (Fig. 3.4.5.1). The Orange-G adsorption onto FMRh was spontaneous and exothermic in conformity with thermodynamic analysis.

The FTIR and SEM analysis of the FMRh conforms the changes of pre as well as post adsorption phenomenon leads to the successful insertion of Orange-G on the bio-adsorbent. The Orange-G uptake can be preferably attributed to a kinetically driven mechanism and the product of surface complexation holds the dye with the FMRh active centers.

https://doi.org/10.1016/j.colcom.2021.100363

Dr. K. Anoop Krishnan

3.4.6 Zwitterion-chitosan bed for the simultaneous immobilization of Zn(II), Cd(II), Pb(II) and Cu(II) from multi-metal aqueous systems

The present-paper describes the synthesis, characterization, and application of a grafted adsorption bed material namely carboxylate

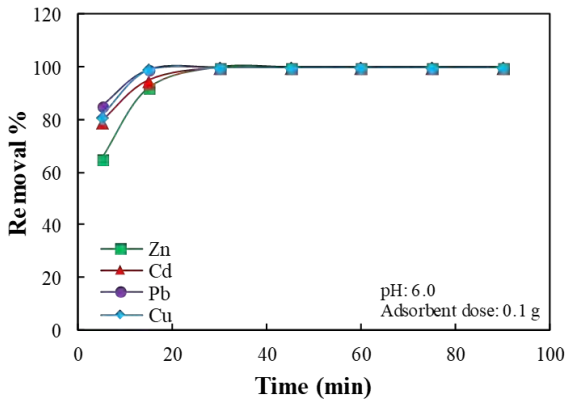


Fig. 3.4.6.1: Adsorption capacity CFCCP-COOH for real water systems up to 50 ppm.

functionalized chitosan copolymer (CFCCP-COOH). The material was synthesized by expanding the landscape of chitosan through co-grafting glycidyl methacrylate with methacrylic acid. The -COOH group introduced trough grafting imparted a zwitterionic nature to the chitosan copolymer which resulted in greater adsorption capacity of the material. The surface of CFCCP-COOH was profiled by XPS, XRD, CHNS Analyzer, Surface Area Analyzer, Zetasizer, and FTIR. A wide spectrum of batch-adsorption studies was carried out for optimizing the conditions for effectively removing heavy metals using CFCCP-COOH from water and wastewaters. In a multi-metal system, for an initial adsorbate concentration of 150 mg/L of each adsorbing ions, CFCCP-COOH maintains an adsorption capacity of 92.27, 108.42, 127.91 and 123.50 mg/g in removing Zn(II), Cd(II), Pb(II) and Cu(II), respectively at pH 6.0 (Fig. 3.4.6.1). The conditions for the Pb(II) adsorption was optimized through response surface methodology (RSM) in view of pH (4.0 to 7.0), adsorbent dose (1.0 to 5.0 g/L) and time (1 to 60 min) at constant temperature of 40°C and initial adsorbate concentration of 25 mg/L. The equilibrium and kinetic data showed good regression with Langmuir isotherm and pseudo-second-order kinetic models, respectively. The CFCCP-COOH was feasibly applied in the treatment of wastewater streams.

https://doi.org/10.1016/j.jclepro.2020.120309

Dr. K. Anoop Krishnan

3.4.7 Environmental influences on zooplankton diversity in the Kavaratti lagoon and offshore, Lakshadweep Archipelago, India

The study summarizes the influences of environmental parameters on zooplankton abundance and distribution pattern of lagoon and offshore waters of Kavaratti Island. It was

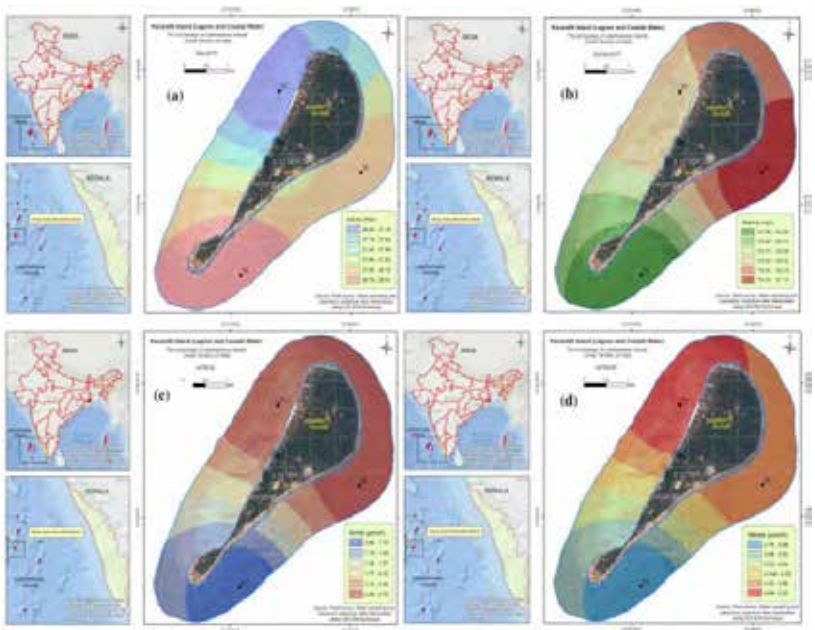


Fig. 3.4.7.1: Spatial interpolation diagram of changes in physicochemical parameters (a) Salinity (b) Alkalinity (c) Nitrite (NO) (d) Nitrate (NO).

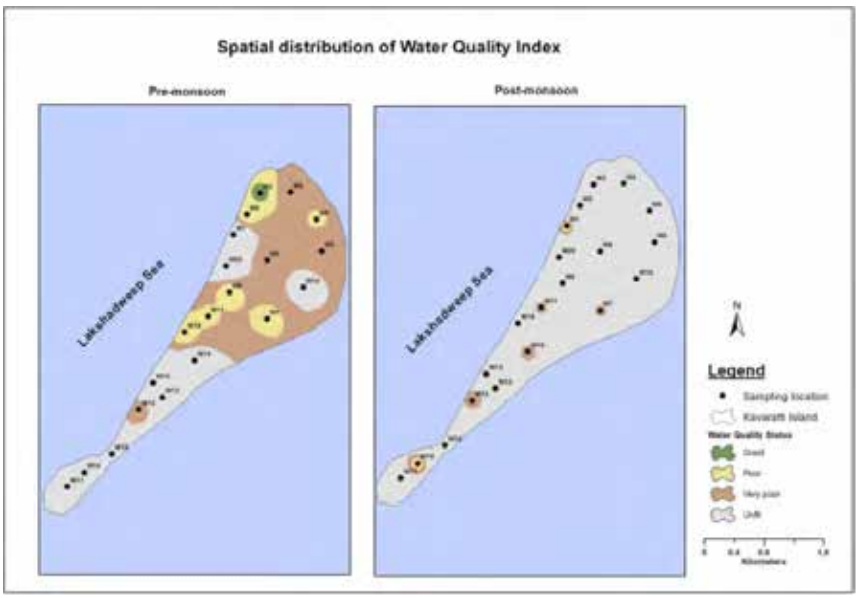


Fig. 3.4.8.1: Spatial distribution map of water quality index in Kavaratti ground water samples.

observed that lagoon ecosystem of Kavaratti atoll is rich in species diversity and composition. The nutrient status was high enough to support the zooplankton community. The study revealed that the zooplankton organism is unique indicators of the pollution status and aquatic ecosystems. Copepods were the most abundant zooplankton group observed during the study from all the stations. The concentration of chlorophyll-a was found to be higher in the surface of lagoon water, which indicates the nutrient enrichment, as well as eutrophic condition of the marine environment. Assemblages of zooplankton in the lagoon region also indicate that the environmental stress on the aquatic ecosystem in responses to natural and anthropogenic disturbances. Highly positive significant correlation of environmental parameters with the zooplankton taxa was found in the study. The composition and distribution of the zooplankton community were locally controlled 0by environmental parameters (Fig. 3.4.7.1) such as salinity, water temperature, DO, silicate, nitrite, and phosphate. It was found that the quality of lagoon water diminished and the extent of pollution would be gradually moved towards the offshore region around the Kavaratti atoll. The study also points out that increased population growth and anthropogenic input in the island was increased which enhances the change of water quality and distress in aquatic health as well as the health of coral reef ecosystem. Therefore, it was proposed that, a managerial action plan needed to reduce the human-induced pressure on the lagoon ecosystem especially in coral reef and lagoon of the Kavaratti atoll.

https://doi.org/10.1016/j.rsma.2020.101330

Dr. S. Kaliraj and Dr. K. Anoop Krishnan

3.4.8 Seasonal variability of groundwater quality in coastal aquifers of Kavaratti Island, Lakshadweep Archipelago, India

Lakshadweep Archipelago is comprised of several tiny coral atolls and scattered in the Arabian Sea off the south-west of India. Ground water is the only available fresh water resource for the islanders. For this study, a total of 20 groundwater samples (Fig. 3.4.8.1) were collected randomly from the open wells that cover the entire area of the island. The physico-chemical parameters of groundwater were analyzed in pre- and post-monsoon seasons during the year 2016–2017.

The concentration of a majority of the chemical constituents exceeds the standards of WHO during post-monsoon than pre-monsoon season. EC content exhibited the violation of drinking water quality standards and the

highest value of EC ranges 1023–6874 µS/cm recorded. TDS concentration range from 574.6 to 1503.4 mg/L and 665–4468 mg/L in pre- and post-monsoon seasons respectively. Gibb's plot revealed that the evaporation is the dominant factor controlling the mechanism of ground water hydrochemistry. The water quality index suggested that both pre-monsoon and post-monsoon around 93.95% of the samples are unsuitable for drinking purposes. The suitability of groundwater for irrigation was studied by calculating the percent of sodium, sodium adsorption ratio, magnesium hazard and Reveille's index. The Wilcox and USSL plots also indicated that most of the groundwater samples were found to be unsuitable for irrigation. HFE diagram productively delineates that groundwater of the study area has strong influence of sea water in the fresh water aquifers. The highest level of significant correlation was observed between Mg-TH ($r^2 = 0.87$), EC-TDS ($r^2 = 0.86$), and Cl–Na ($r^2 = 0.77$) respectively. As a whole, it is observed that the groundwater is not suitable for drinking, irrigation and industrial purposes due to the exceeding of chemical parameters from their standard limits. Therefore, groundwater management measures may be worked out regionally to improve water quality by artificial recharge, rain water harvesting, periodic disinfection of the wells and saving the fresh water stocks in the island accordingly.

https://doi.org/10.1016/j.gsd.2020.100377

Dr. S. Kaliraj and Dr. K. Anoop Krishnan

3.4.9 Assessment of urban river water quality and developing strategies for phosphate removal from water and wastewaters: Integrated monitoring and mitigation studies

In this work, the water quality status of the surface water that lies around the Karamana river basin, Trivandrum urban area was studied on the basis of the water quality index (WQI) method. The eutrophic condition of the basin is revealed, and proper mitigation strategy was adopted for the removal of phosphate species using pillared clay materials. Proper sampling was carried out in the urban rivers, and various physico-chemical parameters for evaluating the quality of water. WQI values obtained for these riverine systems are in the range 317.7–3005.1, indicating that the water is not suitable without treatment for any domestic activities. Also, phosphate ions in the range 1.98–20.52 mg/L reflect the dominance of phosphate species in surface water. A proper mitigation strategy was adopted for the selective removal of phosphate ions using adsorption technique by using zirconium-pillared bentonite clay (ZPBC) prepared by the stirring–ageing technique.

The batch adsorption experiment performed on simulated phosphate solution shows that for 2.0 g/L of ZPBC a maximum phosphate adsorption capacity of 35.71 mg/g was achieved in 30 min at pH 3.0. The data obtained were used to study models in kinetics and isotherm (Fig. 3.4.9.1).

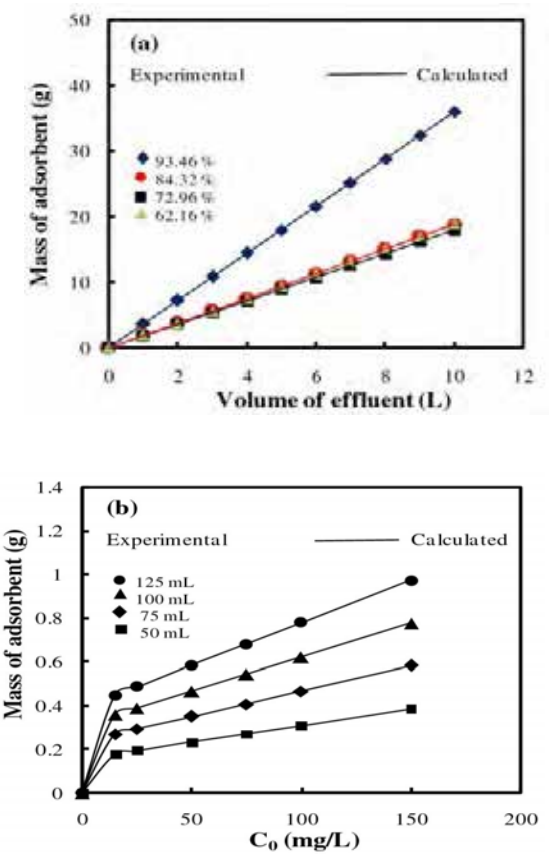


Fig. 3.4.9.1: (a) Mass of adsorbent ZPBC against different volumes for different percentage removal of phosphate ions and (b) mass of adsorbent ZPBC against different initial concentrations and different volumes for removal of phosphate ions from aqueous solutions.

The reusability of spent ZPBC for five continuous cycles without major loss in adsorption capacity using 0.025 M Na_2CO_3 extractant was proved from the desorption study. A single-stage reactor was also designed from the isotherm data and proved to be effective. The applicability of the adsorbent towards phosphate anions was successfully checked in the laboratory using surface water collected and found that the complete removal of phosphate was achieved using 6.0, 8.0 and 10.0 g/L of ZPBC.

https://doi.org/10.1007/s42452-020-2571-0

Dr. K. Anoop Krishnan

3.4.10 Export of particulate organic carbon by the mountainous tropical rivers of Western Ghats, India: Variations and controls

Global rivers transport biogeochemical fluxes from continents to the oceans realm and are connecting three large carbon pools of the planet viz. soil, atmosphere and ocean and affects the atmospheric carbon inventory over a broad range of timescales. Organic carbon (OC) transported by rivers act as one of the primary food sources for the aquatic and marine organism and these inputs are essential for improving the scientific understanding of how terrestrial contributions influence biogeochemical cycles and food-webs in the coastal waters. Rivers transport OC both in dissolved (DOC), and particulate (POC) forms, collectively termed as total organic carbon (TOC). Most of the regional and global-scale empirical studies dealing with the POC transport face problem of the inadequate representation of data of rivers draining different climate zones and catchment sizes especially small mountainous rivers. Transport of organic carbon by small mountainous rivers is essential, but the poorly constrained component of the global carbon cycle. In the current context, an extensive seasonal sampling of 70 sizeable tropical coastal rivers, draining the Western Ghats (WG) of India was carried out to analyze the particulate organic carbon (POC) contents form these rivers. This study aimed

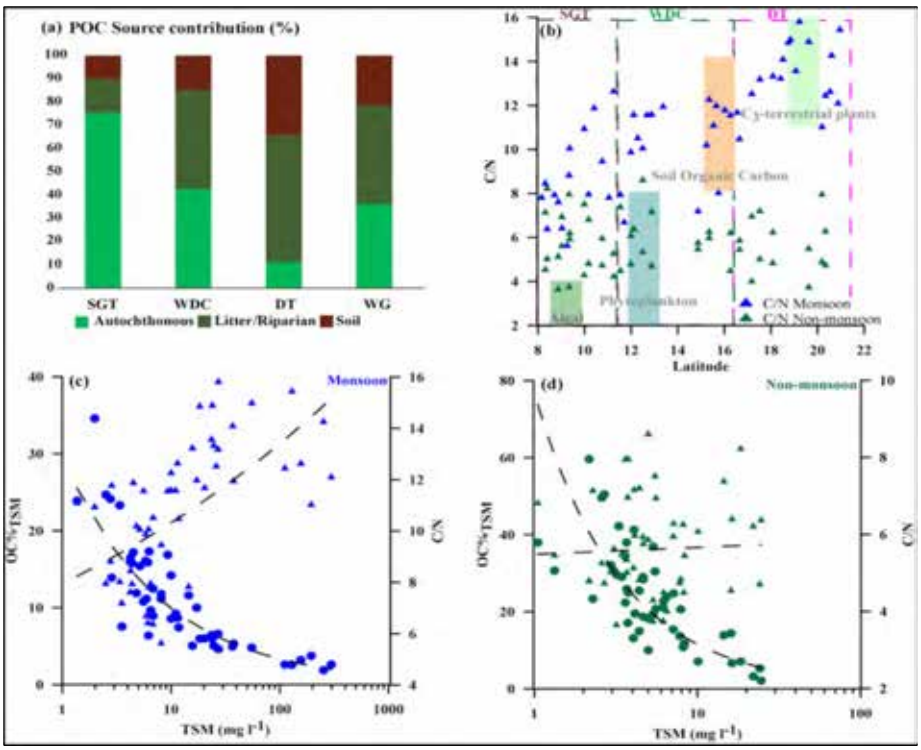


Fig. 3.4.10.1: (a) Relative distribution of source of POC pools for the SGT, WDC, DT blocks and the entire Western Ghats; Characterizing POC pools through C/N ratios, (b) distribution of C/N ratios of autochthonous to allochthonous pools; TSM vs OC%TSM a and C/N plots for (c) monsoon and (d) non-monsoon seasons.

to investigate the spatiotemporal variability in POC contents, to estimate flux and to identify environmental controls on POC sources and transport characteristics across the region. The results suggests that, WG region approximately covering 0.25% of Asia's land area exports 0.79 Tg of POC to Arabian sea and hence contributing to the 1% of Asia's riverine POC flux to the oceans. The averaged value of organic carbon (OC) in the particulate samples is 3.24%, and the mean POC concentration is 2.86 mg/L (Fig. 3.4.10.1). For source appropriation samples were classified based on total suspended matter (TSM) and the C/N ratios of POC samples (Fig. 3.4.10.1). Among the total transports of POC, Litter/riparian (42.5%) pools are the largest source of organic matter, followed by autochthonous (36%) and soil (21.5%) for the WG region. However, locally autochthonous sources contribute exceptionally to POC pools, indicating a favorable environmental condition for the growth of algae and phytoplankton which is in contrast to historical studies reporting the contribution of the autochthonous sources for the global rivers to be between 8 and 28% of POC. Thus, current study highlights the dominance of primary production in the POC pool in coastal tropical environments. This study demonstrates the influence of various environmental parameters on the origin and supply of POC fluxes at catchment scales (hydrological, climatological, physical characteristics of catchment, land-use), in-stream processes (aquatic primary production, sediment deposition, and remobilization etc.). This study also highlights the need of comprehensive source to sink investigations to provide detailed descriptions of how riverine carbon dynamics affected by inputs, in-stream transformation, and deposition.

https://doi.org/10.1016/j.scitotenv.2020.142115.

Shri. Badimela Upendra

3.5 Marine Geoscience Group

3.5.1 Influence of Intra-seasonal Oscillations on the surface current along southwest coast of India

Seasonal variations in tropical intra-seasonal oscillations (ISO) have been reported earlier by several researchers. Studies showed that there existed a distinct propagation pattern during boreal winter and boreal summer. The Bimodal ISO index comprising of two modes viz. Madden-Julian Oscillation (MJO) and Boreal Summer Intra-Seasonal Oscillation (BSISO) is used to represent the state of ISO at any particular time of a year. Of the two modes, the MJO has a prominent eastward propagation of active and suppressed convection along the equator. In the case of BSISO, a prominent northward propagation (30-60 days) is observed in the Indian Ocean and westward propagating 10-20 day mode in the northwestern tropical. BSISO which is prominent during June-October, has significant influence on the short-term climate variability in the Asian Summer Monsoon and is of more complex nature compared to MJO.

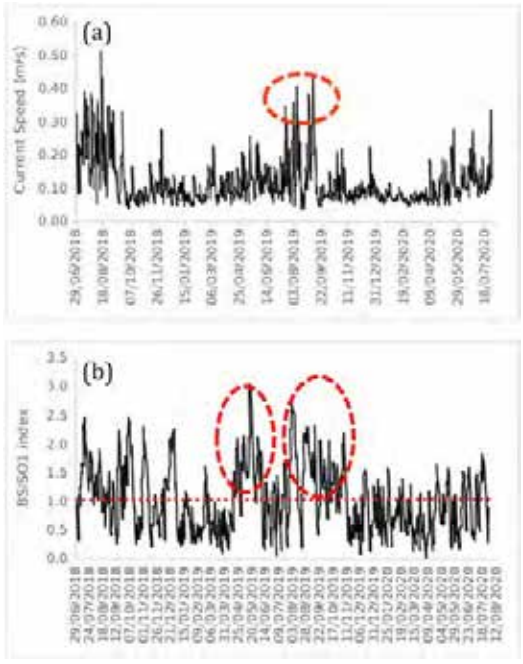


Fig. 3.5.1.1: (a) Time series of current speed in m/s off Trivandrum from wave rider buoy with acoustic current meter, (b) BSISO1 Index (Lee et al., 2013) during the period of 1st July 2018 to 31st July 2020.

The MJO mode is represented by Real-time Multivariate MJO (RMM) index developed by Wheeler and Hendon (2004) and is widely used. Later Lee et al. 2013 improved the RMM index for real-time monitoring and prediction of the BSISO by suggesting two real-time indices - BSISO1 and BSISO2. This newly defined indices are based on multivariate empirical orthogonal

function (MV-EOF) analyses of daily anomalies of outgoing long-wave radiation (OLR) and zonal wind at 850 hPa (U850) in the region 10°S–40°N Lat., 40–160°E Long. for the extended boreal summer season (May–October) over a period of 30-years (1981–2010). These two indices proposed by Lee et al., 2013 represent the northward and northwestward propagation characteristics better than the RMM index of Wheeler and Hendon. For the present study, the BSISO1 index defined by the first two principal components of the MV-EOF analysis is used.

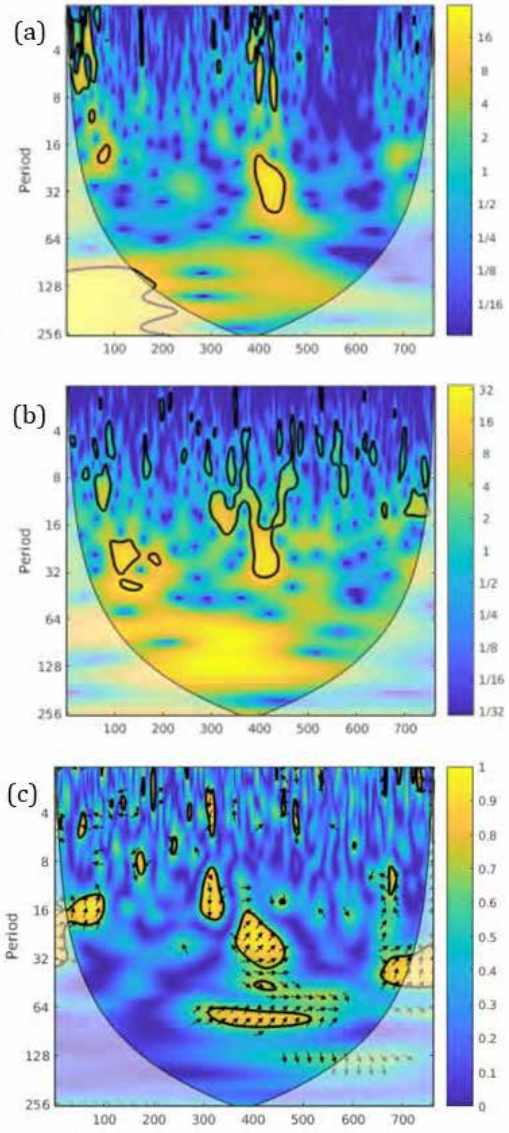


Fig. 3.5.1.2: Wavelet analysis of (a) current speed, (b) BSISO1 Index of Lee et al., 2013 and (c) wavelet coherence analysis of measured current speed and BSISO1 Index. The period considered for the analysis is from 1st July 2018 to 31st July 2020.

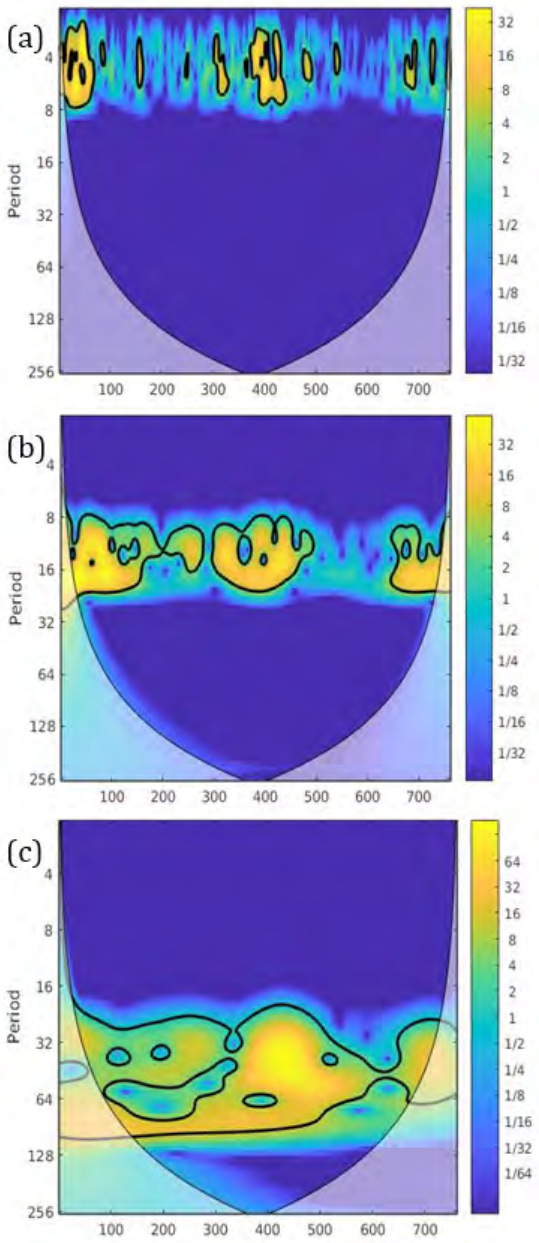


Fig. 3.5.1.3: Band-pass filtered current speed (using 6th order Butterworth filter), showing (a) 3-7 days synoptic oscillations, (b) 10-20 days quasi-biweekly oscillations and (c) 30-90 days oscillations. The period considered for the analysis is from 1st July 2018 to 31st July 2020.

In order to study the influence of BSISO1 mode on the surface current, measured current parameters from the wave rider buoy with acoustic current meter, deployed off Trivandrum at 20 m water depth (Lat.: 8° 27.681' N, Long.: 76° 55.262' E) was used. Continuous 10 minutes interval 2-year current data from the current

meter buoy (1st July 2018 to 31st July 2020) has been processed and analysed. The current speed is showing variations with a maximum speed of 0.45 m/s during the period of July-August 2019 which is shown as red dotted circle in Fig. 3.5.1.1.a. The BSISO1 Index by Lee et al., 2013 during the same period is shown in Fig. 3.5.1.1.b.

Wavelet analysis of daily averaged current speed shows an oscillation of 20-50 days during the period of July-August 2019 (Fig. 3.5.1.2.a). The thick black line gives 5 % significance level (i.e., 95 % confidence level) for the observed parameter and the thin black line indicates the cone of Influence. The BSISO1 Index for the same two-year period when subjected to wavelet analysis, also shows a similar oscillation pattern (Fig. 3.5.1.2.b). Results of the wavelet coherence analysis for the same is shown in Fig. 3.5.1.2.c, where the vectors indicate the relative phase difference and the colour represent the strength of coherence. The coherence analysis clearly shows oscillation for the same period but with a phase lag in the BISISO1 component.

For detailed study of the oscillation pattern, bandpass filtering of current speed is carried out by using 6th order Butterworth filter considering 3 different time scales i.e., 3-7 days synoptic oscillations, 10-20 day quasi-biweekly oscillations and 30-90 days intra-seasonal oscillations (Fig. 3.5.1.3 a-c). The filtered current speed shows the influence of both synoptic scale oscillations and stronger quasi-biweekly mode, that is evident during the boreal summer monsoon period. Further analysis is in progress to establish the influence of the ISO using the OLR anomaly and zonal wind (at U850 hpa).

3.5.2 Observation of extended isothermal layer variability over the Alleppey Terrace region in the coastal ocean along the south eastern Arabian Sea

The Lakshadweep Sea located off the southwest coast of India is considered as one of the most dynamic regions of the Indian Ocean and this can be attributed to the confluence of Arabian Sea, Bay of Bengal, and the Equatorial Indian Ocean waters. In addition, several other observed phenomena such as presence of warm pool, cold pool, barrier layer, sub-surface thermal inversion, differential warming of layers, vortex formation related to monsoon onset etc. contribute to the complexity in the oceanic and atmospheric processes in this region. The presence of Alleppey Terrace (AT), a unique bathymetry feature which exists as an anomalous protrusion in the form of a terrace like feature in the mid-continental slope off the south west coast of India adjoining the eastern boundary of the Lakshadweep Sea, may also have significant influence on the oceanic processes. In spite of the huge lateral extent (>35000 sq.km) and its unique position, the AT is the only such anomaly observed along the entire west coast of India. The ocean dynamics in this region being very complex, related studies are sparse mainly because of the limitation in getting site specific primary data.

The transfer of mass, momentum, and energy across the mixed layer provides play dominant role on the observed oceanic motions. The thickness of the mixed layer determines the heat content and mechanical inertia of the layer which directly interacts with the atmosphere. The changes in salinity and temperature alter the heat and salt budgets of the region. For in-depth understanding of the dynamics of this region and to throw some light on the underlying processes by identifying the main driving forces, NCESS had conducted a research expedition onboard Sagar Kanya (SK 362) during 7th October to 5th November, 2019. As part of this scientific cruise, in-situ CTD data were collected at 53 stations covering 8 transects as shown in Fig. 3.5.2.1. Some of the preliminary findings obtained from the measurement are presented here.

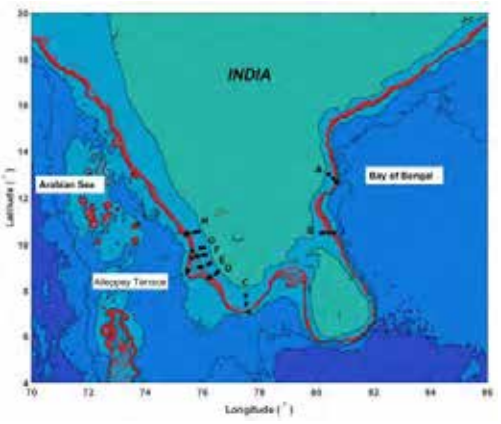


Fig. 3.5.2.1: Study area map showing the CTD profile stations.

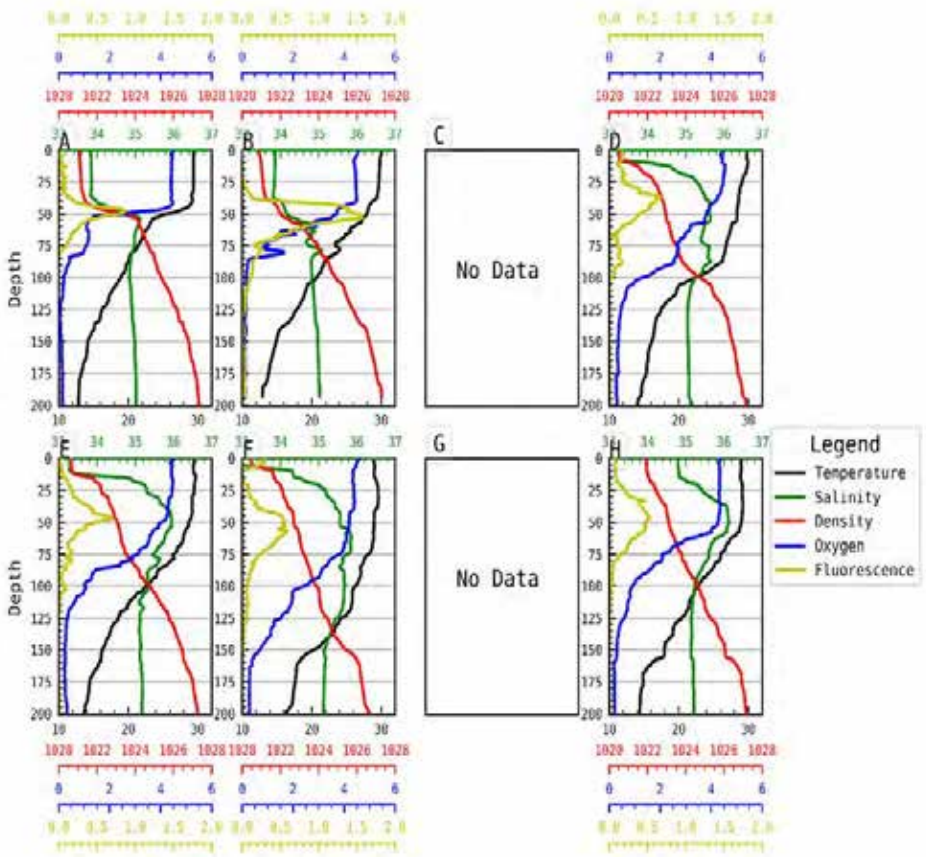


Fig. 3.5.2.2: Vertical profiles of parameters measured at 200 m depth contour.

Significant variations in temperature observed at about 200 m depth contour at stations A (Bay of Bengal (BoB) and H. The vertical profile measurements of various oceanic parameters at 200 m depth contour are presented in Fig. 3.5.2.2. The minimum Isothermal Layer Depths (ILD) are observed at Station A which is located in the BoB and at station H (located North of Alleppey terrace) in the Arabian Sea (AS). The region lying between Stations D and G shows an increasing trend in ILD, particularly between Stations D and F, with a maximum at Station F and then decreases towards the northern side of the Alleppey terrace. From the measurements, it can be inferred that the presence of Alleppey terrace in the region between stations D and H, has contributed to the increase in the Isothermal Layer Depth (ILD) and subsequent shifting of the thermocline towards the deeper region around the Alleppey Terrace. Similar variations are observed in the primary analysis of data pertaining to other parameters such as Salinity, Oxygen and Florescence which substantiates the fact that the Alleppey Terrace in the SE Arabian Seas plays a dominant role in the vertical extension of the scalar parameters towards deeper region in the coastal ocean.

3.5.3 ENSO modulated nearshore hydrodynamics along the SW coast of India

The wave pattern along the SW coast of India exhibits large inter-annual variability. Of the various factors that contribute to the variability, the El Niño–Southern Oscillation (ENSO) is be considered as one of the major factors. To study the influence of ENSO on the coastal wave pattern, the 42-year re-analysis data from ERA-5 (from 1979 -2020) along with the measured directional wave data from a wave rider buoy (WRB) deployed at 20 meter off Valiyathura in Trivandrum and the short-term longshore current from a Recording Current Meter (RCM) installed at 2-meter water depth were analysed.

The significant wave height (H_s) anomaly observed along the SW coast of India has

positive correlation with the La Niña years and vice versa for El Niño years. For detailed study, the data pertaining to relatively strong El Niño years - 1983, 1987, 1997 and 2015 as well as the La Niña years - 1989, 1996, 1999 & 2010 during the 42-year period from 1979 to 2020 were analysed. The anomalies in H_s for the selected years are as shown in Fig. 3.5.3.1. The correlation analyses carried out using the yearly averaged wind sea and swell wave heights along with the Niño3 index at selected locations (6 locations around southern tip of India and Sri Lanka) for a period of 42 years indicate negative correlation (-0.4 to -0.5) for wind sea wave height whereas the swell wave height has weak correlation (0 to -0.2). From the analyses results it can be concluded that during the El Niño years, H_s shows negative anomaly over the southern tip of the Indian peninsula and also over south of Sri Lanka whereas it is just the reverse in the case of La Niña. The anomaly in H_s can be attributed to the changes in wind sea wave height forced by the local wind conditions during both positive and negative phases of ENSO.

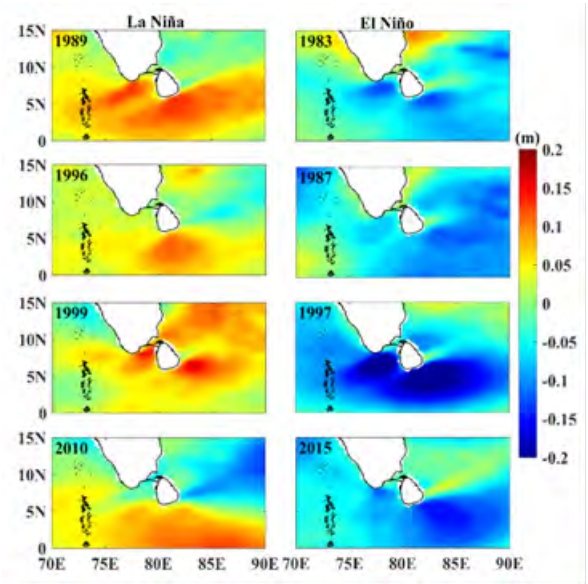


Fig. 3.5.3.1: Significant wave height (H_s) anomaly during the strong La Niña (left panel) and El Niño (right panel) years.

The SW coast of India, being a micro tidal region shows characteristics of a typical wave dominated coast and this makes it distinct from other locations along the west coast of India which fall under the meso and macro tidal classification. The measured longshore current at 2 m water depth (from RCM) and the H_s at 20m water depth (WRB data) off the Valiyathura coast gives clear indication that the observed currents are predominantly wave induced. Since the wave induced currents, particularly the longshore play a major role in the nearshore hydrodynamics, the observed interannual variability or anomaly in the significant wave height can influence the nearshore currents as well as the sediment transport in the region. This in turn can affect the shoreline dynamics which is a deciding factor for assessing the stability of the coast depending on the erosion/accretion pattern. In order to establish the relation between the longshore currents and the shoreline stability, further analyses based on numerical modelling studies using Delft3D has been initiated. For validation of the model results, a new set of hydrodynamic data collection pertaining to the nearshore region is planned.

3.5.4 Development of video monitoring system for coastal applications

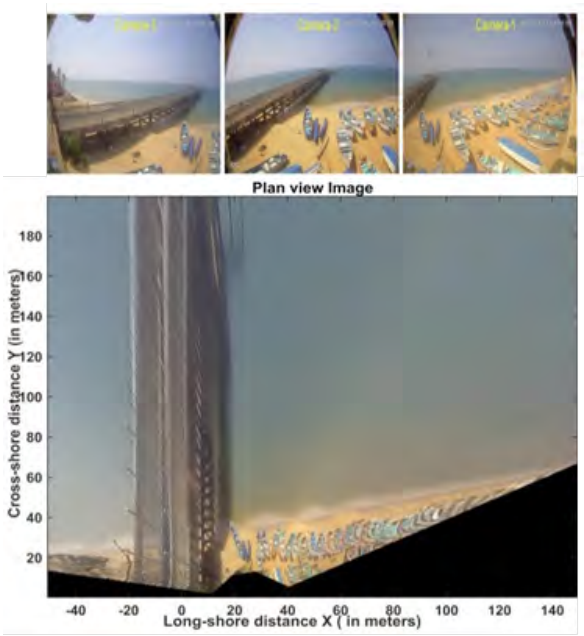


Fig. 3.5.4.1: Planview image generation from Timex images.

Development of a new Video Beach Monitoring System for India has been initiated with the installation of the first pilot camera station at Valiyathura beach, Trivandrum

coast. The integrated video monitoring station at Valiyathura with three cameras, uses the processing tools developed inhouse for deriving the parameters like beach width, surf zone and swash widths, wave run up, etc. Data processing involve generation of image products such as Timex images, Variance images and pixel products from the recorded videos. Open-source toolboxes are used for camera calibration, geo rectification and planview generation (Fig. 3.5.4.1). The rectified Timex images are further analyzed using image processing tools for computation of parameters like beach width, surf zone width, wave run-up. and the results have been successfully validated (Fig. 3.5.4.2) with field measurements (good correlation of 90%). The validated set of data is being used to derive the relation between wave parameters and wave run-up for beaches falling under different wave energy regimes.

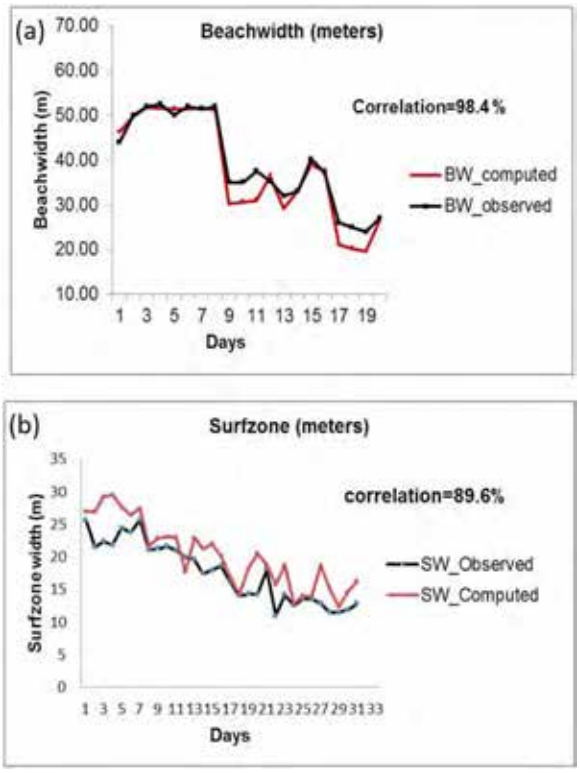


Fig. 3.5.4.2: Validation of video derived parameters (a) Beach width and (b) Surfzone width.

New modules and installation of VBMS station: The fourth VBMS station was installed at Kovalam, Trivandrum during March 2021 to monitor the occurrence of rip currents as this location is prone to rip currents which can be fatal. The VBMS Kovalam is an advanced system fully solar powered with one optical camera and facility for real time data transfer to the shore station at NCESS. As part of the VBMS based rip current study, an algorithm for automatic extraction of swash extensions from timestack images is developed and being tested.

https://doi.org/10.2112/SI89-020.1

Shri. Ramesh Madipally

3.5.5 Submarine Groundwater Discharge

Fig. 3.5.5.1: Schematic representation of important natural biogeochemical reactors that attenuate nitrogen pollution and modify N/P ratios associated with submarine groundwater discharge.

The behaviour of Subterranean estuary at Varkala SGD zone was investigated under SGD Project, using flux measurements and stable isotopes. Tropical urbanized coastal regions are hotspots for the discharge of nutrient-enriched groundwater, which can affect sensitive coastal ecosystems. Fresh groundwater was highly enriched in NO_3 from sewage or manure. Submarine groundwater discharge and nearshore groundwater discharge were equally important contributors to coastal NO_3 fluxes with 303 mmol NO_3 $m^{-1}day^{-1}$ in submarine and 334 mmol NO_3 $m^{-1}day^{-1}$ in nearshore groundwater discharge. However, N/P ratios in nearshore groundwater discharge were up to 3 orders of magnitude greater than that in submarine groundwater, which can promote harmful algae blooms. As groundwater flowed through the beach, N/P ratios decreased toward Redfield ratios due to the removal of 30−50% of NO_3 due to denitrification and production of PO_4 due to mineralization of organic matter. Overall, tropical beaches can be important natural biogeochemical reactors that attenuate

nitrogen pollution and modify N/P ratios in submarine groundwater discharge.

Tropical Beaches Attenuate Groundwater Nitrogen Pollution Flowing to the Ocean. Till Oehler, Murugan Ramasamy, Mintu E. George, Suresh Babu D.S., Kirstin Dähnke, Markus Ankele, Michael E. Böttcher, Isaac R. Santos, and Nils Moosdorf. Environ. Sci. Technol. 2021, 55, 8432−8438. https://doi.org/10.1021/acs.est.1c00759

3.6 Atmospheric Science Group

3.6.1 Assessment of boundary layer parameterization schemes during a land depression over Central India

Planetary Boundary Layer (PBL) is the lowest part of atmosphere, which is directly influenced by the Earth's surface. It directly influences surface ecosystem and act as a buffer zone for the exchange energy and moisture between Earth's surface and free atmosphere. The study examines the performance of boundary layer parameterization schemes in Weather Research and Forecasting (WRF) model during a cyclonic storm/depression. A land depression was formed as an upper air cyclonic circulation over the northeast Bay of Bengal (BoB) on 19th July 2014, induced a low-pressure area over the Gangetic West Bengal and Odisha with associated cyclonic circulation extending up to 7.6 km on 20th July. The system stayed as depression during 21–23rd July. We investigated the surface and boundary layer features during 14–23rd July to understand the characteristics prior to the landfall of the depression and during its progression over land. The WRF version 3.6 mesoscale model developed by the National Center for Atmospheric Research (NCAR) was used for the study. The model is initialized at 00 UTC on 13th July 2014 and simulations were carried out for 10 days and 12 hours. National Center for Environmental Prediction - National Center for Atmospheric Research (NCEP-NCAR) Final global reanalysis (FNL) was used to provide initial and lateral boundary conditions. The daily rainfall recorded at the India Meteorological Department (IMD) meteorological station nearest to the experimental site during the wet period 13–23 July 2014 showed the incidence of precipitation from 16th July onwards with rainfall above 8 cm on 21st July. The chosen period includes dry days from 13th to 16th July without rainfall, which is corresponding to the break in active transition phase of the monsoon, as evident from the IMD report as well as from the spatial distribution of rainfall obtained from satellite data sources. The model simulation shows that out of the six schemes, ACM2 and MYNN2 scheme temperatures are better compared with the observation (Fig. 3.6.1.1.a). The above results indicate that simulations from the PBL schemes are generally poor in the presence of clouds and precipitation. One possible reason could be that the clouds are not adequately simulated in the model, as inferred from the large differences seen between the observed and simulated shortwave and longwave radiation components. Overall, the model comparisons showed positive biases in the surface air temperature and wind speed and negative biases in the water vapor, which persisted throughout the simulation for all six PBL schemes.

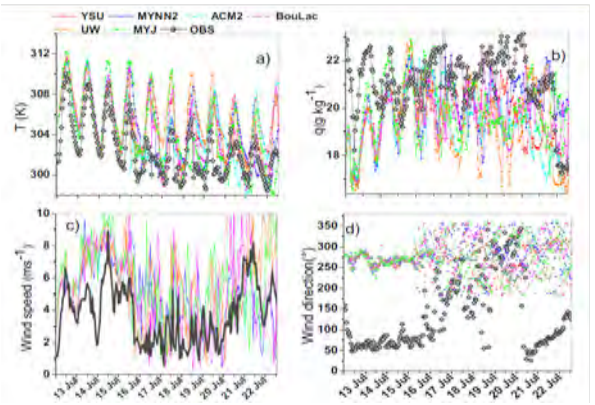


Fig. 3.6.1.1: Comparison of the diurnal variation of model-simulated (6 PBL schemes) and tower observed: (a) air temperature (T), (b) mixing ratio (q), (c) wind seed, and (d) wind direction for 13th July to 23rd July 2014, starting at 00 UTC.

This work was done in collaboration with Anusha Sathyanadh, Thara V. Prabha, Subharthi Chowdhuri, B. Balaji, and Anandakumar Karipot (IITM and Savitribai Phule Pune University). https://doi.org/10.1007/s00704-021-03532-0.

Dr. E. A. Resmi

3.6.2 A study on cloud cover in South India

Clouds in the atmosphere play a key role in Earth's energy and water budgets. This study examines the cloud cover changes in two nearer and distinct locations in south India, one near-coastal region in Thiruvananthapuram and the other in Southern Western Ghats at Rajamalay,

Munnar. The study validated the following reanalysis product with Lufft Cloud Height Meter (CHM) 15k Ceilometer observations in both the locations during 2017: ECMWF Reanalysis (ERA)-5, ERA-Interim and Modern Era Retrospective-Analysis for Research and Applications (MERRA)-2 reanalysis data. ERA5 daily cloud cover data has the lowest Root Mean Square Error (RMSE) (20%) than the other reanalysis datasets.

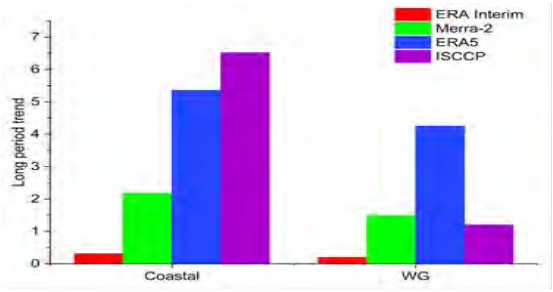


Fig. 3.6.2.1: Long term trend in cloud cover in coastal and Western Ghats locations for different reanalysis and observational data sets.

Correlation between daily ceilometer cloud cover observation and reanalysis datasets shows that ERA5 data has better temporal cloud cover anomaly (0.8) at Rajamalay in southern Western Ghats. All reanalysis datasets show significant correlation (0.01 level) with the ceilometer observations. RMSE (correlation) is higher (lower) in coastal region. Further, a long period cloud cover trend (1985-2016) in both the locations is calculated from multiple reanalysis and International Satellite Cloud Climatology Project (ISCCP) cloud datasets. All these datasets show a consistent and significant (0.01 level) increasing cloud cover trend in both the locations (Fig. 3.6.2.1). ISCCP cloud amount shows the highest increasing trend compared to reanalysis datasets (5.9%). In the coastal location, the cloud cover trend is much higher and all the datasets agree well within it. A long period correlation analysis is performed between cloud cover variability in the study region and north Indian ocean Sea Surface Temperature (SST) to understand their relation. Bay of Bengal SST is highly positively correlated with the cloud cover in the study region (significant at 0.01 level). This suggests that the observed increase in cloud cover has a strong bearing on the north Indian Ocean warming.

https://doi.org/10.5194/egusphere-egu2020-7911

Dr. C. K. Unnikrishnan

3.6.3 Satellite-observed lightning hotspots in India and lightning variability over tropical South India

Lightning characteristics in India are examined

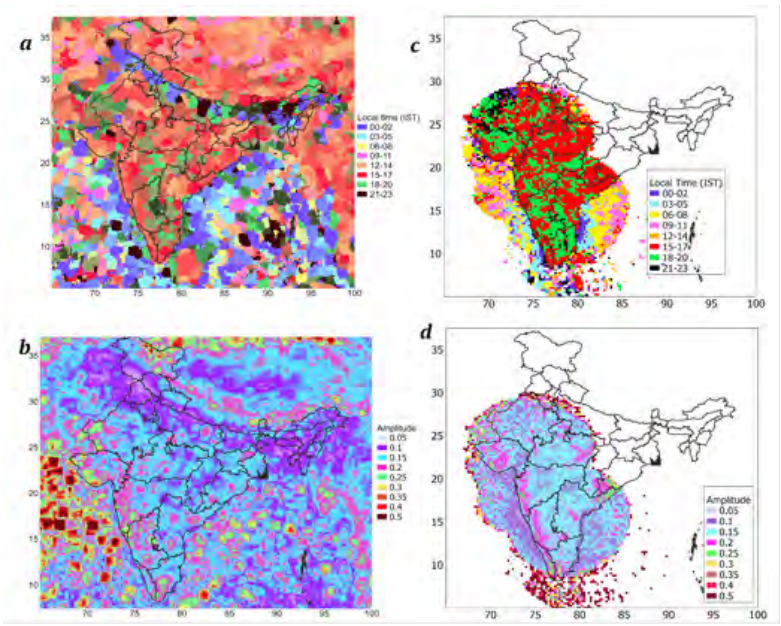


Fig. 3.6.3.1: (a) The phase angle (hour of maximum lightning occurrence) (b) amplitude by diurnal Harmonic analysis on LIS high resolution hourly lightning climatology. (c) phase angle (d) amplitude explained by diurnal Harmonic analysis in ILDN data (2014-2016).

with satellite-based Lightning Imaging Sensor (LIS) and ground-based Indian Lightning Detection Network (ILDN). LIS observations indicated that synoptic weather systems are the major contributors of lightning in India, especially in frequently lightning-hit areas (i.e., lightning hotspots) of the country. Western disturbances (mid-tropospheric systems with extratropical origin) are the greatest contributor of lightning in the Himalayas (93%), whereas tropical cyclonic storms and low-pressure systems (oceanic in origin) are the key lightning contributors in parts of eastern India (43%). The lower tropospheric troughs contribute lightning in other hotspots in the country. This study, for the first time, reported the occurrence of significantly high lightning activity before active monsoon spells in the Central Indian region (65-87° E, 18-27° N). Therefore, there is a need to further examine the possibility of using satellite-based lightning observations in the reliable prediction of monsoon spells. Harmonic analysis was used to study diurnal lightning-flash density. The maximum observed standardized diurnal amplitude of lightning activity was 0.35, and maximum explained diurnal variation was 15%. Also, we compared the ILDN data and LIS observations, and found good agreement regarding lightning variability. LIS data showed an increase in annual lightning activity in tropical South-western India (SWI), and the results also suggested that during El Niño and negative Indian Ocean Dipole periods, SWI experiences above-average lightning activity.

This work was done in collaboration with Sunil Pawar and V. Gopalakrishnan (Indian Institute of Tropical Meteorology, Pune).

https://doi.org/10.1016/j.asr.2021.04.009

Dr. C. K. Unnikrishnan

3.6.4 Impact of the 2018 Mars global dust storm on the ionospheric peak: A study using a photochemical model

Mars has the greatest dust storms in the solar system, which occur infrequently but are able to obscure the planet's surface and last for several months. Such planet-encircling dust events affect all layers of the Martian atmosphere, the most notable effect being the expansion of the neutral atmosphere due to intensified solar heating through atmospheric dust loading. As a result, the peak of the ionosphere, where the plasma density is maximized, is elevated to greater heights. Such a global storm event took place on Mars in June 2018 and lasted for 2–3 months. The spacecraft observations of the Martian ionospheric peak during this event were mostly confined to the northern hemisphere where the storm originated and only very limited observations are available in the southern hemisphere (SH). In the present study, we investigate how the peak of the ionosphere in the SH of the planet varied during the onset phase of the global storm in 2018. We found that the peak altitude increased by 7–10 km. In addition, we report that the response was not immediate, but instead took around 22–26 days for the enhancement to appear in the ionospheric peak altitude of the SH.

This work was done in collaboration with Dr. Smitha V. Thampi of Space Physics Laboratory, VSSC, Dr. Anil Bhardwaj of Physical Research Laboratory, Ahmedabad, and Dr. Xiaohua Fang of Laboratory for Atmospheric and Space Physics, University of Colorado, Boulder, USA.

https://doi.org/10.1029/2021JE006823

Dr. Vrinda Mukundan

4. Research Output

4.1 Publications

4.1.1 In Journals

1. Anant Misra, Ashwin Singh, **Suresh Babu, D. S.**, Vikrant Jain, Mithila Verma, Brijesh K. Bansal, Manish Kumar (2020). Sediment and Submarine Groundwater Discharge mediated Arsenic flux into the Bay of Bengal, India: An appraisal. Current Pollution Reports, Vol. 6 (3), pp. 206-216. https://doi.org/10.1007/s40726-020-00154-4

2. **Anoop, T. R.**, **Sheela Nair, L.**, **Prasad, R.**, **Reji Srinivas**, **Ramachandran, K. K.**, **Prakash, T. N.**, Balakrishnan Nair, T.M. (2020). Locally and remotely generated wind waves in the southwestern shelf sea of India. Journal of Coastal Research, Special Issue 89, pp. 77-83. https://doi.org/10.2112/SI89-014.1

3. Anusha Sathyanadh, Thara V. Prabha, Subharthi Chowdhuri, Balaji, B., **Resmi, E. A.**, Anandakumar Karipot (2021). Evaluation of PBL parameterization schemes against direct observations during a land depression over Central India. Theoretical and Applied Climatology, Vol. 144 (1-2), pp. 253–271. https://doi.org/10.1007/s00704-021-03532-0

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13. **Resmi, R.**, **Krishnakumar, A.**, **Anoop Krishnan, K.** (2021). GIS-based water quality assessment of Chalakudy river basin, southern Western Ghats, India - Groundwater Resources Development and Planning in the Semi-Arid Region, Springer International Publishing, Pande, C. B., Moharir, K. N. (Eds). ISBN: 978-3-030-68123-4, Chapter 17, pp. 353-368. https://doi.org/10.1007/978-3-030-68124-1_18

14. **Uma Mohan**, **Krishnakumar, A.** (2021). Seasonal variation of groundwater quality in Kallada basin, southern Western Ghats of India - Groundwater Resources Development and Planning in the Semi-Arid Region, Springer International Publishing, Pande, C. B., Moharir, K. N. (Eds). ISBN: 978-3-030-68123-4, Chapter 17, pp. 335-352. https://doi.org/10.1007/978-3-030-68124-1_17

4.3 Patent Awarded

1. A patent was granted for an invention entitled 'A multi-spectral diffuse reflectance imaging system for diagnosis of oral cavity cancer' to Dr. J. L. Jayanthi (NCESS) and Dr. Subhash Narayanan. Intellectual Property India, Patent No. 347763 dated 25/09/2020. Official Journal of the Patent Office, Issue No. 40/2020, Part - XI, pp. 51971.

5. External and Consultancy Projects

NCESS carried out few external grant-in-aid projects and a number of consultancy projects during the year 2020-2021. The externally funded projects were sponsored by Govt. of Kerala and Govt. of India agencies. The consultancy projects were undertaken mainly for the demarcation of HTL and LTL for Coastal Regulation Zone.

Coastal Zone Management

Rapidly changing land use have adversely affected the coastal ecosystems, coastal morphology and livelihood resources of the coastal areas of our country. A significant percentage of the population live in the coastal area; the demographic pressure and higher economic and other subsistence activities deteriorate the quality of coastal environment. In order to conserve the coastal ecosystems of the country, the Government of India issued Coastal Regulation Zone (CRZ) Notification under the Environment Protection Act (1986) for regulating various activities in the coastal zone. The CZM Lab at NCESS has been actively involved in the demarcation of High Tide Level (HTL) and Low Tide Level (LTL) and related coastal morphologies and the preparation of Coastal Zone Management Plans (CZMPs) and CRZ maps at state and local levels. Currently, the NCESS is the dominant player in the country in undertaking CRZ projects related to the demarcation of HTL and LTL for coastal zone management.

During 2018-19, CZMP for the state of Kerala and three districts of Maharashtra were accomplished. In Kerala, there are 10 coastal districts where CRZ is applicable. The project mainly engaged in the preparation of CZM Plan Maps in 1:25K and local level CZMP Maps in 1:4 K scale, for application at the local level with cadastral base and survey plot information. The generated geo-database to these states has been verified and approved by the National Centre for Sustainable Coastal Management (NCSCM) and later approved by the Ministry of Environment, Forest and Climate Change, Government of India. Around 15 consultancy projects were completed during the year and 14 consultancy works were in progress.

Table 5.1: List of external grand-in-aid projects

Sl. No.	Project Title	Funding Agency	Group	Project Period	Total Outlay (Rs. in lakh)
1	Environmental monitoring of water and sediment quality parameters in the back waters of Cochin Port Trust	Cochin Port Trust, GoI	BgG	2017-22	30.00
2	KSCSTE-Best Paper Award-Project titled "Hydrological response of river basins to climate change-A case study from Kerala, India"	Kerala State Council for Science, Technology & Environment	HyG	2018-20	1.00
3	Women Scientist Scheme A (WOS-A) entitled "Assessing the trace gas amounts and analysis of their pathways over Indian region using various remote & in-situ data sources for delivering climate action plans" - Dr. Anila Alex	Department of Science and Technology, GoI	HyG	2018-21	31.11
4	DST Inspire Faculty Award - Innovation in science pursuit for inspired research - Dr. Tripti Muguli	Department of Science and Technology, GoI	MGG	2018-23	35.00
5	Teachers Associateship for Research Excellence (TARE) to Dr. Rajaveni S.P.	Department of Science and Technology, GoI	MGG	2019-22	3.35
6	Desertification and land degradation: Monitoring, vulnerability assessment and combating plans	Space Applications Centre, ISRO, GoI	CDG	2017-21	4.25
7	Preparation of Coastal Zone Management Plan (CZMP) of Kerala with respect to the CRZ notification 2019	Kerala Coastal Zone Management Authority	MGG	2020-21	198.55
8	DST Inspire Faculty Award - Innovation in science pursuit for inspired research - Dr. Vrinda Mukundan	Department of Science and Technology, GoI	ASG	2020-25	22.00
9	"Back to Lab" – Post Doctoral Fellowship Programme – Project entitled "Socio economic and environmental viability of Pamba Achankovil - Vaippar Link" – Dr. Smitha P. S.	Kerala State Council for Science, Technology & Environment	BgG	2021-24	14.17

Table 5.2: List of CRZ reports prepared during the period 2020-2021

Sl. No.	Report No.	File No.	Project Name	Monitoring Committee	Investigators	Project Staff
1	NCESS-CRZ-07-2020	CRZ/14/2019	Kayamkulam Municipality, Alappuzha (proposed Central Private Bus Stand at Kayamkulam Municipality)	Dr. K.K. Ramachandran Dr. D.S. Suresh Babu Dr. L. Sheela Nair	Dr. K.K. Ramachandran Mr. M. Ramesh Kumar	Mr. Sajith S.L. Dr. Shylesh Chandran M.S. Mr. Sachidananandan T.L. Mrs. Reshmi Krishnan V.B.
2	NCESS-CRZ-08-2020	CRZ/23/2019	Kerala State Coastal Area Development Corporation Limited (establishment of brackish water fish hatchery at Odayam in Varkala, Thiruvananthapuram)	Dr. K.K. Ramachandran Dr. D.S Suresh Babu Dr. L. Sheela Nair	Dr. K.K. Ramachandran Mr. M. Ramesh Kumar	Dr. Shylesh Chandran M.S. Mr. Sachidananandan T.L. Mrs. Reshmi Krishnan V.B.
3	NCESS-CRZ-09-2020	CRZ/05/2019	KVR Group of Companies (proposed commercial building at Payyannur Municipality, Kannur)	Dr. K.K. Ramachandran Dr. D.S Suresh Babu Dr. L. Sheela Nair	Dr. K.K. Ramachandran Mr. M. Ramesh Kumar	Mr. James Varghese Dr. Shylesh Chandran M.S. Mr. Sachidananandan T.L. Mrs. Reshmi Krishnan V.B.
4	NCESS-CRZ-10-2020	CRZ/24/2019	Baby Memorial Hospital Ltd, Kozhikode (construction of hospital building at Kasaba, Kozhikode Corporation)	Dr. K.K. Ramachandran Dr. D.S Suresh Babu Dr. L. Sheela Nair	Dr. K.K. Ramachandran Mr. M. Ramesh Kumar	Mr. James Varghese Dr. Shylesh Chandran M.S. Mr. Sachidananandan T.L.
5	NCESS-CRZ-11-2020	CRZ/28/2019	Kunnungal Marina Resort, Thrissur (construction of Resort at Valappad Village, Thrissur District)	Dr. K.K. Ramachandran Dr. D.S Suresh Babu Dr. L. Sheela Nair	Dr. K.K. Ramachandran Mr. M. Ramesh Kumar	Mr. A. Lakshmanan Dr. Shylesh Chandran M.S. Mr. Sajith S.L. Mrs. Reshmi Krishnan V.B. Mr. Sachidananandan T.L.
6	NCESS-CRZ-13-2020	CRZ/15/2019	District Tourism Promotion Council, Kannur (construction of Bridge at Choodadu, Madayi, Kannur)	Dr. K.K. Ramachandran Dr. D.S Suresh Babu Dr. L. Sheela Nair	Dr. K.K. Ramachandran Mr. M. Ramesh Kumar	Mr. James Varghese Dr. Shylesh Chandran M.S. Mrs. Reshmi Krishnan V.B. Mr. Sachidananandan T.L.
7	NCESS-CRZ-03-2019 (A)	CRZ/31/2017	Department of Tourism (proposed Muzhappilangadu Beach Development at Kannur District)	Dr. K.K. Ramachandran Mr. M. Ramesh Kumar Dr. D.S Suresh Babu	Dr. K.K. Ramachandran Dr. M. Rameshan	Dr. Shylesh Chandran M.S. Dr. M. Rameshan Mr. Sajith S.L. Mr. James Varghese Mrs. Reshmi Krishnan V.B.
8	NCESS-CRZ-04-2019 (A)	CRZ/32/2017	Department of Tourism (proposed upgradation of existing Dharmadom Beach, Kannur District)	Dr. K.K. Ramachandran Mr. M. Ramesh Kumar Dr. D.S Suresh Babu	Dr. K.K. Ramachandran Dr. M. Rameshan Mr. M. Ramesh Kumar	Dr. M. Rameshan Dr. Shylesh Chandran M.S. Mr. Sajith S.L. Mr. James Varghese Mr. A. Lakshmanan Mrs. Reshmi Krishnan V.B.

9	NCESS-CRZ-14-2020	CRZ/07/2020	Fathima Hospital & Palliative Care Centre, Thiruvananthapuram (construction of hospital building)	Dr. K.K. Ramachandran Dr. D.S Suresh Babu Dr. L. Sheela Nair	Dr. K.K. Ramachandran Mr. M. Ramesh Kumar Dr. Shylesh Chandran	Dr. Shylesh Chandran M.S. Mr. Sachidananandan T.L. Mrs. Reshmi Krishnan V.B.
10	NCESS-CRZ-15-2020	CRZ/11/2020	KITCO Ltd (development of Indian Coast Guard Radar Station at Vizhinjam, Thiruvananthapuram, Kerala)	Dr. L. Sheela Nair Dr. D.S. Suresh Babu Dr. Reji Srinivas Mr. Ramesh Madipally	Dr. Reji Srinivas Mr. M. Ramesh Kumar Mr. M.K. Sreeraj	Dr. Shylesh Chandran M.S. Mr. Sachidananandan T.L. Mrs. Reshmi Krishnan V.B.
11	NCESS-CRZ-16-2020	CRZ/36/2019	Kerala State Housing Board, Division Office Kollam (construction of Taluk Hospital Building at Neendakara)	Dr. L. Sheela Nair Dr. D.S. Suresh Babu Dr. Reji Srinivas Mr. Ramesh Madipally	Dr. Reji Srinivas Mr. M. Ramesh Kumar	Dr. Shylesh Chandran M.S. Mr. Sachidananandan T.L. Mrs. Reshmi Krishnan V.B.
12	NCESS-CRZ-01-2021	CRZ/39/2018 CRZ/16/2020	National Highway Authority of India, Kakkanad (development of NH-66 of Ramanattukara –Edappally Section in the state of Kerala & Scrutiny charge for the additional three tidal waterbodies crossing in the proposed NH-66 alignment)	CRZ/39/2018: Dr. K.K. Ramachandran Dr. D.S Suresh Babu Dr. L. Sheela Nair CRZ/16/2020: Dr. L. Sheela Nair Dr. D.S. Suresh Babu Dr. Reji Srinivas Mr. Ramesh Madipally	Dr. D.S. Suresh Babu Dr. Reji Srinivas Dr. K.K. Ramachandran Mr. M. Ramesh Kumar Dr. Shylesh Chandran	Mr. Sajith S.L. Dr. Shylesh Chandran M.S. Mr. Sachidananandan T.L. Mrs. Reshmi Krishnan V.B.
13	NCESS-CRZ-02-2021	CRZ/20/2019	National Disaster Response Force, Tamil Nadu (construction of semi-permanent huts at Thiruvankulam, Kanayannur Taluk, Ernakulam District)	Dr. L. Sheela Nair Dr. D.S. Suresh Babu Dr. Reji Srinivas Mr. Ramesh Madipally	Dr. Reji Srinivas Dr. Shylesh Chandran	Mr. Sachidananandan T.L. Ms. Anusha A. Mr. Sharoof Ahammed Mr. Akhil Chandran V. Mrs. Krishnapriya S. Mrs. Reshmi Krishnan V.B.
14	NCESS-CRZ-03-2021	CRZ/26/2020	Cochin University of Science and Technology (construction of Academic Block at CUSAT Lakeside campus)	Dr. L. Sheela Nair Dr. D.S. Suresh Babu Dr. Reji Srinivas Mr. Ramesh Madipally	Dr. Reji Srinivas Mr. M. Ramesh Kumar	Dr. Shylesh Chandran M.S. Mr. Sachidananandan T.L. Mrs. Reshmi Krishnan V.B. Mrs. Krishnapriya S. Mr. Akhil Chandran V. Mr. Sharoof Ahammed Ms. Anusha A.
15	NCESS-CRZ-04-2021	CRZ/03/2021	Kerala Road Fund Board (construction of Nayarthodu bridge)	Dr. L. Sheela Nair Dr. D.S. Suresh Babu Dr. Reji Srinivas Mr. Ramesh Madipally	Dr. Reji Srinivas Mr. M. Ramesh Kumar	Dr. Shylesh Chandran M.S. Mr. Sachidananandan T.L. Mrs. Reshmi Krishnan V.B.

Table 5.3: Ongoing Consultancy Projects

Sl. No.	Project Title	Funding Agency	Total Outlay (Rs. in lakh)	Fund Received during the year (Rs. in lakh)
1	Delineation of HTL/ LTL and preparation of CRZ status report	Peter Paul (construction of resort in Kaipamangalam, Thrissur, Kerala)	3.15	--
2	-do-	Aashrami Consultancy & Technology Pvt Ltd (proposed commercial cum residential building at Thoppumpady village, Kochi, Ernakulam District)	3.15	--
3	-do-	Kochi Municipal Corporation, Ernakulam (construction of new park behind DLF apartments on the banks of Chilavannur Kayal under Amrut Mission at Kochi)	3.15	--
4	-do-	Manthra Beach Resorts Pvt Ltd, Kasaragod (proposed resort at Ozhinjavalappu in Kasaragod District, Kerala)	3.15	--
5	-do-	Abdulla Kutty Haji (proposed commercial cum lodge building at Nagaram village, Kozhikode District)	3.15	--
6	-do-	Public Works Department, Road Division, Kollam (construction of Perumon Bridge, Konnayil Kadavu bridge, Kannankattu Kadavu Bridge, Kattilkadavu Bridge, Asramam Link Road Phase 4, Fathima Island- Arulappanthuruth Bridge)	11.00	--
7	-do-	Agency for Development of Aquaculture, Kerala (establishment of fish feed mill at Thalai, Kannur)	3.15	--
8	-do-	Cochin Corporation, Ernakulam (construction of road, ring bund protection wall around Thanthonnithuruth Island)	3.15	--
9	-do-	Thalassery Municipality (commercial building - order from the Hon'ble High court of Kerala)	3.15	--
10	-do-	Sree Rosh Builders, Kannur (construction of residential apartment and recreation building in Kannur II village, Kannur District, Kerala)	3.15	--
11	-do-	The Superintendent, RHTC (Taluk Hospital) Chettikadu (construction of Taluk Hospital at Chettikadu, Alappuzha District)	3.15	--
12	-do-	KITCO Ltd, Ernakulam (site at Foreshore Road, Ernakulam - project for Kerala Shipping and Inland Navigation Corporation)	3.15	--
13	-do-	Public Works Department, Bridge Division, Thiruvananthapuram (construction of Karma Bridge across Canoli canal along Bharathapuzha river connecting Ponnani port and Chamravattom regulator in Malappuram District)	3.15	3.15
14	-do-	Department of Tourism, Thiruvananthapuram (For the project "Rejuvenation of Akkulam Lake and its watershed, Rebuilding Kerala, the sustainable way")	3.15	3.15

6. New Facilities

NCESS procured many sophisticated analytical facilities for carrying out front-line research in the field of earth science studies during the financial year. The instruments procured and their key characteristics are furnished below

Sl. No.	Name of the equipment / facility	Make / Model	Application	Photograph of the facility/ instrument
1	Class 10000 Clean lab		Clean chemistry and isotope geochemical studies.	
2	Critical Zone Observatory (CZO) Network		CZOs established in Attappadi, Munnar and Aduthurai, for generating continuous data of key Critical Zone variables. CZOs are equipped with rain gauges, automatic weather stations, profile soil moisture sensors, digital pan evaporimeters and rain water collectors.	
3	Bench Top Soil Hydraulic Conductivity Meter	Meter AG, KSAT	Laboratory scale automated setup for determination of soil saturated hydraulic conductivity - uses both the falling head and constant head methods on a soil core.	
4	Dual Head Infiltrometer	Meter Inc, SATURO	Field scale automated setup for determination of infiltration rates and field saturated hydraulic conductivity.	

5	Sediment Processing Laboratory		A wet laboratory with fume hood, laminar flow, and ultrasonic cleaner has been installed for conducting studies on paleoclimatic, paleoceanographic and paleo sea-level reconstruction using sedimentary archives from coastal, marine and lacustrine environments.	
6	UV-Vis-NIR Spectrophotometer	Shimadzu/ UV 3600 PLUS	Multi element analysis using radiation absorption measurements. Quantitative and qualitative analysis of nutrients and metals.	
7	Ultra-High Performance Liquid Chromatography	Shimadzu/ NEXERA X2	Multi-element analysis (major and trace elements, from B/Be to U) of rock samples for chemical dating (geochronology).	
8	Continuous Flow Analyzer	SKALAR/ SAN++	Capable of analyzing 10 water quality parameters with a 20 ml of sample Updated existing system with five more modules (Total alkalinity, Total hardness, Chloride, Sulphate, Fluoride).	

9	Continuous monitoring sensors		NCESS deployed electrical conductivity and water level data loggers (Onset-HOBO Loggers) into bore well, installed 70 m landward of the shoreline to understand the behaviour of the coastal aquifer in response to tidal forcing. Four sensors were deployed at Odayam, Varkala, with one water level logger at the bottom and three conductivity sensors at depths of 0 m, 2 m, and 4 m from the well's bottom for a total depth of 4.2 m. Data procurement and evaluation are in progress under the SGD project.	
10	Microwave Radiometer augmented at HACPO, Rajamalay, Munnar.	RPG Radiometer Physics GmbH / RPG-HATPRO	Ground based remote sensing instrument for measuring vertical profiles of atmospheric temperature, humidity and liquid water content (0-10 km). The microwave radiometer measures brightness temperatures at the following frequencies: 22-31 GHz: 7 channels in the absorption band of water and 51-58 GHz: 7 channels in the absorption band of oxygen.	
11	Fog Monitor augmented at HACPO, Rajamalay, Munnar	DMT / Model: FM-120	A fog/cloud-particle spectrometer to measure particle concentration, median volume diameter (MVD), equivalent diameter (ED), and liquid water content (LWC).	

7. Conference, Seminar & Workshop

7.1 Training on Flood Modelling

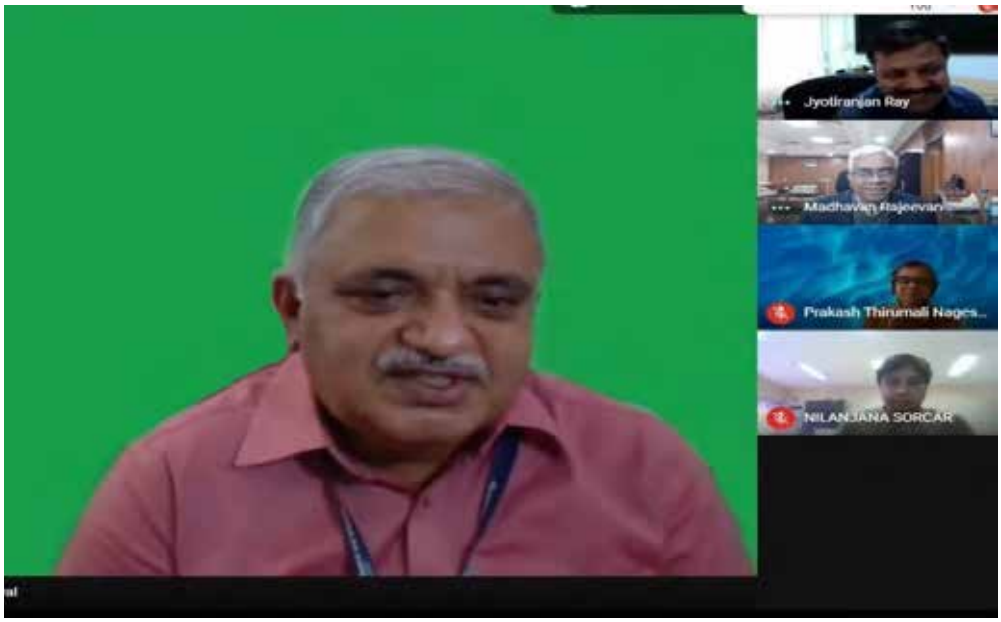
A 7-day online training programme on 'MIKE Flood' was organized by Hydrology Group at NCESS in September 2020. The training session was conducted by DHI India Water & Environment Private Ltd., New Delhi. The training was followed by a 13-day hands-on session during October and December 2020.

7.2 Webinar on Hydrodynamics of beach placer deposits

A webinar on "Hydrodynamics of Beach Placer Deposits and their Sustainable Exploitation – Way Forward" was conducted on 23rd November 2020. Dr. T. N. Prakash, Scientist-G (Rtd.) & Senior Consultant, NCESS, delivered the lecture.

7.3 NCESS Foundation Day 2021

National Centre for Earth Science Studies (NCESS) celebrated its 7th Foundation Day on 01st January 2021. The online function was presided by Dr. M. Rajeevan, Hon'ble Secretary, MoES. The Foundation Day lecture was delivered by Dr. Vinay Kumar Dadhwal, Director, IIST, Thiruvananthapuram titled "Changing landscapes of Earth observation data from space and its applications". Dr. Jyotiranjan S. Ray, Director, NCESS gave the welcome address.



7.4 Training on electric resistivity survey profiling

The Submarine Groundwater Discharge (SGD) project team, NCESS conducted a training session on Electric Resistivity Survey at Manipal Academy of Higher Education (MAHE), Manipal during March, 2021. As part of the training session, ERT profiling has been prepared at some of the research sites in Karnataka coast.

7.5 Papers presented in Conference / Seminar / Symposium

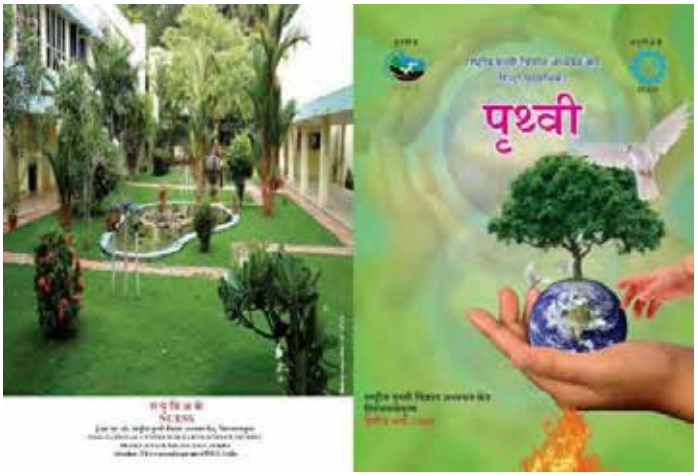
Name	Conference/Seminar/ Symposium	Title of the paper / poster
Unnikrishnan C. K.	EGU (European Geosciences Union) General Assembly – 2020 during 04-08 May 2020. (Online)	A study on cloud cover in reanalysis datasets in tropical South India.
Amal Dev J.	Goldschmidt at Hawaii, USA, during 21-26 June 2020. (Online)	Timing of high-grade metamorphism in Madurai Block, south India: Insights from new U-Pb zircon & monazite ages.
Sajna S.	Goldschmidt at Hawaii, USA, during 21-26 June 2020. (Online)	Age and petrogenesis of granulites from Nagercoil Block, South India.
Amal Dev J.	AGU Fall Meeting 2020 during 01-17 December 2020. (Online)	Decoding Rodinia events in South India: Evidences from Late Tonian ages within granulites.
Sneha Mukherjee	AGU Fall Meeting 2020 during 01-17 December 2020. (Online)	U-Pb Zircon geochronology and structural control of the hydrothermal vein-type uranium deposit at Chitrial, Eastern Dharwar Craton, India.
Sribin C.	AGU Fall Meeting 2020 during 01-17 December 2020. (Online)	Mantle deformation beneath the southern part of Western Ghats.
Merin Mariam Mathew	33rd Kerala Science Congress held at Trivandrum, Kerala during 25-30 January 2021.	Modelling the impact scenario for flooding in Kerala- Case study of Pamba river basin.
Vrinda Mukundan	Indian Planetary Science Conference at Physical Research Laboratory, Ahmedabad during 25-26 February 2021. (Virtual Conference)	Response of the Martian ionospheric peak to the planet encircling dust event of June 2018.
Jeenu Jose	International Conference on Challenges of Disasters: Vulnerability, Adaptation and Resilience organized by Jamia Millia Islamia, New Delhi during 02-03 March 2021. (Online)	Impacts of Kerala Flood 2018 on groundwater suitability in River Periyar lower basin using GIS based WQI model.

Kaliraj S.	International Conference on Challenges of Disasters: Vulnerability, Adaptation and Resilience organized by Jamia Millia Islamia, New Delhi during 02-03 March 2021. (Online)	Desertification Vulnerability Assessment in humid tropics and sub-tropical regions of India using Remote sensing & GIS techniques.
Vrinda Mukundan	52nd Lunar and Planetary Science Conference held at Houston, USA during 15-19 March 2021. (Virtual Conference)	A modeling study on the effect of the 2018 Mars global dust storm on the ionospheric peak.
Aditya S. K.	Indian National Groundwater Conference organized by Jawaharlal Nehru Technical University, Hyderabad during 22-24 March 2021. (Virtual Conference)	Hydrochemistry and stable isotope characteristics of groundwater in the upper reaches of Periyar river, southern Western Ghats, India.
Alice Thomas	International Conference on hydraulics, water resources and coastal engineering (Hydro 2020) held at NIT Rourkela during 26-28 March 2021.	A review of evolutionary algorithms in inverse modeling for groundwater flow and transport parameter estimation.

8. Extension Activities

8.1 NCESS Hindi Magazine: 'Prithvi'

Dr. N. Purnachandra Rao, Director, NCESS released the second edition of Hindi magazine 'Prithvi' on 21st May 2020. Besides the Hindi articles, the magazine also describes the scientific activities of the institute. A booklet titled 'Prashaasanik Vakya Shrinkhala (Administrative Sentence Series)' was also released to familiarize employees with administrative terms and to encourage the use of Hindi language among them.



8.2 Swachhata Pakhwada

As part of Swachhata Pakhwada, cleaning of office premises was carried out during 01-15 July, 2020. Also, to mark the conclusion of Swachhata Pakhwada, a one-day activity was organized on 15th July, 2020 for cleaning and sanitizing the office space and laboratories while ensuring social distancing in the wake of COVID pandemic.

8.3 Hindi Fortnight Celebrations

Hindi fortnight during the year 2020-21 was organized during 07-21 September 2020. The programme was inaugurated by Shri. Chilukuri Venkata Subbarao, Senior Hindi Officer, CSIR-NGRI, Hyderabad on 07th September 2020 through video conference. As part of the programme various online competitions viz. essay writing, short story writing, etc. were conducted. The valedictory function was held on 21st September 2020. Dr. V. Nandakumar, Director (i/c) inaugurated the function and distributed the prizes to the winners of the competitions.

8.4 Vigilance Awareness Week

As per the circular from Central Vigilance Commission, the Vigilance Awareness week was observed from 27th October to 02nd November 2020 with the theme 'Vigilant India, Prosperous India. NCESS employees took the integrity pledge on 02nd November 2020 to mark the solidarity with the vision of corruption-free India and to emphasize the importance of integrity in public life.


CENTRAL VIGILANCE COMMISSION

Certificate of Commitment

This is to certify that

NATIONAL CENTRE FOR EARTH SCIENCE STUDIES

has adopted the Integrity Pledge and is committed to uphold highest standards of integrity and good governance and to follow ethical practices in conducting its activities.

P. Daniel

8.5 Fit India Freedom Run, PM's Jan Andolan Campaign

NCESS successfully organized the Fit India Freedom Run, on 29th September 2020, an initiative of Ministry of Youth Affairs and Sports to encourage fitness and help all citizens to get freedom from obesity, laziness, stress, anxiety, diseases, etc., and to promote fitness as a daily routine. Also, in connection with PM's Jan Andolan campaign for COVID-19 appropriate behaviour, a pledge was taken by the employees of NCESS on 09th October 2020.

8.6 Participation in Science Expositions

National Centre for Earth Science Studies participated in the 6th edition of 'India International Science Festival (IISF)' held at New Delhi during 22-25 December 2020. NCESS was part of the virtual mode poster exhibition by Ministry of Earth Sciences.

8.7 Earth Science Forum

The Earth Science Forum (ESF) of NCESS organized 12 online lectures during 2020-21 on different themes of Earth Sciences by scientists and researchers from NCESS. The first talk of this period was given by Ms. Krishna R. Prasad, Research Scholar, Marine Geoscience Group on the topic "Spatio

temporal variations of sediment and water characteristics of a tropical estuarine system, southwest coast of India" on 23rd September 2020 as part of her PhD pre-synopsis presentation. Shri. Arun T. J., Research Scholar, Marine Geoscience Group presented his research work on 'Spatial and temporal studies on sediment and soil of two river systems from diverse climatic settings, southern India'. Dr. Jyotiranjan S. Ray, Director, NCESS delivered the first lecture of 2021 on "Quaternary volcanism in India" on 08th January 2021 through Google Meet. Further on 15th January 2021, Shri. Amal Dev J., Research Scholar, Solid Earth Research Group presented his research work on "Timing and duration of UHT metamorphism in Southern Granulite Terrain and its implications". Dr. Vrinda Mukundan, INSPIRE Faculty, Atmospheric Science Group presented her research work on "Understanding Martian Ionosphere using a Photochemical Model" on 29th January 2021. In February 2021, the weekly presentations were given by; Dr. Anoop T. R., Project Scientist B, Marine Geoscience Group on "Wind waves in ocean"; Smt. Micky Mathew, Research Scholar, Hydrology Group on "Hydro-climatological alterations in southern Peninsular India"; Shri. Sribin C., Research Scholar, Solid Earth Research Group on "An overview of shear wave splitting: Mantle deformation along the Western Ghats"; and Dr. Poornima Unnikrishnan, Research Associate, Marine Geoscience Group on "Modelling Submarine Groundwater Discharge". Ms. Saranya P., Senior Research Fellow, Hydrology Group presented her research work on "Tracing water cycle processes using stable isotopes" on 12th March 2021. Dr. R. Mohamed Asanulla, Project Scientist B, Solid Earth Research Group presented his research work on "Variations in the geomagnetic dipole moment over the historical and geological time scale" on 19th March 2021, and Shri. R. K. Sumesh, Project Scientist B, Atmospheric Science Group on "Microphysics of precipitation over the Western Ghats" on 26th March 2021.

9. Staff Details

9.1 Director's Office

Dr. N. Purnachandra Rao	Director (till 21.05.2020)
Dr. V. Nandakumar	Director (addl. charge) (22.05.2020 – 24.09.2020)
Dr. Jyotiranjan S. Ray	Director (from 24.09.2020)
Dr. D. S. Suresh Babu	Scientist-F & Head, DTC
Smt. Jinitha Madhavan	Coordinator Gr. III
Shri. S. R. Unnikrishnan	Scientific Asst. Gr. A
Smt. T. Remani	MTS
Shri. R. Binu Kumar	MTS

9.2 Solid Earth Research Group

Dr. Jyotiranjan S. Ray	Head (addl. charge)
Dr. Tomson J. Kallukalam	Scientist-D & Deputy Head
Dr. Chandra Prakash Dubey	Scientist-C
Dr. B. Padma Rao	Scientist-C
Dr. Nilanjana Sorcar	Scientist-C
Dr. Kumar Batuk Joshi	Scientist-C
Shri. Arka Roy	Scientist-C
Shri. N. Nishanth	Scientific Asst. Gr. B
Smt. G. Lakshmi	Scientific Asst. Gr. A
Shri. Krishna Jha	Scientific Asst. Gr. A
Shri. K. Eldhose	Technician Gr. B

9.3 Crustal Dynamics Group

Dr. V. Nandakumar	Scientist-G & Head
Dr. S. Kaliraj	Scientist-C
Shri. Thatikonda Suresh Kumar	Scientist-C
Ms. Alka Gond	Scientist-C
Shri. S. Shivapriya	Scientific Asst. Gr. A

9.4 Hydrology Group

Dr. D. Padmalal	Scientist-G & Head
Dr. A. Krishnakumar	Scientist-D
Shri. Rajat Kumar Sharma	Scientist-C
Dr. K. Sreelash	Scientist-C
Shri. Prasenjit Das	Scientist-C

9.5 Biogeochemistry Group

Dr. K. Maya	Scientist-F & Head
Dr. K. Anoop Krishnan	Scientist-D
Shri. Badimela Upendra	Scientist-C
Smt. T. M. Liji	Scientific Asst. Gr. B
Ms. P. V. Vinitha	Scientific Asst. Gr. A

9.6 Marine Geoscience Group

Dr. L. Sheela Nair	Scientist-F & Head
Dr. D. S. Suresh Babu	Scientist-F
Dr. Reji Srinivas	Scientist-D
Shri. Ramesh Madipally	Scientist-C
Shri. S. S. Salaj	Scientific Asst. Gr. B
Shri. M. K. Rafeeque	Scientific Asst. Gr. B
Shri. M. K. Sreeraj	Scientific Asst. Gr. B
Shri. Shibu Sasi	Scientific Asst. Gr. A
Shri. N. Sreejith	Scientific Asst. Gr. A

9.7 Atmospheric Science Group

Dr. D. Padmalal	Scientist-G & Head (addl. charge)
Dr. E. A. Resmi	Scientist-D & Deputy Head
Shri. Dharmadas Jash	Scientist-C
Dr. C. K. Unnikrishnan	Scientist-C
Smt. Nita Sukumar	Scientific Asst. Gr. B

9.8 Central Geomatics Laboratory

Dr. Reji Srinivas	Scientist-D & Co-ordinator
Shri. S. S. Salaj	Scientific Asst. Gr. B
Shri. P. B. Vibin	Scientific Asst. Gr. B
Shri. M. K. Rafeeque	Scientific Asst. Gr. B
Smt. M. Lincy Sudhakaran	Scientific Asst. Gr. A

9.9 Library

Dr. D. S. Suresh Babu	Scientist-F & Co-ordinator
Smt. K. Reshma	Scientific Asst. Gr. B

9.10 Administration

Shri. D. P. Maret	Senior Manager
Shri. A. Saji	Manager (from 29.06.2020)
Shri. M. Madhu Madhavan	Deputy Manager
Smt. R. Jaya	Deputy Manager
Smt. G. Lavanya	Deputy Manager
Smt. Indu Janardanan	Scientific Asst. Gr. B
Shri. P. Rajesh	Executive
Smt. P. C. Rasi	Executive
Smt. Femi R. Srinivasan	Executive
Smt. Smitha Vijayan	Executive
Smt. D. Shimla	Junior Executive
Shri. P. H. Shinaj	Junior Executive
Smt. K. S. Anju	Junior Executive
Smt. V. Sajitha Kumary	Junior Executive
Smt. Seeja Vijayan	Junior Executive
Shri. M. K. Adarsh	Technician Gr. A
Shri P. Rajendra Babu	MTS (till 31.03.2021)
Shri. P. Saseendran Nair	MTS
Shri. P. S. Anoop	MTS
Smt. P. S. Divya	MTS
Shri. K. Sudheer Kumar	MTS
Shri. M. R. Murukan	MTS

9.11 Retirements

Dr. K. K. Ramachandran
Scientist-F & Head,
Atmospheric Processes, CGL
Superannuated on 31 May 2020

Shri. P. Rajendra Babu
MTS
Purchase & Stores
Superannuated on 31 March 2021

9.12 New Appointments

Shri. A. Saji
Manager
Finance & Accounts

10. Balance Sheet

NCESS

NATIONAL CENTRE FOR EARTH SCIENCE STUDIES

(Ministry of Earth Sciences, Government of India)

Akkulam, Trivandrum

Audit for the Period

2020 – 2021

A J Mohan & Associates

Chartered Accountants

INDEX

A J Mohan & Associates
Chartered Accountants
FRN: 002468N

Pavilion- G 223,
Panambilly Nagar,
Kochi- 36, Kerala
anith.pa@ajmohan.com/+8828171868

[See Rule 238 (1)]

UTILIZATION CERTIFICATE FOR THE YEAR 2020-21 IN RESPECT OF RECURRING/NON-RECURRING GRANTS-IN-AID SALARIES AND GENERAL

1. Name of the Scheme: National Centre for Earth Science Studies (Autonomous Bodies)
2. Whether recurring or non-recurring grants: Both
3. Grants position at the beginning of the Financial year:

(i) Cash in Hand/Bank : Rs. 1,69,00,458.25
(ii) Unadjusted advances :Rs.(1,41,98,507.80)
(iii) Total : Rs. 27,01,950.50

Details of grants received, expenditure incurred and closing balances: (Actual)

(Amount in Rupees)

Unspent Balances of Grant Received (Figure as at Sl. No. 3(iii))	Interest/Other Receipts earned thereon	Interest Deposited back to the Govt	Grant received during the year			Total Available Funds	Expenditure Incurred	Closing Balance
1	2	3	4			5	6	7
			Sanction No.	Date	Amount	(1+2+4-3)		(5-6)
27,01,950.50	22,85,283.00	18,84,287.00	#	#	12,50,00,000.00	12,81,02,946.50	12,03,97,641.38	77,05,305.12

MoES/P.O(NCESS)/3/2015-PT dated 29.04.2020 - Rs.1,37,00,000.00
MoES/P.O(NCESS)/3/2015-PT dated 22.05.2020 – Rs. 2,38,00,000.00
MoES/P.O(NCESS)/3/2015-PT dated 14.08.2020 – Rs. 2,40,00,000.00
MoES/P.O(NCESS)/3/2015-PT dated 28.10.2020 – Rs. 2,75,00,000.00
MoES/P.O(NCESS)/3/2015-PT dated 23.03.2021 – Rs. 2,90,00,000.00
MoES/P.O(NCESS)/3/2015-PT dated 30.03.2021 – Rs. 70,00,000.00

Component wise utilization of grants :

Grant in aid General	Grant in aid Salary	Total
Rs. 2,64,99,085.38	Rs.9,38,98,556.00	Rs. 12,03,97,641.38

Grants position at the end of the financial year

a. Cash in Hand/ Bank : Rs. 1,44,91,236.12
b. Unadjusted advances : Rs. (67,85,931.00)
c. Total : Rs. 77,05,305.12

AJ MOHAN & ASSOCIATES CHARTERED ACCOUNTANTS

Certified that I have satisfied myself that the conditions on which grants were sanctioned have been duly fulfilled/are being fulfilled and that I have exercised the following checks to see that the money has been actually utilized for the purpose for which it was sanctioned:

i. The main accounts and other subsidiary accounts and registers (including assets registers) are maintained as prescribed in the relevant Act/Rules/Standing instructions (mention the Act/Rules) and have been duly audited by designated auditors. The figures depicted above tally with the audited figures mentioned in financial statements/accounts.

ii. There exist internal controls for safeguarding public funds/assets, watching outcomes and achievements of physical targets against the financial inputs, ensuring quality in asset creation, etc. & the periodic evaluation of internal controls is exercised to ensure their effectiveness.

iii. To the best of our knowledge and belief, no transactions have been entered that is in violation of relevant Act/Rules/standing instructions and scheme guidelines.

iv. The responsibilities among the key functionaries for the execution of the scheme have been assigned in clear terms and are not general in nature.

v. The benefits were extended to the intended beneficiaries and only such areas/districts were covered where the scheme was intended to operate.

vi. The expenditure on various components of the scheme was in the proportions authorized as per the scheme guidelines and terms and conditions of the grants-in-aid.

vii. It has been ensured that the physical and financial performance under National Centre for Earth Science Studies has been according to the requirements, as prescribed in the guidelines issued by Govt. of India and the performance/targets achieved statement for the year to which the utilization of the fund resulted in outcomes given in the financial statements duly enclosed.

viii. The utilization of the fund resulted in outcomes given in the financial statements duly enclosed.

ix. Details of various schemes executed by the agency through grants-in-aid received from the same Ministry or from other Ministries is enclosed.

Trivandrum
20-09-2021

For AJ Mohan & Associates
Chartered Accountants
FRN 002468N

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

CA ANITH PA
Partner
Membership No :226894
UDIN :21226894AAAAKT4133

A J Mohan & Associates
Chartered Accountants
FRN: 002468N

Pavilion- G 223,
Panambilly Nagar,
Kochi-36, Kerala
anith.pa@ajmohan.com/+8828171868

GFR 12 - A

[See Rule 238 (1)]

UTILIZATION CERTIFICATE FOR THE YEAR 2020-21 IN RESPECT OF RECURRING/NON-RECURRING GRANTS-IN-AID CREATION OF CAPITAL ASSETS

1. Name of the Scheme: National Centre for Earth Science Studies (Autonomous Bodies)
2. Whether recurring or non-recurring grants: Both
3. Grants position at the beginning of the financial year:

(i) Cash in Hand/Bank :Rs 3,82,47,932.00
(ii) Unadjusted advances : Rs 4,38,16,572.00
(iii) Total : Rs.8,20,64,504.00

Details of grants received, expenditure incurred and closing balances: (Actual)

(Amount in Rupees)

Unspent Balances of Grant Received (Figure as at Sl. No. 3(iii))	Interest earned thereon	Interest Deposited back to the Govt	Grant received during the year			Total Available Funds	Expenditure Incurred	Closing Balance
1	2	3	4			5	6	7
			Sanction No.	Date	Amount	(1+2+3+4)		(5-6)
8,20,64,504.00	0.00	0.00	#	#	0.00	8,20,64,504.00	1,57,47,715.00	6,63,16,789.00

Grants position at the end of the financial year

a. Cash in Hand/ Bank : Rs2,77,34,551.00
b. Unadjusted advances : Rs.3,85,82,238.00
c. Total : Rs.6,63,16,789.00

A J MOHAN & ASSOCIATES CHARTERED ACCOUNTANTS

Certified that I have satisfied myself that the conditions on which grants were sanctioned have been duly fulfilled/are being fulfilled and that I have exercised following checks to see that the money has been actually utilized for the purpose for which it was sanctioned:

(i) The main accounts and other subsidiary accounts and registers (including assets registers) are maintained as prescribed in the relevant Act/Rules/Standing instructions (mention the Act/Rules) and have been duly audited by designated auditors. The figures depicted above tally with the audited figures mentioned in financial statements/accounts.

(ii) There exist internal controls for safeguarding public funds/assets, watching outcomes and achievements of physical targets against the financial inputs, ensuring quality in asset creation etc. & the periodic evaluation of internal controls is exercised to ensure their effectiveness.

(iii) To the best of our knowledge and belief, no transactions have been entered that are in violation of relevant Act/Rules/standing instructions and scheme guidelines.

(iv) The responsibilities among the key functionaries for execution of the scheme have been assigned in clear terms and are not general in nature.

(v) The benefits were extended to the intended beneficiaries and only such areas/districts were covered where the scheme was intended to operate.

(vi) The expenditure on various components of the scheme was in the proportions authorized as per the scheme guidelines and terms and conditions of the grants-in-aid.

(vii) It has been ensured that the physical and financial performance under National Centre for Earth Science Studies has been according to the requirements, as prescribed in the guidelines issued by Govt. of India and the performance/targets achieved statement for the year to which the utilization of the fund resulted in outcomes given in the financial statements duly enclosed.

(viii) The utilization of the fund resulted in outcomes given in the financial statements duly enclosed.

(ix) Details of various schemes executed by the agency through grants-in-aid received from the same Ministry or from other Ministries is enclosed.

Trivandrum
20-09-2021

For AJ Mohan & Associates
Chartered Accountants
FRN 002468N

AJ MOHAN & ASSOCIATES CHARTERED ACCOUNTANTS

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

CA ANITH PA
Partner
Membership No :226894
UDIN : 21226894AAAAKT4133

A J Mohan & Associates
Chartered Accountants
FRN: 002468N

Pavilion- G 223,
Panambilly Nagar,
Kochi-36,Kerala
anith.pa@ajmohan.com/+8828171868

GFR 12 - A
[See Rule 238 (1)]
UTILIZATION CERTIFICATE FOR THE YEAR 2020-21
IN RESPECT OF RECURRING/NON RECURRING
GRANTS-IN-AID SEISMOLOGY AND GEODYNAMICS (SAGE)/R&D PROGRAMMES

1. Name of the Scheme : Seismology And Geosciences (SAGE)
2. Whether recurring or non-recurring grants : Both
3. Grants position at the beginning of the Financial year :

(i) Cash in Hand/Bank : Rs. 0.88
(ii) Fund Diversion : Rs. (2,89,89,543.00)
(iii) Unadjusted advances : Rs 6,24,19,256.76
(iv) Total : Rs. 3,34,29,714.64

Details of grants received, expenditure incurred and closing balances: (Actual)
(Amount in Rupees)

Unspent Balances of Grant Received (Figure as at Sl. No. 3(iv))	Interest earned thereon	Interest Deposited back to the Govt	Grant received during the year			Total Available Funds	Expenditure Incurred	Closing Balance
1	2	3	4			5	6	7
			Sanction No.	Date	Amount	(1+2+4-3)		(5-6)
3,34,29,714.64	9,33,548.00	8,95,133.00	#	#	10,25,00,000.00	13,59,68,129.64	13,69,41,334.48	(9,73,204.84)

MOES/P.O.(Seismo)/8/(14)-A/2017 dated 28.07.2020 – Rs.2,25,00,000/-
MOES/P.O.(Seismo)/8/(14)-A/2017 dated 20.01.2021 – Rs.8,00,00,000/-

Component wise utilization of grants :

Non -Recurring	Recurring	Total
Rs.6,32,96,307.00	Rs.7,36,45,027.48	Rs.13,69,41,334.48

Grants position at the end of the financial year

a. Cash in Hand/ Bank : Rs. 0.90
b. Fund Diversion : Rs. (3,16,55,236.00)
c. Unadjusted advances : Rs.3,06,82,030.26
d. Total : Rs. (9,73,204.84)

(i) Certified that I have satisfied myself that the conditions on which grants were sanctioned have been duly fulfilled/are being fulfilled and that I have exercised following checks to see that the money has been actually utilized for the purpose for which it was sanctioned:

(ii) The main accounts and other subsidiary accounts and registers (including assets registers) are maintained as prescribed in the relevant Act/Rules/Standing instructions (mention the Act/Rules) and have been duly audited by designated auditors. The figures depicted above tally with the audited figures mentioned in financial statements/accounts.

(iii) There exist internal controls for safeguarding public funds/assets, watching outcomes and achievements of physical targets against the financial inputs, ensuring quality in asset creation etc. & the periodic evaluation of internal controls is exercised to ensure their effectiveness.

(iv) To the best of our knowledge and belief, no transactions have been entered that are in violation of relevant Act/Rules/standing instructions and scheme guidelines.

(v) The responsibilities among the key functionaries for execution of the scheme have been assigned in clear terms and are not general in nature.

(vi) The benefits were extended to the intended beneficiaries and only such areas/districts were covered where the scheme was intended to operate.

(vii) The expenditure on various components of the scheme was in the proportions authorized as per the scheme guidelines and terms and conditions of the grants-in-aid.

(viii) It has been ensured that the physical and financial performance under National Centre for Earth Science Studies has been according to the requirements, as prescribed in the guidelines issued by Govt. of India and the performance/targets achieved statement for the year to which the utilization of the fund resulted in outcomes given in the financial statements duly enclosed.

(ix) The utilization of the fund resulted in outcomes given in the financial statements duly enclosed.

(x) Details of various schemes executed by the agency through grants-in-aid received from the same Ministry or from other Ministries is enclosed.

Trivandrum
20-09-2021

For AJ Mohan & Associates
Chartered Accountants
FRN 002468N

AJ MOHAN & ASSOCIATES CHARTERED ACCOUNTANTS

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

CA ANITH PA
Partner
Membership No :226894
UDIN : 21226894AAAAKT4133

A J Mohan & Associates
Chartered Accountants
FRN: 002468N

Pavilion- G 223,
Panambilly Nagar,
Kochi-36,Kerala
anith.pa@ajmohan.com/+8828171868

INDEPENDENT AUDITORS REPORT

To,

The Director

National Centre for Earth Science,

Thiruvananthapuram, 695011

REPORT ON THE FINANCIAL STATEMENTS

We have audited the accompanying financial statements of National Centre for Earth Science Studies, Thiruvananthapuram, 695011 which comprise the balance sheet as at 31.03.2021, and the income and expenditure account for the year ended, and a summary of significant accounting policies and other explanatory information

UNQUALIFIED OPINION

In our opinion and to the best of our information and according to the explanation given to us, 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 National Centre for Science as at 31st March, 2021
b) In the case of Income and Expenditure Account, of the expenditure over Income /Income over expenditure for the year ended on that date

EMPHASIS ON MATTER PARAGRAPH

We drew attention to the Subheading Loans and Advances in the Notes to Financial Statements where the receivables have been booked and carried forward from the previous years without any movements. The realizability of the same could not be verified due to the absence of proper documents.

The physical verification of the fixed assets has not been conducted during the year to verify whether [illegible] in serviceable condition and the verification with fixed register

A J MOHAN & ASSOCIATES CHARTERED ACCOUNTANTS

We drew attention to the fact that the security services availed come under the ambit of reverse charge mechanism of GST and the borrower is paying the GST on forward basis and not on a reverse charge basis.

Our opinion is not modified because of the above factors

RESPONSIBILITIES OF MANAGEMENT AND THOSE CHARGED WITH GOVERNANCE FOR THE FINANCIAL STATEMENTS

The 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 entity in accordance with Accounting Standards issued by the Institute of Chartered Accountants of India and in accordance with accounting principles generally accepted in India and for such, internal control as management determines is necessary to enable the preparation of financial statements that are free from material misstatement, whether due to fraud or error.

Those charged with governance are responsible for overseeing the entity's financial reporting

AUDITORS RESPONSIBILITY FOR THE AUDIT OF FINANCIAL STATEMENTS

Our responsibility is to express an opinion on these financial statements based on our audit. We have conducted our audit in accordance with standards on auditing issued by the Institute of Chartered Accountants of India. Those Standards require that we have complied with the ethical requirements and plan and perform the audit to obtain reasonable assurance about whether the financial statements as a whole are free from material misstatement, whether due to fraud or error and to issue an auditor's report that includes our opinion.

As part of an audit in accordance with standards on audit, we exercise professional judgment and maintain professional; skepticism throughout the audit:

We also obtain an understanding of internal control relevant to the audit 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 entity's internal control

Evaluate the appropriateness of accounting policies used and the reasonableness of accounting estimates and related disclosures made by management

We believe that the audit evidence obtained by us is sufficient and appropriate to provide a basis for our audit opinion on the financial statements

Other Matters

(a) We have sought and obtained all the information and explanations which to the best of our knowledge and belief were necessary for the purpose of our audit

(b) The balance sheet and the income and expenditure dealt by this report are in agreement with the books of account

Place: Trivandrum

Date : 20-09-2021

For A J Mohan & Associates

Chartered Accountants

FRN :002468N

A J MOHAN & ASSOCIATES CHARTERED ACCOUNTANTS

CA ANITH PA

Partner

Membership No: 226894

UDIN: 21226894AAAAKT4133

NATIONAL CENTRE FOR EARTH SCIENCE STUDIES
Ministry of Earth Science, Government of India

Balance Sheet as on 31st March, 2021

Particulars	Sch No.	2020-21	2019-20
		Rs.	Rs.
Liabilities			
Capital Reserve	1	45,92,96,121.84	46,62,43,759.50
General Reserve	2	(3,13,74,204.00)	(3,10,23,482.00)
Unspent Balance GOI –MoES	3	7,30,48,889.28	11,81,96,169.14
Unspent Balance of Projects	4	16,26,73,777.64	16,64,10,056.90
Corpus Fund	5	18,09,32,191.23	17,19,94,366.71
Current Liabilities	6	1,47,84,931.00	2,39,50,411.75
Total		**85,93,61,706.99**	**91,57,71,282.00**
Assets			
Fixed Assets	7	45,92,96,121.84	46,62,43,759.50
Current Assets, Loans & Advances	8	40,00,65,585.15	44,95,27,522.50
Total		**85,93,61,706.99**	**91,57,71,282.00**
Notes forming part of Accounts	16		

Trivandrum
20-09-2021

For A J Mohan & Associates
Chartered Accountants
FRN 002468N

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

CA ANITH P A
Partner
Membership No :226894
UDIN: 21226894AAAAKT4133

A J MOHAN & ASSOCIATES CHARTERED ACCOUNTANTS

NATIONAL CENTRE FOR EARTH SCIENCE STUDIES

Ministry of Earth Science, Government of India

Income & Expenditure for the year ended 31st March, 2021

Particulars		Sch No.	2020-21	2019-20
			Rs.	Rs.
Income				
Operation and Maintenance Grant				
Grant Received	12,50,00,000.00	9	12,24,18,306.00	13,70,02,837.00
Less: Capital Expenditure	25,81,694.00			
Interest from deposits			39,332.00	-
Other Income		10	3,61,664.00	68,066.00
Depreciation Written Back			8,65,64,248.09	7,16,34,765.46
Total - A			**20,93,83,550.09**	**20,87,05,668.46**
Expenditure				
Staff Salary & Benefits		11	9,38,98,556.00	10,97,98,165.00
Other Institutional Expenses				
Total of Other Institutional Expenses	2,64,99,085.38	12		
Less: Capital Expenditure	25,81,694.00		2,39,17,391.38	3,40,58,825.00
Depreciation			8,65,64,248.09	7,16,34,765.46
Total - B			**20,43,80,195.47**	**21,54,91,755.46**
Excess of Income over expenditure (A-B)			50,03,354.62	- 67,86,087.00
Excess of Income over expenditure of Prev. Year			27,01,950.50	94,88,037.50
Total			**77,05,305.12**	**27,01,950.50**
Notes forming part of Accounts		16		

Trivandrum
20-09-2021

For A J Mohan & Associates
Chartered Accountants
FRN 002468N

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

CA ANITH PA
Partner
Membership No :226894
UDIN : 21226894AAAAKT4133

National Centre for Earth Science Studies
Ministry of Earth Science, Government of India
Receipts & Payments Account for the year ended 31st March, 2021

Receipts	Amount	Amount	Payments	Amount	Amount
Opening Balance			Advertisement		22,807.00
Sbi Akkulam	5,51,48,391.13		Advertisement Charges For R&D		47,593.00
Sbi E-Tax	2,50,633.00		Air Conditioners		4,70,618.00
Imprest	15,150.00	5,54,14,174.13	Akv Enterprises, Canada		2,43,595.00
			Analytical Charges		72,000.00
Grant From Government:			Audit Fees		94,400.00
Operations & Maintenance	12,50,00,000.00		Bank Charges		55,394.86
Research & Development - Sage	10,25,00,000.00	22,75,00,000.00	Boat Hire Charges		15,234.00
			Books & Journals		22,92,927.00
Other Receipts:			Cgst		9,88,927.00
Application Fee (Right To Info		20.00	Cgst Tds		1,15,834.00
Cash Deposits		1,672.00	Chemicals/ Consumables		1,05,83,337.00
Profit/Loss On Sale Of Asset		38,069.00	Children Education Allowance		9,45,000.00
Other Receivables		53,250.00	Communication /Postage Charges		5,628.00
Refund From Ksebt		56,419.00	Computer System & Accessories		45,39,079.00
Tds Receivable		1,21,850.00	Consultant Fee/ Charges		4,84,932.00
Miscellaneous Receipts		2,84,338.00	Consultants Charges		12,12,606.00
Fund Diversion		26,65,693.00	Consumables		3,31,561.00
Margin Money On Lc - Ncess		2,27,17,316.00	Contingency		45,08,862.00
			Contribution To Epf		33,33,315.00
			Contribution To Epfif		25,425.00
			Contribution To Nps		28,11,276.00
			Contribution To Pension Scheme		3,80,000.00
			Co-Operative Recovery		43,000.00
			Cost Of Power/Electricity-Labs		2,596.00
			Electrical Fittings To Buildin		6,400.00
			Electrical/Ups Installations		6,48,456.00
			Electricity Charges		33,69,234.00
			Emd Received		29,00,005.75
			Epf Administrative Charges		1,60,869.00
			Epf Staff		58,87,606.00
			Equipments Repair Charges/Amc		8,58,194.00
			Field Expenses		6,00,000.00
			Furniture		7,54,751.00
			Gpf Central		3,62,614.00
			Gsis		49,730.00
			Hire Charges Of Vehicles		24,87,088.00
			Hospitality Expenses		1,16,291.00
			Igst		54,99,768.00
			Igst Tds		1,99,944.00
			Incentive/Awards To Staff		32,500.00
			Income Tax Staff		67,83,295.00
			Insurance Labs & Equipments		6,532.00
			Kfc		11,648.00
			Laboratory Equipment		2,00,53,075.00
			Land Lease		98.00
			Leave Salary & Pension Contrib		70,487.00
			Leave Travel Concession		4,41,675.00
			Legal Charges		1,84,800.00
			Lic		6,49,096.00
			Lic Gg Scheme For Staff		7,24,423.00
			Major Software		7,15,643.00
			Medical Expense Reimbursement		4,09,620.00
			Membership/Registration		73,208.00
			Ncess Co-Operative Society		22,745.00
			Nps Service Charges		6,337.00
			Nps Staff		28,11,276.00
			Office Equipments		13,342.00
			Petrol Diesel & Oil		1,07,821.00
			Pm Cares Fund		1,68,500.00

A. MOHAN & ASSOCIATES CHARTERED ACCOUNTANTS

National Centre for Earth Science Studies
Ministry of Earth Science, Government of India
Receipts & Payments Account for the year ended 31st March, 2021

Receipts	Amount	Amount	Payments	Amount	Amount
			Prepaid Taxes & Insurance-Vehi		7,917.00
			Previous Years Salary		76,608.00
			Printing & Publication Cost		2,24,068.02
			Printing & Stationery		13,82,904.00
			Prior Period Expenses		10,41,575.00
			Prior Period Expenses-Others		3,19,302.00
			Professional Tax		2,76,250.00
			Remuneration To Project Staff		2,43,39,453.00
			Rent		9,89,420.00
			Repairs & Maint Of Building		21,63,498.00
			Repairs & Maintenance		1,43,006.00
			Repairs & Maintenance-Others		8,30,901.00
			Repairs & Maintenance-Vehicles		58,582.00
			Salaries-Others		5,65,04,004.00
			Salary-Other Institutes		82,93,937.00
			Sb-Gardening		33,000.00
			Sb-Housekeeping		11,28,423.00
			Sb-Swachtha Mission		2,218.00
			Sb-Swachtha Pakhwada		13,447.00
			Security Deposit Received		2,06,294.00
			Semi/Conf/Wkshp/Trng/Brstmng		72,124.00
			Sgst		9,88,937.00
			Sgst Tds		1,15,834.00
			Shimadzu(Asia Pacific)Pte Ltd.		44,12,950.00
			Sitting Fee Visiting Experts		3,600.00
			Sitting Fee/ Honor-Visiting Ex		92,000.00
			Subscription To Ncess Rec-Club		16,600.00
			Sundry Creditors For Expenses		52,43,774.00
			Sundry Creditors For Supplies		30,37,423.00
			Taxes & Insurance-Vehicles		12,670.00
			Training Expenses		4,49,400.00
			Travelling Expense		83,346.00
			Travelling Expense To Visiting		1,149.00
			Vehicle Hire Charges		8,15,961.00
			Water Charges		64,962.00
			Income Tax Contractor		1,29,488.00
			Payments For Civil Works - Cpwd		1,07,29,548.00
			Staff Advances:		
			Other Advance		17,77,217.59
			Tour Advance		15,61,075.89
			Rolling Contingent Advance		91,283.00
			Grants To Other Institutes		
			Anna University		8,41,000.00
			Cusat		10,99,500.00
			Cwrdm		8,50,000.00
			Jawaharlal Nehru University		12,38,000.00
			Manipal Academy Of Higher Educ		17,14,000.00
			National Institute Of Oceanogr		8,23,000.00
			Nit, Karnataka		1,55,000.00
			Pondicherry University		20,30,000.00
			V.O.Chidambaram College		11,55,000.00

AJ MOHAN & ASSOCIATES CHARTERED ACCOUNTANTS

National Centre for Earth Science Studies
Ministry of Earth Science, Government of India
Receipts & Payments Account for the year ended 31st March, 2021

				Payments For Import Purchases Of Equipments		
				Cameca, France		1,31,43,412.00
				Droplet Measurement Technolo		90,86,794.00
				Eosonde Research Services Llc		1,38,328.00
				Gem Systems,Inc.,Canada		98,274.00
				Geometrics Inc.,Usa		10,20,517.00
				Ids Georadar S.R.L, Italy		32,79,668.00
				Ps Analytical Ltd.,England		4,33,764.00
				Rbr Limited, Canada		20,40,785.00
				Rpg-Radiometer Physics Gmbh		29,88,995.00
				Savillex Corporation,Usa		16,11,603.00
				Skalar Analytical B.V		37,66,543.00
				Teledyne Rd Instruments,Usa		74,035.00
				Tescan Brno, Czech Republic		90,214.00
				Closing Balance:		
				Sbi Akkulam	4,22,25,788.02	
				Sbi E-Tax	1,21,145.00	
				Imprest	7,287.00	4,23,54,220.02
TOTAL		**30,88,52,801.13**		**TOTAL**		**30,85,99,840.13**

For A J Mohan & Associates

Chartered Accountants

FRN : 002468N

A J MOHAN & ASSOCIATES CHARTERED ACCOUNTANTS

CA ANITH PA

Partner

Membership No: 226894

UDIN: 21226894AAAAKT4133

NATIONAL CENTRE FOR EARTH SCIENCE STUDIES
MINISTRY OF EARTH SCIENCE, GOVERNMENT OF INDIA
Schedules Forming part of Balance Sheet

Schedule 1 - Capital Reserve

Particulars	Sch.No	As at 31.3.2021	As at 31.3.2020
		Rs.	Rs.
Opening Balance		46,62,43,759.49	24,92,85,953.95
Add: Addition to Capital Asset		8,17,33,602.00	28,80,15,228.00
Add: Transfer from External Projects		6,25,598.43	5,78,791.00
Less: Depreciation		8,65,64,248.09	7,16,34,765.46
Less: Sale of Fixed Assets		27,42,590.00	1,448.00
Closing balance		**45,92,96,121.84**	**46,62,43,759.49**

Schedule 2 - General Reserve

Particulars	Sch.No	As at 31.3.2021	As at 31.3.2020
		Rs.	Rs.
Plan fund from GOK			
Opening Balance		59,67,205.00	59,67,205.00
Add: Receipts for R&D from operations and maintenance fund			
Less: Plan Revenue Expenditure for the year		(1,10,375.00)	
Less: Plan Capital Expenditure for the year			
Add: Interest Received and other income			
Add: Previous Year Adjustments			
Closing Balance		**58,56,830.00**	**59,67,205.00**
Non Plan Fund from GOK			
Opening Balance		(3,69,90,687.00)	(3,15,20,576.00)
Add: Receipts during the year			
Less: Non Plan Revenue Expenditure for the year		2,40,347.00	54,70,111.00
Closing Balance		**(3,72,31,034.00)**	**(3,69,90,687.00)**
Total		**(3,13,74,204.00)**	**(3,10,23,482.00)**

Schedule 3 - Unspent Balance GOI - MoES

Particulars	Sch.No	As at 31.3.2021	As at 31.3.2020
Operation and Maintenance Fund		Rs.	Rs.
Grant in aid for salaries and general (OPMA)			
Opening Balance		27,01,950.50	94,88,037.50
Add: Grant Received during the year	9	12,50,00,000.00	14,04,00,000.00
Less: Revenue Expenditure	11 & 12	11,78,15,947.38	14,38,56,990.00
Less: Capital Expenditure	11 & 12	25,81,694.00	33,97,163.00
Add: Income from Interest & Other Income	10	4,00,996.00	68,066.00
Closing Unspent Balance of Grant		**77,05,305.12**	**27,01,950.50**
Grant in aid for creation of capital assets (Major works)			
Opening Balance		8,20,64,504.00	4,38,66,958.00
Add: Grant Received during the year		-	4,00,00,000.00
Less: Revenue Expenditure		69,570.00	50,386.00
Less: Capital Expenditure	15	1,56,78,145.00	17,52,068.00
Add: Income from Interest & Other Income			-
Closing Unspent Balance of Grant		**6,63,16,789.00**	**8,20,64,504.00**

Seismological and Geoscience (SAGE)			
(Research & Development Programme)			
Opening Balance		3,34,29,714.64	16,06,45,371.06
Add: Grant Received during the year		10,25,00,000.00	23,65,00,000.00
Less: Revenue Expenditure	13	7,36,45,027.48	8,08,51,107.42
Less: Capital Expenditure	14	6,32,96,307.00	28,28,64,549.00
Add: Income from Interest & Other Income		346.00	
Add: Income from sale of assets		38,069.00	
Closing Unspent Balance of Grant		**(9,73,204.84)**	**3,34,29,714.64**
Closing Unspent Balance		**7,30,48,889.28**	**11,81,96,169.1**

Schedule 4 - Unspent Balance of Projects

Particulars	Sub Sch No.	As at 31.3.2021	As at 31.3.2020
		Rs.	Rs.
Research Projects	A	1,47,79,740.14	1,30,93,522.14
Divisional Core Research Projects	A	1,74,83,397.54	1,16,70,473.80
Service Component Projects	A	(3,41,850.00)	47,00,547.50
Consultancy Projects	B	13,07,52,489.96	13,69,45,513.46
Total		**16,26,73,777.64**	**16,64,10,056.90**

Schedule 5 - Corpus Fund

Particulars	Sch.No	As at 31.3.2021	As at 31.3.2020
		Rs.	Rs.
Opening Balance		17,19,94,366.71	15,02,10,904.71
Add: Interest Received Fixed Deposit		19,01,103.00	1,44,60,253.00
Add: Income from Consultancy Projects		36,43,213.02	
Add: Overhead Charges		18,10,124.00	37,94,675.00
Add: Other Receipts		15,83,384.50	35,28,534.00
Closing Unspent		**18,09,32,191.23**	**17,19,94,366.71**

Schedule 6 - Current Liabilities

Particulars	Sch.No	As at 31.3.2021	As at 31.3.2020
		Rs.	Rs.
Common Fund		35,668.00	35,668.00
EMD		27,94,467.00	56,94,472.75
License Fee Payable		-	-
Tax Deducted at Source Payable Contractors		1,20,145.00	2,49,633.00
Tax Deducted at Source Payable Staff		4,73,500.00	3,82,000.00
Security Deposit		3,41,268.00	5,47,562.00
EPF Staff		4,86,315.00	7,34,524.00
Subscription to NCESS Rec- Club		1,500.00	-
Co-Operative Recovery		13,000.00	-
NPS Staff		2,41,481.00	2,24,513.00
GPF Central			-
GSLIS		4,470.00	-
KFC		1,050.00	12,698.00
LIC		59,552.00	-
NCESS Co-Operative Society		4,441.00	-
Sundry creditors for expenses		88,21,089.00	52,58,689.00
Sundry creditors for supplies		13,06,280.00	30,37,423.00
GST payable		-	
GST TDS		25,171.00	74,52,461.00
		1,05,876.00	3,20,768.00
Total		**1,47,84,931.00**	**2,39,50,411.75**

NATIONAL CENTRE FOR EARTH SCIENCE STUDIES

Ministry of Earth Science

Schedules Forming Part of Balance Sheet as on 31.03.2021

Schedule 7- Fixed Assets

Sl No.	Particulars	Balance as on 1st April 2020	Additions		Deletion / Adjustments	Balance as on 31st March 2021	Rate %	Depreciation Provided during the year	Balance as on 31st March 2021
			More than 180 days	Less than 180 days					
		Rs.	Rs.	Rs.	Rs.	Rs.		Rs.	Rs.
1	Buildings	1,67,11,877.38	-	-	-	1,67,11,877.38	10.00	16,71,187.74	1,50,40,689.64
2	Library Books	46,67,391.18	3,11,876.00	19,81,051.00		69,60,318.18	40.00	23,87,917.07	45,72,401.11
3	Computers	1,33,62,687.68	11,41,695.00	35,49,033.00	6,442.00	1,80,46,973.68	40.00	65,08,982.87	1,15,37,990.81
4	Furnitures & Fixtures	1,03,72,817.74	1,72,430.00	8,58,476.00	-	1,14,03,723.74	10.00	10,97,448.57	1,03,06,275.16
5	Laboratory Equipments	37,71,03,822.91	1,63,25,764.00	3,90,35,196.43	24,06,415.00	43,00,58,368.34	15.00	6,15,81,115.52	36,84,77,252.82
6	Office Equipments	94,10,879.73	20,892.00	89,463.00	2,43,439.00	92,77,795.73	15.00	13,84,959.63	78,92,836.09
7	Plant & Machinery	24,701.34	-	-	-	24,701.34	15.00	3,705.20	20,996.14
8	Electrical Installations	83,76,738.60	3,31,913.00	34,46,814.00	86,294.00	1,20,69,171.60	15.00	15,51,864.69	1,05,17,306.91
9	Vehicles	4,93,306.87				4,93,306.87	15.00	73,996.03	4,19,310.84
10	Research Boats	1,475.38	-	-	-	1,475.38	20.00	295.08	1,180.30
11	Softwares	2,57,18,060.71	-	8,53,971.00	-	2,65,72,031.71	40.00	1,03,02,775.68	1,62,69,256.03
12	Work In Progress		1,42,40,626.00			1,42,40,626.00			1,42,40,626.00
	Total	**46,62,43,759.50**	**3,25,45,196.00**	**4,98,14,004.43**	**27,42,590.00**	**54,58,60,369.93**		**8,65,64,248.09**	**45,92,96,121.84**

AJ MOHAN & ASSOCIATES CHARTERED ACCOUNTANTS

NATIONAL CENTRE FOR EARTH SCIENCE STUDIES
MINISTRY OF EARTH SCIENCE, GOVERNMENT OF INDIA
Schedules Forming part of Balance Sheet

Schedule 8 – Current Assets, Loans & Advances

Particulars		As at 31.3.2021	As at 31.3.2020
		Rs.	Rs.
A. Current Assets			
1. Stock – in – hand		16,12,259.00	7,91,494.00
2. Cash & Bank Balance			
SBI – Consultancy Projects	7,55,54,960.96		8,41,43,239.46
SBI – External Projects	3,08,99,369.68		2,76,92,823.44
SBI – NCESS	4,22,25,788.02		5,51,48,391.13
SBI – Corpus Fund	6,220.23		395.71
Treasury Accounts (GOK)	11,000.00		11,000.00
SBI – NCESS E-TAX	1,21,145.00		2,50,633.00
Term Deposits	16,04,72,419.00		15,26,30,937.00
Imprest Balances	7,287.00		15,150.00
		30,92,98,189.89	31,98,92,569.74
Total A (1+2)		**31,09,10,448.89**	**32,06,84,063.74**
B. Loans, Advances & Other Assets			
1.Deposits			
Deposit with EPF			1,10,375.00
Deposit with KSEB		6,24,610.00	6,24,610.00
Deposit with T K Varghese and Son		6,000.00	6,000.00
Deposit with BSNL		3,000.00	3,000.00
Deposit with drinking water		300.00	300.00
Cylinder deposit		1,900.00	1,900.00
Caution deposit		3,000.00	3,000.00

A.V. MOHAN & ASSOCIATES CHARTERED ACCOUNTANTS

2. Advances &other amount recoverable in cash or in kind or for value to be recovered			
Tour Advance		18,53,071.89	62,79,704.00
Other Advance		24,01,314.17	58,48,242.56
Rolling Contingent Advance		1,12,715.00	2,25,000.00
Margin Money on LC NCESS		53,46,041.00	2,80,63,357.00
Advance to staff – External/Consultancy Projects		7,96,416.00	5,68,159.00
Advance to Suppliers – NCESS		4,80,58,227.00	5,95,66,668.00
Leave Salary Receivable		1,35,990.00	38,854.00
Salary Receivable		6,40,079.00	6,40,079.00
Accrued Interest- CORFU		75,53,552.00	75,52,952.00
TDS Receivable – External Projects		2,41,215.00	2,24,194.00
TDS Receivable – Consultancy Projects		1,88,000.00	3,63,600.00
TDS Receivable – NCESS		-	46,250.00
Grants to Other Institutes		1,76,16,936.20	1,51,58,429.20
Gratuity Recievable KSCTSE		29,98,600.00	29,98,600.00
GST Receivable		40,800.00	40,800.00
Prepaid expenses		7,917.00	2,84,352.00
Service Tax Interest Receivable		10,163.00	10,163.00
Service Tax Receivable		1,84,870.00	1,84,870.00
Other Receivable		3,30,419.00	
Total B (1+2)		**8,91,55,136.26**	**12,88,43,458.76**
Total (A+B)		**40,00,65,585.15**	**44,95,27,522.50**

A.MOHAN & ASSOCIATES CHARTERED ACCOUNTANTS

NATIONAL CENTRE FOR EARTH SCIENCE STUDIES

MINISTRY OF EARTH SCIENCE, GOVERNMENT OF INDIA

Schedules Forming part of Income and Expenditure

Schedule 9 – Grant Received

Particulars	As at 31.3.2021	As at 31.3.2020
	Rs.	Rs.
Grant in aid salaries and general (OPMA)		
Add: Grant Received During the Year	12,50,00,000.00	14,04,00,000.00
Total	**12,50,00,000.00**	**14,04,00,000.00**

Schedule 10 – Interest & Other Income

Particulars	As at 31.3.2021	As at 31.3.2020
	Rs.	Rs.
Miscellaneous Receipts	3,61,474.00	67,556.00
Sale of Usufructs	-	230.00
Sale of Tender Forms		-
Application Fee (Right to Information Act)	190.00	280.00
Interest on Fixed deposits		-
Interest From Deposit	39,332.00	-
Total	**4,00,996.00**	**68,066.00**

AJ MOHAN & ASSOCIATES CHARTERED ACCOUNTANTS

Schedule 11 – Staff Salary & Benefits

Particulars	As at 31.3.2021	As at 31.3.2020
	Rs.	Rs.
Salary Director	20,15,179.00	33,87,690.00
Salaries Others	7,10,35,545.00	7,36,10,224.00
Salary Other Institutes	94,36,601.00	2,23,75,973.00
Contribution to EPF	33,53,315.00	41,75,515.00
Contribution to EPS	3,80,000.00	3,92,500.00
EPF Administrative Charges	1,55,174.00	1,90,339.00
Contribution to EPF IF	25,425.00	27,225.00
Contribution to NPS	28,11,276.00	25,90,662.00
Children Education Allowance	9,45,000.00	8,64,000.00
Leave Salary & Pension Contribution	70,487.00	5,71,176.00
Leave Travel Concession	24,01,900.00	3,13,683.00
Incentives to Staff	32,500.00	38,900.00
LIC GG Scheme for Staff	7,24,423.00	6,87,841.00
Medical Expenses Reimbursement	4,27,268.00	1,55,411.00
Previous Year Salary	76,608.00	4,17,026.00
Nps Service Charges	7,855.00	
Total	**9,38,98,556.00**	**10,97,98,165.00**

AJ MOHAN & ASSOCIATES CHARTERED ACCOUNTANTS

Schedule 12 - Other Institutional Expenses		
Particulars	**As at 31.3.2021**	**As at 31.3.2020**
	Rs.	**Rs.**
Computer System & Accessories	2,42,497.00	78,057.00
Electrical /UPS Installations	3,144.00	28,028.00
Air Coditioners		54,700.00
Canteen Equipment		-
Electrical fittings to buildings	6,400.00	
Library Books & Journals	22,92,927.00	18,99,010.00
Major software		11,39,734.00
Furniture		1,51,334.00
Office Equipments	36,726.00	46,300.00
Advertisement	1,69,554.00	19,78,119.00
Audit Fee	94,400.00	1,41,600.00
Bank charges	2.38	-
Consultant fee	4,89,667.00	6,82,000.00
Consumables	14,92,988.00	8,90,562.00
Contingency	51,52,126.00	54,14,532.00
Electricity Charges	38,65,663.00	43,40,511.00
Hospitality Expenses	1,34,733.00	17,42,201.00
Legal Charges	2,17,800.00	3,15,910.00
News Papers & Periodicals	999.00	-
Parlimentary Committee Expenses		79,090.00
Petrol , Diesel & Oil	2,25,849.00	2,81,543.00
Postage & Communication	3,85,910.00	4,86,966.00
Printing & Stationery	5,48,527.00	7,38,442.00
Prior Period Expenses	7,84,802.00	16,61,578.00
Remuneration to Project Staff	29,77,886.00	38,09,185.00
Repairs & Maintenance - Others	15,30,752.00	12,75,226.00
Repairs & Maintenance - Building	23,05,745.00	28,16,733.00
Repairs & Maintenance - Vehicle	76,931.00	65,446.00
Research Council Expenses		61,557.00
Seminar/Conference	84,289.00	16,00,040.00
Sitting Fee/Honor-Visiting Expenses	1,05,740.00	1,86,860.00
Swachh Bharath- Gardening	67,200.00	6,68,052.00
Swachh Bharath- House Keeping	14,85,144.00	6,06,770.00
Swachh Bharath Pakhwada	2,81,204.00	82,230.00
Taxes & Insurance Vehicles	12,670.00	22,252.00
Travelling Expenses	1,09,930.00	8,19,531.00
Travelling Expenses for Visiting Expert	1,149.00	15,17,467.00
Vehicle Hire Charges	11,98,453.00	16,66,827.00
Water Charges	64,962.00	1,07,595.00
Sb-Swachtha Mission	52,218.00	
Land Lease	98.00	
Total	**2,64,99,085.38**	**3,74,55,988.00**

Schedule 13 - Research & Development Revenue Expenses

Particulars	As at 31.3.2021	As at 31.3.2020
	Rs.	Rs.
Advertisement charges for R&D	81,845.00	28,22,309.00
Bank charges	55,392.48	1,28,172.98
Boat hire charges	49,324.00	6,46,891.00
Chemicals/ consumables	1,91,94,110.00	1,60,32,588.64
Chemicals/ consumables to other institutes	18,30,451.00	5,97,895.00
Cost Of Power/Electricity - Labs	29,746.00	2,893.00
Contingency	2,06,244.00	12,29,536.00
Contingency other institutes	5,95,741.00	3,21,817.80
Consultants charges	12,12,606.00	5,01,500.00
Communication /postage charges	1,451.00	73,110.00
Equipments repair charges/ AMC	17,19,543.00	23,13,299.00
Field expenses	10,34,490.00	11,41,555.00
Field expenses to other institutes	19,14,205.00	16,39,622.00
Hire charges of vehicles	35,49,333.00	45,84,902.00
Insurance labs & equipments	2,23,850.00	1,67,700.00
Membership / Registration	73,208.00	3,90,649.00
Overhead charges to other institutes	7,95,763.00	9,55,447.00
Printing & publication cost	2,24,068.02	3,04,588.00
Printing & stationery	8,96,258.00	75,662.00
Prior period expenses	83,82,724.98	25,39,016.00
Repairs and maintenance	35,12,331.00	14,27,695.00
Remuneration to project staff	2,37,10,190.00	2,81,54,554.00
Remuneration to other institute	23,10,833.00	21,74,789.00
Recognition Fee/ Doct Committee		80,000.00
Rent	11,98,345.00	1,86,705.00
Seminar, symposium & workshop		14,73,492.00
Sitting fee Visiting Experts	3,600.00	66,748.00
Travelling Expense for visiting experts	-	6,70,312.00
Travelling expense	3,05,737.00	1,01,47,659.00
Training Expenses	4,49,400.00	
Analytical Charges	84,238.00	
Total	**7,36,45,027.48**	**8,08,51,107.42**

Schedule 14 - Research & Development Capital Expenses

Particulars	As at 31.3.2021	As at 31.3.2020
	Rs.	Rs.
Computer System & Accessories	4441632.00	10015751.00
Electrical /UPS Installations	939312.00	915673.00
Major Software	853971.00	12218270.00
Furniture	1004580.00	1133147.00
Office equipment	36503.00	29780.00
Laboratory equipment	54663803.00	257342632.00
Air conditioners	1356506.00	1181628.00
Survey and Mapping Equipment		27668.00
Total	**63296307.00**	**282864549.00**

Schedule 15 -Creation of capital assets (Major Works)

Particulars	As at 31.3.2021	As at 31.3.2020
	Rs.	Rs.
(a) Revenue Expenditure:		
Minor Civil Works (Repairs & Maintenance)	69,570.00	50,386.00
(b) Capital Expenditure:		
Major Civil Works	14,37,519.00	17,52,068.00
Work In Progress	1,42,40,626.00	
Total	**1,57,47,715.00**	**18,02,454.00**

NATIONAL CENTRE FOR EARTH SCIENCE STUDIES
MINISTRY OF EARTH SCIENCE, GOVERNMENT OF INDIA

Sub Schedule A

Statement of Unspent Balance in respect of Grant in Aid received for Research from Ministries/Departments/ Organisations of Central/State Governments, Divisional Core Research Projects and Service Component Projects from 01/04/2020 to 31/03/2021

Project	Opening Balance Rs.	Amount Received Rs.	Amount Refunded Rs.	Net Amount Received Rs.	Net Amount Available Rs.	Amount Utilised Rs.	Closing Balance Rs.
Research Projects							
							-
COMAPS4	-						
CSIR25	11,537.00				11,537.00		11,537.00
CSIR26	-						
DMD2	-	3,890.00	3,890.00				
DST79	-						
DST80	1,86,598.00		1,86,598.00	(1,86,598.00)			-
DST82	-	4,995.00		4,995.00	4,995.00		4,995.00
DST84	-						
DST85	13,28,831.00	34,902.00		34,902.00	13,63,733.00	45,000.00	13,18,733.00
DST86	3,55,161.00	4,82,795.00		4,82,795.00	8,37,956.00	8,32,128.00	5,828.00
DST87	8,836.00	14,27,585.00		14,27,585.00	14,36,421.00	8,92,784.00	5,43,637.00
DST88	-						
DST89	9,08,285.14	22,59,631.00		22,59,631.00	31,67,916.14	23,50,473.00	8,17,443.14
DST90	2,42,087.00	5,103.00		5,103.00	2,47,190.00	51,514.00	1,95,676.00
DST91	1,74,430.00	4,53,655.00		4,53,655.00	6,28,085.00	4,24,598.00	2,03,487.00
DST92		22,12,684.00		22,12,684.00	22,12,684.00	11,88,125.00	10,24,559.00
FC	1.00				1.00		1.00
IDRB1	3,18,081.00				3,18,081.00	62,824.00	2,55,257.00
KSCS28	4,77,347.00	12,888.00		12,888.00	4,90,235.00		4,90,235.00
KSCS29	87,03,777.00	1,39,422.00		1,39,422.00	88,43,199.00	79,650.00	87,63,549.00
KSCS31	-	56,714.00		56,714.00	56,714.00	56,714.00	-
KSCS34	-	2,91,657.00	13,157.00	2,78,500.00	2,78,500.00	2,78,500.00	-
KSCS36	5,086.00	3,44,914.00		3,44,914.00	3,50,000.00	3,30,000.00	20,000.00
KSCS37	1,362.00	3,15,723.00		3,15,723.00	3,17,085.00	3,14,359.00	2,726.00
KSCS38	14,040.00	3,11,121.00		3,11,121.00	3,25,161.00	3,05,161.00	20,000.00
KSCS40	20,052.00	24,200.00		24,200.00	44,252.00		44,252.00
KSCS41	-	6,20,800.00		6,20,800.00	6,20,800.00	6,00,800.00	20,000.00
KSCS42	-	4,72,400.00		4,72,400.00	4,72,400.00		4,72,400.00
KCZMA	50,00,000.00	50,00,000.00		50,00,000.00	1,00,00,000.00	97,87,774.00	2,12,226.00
MAPAN	-						
MOES10	-						
MOES12	-						
MOES9	-						
SAC15	3,38,011.00	5,98,438.00		5,98,438.00	9,36,449.00	5,83,250.00	3,53,199.00
UGC6	-	10,263.00	10,263.00	-	-	-	-
							-
							-
Total	**1,80,93,522.14**	**1,50,83,780.00**	**2,13,908.00**	**1,48,69,872.00**	**3,29,63,394.14**	**1,81,83,654.00**	**1,47,79,740.14**

A.J MOHAN & ASSOCIATES CHARTERED ACCOUNTANTS

NATIONAL CENTRE FOR EARTH SCIENCE STUDIES
MINISTRY OF EARTH SCIENCE, GOVERNMENT OF INDIA

Sub Schedule A

Project	Opening Balance Rs.	Amount Received Rs.	Amount Refunded Rs.	Net Amount Received Rs.	Net Amount Available Rs.	Amount Utilised Rs.	Closing Balance Rs.
Divisional Core Research Projects							
ENDF	11,37,486.00	13,474.00		13,474.00	11,50,960.00	11,50,960.00	-
GEOMAT	42,60,885.00	-	-	-	42,60,885.00	-	42,60,885.00
MACIS	62,72,102.80	1,00,27,055.34		1,00,27,055.34	1,62,99,158.14	30,76,645.60	1,32,22,512.54
Total	**1,16,70,473.80**	**1,00,40,529.34**	-	**1,00,40,529.34**	**2,17,11,003.14**	**42,27,605.60**	**1,74,83,397.54**
Service Component Projects							
AAS	1,215.50	1,32,412.00		1,32,412.00	1,33,627.50	1,32,412.50	1,215.00
CPT3	-						
CPT4	3,39,966.00	2,70,000.00		2,70,000.00	6,09,966.00	2,95,297.00	3,14,669.00
DECC2	(2,97,768.00)			-	(2,97,768.00)		(2,97,768.00)
DECC3	(3,42,866.00)				(3,42,866.00)	21,500.00	(3,64,366.00)
LDSP							
LRSA	-	4,200.00		4,200.00	4,200.00	4,200.00	-
PSA	-	16,200.00		16,200.00	16,200.00	16,200.00	-
RSA3							
SEM	-	6,600.00		6,600.00	6,600.00	6,600.00	-
TKH1							
XRF	-	1,72,412.00		1,72,412.00	1,72,412.00	1,68,012.00	4,400.00
							-
Total	**(2,99,452.50)**	**6,01,824.00**	-	**6,01,824.00**	**3,02,371.50**	**6,44,221.50**	**(3,41,850.00)**
Grand Total	**2,94,64,543.44**	**2,57,26,133.34**	**2,13,908.00**	**2,55,12,225.34**	**5,49,76,768.78**	**2,30,55,481.10**	**3,19,21,287.68**

NATIONAL CENTRE FOR EARTH SCIENCE STUDIES

MINISTRY OF EARTH SCIENCE, GOVERNMENT OF INDIA

Sub Schedule B

Statement of Unspent Balance of Consultancy Projects for the year 2020-2021

	Project	Opening Balance	Consultancy Fee Received	Consultancy Expenses	Incentive Money to Staff	Transferred to Corpus Fund	Transferred to CESS Fund	Transferred to Common Fund	Total Expense	Closing Balance
1	CONY	-	12,61,498.00			12,61,498.00			12,61,498.00	-
2	CONY196	12,26,857.00	-	-	-	-	-	-	-	12,26,857.00
3	CONY201	11,82,248.00	-	-	-	-	-	-	-	11,82,248.00
4	CONY281	4,95,088.00	-	-	-	-	-	-	-	4,95,088.00
6	CONY308	25,500.00	-	-	-	-	-	-	-	25,500.00
7	CONY309	2,32,879.00	-	-		-			-	2,32,879.00
8	CONY312	97,059.00	-	-	-	-	-	-	-	97,059.00
9	CONY315	1,86,145.00	-	-	-	-	-	-	-	1,86,145.00
10	CONY317	6,63,588.00	-	-	-	-	-	-	-	6,63,588.00
11	CONY329	7,35,944.00	-	-	-	-	-	-	-	7,35,944.00
12	CONY330	5,24,537.00	-	-	-	-	-	-	-	5,24,537.00
13	CONY334	15,58,102.00	-	-	-	-	-	-	-	15,58,102.00
14	CONY343	7,81,831.00	-	-	-	-	-	-	-	7,81,831.00
15	CONY344	10,22,999.00	-	-		-			-	10,22,999.00
16	CONY345	2,98,592.00	-	-	-	-	-	-	-	2,98,592.00
17	CONY346	2,51,375.00	-	-	-	-	-	-	-	2,51,375.00
18	CONY349	5,53,429.00	-	-	-	-	-	-	-	5,53,429.00
19	CONY355	2,29,338.00	-	-	-	-	-	-	-	2,29,338.00
20	CONY356	5,83,332.00	-	-	-	-	-	-	-	5,83,332.00
21	CONY360	1,84,812.00	-	-	-	-	-	-	-	1,84,812.00
22	CONY361	1,80,75,977.00	-			-				1,80,75,977.00
23	CONY363	3,37,391.00	-	-	-	-	-	-	-	3,37,391.00
24	CONY365	2,29,166.00	-	-		-			-	2,29,166.00
25	CONY369	12,89,318.00	-	-		-			-	12,89,318.00
26	CONY370	8,88,532.00	-	-		-			-	8,88,532.00
27	CONY371	2,24,143.00	-	-		-			-	2,24,143.00
28	CONY372	2,05,925.00	-	-		-			-	2,05,925.00
29	CONY374	2,10,000.00	-	-		-			-	2,10,000.00
31	CONY378	8,96,71,427.00	-							8,96,71,427.00
32	CONY379	85,829.00	-							85,829.00

A.T. MOHAN & ASSOCIATES CHARTERED ACCOUNTANTS

NATIONAL CENTRE FOR EARTH SCIENCE STUDIES

MINISTRY OF EARTH SCIENCE, GOVERNMENT OF INDIA

Sub Schedule B

	Project	Opening Balance	Consultancy Fee Received	Consultancy Expenses	Incentive Money to Staff	Transferred to Corpus Fund	Transferred to CESS Fund	Transferred to Common Fund	Total Expense	Closing Balance
33	CONY380	2,52,460.00	-	-		-			-	2,52,460.00
34	CONY381	2,64,841.00	-	-		-			-	2,64,841.00
35	CONY383	99,904.00	-	-		-			-	99,904.00
36	CONY384	2,51,605.00	-	-		-			-	2,51,605.00
37	CONY385	2,80,099.00	-	-		-			-	2,80,099.00
38	CONY386	10,19,850.00	-	-		-			-	10,19,850.00
50	CONY447	80,500.00	-	-		-			-	80,500.00
51	CONY457	57,240.00	-	57,240.00		-			57,240.00	-
54	CONY465	2,09,400.00	-	-		-			-	2,09,400.00
55	CONY466	2,09,400.00	-	-		-			-	2,09,400.00
56	CONY467	2,09,400.00	-	-		-			-	2,09,400.00
58	CONY468	2,09,400.00	-	-		-			-	2,09,400.00
59	CONY469	2,09,400.00	-	-		-			-	2,09,400.00
60	CONY473	2,09,400.00	-	-	-	-			-	2,09,400.00
61	CONY474	2,09,400.00	-	2,09,400.00		-			2,09,400.00	-
62	CONY475	2,09,400.00	-	2,09,400.00	-	-			2,09,400.00	-
63	CONY476	3,80,000.00	-	3,80,000.00		-			3,80,000.00	-
64	CONY477	2,09,400.00	-	2,09,400.00		-			2,09,400.00	-
65	CONY478	2,09,400.00	-	2,09,400.00		-			2,09,400.00	-
66	CONY479	2,10,000.00	-	2,10,000.00		-			2,10,000.00	-
67	CONY480	1,52,000.00	-	1,52,000.00		-			1,52,000.00	-
68	CONY481	2,09,400.00	-	2,09,400.00		-			2,09,400.00	-
69	CONY482	7,49,991.00	-	7,49,991.00					7,49,991.00	-
70	CONY483	60,240.00	-	60,240.00					60,240.00	-

AJ MOHAN & ASSOCIATES CHARTERED ACCOUNTANTS

NATIONAL CENTRE FOR EARTH SCIENCE STUDIES

MINISTRY OF EARTH SCIENCE, GOVERNMENT OF INDIA

Sub Schedule B

Sl No.	Project	Opening Balance	Consultancy Fee Received	Consultancy Expenses	Incentive Money to Staff	Transferred to Corpus Fund	Transferred to CESS Fund	Transferred to Common Fund	Total Expense	Closing Balance
71	CONY484	5,09,189.00	-	3,895.00					3,895.00	5,05,294.00
72	CONY485	1,14,000.00	-	1,14,000.00					1,14,000.00	-
73	CONY486	2,07,127.00	-	2,07,127.00					2,07,127.00	-
74	CONY487	2,09,265.00	-	2,09,265.00					2,09,265.00	-
75	CONY488	2,07,195.00	-	1,000.00					1,000.00	2,06,195.00
76	CONY489	4,29,780.00	-	4,29,780.00					4,29,780.00	-
77	CONY490	6,22,000.00	-	65,844.00					65,844.00	5,56,156.00
78	CONY491	2,09,400.00	-	2,09,400.00		-			2,09,400.00	-
79	CONY492	2,10,000.00	-	175.00		-			175.00	2,09,825.00
80	CONY493	2,10,000.00	-	2,10,000.00		-			2,10,000.00	-
81	CONY494	2,10,000.00		2,10,000.00					2,10,000.00	-
82	CONY495	2,10,000.00		11,260.00					11,260.00	1,98,740.00
83	CONY496	37,115.00		37,115.00					37,115.00	-
84	CONY497	2,00,723.46		13,528.00					13,528.00	1,87,195.46
85	CONY498	2,00,689.00		2,00,689.00					2,00,689.00	-
86	CONY499	2,08,205.00		2,08,205.00					2,08,205.00	-
87	CONY500	2,10,000.00		2,10,000.00					2,10,000.00	-
88	CONY501	2,07,779.00		2,07,779.00					2,07,779.00	-
89	CONY502	2,10,000.00								2,10,000.00
90	CONY503	-								-
91	CONY504	2,07,353.00								2,07,353.00
92	CONY505	2,07,521.00		3,175.00					3,175.00	2,04,346.00
93	CONY506	2,07,358.00		4,705.00					4,705.00	2,02,653.00
94	CONY507	2,03,303.00		2,03,303.00					2,03,303.00	-
95	CONY508	2,07,353.00		2,07,353.00					2,07,353.00	-
96	CONY509	2,10,000.00		2,10,000.00					2,10,000.00	-
97	CONY510	2,10,000.00		2,10,000.00					2,10,000.00	-
98	CONY511	2,10,000.00		2,10,000.00					2,10,000.00	-
99	CONY512	4,30,500.00		1,42,770.00					1,42,770.00	2,87,730.00
100	CONY513	2,10,000.00								2,10,000.00
101	CONY514	1,14,000.00		35.50					35.50	1,13,964.50
102	CONY515	2,10,000.00		10,000.00					10,000.00	2,00,000.00
103	CONY516	2,10,000.00								2,10,000.00
104	CONY517	2,28,812.00		250.00					250.00	2,28,562.00
105	CONY518	2,07,353.00								2,07,353.00
106	CONY519	8,36,000.00		3,54,000.00					3,54,000.00	4,82,000.00
107	CONY520		3,15,001.00	1,66,900.00					1,66,900.00	1,48,101.00
108	CONY521		3,15,000.00	1,05,000.00					1,05,000.00	2,10,000.00
109	CONY522		3,15,000.00	1,05,000.00					1,05,000.00	2,10,000.00
	TOTAL	**13,69,45,513.46**	**22,06,499.00**	**71,38,024.50**	-	**12,61,498.00**	-	-	**83,99,522.50**	**13,07,52,489.96**

Schedule 16

Notes on Financial Statement for the Financial Year ended 31st march 2021

Organizational Information

National Centre for Earth Science Studies is a Society has taken over by the Ministry of Earth sciences, Government of India on 1st 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.

Accounting Policies

The society follows mercantile system of accounting and recognizes income and expenditure on accrual basis except for government grants and other income.

Fixed Assets and Depreciation

All the fixed assets of the Centre of Earth Sciences as on 31.12.2013 have been taken over by National Centre for Earth Studies (NCESS) other than land land owned by the Government of Kerala. As per GO (Ms) no 468/2013 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 the Centre for Earth Studies (CESS) to the Ministry of Earth Sciences, Government of India for 99 years at Rs 1 /- Acre per year for the operation of the Centre.

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 Department. Funds utilized for acquiring fixed assets from Grants received are transferred to Capital Reserve.

Depreciation is charged to the fixed assets on the Written Value Method 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 the closure of projects / or on receipt of permission from concerned department /ministry. Depreciation on assets acquired out of grants has been written back from the capital reserve.

The center has not conducted physical verification of fixed assets during the year. The book value of the fixed assets as per books of accounts is pending to be reconciled with value as per the asset register.

Current Assets

Cash and balance represent the balances with the society, grant in aid projects, and consultancy project Accounts. Closing Stock of chemicals, glassware, consumables and stationery items are at cost as certified by the management. Cash equivalents like term deposits and bank balances are as per the confirmations provided.

Loans and advances

Advance to staff represents balance with them for meeting the expenses in connection with the conduct of research programs and are considered good and secured

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

Certain balances in advances & other amount recoverable in the books as under pending without any movement for more than one year and are subject to confirmation by counter parties

1)Gratuity Receivable from KSCTSE -Rs 29,98,600.00

2)Service Tax Interest Receivable -Rs 10,163.00

3)Service Tax Receivable – Rs 1,84,870.00

4)Salary Receivable – Rs 6,40,079

Provision for Possible Loss on overdue debit balances carried forward under loans and advances could not been ascertained for want of details

Capital Work in Progress

Work in Progress is treated as Capital Expenditure and is shown in the Utilization Certificate. This will be adjusted in due course against respective heads of account, once the work is fully completed.

As per the confirmation certificate obtained from the CPWD, the balance of advance received as per the CPWD Statement is Rs 2,82,61,146.00 as per NCESS books of accounts it is Rs 3,06,33,602.00 difference of Rs 23,72,456 is observed that account settlement process not yet completed.

Capital Reserve

The amount received from the Ministry of Earth Sciences and other institutions utilized for acquiring the fixed assets is credited to capital reserve and the depreciation charged in the income and expenditure statement is written back by debiting the capital reserve.

The capital reserves as on date of taking over are carried forward after deducting the value of land not taken over.

General Reserve

The negative figure of Rs Crores was due to the non -receipt of non-plan funds from the Kerala State Council for Science, Technology and Environment (KSCTSE) and overspent during erstwhile CESS period.

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Corpus Fund

In order to maintain corpus fund approval from the Administrative Ministry is required, however no such approval has been obtained from MOES.Since receipts accrued to NCESS is utilized as main source of receipts for Corpus Fund, obtaining approval from MOES is mandatory. The unspent balances of Consultancy projects that are concluded and closed are transferred to Corpus Fund and MACIS (Divisional Core research project).

Research Program Funds

The balance of the grant for the research programs remaining unspent is stated as Research program under Unspent balance GOI -MOES. During the year, the society has received Rs 10.25 Crores funds towards Research Program Grant from the Ministry of Earth sciences. Excess Expenditure as on 31st March 2021 is Rs 9.73 Lakhs.

Unspent Balance of Projects

The unspent balances of grant received for the conduct of sponsored R&D projects sanctioned by Ministries /Departments of Government of India /Kerala, Consolidated service projects from various agencies are carried forward as unspent balance of projects. During the year Centre has received an amount of Rs 2.77 Crore and unspent balance at the end of the period amounts to Rs 16.26 Crores

Operation and Maintenance Fund

Unspent balance of Grant received from the Ministry of Earth Sciences (MOES) for operation and maintenance expenditure and other income of NCESS is stated as the balance of operation and Maintenance Fund. The excess of income over expenditure or deficit over expenditure in the statement of Income and Expenditure is credited or debited in the account. Unspent balance as on 31st March 2021 is 77.05 Lakhs.

Projects

The Committees consisting the heads of respective projects and other technical personnel are monitoring the status of various projects, including the financial budgets and noting down the minutes of the output of such meeting. The various assets of the project purchased by NCESS are located at such projects. Income and Expenditure of External/Consultancy projects are accounted on cash basis. The unspent amount on the completion of consultancy projects is transferred to NCESS.

Retirement benefits

Leave encashment is accounted for on cash basis, no provision for leave encashment is made in the accounts

Interest received

The society parks fund in short term deposit with bank and also in Savings bank accounts with State Bank of India. The interest received in the said accounts is refunded to Ministry of Earth Sciences. Interest earned on corpus fund is added to the corpus fund itself and not included in the income of the society

Contingent Liabilities

Contingent liability is Possible obligation that may arise in the future depending on occurrence or non-occurrence of one more uncertain event. The following are the legal cases pending in various courts

Details of court case as on 31st March 2021.

Sl No	Writ Petition/ Case Number	Case Particulars	Present Status (as on 31.03.2021)	Likely financial Obligation
1	ATA No: 698 (07) 2013 before the EPF Appellate Tribunal, New Delhi	Petition filed by former employees of CESS seeking payment of Employers share of PF Contribution to the EPF on the pay revision arrears	Appeal Filed through Adv. Ajith S Nair and Adv Nidosh Rathore is appearing before the Tribunal. Stay granted by EPF Appellate Tribunal, New Delhi	Rs. 3.67 Crores (Approx.) Self-contained note with relevant details sent to MoES already
2	WP © No: 15845 of 2015 filed by P. Girija before the before the Honorable High Court of Kerala	Pay scale of Scientist B till date of retirement in 30.09.2006	Hon'ble High Court dismissed the petition vide Judgement dated 24th September 2019.	Petitioner filed Writ Appeal No.269 of 2019 requesting to quash the direction dated 24.09.2019
3	WP © No: 13704/2016 filed K.V.Thomas& others	Pension Case	Judgement awaited	Not known at present
4	Appeal filed on 10-08-2015 before the Appellate Tribunal, Bangalore	Demand to remit service tax against fund received towards grant-in-aid during period from 2002-05 and 2010-11	Case is pending before Customs Excise and Service Tax Appellate Tribunal, Bangalore	Against the Order-in-Appeal, NCESS had filed Appeals (A. Nos. ST/21752 & 21754/2015-DB) before the Customs, Excise and Service Tax Appellate Tribunal, Bangalore. The Registry of the Tribunal had raised a defect notice. The defect notice was to depos 10% of t disputed tax as

MOHAN & ASSOCIATES CHARTERED ACCOUNTANTS

				mandatory pre-deposit as per amended Section 35F of the Central Excise Act, 1944. The Appeals were posted for hearing on the defect before the Hon'ble Tribunal on 18.02.2016. After noting the submission, the Hon'ble Tribunal has directed NCESS to deposit 10% of the disputed tax amount within 4 weeks and report compliance on 11.04.2016. Against A.No. 21752, NCESS had deposited Rs.3,70,740/- on 30.03.2016 and against A. No. 21754 deposited to Rs. 35,224/- on 28.03.2016. Outcome of the case is awaited
5	WP © No: 32888 of 2017 filed by Rajesh P and others before the Honorable High Court of Kerala	Consider placing the petitioners in PB 2 i.e. 9300-34800 with GP 4200/- and for other reliefs.	Counter Affidavit furnished.	Not Known
6	WP © No: 23371 of 2018 filed by Anju K S and others before the Honorable High Court of Kerala	Consider placing the petitioners in PB 2 i.e. 9300-34800 with GP 4200/- and for other reliefs.	Counter Affidavit furnished	Not Known

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7	WP © No: 8515 of 2019 filed by Dr. C N Mohanan and others before the Honorable High Court of Kerala	Requesting unlimited gratuity as per KSCSTE rules	Counter Affidavit forwarded to ASG office for vetting	-----
8	WP © No: 8960 of 2019 filed by Shri. John Mathai and others before the Honorable High Court of Kerala	Requesting unlimited gratuity as per KSCSTE rules	Counter Affidavit filed	Decision awaited
9	WPC 2181/2019 filed by M/s Summer Cabs before the Honorable High Court of Kerala.	To stay the tender process and to award the vehicle contract to M/s Summer Cabs	Counter Affidavit filed	Decision awaited
10	WPC14049/2019 filed by Smt. Sreelekshmi and others before Hon'ble high court	Extension of contract engagement beyond 30.06.2019 and regularization in the services of NCESS.	Hon'ble High Court dismissed the petition vide Judgement dated 26th August 2019.	Petitioners filed Writ Appeal No.2259 of 2019 requesting to quash the direction dated 26th August 2019

A J MOHAN & ASSOCIATES CHARTERED ACCOUNTANTS