




NCESS ANNUAL REPORT 2023-2024

NATIONAL CENTRE FOR EARTH SCIENCE STUDIES

An autonomous institute under the Ministry of Earth Sciences, Government of India

Committed to Our Earth Our Future

FRONT COVER

Top Panel

(clockwise from centre)

1. Geological fieldwork at Vestfold Hills in Antarctica.
2. Seismological Observatory at Larsemann Hills in Antarctica.
3. Eddy Covariance Station at Attappadi in Kerala.
4. Groundwater Discharge at Varkala Cliff in Kerala.
5. A view of mountainous terrain in Munnar, Kerala.
6. A view of mountainous watershed in Vattavada, Kerala

Bottom Panel

Lowlevel clouds near Rajamalay in Munnar, Kerala.

Annual Report 2023 – 2024

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National Centre for Earth Science Studies

Coordination & Compilation Dr. Tomson J. Kallukalam
Shri. S. R. Unnikrishnan

वार्षिक प्रतिवेदन
ANNUAL REPORT

2023-2024

ई एस एस ओ – राष्ट्रीय पृथ्वी विज्ञान अध्ययन केन्द्र
(पृथ्वी विज्ञान मंत्रालय, भारत सरकार)
आक्कुलम, तिरुवनंतपुरम – 695011, भारत

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(Ministry of Earth Sciences, Govt. of India)
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RESEARCH AND DEVELOPMENT ACTIVITIES

Vision: To excel in solid earth research and its applications.

Mission: Foster multi-disciplinary research in emerging areas of solid earth science and provide services by utilizing the knowledge for earth sciences applications and generate leadership capabilities in selected areas.

Contents

From the Director's Desk

Greetings! The National Centre for Earth Science Studies (NCESS) has witnessed significant growth during 2023-24 with the evolution of major research programs and collaborations at the national and international levels, substantial investments in infrastructure, field and lab equipment, and a quality rise in research publications. From the Directors' desk, I am excited to share our progress and the impact of our pursuit of knowledge and innovation. In a year marked by challenges and opportunities, our institute has continued to thrive, driven by our unwavering commitment to excellence and our dedication to advancing the frontiers of Earth Science research. The following are some highlights of our activities during the reporting period.

The institute procured the state-of-the-art IRMS facility, which is coupled with an elemental analyser and a head-space analyser, and is all set for procuring new LA-HR-ICPMS and XRD facilities to strengthen the analytical capability of the institute. The Clean Chemistry Lab (class 10000 with class 100 workstations) is under preparation. With this, NCESS is poised to be one of the best centres in the country for advanced research in geochemistry, geochronology and isotope studies.

On the research front, the following significant results/achievements have been reported by the researchers of NCESS.

NCESS team is all set to study the correlation between East Antarctica and India, their connection before the break-up and models of their geodynamic evolution with the addition of a Broadband Seismological Station in Larsemann Hills, Antarctica. Further, the research aims to unfold the continental evolution of the Eastern Ghats Belt, Himalayas and Archean Cratons like Bundelkhand. As a part of the research activities in crustal dynamics, studies have been taken to find the utility of fluid inclusion studies in petroleum system modelling and to unfold the phenomena of landslides in southern Peninsular India.

India's rapidly changing water scenario regarding its near-surface terrestrial environment, termed the Critical Zone, is investigated. The Critical Zone of the country is under immense stress due to rapid urbanisation, economic developments and climate change issues. NCESS has established three CZOs in Peninsular India and is establishing more CZOs as part of the TERRAIn network. The scientists of NCESS studied the hydrology, biogeochemistry, and pollution aspects of rivers and estuaries in Peninsular India, and the results have been published in highly cited journals.

The frequent occurrence of hazards like beach erosion, coastal flooding, etc., along the sea coast of India, particularly during non-monsoon periods, has always been a matter of concern to the seaside community and the government. NCESS developed a coupled coastal monitoring framework to study wave current interactions in the nearshore region. In addition, we introduced a new method using smartphones, a citizen science model, to study the rip current processes. NCESS also studied the prospects for viable REE deposits in Central Kerala and the distribution - pollution potential of heavy metals in subterranean estuaries in southern India. In the second phase of the Submarine Groundwater Discharge (SGD) project, we incorporated hydrochemical analyses to study groundwater-seawater interactions and

quantification of submarine fresh groundwater discharge. By integrating remote sensing and numerical modelling, the study will offer a more refined and comprehensive perspective on SGD processes.

NCESS is continuing its research to understand the cloud microphysics and precipitation systems of Peninsular India. Our researchers analysed localised features during wet and dry rainfall episodes over the southern tip of India. NCESS has taken up in-depth studies to unfold the atmospheric phenomena in the changing climate scenarios of the country.

NCESS is one of the few institutes in the country authorised to prepare Coastal Regulation Zone status reports. NCESS has prepared the Coastal Zone Management Plan (CZMP) for the Government of Kerala. NCESS is also entrusted with preparing the CZMP of the State of Goa, besides carrying out several smaller consultancy projects for others.

With regard to extension activities, during the reporting period, NCESS organised a two-day National Workshop on Geodynamic Evolution to foster innovative ideas and provide insights into the frontline research among the research community, and Prof. Somnath Dasgupta, INSA Senior Scientist, gave the keynote address. NCESS observed its 10th Foundation Day on 01st January 2024 with a lecture by Prof. (Dr.) Janki Andharia from Tata Institute of Social Sciences. In connection with the Global Science Festival of Kerala, a lecture was delivered by Prof. M. Santosh from China University of Geosciences on 05th January 2024. Dr. D. Bala Subrahamanyam, Scientist SG and Head, NAM Branch, Space Physics Laboratory, delivered a talk on "Laxman Rekha in numerical weather predictions: Face your dilemmas and inhibitions" in Hindi to celebrate the World Hindi Day on 10th January 2024. In addition, NCESS organised workshops on Hindi, vigilance awareness, cyber security, sexual harassment prevention and self-defence for women. NCESS also celebrated the Rashtriya Ekta Diwas, World Environment Day, Swachhata Hi Sewa, National Science Day, International Women's Day, World Water Day, etc. NCESS led and actively participated in the 'Swachh Sagar, Surakshit Sagar' – coastal clean-up campaign of the Government of India by carrying out clean-up activities on two beaches of Kerala. NCESS conducted an outreach program for science education, public outreach and awareness from 21-23 February 2024 in Wayanad, Kerala, where scientists from NCESS delivered lectures at government schools and interacted with the residents in tribal colonies about environmental issues and created awareness of geohazards. The internal seminar series of NCESS, Earth Science Forum, was also very active during the period, with ten lectures to improve the academic activities within the institute.

Our researchers have continued to push boundaries and make significant contributions across a wide range of disciplines. We have published 60 peer-reviewed research papers and 11 book chapters and presented 47 papers at various conferences, some of which have been recognised as ground-breaking in their respective fields. Three research scholars were awarded PhD degrees, and four were awarded best paper at conferences. Several colleagues were invited to serve as chairs/members in editorial boards of journals, boards of studies of universities, and various expert/advisory committees. Our scientists delivered 14 invited talks in multiple institutes/conferences/symposia.

On the organisational front, several objectives were achieved during 2023-24. Three scientists were recruited, and action was taken to fill the vacant project staff positions. Highly motivated young minds drive NCESS, and I hope new incumbents will join in the advertised regular and project positions to strengthen the R&D activities with more vigour and enthusiasm. The Centre eagerly looks forward to completing the infrastructure development activities like renovating the administration block, constructing a guest house and hostel facility for research scholars, etc., while committing to green technology. A new transformer and a DG set were installed at NCESS to cater to the requirements of all sophisticated laboratories. Through consultancy activities, NCESS could generate corpus funds, which shall be utilised for staff welfare schemes.

NCESS made significant progress in terms

of scientific research during 2023-24, and as a national institute, we have risen to a greater height in terms of scientific research. None of these achievements would have been possible without the dedication and hard work of our talented researchers and staff and the unwavering support of our friends and partners. As we look ahead to the future, we remain committed to our mission and will continue to explore new horizons in research. We are proud to be part of an institute that not only works toward achieving the mandate set by the government but also caters to local societal needs. In my first year as the Director of NCESS, I wish, with the sincere and enthusiastic support of the staff and the MoES, that NCESS will scale even greater heights and provide significant leadership in Geoscience research at the national and international levels in the years ahead. On behalf of NCESS, I am delighted to place this Annual Report before all well-wishers of this unique institute.

Prof. N. V. Chalapathi Rao
FNA, FASc, FNASc
Director, NCESS

Governance

Statutory Committees

1. The Society

Hon'ble Minister Ministry of Earth Sciences, Government of India	President
Minister in-charge in the concerned scientific ministry, Government of Kerala	Member
Secretary Ministry of Earth Sciences, Government of India	Member
Secretary Department of Space, Government of India	Member
Secretary Department of Scientific & Industrial Research, Government of India	Member
Principle Secretary in-charge of the department handling MoES or concerned scientific ministry, Government of Kerala	Member
Additional Secretary & Finance Advisor Ministry of Earth Sciences, Government of India	Member
Joint Secretary Ministry of Earth Sciences, Government of India	Member
Dr. Harsh K. Gupta Former Secretary, Department of Ocean Development/ Ministry of Earth Sciences, Government of India	Member
Dr. P. S. Goel Former Secretary, Ministry of Earth Sciences, Government of India	Member
Dr. Shailesh Nayak, Former Secretary, Ministry of Earth Sciences, Government of India & Director, National Institute of Advanced Studies, Bengaluru	Member

Dr. K. Radhakrishnan Former Chairman, Indian Space Research Organisation, Bengaluru	Member
Dr. Satheesh Reddy Former Secretary, Department of Defence R&D	Member
Dr. K. J. Ramesh Former Director General, India Meteorological Department	Member
Director National Centre for Earth Science Studies	Member Secretary

2. The Governing Body (GB)

Secretary Ministry of Earth Sciences, Government of India	Chairperson
Additional Secretary & Finance Advisor Ministry of Earth Sciences, Government of India	Member
Joint Secretary Ministry of Earth Sciences, Government of India	Member
Chairperson Research Advisory Committee -National Centre for Earth Science Studies	Member
Director National Centre for Earth Science Studies	Member
Scientist G/Hand Programme Head - NCESS Ministry of Earth Sciences, Government of India	Member
Senior-most Scientist National Centre for Earth Science Studies	Member
Representative, NITI Aayog	Member
Dr. S. Rajan Former Director, National Centre for Polar and Ocean Research	Member

Dr. Kalachand Sain Director, Wadia Institute of Himalayan Geology	Member
Dr. Dinesh Gupta Former Director General, Geological Survey of India	Member
Dr. Prakash Chauhan Director, National Remote Sensing Centre	Member
Head/In-charge of Administration National Centre for Earth Science Studies	Member Secretary

3. The Finance Committee (FC)

Additional Secretary & Finance Advisor Ministry of Earth Sciences, Government of India	Chairperson
Director National Centre for Earth Science Studies	Member
Director Indian Institute of Tropical Meteorology	Member
Scientist G/H and Programme Head - NCESS Ministry of Earth Sciences, Government of India	Member
Head/In-charge of Administration National Centre for Earth Science Studies	Member
Ms. Mahua Pal Additional Deputy Comptroller & Auditor General	Member
Ms. Neeru Abrol Ex. CMD & Director (Finance), National Fertilizers Limited	Member
Senior Finance Officer National Centre for Earth Science Studies	Member Secretary

4. The Research Advisory Committee (RAC)

Prof. Talat Ahmad Former Vice Chancellor, University of Kashmir	Chairperson

Director National Centre for Earth Science Studies	Member
Scientist G/H and Programme Head - NCESS Ministry of Earth Sciences, Government of India	Member
Dr. S. Rajan Former Director, National Centre for Polar and Ocean Research	Member
Dr. Kalachand Sain Director, Wadia Institute of Himalayan Geology	Member
Dr. Dinesh Gupta Former Director General, Geological Survey of India	Member
Dr. Prakash Chauhan Director, National Remote Sensing Centre	Member
Prof. Isaac Santos Professor of Marine Biogeochemistry, University of Gothenburg, Sweden	Member
Dr. S. Balakrishnan Professor, Pondicherry University	Member
Dr. P. P. Mujumdar Professor, Indian Institute of Science, Bengaluru	Member
Dr. Kusala Rajendran Professor (Retd.), Indian Institute of Science, Bengaluru	Member
Dr. Kanchan Pande Professor, Indian Institute of Technology, Mumbai	Member
Senior-most Scientist National Centre for Earth Science Studies	Member Secretary

Preface

The research activities of NCESS are carried out under the theme "Geodynamics and Surface Processes (GSP)", which focuses on the geodynamic evolution of the Indian plate, complexities of coastal processes, surface and groundwater hydrology, global changes and its impacts, climate-linked near-surface dynamics, critical zone processes and natural hazards. Fifteen research projects are currently being implemented by the six Research Groups of the Centre: Solid Earth Research Group (SERG), Crustal Dynamics Group (CDG), Hydrology Group (HyG), Biogeochemistry Group (BgG), Marine Geoscience Group (MGG), and Atmospheric Science Group (ASG).

Solid Earth Research Group (SERG): The main research objective of the Solid Earth Research Group is to understand the origin and evolution of the planet Earth and its various reservoirs, such as the crust, mantle and core. To achieve this, the group focuses on deciphering the timescales and understanding the processes of geodynamic evolution of the Archean cratons, Proterozoic mobile belts, Purana Basins and mountain belts of Peninsular India. In addition, the group's research also aims to understand the chemical evolution of the Earth's mantle since the earliest differentiation events by studying mantle-derived rocks of different ages at different tectonic settings, including active subduction zones. Other activities of the group include delineation of lithospheric structures under various Indian crustal blocks and shear zones, evolution of Quaternary landscapes, and muon tomography of Indian volcanoes.

Crustal Dynamics Group (CDG): The Group addresses scientific issues related to near-surface dynamic processes on land. The focus has been on understanding the causes and effects of slope failures, with the help of satellite imagery, field studies, and geochemical characterization of soil/rock, as well as trying to predict landslides and suggest mitigation measures. The group's activities also include understanding hydrocarbon fluid movements in sedimentary basins, leading to mineralization.

Hydrology Group (HyG): The Hydrology Group is engaged in the studies of the Earth's critical zone, river and groundwater hydrology, paleoclimate studies, riverine flooding, and anthropogenic contamination and mitigation measures. The group has established critical zone observatories and river/environment monitoring stations in southern peninsular India for continuous measurements of key hydro-meteorological/environmental parameters, and understanding of the effect of natural and anthropogenic forcings on the freshwater systems. The group's initiatives receive considerable importance as these studies are very important in chalking out strategies for containing the adversities of economic growth and making the country's developments environment-inclusive.

Biogeochemistry Group (BgG): Biogeochemistry Group focuses on the study of physicochemical, geological and biological processes and reactions that govern the characteristics of the natural environment. The group also studies the changes in the biogeochemical cycles of elements in the current climate change scenario. The group employs geochemical/isotopic and microbiological modelling to interpret environmental processes and their effects on the global biogeochemical cycles. The thrust areas of research include biogeochemical studies in waters of estuaries, coastal oceans, springs and freshwater bodies on land with an 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 understanding waves, currents, and sediment transport and their effects on beaches and nearshore environments, with a special emphasis on modelling coastal processes along the west coast of India. The activities include running high-resolution numerical models capable of simulating coastal ocean dynamics and boundary exchanges, establishing a video-based Coastal Monitoring network and investigating the evolution of coastal ocean terraces. The national network project on Submarine Groundwater Discharge, aimed at quantifying the amount and understanding the impact of fresh groundwater discharge to the Bay of Bengal and the Arabian Sea, also forms a significant activity of the group.

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 the Western Ghats to improve the forecasting of meteorological hazards.

1. Research Highlights

1.1 Identifying crust formation and recycling signatures from the Precambrian Southern Granulite Terrane using zircon U-Pb/Hf geochronology

The Southern Granulite Terrane (SGT) of southern India preserves a record of crustal evolution from the late Archean to Cambrian, marked by polyphase deformation, metamorphism, and magmatism. It comprises distinct crustal blocks separated by shear zones linked to fragments such as Madagascar, Sri Lanka, and Antarctica. The timing and processes of assembly within the SGT and its relation to East Gondwana are still debated. This study, using zircon U-Pb/Hf isotopic data from central SGT basement rocks, identifies four crustal growth phases: (1) Neoarchean–early Paleoproterozoic, (2) Rhyacian–Orosirian, (3) late Tonian, and (4) Ediacaran–Cambrian. Early phases exhibit juvenile magmatism, while later stages show crustal reworking. New U-Pb and Hf isotopic data from quartzites in a key SGT region reveal five age peaks (~2500 Ma, ~2000–1900 Ma, ~1100–1000 Ma, ~800–700 Ma, and ~550 Ma). Hf isotopic data indicate juvenile magmatism until ~1900 Ma, followed by extensive crustal recycling. These patterns align with nearby fragments such as Madagascar, Sri Lanka, and Antarctica, suggesting a shared pre-Gondwanan origin and tectonic evolution, challenging current geodynamic models.

https://doi.org/10.1130/B36777.1
https://doi.org/10.1016/j.precamres.2024.107348

1.2 Depositional age and formation conditions of Archean banded iron formations, Bundelkhand Craton, Central India: Geochemistry, neodymium isotopes and U-Pb zircon geochronology

This study presents major and trace element concentrations, U-Pb zircon geochronology, and neodymium isotopic compositions of the banded iron formations (BIFs) from the Bundelkhand Craton, India. The study aims to constrain the source characteristics, depositional age and evaluate the paleoenvironmental implications of the Meso-Neoarchean seawater from which the BIF precipitated. The broad range of isotopic values and the above-noted geochemical signatures suggest that the BIF from the Bundelkhand Craton had significant inputs from submarine hydrothermal sources and pre-existing continental crust. The elevated manganese concentrations in BIFs from Mauranipur may imply the availability of free oxygen in seawater on the Bundelkhand Craton during the Mesoarchean.

https://doi.org/10.1016/j.precamres.2023.107254

1.3 Imaging of crustal structure beneath the Larsemann Hills, Antarctica, using scattered wave technique

The crustal structure is crucial in understanding and deciphering the tectonic setting and its evolution. In this study, the data obtained from the first-ever established broadband seismological observatory at Larsemann Hills, East Antarctica, has been utilised for the P receiver function (PRF) analysis and H-K stacking to decipher the crustal thickness, Poisson's ratio and the intracrustal layer. Further, the obtained PRFs were inverted using Bayesian

inversion to get the crustal structure. The results obtained from H-K analysis reveal a crustal thickness of ~37.9 km, and the corresponding Poisson's ratio is 0.19. The inversion technique also yielded consistent results, indicating a Moho depth of ~37 km with a velocity jump from 4.1 km/s to 4.6 km/s and an intra-crustal layer at around 16 km with a velocity jump from 3.95 km/s to 4.06 km/s. It indicates a Poisson's ratio of 0.20. These findings suggest that the crust beneath the Larsemann Hills is felsic and has high crustal shear wave velocity. Further, the variation in the crustal thickness along the coast of the Princess Elizabeth Land region, ranging from 37.9 km to 36 km, with the intra-crustal layer variation from 16 km to 13 km, distinguishes the Neoproterozoic Larsemann Hills from the Archean-Mesoproterozoic Vestfold Hills.

https://doi.org/10.1016/j.polar.2023.100980

1.4 Utility of fluid inclusion paleo-temperature in petroleum system modelling

The paleotemperature (Th) data from fluid inclusions are utilised for thermal history modelling using PetroMod software. Generally, bottom hole temperature (BHT) and vitrinite reflectance (Ro) measurements, though they are inaccurate estimates, are widely used in petroleum system modelling (PSM) in the oil industry for calibration purposes. Th represents the minimum temperature of fluid entrapment at the time of oil formation estimated from the fluid-inclusion study, which provides a more robust temperature estimate for building the thermal models for PSM. Fluid inclusion parameters, along with Rock-Eval pyrolysis analysis, have been used to predict the maturity of oil in terms of API gravity and the maturity of source rocks, respectively. Two exploratory wells, RV-1 (Mumbai Offshore Basin) and KK4C-A-1 (Kerala-Konkan offshore basin), India, were examined. The Th from most of the fluid inclusions of wells RV-1 and KK4C-A-1 fell in the oil window range of 60-140°C, suggesting thermal conditions favourable for oil generation in both wells. Th of coeval aqueous inclusions and the Hydrocarbon Fluid inclusions (HCFIs) were used to calibrate PSM. Vital parameters show that the source rocks of well RV-1 are mature, and those of well KK4C-A-1 are immature. Two sets of PSM are created in terms of generation and expulsion for the dry wells RV-1 and KK4C-A-1 and calibrated for each well using fluid inclusion Th and BHT. From the fluid inclusion analysis method, it is evident that hydrocarbon generation happened in both wells. The paleotemperature indicates that the formations of both wells were subjected to temperatures in the oil window range, even though they were designated as dry wells in the present scenario. The present study highlights the application of fluid inclusion paleotemperature (Th) during calibration instead of commonly used methods. We could obtain desirable and accurate data output from PSM using Th calibration.

https://doi.org/10.1016/j.engeos.2023.100256

1.5 Development of video beach monitoring system for the Indian coast

NCESS is working on the development of a video beach monitoring system for the Indian coast. As part of the project, new algorithms for nearshore hydrodynamics are introduced. A coupled coastal monitoring framework that uses satellite data, video data and numerical model is introduced to study the influence of hard structures on sandy beaches in terms of erosion/accretion patterns and wave current interactions in the nearshore region. In addition, NCESS introduced a new method using smartphones (developed as a citizen science model) to collect videos that can be processed later to study the rip current processes.

https://doi.org/10.1016/j.ocecoaman.2023.106619

https://doi.org/10.1016/j.ocecoaman.2023.106776

1.6 Analysis of localised features during wet and dry rainfall episodes over the southern tip of India

The large spatial and temporal variability of wet and dry spells of the Indian Summer Monsoon poses a significant challenge in understanding and predicting monsoonal rainfall. This challenge is further exacerbated over smaller regions, such as the southern tip of India. This study investigates the characteristic features and possible precursors for wet and dry spells of rainfall over the southern tip of India. We also explore the variability in monsoon low-level jets with wet and dry spells over a coastal station Thiruvananthapuram (8.48°N, 76.95°E) in southwest India using in-situ observations and other ancillary datasets. The results show that a wet spell spanning 3-4 days contributes about 30% of seasonal rainfall. Wet spells are characterised by westerly wind anomaly in the southern tip of India and easterly wind anomaly in northern India, leading to anomalous cyclonic vorticity over the Indian subcontinent. The opposite happens during dry spells. These results indicate that using in-situ observations and large-scale reanalysis datasets may provide valuable information on the precursors for wet and dry spells over the southern tip of India, which can help regional- and city-level planning and management of water resources.

https://doi.org/10.1002/joc.8267

2. Awards, Honours & Human Resource Development

2.1 Awards

As a part of Know the Eminent Scientists initiative, MoES applauded the eminence of Dr. Jyotiranjan S. Ray, Director NCESS, for his monumental strides in Geology in India on 15 August 2023. Dr. Jyotiranjan S. Ray is a geochemist and geochronologist known for his studies on the geochronology of the Indian subcontinent. He earned PhD in Geology from the Physical Research Laboratory, Ahmedabad, India and an MTech in Applied Geology from IIT Roorkee. He has authored a book, Vindhyan Geology: Status and Perspectives, published in 2006 by the Indian Academy of Sciences.

Dr. E. A. Resmi, Scientist E & Group Head, Atmospheric Science Group, received the 'Best Oral Presentation Award' for the paper entitled "Microphysical transition features of intermittent pre-monsoon rainfall to monsoon onset over southern peninsular India" in the National Symposium 'TROPMET-2023': Changing Dynamics of Arid Region and Impact on Weather and Climate over Indian Subcontinent" held at Jaipur during 22-24 November 2023.

Smt. Nayana V. Haridas, Research Scholar, Hydrology Group, received the 'Best Oral Presentation Award in Student Category' for the paper entitled "Late quaternary paleoclimatic variability in a sediment core from Bay of Bengal: a multiproxy study" in the 36th Kerala Science Congress held at Government College, Kasaragod during 08-11 February 2024.

Dr. Jeenu Mathai, Project Scientist I, Marine Geoscience Group, received the 'Best Oral Presentation Award in Scientist Category' for the paper entitled "Bridging Models and Reality: An Approach to Quantify Submarine Groundwater Discharge Flux through Field Surveys and Numerical Modeling" in the 36th Kerala Science Congress held at Government College, Kasaragod during 08-11 February 2024.

Dr. A. R. Aswini, Postdoctoral Fellow, Atmospheric Science Group, received the 'Best Poster Award in Scientist Category' for the paper entitled "Characterisation of boundary layer height over a high-altitude site in Western Ghats using a ceilometer and

microwave radiometer" in the 36th Kerala Science Congress held at Government College, Kasaragod during 08-11 February 2024.

Smt. Uma Mohan, has been awarded PhD degree on 14 August 2023 under the Faculty of Applied Sciences and Technology, University of Kerala for her thesis "Geoenvironmental studies of the land & water systems in Kallada Basin, southern Western Ghats, India". Dr. A. Krishnakumar, Scientist-E, Hydrology Group was her supervising guide.

Smt. B. S. Praseetha, has been awarded PhD degree on 07 August 2023 under the Faculty of Marine Sciences, Cochin University of Science and Technology for her thesis "Geochemistry of estuarine and inner shelf sediments". Dr. T. N. Prakash (Retd.), Scientist-G and Group Head, Coastal Processes Group was her supervising guide.

Shri. M. K. Rafeeque, has been awarded PhD degree on 28 November 2023 under the Faculty of Science, University of Kerala for his thesis "Landform dynamics and its impact on stability of coastal zone of Kozhikode, West coast of India". Dr. D. S. Suresh Babu (Retd.), Scientist-F, Marine Geoscience Group was his supervising co-guide.

2.2 Invited / Nominated Membership

Dr. V. Nandakumar

Member, Scientific Advisory Committee, Geochronology Facility, Inter-University Accelerator Centre (IUAC), New Delhi.

Dr. Maya K

Life Member, Indian Society of Remote Sensing.

Life Member, Indian Society of Applied Geochemists.

Life Member, Geological Society of India.

Life Member, Gondwana Geological Society.

Life Member, Ocean Society of India.

Member, International Association of Sedimentologists.

Member, Asia Oceania Geosciences Society (AOGS).

Dr. K. Anoop Krishnan

Member, Board of Studies in Environmental Sciences and Water Management, University of Calicut.

Member, Board of Studies, U.G. BSc Chemistry (Affiliated Colleges), Manonmaniam Sundaranar University, Tamil Nadu, India

Member, Board of Studies, PG Department of Chemistry, FMN College, Kollam.

Life Member, Ocean Society of India.

Advisory Committee Member, National Conference on Reviving Wetlands, CWRDM, Government of Kerala.

Dr. A. Krishnakumar

Member, Academic Committee, Sree Narayanaguru Open University, Kerala.

Member, Board of Studies in Environmental Sciences and Water Management, University of Calicut.

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

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

Member, Committee constituted by the Hon'ble High Court of Kerala to prepare a report on the issues regarding soil quarrying activities in Palamel Grama Panchayath, Alappuzha district, Kerala.

Dr. E. A. Resmi

Scientific Expert Member, Kerala State Disaster Management Authority.

Member, Ocean Society of India (OSI).

Dr. K. Sreelash

Member, Sub-committee on outsourcing of water resource modelling work in connection with the Kerala State Remote Sensing and Environment Centre project entitled 'Study on the possible impact on the groundwater system by the construction of warehouse in Kottukal Village for Vizhinjam Sea Port'.

Member, Committee for issuance of No Objection Certificate for constitutional activities near reservoirs.

Dr. B. Padma Rao

Member, European Geosciences Union (EGU)

Associate Member, American Geophysical Union (AGU).

Life Member, Ocean Society of India (OSI).

Co-Scientist, Working Group on applications based on AI/ML/DL tools, constituted by MoES, Government of India.

Member, Technical committee for validation of the security schemes at Sree Padmanabha Swamy Temple, Government of Kerala.

Dr. S. Kaliraj

Life Member, Indian Society of Remote Sensing.

Life Member, Ocean Society of India.

Life Member, Indian Society of Geomatics.

Member, International Society for Photogrammetry and Remote Sensing.

Dr. C. K. Unnikrishnan

Member, Scientific Instrumentation Technical Committees, National Atmospheric Research Laboratory.

Member, Technical Committee for procurement of 50m Tower Weather Sensors, National Atmospheric Research Laboratory.

Member, Kerala State Council for Science, Technology and Environment (KSCSTE) Postdoctoral Selection Committee 2023.

Member, Doctoral Committee, Department of Atmospheric Sciences, Cochin University of Science and Technology.

Member, Doctoral Committee, Department of Physics, Kerala University.

Member, American Meteorological Society.

Member, Judging Panel, AGU Annual Meeting 2023, San Francisco, USA, Outstanding Student Presentation Awards.

Member, Judging Panel, Annual Symposium organized by Jackson School of Geosciences, University of Texas, Austin, USA.

2.3 Invited Lectures / Chairing of Technical Sessions

Prof. N. V. Chalapathi Rao

Delivered an invited talk on "Contributions of NCESS towards Indian Geosciences: A four and half decade long scientific odyssey" at the National Conference on Geosciences for Sustainable World (GSW-2024) held at Department of Geophysics, Banaras Hindu University, Varanasi during 06-07 March 2024.

Delivered a talk on "Mineralogy and mineral chemistry: techniques, importance & applications" as part of the Advanced Training Programme on Analytical Geochemistry held at CSIR-NGRI on 13 March 2024.

Delivered a talk on "Kimberlites, related rocks and diamonds: capsules of mantle processes through the geological time" as the chief guest of the Shri. T. M. Mahadevan Memorial Lecture organized by the Department of Marine

Geology and Geophysics, Cochin University of Science and Technology on 25 March 2024.

Dr. Tomson J. Kallukalam

Delivered an invited talk on "Timekeepers in Earth Science" in the Geosciences Talk Series organised as part of the Global Science Festival Kerala (GSFK-2024) held at Thiruvananthapuram on 05 February 2024.

Dr. K. Anoop Krishnan

Chaired a session in the International Conference on Environmental Pollution and Health: Governance for a Sustainable Future (ICEGSF-2023) organized by the Department of Environmental Sciences, University of Kerala, Thiruvananthapuram during 22-24 November 2023.

Delivered an invited talk on "Instrumental methods in hydrogeochemical studies: Lab to field scale approach" as part of the National Level Workshop on Instrumental Methods of Analysis held at the Department of Chemistry, University College, Trivandrum on 29 November 2023.

Delivered invited lectures on "Hydrogeochemistry: Importance and scientific way of monitoring the water resources & Mitigation approach in containing the pollutants in water and wastewater sources" as part of the National Seminar on 'Emerging Green Initiatives in Science and Technology (EGIST-2023)' held at Department of Chemistry, Government College, Chittur, Palakkad on 07 December 2023.

Delivered an invited lecture on "Safeguarding water quality: The role of hydrobiogeochemistry in monitoring studies" as part of the Seminar on 'General and Applied Aspects of Chemistry' held at the Department of Chemistry, Nanjil Catholic College of Arts & Science, Kaliyikkavilai, Kanyakumari on 27 March 2024.

Dr. A. Krishnakumar

Chaired a technical session in the National Seminar on Conventional, Renewable Energy Sources and Climate Change Perspective organized by Gondwana Geological Society, Nagpur in association with the Geological Survey of India held at Nagpur during 23-24 June 2023.

Served as Resource Person for 25th Refresher Course in Environmental Studies organized by the Malaviya Mission Teacher Training Centre, UGC - Human Resource Development Centre, University of Calicut and handled a session on 'Climate change: A scientific appraisal' on 06 October 2023.

Chaired a session in the International Conference on Environmental Pollution and Health: Governance for a Sustainable Future (ICEGSF-2023) organized by the Department of Environmental Sciences, University of Kerala, Thiruvananthapuram during 22-24 November 2023.

Dr. E. A. Resmi

Chaired a session in the 'MARICON 2024' held at Cochin University of Science and Technology, Kochi during 12-14 December 2024.

Dr. B. Padma Rao

Delivered an invited talk on "Unearthing Secrets: The Power of Seismology in Subsurface Exploration" at Present Day Advancements in Geoscience (PAGe-2024) held at Cochin University of Science and Technology on 07 February 2024.

Dr. S. Kaliraj

Co-chaired a session in the National Seminar on Water: Sustainable Management & Challenges (WSMAC 2023) held at Dept. of Geology, Malankara Catholic College, Mariagiri during 04-05 May 2023.

Delivered an invited lecture on "Spatial intelligence in geo-environmental hazard assessment" as part of the National Seminar on Disaster Resilience through Geospatial Intelligence held at Government Arts & Science College, Palakkad on 09 November 2023.

Delivered an invited lecture on "LiDAR applications in advanced surveying" as part of the 5-day Faculty Development Programme held at Mar Baselios College of Engineering & Technology, Thiruvananthapuram on 12 January 2024.

Delivered an invited lecture on "Satellite image-based estimation of phytoplankton (Chl-a) and its seasonal variability" as part of the programme on Synergizing Satellite-based Phytoplankton Monitoring with Industry 4.0 for Sustainable Smart Agriculture held at Holy Cross College, Nagercoil, Tamil Nadu, on 01 March 2024.

Dr. Kumar Batuk Joshi

Delivered an invited lecture on "Detrital zircons: Story from Indian subcontinent" at the University of Turku, Turku, Finland on 08 November 2023.

Convened a session on "Early Earth: Mantle-crust evolution in Hadean and Archean Eons" in Goldschmidt 2023 held at Lyon, France during 09-14 July 2023.

Convened a session on "Paleoclimate, paleoweathering, paleoprovenance and machine learning on sediments during Late Quaternary period" in INQUA-2023 Congress held at Rome, Italy during 14-20 July 2023.

Dr. A. Prajith

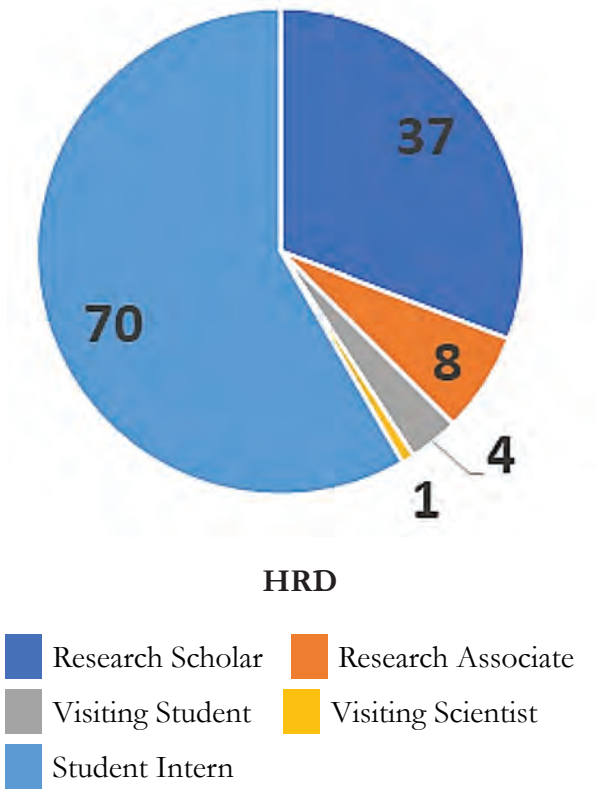
Delivered an invited talk on "Late Cretaceous and early Cenozoic hotspot plume tectonic activities in the Arabian Sea and Indian subcontinent: special reference to volcanic geochemistry" in the National Seminar on Recent Trends in Geo-environmental Research organized by Government College Kasaragod on 16 February 2024.

2.4 Visits Abroad

Dr. C. K. Unnikrishnan, Scientist C, Atmospheric Science Group, visited the Department of Earth and Planetary Sciences, University of Texas, Austin, USA as part of the Science and Engineering Research Board - International Research Experience (SERB-SIRE) fellowship programme during September 2023 - February 2024.

2.5 Human Resource Development

NCESS has a robust Human Resource Development scheme. The programs under this scheme are PhD program, Research Associateship, Visiting Scientist program, Visiting Student program and Student Internship. Currently, 39 junior and senior research fellows are working on their PhD. These fellows are registered in Cochin University of Science and Technology (CUSAT) / Kerala University through MoUs with NCESS. Eight Research Associates are carrying out their postdoctoral research in NCESS at this time. NCESS trains about 50 M.Sc. / B.Sc. students each year as part of the internship program. Besides, many scientists of NCESS co-supervise Ph.D. / M.Sc. / M.Tech. students from other organizations/ universities for their thesis/project works.



3. Research Activities

3.1 Solid Earth Research Group

3.1.1 Age and petrogenesis of mafic granulites from central Madurai block, South India: Implications on regional tectonics

The Precambrian Southern Granulite Terrane (SGT) in southern India preserves high- to ultrahigh-temperature (HT-UHT) granulites, notably in the Kambam UHT belt. This study analyses the petrology, geochemistry, and geochronology of associated mafic granulites to explore their origin and tectonic context. These granulites are low- to medium-K tholeiites, formed by partial melting of a subduction-modified mantle with a spinel/garnet lherzolite composition. Zircon U–Pb dating places their emplacement at 612–625 Ma, with metamorphism between 581–531 Ma, aligning with HT-UHT events, whereas Zircon Hf isotopes suggest magma derived from reworked Archean-Proterozoic sources. These new results suggest an alternative heat source for the formation of HT-UHT granulites in the Kambam UHT belt, which may represent a significant terrane boundary within the SGT.

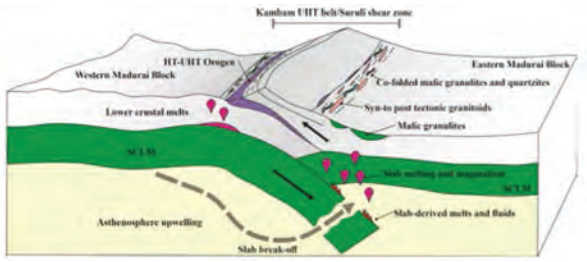


Fig. 3.1.1.1: Schematic illustration of petrogenetic/tectonic model proposed for the generation of mafic granulites and associated lithologies in KUB.

This work was done in collaboration with T. Vijaya Kumar of CSIR-NGRI, Hyderabad.

https://doi.org/10.1017/S0016756823000079

Amal Dev J., Tomson J. K., Nilanjana Sorcar

3.1.2 Tracing the crustal evolution of the Precambrian Southern Granulite terrane in East Gondwana: New insights from zircon U-Pb/Hf geochronology

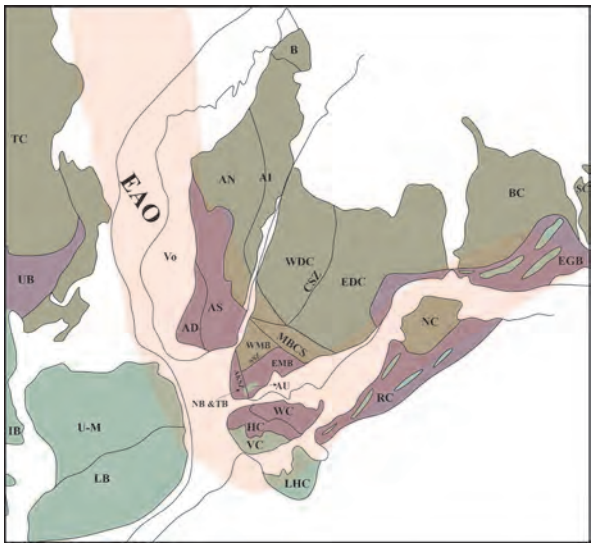


Fig. 3.1.2.1: Proposed geodynamic model for the assembly of the East Gondwana supercontinent.

The Precambrian Southern Granulite Terrane (SGT) of South India records crustal evolution from the late Archean to Cambrian, with evidence of polyphase deformation, metamorphism, and magmatism. The terrane consists of distinct crustal blocks separated by shear/suture zones linked to supercontinent fragments like Madagascar, Sri Lanka, Africa, Eastern Ghats, and Antarctica. However, the timing and mechanism of their assembly within the SGT and its connection to East Gondwana are debated. This study, using zircon U-Pb/Hf isotopic data from basement charnockites, gneisses, granitoids, and alkaline intrusions in the central SGT, identifies four crustal growth phases: (1) Neoarchean–early Paleoproterozoic, (2) Rhyacian–Orosirian, (3) Late Tonian, and (4) Ediacaran–Cambrian. Early phases show juvenile magmatic signatures, while later phases involve significant reworking of older crust. Our

new results, combined with existing data from other Gondwanan terranes, suggest a common Paleoproterozoic ancestry for the Southern Granulite Terrane and its corresponding Gondwanan fragments, proposing a revision to the existing geodynamic models.

https://doi.org/10.1130/B36777.1

Tomson J. K., Amal Dev J.

3.1.3 Timing of garnet growth in granulites from southern India: Insights from zircon-monazite-garnet REE partition modeling

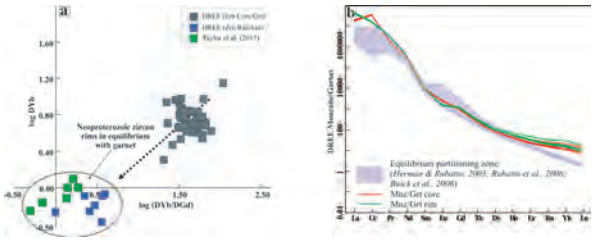


Fig. 3.1.3.1: (a) log (D_{Yb}/D_{Gd}) vs. log (D_{Yb}) plot for individual zircons core and rim composition against garnet. (b) Calculated partitioning coefficient between monazite and garnet compared with available partition coefficient values of natural garnet-monazite pairs.

The Nagercoil block, located at the southernmost part of the Southern Granulite Terrane in south India, predominantly consists of garnet-bearing I-type massive charnockites. These charnockites record two significant thermal events during the Palaeoproterozoic (~2.0–1.9 Ga) and Neoproterozoic (~550 Ma). However, the timing and processes of garnet growth in relation to these events remain unclear. This study employs rare earth element (REE) partition modelling between garnet and age-constrained accessory phases such as zircon and monazite to determine the timing of garnet formation. U-Pb dating of zircon cores indicates protolith emplacement at ~2.0 Ga, while zircon rims and monazites date Neoproterozoic metamorphism at ~550 Ma. REE modelling reveals that Neoproterozoic zircon rims and monazites are in equilibrium with garnet, whereas Palaeoproterozoic zircon cores are not. These findings suggest that garnet formation in the Nagercoil charnockites occurred during the Neoproterozoic metamorphism, linked to the final assembly of the Gondwana supercontinent.

https://doi.org/10.1007/s12594-023-2457-x

Sajna S., Tomson J. K., Amal Dev J., Nilanjana Sorcar

3.1.4 Detrital zircon U-Pb ages and Hf isotopes of quartzites from Southern Granulite Terrane, India: Implications for the Precambrian crustal evolution and paleogeography

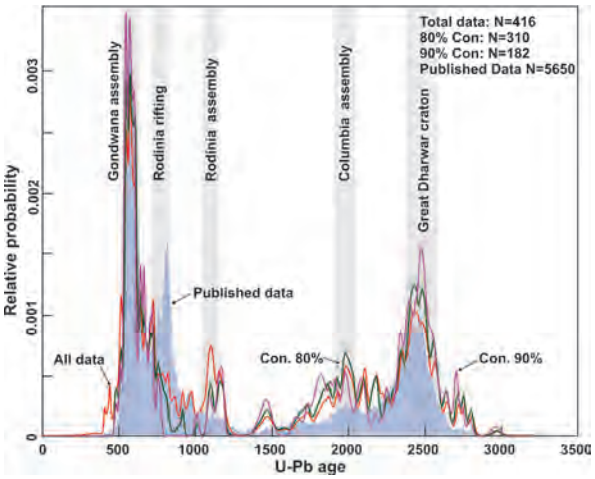


Fig. 3.1.4.1: Probability density distribution plot of zircon U-Pb ages for quartzite samples from Madurai block.

The tectonic evolution of the Southern Granulite Terrane (SGT) in southern India and its relationship with adjacent continental fragments within supercontinent assembly and dispersal models remain contentious, largely due to a lack of comprehensive zircon U-Pb and Hf isotopic data from various crustal blocks. This study addresses this gap by generating new zircon U-Pb and Hf isotopic data from quartzites in a key SGT segment and correlating them with data from adjacent continental fragments. The U-Pb data reveal five distinct age peaks at ~2500 Ma, ~2000–1900 Ma, ~1100–1000 Ma, ~800–700 Ma, and ~550 Ma. The Hf isotopic signatures indicate juvenile magmatic additions up to ~1900 Ma, followed by significant crustal recycling. These detrital

ages and Hf isotopic patterns closely resemble those of nearby terranes, including Madagascar, Sri Lanka, Africa, Eastern Ghats, and Antarctica, suggesting a shared pre-Gondwanan ancestry and a common evolutionary history for these regions.

https://doi.org/10.1016/j.precamres.2024.107348

Tomson J. K., Amal Dev J.

3.1.5 Provenance of mesozoic sandstones in the Saurashtra Basin using heavy minerals geochemistry and geochronology: Implications for paleogeographic reconstruction in Western India

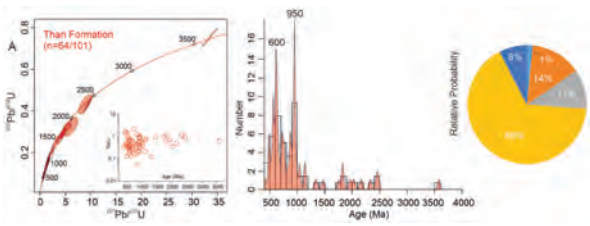


Fig. 3.1.5.1: Wetherill Concordia plots, relative age population diagrams, and source age contribution pie charts showing ages for Than Formation from Saurashtra Basin.

The Mesozoic sediments of the Dhrangdhara Group in western India are sourced from two distinct Precambrian terranes, identified through a combination of petrography, mineral chemistry, and U-Pb zircon and U-Th-total Pb monazite dating. Geochemical analysis of rutile and tourmaline indicates sediment supply from metapelites, granites, pegmatites, quartz veins, and tourmalinites. U-Pb zircon data reveals four major age populations: Archean (3584–2502 Ma), Paleoproterozoic (2499–1642 Ma), Mesoproterozoic (1595–1010 Ma), and Neoproterozoic (993–539 Ma), while monazite ages cluster around 900–700 Ma and ~500 Ma. These data suggest the sediments were mainly derived from metasedimentary rocks of the Aravalli-Delhi Fold Belt (ADFB) with additional input from Archean gneisses and granites, such as Mewar Gneisses and Berach Granite. The zircon and monazite ages correlate with significant global tectonic events, including the Bhilwara Orogeny, Columbia and Rodinia supercontinent assemblies and the breakup of Rodinia and the assembly of Gondwana.

This work was done in collaboration with P. K. Rajak, N. Prabhakar, S. Banerjee and B. G. George of IIT, Mumbai.

https://doi.org/10.1016/j.marpetgeo.2024.106732

Amal Dev J., Tomson. J. K.

3.1.6 Metamorphic evolution of granulites from Grovnes peninsula of Larsemann Hills, East Antarctica: Constraints from phase equilibrium modelling and geochronology

Petrology, geothermobarometry, and phase equilibrium modelling of garnetiferous felsic gneiss from Grovnes peninsula in the Larsemann Hills of Prydz Bay, East Antarctica, provide pristine evidence for the preservation of high-grade metamorphic imprint in the area. The metamorphic evolution of the sample is demonstrated by the development of the assemblage Grt + Bt + Melt + Pl + Sill + Kfs + Qtz + Ilm at peak metamorphic conditions of ~790°C and ~7.5 kbar, which subsequently underwent retrogression and cooling to lower P-T conditions along a clockwise path. Texturally constrained chemical dating of monazites constrains the timing of peak metamorphism and garnet formation at ~575 Ma, whereas the apatite U–Pb ages (Fig. 3.1.6.1a) constrain cooling ages at ~518 Ma. The chemical behaviour of apatites in partial melting scenarios helps unravel the post-peak evolution of high-temperature granulites. Chondrite normalized REE pattern of apatites demonstrates a negatively sloping REE pattern with near flat LREE and strongly depleted HREE. The apatites are also characterized by a prominent negative europium anomaly (Fig. 3.1.6.1b) indicative of their formation in a chemical environment, which favoured coeval growth of an Eu sinking phase. Similar negative anomalies of Eu and depletion in HREEs suggest the co-genetic growth of apatites

and monazites in a plagioclase-replenished environment where it acts as a sink for Eu. The increased modal abundance of plagioclase towards lower P-T values further manifests the growth of plagioclase during apatite precipitation. Apatites are generally known to grow in response to the crystallization of melt during cooling to the solidus in both closed- and open systems. In this context, the formation of apatites can be explained in response to cooling, which is texturally represented as the breakdown of garnet. REE composition of garnet rims demonstrates depletion in Y concentrations, while the monazite rims formed in response to cooling are also depleted in Y concentrations. These observations indicate that Y released during the garnet breakdown in response to cooling is most likely incorporated into apatites in the melanosome. As garnet breakdown releases insignificant P, the stabilization of apatite must have been aided by melt loss together with the decomposition of monazite, which is well established in natural systems. Moreover, the depletion of HREEs in apatites, monazites, and garnet rims suggests the coeval growth of the HREE scavenging phase, possibly zircon, which is supported by the preservation of tiny zircon grains in association with garnet and apatite. Although apatites are expected to incorporate HREE released during the breakdown of HREE-enriched phases (e.g., garnet) in natural systems, the poor HREE enrichment in the studied system can be accounted for the melt loss suffered by the sample during the final stages of metamorphism. All these arguments suggest that U-Pb ages recovered from apatites (~518 Ma) can be treated as their cooling ages. Thus, the clockwise P- T- t trajectory of the studied samples, together with the Ediacaran-Cambrian metamorphic/ cooling ages, demonstrate the long-lived nature of metamorphism in Prydz Bay, which is ascribed to collisional tectonism prevalent during the final stages of the assembly of East Gondwana supercontinent. Similar results from adjacent continental fragments, including Sri Lanka, Eastern Ghats Belt, Madagascar, and South India, suggest their coeval metamorphic evolution during the East African orogeny.

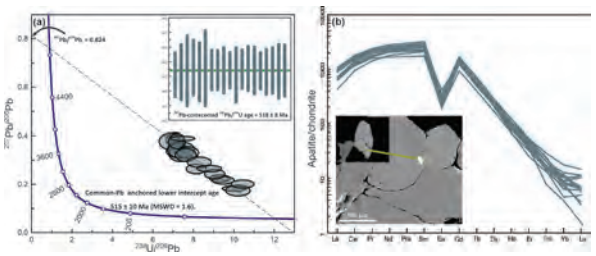


Fig. 3.1.6.1: (a, b): U–Pb geochronological data of apatites from garnetiferous felsic gneiss presented in Tera-Wasserburg diagrams. Inset shows weighted average ^{207}Pb-corrected $^{206}Pb/^{238}U$ ages. (b) Chondrite normalized REE patterns for apatites. Inset: BSE image showing the internal structure and textural location of apatites.

https://doi.org/10.1016/j.polar.2023.100982

Nilanjana Sorcar, Amal Dev J., Sneha Mukherjee, Kumar Batuk Joshi, Padma Rao B.

3.1.7 Imaging of crustal structure beneath the Larsemann Hills, Antarctica, using scattered wave technique

Antarctica is one of the least explored regions on Earth due to thick ice coverage over the region and logistical constraints. The Antarctic continent and the surrounding oceans are key parts of Earth's system and can provide vital information on crustal evolutionary processes operating on the Earth's surface. Though studies have been undertaken to decipher the crustal structure of Antarctica, seismic measurements are sparse due to the limited number of stations, especially in the East Antarctica region. The crustal structure in terms of crustal thickness, shear wave velocities, and Poisson's ratio plays a crucial role in understanding and deciphering the tectonic setting and its evolution. Thus, the present study focuses on deciphering the crustal structure beneath the Larsemann Hills utilising the maiden dataset from the seismic observatory

(BRTI) established at Larsemann Hills with the help of the receiver function technique and Bayesian inversion.

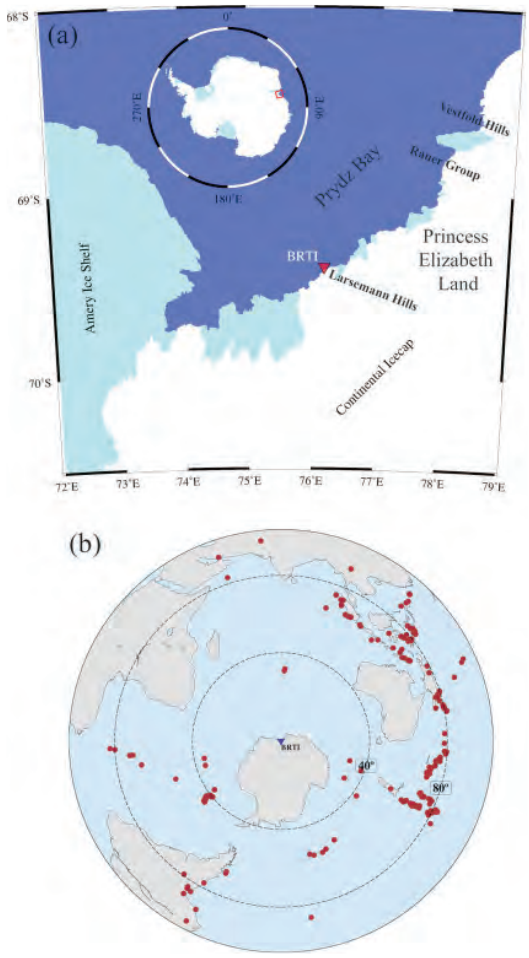


Fig. 3.1.7.1: (a) Location of the broadband seismological observatory (BRTI: blue inverted triangle). (b) The geographical distribution of teleseismic events (brown circles) whose waveforms were recorded at the BRTI observatory was utilised in the present study.

This study's data was collated from the seismological observatory (BRTI) during the 42nd Indian Scientific Expedition to Antarctica, from 31-12–2021 to 05-01-2023. The data has been pre-processed and considered only those waveforms of global earthquakes with a magnitude greater than 5 and an epicentral distance of 30°-95°. Further, the waveforms having signal-to-noise ratio (SNR) ≥2.5 are only used for the analysis, as these are considered noise-free waveforms. These selection criteria resulted in 404 waveforms from 404 earthquakes recorded at the BRTI station (Fig. 3.1.7.1). Further, the extended-time multi-taper frequency domain cross-correlation receiver function (ET MTRF) technique has been utilised to compute the P receiver functions (PRFs) and the H–K stacking to decipher the crustal thickness, Poisson's ratio and the intra-crustal layer. The obtained PRF data were inverted using Bayesian inversion to strengthen these results further and interpret the crustal structure. The results obtained from H-K analysis reveal a crustal thickness of ~37.9 km, and the corresponding Poisson's ratio is 0.19. The inversion technique also yielded consistent results, indicating a Moho depth of ~37 km with a velocity jump from 4.1 km/s to 4.6 km/s and an intra-crustal layer at around 16 km with a velocity jump from 3.95 km/s to 4.06 km/s (Fig. 3.1.7.2). It indicates a Poisson's ratio of 0.20.

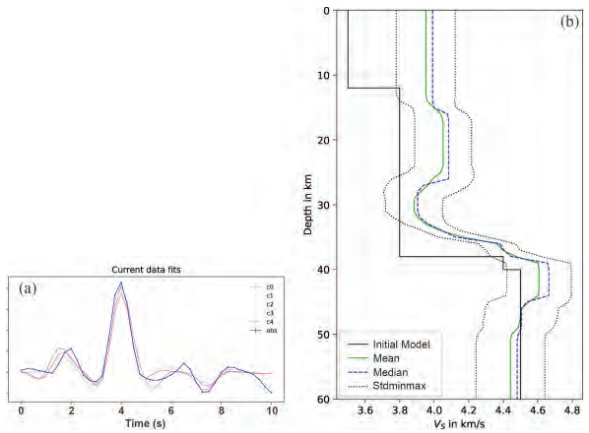


Fig. 3.1.7.2: The best fitting PRFs of the top 5 chains are indicated as different colours according to the index, along with the input or observed PRF (blue trace). (b) The mean (solid green line) and median (dotted blue line) velocity models of the best-fitting results. The minimum and maximum standard deviations of the best-fitting models are indicated as dotted black lines. The solid black line indicates the initial velocity model.

These findings suggest that the crust beneath the Larsemann Hills is felsic and has high crustal shear wave velocity. Geological studies conducted in the region of Larsemann Hills indicate that the main rock types in this region are garnetiferous granite, granodiorite gneiss,

paragneiss, metapelites, granulite and granitoid, which align with the obtained low Poisson's ratio. Further, the results were compared with the structure beneath the Vestfold Hills, located ~100 km northeast of the BRTI seismic station, to understand the structure along the Princess Elizabeth Land region. The results indicate that the variation in crustal thickness along the coast of Princess Elizabeth Land, ranging from 37.9 km to 36 km, with an intra-crustal layer variation from 16 km to 13 km, distinguishes the Neoproterozoic Larsemann Hills from the Archean-Mesoproterozoic Vestfold Hills.

https://doi.org/10.1016/j.polar.2023.100980

Padma Rao B.

3.1.8 Depositional age and formation conditions of Archean banded iron formations, Bundelkhand Craton, Central India: Geochemistry, neodymium isotopes and U-Pb zircon geochronology

This study presents major and trace element concentrations, U-Pb zircon geochronology, and neodymium isotopic compositions of the banded iron formations (BIFs) from the Bundelkhand Craton, India. The study aims to constrain the source characteristics, depositional age and evaluate the paleoenvironmental implications of the Meso-Neoarchean seawater from which the BIF precipitated. A 2898±26 Ma rounded zircon grain in the Girar BIFs indicates their maximum depositional age, consistent with the reported age of the metabasalts (2989±190 Ma). Considering the errors, we consider the age of the studied BIFs to be ca. 2850 Ma. The BIFs from Mauranipur are associated with 2810 Ma dacite and formed simultaneously. They have zircon with ages of 2718±22, 2573±66, 2070±29 and 1934±39 Ma. The BIFs from Babina are associated with 2540 Ma felsic volcanics and can be considered of the same age. Our study shows that the sedimentation of BIF in the Girar and Mauranipur greenstone belts took place in the Mesoarchean between ca. 2850 and 2810 Ma, respectively, and in the Babina greenstone belt in the Neoarchean at ca. 2540 Ma.

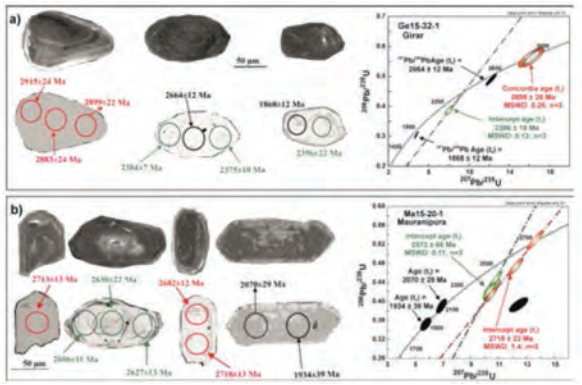


Fig. 3.1.8.1: (a) BSE, CL images of the zircons as well as U-Pb zircon concordia plot for the Girar BIF; (b) BSE, CL images of the zircons as well as concordia plot for the Mauranipur BIF. The circles on the CL images mark the area where U-Pb measurements were carried out. The ages listed in the CL images are $^{207}Pb/^{206}Pb$ ages.

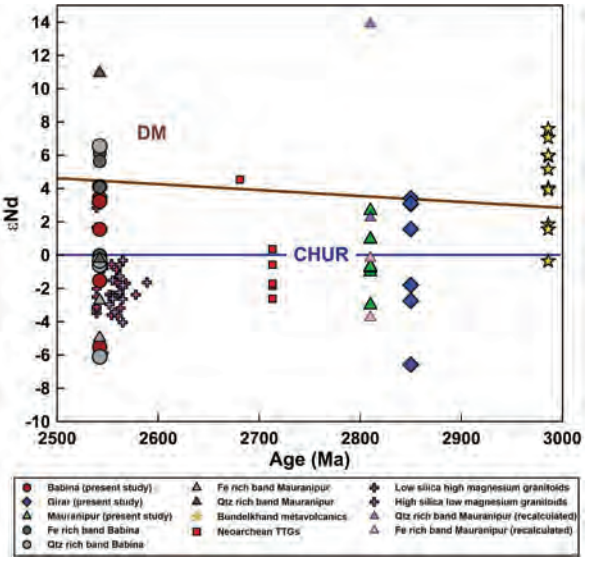


Fig. 3.1.8.2: εNd(t) vs time (zircon ages) evolution diagram for BIFs from Bundelkhand Craton. Comparative data for TTGs, BIFs, high silica low magnesium granitoids, low silica high magnesium granitoids and metavolcanics taken from previous studies. Quartz-rich band Mauranipur (recalculated) and Ferich band Mauranipur (recalculated) show previously published Nd isotopic data recalculated to t = 2810 Ma.

A positive correlation between TiO_2 and Zr, Al_2O_3 and Zr, Zr and Th/U, Y and Zr, Ni and Cr, as well as Hf and Zr, may suggest a detrital component to the BIF derived from terrigenous mafic and felsic sources. The PAAS normalized

REE patterns of the Bundelkhand BIFs are characterized by depleted LREEs, positive La, Eu, Y anomalies and Y/Ho ratios, mostly ranging between 18 and 47. The studied BIFs are broadly similar to worldwide BIF occurrences at the time, except the Mauranipur BIFs, which show elevated MnO concentrations (0.92 to 4.82 wt%). The studied BIF samples from the Bundelkhand Craton display a wide range of εNd(t) ranging from − 6.57 to + 4.12. The broad range of isotopic values, along with the above-noted geochemical signatures, suggest that the BIF from the Bundelkhand Craton had significant inputs from submarine hydrothermal sources as well as pre-existing continental crust. The elevated manganese concentrations in BIFs from Mauranipur may imply the availability of free oxygen in seawater on the Bundelkhand Craton during the Mesoarchean.

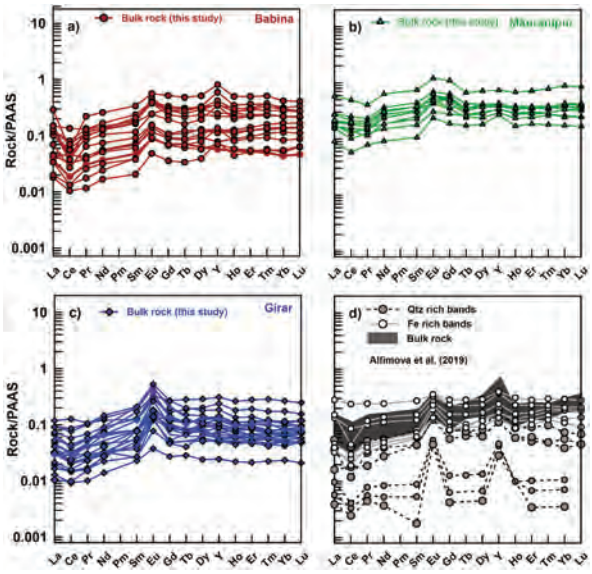


Fig. 3.1.8.3: PAAS-normalized REE diagram for Bundelkhand BIFs from a) Babina, b) Mauranipur, c) Girar and d) BIFs from Alfimova et al. (2019). PAAS normalizing values are from Taylor and McLennan (1985).

This work was done in collaboration with Alexander Slabunov of Karelian Research Centre, Russia; Sunil Kumar Singh of NIO, Goa; and Vinai K Rai of Arizona State University, USA.

https://doi.org/10.1016/j.precamres.2023.107254

Kumar Batuk Joshi

3.1.9 Imaging of Moho topography with conditional generative adversarial network from observed gravity anomalies

Accurate estimation of Moho topography plays a crucial role in understanding Earth's structure, geodynamic processes, and resource exploration. This study presents a novel approach that utilizes conditional Generative Adversarial Networks (cGAN) to reveal Moho topography based on observed gravity anomalies. Synthetic training datasets of Moho topography were generated using the FFT filtering method due to the scarcity of true datasets. Spherical prism-based forward gravity modelling was employed to evaluate the resulting gravity anomalies. We compared the performance of our developed deep learning algorithm cGAN (conditional Generative Adversarial Networks) with a traditional inversion technique using various synthetic datasets and a real case study in southern peninsular India, a geologically diverse region comprising ancient continental tectonic blocks. Bott's inversion scheme was employed as a verification method for the Moho surface estimation using the presented deep learning model. Spherical prism-based forward gravity modelling corrected anomalies for topography, bathymetry, sediments, crustal heterogeneities, and mantle heterogeneities. By removing these effects, we isolated the gravity contribution solely related to pure Moho undulation. The mean Moho depth and density contrast between the crust and mantle were derived from seismic constraints to improve estimation accuracy. The findings demonstrate the potential of the cGAN and spherical prism-based gravity modelling approach in accurately estimating the Moho topography, offering insights into Earth's subsurface structures and enhancing our understanding of geodynamic processes and resource exploration efforts. A generative DL model known as conditional Generative Adversarial Network (cGAN) accurately inverted 3D Moho topographies using observed gravity anomalies. This application represents

a novel approach in the field. An essential prerequisite for any DL model is the utilization of comprehensive real datasets during training. It enables the model to effectively capture the inherent correlation between the input and output sets, thereby facilitating the attainment of precise and dependable outputs. Nevertheless, due to the limited availability of authentic datasets, we created artificial training data for Moho undulations using the FFT filtering technique to closely mimic actual data. To assess the gravitational anomalies arising from the synthetic Moho undulations, we employed tesseroid-based forward gravity modelling. We compared the outcomes derived from our developed DL algorithm and a conventional inversion scheme, using diverse synthetic data sets and one real case study of southern India.

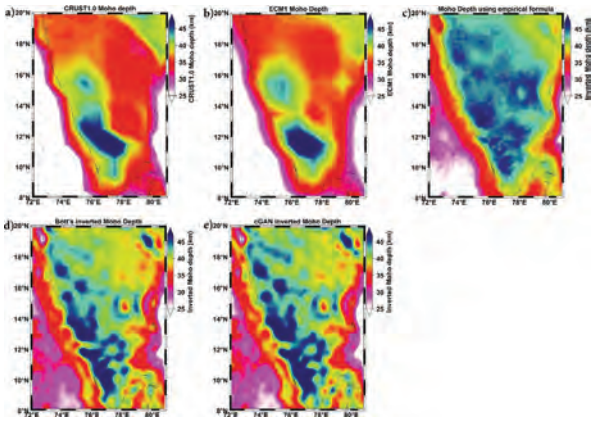


Fig. 3.1.9.1: Estimated Moho depth of southern India from (a) CRUST1.0 global gravity model, (b) Earth Crustal Model 1 (ECM1) global gravity data, (c) empirical formulation. (d) traditional Bott's inversion scheme, (e) cGAN scheme.

https://doi.org/10.1016/j.jseaes.2024.106093

Arka Roy, Rajat Kumar Sharma, Dharmadas Jash, Padma Rao B., Amal Dev J., Tomson J. K.

3.2 Crustal Dynamics Group

3.2.1 Engineering geological investigation and runout modelling of the disastrous Taliye landslide, Maharashtra, India of 22 July 2021

The Taliye landslide, a hill slope debris flow, is one of the recent large-scale landslides in India in terms of mortality and socio-economic predicaments. In general, the Taliye area exhibits a moderately dissected plateau relief, and the landslide was initiated from a north-westerly slope of a west trending major ridge and flowed through a paddy field to bury houses located just below it. The landslide had a total runout of 563 m and maximum width of 230 m at the toe. The heavy rainfall and presence of a narrow stream may be the prime triggering factors, but the affected area had also been exposed to human interference for farming as well as for habitation. Given its socio-economic relevance and landslide proneness of this area, a post-event engineering geological investigation and numerical modelling of this landslide have been carried out to have a closer look at its type, causes of failure, back calculation of run-out characteristics, as well as to calibrate frictional parameters for this area. The numerical modelling package, rapid mass movements (RAMMS) was used to undertake back analysis of this debris flow by referring the original flow shape. For the precise preference of Voellmy frictional parameters, dry-Coulomb friction (μ) and viscous-turbulent friction (ξ) coefficients, this study applies the popular receiver operative characteristics (ROC) technique as the model validation tool. The landslide may have initiated as a talus or translational failure of shallow soil on the hillock, but later might have transformed into a debris flow by entraining materials from the paddy field. Amongst the different combinations of frictional parameters, the model with μ of 0.06 m/s^2 and ξ of 1450 m/s^2 has emerged as the best with an area under the curve (AUC) value of 0.883 for the ROC assessment. With these calibrated frictional parameters, the maximum flow velocity of this debris flow was simulated to be in the order of 5.26 m/s taking place at the middle reaches, and the maximum flow velocity and pressure were derived as 21 m/s and 0.92 kPa, respectively, concentrated in the hillock zone. Although it was a rain-induced failure, the investigation suggests

that improper slope management practices might have amplified its magnitude and got manifested as devastating landslide. Therefore, human activities in these hilly regions shall be supported with systematic landslide hazard evaluation, and here in this case, the calibrated frictional parameters may be useful for debris flow modelling and landslide risk reduction in the area.

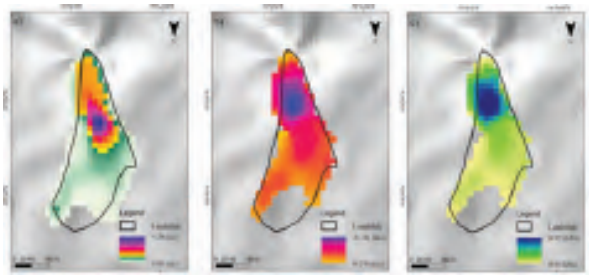


Fig. 3.2.1.1: Flow parameters of debris flow (a) flow height, (b) flow velocity and (c) flow pressure.

Based on a request from the District Collector of Thrissur, we have conducted a geophysical survey, i.e., ERT survey and field geomorphology, to understand the subsurface nature of the terrain, where the local people were suspecting soil piping in Puthur village, Thrissur taluk. A comprehensive scientific report was submitted in this regard.

We attempted landslide susceptibility mapping using the Analytical Hierarchy Process (AHP), Frequency Ratio (FR), and Shannon entropy in the Upper Cauvery catchment in the Kodagu district of Karnataka state, where extensive landslides occurred during the 2018 extreme rainfall event. Landslide inventory creation was also attempted; extensive fieldwork was carried out. In addition, a few places have been selected for future subsurface mapping using GPR and ERT.

https://doi.org/10.1007/s11069-023-05985-0

Bipin Peethambaran, Nandakumar V.

3.2.2 Utility of fluid inclusion paleo-temperature in petroleum system modelling

Burial history and thermal maturity models were created for two dry wells, RV-1 and KK4C-A-1, from the Kerala-Konkan and Mumbai offshore basins, using 1D PetroMod (Version 2018.2). In our study temperature of homogenisation (Th) data of fluid inclusions obtained from microthermometric analyses were used for the thermal history modelling in the PetroMod software. Bottom Hole Temperatures (BHT), Vitrinite reflectance (VRo) and heat flow are widely used in the oil industry for thermal calibration. Compared to commonly used thermal calibration parameters, fluid inclusion homogenisation temperature (Th) representing the minimum entrapment temperature at the time of entrapment of fluid inclusion in the geological past could yield better results in the PSM study.

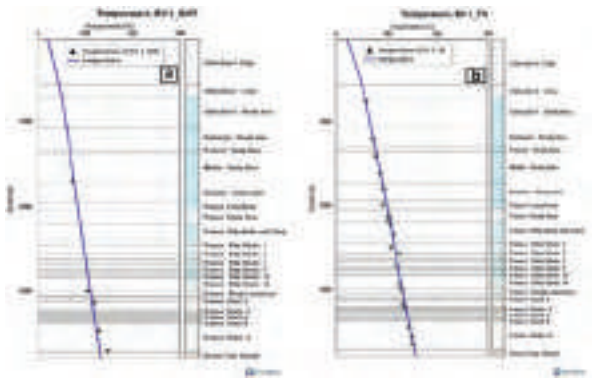


Fig. 3.2.2.1: (a) Temperature calibration using Bottom Hole Temperature (BHT) for RV-1 well, (b) Temperature calibration using Paleotemperature (Th) for RV-1 well.

Results: (values in Mtons)

Well Name	BHT Calibration		Th Calibration	
	Generation	Expulsion	Generation	Expulsion
RV-1	0.75	0	2.8	2.3
KK4C-A1	0.21	0.007	0.24	0.18

In geologically older (Purana/ Proterozoic) basins, where organic matter presence is unavailable, Vitrinite Reflectance (VRo) data could not be obtained, and oil prospectus estimation becomes difficult. In such circumstances, fluid inclusion paleotemperature data can be a direct substitute for Bottom

Hole Temperature (BHT), and VRo (Vitrinite reflectance) in Petroleum System Modelling (PSM), a vital tool for oil exploration.

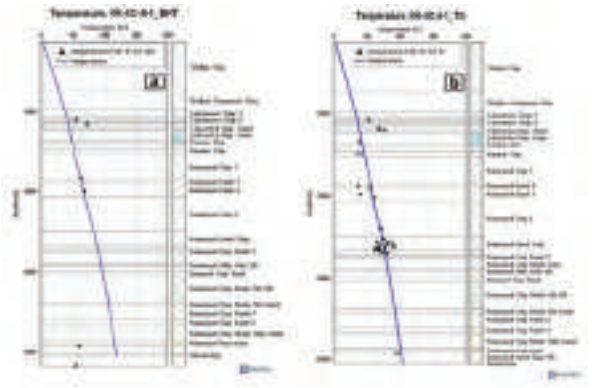


Fig. 3.2.2.2: (a) Temperature calibration using Bottom Hole Temperature (BHT) for KK4C-A-1 well, (b) Temperature calibration using Paleotemperature (Th) for KK4C-A-1 well.

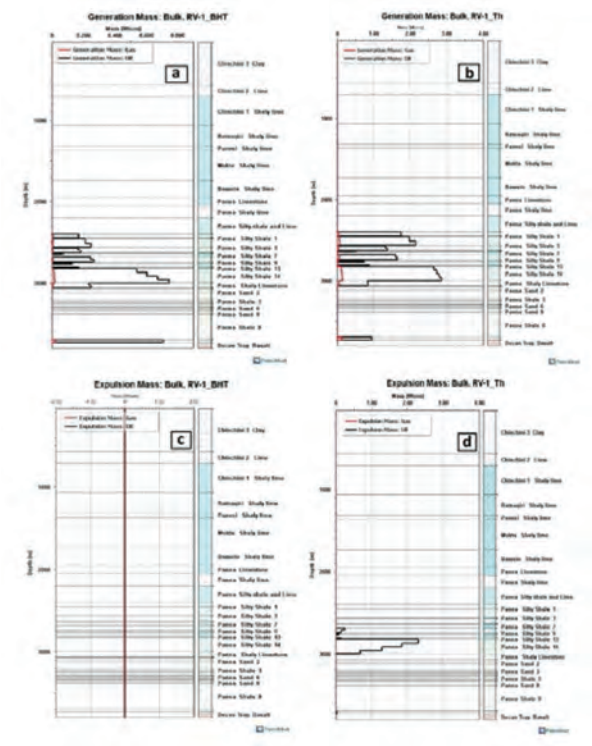


Fig. 3.2.2.3: (a) RV-1 well generation using BHT calibration, (b) RV-1 well generation using Th calibration, (c) RV-1 well expulsion using BHT calibration, and (d) RV-1 well expulsion calibrated using Th.

Compared to commonly used thermal calibration parameters fluid inclusion homogenisation temperature (Th) from the fluid inclusion assemblages could yield better verifiable results in the PSM study. In PSM, we could obtain enhanced results with more accuracy of data when we calibrated the models with Th (Paleotemperature), and it contributes to the understanding of oil generation and expulsion history from the dry wells RV-1 and KK4C-A1 well.

Fig. 3.2.2.4: (a) KK4C-A-1 well generation using BHT calibration, (b) KK4C-A-1 well generation using Th calibration, (c) KK4C-A-1 well expulsion using BHT calibration, and (d) KK4C-A-1 well expulsion calibrated using Th.

https://doi.org/10.1016/j.engeos.2023.100256

Nandakumar V., Shivapriya S., Silpa Thankan

3.3 Hydrology Group

3.3.1 Rock–water interaction, chemical weathering, and solute transport of two rivers draining contrasting climate gradients in Western Ghats, India

Rock–water interactions and chemical weathering are critical factors determining the quality and quantity of solute transport in river catchments. However, most studies in this field have been limited to temperate regions, and data from the tropics and subtropics are scarce, particularly for small rivers that are more responsive to environmental and climate

changes. The study investigated chemical weathering, its causal mechanisms and controlling factors that determine changes in the quality and quantity of solutes in two small, tropical mountainous rivers-the west-flowing Thuthapuzha river and the east-flowing Bhavani river-that drain through contrasting climate and geologic gradients across the southern part of the Western Ghats, in India. This region has an elevated passive continental margin and is an ecologically sensitive area. Hydrochemical analysis of river water revealed that the cationic and anionic concentrations in the samples are in descending order of importance: $Ca^{2+-} > Na^{+} > Mg^{2+} > K^{+}$ and $HCO_3 > Cl > SO_4^{2}$. Principal component analysis (PCA) indicated that geogenic factors (geology, chemical weathering, and leaching/erosion) have a significant role in determining the hydrochemical characteristics of the rivers.

A detailed analysis of the major ion ratios and forward and inverse modelling was performed to discriminate the relative contributions of silicate weathering in the river basins. The weathering index computed from the molecular ratio of cations and silica concentrations suggested that silicate weathering leads to kaolinite formation in the soil profile. Carbonic acid is considered the major chemical weathering agent in the study area. The carbon dioxide consumption rate (CCR) estimated for the Thuthapuzha river, which drains the humid western flank of the Western Ghats, was $2.18x10^5$ $mol.km^{-2}.year^{1}$, whereas the Upper Bhavani River drains the Western Ghats's semi-arid area was $1.39x10^5$ $mol.km^{-2}.year^{-1}$. The weathering index values, calculated based on the molecular ratio of dissolved cations and silica concentrations in the rivers (Re), suggest that kaolinite formation is predominant in the study area due to the breakdown of rock-forming alumino silicates. The denudation rate was higher during the monsoon season, indicating that precipitation and discharge influence chemical denudation in the area. Compared to the global average, the denudation rates of the Thuthapuzha and Upper Bhavani rivers were higher. Multivariate statistical analysis reveals that geological characteristics and climate gradients of the river basins play a significant role in determining the water chemistry of these rivers, as opposed to anthropogenic factors. The study highlights the interplay of climatic factors and the geologic characteristics of the terrain that significantly influence the nature and attributes of solute transport through the rivers in the study area.

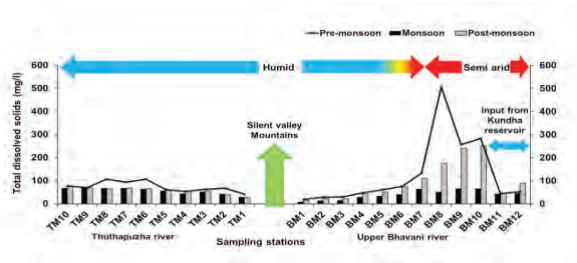


Fig. 3.3.1.1: Spatial variation of total dissolved solids (TDS) along the master channel of Thuthapuzha (TM) and Bhavani rivers (BM) during pre-monsoon, monsoon and post-monsoon seasons.

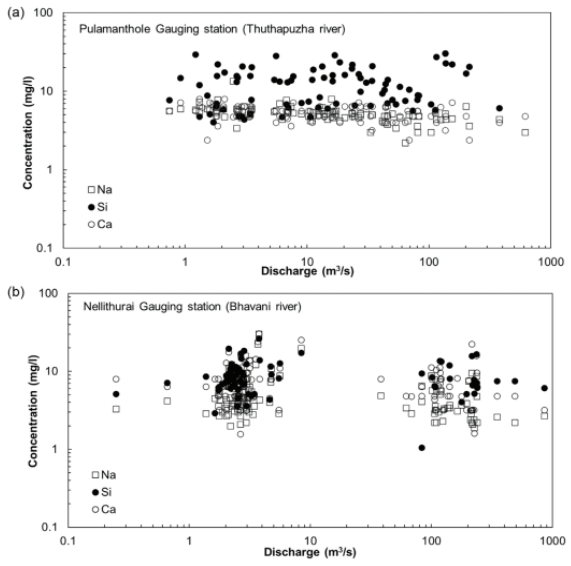


Fig. 3.3.1.2: Concentration–discharge relationship for Na, Si and Ca at (a) Pulamanthole and (b) Nellithurai gauging stations (same number of log units for both concentration and discharge).

This work was done in collaboration with K. Sajan of Cochin University of Science and Technology, Kochi.

https://doi.org/10.1002/esp.5598

Vipin T. Raj, Gayathri J. A., Vandana M., Sreelash K., Maya K., Padmalal D.

3.3.2 Hydroclimatic variability in the Core Monsoon Zone (CMZ) of India and its linkage with the marine and continental records - An overview

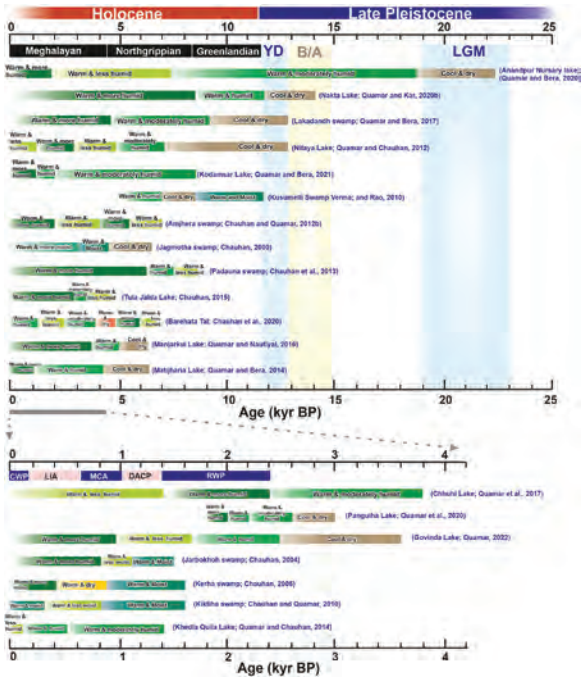


Fig. 3.3.2.1: The comparison of the paleoclimate reconstruction conducted in the central part of the CMZ (Madhya Pradesh and Chhattisgarh). The climate reconstruction has been made based on the palynological proxy.

The primary element of the Asian Monsoon System, the Indian Summer Monsoon (ISM), is responsible for the intricate ocean-atmospheric-coupled mechanism of the tropics, which is essential to transmitting heat between the hemispheres on Earth. About 80 % of the rainfall over India and its neighbouring regions is caused by the ISM, which has a pivotal impact on the socio-economic development and agricultural productivity of the world's most populated areas. The annual ISM rainfall intensity over the Indian landmass during the peak rainfall months (July and August) is generally represented by the ISM variability over the Core Monsoon Zone (CMZ; latitudes: 18°N - 28°N; longitudes: 65°E - 88°E) of India. Thus, the CMZ is the crucial region for categorising weak or strong monsoon periods, often referred to as 'break' or 'active' spells, respectively, depending on how sensitive it is to ISM oscillations. The present study has reviewed the response of the ISM over the Indian subcontinent, primarily over the CMZ, which has been broadly divided into central CMZ (Madhya Pradesh and Chhattisgarh) and peripheral CMZ (Gujarat, Rajasthan, northern Maharashtra, Uttar Pradesh, Haryana, Bihar, Jharkhand, north and central Odisha).

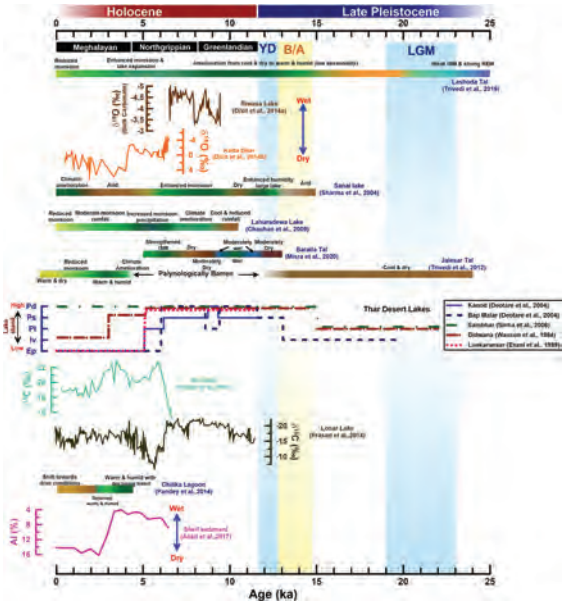


Fig. 3.3.2.2: Comparison of climate reconstruction from the studies located in the peripheral regions of the CMZ (Gujarat, Rajasthan, northern Maharashtra, Uttar Pradesh, Haryana, Bihar, Jharkhand and Odisha). [In Thar desert lakes, the lake levels are abbreviated as follows: Pd-Perennial deep, Ps-Perennial shallow, Pl-Playa Lake, Iv-Intermittent variable, Ep-Ephimeral].

The studies from CMZ are being compared with the other regional and global records since the Last Glacial Maximum (LGM; ~20 ka) to address the ISM variability with the global climate dynamics. The present review demonstrated that the CMZ witnessed a weak ISM during the LGM, comparable with other regional records. However, the central CMZ witnessed a cool and dry climate, while the peripheral CMZ showed the influence of winter precipitation linked with the enhanced Siberian High. Weak ISM prevailed during the Younger

Dryas (YD; ~13–11.7 ka), while the onset of the Holocene (~11.7 ka) witnessed a strong ISM over the entire CMZ associated with the high solar insolation. Nevertheless, selected studies indicated a delayed ISM intensification over the central CMZ region. Concisely, the present study revealed that the CMZ of Indian landmass has been more responsive towards the stronger ISM phases [Holocene Climate Optimum (HCO; 11.8–6 ka); Minoan Warm Period (MWP; ~3.3 ka); Roman Warm Period (RWP; 2.5–1.45 ka); Medieval Climate Anomaly (MCA; 1.05–0.65 ka) and Current Warm Period (CWP; 0.1 ka to Present)] than the weaker ISM periods [Dark Age Cold Period; (DACP: 1.45–1.05 ka) and Little Ice Age; (LIA: 0.65–0.1 ka)].

This work was done in collaboration with Mohammad Firoze Quamar, Biswajeet Thakur and Ratan Kar of Birbal Sahni Institute of Palaeosciences, Lucknow.

https://doi.org/10.1016/j.palaeo.2023.111844

Upasana Swaroop Banerji

3.3.3 Influence of COVID-19 lockdown on river water quality and assessment of environmental health in an industrialised belt of southern Western Ghats, India

The COVID-19 pandemic and sudden lockdown have severely hampered the country's economic growth and socio-cultural activities while positively affecting the overall fitness of the environment, especially air and water resources. Increased urbanisation and rapid industrialisation have led to rising pollution and deterioration of rivers and associated sectors such as agriculture, domestic and commercial needs. However, various studies in different parts of the country indicate that the COVID-19 pandemic has changed the entire ecosystem. However, it is noted that studies are lacking in the Southern Western Ghats region of India. Therefore, the present study attempts to investigate how the continuous lockdowns affect the River Water Quality (RWQ) during lockdown (October 2020) and post-lockdown (January 2021) periods in the lower catchments (Eloor-Edayar industrialised belt) of Periyar river, Kerala state, South India. Thirty samples (15 samples each) were analysed based on drinking water quality, irrigational suitability, and multivariate statistical methods to evaluate the physical and chemical status of RWQ. The results of the Water Quality Index (WQI) for assessing drinking water suitability showed a total of 93% of samples in the Excellent and Good category during the lockdown. In comparison, only 47% of samples were fit for drinking during the post-lockdown period. Irrigational suitability indices like Mg Hazard, KR, PI, SAR, and Wilcox diagrams revealed lockdown period samples more suitable for irrigational activities than post-lockdown samples with site-specific changes. Spearman rank correlation analysis indicated EC and TDS with a strong positive correlation to Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}, TH, SO_4^{2-} and Cl^{-} during both periods, as well as strong positive correlations within the alkaline earth elements (Ca^{2+} and Mg^{2+}) and alkalis (Na^{+} and K^{+}). Three significant components were extracted from Principal Component Analysis (PCA), explaining 88.89% and 96.03% of the total variance for lockdown and post-lockdown periods, respectively. Variables like DO, BOD, Ca^{2+}, NO_3^{-} and Cl^{-} remained in the same component loading during both periods, elucidating their natural origin in the basin. The health risk assessment results based on the US EPA represented hazard quotient and hazard index values below the acceptable limit, signifying no potential non-carcinogenic risk via oral exposure, except for suggesting that children are more vulnerable to adverse effects than adults. Furthermore, this study also shows that the rejuvenation of river health during lockdown offers ample scope to policymakers, administrators, and environmentalists in deriving appropriate plans for restoring river health from anthropogenic stress.

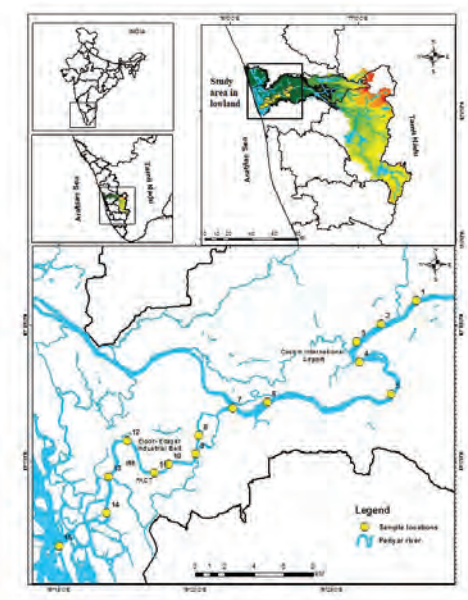


Fig. 3.3.3.1: Location and sampling sites in the study area.

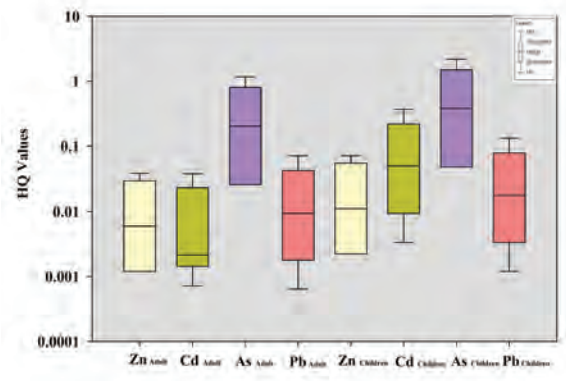


Fig. 3.3.3.2: Hazard quotient values of different metal ions in adults and children.

https://doi.org/10.1007/s11356-023-27397-0

Aditya S. K., Krishnakumar A., Anoop Krishnan K.

3.3.4 Principal component analysis to assess the heavy metal enrichment in urban soils of Kabini Basin: Emerging concerns

Heavy metal enrichment in urban soils demarcates a primary ecological concern. The emerging industries, settlements and agricultural lands on the bank of the Kabini River resulted in prominent changes in water and soil geochemistry. In the present work, 20 soil samples from the Kabini Basin have been checked for trace metals concentration and assessed following a multivariate statistical approach. The PCA has been conducted to characterise the trace metals as per the common source of origin, as shown in Fig. 3.3.4.1. The factors distinguished the heavy metals into three components with an overall variance of 82.53%. Higher loading of various heavy metals indicates natural and anthropogenic interferences in soil. The baseline data generated from the present study provides insight into the concentration of heavy metals, which would further be helpful in the conservation and management of soil resources of the basin.

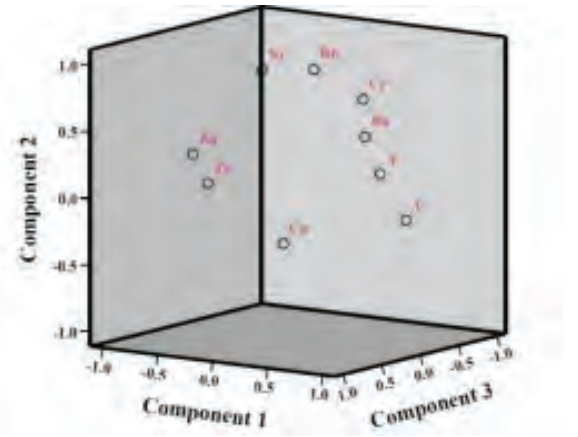


Fig. 3.3.4.1: Loading plot of heavy metals.

https://doi.org/10.56153/g19088-023-0155-36

Himanshi Gupta, Krishnakumar A., Anoop Krishnan K.

3.4 Biogeochemistry Group

3.4.1 Seasonal assessment of sedimentological parameters in the estuarine and coastal compartments of southwest India

The study focuses on the sedimentological characteristics and environmental impact on the Kadinamkulam Estuary and adjacent coastal areas in Southwest India. It examines how seasonal- pre-monsoon, monsoon, and post-monsoon physico-chemical variations of bottom waters; sediment texture; organic carbon; heavy metals such as Cu, Cr, Ni, Zn, Pb, and Hg; and macrobenthic composition in the study area. The sampling transects did not

record Severe heavy metal contamination (CF < 1). Retting coconut husk in the estuary resulted in hypoxic conditions of bottom waters (D.O > 3 mgl^{-1}) during pre- and post-monsoon seasons. The investigation is significant in understanding the interplay between natural processes and anthropogenic activities on estuarine health. Salinity (> 20 psu) and alkaline pH favoured metabolic activity of bivalves and clay/heavy clay texture pattern with comparatively high organic matter preferred growth of bivalves in estuarine-marine mixing zone and coastal transects. PCA studies concluded that further uncontrolled anthropogenic activities in the estuary would intensify the heavy metal concentration of Cu, Cr, and Ni in the surface sediments, leading to probable bioaccumulation in bivalves. Seasonal changes profoundly affect sediment texture and movement. During the monsoon season, heavy rainfall and surface runoff increase silt and clay content in estuarine areas, reducing sand content. It is due to the resuspension of sediments caused by the combined action of tidal forces and monsoon-driven currents. In the post-monsoon period, decreased water flow allows for greater downstream transport of sediments, continuing to alter the estuarine landscape. This dynamic process demonstrates the sensitivity of coastal systems to climatic variations. A critical concern raised in the study is the concentration of heavy metals such as copper (Cu), chromium (Cr), and nickel (Ni) in the estuary. These metals were found to be associated with bivalve populations, and their presence can be linked to both natural processes and human activities, including the retting of coconut husks, a common practice in the region. The potential for bioaccumulation of these metals in bivalves poses ecological risks, mainly as bivalves are key indicators of estuarine health. The study also highlights the role of organic matter-rich, clayey sediment in supporting bivalve growth. Estuarine areas with higher salinity and alkaline conditions, resulting from mixing marine and freshwater systems, were conducive to bivalve populations. Overall, the research underscores the need for careful monitoring of estuarine environments to mitigate the impact of pollution and ensure the sustainability of these vital ecosystems.

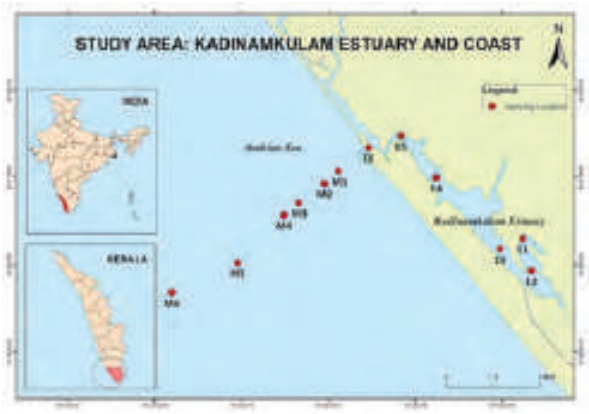


Fig. 3.4.1.1: Study area: Kadinamkulam estuary and coast.

https://doi.org/10.1007/s11270-023-06457-8

Syam Sunny, Maya K., Sreelesh R.

3.4.2. Batch adsorption studies incorporating response surface methodology for the elimination of acephate

Banned pesticides are continuously preferred by the planters of the Idukki District, irrespective of their toxicity. Among the banned pesticides, acephate is preferred because of its high solubility in water and persistent character. Unfortunately, it detriments the biota, leading to neurogenic, carcinogenic, and physiological disorders in fish. The plantation near the Periyar River basin is contaminated with residues of pesticides, which eventually drain into the river. There is an urgent need for the removal of acephate. Therefore, we have focused on removing acephate into the lab scale. Batch adsorption studies were carried out to remove acephate. We selected a material Fe-MMT (Fe_3O_4-montmorillonite), which is benign and possesses a high adsorption capacity to-wards acephate. Adsorbent properties were examined using various analytical tools, such as XRD, SEM, FTIR, and a surface area analyser. Adsorption followed Langmuir with first-order kinetic. Kinetic plots exhibited multistage adsorption, indicating film diffusion and pore diffusion during the adsorption, or

the adsorption mechanism is chemisorption, physisorption, and Lewis's acid-base interaction. Response surface methodology involving CCD (central composite design) was extracted to maximise the adsorption of acephate onto Fe-MMT. Dosage and concentration seem to be the major parameters that influenced the adsorption. Adsorption peaked (83.18%) at optimum conditions corresponding to pH 6, initial acephate concentration of 2 mg/L, and adsorbent dosage corresponding to 0.5 g/L.

https://doi.org/10.3390/ECWS-7-14309

Shiny Raj R., Anoop Krishnan K.

3.4.3 Performance of novel pillared eggshell-bentonite clay bio-composite for enhanced phosphate adsorption from aqueous media

For ages, phosphorous eutrophication has globally become a primary water quality issue in the riverine system. Naturally abundant clay and eggshell adsorbent materials have been considered among innumerable phosphate removal approaches due to their discrete advantages. Yet, unmodified clay and eggshells have limited phosphate adsorption capacity. This article investigates the effects of phosphate adsorption from an aqueous solution on iron-pillared eggshell-modified bentonite clay biocomposite (IPESMB). The diffusion mechanism, electrostatic interaction, and ion exchange mechanisms play a significant role in effective phosphate removal at low pH (pH 3.0). The positive potential developed within the clay minerals can be neutralised with phosphate's negative potential, suggesting a high adsorption capacity. The performance of the developed bio-composite during factorial operations is further calibrated by designing an adsorption reactor. Phosphate adsorption onto IP-ESMB was endothermic, chemisorption, and spontaneous with pseudo-second-order kinetics. Thus, the current study displays a modified clay mineral, which can effectively serve as a green adsorbent to minimise phosphorous eutrophication in a natural water system.

https://doi.org/10.1016/j.gsd.2023.100960

Sandhya Sudhakaran, Anoop Krishnan K.

3.4.4 Impact of stone quarries on groundwater quality at Achenkovil river basin, southern Western Ghats, India: Investigation using WQI and GIS

The quality concern of groundwater owing to human activities is mounting at a shocking rate in many of the river basins in Southern India. A study was carried out in this work to determine the quality of groundwater in the Achenkovil River Basin (ARB) in the Southern Western Ghats region of Kerala, India. A total of 25 dug well water samples were collected from the vicinity of aggregate quarries during the pre and post-monsoon seasons of 2020–2021. The water quality index has been applied to categorise the water quality, namely, excellent, good, poor, etc., to infer water quality to the people and policymakers in the concerned area. The WQI results showed that 12% of the water samples were good, and 28% were very poor. The Hill-Piper Trilinear diagram reveals that the groundwater of the study area falls under Ca^{2+}/Mg^{2+}, and HCO_3^- and SO_4^{2-}, Cl^-, Mg^{2+} types. The hydro-chemistry of the rock-dominant water type of the quarrying area is inhibited by geogenic processes along with the percolation of prevailing quarry leachate and infiltration into the nearby wells. The correlation matrix has been created and analysed to observe their significant impetus on the assessment of groundwater quality. According to the various indices, the overall quality of groundwater systems in the quarrying area is not fit for domestic consumption without mandatory quality treatment, but it is suitable for irrigation.

https://doi.org/10.1002/tqem.22079

Reghunadh K., Sibin Antony, Arun V., Krishnakumar A., Vishnu Maya, T. M., Anoop Krishnan K.

3.4.5 Lignocellulosic magnetic biochar with multiple functionality: A green chelating system for water purification

For the bioremoval of Fe(III) ions, an active magnetic filter media is synthesised by ultrasound centrifugation. By coprecipitation, a magnetic nanoparticle was synthesised; it was then multi-functionalised with a chelating agent, Humic acid (HA), onto a microwave-assisted chemically activated powdered biochar of banana pseudo stem (BPSC), resulting in an incorporation of functional groups like -COOH, -OH, -NH_2. Textural and magnetic properties were analysed via FT-IR, XPS, BET, FESEM, AFM, TG, DTA, VSM, XRD and CHNS analysers. The adsorption capacity and efficiency of γ-BPSC/HA adsorption were 34.25 mg/g and 98.5%, respectively. XPS analysis confirmed that the adsorbent's metal ions were bound to specific binding sites and had a specific capturing mechanism. A mechanism of spontaneous complexation was accomplished because of the heterogeneity of the surface, electrostatic forces, pore filling, H-bonding, and π-π stacking. Follows PSO kinetics and favours Freundlich isotherm. The adsorbent substance shows a remarkable capacity for regeneration, assuring the substance's stability and reusability.

https://doi.org/10.1016/j.jece.2023.110947

Bency John, Harsha Mahadevan, Anoop Krishnan K.

3.4.6 Assessment of hydro-geochemical indices of Periyar river in Eloor Industrial Belt (Kerala), India to identify potential environmental impacts

The study investigated the role of hydrogeochemical parameters that act as indicators of environmental pollution in industrial areas of the Periyar River, Kerala, India. A total of 20 water/sediment samples were collected along the industrial stretch of the Eloor-Vypin area during the pre-monsoon season of the year 2020. Among the hydrochemical parameters, the extent of pollution was assessed by measuring nutrients and heavy metal concentration. The micronutrients such as silicate (640-3440µg/L), ammonia (4.42-894.2µg/L), phosphate (28.65-132.41µg/L), nitrite (3.12-30.14µg/L), and nitrate (50.13-851.97µg/L) were found to have higher enrichment at locations near the industrial areas of the study. The identified heavy metals, Zn, Mn, Pb, Cr, Cd, and Th, having concentrations ranging from 1.0-152.4, 1.2-49.2, 1.2-31.7, 3.0-26.2, 1.1-13.3, 0.1-3.2µg/L, respectively. Various pollution indices suggest the sediments have low to moderate heavy metal contamination. The conditions may worsen in the future if industrial activities continue in an unregulated manner.

https://doi.org/10.56153/g19088-023-0159-44

Arun V., Vishnu Maya T. M., Sibin Antony, Vinu V. Dev, Gayathri S., Krishnakumar A., Anoop Krishnan K.

3.4.7 Paleoclimatic analysis of quaternary sediments associated with the floodplain deposits of a tropical estuary along the southwestern coast of India

The coastal regions of southwest India, which fall under the tropical regime, have witnessed many transgression-regression events and climatic extremes during the Quaternary Period. A core, 15 m long, was recovered from the floodplains associated with a typical backwater body (lake) on the southwestern coast of India. The granulometric analysis proved the dominance of sand and silt fractions and extremely high energy conditions over the entire core. The TOC/TN ratio indicated a domination of the C4-type over the C3-type plants in the lower half of the core, suggesting a warm climate. The C3-type plants prevail in the upper part of the core, thus reflecting cool and wet environments. The core's extremely low TOC/TN ratio (0.33% to 10%) indicates short periods of very high rainfall events, the rapid influx of nutrients to the basin, and the basin's eutrophication. The presence of slightly brackish, brackish/marine and marine benthic foraminifers at 12.5–9 m

depth indicates episodes of transgression and regression. The derived AMS radiocarbon dates suggest the Marine Isotope Stage 3 for the lower part of the core.

This work was done in collaboration with Divya Murali, Rajesh Reghunath, Pranav Prakash, Sruthy Rose Baby of University of Kerala, Trivandrum; and Ravi Bhushan of PRL, Ahmedabad.

https://doi.org/10.24425/sq.2023.148038

Anoop Krishnan K.

3.4.8 Assessment of land degradation vulnerability in the semi-arid region of southern India using GIS-based MEDALUS approach

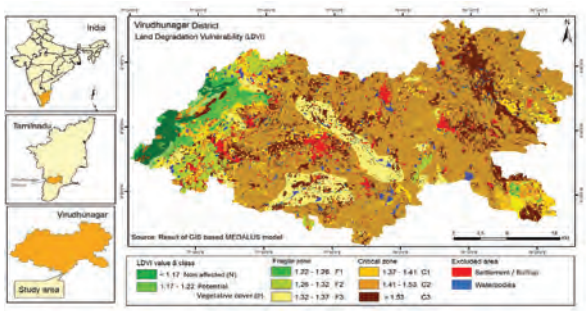


Fig. 3.4.8.1: The map showing land degradation vulnerable zones in the semi-arid region of Virudhunagar district in Tamil Nadu, southern India.

The GIS-based MEDALUS model is executed in the semi-arid region of Virudhunagar district in Tamil Nadu, South India, to calculate the land degradation vulnerability index (LDVI) by analysing multiple geo-environmental parameters derived from Landsat OLI image (30m), SOI topographical maps, SRTM DEM (30m), GSI-published geology maps, soil maps, and IMD rainfall data.

The result of the LDVI map is classified into four classes based on their degree of vulnerability such as (i) non-affected zone (N), (ii) potential vegetative cover (P), with the estimated LDVI value of < 1.22, (iii) fragile zone (F1, F2, F3), and the LDVI value of 1.22 – 1.37, (iv) critical zone (C1, C2, C3) with the LDVI value of > 1.37. The critical zones indicate severe land degradation in the different parts that cause adverse impacts on soil fertility and agriculture productivity. About 84.95% of the areas fall under critical land degradation in land use/land cover (LULC) features due to soil erosion, salinity, and removal of nutrients. The sub-classes of critical zones, namely C1, C2, and C3, are spatially estimated at 9.78%, 60.34%, and 14.81%, respectively. Moreover, 6.73% of the area falls under fragile zones, including F1, F2, and F3 sub-classes, with areas of 0.86%, 2.26%, and 3.60%, respectively. Due to rapid runoff and poor infiltration, the LULC features experience moderate degradation around the foothills and pediplains. About 1.76% of the area is noted as non-affected zones, covering forest cover, plantations, and irrigated lands, whereas they retain soil nutrients, humus, and fertility conditions. The study concluded that the larger landmass fell under land degradation; therefore, scientific practices will be implemented for land and soil management activities. The study's outcome is a primary information source for planning and developing land resources for long-term scenarios.

This work was done in collaboration with N. Chandrasekar of Manonmaniam Sundaranar University, Tamil Nadu; Manish Parmar of ISRO-SAC, Ahmedabad; R. G. Rejith of Environmental Resources Research Centre, Thiruvananthapuram; S. Dharumarajan and M. Lalitha of National Bureau of Soil Survey and Land Use Planning, Bangalore; and K. Chandramohan of Tamil University, Thanjavur.

https://doi.org/10.1016/B978-0-443-18773-5.00038-7

Kaliraj S.

3.4.9 Rainfall-runoff impacts on riverine landforms of the Thamirabarani sub-basin, southern India, using the GIS-based NRCS-CN approach

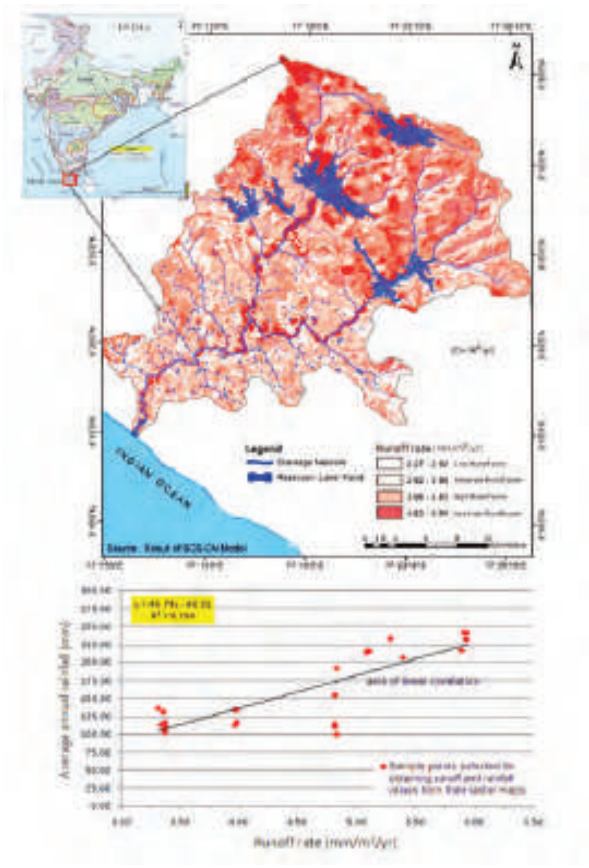


Fig. 3.4.9.1: The map showing the rainfall-runoff rate in the Thamirabarani sub-basin, Kanyakumari district, Southern India.

The Thamirabarani River sub-basin is located in the southern part of the Western Ghats in the Kanyakumari district of Tamil Nadu, India. The basin's topography is unique, with steep-sloped valleys, valley fills, and short-length streams with intensive flows. This study utilised the GIS-based Natural Resource Conservation Service-Curve Number (NRCS-CN) model to assess rainfall-induced runoff by analysing various hydrological parameters. The curve number (CN) is assigned to each hydrologic soil group (HSGs) based on the measurement of initial abstraction (Ia) and potential maximum retention (S) derived from soils, land use/land cover, antecedent soil moisture, etc. The study found that the estimated runoff from the entire basin area was 2.27 – 5.94 mm/m^2/yr. A higher runoff rate (4.83 – 5.94 mm/m^2/yr) was noted in the upland range of the swift surficial terrains in the north and north-eastern parts, which includes undulated structural hills, steep-sloped valleys, inselberg, and denudational hills.

In contrast, a moderate runoff rate (2.92 – 3.98 mm/ m^2/yr) was estimated in the middle parts of pediplains, which consist of croplands, plantations, riverbanks, fallows, and built-up areas. The lower runoff rate (< 2.92 mm/ m^2/yr) sparsely occurred in different middle and southern landforms, including pediplains, riverbanks, natural vegetative covers, valley-filled sediment deposits, etc. Rainfall induced higher runoff from the swift surficial terrains of the upland range in the north and north-eastern parts, especially undulated structural hills, steep-sloped valleys, inselberg, and denudational hills, due to the work of swift surficial terrains and slope gradient of the associated landforms than the other parts. The runoff is moderate in the middle parts of pediplains, consisting of croplands, plantations, riverbanks, fallows, and built-up areas. However, the lower runoff occurs in the isolated patches of the middle and southern parts, including pediplains, riverbanks, natural vegetative covers, sediment deposits, etc. The runoff from the basin is functionally influenced by regimes of hydrogeomorphic processes depending on the site-specific topographic conditions subject to soils and land use/land cover features. Overall results indicate higher runoff over the swift surficial landforms in the north and north-eastern parts due to intensive flow through short-length stream orders. Due to maximum retention and infiltration processes, the gently sloped landforms are noted at lower runoff. This study provides a primary database for understanding the effects of rainfall-runoff on hydromorphological processes in basin environments.

This work was done in collaboration with N. Chandrasekar of Manonmaniam Sundaranar University, Tamil Nadu and M. Lalitha of National Bureau of Soil Survey and Land Use Planning, Bangalore.

https://doi.org/10.1016/j.jher.2023.07.001

Kaliraj S.

3.4.10 Assessment of soil erosion in a tropical mountainous river of the Western Ghats, southern India using GIS-based RUSLE, SDR and AHP techniques

Assessment of soil erosion is an essential process for monitoring and management of land and soil resources and is vital for understanding environmental and socio-economic problems. Nowadays, the rapid growth of urbanisation and developmental activities increases severe impacts on soil erosion in various parts of the Western Ghats, and it makes it necessary to assess soil erosion and planning of soil conservation activities towards sustainable development. The Vamanapuram River Basin (VRB), is a torrid zone consisting of mountain river flow from the Western Ghats in Southern India. This study estimates soil erosion from the basin using the revised universal soil loss equation (RUSLE) model in GIS environment. Five parameters are used in the RUSLE model to calculate "A": rainfall erosivity (R), soil erodibility (K), topographic factor (LS), crop management factor (C), and erosion control practice factor (P). To compute these five parameters, slope, rainfall, normalised vegetation index, digital elevation model, and land use/land cover (LULC) are used along with the texture data of soil samples collected from VRB.

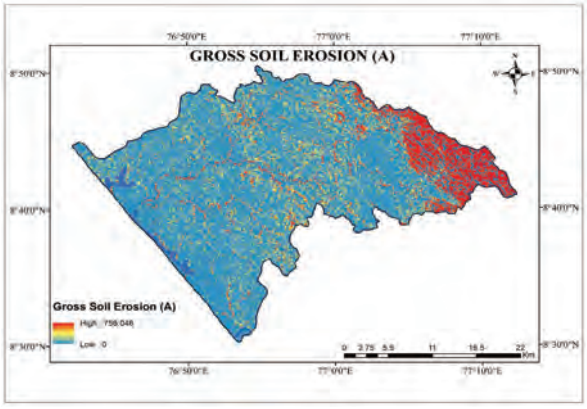


Fig. 3.4.10.1: Gross soil erosion distribution within the Vamanapuram River Basin.

The estimated A value range is 0 to 756 $t.ha^{-1}.year^{-1}$, as shown in Fig. 3.4.10.1, with a mean of 1.275 $t.ha^{-1}.year^{-1}$, whereas the sediment yield estimated through the sediment delivery ratio model ranges from 0 to 510.01 $t.ha^{-1}.year^{-1}$, with a mean of 0.266 $t.ha^{-1}.year^{-1}$. Further, a soil erosion potential index map is developed to identify the erosion-prone zones of VRB using the geo-environmental thematic maps following the analytic hierarchy process. Moreover, soil erosion is evaluated with respect to LULC types, and the rainfall impacts on soil erosion are assessed and quantified for VRB, given the marked variations in rainfall in recent times that are due to extreme climatic events (cyclones/high rainfall/floods) along the west coast of India. It is achieved by modifying the R factor in the RUSLE model by adding one standard deviation to the mean 15-year rainfall and subtracting one standard deviation from the same 15-year mean rainfall. Results suggest that increasing or decreasing the rainfall by one standard deviation of the long-term average causes a significant increase in low and medium soil erosion regions.

This work was done in collaboration with G. Sreenivasulu of Yogi Vemana University, Andhra Pradesh.

https://doi.org/10.1016/B978-0-443-18773-5.00027-2

Asna Nizar, Ciba M., Upendra B., Anoop Krishnan K.

3.5 Marine Geoscience Group

3.5.1 Analysis of beach stability and nearshore hydrodynamics of a structure influenced medium energy coast in India

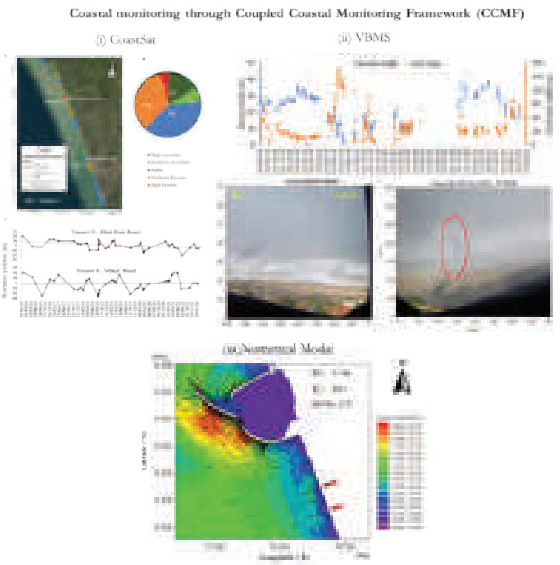


Fig. 3.5.1.1: Coupled Coastal Monitoring Framework: (i) CoastSat-based shoreline analysis – showing erosion/

accretion patterns, erosion hotspots and erosion trends at southern and northern sectors of the breakwater (ii) VBMS observations – Beach surf zone characteristics and rip like channel formations (iii) Numerical model – Nearshore currents showing rip like current patterns at two locations with less intensity.

A novel Coupled Coastal Monitoring Framework (CCMF) was used to analyse coastal hydrodynamics and the influence of hard structures on Kozhikode Beach in Kerala, India. The CCMF integrates satellite remote sensing, VBMS, and numerical modelling schemes to assess the status and trends of the coastal environment for 2018-2021. The study reveals that 38% of the total coast is under erosion, with the northern sector of the breakwater being highly erosive and the southern sector being stable. Beach nourishment is recommended as a complementary modification to minimise coastal erosion, while hard structures are discouraged. The study also identifies two rip-like channel formation hotspots at Kozhikode Beach, highlighting the need for immediate attention and appropriate site-specific remedial measures. The findings of this study have important implications for the management and conservation of coastal environments.

https://doi.org/10.1016/j.ocecoaman.2023.106619

Ramesh M., Swathy Krishna, P. S., Amrutha Raj V., Sheela Nair L.

3.5.2 Practical use of smartphone cameras in rip current monitoring studies

This study focuses on detecting and analysing rip currents through a low-cost smartphone-based beach monitoring system (SBMS) by taking advantage of multiple in-built cameras and onboard memory. The famous tourist destination, RK Beach, on the east coast of India, has been chosen for the study, as it is experiencing a high number of drownings (525 causalities since 2006). Videos of 20-minute duration were collected covering different time frames in 2022, and an open-source Quantitative Coastal Imaging Toolbox (QCIT) toolbox was used to process the videos. Rectified Timex images are generated and utilised to analyse the morphodynamic changes of the beach. Several rip currents have been observed along the coast, with the strongest having a maximum length of 242 m and a width of 55 m. Beach modal states have been computed to determine the rip current hazard associated with it. Sequential transect data indicated the existence of waves at infra-gravity motions within the rip current channels. During the study period, the beach was dominated by the Transverse Bar and Rip (TBR) beach type, which is known for its rip current danger. Rhodamine dye experiments have been conducted to measure the strength of the rip currents practically using video data and field data synergistically. The study is the first to explore the potential application of low-cost smartphones to monitor rip currents at any beach scientifically. Our study would help extend this work further for beach sites and can be applied to projects with limited funds. We suggest using this methodology as a preliminary study before setting up a permanent video monitoring station.

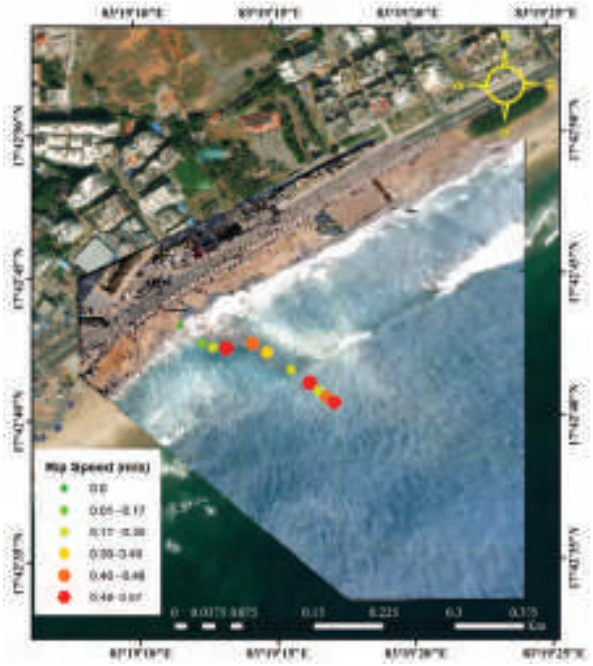


Fig. 3.5.2.1: Rip current speed estimation on Google Earth image on 30 August 2022.

This work was done in collaboration with S. V. V. Arun Kumar and Rashmi Sharma of Space Application Centre, Ahmedabad; B. Gireesh and C. V. Naidu of Andhra University, Visakhapatnam.

https://doi.org/10.1016/j.ocecoaman.2023.106776

Venkateswarlu Ch., Ramesh M., Sheela Nair L.

3.5.3 Wind, wave and tide induced coastal flooding along the southwest coast of India

In September 2018, a flash flood occurred in Valiyathura, Thiruvananthapuram, along the southwest coast of India. This event was caused by high-period swells from the Southern Indian Ocean coinciding with the Perigean Spring Tide, along with increased wind speed sustained for more than 6 hours. The wind and wave directions were aligned in a direction less than 80°, which resulted in water piling up and inundating the coastal stretch. High energy swell waves with a period of 16 seconds and a significant wave height of 1.5 meters led to higher wave runup, resulting in coastal flooding due to a reduction in beach slope prior to the event. The study also found that this caused the movement of finer sediments offshore, indicating beach erosion. Field observations of decreased beach volume and increased grain size after the event corroborated these findings well.

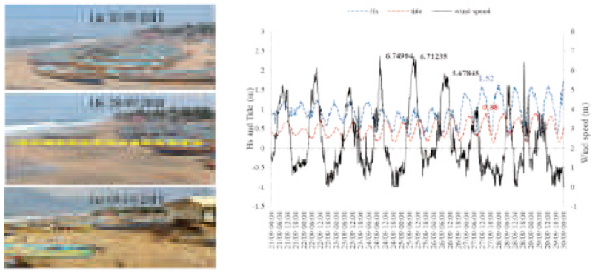


Fig. 3.5.3.1: Coastal flooding on 26-09-2018 due to wind, wave and tide interactions.

https://doi.org/10.1016/j.rsma.2023.102968

Swathy Krishna P. S., Tiju I. V., Sheela Nair L., Ramesh M.

3.5.4 Remotely induced storm effects on the coastal flooding along the southwest coast of India

On 19 March 2019, an unexpected coastal inundation occurred in the Valiyathura-Shangumukham coastal stretch along the southwest coast of India, which was not induced by a storm or cyclone and had no prompt forecast or warning. The causative factor for this inundation was investigated by analysing ERA5 winds and waves over a global domain and fine-scale modelling for the Thiruvananthapuram - Alappuzha coast. The study found that high swells were generated by a storm system in the Indian-Atlantic-Southern Oceans (IASO) interface during March 10-12, 2019, and these swells propagated towards the North Indian Ocean. We have named these swells as "IASO Swells". The arrival time of these swells (~7 days) was matched with the low-frequency spectra measured off Varkala, and the high celerity of these waves, along with the presence of a fully developed/reflective beach, caused an 83 m inundation with a high runup. The study suggests that a more detailed understanding of these swells' climatological features will help better assess forecasts and provide early warnings to the public.

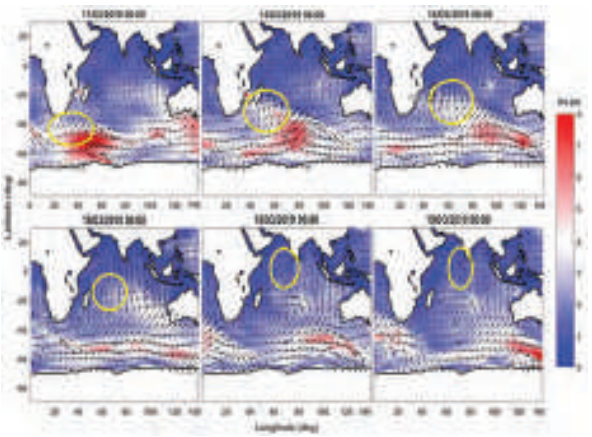


Fig. 3.5.4.1: Propagation of IASO interface swells into NIO during March 2019.

This work was done in collaboration with V. M. Aboobacker of Qatar University, Doha.

https://doi.org/10.1016/j.oceano.2023.03.003

Swathy Krishna P. S., Ramesh M., Sheela Nair L.

3.5.5 Prospects for viable REE deposits in the lateritic-derived river sediments deposited in the central part of Kerala

The sediments in the lower reaches of 21 rivers from Kerala were investigated to understand the influence of lateritic weathering on their mineralogy and geochemistry. The Geochemical characteristics of river sediments indicate that sediments are mainly derived from lateritic weathering. In this study, we have documented rare earth elements (REE) enrichment in (a) the clay and silt fractions of river sediments from central Kerala and (b) the silt fractions of river sediments from southern Kerala. The former corresponds to the weathering products of laterites, while the latter is detrital and associated with heavy minerals.

Fig. 3.5.5.1 shows the rare earth oxide (REO) content of the clay and silt fractions of sediments. The total REO content of the clay (327–621 μg/g) and silt fractions (339– 1132 μg/g) of river sediments from central Kerala (Fig. 3.5.5.1) is significantly higher than in the Upper Continental Crust (239.51 μg/g), and Post-Archean Australian Shale (326.81 μg/g). The ΣREO range of river sediments (327–1132 μg/g) is within that reported for ion-adsorption-type deposits (IADs) from China (300–7000 μg/g), Madagascar (300–3500 μg/g), Africa (900–4000 μg/g), Asia (300–3300 μg/g) and South America (3260 μg/g).

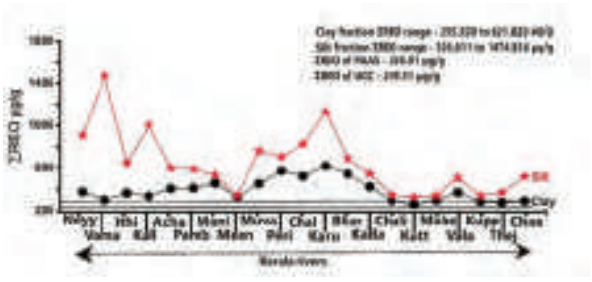


Fig. 3.5.5.1: Total Rare earth oxide (ΣREO) content of the sediments in different rivers. Neyy- Neyyar; Vama – Vamanapuram; Ithi-Ithikhara; Kall-Kallada; Acha-Achankovil; Pamb-Pamba; Mani-Manimalayar; Meen-Meenachil; Muva-Muvathupuzha; Peri-Periyar; Chal-Chalakudi; Karu-Karuvannur; Bhar-Bharatpuzha; Kada-Kadalundy; Chali-Chaliyar; Kutt-Kuttyadi; Mahi-Mahi; Vala-Valapatanam; Kupp-Kuppam; Thej-Thejaswini; Chan-Chandragiri.

The average Th content in the clay fractions of river sediments from central Kerala (14.3 μg/g) is close to that of UCC (8.5 μg/g) and PAAS (14.6 μg/g). Although the average Th content of the silt fractions (29.6 μg/g) of sediments from central Kerala is slightly higher than the clay fractions, the highest ΣREE associated with the lowest Sm/Nd ratios in silt from central Kerala suggests that the REEs occur largely as adsorbed ions on weathered products of laterites and may be easily extracted using low-cost leaching techniques. Therefore, the river clay of central Kerala may serve as a viable REE deposit. This REE deposit differs from the placer sand deposits on the beaches of south Kerala.

This work was done in collaboration with S. S. Babu, V. Purnachandra Rao, , R. V. Ramana and N. Satya Sree of Vignan's University, Guntur ; and M. Ram Mohan of CSIR-NGRI, Hyderabad.

https://doi.org/10.1007/s12040-023-02153-7

https://doi.org/10.18520/cs/v126/i3/345-359

Prajith A.

3.5.6 Seasonal distribution and pollution potential of dissolved heavy metals and nutrients in subterranean estuaries in southern India

The study provides a comprehensive analysis of the impact of Submarine Groundwater Discharge (SGD) on coastal ecosystems along the Kerala coast, focusing on SGD's role as a significant pathway for transporting dissolved heavy metals and nutrients into these ecosystems. Field sampling was conducted

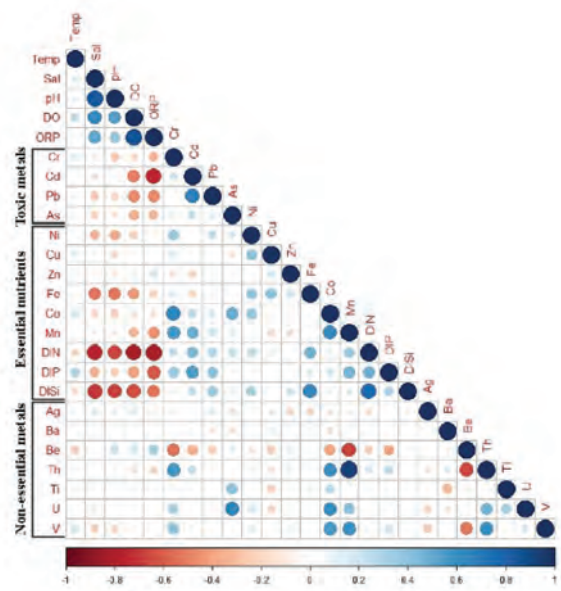


Fig. 3.5.6.1: Pearson correlation coefficient matrix for dissolved heavy metal concentrations and the groundwater physicochemical parameters.

at 15 sites along the Kerala coast, covering approximately 450 km from Karumkulam to Vadakara. Groundwater samples were collected from intertidal beach sediments during low tide, and various physicochemical parameters, including temperature, salinity, pH, dissolved oxygen (DO), and oxidation-reduction potential (ORP), were measured. The concentrations of dissolved inorganic nitrogen (DIN), dissolved inorganic phosphorus (DIP), and dissolved inorganic silica (DISi) were analysed using spectrophotometry, while heavy metal concentrations were determined using inductively coupled plasma-optical emission spectrometry (ICP-OES). Fig. 3.5.6.1 illustrates the Pearson correlation coefficient matrix for dissolved heavy metal concentrations and various groundwater physicochemical parameters. The analysis reveals that pH positively correlates with groundwater salinity ($R = 0.83$; $p < 0.001$). A negative correlation is observed between lead (Pb) and dissolved oxygen (DO) ($R = -0.462$; $p < 0.001$). Additionally, cadmium (Cd) and Pb correlate negatively with DO and oxidation-reduction potential (ORP). Nickel (Ni) and iron (Fe) negatively correlated with salinity, pH, and DO. Furthermore, dissolved inorganic nitrogen (DIN) and dissolved silica (DISi) also display negative correlations with groundwater salinity (DIN: $R = -0.753$; DISi: $R = -0.691$; both $p < 0.001$).

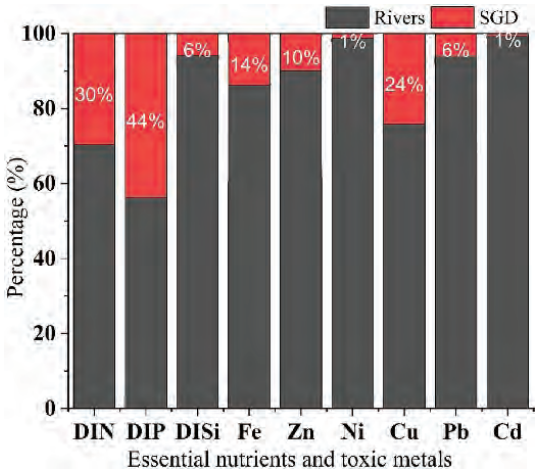


Fig. 3.5.6.2: The percentage contribution of essential nutrients and toxic metals to the Kerala coast via different sources.

Fig. 3.5.6.2 shows the percentage contribution of essential nutrients and toxic metals to the Kerala coast from various sources. River flux data indicates that SGD is a significant source of dissolved inorganic nitrogen (DIN), dissolved inorganic phosphorus (DIP), dissolved silica (DISi), iron (Fe), zinc (Zn), copper (Cu), and lead (Pb) to the Arabian Sea. The average concentrations of metals were ranked as follows: pre-monsoon > monsoon > post-monsoon, with 3 to 12-fold higher groundwater metal concentrations than the adjacent seawater. Average SGD-derived essential metal fluxes were five times higher than toxic ones, with Fe and Zn contributing over 90%. The Single Factor Contamination Index indicated minimal contamination at most sites, with only two sites showing moderate ecological risk due to arsenic. The higher Fe, Cu, and Zn fluxes were likely due to increased anthropogenic activities. SGD-derived nutrient fluxes were a vital source of DIP for primary production in coastal waters,

representing 30% and 44% of the DIN and DIP inputs, respectively. The study highlights the crucial role of SGD in maintaining nutrient budgets along the southwestern Indian coast. While pollution indices suggest minimal ecological and human risk from heavy metals in most coastal groundwater systems, the accumulation of essential nutrients and toxic metals in aquifers poses long-term risks. The findings emphasise the need for expanded studies to assess ecological risks better and inform future groundwater management strategies to mitigate heavy metal contamination.

This work was done in collaboration with N. K. Vishnudattan, S. Bijoy Nandan, E. H. Aravind of Cochin University of Science and Technology, Kochi; Douglas R. Tait of Southern Cross University, Australia; and P. R. Jayachandran of King Fahd University of Petroleum & Minerals, Saudi Arabia.

https://doi.org/10.1016/j.marpolbul.2023.115339

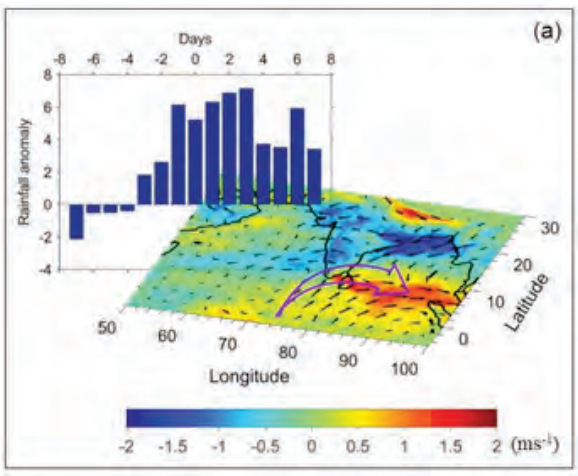
Suresh Babu D. S.

3.6 Atmospheric Science Group

3.6.1 Analysis of localised features during wet and dry rainfall episodes over southern tip of India

The large spatial and temporal variability of wet and dry spells of the Indian Summer Monsoon poses a great challenge in understanding and predicting monsoonal rainfall. This challenge is further exacerbated over smaller regions, such as the southern tip of India, which receives the first spell of ISM rainfall. This study investigates the characteristic features and possible precursors for wet and dry spells of rainfall over the southern tip of India. The observed changes in the recent decades deserve a detailed investigation of rainfall activities over the southern tip of India. Keeping these aspects in view, the primary objectives of this study are: (i) to document the variation in wet and dry spells in the southern tip of India based on in-situ observations and other ancillary datasets; (ii) to understand the role of monsoon LLJ in determining the wet and dry spell days in the southern tip of India; and (iii) to investigate the dynamical and tropospheric thermal structures of the atmosphere during wet and dry spells.

We also explore the variability in monsoon low-level jets with wet and dry spells over a coastal station Thiruvananthapuram (8.48°N, 76.95°E) in southwest India using in-situ observations and other ancillary datasets. Characterisation of wet and dry spells using station data over Thiruvananthapuram reveals that a summer monsoon season witnesses 1-2 wet spells of 3-4 days duration, contributing about 30% of seasonal rainfall. The longer dry spells of > 7 days contribute only < 3.2% of rainfall. Wet and dry spells occur frequently (<60%) during the first half of the monsoon season (June-July months). Wet spells are characterised by westerly wind anomaly in the southern tip of India and easterly wind anomaly in northern India, leading to anomalous cyclonic vorticity over the Indian subcontinent. The opposite happens during dry spells. These characteristics are prominent from two days before the initiation of the spells, suggesting they may be used as precursors for forecasting wet and dry spells over Thiruvananthapuram.



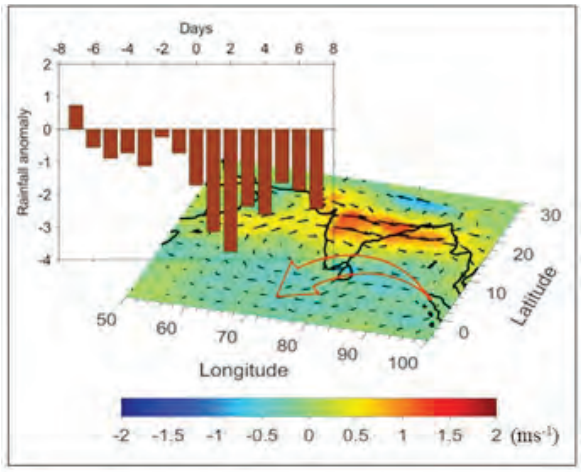


Fig. 3.6.1.1: Composite anomaly of zonal winds (ms^{-1}) overlaid with vector at 850 hPa on d-2 day in (a) wet spells and (b) dry spells. Anomalies were calculated after subtracting the climatological daily mean for 1981-2020. The southerly winds from the Arabian Sea and westerlies in the Bay of Bengal strengthened at 5°N latitude (marked with purple curved arrow) on d-2 day at 850 hPa level that acts as the primary precursor for the wet spells. The easterly wind anomalies developed over the equatorial Indian Ocean located to the south and southwest of the southern tip (marked with red curved arrow), act as a precursor for the onset of dry spells. The corresponding temporal evolution (±8 days) of rainfall anomalies (mm) averaged over the southern region (70°-85°E, 5°S-15°N) in wet and dry spells are represented as bar graph.

During dry spells, warmer temperatures are frequent in lower levels (~0.5°C), registering peaks in temperatures between 2-4 km level. Even though the cloud layer distribution peaks below 2 km, the mid-layer moistening in wet spells is evident in the regional observations. Analysis of low- to mid-tropospheric (2 and 4 km) humidity reveals significant moistening (drying) during wet (dry) spells (Fig. 3.6.1.1). Yet, both wet and dry spells experience humid (>80%) boundary layer. The differences in mid-level humidity and thermodynamical structures between wet and dry spells seem to contribute to distinct rainfall characteristics over the southern tip of India. These results indicate that using in-situ observations along with large-scale reanalysis datasets may provide valuable information on the precursors for wet and dry spells over the southern tip of India, which can help regional- and city-level planning and management of water resources.

This work was done in collaboration with B. Preethi of IITM, Pune; R. S. Ajayamohan of Institute of Applied Technology, Abu Dhabi; Pallav Ray of Florida Institute of Technology, USA.

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Resmi E. A., Unnikrishnan C. K., Nita Sukumar, Sumesh R. K., Dharmadas Jash

3.6.2 Use of multiplatform in-situ observation to study vertical structure and microphysics of clouds during southwest monsoon over Western Ghats, India

A combination of radiosonde profiles with collocated in-situ ground and aircraft measurements is used for the first time to study the vertical structure and microphysics of clouds during southwest monsoon over the Western Ghats, India. The morphology of clouds is detailed with the help of radiosonde observations and classified as low, mid, and high-level clouds depending on the cloud base height. Radiosonde sounding profiles indicated occurrences of both single and multi-layered clouds, with higher occurrences of single-layered (~35%) clouds during the monsoon transition period (June and September) and two-layered (~42%) during the core monsoon period (July and August). The dominance of low (~30%) and high-level (~60%) clouds was noticed compared to mid-level clouds over the observational site during the southwest monsoon.

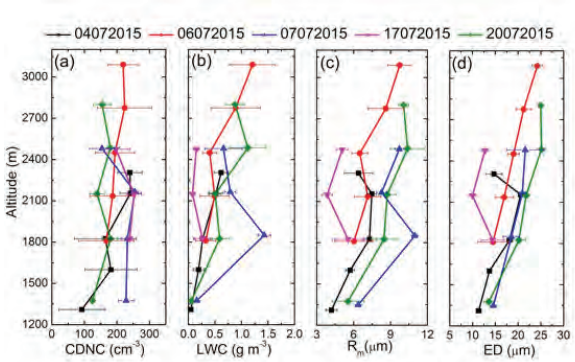

Fig. 3.6.2.1: Altitude variation of (a) CDNC, (b) LWC, (c) ED and (d) Rm, for five cases, respectively, from cloud droplet probe observations onboard aircraft.

A steep decline in the number concentrations

of droplets greater than 25 μm diameter is observed at altitudes above 1800 m (~500 meters above surface (i.e. above HACPL altitude, 1348m AMSL)), indicating accelerated collision-coalescence. It can happen due to a combination of clean conditions or the cloud dynamics affected by orographic features and high supersaturation (SS) availability. Droplets larger than 40 μm diameter from the ground observation suggest the possibility of warm rain initiation at a small distance above the cloud base or warm rain formation even below 2 km altitude. Warm cloud microphysics was investigated using collocated ground and airborne in-situ measurements. Irrespective of the cloud type, the liquid water content and the effective droplet diameter increased with altitude. One of the key results is the rapid broadening of the cloud droplet size distribution with height. The concentration of droplets above 25 μm diameters showed a steep decrease at altitudes above 1800 m, suggesting active collision-coalescence.

This work was done in collaboration with P. P. Leena, Mercy Varghese, V. Anil Kumar, G. Pandithurai, Rohit D. Patil and Thara V. Prabha of IITM Pune; and Jithin S. Kumar of Cochin University of Science and Technology, Kochi.

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Resmi E. A.

3.6.3 A statistical study on cloud base height behaviour and cloud types during southwest monsoon over a high-altitude site in Western Ghats, India

In the present work, a statistical understanding of cloud base height (CBH) behaviour over a high-altitude site (Mahabaleshwar, 17.92°N, 73.66°E, and 1348 m above mean sea level) in the Western Ghats, India has been detailed using Ceilometer measurements. The study focused on the southwest monsoon (June to September), including May and October, for 2019-2021. Cloud occurrence frequency showed clear monthly variation from May to October, with maxima during the southwest monsoon. A clear altitude-temporal variability in CBH 1, 2, and 3 has been noticed over the study region. Irrespective of CBH layers, May and October showed lower (higher) CBH during daytime (night-time). JJAS exhibited less significant diurnal variability with low values of CBH throughout the day. This diurnal variability is probably due to the mountain–valley breeze circulation, topography, humid-dry air during respective months, etc. Similarly, the monthly variation of CBH showed higher mean values during May and October compared to JJAS, particularly in CBH 1 and CBH 2; however, CBH 3 did not show significant variation. Comprehensive analysis using CBH 1 showed mean values of 2919 ± 4129, 348 ± 1327, and 2666 ± 3429 m AGL for May, JJAS and October. Monthly and seasonal variations of mean CBH (lowest layer) showed high values during May and October, whereas low values were observed during the southwest monsoon season. Analysis showed the presence of layered clouds over the study region. Cloud-type classification based on CBH showed a higher percentage of low and mid-level (mid-level) clouds during May (October). Low-level clouds were dominant during the southwest monsoon over the study region. Further, CBH behaviour and cloud types were investigated under various environmental conditions or phases associated with the respective season/ month. Distinct variations in CBH frequency distribution and cloud types are noted from the classified conditions/ phases. The results indicated that the study region receives a good amount of rainfall from the low-level clouds during the southwest monsoon season, whereas low-level and mid-level clouds significantly contribute to the total precipitation during May and October. It is the first such report using long-term ground-based observation from a high-altitude complex terrain like the Western Ghats explicitly on CBH behaviour.

This work was done in collaboration with P. P. Leena, V. Anil Kumar, K. Chakravarty, Rohit D. Patil and G. Pandithurai of IITM, Pune; Dhwanit J. Mise and P. Pradeep Kumar of Savitribai Phule Pune University, Pune; and K. S. Nirmin of Cochin University of Science and Technology, Kochi.

https://doi.org/10.1007/s12524-024-01808-2

Resmi E. A.

4. Research Output

4.1 Publications

4.1.1 Papers in Journals (SCI)

1. **Aditya, S. K., Krishnakumar, A., Krishnan, K. A.** (2023). Influence of COVID-19 lockdown on river water quality and assessment of environmental health in an industrialised belt of southern Western Ghats, India. Environmental Science and Pollution Research, Vol. 30 (28), pp. 72284–72307. https://doi.org/10.1007/s11356-023-27397-0

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4.1.2 Papers in Journals (non-SCI)

1. **Arun, V., Maya, T. M. V.,** Rijulal, G., **Antony, S., Dev, V. V., Gayathri, S., Krishnakumar, A., Krishnan, K. A.** (2024). Assessment of hydro-geochemical indices of Periyar river in Eloor Industrial Belt (Kerala), India to identify potential environmental impacts. Journal of Geosciences Research, Vol. 9 (1), pp. 30-40. https://doi.org/10.56153/g19088-023-0159-44

2. **Gupta, H., Krishnakumar, A., Krishnan, K. A.** (2023). Principal Component Analysis to Assess the Heavy Metal Enrichment in the Urban Soils of Kabini Basin: Emerging Concerns. Journal of Geosciences Research, Vol. 8 (2), pp. 160-163.

3. Murali, D., Reghunath, R., Prakash, P., Bhushan, R., **Krishnan, K. A.,** Baby, S. R. (2024). Paleoclimatic analysis of quaternary sediments associated with the floodplain deposits of a tropical estuary along the southwestern coast of India. Studia Quaternaria, Vol. 41 (1), pp. 13-21. https://doi.org/10.24425/sq.2023.148038

4. **Nandakumar, V., Shivapriya, S., Thankan, S.** (2023). Utility of fluid inclusion paleo-temperature in petroleum system modelling: A case study from western offshore, India. Energy Geoscience, Vol. 5 (2), Art. 100256. https://doi.org/10.1016/j.engeos.2023.100256

5. Nizam, T., **Krishnan, K. A.,** Joseph, A., Krishnan, R. R. (2024). Isotherm, kinetic and thermodynamic modelling of liquid phase adsorption of the heavy metal ions Zn(II), Pb(II) and Cr(VI) onto $MgFe_2O_4$ nanoparticles. Groundwater for Sustainable Development, Vol. 25, Art. 101120. https://doi.org/10.1016/j.gsd.2024.101120

6. Prabhakar, V. N., Rai, S., Jain, V., **Ray, J. S.**, Bhushan, R. (2023). Evidence for the presence of prehistoric hunter-gatherer communities on Khadir Island, Great Rann of Kachchh, Gujarat. Man and Environment, Vol. 48 (1), pp. 5-14.

7. **Prasad, M., Dubey, C. P.** (2023). Crustal and lithospheric variations along the western passive continental margin of the Indian peninsula. Global Journal of Earth Science and Engineering, Vol. 10, pp. 01-13. https://doi.org/10.15377/2409-5710.2023.10.1

8. **Raj, V. T., Gayathri, J. A., Sharma, R. K.,** Redkar, B. L., **Sreelash, K., Padmalal, D.,** Sajan, K. (2023). Tracing the sources of river waters using stable isotopes ($\delta^{18}O$ and $\delta^{2}H$) in two mountainous watersheds, southern Western Ghats, India. Journal of Geosciences Research, Vol. 8 (2), pp. 89-99.

9. **Reghunadh, K., Antony, S., Arun, V., Krishnakumar, A., Abhirami, J. S., Shehna, S., Shaziya, S., Maya, T. M. V., Krishnan, K. A.** (2023). Impact of stone quarries on groundwater quality at Achenkovil river basin, southern Western Ghats, India: Investigation using WQI and GIS. Environmental Quality Management, Vol. 33 (2), pp. 325-341. https://doi.org/10.1002/tqem.22079

10. Shaginimol, C. N., Manojkumar, B., **Kaliraj, S.** (2023). Application of remote sensing and GIS in site selection for sustainable aquaculture in India - A review. Pollution Research, Vol. 42 (2), pp. 223-237. http://doi.org/10.53550/PR.2023.v42i02.009

11. **Sudhakaran, S.,** Mahadevan, H., Fathima, S. L., **Krishnan, K. A.** (2023). Performance of novel pillared eggshell-bentonite clay bio-composite for enhanced phosphate adsorption from aqueous media. Groundwater for Sustainable Development, Vol. 22, Art. 100960. https://doi.org/10.1016/j.gsd.2023.100960

4.1.3 Papers in Edited Volumes / Monographs

1. Adhikari, K., Lalitha, M., Dharumarajan, S., **Kaliraj, S.,** Chakraborty, R., Kumar, N. (2024). Introduction to soils: soil formation, composition, and its spatial distribution - Remote Sensing of Soils: Mapping, Monitoring, and Measurement, Elsevier Ltd., Dharumarajan, S., Kaliraj, S., Adhikari, K., Lalitha, M., Kumar, N. (Eds). ISBN: 978-0-44-318773-5, Chapter 1, pp. 3-11. https://doi.org/10.1016/B978-0-443-18773-5.00015-6

2. Chandramohan, K., Elayapillai, P., Vijayalakshmi, G., **Kaliraj, S.** (2024). Evaluating the relation of NDVI, NDWI, SMI, and LAI to land and soil degradation processes — a case study of Virudhunagar district, Tamil Nadu, India - Remote Sensing of Soils: Mapping, Monitoring, and Measurement, Elsevier Ltd., Dharumarajan, S., Kaliraj, S., Adhikari, K., Lalitha, M., Kumar, N. (Eds). ISBN: 978-0-44-318773-5, Chapter 43, pp. 689-697. https://doi.org/10.1016/B978-0-443-18773-5.00040-5

3. Dharumarajan, S., Lalitha, M., Kalaiselvi, B., **Kaliraj, S.,** Adhikari, K., Vasundhara, R., Niranjana, K. V., Hegde, R., Pradeep, C. M., Hittanagi, P., Ramamurthy, V. (2024). Remote sensing of soils: spectral signatures and spectral indices - Remote Sensing of Soils: Mapping, Monitoring, and Measurement, Elsevier Ltd., Dharumarajan, S., Kaliraj, S., Adhikari, K., Lalitha, M., Kumar, N. (Eds). ISBN: 978-0-44-318773-5, Chapter 2, pp. 13-23. https://doi.org/10.1016/B978-0-443-18773-5.00033-8

4. **Kaliraj, S.,** Adhikari, K., Dharumarajan, S., Lalitha, M., Kumar, N. (2024). Remote sensing and geographic information system applications in mapping and assessment of soil resources - Remote Sensing of Soils: Mapping, Monitoring, and Measurement, Elsevier Ltd., Dharumarajan, S., Kaliraj, S., Adhikari, K., Lalitha, M., Kumar, N. (Eds). ISBN: 978-0-44-318773-5, Chapter 3, pp. 25-41. https://doi.org/10.1016/B978-0-443-18773-5.00014-4

5. **Kaliraj, S.,** Bhagyashree, S., Mahanta, B., Lalitha, M., Chandrasekar, N., (2024). Mapping of slope failure hazard zonation subject to soil characteristics: a case study of the Chaliyar River Basin, the Western Ghats, South India - Remote Sensing of Soils: Mapping, Monitoring, and Measurement, Elsevier Ltd., Dharumarajan, S., Kaliraj, S., Adhikari, K., Lalitha, M., Kumar, N. (Eds). ISBN: 978-0-44-318773-5, Chapter 39, pp. 625-644. https://doi.org/10.1016/B978-0-443-18773-5.00043-0

6. **Kaliraj, S.,** Chandrasekar, N., Parmar, M., Rejith, R. G., Dharumarajan, S., Lalitha, M., Chandramohan, K. (2024). Assessment of land degradation vulnerability in the semi-arid region of Southern India using GIS-based MEDALUS approach - Remote Sensing of Soils: Mapping, Monitoring, and Measurement, Elsevier Ltd., Dharumarajan, S., Kaliraj, S., Adhikari, K., Lalitha, M., Kumar, N. (Eds). ISBN: 978-0-44-318773-5, Chapter 37, pp. 591-608. https://doi.org/10.1016/B978-0-443-18773-5.00038-7

7. **Kaliraj, S., Srinivas, R.,** Kiruthika, N., Vairaveni, E., Mohamed, H., Palanivel, K., Lakshumanan, C., Chandrasekar, N. (2024). Remote sensing indices-based soil properties measurement – a case study of the Thamirabarani River Basin, South India - Remote Sensing of Soils: Mapping, Monitoring, and Measurement, Elsevier Ltd., Dharumarajan, S., Kaliraj, S., Adhikari, K., Lalitha, M., Kumar, N. (Eds). ISBN: 978-0-44-318773-5, Chapter 4, pp. 45-63. https://doi.org/10.1016/B978-0-443-18773-5.00030-2

8. **Krishnakumar, A., Aditya, S. K., Krishnan, K. A., Prijilal, K. G.** (2024). Geochemistry and health status of soils in the agroforestry dominated hrml regions of Idukki, southern Western Ghats, India - Sustainable and Conservation Management of Environmental Resources in India, Apple Academic Press, Chakravarty, S., Vineeta, Bhat, J. A., Kumar, M., Shukla, G. (Eds). ISBN: 978-1-774-91592-9, Chapter 14, pp. xx-xx. https://doi.org/xx

9. Lalitha, M., Dharumarajan, S., Kumar, K. S. A., Srinivasan, R., **Kaliraj, S.,** Senthilvalavan, P., Hegde, R., Singh, S. K. (2024). Mapping of Mesquite (Prosopis juliflora) invasion in salt-affected soils of semiarid tropics: a case study - Remote Sensing of Soils: Mapping, Monitoring, and Measurement, Elsevier Ltd., Dharumarajan, S., Kaliraj, S., Adhikari, K., Lalitha, M., Kumar, N. (Eds). ISBN: 978-0-44-318773-5, Chapter 30, pp. 469-475. https://doi.org/10.1016/B978-0-443-18773-5.00012-0

10. **Nizar, A., Upendra, B., Ciba, M.,** Sreenivasulu, G., **Krishnan, K. A.** (2024). Assessment of soil erosion in a tropical mountainous river of the Western Ghats, Southern India, using GIS-based RUSLE, SDR and AHP techniques - Remote Sensing of Soils: Mapping, Monitoring, and Measurement, Elsevier Ltd., Dharumarajan, S., Kaliraj, S., Adhikari, K., Lalitha, M., Kumar, N. (Eds). ISBN: 978-0-44-318773-5, Chapter 33, pp. 505-523. https://doi.org/10.1016/B978-0-443-18773-5.00027-2

11. Remote Sensing of Soils: Mapping, Monitoring, and Measurement (2024). Elsevier Ltd., Dharumarajan, S., **Kaliraj, S.,** Adhikari, K., Lalitha, M., Kumar, N. (Eds). ISBN: 978-0-44-318773-5, 43 Chapters, 717 pages. https://doi.org/10.1016/C2022-0-00254-3

4.2 Papers presented in Conferences / Seminars / Symposia

1. **Aditya, S. K., Krishnakumar, A.,** Kumar, S., **Krishnan, K. A.** (2024). Stable isotopic variability and quality assessment of Periyar River, southern Western Ghats, India. International Conference on Future of Water Resources (ICFWR) organised by Indian Water Resources Society and DWRD&M, IIT Roorkee during 18-20 January 2024.

2. **Aswini, A. R., Resmi, E. A., Sumesh, R. K.** (2024). Characterisation of boundary layer height over a high-altitude site in western ghats using a ceilometer and microwave radiometer. 36th Kerala Science Congress held at Kasaragod during 08-11 February 2024.

3. Bhowmik, S. K., Pradhan, B., Lukose, L., **Sorcar, N.,** Chakraborty, S. (2023). Evidence for extremely rapid (sub-Myr timescales) UHT Metamorphic sole formation during spontaneous subduction initiation in Nagaland–Manipur ophiolite belt, Indo-Myanmar ranges. Goldschmidt 2023 Conference held online during 09-14 July 2023.

4. **Das, P., Maya, K., Padmalal, D.,** Laskar, A. H., Sudheer, A. K., Kumar, S. (2023). Evolution of thermal springs in the west coast geothermal province, India: Evidence from hydrogeochemical and stable isotope studies. Goldschmidt 2023 Conference held online during 09-14 July 2023.

5. Deepchand, V., Rajesh, V. J., **Dev, J. A., Sorcar, N., Tomson, J. K.,** Kumar, R. B. (2023). Origin and tectonothermal evolution of lodestones in the layered ultramafic intrusions of Coorg Block: Insights from textural, chemical, and geothermometric constraints. International Association for Gondwana Research (IAGR) Convention and 20th International Conference on Gondwana to Asia held online during 07-12 October 2023.

6. **Dev, J.A., Tomson, J. K.** (2023). LA-ICPMS zircon-monazite- titanite-rutile-apatite chronology: A robust tool to understand t-T evolution of long-lived orogens. North American Workshop on Laser Ablation held at University of Notre Dame during 05-09 June 2023.

7. **Gupta, H., Krishnakumar, A., Krishnan, K. A.** (2023). Estimation of pollution indices from the surface sediments of Kabini interstate-river, south Western Ghats, India. International Conference on Environmental Pollution and Health: Governance for Sustainable Future (ICEGSF- 2023) held at University of Kerala, Trivandrum during 22-24 November 2023.

8. **Gupta, H., Krishnakumar, A., Krishnan, K. A.** (2024). Water quality and sediment contamination assessment of Kabini river, southeastern Western Ghats, India using statistical approach. International Conference on Waste Recycling and Environmental Technology (WRET-2024) held at Babasaheb Bhimrao Ambedkar University, Lucknow during 08-09 February 2024.

9. **Haridas, N. V., Banerji, U. S., Padmalal, D., Maya, K.,** Kurian, J., Bhushan, R. (2024). Late quaternary paleoclimatic variability in a sediment core from Bay of Bengal: A multiproxy study. 36th Kerala Science Congress held at Kasaragod during 08-11 February 2024.

10. **Jose, J., Krishnakumar, A., Krishnan, K. A.** (2023). Evaluation of groundwater quality using water quality index within the buffer zone of Ashtamudi Ramsar wetland system, Kollam, Kerala. International Conference on Environmental Pollution and Health: Governance for Sustainable Future (ICEGSF- 2023) held at University of Kerala, Trivandrum during 22-24 November 2023.

11. **Joshi, K. B., Sorcar, N.,** Halla, J., Singh, R., Ahmad, T. (2023). Petrography, mineral chemistry and whole rock geochemistry of MMEs and associated granitoids from Bundelkhand craton, Central India. Goldschmidt 2023 Conference held online during 09-14 July 2023.

12. **Kaliraj, S., Krishnan, K. A.,** Kiruthika, K., Vairaveni, K., Chandrasekar, N. (2023). Remote sensing indices-based measurement of soil properties using Landsat 9 - OLI data. GeoVista 2023 National Seminar held at Central University of Tamil Nadu during 06-07 July 2023.

13. Karmakar, S., Bose, S., Ghosh, G., **Sorcar, N., Mukherjee, S.** (2023). Evidence of high-pressure metamorphism along the Mahanadi Shear Zone in the Eastern Ghats Province, eastern India: implications on tectonics and continental assembly involving India and East Antarctica. EGU General Assembly 2023 held online during 23–28 April 2023.

14. **Krishnakumar, A., Aditya, S. K., Krishnan, K. A.** (2024). Impact of 2018 climate change in ground water quality: Assessment of environmental pollution and health in Periyar basin, southern Western Ghats, India. International Conference on Climate Change and Natural Resource Management for Sustainable Development (ICNS-2024) held at Mizoram University during 13-15 March 2024.

15. **Kumar, S., Resmi, E. A., Jash, D., Unnikrishnan, C. K., Sumesh, R. K.** (2023). The investigation of hydrometeors structure and thermodynamic feature in mixed phase cloud system over the Western Ghats. National Symposium on Tropical Meteorology (TROPMET 2023) held at Jaipur during 22-24 November 2023.

16. **Kumar, T. S., Kotluri, S. K., Nandakumar, V.** (2023). Geomorphological and geotechnical characteristics of 2021 landslides and flood in Kerala. 60th Annual Convention of IGU on Advances in Geosciences with special reference to coastal hazards held at Cochin University of Science and Technology during 22-24 November 2023.

17. **Kumar, T. S.,** Sreekumar, S., **Nandakumar, V.,** Arpitha, G. A. (2024). Crafting a resilient future – A blueprint for disaster management and mitigation - A case study from local communities of Western Ghat hills of India. National Conference on Geosciences for Sustainable World 2024 held at Banaras Hindu University during 06-07 March 2024.

18. Kumari, P., **Sharma, R. K., Sreelash, K.** (2023). Integrating machine learning and multi-sensor data for accurate soil moisture prediction: A case study from the mountainous catchment in southern Western Ghats. AGU 2023 meeting held online during 11-15 December 2023.

19. **Lal, A., Arun, V., Maya, T. M. V., Rajalekshmi, R.,** Akshaya, N., Sherieff, S., Rijulal, G., **Krishnakumar, A., Krishnan, K. A.** (2023). Hydrogeochemical characteristics of Cochin estuary around Willington Island, Kerala, India. International Conference on Environmental Pollution and Health (ICEGSF-2023) held at University of Kerala, Trivandrum during 22-24 November 2023.

20. **Mathai, J., Sreelash, K., Nidhin, K, Behera, A. K., Upendra, B., Srinivas, S.** (2024). Bridging models and reality: An approach to quantify submarine groundwater discharge flux through field surveys and numerical modelling. 36th Kerala Science Congress held at Kasaragod during 08-11 February 2024.

21. **Maya, T. M. V., Lal, A., Rajalekshmi, R.,** Jaya, D. S., **Krishnakumar, A., Krishnan, K. A.** (2023). Recent environmental changes in the quality of water and soil strata of Tungabhadra river basin, India. International Conference on Environmental Pollution and Health (ICEGSF-2023) held at University of Kerala, Trivandrum during 22-24 November 2023.

22. **Maya, T. M. V., Lal, A., Rajalekshmi, R.,** Jaya, D. S., Rijulal, G., **Krishnakumar, A., Krishnan, K. A.** (2024). Recent environmental changes in the quality of water and soil strata of Bhadra river basin, Karnataka, India. International Conference on Climate Change and Natural Resources Management for Sustainable Development (ICNS-2024) held at Mizoram University during 12-15 March 2024.

23. **Maya, T. M. V., Lal, A.,** Rijulal, G., **Rajalekshmi, R.,** Jaya, D. S., **Krishnakumar, A., Krishnan, K. A.** (2024). Integrated monitoring and mitigation approach in managing phosphate enriched water resources in Tungabhadra River Basin, India. International Conference on Climate Change and Natural Resources Management for Sustainable Development (ICNS-2024) held at Mizoram University during 12-15 March 2024.

24. **Mohan, U., Krishnakumar, A.** (2023). Environmental study of surface water systems of the coastal zones of Kallada river with reference to irrigation water quality assessment. International Conference on Environmental Pollution and Health: Governance for Sustainable Future (ICEGSF- 2023) held at University of Kerala, Trivandrum during 22-24 November 2023.

25. Nair, V. M., Sarbadhikari, A. B., Srivastava, Y., **Sorcar, N., Mukherjee, S.** (2024). Unveiling martian magmatic processes: geochemical perspectives on poikilitic shergottites. International Conference on Planets, Exoplanets and Habitability held at Physical Research Laboratory, Ahmedabad, during 05-09 February 2024.

26. **Prajith, A., Srinivas, R., Sreeraj, M. K., George, B. G., Ray, J. S.** (2023). Remnants of Reunion-Deccan hotspot volcanism in Alleppey Terrace, Kerala offshore, India. Eighth National Conference of Ocean Society of India (OSICON-23) held at INCOIS, Hyderabad during 23-25 August 2023.

27. Prakash, N., Sherieff, S., **Lal, A., Rajalekshmi, R., Maya, T. M. V., Krishnakumar, A., Krishnan, K. A.** (2023). Limnological studies to assess the water quality of ponds in Pothencode panchayath, Thiruvananthapuram, Kerala. International Conference on Environmental Pollution and Health (ICEGSF-2023) held at University of Kerala, Trivandrum during 22-24 November 2023.

28. **Raj, R. S., Krishnan, K. A.** (2023). Batch adsorption studies incorporating response surface methodology for the elimination of acephate. 7th International Electronic Conference on Water Sciences held during 15–30 March 2023.

29. **Raj, R. S., Krishnan, K. A.** (2023). Spatial distribution and hydrogeochemical facies of the emerging contaminant acephate and fenvalerate in the cardamom plantations spread out in the highlands of Idukki district, Kerala, India. International Conference on Environmental Pollution and Health (ICEGSF-2023) held at University of Kerala, Trivandrum during 22-24 November 2023.

30. **Rajalekshmi, R, Antony, S., Maya, T. M. V., Lal, A.,** Rijulal, G., **Krishnakumar, A., Krishnan, K. A.** (2023). Revealing the hidden spring water resources in Idukki district, Kerala, India and their assessment through water quality index. International Conference on Environmental Pollution and Health (ICEGSF-2023) held at University of Kerala, Trivandrum during 22-24 November 2023.

31. **Rao, B. P., Jha, K., Kumar, T. S.** (2023). Broadband seismological observatory – Analysis of noise characteristics and crustal structure beneath the Larsemann Hills, Antarctica. National Conference for Polar Sciences (NCPS) held at NCPOR, Goa during 16-19 May 2023.

32. **Rao, B. P., Sribin, C., Jha, K.,** Kumar, M. R. (2023). Evolution of the Western Ghats: Constraints from receiver function imaging, harmonic decomposition and core-refracted shear wave splitting analysis. National Workshop on Geodynamic Evolution of South India - Eastern Ghats - Antarctica: Current Perspectives and Future Prospects held at NCESS, Thiruvananthapuram during 11-12 September 2023.

33. **Resmi, E. A.,** Preethi, B., Ajayamohan, R. S., Ray, P., **Unnikrishnan, C. K., Nita, S., Sumesh, R. K., Jash, D.** (2024). Response of monsoon low-level jet during wet and dry rainfall episodes over southern tip of India. 36th Kerala Science Congress held at Kasaragod during 08-11 February 2024.

34. **Resmi, E. A., Sumesh, R. K.,** Manoj, M. G., **Unnikrishnan, C. K.** (2023). Microphysical transition features of intermittent pre-monsoon rainfall to monsoon onset over southern peninsular India. National Symposium on Tropical Meteorology (TROPMET 2023) held at Jaipur during 22-24 November 2023.

35. **Roy, A. and Rao, B. P.** (2023). Gravity inversion with seismic constraints to map the crustal thickness beneath Antarctica. National Conference for Polar Sciences (NCPS) held at NCPOR, Goa during 16-19 May 2023.

36. **Roy, A., Sharma, R. K., Jash, D.** (2023). A novel approach for unveiling Moho architecture from observed gravity anomalies by utilising conditional generative adversarial networks. AGU 2023 meeting held online during 11-15 December 2023.

37. Sayeed, M. A., **Sharma, R. K.** (2024). Understanding the impact of land use and land cover change on groundwater level dynamics: a geospatial analysis. Roorkee Water Conclave 2024 held at IIT Roorkee during 03-06 March 2024.

38. Sherieff, S., **Lal, A., Rajalekshmi, R.,** Prakash, N., Akshaya, N., Rijulal, G**., Krishnakumar, A., Krishnan, K. A.** (2023). Appraisal of drinking water potential of various ponds in Vembayam panchayat Thiruvananthapuram, Kerala. International Conference on Environmental Pollution and Health (ICEGSF-2023) held at University of Kerala, Trivandrum during 22-24 November 2023.

39. Singha, A., Tiwari, A. K., Sarkar, T., **Sorcar, N., Mukherjee, S.** (2023). Petrological characterisation of the Cryogenian lower crust of southern India: Evidence from charnockites and metapelites from the northern part of Madurai Block. EGU General Assembly 2023 held online during 23–28 April 2023.

40. **Smitha, P. S., Maya, K.,** Sudheer, K. P., **Sreelash, K., Padmalal, D.** (2024). An improved technique to increase the bare soil mapping accuracy in wetlands and urban areas. 36th Kerala Science Congress held at Kasaragod during 08-11 February 2024.

41. **Sorcar, N., Joshi, K. B.** (2023). Tectonothermal evolution of Chilka Granulite Complex, Eastern Ghats Belt, India: Constrained from U-Pb/Hf isotopic studies. Goldschmidt 2023 Conference held online during 09-14 July 2023.

42. **Sreelesh, R., Dutta, M. K., Sreelash, K., Maya, K.** (2024). Spatial and temporal hydro-geochemistry in the Munnar CZO, southern Western Ghats, India: Exploring chemostatic behaviour across water sources. 36th Kerala Science Congress held at Kasaragod during 08-11 February 2024.

43. **Sumesh, R. K., Resmi, E. A., Unnikrishnan, C. K.** (2023). Variability in orographic precipitation over southwest coast of peninsular India in response to synoptic circulations during Indian summer monsoon. National Symposium on Tropical Meteorology (TROPMET 2023) held at Jaipur during 22-24 November 2023.

44. Tiwari, A. K., Sarkar, T., **Sorcar, N., Mukherjee, S.** (2023). Petrochronological appraisal on the timing and duration of ultrahigh-temperature metamorphism in southern India: Insights from charnockite and sapphirine bearing semipelitic granulites from the Madurai Block. EGU General Assembly 2023 held online during 23–28 April 2023.

45. **Unnikrishnan, C. K., Malavika, G. R., Mobin Raj, V. C.,** Gopalakrishnan, V., Pawar, S., **Andrews, A.** (2023) A study on deep neural networks model for lightning forecasting in the tropical South Asian region. AGU 2023 meeting held online during 11-15 December 2023.

46. **Unnikrishnan, C. K.,** Santhana, Rajeevan, M. (2023), Changes in north east monsoon over South Asia. 104th AMS Annual Meeting and 37th Conference on Climate Variability and Change held during 28-31 January 2024.

47. **Upendra, B., Ciba, M., Vidya, S., Arun, V., Krishnan, K. A.** (2024). Silicate weathering and associated CO_2 consumption rates of Vamanapuram River draining Southern Granulite Terrain, India. Conference on Advances in Environmental Sustainability, Energy and Earth Science (AESEE – 2024) held at SRM University during 13-17 March 2024.

5. External and Consultancy Projects

NCESS carried out several external grant-in-aid and consultancy projects in 2023-2024. The central and state government agencies sponsored the externally funded projects. The consultancy projects were mainly to demarcate HTL and LTL for the Coastal Regulation Zone.

Coastal Zone Management

The coastal policy of the Government of India and the coastal states is to develop the country's coastal regions within the framework. It will ensure the utilization of coastal resources to their optimum potential and sustain the functional integrity of coastal ecosystems. This approach will also help to contain, to a certain extent, the impact of coastal hazards on coastal communities and properties. Regulating high-impact activities in the coastal zone through CRZ is one of the most effective tools for this endeavour.

As part of preparing the Coastal Zone Management Plan (CZMP) of Kerala as per the 2019 Regulation, extensive ground truth was collected in all the ten districts of Kerala where CRZ is applicable, and modifications were made to the maps prepared on the GIS platform. The entire state's HTL and LTL geodatabase was sent to the National Centre for Sustainable Coastal Management (NCSCM) for its validation as per the direction of the Ministry of Environment, Forest and Climate Change, Government of India.

Around 15 consultancy projects were completed during the period, and 10 were in progress.

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

Sl. No.	Project Title	Funding Agency	Total Outlay (Rs. in lakh)
1	DST Inspire Faculty Award - Innovation in science pursuit for inspired research - Dr. Tripti Muguli	Department of Science and Technology, GoI	35.00
2	DST Inspire Faculty Award - Innovation in science pursuit for inspired research - Dr. Vrinda Mukundan	Department of Science and Technology, GoI	22.00
3	"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	14.17
4	Sediment budgeting and studies on waves in the VISL project site and adjoining area	Vizhinjam International Seaport Limited	98.44
5	Identification and monitoring of rip currents at Rushikonda blue-flag certified beach, Visakhapatnam SAMUDRA - TDP project at SAC	Space Applications Centre, ISRO, GoI	17.99
6	Science Research Scheme – Project entitled "Estimation of soil water fluxes in the high-altitude mountainous watersheds in Kerala using in-situ observation and modelling."	Kerala State Council for Science, Technology & Environment	14.38

7	Women Scientist Scheme-A - Project entitled "Hydrogeochemical vis-à-vis GHG emission studies in Karuvannur river basin, southern Western Ghats, India with special reference to environmental pollution and climate change" - Ms. Siji Sadasivan	Department of Science and Technology, GoI	18.80
8	A study on the impacts of soil moisture and land use land cover (LULC changes on the recent heat waves in India under the SERB International Research Experience (SIRE) Program	Department of Science and Technology, GoI	17.78
9	Preparation of Coastal Zone Management Plan (CZMP) with respect to the CRZ Notification 2019 for the state of Goa	Department of Environment of Climate Change	85.84
10	Paleo-vegetation changes and burial efficiency of organic carbon in different depositional conditions in Bay of Bengal and Andaman Sea during Late Quaternary and their environmental implications	Department of Science and Technology, GoI	20.55
11	To investigate the role of rock physical & mechanical properties, permeability, pore fluid pressure & frictional resistance on physics of earthquake processes from advanced laboratory experimentation	Department of Science and Technology, GoI	16.83
12	Chief Minister's Nava Kerala Post-Doctoral Fellowship (CMNPF 2023) - Dr. A. R. Aswini	Kerala State Higher Education Council	8.00

Table 5.2: List of completed CRZ consultancy projects

Sl. No.	Report No.	File No.	Project Name
1	NCESS/CRZ/05/2023	CRZ/29/2022	KITCO-GIDA (Proposed development of stadium in 290.57 Are at Thalassery Village, Kannur)
2	NCESS/CRZ/06/2023	CRZ/16/2022	Chief Engineer, Harbour Engineering Department, Thiruvananthapuram (Construction of fishing harbour at Pozhiyoor in Kulathur Panchayath, Thiruvananthapuram)
3	NCESS/CRZ/07/2023	CRZ/23/2021	Harbour Engineering Subdivision, Muthalappozhy (Development of Perumathura Beach, Thiruvananthapuram)
4	NCESS/CRZ/08/2023	CRZ/15/2022	Directorate of Ports and Inland Water Transport, Odisha (Construction of ro-pax jetty and allied infrastructure at Balugauan in Khurda and Krushaprasadgada in Puri Districts)
5	NCESS/CRZ/09/2023	CRZ/32/2022	Adani Airport Holdings Limited, Thiruvananthapuram (City side development of Thiruvananthapuram International Airport)

6	NCESS/CRZ/10/2023	CRZ/34/2022	Mr. Kashyap through KITCO (Dredging of sand from Azhikal Port, Kannur)
7	NCESS/CRZ/11/2023	CRZ/31/2022	City Management Unit, Amruth - Kochi Corporation, Ernakulam (Construction of decentralized sewerage system in Edakochi)
8	NCESS/CRZ/12/2023	CRZ/04/2023	CMC Boys School, Elathur, Kozhikode (Construction of school buildings at Elathur Village, Kozhikode)
9	NCESS/CRZ/13/2023	CRZ/25/2022	Executive Engineer, Kerala Road Fund Board (Construction of Chendamangalam - Mattupuram Bridge, Ernakulam)
10	NCESS/CRZ/14/2023	CRZ/30/2022	Secretary, Tanur Municipality (Construction of material recovery facility centre, Malappuram)
11	NCESS/CRZ/15/2023	CRZ/21/2022	Adani Ports and Special Economic Zone, Gujarat (Construction of desalination plants and associated intake & outfall facilities as part of the development of industrial park / SEZ at Mundra, Gujarat)
12	NCESS/CRZ/16/2023	CRZ/05/2022	Executive Engineer, Kerala Road Fund Board (Construction of Perumbalam - Panavally Bridge, Alappuzha)
13	NCESS/CRZ/17/2023	CRZ/12/2023	Ms. Shamla T. / Shabna T., Velliparamba, Kuttikattoor, Kozhikode (Construction of auditorium cum commercial building in Elathur Village, Kozhikode)
14	NCESS/CRZ/01/2024	CRZ/16/2023	Mr. Nitin Kumar Jayantilal Parekh, Moonalingal, Kozhikode (Construction of a building in Nagaram Village, Kozhikode)
15	NCESS/CRZ/02/2024	CRZ/11/2022	Executive Engineer, Kerala Road Fund Board (Construction of Nedumbrakkadu - Vilakkumaram Bridge across Vayalar Kayal, Alappuzha)

Table 5.3: List of ongoing CRZ consultancy projects

Sl. No.	Project Title	Funding Agency	Fund received (Rs. in lakh)
1	Delineation of HTL/ LTL and preparation of CRZ status report	Secretary, Kumbala Grama Panchayath, Kasaragod (Construction of school building at Koipady Kadapuram, Kumbala, Kasaragod)	3.71
2	-do-	Kodath Resorts Pvt. Ltd., Chavakkad, Thrissur (Construction of Ayurveda Resort at Chavakkad, Thrissur)	3.71
3	-do-	Secretary, Chavakkad Municipality, Thrissur (Construction of the municipal office building at Chavakkad, Thrissur)	3.59
4	-do-	Mr. Subair Kunheente Purakkal, Tanur, Malappuram (Construction of auditorium building at Tirur Taluk, Tanur, Malappuram)	3.71
5	-do-	Mr. T. Sidharth Murali, Vyttila, Ernakulam (Construction of residential building in Kochi Corporation, Ernakulam)	3.71
6	-do-	Mr. Arshad N., Kinassery, Pokkunnu, Kozhikode (Construction of commercial building at Valayanad Village, Kozhikode)	3.71
7	-do-	Mr. Suresh P. Rajan and Bloomy Suresh, Kaloor, Ernakulam (Construction of the residential building in Maradu Municipality, Ernakulam)	3.71
8	-do-	Executive Engineer, Kerala Road Fund Board (Construction of Chinganattukadavu Bridge across Chavakkad Canoli Canal in Guruvayur LAC, Thrissur)	3.40
9	-do-	Mr. Muhammed Neerthunichalil, Thrikaripur, Kasaragod (Construction of shop building at Nileshwar Village, Hosdurg, Kasaragod)	3.71
10	-do-	Secretary, Kaipamangalam Grama Panchayath, Thrissur (Construction of Vismaya Theeram Park, Kaipamangalam, Thrissur)	3.71

6. New Facilities

During the financial year, NCESS procured many sophisticated analytical facilities to carry out front-line research in earth science studies. 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.	Isotope Ratio Mass Spectrometer (IRMS)	Elementar Isoprime Precision	For the measurement of stable isotopes (δD, $\delta^{18}O$, and $\delta^{13}C$) in water, ($\delta^{13}C$ and $\delta^{18}O$) in carbonate shells, and ($\delta^{13}C$, $\delta^{15}N$, and $\delta^{34}S$) in sediments.	
2.	Eddy Covariance Systems	Campbell Scientific / IRGASON	The Eddy Covariance Systems measure vertical turbulent fluxes within atmospheric boundary layers. The method analyses high-frequency wind and scalar atmospheric data series, gas, energy, and momentum, which yields values of fluxes of these properties. It estimates momentum, heat, water vapour and carbon dioxide flux. NCESS has established Eddy Covariance systems in Attappadi, Munnar and Aduthurai Critical Zone Observatories.	

3.	COSMOS Soil Moisture Stations	Hydroinnova / CRS2000 / B	The COSMOS Soil Moisture Stations use the cosmic-ray method to non-invasively monitor water content in the top 50 cm of soil. With the cosmic-ray method, one obtains a spatial average over a lateral radius of approximately 300 m, providing an unprecedented observation scale. The system measures naturally occurring cosmic-ray neutrons, which are used as a proxy for soil water content.	
4.	Water Purification System - MilliQ	Merck MilliQ	Provide Type-1 (ultrapure) and Type-2 water for laboratory standard preparations and other analytical purposes.	
5.	PM10 and PM2.5 aerosol samplers at HACPO, Rajamallay, Munnar.	Envirotech Respirable Dust Sampler APM 460 and APM 550EL	Aerosol field samplers collect ambient particulate matter less than 10 µm and less than 2.5 µm in diameter on filter substrates.	

7. Conference, Seminar & Workshop

7.1 National Workshop on Geodynamic Evolution

NCESS organised a two-day National Workshop on 'Geodynamic Evolution of South India - Eastern Ghats - Antarctica: Current perspectives and future prospects' during 11-12 September 2023. Prof. Somnath Dasgupta, INSA Senior Scientist, ISI Kolkata, gave the keynote address on the topic 'Geodynamic evolution of the Indian Proterozoic mobile belts: Development of the greater Indian landmass & supercontinent cycle'. The workshop extended six sessions with about 19 paper presentations and concluded with a panel discussion.

7.2 Training Program on 'Eddy Covariance Systems'

The Hydrology Group of NCESS organised a technical talk and one-day training program on 'An introduction of eddy covariance technique from theories to instruments and to data processing' on 23 November 2023 at Neyyar Hall. The training was provided by Dr. Bai Yang, Campbell Scientific Inc., Logan, Utah, USA.

7.3 NCESS Foundation Day Lecture 2024

The National Centre for Earth Science Studies celebrated its 10th Foundation Day on 01 January 2024. The Foundation Day Lecture was delivered by Prof. (Dr.) Janki Andharia, Chairperson, Centre for Disasters & Development, Jamsetji Tata School of Disaster Studies, Tata Institute of Social Sciences, Mumbai. The title of the talk was "Navigating the Nexus: towards bridging the science-policy-society divide in disaster management". Dr. M. Rajeevan, Vice Chancellor, Atria University, Bengaluru and Former Secretary, MoES, and Dr. M. Baba, Former Director, CESS, were the guests of honour. Dr. V. Nandakumar, Director (i/c), NCESS, presided over the function and honoured the Chief Guest and guests of honour by offering 'Ponnada' and Memento. An open day was organised as part of the programme, and college students visited the laboratories and interacted with NCESS scientists.

7.4 Global Science Festival Kerala (GSFK) 2024

Under the auspice of Global Science Festival Kerala (GSFK) 2024, a lecture titled "Earth's odyssey from habitable to sustainable planet: The nexus of resources, climate, and environment on Earth" was delivered by Prof. M. Santosh, China University of Geosciences, Beijing on 05 January 2024. About 60 delegates, including scientists, researchers, and postgraduate students from other institutes and universities, attended the talk organised by NCESS in collaboration with KSCSTE, Govt of Kerala.

8. Extension Activities

8.1 Self Defence Training Program for Women

A training program on self-defence for women employees and students was organised at NCESS on 02 June 2023 as part of the activities of the NCESS Internal Complaints Committee for Prevention of Harassment of Women at Work Place. The training program was conducted by a group of police officers from the Kerala Police Defence Team and Nirbhaya Volunteers.

8.2 World Environment Day

Prof. Jyotiranjan S. Ray, Director, NCESS, administered the "Mission - Lifestyle for Environment (LiFE)" pledge to the staff on 05 June 2023 as part of the World Environment Day 2023 celebrations. In connection with the programme, the employees planted over 100 tree saplings of different varieties inside the campus to contribute to a greener, healthier and sustainable future.

8.3 International Coastal Clean-up Day

As part of the International Coastal Clean-up Day, NCESS organised coastal clean-up activities at Kovalam beach in Trivandrum and Azheekal beach in Kollam on 16 September 2023. Dr. Reji Srinivas, Scientist D, MGG, coordinated the event at Kovalam Beach and Shri. Ramesh Madipally, Scientist C, MGG, coordinated the event at Kollam Beach.

8.4 Hindi Fortnight

The inaugural function of Hindi Fortnight 2023 was organised on 27 September 2023. Dr. V. Nandakumar, Director (i/c), NCESS, inaugurated the function. Various competitions, viz., essay writing, dictation, quiz, recitation, debate, etc., were conducted as part of the programme. The valedictory function was held on 12 October 2023. Smt. Bindya K. R., Deputy Registrar (Administration), Indian Institute of Space Science and Technology, Thiruvananthapuram, inaugurated the function and distributed the prizes to the winners of the competitions.

8.5 Swachhata Hi Sewa

As part of the Swachhata Hi Sewa 2023 special campaign, office premises were cleaned on 06 October 2023. A gathering was organised to take the Swachhata Pledge. It was followed by distributing cleaning materials/kits to various divisions for cleaning office space/labs and office premises.

8.6 Vigilance Awareness Week

As per the Central Vigilance Commission circular, Vigilance Awareness Week was observed from 30 October to 5 November 2023 with the theme "Say No to Corruption; Commit to the Nation". The staff and students of NCESS took the Integrity Pledge to commence the observation of Vigilance Awareness Week on 30 October 2023. Students from Government Model Girls Higher Secondary School, Pattom, Kendriya Vidyalaya, Pattom, Loyola School, Sreekariyam, MGM School, Akkulam, Kendriya Vidyalaya, Akkulam, St. Mary's Higher Secondary School, Pattom, and The School of Good Shepherd, Akkulam, actively participated in essay writing, elocution and poster competitions

organised as part of the event. The winners of the competitions were awarded cash prizes, and all the participants were presented with certificates and mementoes.

The valedictory function was organised on 02 November 2023. Shri. M. R. Ajithkumar IPS, Additional Director General of Police (Law and Order), was the Chief Guest. The chief guest delivered a talk on vigilance awareness and distributed the prizes to the winners of various competitions.

8.7 Rashtriya Ekta Diwas

NCESS Staff and students took the "Rashtriya Ekta Diwas" Pledge administered by the Director, NCESS, on 31 October 2023 as part of the National Unity Day 2023 celebrations. Subsequently, 'Run for Unity' was organised as part of the event. Students from Alan Feldman Public School, Kazhakuttom, and Govt. Higher Secondary School, Vettor, Varkala, actively participated in quiz and speech competitions organised as part of the event. The winners of the competitions were awarded Cash prizes, and all the participants were presented with Certificates and mementoes.

8.8 National Cyber Security Awareness Month

Dr. Dittin Andrews, Joint Director, Cyber Security Group, CDAC, delivered a talk on 31 October 2023 on "Cyber Security" in the Cyber Security Awareness Program organised as part of the National Cyber Security Awareness Month 2023 observance.

8.9 Sexual Harassment at Workplace Prevention Week

National Centre for Earth Science Studies organised the "Sexual Harassment at Workplace Prevention Week - 2023" and awareness program from 04 - 08 December 2023. As part of the event, an awareness video documentary display was organised on 04 December, followed by a documentary review writing competition. A talk on "The Sexual Harassment of Women at Workplace (Prevention, Prohibition, and Redressal) Act, 2013," was delivered by Dr. Anitha S, Assistant Professor, Department of Personnel Management, Loyola College, Trivandrum, on 07 December 2023, followed by a quiz competition. Posters were displayed on campus to create awareness of preventing sexual harassment in the workplace.

8.10 World Hindi Day

World Hindi Day 2024 was celebrated on 10 January 2024 at NCESS. Dr. D. Bala Subrahamanyam, Scientist SG and Head, NAM Branch, Space Physics Laboratory, VSSC, was the chief guest and delivered a talk on "Laxman Rekha in numerical weather predictions: Face your dilemmas and inhibitions".

8.11 NCESS - MoES Outreach Program

NCESS conducted an outreach program for Science Education, Public Outreach & Awareness from 21-23 February 2024 in Wayanad, Kerala. As part of this program, NCESS organised a workshop on "Earth Science and Geo Hazards" at the Government Higher Secondary School, Padinjarathara, Wayanad on 21 February 2024 and at Government Vocational Higher Secondary School Mananthavady, Wayanad on 23 February 2024. Dr. V. Nandakumar, Scientist G & Group Head CDG, inaugurated the workshops. Senior scientists from NCESS delivered scientific lectures during the event. Additionally, various competitions were conducted for students as part of the program, and science kits were distributed to them.

Scientists of NCESS, committed social workers, and ST Promoter visited the Mathol Tribal Colony in the 20th Ward of Panamaram Grama Panchayat on 22 February 2024. Situated in the river basin of the Panamaram River, a tributary of the Kabani River, the colony faces the constant threat of floods and experiences severe drought and water scarcity in summer. The team led by Dr. V. Nandakumar, Senior Scientist of NCESS, interacted with the residents about various environmental issues faced by the colony. The team also shared their scientific knowledge and expertise, suggested remedial measures, and created awareness of geohazards. Scientific kits were distributed to the students of the colony.

8.12 National Science Day

Prof. J. N. Moorthy, Director, IISER Thiruvananthapuram, delivered a talk on the topic "Science, Technology, Society and Sustainability" at Pamba Hall, NCESS, as part of the National Science Day 2024 celebration at NCESS on 28 February 2024.

8.13 International Women's Day

NCESS celebrated International Women's Day 2024 on 18 March 2024. Dr. Kusala Rajendran, Prof. of Seismology (Retd.), Centre of Earth Sciences, IISc Bengaluru, was the Guest of Honour and delivered a talk on the topic 'On being a geophysicist'. Dr. M. Rajeevan, Vice Chancellor of Atria University & Former Secretary of MoES, was the Chief Guest. The flyer of the book 'The Rumbling Earth' written by Dr. C. P. Rajendran and Dr. Kusala Rajendran was released during the event by the Chief Guest. As part of the celebrations, competitions like essay writing, pencil drawing, group song and quiz were organised, and the winners were given cash awards.

8.14 World Water Day

Dr. E. Shaji, Professor & Head of Department, Department of Geology, University of Kerala, delivered the World Water Day 2024 lecture on 22 March 2024 at Pamba Hall, NCESS. The topic of the lecture was "Groundwater Resources of Kerala: The Sustainability Challenges".

8.15 Distinguished Lectures by Eminent Researchers

As part of the Distinguished Lectures by eminent researchers in various disciplines, the Earth Science Forum (ESF) of NCESS organised three lectures in 2023-24.

1. Dr. Akeek Maitra, Postdoctoral Fellow, Geochronology and Isotope Geochemistry Laboratory, Institute of Geological Sciences, Polish Academy of Sciences, delivered a talk on "Evolution of the Subathu Foreland basin of Himachal Pradesh, India: Implications for Himalayan Orogeny from detrital records with geo-thermochronological constraints" on 19 April 2023.

2. Dr. K. Subrahmaniyan, Director, Tamil Nadu Rice Research Institute (TRRI), Aduthurai, delivered a talk on "Integrated farming system approaches for adapting climate change" on 20 September 2023.

3. Prof. C. Shaji, Associate Professor, Centre for Oceans, Rivers, Atmosphere and Land Sciences (CORAL), Indian Institute of Technology, Kharagpur, delivered a talk on "Various physical forcing of Chl-a bloom in the Bay of Bengal" on 27 December 2023.

8.16 Earth Science Forum

The Earth Science Forum (ESF) of NCESS organised seven lectures during 2023-24 on different themes of Earth Sciences by scientists and researchers from NCESS.

1. Ms. P. S. Swathy Krishna, Research Scholar, Marine Geoscience Group, presented her work on "Coastal flooding and related processes along the SW coast of India" on 03 April 2023.

2. Shri. Ramesh Madipally, Research Scholar, Marine Geoscience Group, presented his work on

"Study on coastal hydrodynamics along the southwest coast of India through video monitoring techniques" on 05 April 2023.

3. Ms. S. Sajna, Research Scholar, Solid Earth Research Group, presented her work on "Spatial and temporal evolution of granulites from Nagercoil Block, southern India: Constraints from geochemistry and geochronology" on 18 April 2023.

4. Dr. Tripti Muguli, DST-INSPIRE Faculty, Marine Geoscience Group, presented her work on "Isotopic fingerprinting of Indian monsoon systematics, tropical ecohydrology and climate dynamics in the Western Ghats and west coast of India" on 12 July 2023.

5. Dr. Aswini A. R., Postdoctoral Research Fellow, Atmospheric Science Group, presented her work on "Characteristics of atmospheric aerosol composition over the Indian region: Role of carbonaceous components and climatic implications" on 09 August 2023.

6. Shri. Vipin T. Raj, DST-INSPIRE Fellow, Hydrology Group, presented his work on "Hydrogeochemistry and water suitability of Bhavani and Thuthapuzha rivers draining contrasting climate gradients in Western Ghats, India" on 15 November 2023.

7. Shri. C. Sribin, Research Scholar, Solid Earth Research Group, presented his work on "Seismological insights on the geodynamic history of the Western Ghats from shallow crustal structure and upper mantle anisotropy" on 22 December 2023.

8.17 Student Visits

1. M.Tech Students (sponsored students and officers working in different state and central govt dept.) from the Department of Civil Engineering, Indian Institute of Science (IISc), Bangalore, visited the hydrological monitoring stations in Vamanapuram Experimental Catchment (VAMEC) during 11-12 November 2023. NCESS Scientists have provided on-site training and demonstrations of the applications of hydrological instrument sensors to the participants of the training programme.

2. Science students from Government Arts College, Coimbatore, Tamil Nadu, visited NCESS on 07 March 2024. A dynamic interaction with scientists working in hydrology, atmospheric, and geosciences enlightened the young minds. The students also visited XRF, Petrology, PSA, EPMA and LA-ICPMS facilities of NCESS.

9. Staff Details

9.1 Director's Office

Dr. Jyotiranjan S. Ray	Director (till 23.09.2023)
Dr. V. Nandakumar	Director (addl. charge) (from 25.09.2023 to 13.02.2024)
Prof. N. V. Chalapathi Rao	Director (from 14.02.2024)
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. Tomson J. Kallukalam	Scientist-E & Head
Dr. Chandra Prakash Dubey	Scientist-D
Dr. B. Padma Rao	Scientist-D
Dr. Nilanjana Sorcar	Scientist-D
Dr. Kumar Batuk Joshi	Scientist-D
Shri. Arka Roy	Scientist-D
Dr. Bivin Geo George	Scientist-B (till 31.05.2023)
Shri. S. S. Salaj	Scientific Asst. Gr. B
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
Shri. Thatikonda Suresh Kumar	Scientist-C
Dr. Kotluri Sravan Kumar	Scientist-B (from 31.07.2023)
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-E
Shri. Rajat Kumar Sharma	Scientist-D
Dr. K. Sreelash	Scientist-D
Shri. Prasenjit Das	Scientist-D

9.5 Biogeochemistry Group

Dr. K. Maya	Scientist-F & Head
Dr. K. Anoop Krishnan	Scientist-E
Shri. Badimela Upendra	Scientist-D
Dr. S. Kaliraj	Scientist-D
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-G & Head
Dr. Reji Srinivas	Scientist-E
Shri. Ramesh Madipally	Scientist-D
Dr. A. Prajith	Scientist-B
Dr. Ajit Kumar Behera	Scientist-B (till 23.11.2023)
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. E. A. Resmi	Scientist-E & Head
Shri. Dharmadas Jash	Scientist-D
Dr. C. K. Unnikrishnan	Scientist-C

Dr. Tejavath Charan Teja	Scientist-B (from 18.09.2023)
Smt. Nita Sukumar	Scientific Asst. Gr. B

9.8 Central Geomatics Laboratory

Dr. Reji Srinivas	Scientist-E & Coordinator
Shri. P. B. Vibin	Scientific Asst. Gr. B
Smt. M. Lincy Sudhakaran	Scientific Asst. Gr. A

9.9 Library

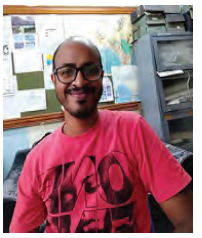
Shri. T. Bavijesh	Scientist-B (Librarian) (from 27.04.2023)
Smt. K. Reshma	Scientific Asst. Gr. B

9.10 Administration

Shri. D. P. Maret	Senior Manager
Shri. A. Saji	Manager
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. S. Anoop	MTS
Smt. P. S. Divya	MTS
Shri. K. Sudheer Kumar	MTS
Shri. M. R. Murukan	MTS

9.11 New Appointments

Shri. T. Bavijesh
Scientist-B (Librarian), Library



Dr. Kotluri Sravan Kumar
Scientist-B, Crustal Dynamics Group

Dr. Tejavath Charan Teja
Scientist-B, Atmospheric Science Group

10. Balance Sheet

NATIONAL CENTRE FOR EARTH SCIENCE STUDIES

(Ministry of Earth Sciences, Government of India)

Akkulam, Trivandrum

Audit for the Period

2023 – 2024

INDEX

GFR 12 - A
[See Rule 238 (1)]
UTILIZATION CERTIFICATE FOR THE PERIOD FROM 01.04.2023 to 31.03.2024
IN RESPECT OF RECURRING/NON-RECURRING GRANTS-IN-AID OPERATION AND MAINTENCE (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. 56,55,132.12
(ii) Unadjusted advances : Rs. (1,11,53,086.70)
(iii) Total : Rs. (54,97,954.58)

4. 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 &Misc Receipts	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)
(54,97,954.58)	1,39,72,324.00	16,34,458.00	#	#	16,00,00,000.00	16,68,39,911.4	15,47,08,067.80	1,21,31,843.62

Sanction Order No: MOES/P.O.(NCESS)/3/2015-Pt. dt 25.05.2023 - Rs. 1,94,00,000.00
Sanction Order No: MOES/P.O.(NCESS)/3/2015-Pt. dt 25.05.2023 – Rs.50,00,000.00
Sanction Order No: MOES/P.O.(NCESS)/3/2015-Pt. dt 07.06.2023 – Rs. 1,00,00,000.00
Sanction Order No: MOES/P.O.(NCESS)/3/2015-Pt. (E-3725) dt 04.07.2023 - Rs. 2,41,00,000.00
Sanction Order No: MOES/P.O.(NCESS)/3/2015-Pt. (E-3725) dt 19.09.2023 - Rs. 2,00,00,000.00
Sanction Order No: MOES/P.O.(NCESS)/3/2015-Pt. dt 19.09.2023 - Rs. 50,00,000.00
Sanction Order No: MOES/P.O.(NCESS)/3/2015-Pt. (E-3725) dt 06.12.2023 - Rs. 2,00,00,000.00
Sanction Order No: MOES/P.O.(NCESS)/3/2015-Pt. (E-3725) dt 30.01.2024 - Rs. 3,00,00,000.00
Sanction Order No: MOES/P.O.(NCESS)/3/2015-Pt. dt 30.01.2024 - Rs. 75,00,000.00
Sanction Order No: MOES/P.O.(NCESS)/3/2015-Pt. (E-3725) dt 21.02.2024 - Rs. 1,65,00,000.00
Sanction Order No: MOES/P.O.(NCESS)/3/2015-Pt. dt 21.02.2024 – Rs.25,00,000.00

GRANTS-IN-AID SALARIES	GRANTS-IN-AID GENERAL	Total
13,15,40,603.00	2,31,67,464.80	15,47,08,067.80

Grants position at the end of the financial year

1. Cash in Hand/ Bank : Rs. 1,88,90,264.34
2. Unadjusted advances : Rs. (67,58,420.72)
1. Total : Rs. 1,21,31,843.62

N.S. SARMA ASSOCIATES * CHARTERED ACCOUNTANTS * TRIVANDRUM PIN-695 023

3

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 (inclUDIN: 24206497BKADXR3196g 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 (Autonomous Bodies) (name of the scheme 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 at Annexure – I duly enclosed.

(viii) The utilization of the fund resulted in outcomes given at Annexure – II duly enclosed (to be formulated by the Ministry/Department concerned as per their requirements/specifications.

(ix) Details of various schemes executed by the agency through grants-in-aid received from the same Ministry or from other Ministries is enclosed at Annexure –II (to be formulated by the Ministry/Department concerned as per their requirements/specifications).

Trivandrum
26-09-2024

For N S Sarma Associates
Chartered Accountants

Saji A	D.P Maret	Prof .N.V.Chalapathi Rao	CA Subramoniya Sarma N
Manager(F&A)	Senior Manager	Director	Partner, M.No:206497
			FRN: 008018S
			UDIN: 24206497BKADXQ8882

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GFR 12 - A
[See Rule 238 (1)]
UTILIZATION CERTIFICATE FOR THE PERIOD FROM 01.04.2023 to 31.03.2024
IN REPECT 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. 2,80,41,205.00
   (ii) Unadjusted advances : Rs. 2,02,92,232.00
   (iii) Total : Rs. 4,83,33,437.00

4. 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)
4,83,33,437.00			#	#	1,00,00,000.00	5,83,33,437.00	53,77,478.00	5,29,55,959.00

Sanction Order No: MOES/P.O.(NCESS)/3/2015-Pt. dated 30.03.2024 – Rs.1,00,00,000/-

Grants position at the end of the financial year
   a. Cash in Hand/ Bank : Rs. 1,45,87,021.00
   b. Unadjusted advances : Rs. 3,83,68,938.00
   c. Total : Rs. 5,29,55,959.00

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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 (inclUDIN: 24206497BKADXR3196g 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 (Autonomous Bodies) (name of the scheme 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 at Annexure – I duly enclosed.

(viii) The utilization of the fund resulted in outcomes given at Annexure – II duly enclosed (to be formulated by the Ministry/Department concerned as per their requirements/specifications.

(ix) Details of various schemes executed by the agency through grants-in-aid received from the same Ministry or from other Ministries is enclosed at Annexure –II (to be formulated by the Ministry/Department concerned as per their requirements/specifications).

Trivandrum
26-09-2024

For N S Sarma Associates
Chartered Accountants

Saji A
Manager(F&A)

D.P Maret
Senior Manager

Prof .N.V.Chalapathi Rao
Director

CA Subramoniya Sarma N
Partner, M.No:206497
FRN: 008018S
UDIN: 24206497BKADXQ8882

6

GFR 12 – A

[(See Rule 238 (1)]

UTILIZATION CERTIFICATE FOR THE PERIOD FROM 01.04.2023 to 31.03.2024 IN REPECT OF RECURRING/NON-RECURRING SEISMOLOGY AND GEODYNAMICS (SAGE)/R&D PROGRAMMES

1. Name of the Scheme: Seismology and Geodynamics (SAGE)
2. Whether recurring or non-recurring grants: Both
3. Grants position at the beginning of the financial year
   - i. Cash in Hand : Rs. 74780146.59
   - ii. Unadjusted Advances : Rs. 32920427.01
   - iii. Total : Rs. 107700573.60

4. Details of grants received, expenditure incurred and closing balances: (Actuals)

Unspent Balances of Grants received years [figure as at Sl. No. 3 (iv)]	Interest Received / Misc Receipt	Interest deposited back to the Governme nt	Grant received during the year			Total Available funds (1+2-3+4)	Expenditure incurred	Closing Balances (5-6)
1	2	3	4			5	6	7
	@	*	Sanctio n No. (i)	Date (ii)	Amount (iii)			
107700573.60	2828787.00	2559788.00	#	#	40855687.41	148825260.01	113752583.93	35072676.08

Sanction Order No: MOES/P.O.(Seismo)/8/(14)-A/2017 dated 04.07.2023 – Rs. 2,66,30,000/-. The remaining amount of Rs. 1,42,25,687.41 has been accounted for as assigned in PFMS.

Non-Recurring	Recurring	Total
60826560.00	52926023.93	113752583.93

Details of grants position at the end of the period

a) Cash in Hand : Rs. 10501347.85
b) Unadjusted Advances : Rs. 24571328.23
c) Total : Rs. 35072676.08

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 (inclUDIN: 24206497BKADXR3196g 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 (Autonomous Bodies) (name of the scheme 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 at Annexure – I duly enclosed.

(viii) The utilization of the fund resulted in outcomes given at Annexure – II duly enclosed (to be formulated by the Ministry/Department concerned as per their requirements/specifications.

(ix) Details of various schemes executed by the agency through grants-in-aid received from the same Ministry or from other Ministries is enclosed at Annexure –II (to be formulated by the Ministry/Department concerned as per their requirements/specifications).

Trivandrum
26-09-2024

For N S Sarma Associates
Chartered Accountants

Saji A	D.P Maret	Prof .N.V.Chalapathi Rao	CA Subramoniya Sarma N
Manager(F&A)	Senior Manager	Director	Partner, M.No:206497
			FRN: 008018S
			UDIN: 24206497BKADXQ8882

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N.S. SARMA ASSOCIATES
CHARTERED ACCOUNTANTS
TC 80/1413, SOUTH STREET, FORT P.O
TRIVANDRUM-695023, PHONE: 0471-2464706, 2575348
E-mail: sarmans06@gmail.com

INDEPENDENT AUDITOR'S REPORT

The Members of

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

Opinion

We have audited the financial statements of **NATIONAL CENTRE FOR EARTH SCIENCE STUDIES, Ulloor - Akkulam Road, Trivandrum - 695011** which comprise the Balance Sheet at March 31st 2024 and the Statementof Income and Expenditure Account for the year then ended, and notes to the financial statements, including a summary of significant accounting policies.

In our opinion, the accompanying financial statements give a true and fair view of the financial position of the entity as at March 31, 2024, and of its Surplus subject to the point No.3 of Emphasis of Matter for the year ended in accordance with the Accounting Standards issued by the Institute of Chartered Accountants of India (ICAI).

Basis for Opinion

We conducted our audit in accordance with the Standards on Auditing (SAs) issued by ICAI. Our responsibilities under those standards are further described in the Auditor's Responsibilities for the Audit of the Financial Statements section of our report. We are independent of the entity in accordance with the ethical requirements that are relevant to our audit of the financial statements in state of Kerala, and we have fulfilled our other ethical responsibilities in accordance with these requirements. We believe that the audit evidence we have obtained is sufficient and appropriate to provide a basis for our opinion.

N.S. SARMA ASSOCIATES * CHARTERED ACCOUNTANTS * TRIVANDRUM PIN 695 023

Other Matter Para

1. During the year as per the order of Honorable High Court of Kerala in the w.r.t petition No. 36579 of 2022 order dated 06-10-2023, society has paid Rs. 1,21,37,690 as Gratuity relating to previous years and the funds for this payment were drawn from the corpus fund.
2. Internal Audit of NCESS is being done by officials from Ministry of Earth Science. During the year 2023-24 audit is currently pending. Audit is usually done in block of years. Last audit was done for the period 01-04-2019 to 31-03-2023. Due to not submission of internal audit for the year 2023-24 we are unable to comment about the effectiveness of audit.
3. The Audited accounts for the financial year ending 2022-23 have not yet been adopted by the Governing Body.
4. The entity received a refund of ₹45,91,559 related to an advance payment from National Remote Sensing Centre (NRSC) made for acquiring satellite imagery services to obtain photographs of the Earth. However, during the financial year, the NRSC introduced a new space policy that mandated the closure of all existing user accounts related to satellite imagery services. As a result, the service provider discontinued access to the imagery services, thereby initiating refunded of the advance amount paid by the users. The contract for these services ended on 09/01/2024.

   Prior to 2019-20, the entity adhered a Cash basis accounting system, under which the advance payment was recorded as an expense. Consequently, the refunded amount has been treated as income in the current financial year.
5. Some of physical assets have been verified during the audit. Specifically, two laboratory equipment assets, the Eddy Covariance System Setup and The Cosmos Soil Moisture Station, located in Attapady and Munnar, respectively, were physically verified. The combined value of these assets is ₹2,21,08,315. The verification was conducted from 06/09/2024 to 08/09/2024.

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6. We observe that there is no movement in the following Advance and Other amount recoverable during the year. We are not been provided with any details to ascertain its realizability or completion of work as envisaged.

Item	Dr Amount	Cr Amount
Common Fund	-	35,668
Salary Receivable	6,40,079	-
Gratuity Receivable	29,98,600	-
Service Tax Receivable	1,84,870	-
Leave Salary Receivable	1,35,990	-
Service Tax Interest Receivable	10,163	-

7. We observe that there is no movement in the following Party's ledger relating to Advance to Suppliers. These figures are carried forward from the previous years.

Party	Dr Amount
Thermo Electron	21,61,384
Elementar UK Ltd	2,07,56,111
Star One IT Solutions	1,02,81,415
Bharat Sanchar Nigam Ltd	1,03,04,280

Responsibilities of Management and Those Charged with Governance for the Financial Statements

Management is responsible for the preparation and fair presentation of the financial statements in accordance with the aforesaid Accounting Standards, 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.

In preparing the financial statements, management is responsible for assessing the entity's ability to continue as a going concern, disclosing, as applicable, matters related to going concern and using the going concern basis of accounting unless management either intends to liquidate the entity or to cease operations, or has no realistic alternative but to do so.

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

Auditor's Responsibilities for the Audit of the Financial Statements

Our objectives are 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. Reasonable assurance is a high level of assurance, but is not a guarantee that an audit conducted in accordance with SAs will always detect a material misstatement when it exists. Misstatements can arise from fraud or error and are considered material if, individually or in the aggregate, they could reasonably be expected to influence the economic decisions of users taken on the basis of these financial statements.

For N S Sarma Associates
Chartered Accountants

CA Subramoniya Sarma N
Partner, M.No:206497
FRN: 008018S
UDIN: 24206497BKADXR3196

Trivandrum
26-09-2024

NATIONAL CENTRE FOR EARTH SCIENCE STUDIES
Ministry of Earth Sciences, Government of India
Ulloor - Akkulam Road, Thiruvananthapuram - 695011
Balance Sheet as at 31st March, 2024

(In Rs)

Particulars	Sch No.	2023-2024	2022-2023
Liabilities			
Capital Reserve	1	39,47,07,265.00	39,44,71,335.43
General Reserve	2	-3,13,74,204.00	-3,13,74,204.00
Corpus Fund	3	19,66,54,108.85	18,64,11,509.85
Unspent Balance of Projects	4	14,86,30,721.17	15,68,44,955.62
Unspent Balance GOI - MoES	5	10,01,60,478.70	15,05,36,056.02
Current Liabilities	6	2,93,74,203.72	2,12,33,792.00
Total		**83,81,52,573.44**	**87,81,23,444.92**
Assets			
Property, Plant and Equipment	7	39,47,07,265.00	39,44,71,335.43
Current Assets, Loans & Advances	8	44,34,45,308.44	48,36,52,109.49
Total		**83,81,52,573.44**	**87,81,23,444.92**
Notes forming part of Accounts	16		

As per our Report of even date.

Trivandrum
26-09-2024

For N S Sarma Associates
Chartered Accountants

Saji A
Manager(F&A)

D.P Maret
Senior Manager

Prof .N.V.Chalapathi Rao
Director

CA Subramoniya Sarma N
Partner, M.No:206497
FRN: 008018S
UDIN: 24206497BKADXR3196

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NATIONAL CENTRE FOR EARTH SCIENCE STUDIES
Ministry of Earth Sciences, Government of India
Income and Expenditure Account for the year ended 31st March, 2024

Particulars		Sch No.	2023-24	2022-2023
			Rs.	Rs.
Income				
Operation and Maintenance Grant				
Grant Received	16,00,00,000.00	9		
Less: Capital Expenditure	15,89,804.00		15,84,10,196.00	12,56,88,484.00
Income from Consultancy Project			2,17,500.00	2,42,000.00
Prior Period Adjustment				1,65,315.00
Transfer from Corpus Fund			1,17,67,622.00	4,07,56,957.00
Other Income		10	3,52,744.00	80,654.00
Depreciation Written Back			6,88,32,065.43	7,02,62,397.00
Total - A			**23,95,80,127.43**	**23,71,95,807.00**
Expenditure				
Staff Salary & Benefits		11	13,15,40,603.00	11,56,50,061.00
Prior Period Expenses- Gratuity			-	4,03,30,066.00
Other Institutional Expenses:				
Total of Other Institutional	2,31,67,464.80			
Less: Capital Expenditure	15,89,804.00	12	2,15,77,660.80	2,58,09,911.70
Depreciation		7	6,88,32,065.43	7,02,62,397.00
Total - B			**22,19,50,329.23**	**25,20,52,435.70**
Excess of Income over expenditure (A-B)			1,76,29,798.20	-1,48,56,628.70
Excess of Income over expenditure of Prev. Year			-54,97,954.58	93,58,674.12
Total			**1,21,31,843.62**	**-54,97,954.58**
Notes forming part of Accounts		16		

As per our Report of even date.

Trivandrum
26-09-2024

For N S Sarma Associates
Chartered Accountants

Saji A	D.P Maret	Prof .N.V.Chalapathi Rao	CA Subramoniya Sarma N
Manager(F&A)	Senior Manager	Director	Partner, M.No:206497
			FRN: 008018S
			UDIN: 24206497BKADXR3196

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Schedule 1 - Capital Reserve

(In Rs)

Particulars	Sch.No	As at 31.3.2024	As at 31.3.2023
Opening Balance		39,44,71,335.43	43,15,34,320.43
Add: Addition to Capital Assets	7	6,77,17,403.00	4,53,67,776.00
Add: Transfer from External Projects		14,43,313.00	96,815.00
Less: Depreciation		6,88,32,065.43	7,02,62,397.00
Less: Sale of Fixed Assets/ Capitalisation of WIP		92,721.00	1,22,65,179.00
Closing balance		**39,47,07,265.00**	**39,44,71,335.43**

Schedule 2 - General Reserve

Particulars	Sch.No	As at 31.3.2024	As at 31.3.2023
Plan fund from GOK			
Opening Balance		58,56,830.00	58,56,830.00
Closing Balance		**58,56,830.00**	**58,56,830.00**
Non Plan Fund from GOK			
Opening Balance		-3,72,31,034.00	-3,72,31,034.00
Closing Balance		**-3,72,31,034.00**	**-3,72,31,034.00**
Total		**-3,13,74,204.00**	**-3,13,74,204.00**

Schedule 3 - Corpus Fund

Particulars	Sub Sch.No	As at 31.3.2024	As at 31.3.2023
Opening Balance		18,64,11,509.85	20,44,32,417.73
Add: Interest Received from Fixed Deposits		1,31,63,064.00	1,21,48,030.00
Add: Income from Consultancy Projects	1	30,86,500.00	32,54,275.12
Add: Overhead Charges recovered from external projects		22,47,528.00	33,41,121.00
Add: Receipts from External Projects		11,94,933.00	21,92,900.00
Add: Interest from Consultancy Projects		23,18,196.00	17,99,723.00
Less: Prior Period Expense - Gratuity		1,17,67,622.00	4,03,30,066.00
Less: OPMA Expenses for Gratuity			4,26,891.00
Closing Unspent		**19,66,54,108.85**	**18,64,11,509.85**

Schedule 4 - Unspent Balance of Projects

Particulars	Sub Sch No.	As at 31.3.2024	As at 31.3.2023
Consultancy Projects	2	13,07,86,437.00	13,25,83,437.00
Research Projects	3	36,21,317.40	21,17,451.24
Divisional Core Research Projects	3	1,04,94,775.77	2,08,47,871.38
Service Component Projects	3	37,28,191.00	12,96,196.00
Total		**14,86,30,721.17**	**15,68,44,955.62**

Schedule 5 - Unspent Balance GOI - MoES

Particulars	Sch.No	As at 31.3.2024	As at 31.3.2023
Operation and Maintenance Fund			
Grant in aid for salaries and general (OPMA)			
Opening Balance		-54,97,954.58	95,23,989.12
Add: Grant Received during the year	9	16,00,00,000.00	12,91,00,000.00
Less: Revenue Expenditure	11 & 12	15,31,18,263.80	18,17,90,038.70
Less: Capital Expenditure	12	15,89,804.00	34,11,516.00
Add: Income from Interest & Other Income	10	3,52,744.00	80,654.00
Add: Receipts from Corpus Fund of Gratuity		1,17,67,622.00	4,07,56,957.00
Add: Income from consultancy		2,17,500.00	2,42,000.00
Closing Unspent Balance of Grant (1)		**1,21,31,843.62**	**-54,97,954.58**
Grant in aid for creation of capital assets (Major works)			
Opening Balance		4,83,33,437.00	5,63,26,440.00
Add: Grant Received during the year		1,00,00,000.00	
Less: Revenue Expenditure	15	1,69,160.00	-
Less: Capital Expenditure		52,08,318.00	79,93,003.00
Closing Unspent Balance of Grant (2)		**5,29,55,959.00**	**4,83,33,437.00**
Seismological and Geoscience (SAGE)			
(Research & Development Programme)			
Opening Balance		10,77,00,573.60	3,71,88,726.10
Add: Grant Received during the year		4,08,55,687.41	13,65,00,000.00
Less: Revenue Expenditure	13	5,29,26,023.93	4,42,90,074.50
Less: Capital Expenditure	14	6,08,26,560.00	2,16,98,078.00
Add: Interest from Bank		2,50,813.00	
Add: Interest from Other-Institutes		18,186.00	
Closing Unspent Balance of Grant (3)		**3,50,72,676.08**	**10,77,00,573.60**
Closing Unspent Balance (1+2+3)		**10,01,60,478.70**	**15,05,36,056.02**

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Schedule 6 - Current Liabilities

Particulars	Sub Sch No	As at 31.3.2024	As at 31.3.2023
Common Fund		35,668.00	35,668.00
EMD		4,26,967.00	18,46,967.00
Tax Deducted at Source Payable Contractors		2,62,797.72	1,14,440.00
Tax Deducted at Source Payable Staff		9,44,000.00	8,17,000.00
Security Deposit		7,14,336.00	7,60,186.00
EPF Staff		7,01,448.00	5,59,084.00
GPF Central		83,266.00	
Subscription to NCESS Rec- Club		1,425.00	1,450.00
Co-Operative Recovery		-	10,000.00
NPS Staff		3,95,486.00	3,30,938.00
GSLIS		4,050.00	4,050.00
LIC		74,241.00	65,104.00
NCESS Co-Operative Society		10,090.00	5,580.00
Taxes/Fee Payable		1,195.00	
Sundry Creditors for Expenses		77,33,890.00	92,95,347.00
Sundry Creditors for Supplies		1,75,93,234.00	70,60,952.00
GST payable:			
CGST		1,71,609.00	89,308.00
SGST		1,71,609.00	89,308.00
IGST		2,934.00	37,325.00
GST TDS Payable		45,958.00	1,11,085.00
Total		**2,93,74,203.72**	**2,12,33,792.00**

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Schedule 7 - Property, Plant and Equipment

		GROSS BLOCK					DEPRECIATION BLOCK				NET BLOCK	
		ADDITIONS			TOTAL							
PARTICULARS	AS AT 31-03-2023	MORE THAN 180 DAYS	LESS THAN 180 DAYS	SALE/LOSS	AS AT 31-03-2024	RAT %	UP TO 31-03-2023	FOR THE YEAR	SALE/ LOSS	UP TO 31-03-2024	AS AT 31-03-2024	AS AT 31-03-2023
BUILDINGS	2,40,72,696.00	-	-	-	2,40,72,696.00	10	1,48,44,740.00	9,22,796.00	-	1,57,67,536.00	83,05,160.00	92,27,956.00
COMPOUND WALL	1,94,66,444.00	-	5,45,066.00	-	2,00,11,510.00	10	39,10,818.00	15,82,816.00	-	54,93,634.00	1,45,17,876.00	1,55,55,626.00
ROADS	58,99,494.00	-	-	-	58,99,494.00	10	8,55,427.00	5,04,407.00	-	13,59,834.00	45,39,660.00	50,44,067.00
COMPUTER SYSTEM & ACCESSORIES	6,21,88,638.00	12,83,328.00	41,93,275.00	92,721.00	6,75,72,520.00	40	5,04,21,072.00	60,21,924.00	-	5,64,42,996.00	1,11,29,524.00	1,17,67,566.00
CANTEEN FURNITURE	1,32,946.00	-	-	-	1,32,946.00	10	50,165.00	8,278.00	-	58,443.00	74,503.00	82,781.00
CANTEEN EQUIPMENT	1,61,544.00	2,500.00	-	-	1,64,044.00	15	99,958.00	9,613.00	-	1,09,571.00	54,473.00	61,586.00
ELECTRICAL INSTALLA	1,35,76,215.00	5,70,424.00	1,60,440.00	-	1,43,07,079.00	15	77,05,133.00	9,78,259.00	-	86,83,392.00	56,23,687.00	58,71,082.00
FURNITURE & FIXTURE	1,57,71,798.00	4,40,497.00	3,93,519.00	-	1,66,05,814.00	10	64,59,120.00	9,94,993.00	-	74,54,113.00	91,51,701.00	93,12,678.00
FABRICATED EQUIPME	46,431.00	-	-	-	46,431.00	15	36,212.00	1,533.00	-	37,745.00	8,686.00	10,219.00
LABORATORY EQUIPM	59,26,28,184.43	3,34,93,148.00	2,21,52,091.00	-	64,82,73,423.43	15	28,97,97,348.00	5,21,10,004.43	-	34,19,07,352.43	30,63,66,071.00	30,28,30,836.43
LIBRARY BOOKS	2,56,88,702.00	-	1,140.00	-	2,56,89,842.00	40	2,37,82,409.00	7,62,745.00	-	2,45,45,154.00	11,44,688.00	19,06,293.00
LOOSE TOOLS	23,933.00	14,500.00	76,200.00	-	1,14,633.00	15	4,920.00	10,742.00	-	15,662.00	98,971.00	19,013.00
OFFICE EQUIPMENTS	1,29,50,758.00	10,880.00	3,90,273.00	-	1,33,51,911.00	15	66,34,889.00	9,78,283.00	-	76,13,172.00	57,38,739.00	63,15,869.00
RESEARCH BOAT	6,074.00	-	-	-	6,074.00	20	5,318.00	151.00	-	5,469.00	605.00	756.00
SURVEY & MAPING EQUIPMENTS	32,07,038.00	-	-	-	32,07,038.00	15	20,07,894.00	1,79,872.00	-	21,87,766.00	10,19,272.00	11,99,144.00
VEHICLES	13,76,408.00	-	-	-	13,76,408.00	15	10,73,456.00	45,443.00	-	11,18,899.00	2,57,509.00	3,02,952.00
FIRE FIGHTING EQUIPM	1,219.00	-	-	-	1,219.00	15	951.00	40.00	-	991.00	228.00	268.00
ELECTRICAL FITTINGS TO	20,13,989.00	1,815.00	-	-	20,15,804.00	15	9,23,626.00	1,63,827.00	-	10,87,453.00	9,28,351.00	10,90,363.00
WATER SUPPLY & SANITARY FITTINGS	63,271.00	-	-	-	63,271.00	15	49,345.00	2,089.00	-	51,434.00	11,837.00	13,926.00
AIR CONDITIONING TO BUILDINGS	62,64,921.00	5,91,368.00	-	-	68,56,289.00	15	26,97,955.00	6,23,750.00	-	33,21,705.00	35,34,584.00	35,66,966.00
FIXTURES & FITTINGS TO	3,27,276.00	-	-	-	3,27,276.00	10	2,04,290.00	12,299.00	-	2,16,589.00	1,10,687.00	1,22,986.00
MAJOR SOFTWARE	7,30,71,641.00	1,77,000.00	-	-	7,32,48,641.00	40	6,59,53,139.00	29,18,201.00	-	6,88,71,340.00	43,77,301.00	71,18,502.00
WORK-IN-PROGRESS	1,30,49,900.00	-	46,63,252.00	-	1,77,13,152.00		-	-	-	-	1,77,13,152.00	1,30,49,900.00
TOTAL	**87,19,89,520.43**	**3,65,85,460.00**	**3,25,75,256.00**	**92,721.00**	**94,10,57,515.43**		**47,75,18,185.00**	**6,88,32,065.43**	**-**	**54,63,50,250.43**	**39,47,07,265.00**	**39,44,71,335.43**
PREVIOUS YEAR	**83,89,62,379.43**	**26,17,522.00**	**4,28,47,069.00**	############	**87,19,89,520.43**		**42,38,75,007.00**	**7,02,62,397.00**	**1,72,271.00**	**49,39,65,133.00**	**39,44,71,335.43**	**43,15,34,320.43**

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Schedule 8 - Current Assets, Loans & Advances

Particulars	Sub Sch No.	As at 31.3.2024	As at 31.3.2023
A. Current Assets			
1. Stock - in - hand			
Stock- Chemical Glassware		23,12,949.00	
Printing and Stationery		99,263.00	13,93,764.00
	(1)	**24,12,212.00**	**13,93,764.00**
2. Cash & Bank Balance			
SBI (Consultancy Projects) SB A/c No.57059896493		10,70,75,840.00	10,87,24,640.00
SBI (External Projects) SB A/c No. 67397703582		1,56,55,711.17	1,73,23,267.62
SBI (NCESS) SB A/c No. 67397703537		3,34,77,285.34	3,36,96,337.12
SBI SB Corfu A/c No. 57059896528		60,063.85	2,08,394.85
KOTAK (SAGE) A/c No. 2246577575		1,05,01,347.85	7,47,80,146.59
Canara Bank A/c No. 110059314342			2,03,272.00
Bank of Maharashtra A/c No. 60430788005		14,11,344.00	9,36,337.00
Treasury Accounts (GOK)		11,000.00	11,000.00
Term Deposits		17,36,22,027.00	17,33,03,115.00
Imprest Balances		7,071.00	6,247.00
Margin Money on LC NCESS		25,61,940.00	28,80,334.00
	(2)	**34,43,83,630.21**	**41,20,73,091.18**
Total A (1+2)		**34,67,95,842.21**	**41,34,66,855.18**
B. Loans, Advances & Other Assets			
1.Deposits			
Deposit with KSEB		7,33,320.00	6,55,570.00
Deposit with T K Varghese and Sons		6,000.00	6,000.00
Deposit with BSNL		3,000.00	3,000.00
Caution Deposit		3,000.00	3,000.00
	(1)	**7,45,320.00**	**6,67,570.00**
2. Advances & other amount recoverable in cash or in kind or for value to be recovered			
Tour Advance		2,90,166.23	2,01,086.01
Other Advance		28,654.00	69,873.30
Rolling Contingent Advance		1,86,565.00	94,469.00
Advance to staff - External/Consultancy Projects		6,742.00	39,375.00
Advance to Suppliers - NCESS		7,30,00,120.00	5,47,65,538.00
Advance to Suppliers - MACIS			49,67,452.00
Leave Salary Receivable		1,35,990.00	1,35,990.00
Salary Receivable		6,40,079.00	6,40,079.00
Accrued Interest- CORFU		1,00,72,018.00	-
TDS Receivable - External Projects		7,70,487.00	7,91,815.00
TDS Receivable - Consultancy Projects		3,72,017.00	5,20,217.00
TDS Receivable - NCESS		7,96,472.00	2,88,972.00
Grants to Other Institutes			34,43,473.00
Gratuity Recievable KSCTSE		29,98,600.00	29,98,600.00
Prepaid Expenses- Postage		11,56,400.00	
Prepaid Expenses- Others		52,54,803.00	3,65,712.00
Service Tax Receivable		1,84,870.00	1,84,870.00
Service Tax Interest Receivable		10,163.00	10,163.00
	(2)	**9,59,04,146.23**	**6,95,17,684.31**
Total B (1+2)		**9,66,49,466.23**	**7,01,85,254.31**
Total (A+B)		**44,34,45,308.44**	**48,36,52,109.49**

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Schedule 9 - Grant Received

(In Rs)

Particulars	As at 31.3.2024	As at 31.3.2023
Grant in aid salaries and general (OPMA)		
Add: Grant Received During the Year	16,00,00,000.00	12,91,00,000.00
Total	**16,00,00,000.00**	**12,91,00,000.00**

Schedule 10 - Other income

Particulars	As at 31.3.2024	As at 31.3.2023
Miscellaneous Receipts	3,01,157.00	53,263.00
Application Fee (Right to Information Act)	174.00	845.00
Interest from Deposit	27,508.00	26,546.00
Sale of Usufructs	23,905.00	
Total	**3,52,744.00**	**80,654.00**

Schedule 11 - Staff Salary & Benefits

Particulars	As at 31.3.2024	As at 31.3.2023
Salary Director	26,09,494.00	40,09,605.00
Staff Salary	9,52,70,672.00	8,90,17,727.00
Salary Other Institutes	79,35,232.00	70,40,314.00
Contribution to EPF	38,03,232.00	38,10,298.00
Contribution to EPS	3,17,500.00	3,61,250.00
EPF Administrative Charges	1,71,696.00	1,73,783.00
Contribution to EPF IF	20,625.00	22,800.00
Contribution to NPS	55,13,467.00	54,26,785.00
Children Education Allowance	9,99,000.00	9,72,000.00
Leave Salary & Pension Contribution	7,99,725.00	13,57,813.00
Leave Travel Concession	4,74,040.00	14,02,310.00
LIC GG Scheme for Staff	90,000.00	8,01,455.00
Medical Expenses Reimbursement	7,39,690.00	8,50,863.00
News Papers & Periodicals	2,91,340.00	-
Gratuity	1,21,94,513.00	
Gratuity - Previous Year		4,03,30,066.00
NPS Service Charges	5,951.00	7,354.00
Telephone Reimburement	3,04,426.00	3,95,704.00
Total	**13,15,40,603.00**	**15,59,80,127.00**

Schedule 12 - Other Institutional Expenses

Particulars		As at 31.3.2024	As at 31.3.2023
Computer System & Accessories		11,27,119.00	2,89,579.00
Electrical /UPS Installations		1,30,924.00	11,67,389.00
Loose Tools			19,500.00
Air Conditioners			8,68,000.00
Canteen Equipment		2,500.00	-
Library Books & Journals		1,140.00	3,25,013.00
Furniture		70,912.00	1,20,903.00
Office Equipments		2,57,209.00	6,21,132.00
	1	**15,89,804.00**	**34,11,516.00**
Advertisement		67,517.00	1,57,296.00
Audit Fee		47,200.00	41,300.00
Bank charges		384.50	88.50
Consultant fee			2,73,290.00
Consumables		8,06,855.00	11,87,624.00
Contingency		7,45,307.00	20,02,712.00
Electricity Charges		52,26,166.00	44,49,480.00
Hospitality Expenses		5,90,468.00	3,42,595.00
Legal Charges		1,05,800.00	16,500.00
Parliamantry Committee Expenses			1,64,298.00
Petrol , Diesel & Oil		2,81,227.00	2,39,520.00
Postage & Communication		1,91,937.30	1,86,391.70
Printing & Stationery		5,28,425.00	4,25,952.00
Prior Period Expenses			4,03,004.00
Remuneration to Project Staff		17,09,368.00	40,33,529.00
Repairs & Maintenance - Others		12,76,499.00	17,21,878.50
Repairs & Maintenance - Building		22,61,844.00	19,77,495.00
Repairs & Maintenance - Vehicle		1,49,656.00	82,308.00
SB-Swachtha Mission		5,18,402.00	-
Security Charges		41,47,319.00	36,72,481.00
Seminar/Conference		7,10,825.00	3,26,450.00
Sitting Fee/Honor-Visiting Expenses		36,000.00	68,297.00
Subscription to Journals			19,81,743.00
Swachh Bharath- Gardening			51,440.00
Swachh Bharath- House Keeping		9,48,720.00	9,48,720.00
Taxes & Insurance Vehicles		11,067.00	19,775.00
Travelling Expenses		9,52,236.00	2,25,419.00
Travelling Expenses for Visiting Experts			4,81,131.00
Vehicle Hire Charges		1,59,027.00	2,38,052.00
Water Charges		1,05,411.00	91,142.00
	2	**2,15,77,660.80**	**2,58,09,911.70**
Total (1+2)		**2,31,67,464.80**	**2,92,21,427.70**

Schedule 13 - Research & Development Revenue Expenses

Particulars	As at 31.3.2024	As at 31.3.2023
Advertisement Charges for R&D	1,28,621.00	2,15,012.00
Analytical Charges	4,42,530.00	11,70,577.00
Boat Hire Charges		29,000.00
Chemicals/ Consumables	84,88,991.00	1,00,26,577.00
Chemicals/ Consumables - Other Institutes	5,17,171.00	14,57,910.00
Cost Of Power/Electricity - Labs	51,809.00	1,37,384.00
Contingency	13,01,908.90	5,42,702.00
Contingency Other Institutes	28,563.00	5,52,475.00
Consultants charges	4,03,333.00	-
Communication /postage charges	16,24,014.00	1,37,781.00
Equipments repair charges/ AMC	65,98,107.00	52,54,956.00
Field expenses	1,24,116.91	7,46,768.50
Field expenses - Other Institutes	1,21,574.00	7,63,747.00
Hire charges of vehicles	30,88,078.60	25,36,827.00
Hospitality Expenses	7,79,882.00	3,41,979.00
Insurance labs & equipments	2,56,435.00	2,56,435.00
Loss on Fixed Assets		9,391.00
Membership / Registration	1,61,500.00	2,47,360.00
Over head charges - Other Institutes	3,40,576.00	2,08,097.00
Personal accident insurance	3,889.00	
Printing & publication cost	6,64,890.01	5,83,077.00
Printing & stationery	1,18,484.00	61,006.00
Prior period expenses		6,19,579.00
Recogonition fee/doct committee	3,00,000.00	3,00,000.00
Repairs and maintenance	96,53,518.00	2,38,512.00
Remuneration to project staff	1,12,85,903.00	88,58,853.00
Remuneration - Project Staff- Other Institutes	9,52,790.00	20,47,203.00
Rent	9,47,200.00	5,55,700.00
Seminar,symposium & workshop	30,81,208.00	2,98,518.00
Sitting fee Visiting Experts	2,18,000.00	1,97,620.00
Travelling Expenses	57,63,629.51	52,96,377.00
Travelling Expenses for Visiting experts	70,861.00	5,98,651.00
Receipt from Satellite Imageries	-45,91,559.00	-
Total	**5,29,26,023.93**	**4,42,90,074.50**

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Schedule 14 - Research & Development Capital Expenses

Particulars	As at 31.3.2024	As at 31.3.2023
Air conditioners	5,91,368.00	91,990.00
Computer System & Accessories	38,06,335.00	77,71,287.00
Electrical /UPS Installations	3,86,440.00	4,38,466.00
Furniture	4,87,104.00	9,01,103.00
Laboratory Equipment	5,52,73,668.00	1,12,83,100.00
Loose tools	90,700.00	
Major Software	1,77,000.00	12,03,832.00
Office Equipment	13,945.00	8,300.00
Total	**6,08,26,560.00**	**2,16,98,078.00**

Schedule 15 -Creation of Capital Assets (Major Works)

Particulars	As at 31.3.2024	As at 31.3.2023
(a) Revenue Expenditure:		
Minor Civil Works (Repairs & Maintenance)	1,69,160.00	-
(b) Capital Expenditure:		
Major Civil Works: Roads		
Compound Wall	5,45,066.00	10,33,183.00
Work In Progress	46,63,252.00	69,59,820.00
Total	52,08,318.00	79,93,003.00
Total (a+b)	**53,77,478.00**	**79,93,003.00**

Sub Schedule No 1

STATEMENT SHOWING CONSULTANCY PROJETS CLOSED DURING THE YEAR

Sl No.	Project	Opening Balance	TDS	Project Balance as on 31-03-2024	Amount Transferred to MACIS	Amount Transferred to Corpus after adjustments
1	CONY 553	2,10,000.00	-	2,10,000.00	74,000.00	1,36,000.00
2	CONY 558	5,23,500.00	91,500.00	6,15,000.00	1,10,000.00	4,13,500.00
3	CONY 560	2,10,000.00	-	2,10,000.00	70,000.00	1,40,000.00
4	CONY 561	2,10,000.00	-	2,10,000.00	55,000.00	1,55,000.00
5	CONY 562	1,78,500.00	31,500.00	2,10,000.00	55,000.00	1,23,500.00
6	CONY 563	4,05,000.00	-	4,05,000.00	75,000.00	3,30,000.00
7	CONY 564	2,10,000.00	-	2,10,000.00	55,000.00	1,55,000.00
8	CONY 565	2,10,000.00	-	2,10,000.00	55,000.00	1,55,000.00
9	CONY 568	2,10,000.00	-	2,10,000.00	55,000.00	1,55,000.00
10	CONY 570	2,10,000.00	-	2,10,000.00	55,000.00	1,55,000.00
11	CONY 572	1,78,500.00	31,500.00	2,10,000.00	55,000.00	1,23,500.00
12	CONY 573	1,78,500.00	31,500.00	2,10,000.00	55,000.00	1,23,500.00
13	CONY 574	2,10,000.00	-	2,10,000.00	55,000.00	1,55,000.00
14	CONY 575	1,78,500.00	31,500.00	2,10,000.00	55,000.00	1,23,500.00
15	CONY 579	2,10,000.00	-	2,10,000.00	55,000.00	1,55,000.00
16	CONY 582	90,000.00	-	90,000.00	10,000.00	80,000.00
17	CONY 583	2,10,000.00	-	2,10,000.00	74,000.00	1,36,000.00
18	CONY 588	2,10,000.00	-	2,10,000.00	74,000.00	1,36,000.00
19	CONY 589	2,10,000.00	-	2,10,000.00	74,000.00	1,36,000.00
	Total	**42,52,500.00**	**2,17,500.00**	**44,70,000.00**	**11,66,000.00**	**30,86,500.00**

Sub Schedule No 2

Statement of Unspent Balance of Consultancy Projects for the year 2023-24

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
1	CONY	-	23,18,196.00	-	-	23,18,196.00	-	-	23,18,196.00	-
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
5	CONY308	25,500.00	-	-	-	-	-	-	-	25,500.00
6	CONY309	2,32,879.00	-	-	-	-	-	-	-	2,32,879.00
7	CONY312	97,059.00	-	-	-	-	-	-	-	97,059.00
8	CONY315	1,86,145.00	-	-	-	-	-	-	-	1,86,145.00
9	CONY317	6,63,588.00	-	-	-	-	-	-	-	6,63,588.00
10	CONY329	7,35,944.00	-	-	-	-	-	-	-	7,35,944.00
11	CONY330	5,24,537.00	-	-	-	-	-	-	-	5,24,537.00
12	CONY334	15,58,102.00	-	-	-	-	-	-	-	15,58,102.00
13	CONY343	7,81,831.00	-	-	-	-	-	-	-	7,81,831.00
14	CONY344	10,22,999.00	-	-	-	-	-	-	-	10,22,999.00
15	CONY345	2,98,592.00	-	-	-	-	-	-	-	2,98,592.00
16	CONY346	2,51,375.00	-	-	-	-	-	-	-	2,51,375.00
17	CONY349	5,53,429.00	-	-	-	-	-	-	-	5,53,429.00
18	CONY355	2,29,338.00	-	-	-	-	-	-	-	2,29,338.00
19	CONY356	5,83,332.00	-	-	-	-	-	-	-	5,83,332.00
20	CONY360	1,84,812.00	-	-	-	-	-	-	-	1,84,812.00
21	CONY361	1,80,75,977.00	-	-	-	-	-	-	-	1,80,75,977.00
22	CONY363	3,37,391.00	-	-	-	-	-	-	-	3,37,391.00
23	CONY365	2,29,166.00	-	-	-	-	-	-	-	2,29,166.00
24	CONY369	12,89,318.00	-	-	-	-	-	-	-	12,89,318.00
25	CONY370	8,88,532.00	-	-	-	-	-	-	-	8,88,532.00
26	CONY371	2,24,143.00	-	-	-	-	-	-	-	2,24,143.00
27	CONY372	2,05,925.00	-	-	-	-	-	-	-	2,05,925.00
28	CONY374	2,10,000.00	-	-	-	-	-	-	-	2,10,000.00
29	CONY378	8,96,71,427.00	-	-	-	-	-	-	-	8,96,71,427.00
30	CONY379	85,829.00	-	-	-	-	-	-	-	85,829.00

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
31	CONY380	2,52,460.00	-	-	-	-	-	-	-	2,52,460.00
32	CONY381	2,64,841.00	-	-	-	-	-	-	-	2,64,841.00
33	CONY383	99,904.00	-	-	-	-	-	-	-	99,904.00
34	CONY384	2,51,605.00	-	-	-	-	-	-	-	2,51,605.00
35	CONY385	2,80,099.00	-	-	-	-	-	-	-	2,80,099.00
36	CONY386	10,19,850.00	-	-	-	-	-	-	-	10,19,850.00
37	CONY447	80,500.00	-	-	-	-	-	-	-	80,500.00
38	CONY517	2,28,562.00	-	-	-	-	-	-	-	2,28,562.00
39	CONY518	2,07,353.00	-	-	-	-	-	-	-	2,07,353.00
40	CONY519	4,82,000.00	-	-	-	-	-	-	-	4,82,000.00
41	CONY526	9,13,500.00	-	-	-	-	-	-	-	9,13,500.00
42	CONY537	3,91,400.00	-	-	-	-	-	-	-	3,91,400.00
43	CONY552	4,05,000.00	-	-	-	-	-	-	-	4,05,000.00
44	CONY553	2,10,000.00	-	2,10,000.00	-	-	-	-	2,10,000.00	-
45	CONY558	6,15,000.00	-	6,15,000.00	-	-	-	-	6,15,000.00	-
46	CONY559	2,10,000.00	-	-	-	-	-	-	-	2,10,000.00
47	CONY560	2,10,000.00	-	2,10,000.00	-	-	-	-	2,10,000.00	-
48	CONY561	2,10,000.00	-	2,10,000.00	-	-	-	-	2,10,000.00	-
49	CONY562	2,10,000.00	-	2,10,000.00	-	-	-	-	2,10,000.00	-
50	CONY563	4,05,000.00	-	4,05,000.00	-	-	-	-	4,05,000.00	-
51	CONY564	2,10,000.00	-	2,10,000.00	-	-	-	-	2,10,000.00	-
52	CONY565	2,10,000.00	-	2,10,000.00	-	-	-	-	2,10,000.00	-
53	CONY566	2,10,000.00	-	-	-	-	-	-	-	2,10,000.00
54	CONY568	2,10,000.00	-	2,10,000.00	-	-	-	-	2,10,000.00	-
55	CONY570	2,10,000.00	-	2,10,000.00	-	-	-	-	2,10,000.00	-
56	CONY571	2,10,000.00	-	-	-	-	-	-	-	2,10,000.00
57	CONY572	2,10,000.00	-	2,10,000.00	-	-	-	-	2,10,000.00	-
58	CONY573	2,10,000.00	-	2,10,000.00	-	-	-	-	2,10,000.00	-
59	CONY574	2,10,000.00	-	2,10,000.00	-	-	-	-	2,10,000.00	-
60	CONY575	2,10,000.00	-	2,10,000.00	-	-	-	-	2,10,000.00	-
61	CONY576	6,45,000.00	-	-	-	-	-	-	-	6,45,000.00
62	CONY577	2,10,000.00	-	-	-	-	-	-	-	2,10,000.00
63	CONY579	3,15,000.00	-	3,15,000.00	-	-	-	-	3,15,000.00	-
64	CONY580	3,15,000.00	-	1,05,000.00	-	-	-	-	1,05,000.00	2,10,000.00
65	CONY581	-	3,15,000.00	1,05,000.00	-	-	-	-	1,05,000.00	2,10,000.00
66	CONY582	-	1,50,000.00	1,50,000.00	-	-	-	-	1,50,000.00	-
67	CONY583	-	3,15,000.00	3,15,000.00	-	-	-	-	3,15,000.00	-
68	CONY584	-	3,15,000.00	1,26,000.00	-	-	-	-	1,26,000.00	1,89,000.00
69	CONY585	-	3,15,000.00	1,26,000.00	-	-	-	-	1,26,000.00	1,89,000.00
70	CONY586	-	3,15,000.00	1,26,000.00	-	-	-	-	1,26,000.00	1,89,000.00
71	CONY587	-	3,15,000.00	1,26,000.00	-	-	-	-	1,26,000.00	1,89,000.00
72	CONY588	-	3,15,000.00	3,15,000.00	-	-	-	-	3,15,000.00	-
73	CONY589	-	3,15,000.00	3,15,000.00	-	-	-	-	3,15,000.00	-
74	CONY590	-	3,15,000.00	1,26,000.00	-	-	-	-	1,26,000.00	1,89,000.00
75	CONY591	-	3,15,000.00	1,05,000.00	-	-	-	-	1,05,000.00	2,10,000.00
76	CONY592	-	3,15,000.00	1,26,000.00	-	-	-	-	1,26,000.00	1,89,000.00
77	CONY593	-	6,30,000.00	2,10,000.00	-	-	-	-	2,10,000.00	4,20,000.00
78	CONY594	-	3,15,000.00	1,26,000.00	-	-	-	-	1,26,000.00	1,89,000.00
	TOTAL	**13,25,83,437.00**	**68,78,196.00**	**63,57,000.00**	**-**	**23,18,196.00**	**-**	**-**	**86,75,196.00**	**13,07,86,437.00**

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Sub Schedule No.3

Statement Showing Unspent Balance of External Project as on 31-03-2024

Project Name	Opening Balance	Amount Received	Amount Refunded	Net Amount Received	Net Amount Available	Amount Utilised	Closing Balance
Research Projects							
CSIR25	16,537.00	-	-	-	16,537.00	-	16,537.00
CSIR26	51,726.00	-	-	-	51,726.00	51,726.00	-
CSIR27	18,795.00	-	18,795.00	-18,795.00	-	-	-
CSIR28	20,000.00	-	20,000.00	-20,000.00	-	-	-
DECC2	-2,97,768.00	-	-	-	-2,97,768.00	-	-2,97,768.00
DECC3	3,45,077.00	-	-	-	3,45,077.00	-	3,45,077.00
DST87	92,636.00	-	92,636.00	-92,636.00	-	-	-
DST89	0.14	15,87,430.00	-	15,87,430.00	15,87,430.14	10,87,838.14	4,99,592.00
DST91	1,33,724.00	76,840.00	-	76,840.00	2,10,564.00	2,10,564.00	-
DST92	-	27,84,300.00	-	27,84,300.00	27,84,300.00	19,33,060.00	8,51,240.00
DST93	-	5,92,544.00	-	5,92,544.00	5,92,544.00	5,92,544.00	-
DST94	-	10,26,952.00	-	10,26,952.00	10,26,952.00	10,09,488.00	17,464.00
DST95	8,02,613.00	-	-	-	8,02,613.00	7,59,565.00	43,048.00
KCZMA	32,117.00	-	-	-	32,117.00	180.00	31,937.00
KSCS32	-	3,50,000.00	-	3,50,000.00	3,50,000.00	3,30,000.00	20,000.00
KSCS41	-	5,99,842.00	-	5,99,842.00	5,99,842.00	5,99,842.00	-
KSCS42	46,594.00	-	-	-	46,594.00	35,200.00	11,394.00
KSCS43	5,42,000.00	-	-	-	5,42,000.00	3,78,358.70	1,63,641.30
KSHEC1	-	2,00,000.00	1,93,300.00	6,700.00	6,700.00	6,700.00	-
KSHEC2	-	40,000.00	-	40,000.00	40,000.00	40,000.00	-
MOES13	2,03,272.00	10,00,000.00	34,247.00	9,65,753.00	11,69,025.00	11,69,025.00	-
MOES14	-	5,00,000.00	-	5,00,000.00	5,00,000.00	5,00,000.00	-
SAC16	1,10,128.10	7,16,452.00	-	7,16,452.00	8,26,580.10	6,79,931.00	1,46,649.10
SERB1	-	15,18,600.00	-	15,18,600.00	15,18,600.00	15,18,600.00	-
SERB2	-	2,17,601.00	-	2,17,601.00	2,17,601.00	2,17,601.00	-
SERB3	-	8,06,537.00	-	8,06,537.00	8,06,537.00	1,24,902.00	6,81,635.00
SERB4	-	14,66,400.00	-	14,66,400.00	14,66,400.00	3,75,529.00	10,90,871.00
Total	**21,17,451.24**	**1,34,83,498.00**	**3,58,978.00**	**1,31,24,520.00**	**1,52,41,971.24**	**1,16,20,653.84**	**36,21,317.40**
Divisional Core							
GEOMAT	42,60,885.00	-	-	-	42,60,885.00	-	42,60,885.00
MACIS	1,65,86,986.38	13,78,229.00	-	13,78,229.00	1,79,65,215.38	1,17,31,324.61	62,33,890.77
Total	**2,08,47,871.38**	**13,78,229.00**	**-**	**13,78,229.00**	**2,22,26,100.38**	**1,17,31,324.61**	**1,04,94,775.77**
Service Component Projects							
AAS	1,233.00	69,407.00	749.00	68,658.00	69,891.00	68,676.00	1,215.00
CPT4	5,02,229.00	-	-	-	5,02,229.00	5,02,229.00	-
DECC4	-	34,33,600.00	-	34,33,600.00	34,33,600.00	4,47,600.00	29,86,000.00
LRSA	200.00	8,400.00	-	8,400.00	8,600.00	8,600.00	-
PSA	1,000.00	2,06,400.00	-	2,06,400.00	2,07,400.00	2,07,400.00	-
SEM	600.00	94,800.00	-	94,800.00	95,400.00	95,400.00	-
VISL	7,89,636.00	20,00,000.00	-	20,00,000.00	27,89,636.00	20,49,260.00	7,40,376.00
XRF	1,298.00	1,86,503.00	1,344.00	1,85,159.00	1,86,457.00	1,85,857.00	600.00
Total	**12,96,196.00**	**59,99,110.00**	**2,093.00**	**59,97,017.00**	**72,93,213.00**	**35,65,022.00**	**37,28,191.00**
Grand Total	**2,42,61,518.62**	**2,08,60,837.00**	**3,61,071.00**	**2,04,99,766.00**	**4,47,61,284.62**	**2,69,17,000.45**	**1,78,44,284.17**

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NCESS, Akkulam, TVM

SIGNIFICANT ACCOUNTING POLICIES AND NOTES TO ACCOUNTS

Schedule No:16

1. Organizational Information:

National Centre for Earth Science Studies, Akkulam, Trivandrum, Kerala is a Society registered under Travancore Cochin Literary, Scientific and Charitable Societies Registration Act, 1955 as an autonomous institution under the Ministry of Earth Science Government of India in the year 2014.

National Centre for Earth Science Studies formerly Centre for Earth Science Studies, was an R&D institution under the Kerala State Council for Science Technology and Environment. The Centre has been taken over by the Ministry of Earth Science, Government of India as per the Memorandum of Understanding signed on 1st January 2014 between the Ministry of Earth Science, Government of India, Science and Technology Department and Kerala state Council for Science, Technology and Environment, Government of Kerala. All the assets and all the liabilities except land have been taken over by the newly established National Centre for Earth Science Studies.

2. Significant Accounting Policies:

a) **Basis of Accounting:**
The Society follows the mercantile system of accounting and recognizes income and expenditure on accrual basis except for Government grants and other income. The accounts were prepared on the basis of a going concern.

b) **Income Recognition:**

The Grant -in-Aid and interest from investment are accounted on cash basis. During the period the Society has received grant from MoES towards Operations and Maintenance, Research Program (recurring and non-recurring) and Major Works. Separate Receipts and Payments Accounts are prepared for research projects (external projects). The balance in the Receipts and Payments Accounts of external projects (unspent balance) are transferred to the donor itself except Service components Projects and Consultancy projects.

c) **Fixed Assets:**

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

The additions to fixed assets during the period are stated at cost. Fixed assets of the Centre are acquired out of grant received (Non-recurring Grant). Assets acquired for the External/sponsored projects (Grant-in-aid) are capitalized on completion of the project/receipt of permission from the concerned Government Department. Fund utilized for acquiring fixed assets from Grants received are transferred to Capital Reserve.

Fixed Assets acquired for Externally Funded Projects/Consultancies are directly charged to the project/Consultancy account at the time of purchase.

d) Depreciation:

Depreciation of fixed assets has been charged under Written Down Value method by applyingthe rates specified under Income Tax Act, 1961.

e) Capital Reserve:

The amount received from the Ministry of Earth Science and other institutions utilized for acquiring Fixed Assets is credited to Capital Reserve and the depreciation charged in the Income & Expenditure statement is written back by debiting the Capital Reserve.

f) General Reserve:

The unspent/overspent balance of the grant received from the Government of Kerala has been stated under General Reserve which will be closed once the advances paid before takeover under the schemes of CESS and upon receipt of over spent balance from the Kerala State Council for Science Technology and Environment. The overspent amount has been utilized out of surplus generated in various income projects like CONY (Consultancy Projects) and Corpus Fund. These amounts are booked as receivables from KSCSTE, Government of Kerala before the takeover period

g) Retirement Benefits:

Liability towards Gratuity is provided through group liability scheme of LIC. The gratuity amount is limited to Rs.20,00,000.

As per the Applicable Accounting Standard -15, provision should be provided for Leaveencashment. But society is accounting the Leave Encashment on cash basis and no provisionfor is made in the books of accounts. The maximum terminal encashment is limited to 300 days and the amount paid is considered as the expense in the year of payment itself.

h) Unspent balances:

It represents unspent portion of the grant received for both recurring and non-recurring purpose.

i) Loans and Advances:

Advances to staff represent the balance with them for meeting the expenses in connection with the conduct of Research Projects (project advance) and are considered good and secured. It includes rolling contingency advance and Travelling advance.

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

j) Current Assets:

Includes Imprest balance, Closing stock of Materials, Consumables and Stationery items at cost as certified by the management. Cash equivalents like term deposit and margin money on Letters of Credit are as per the confirmations provided.

k) Contingent Liabilities

1	Claims against the company not acknowledged as debt	Nil
2	Guarantee and Letters of Credit outstanding	Against 100% margin money deposited (FD) with SBI, Rs.25,61,940.00 /-
3	Other items for which the entity is contingently liable	Nil

I) Pending court cases as on 31-03-2024

1	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. TheRegistry of the Tribunal had raised a defectnotice. The defect notice was to deposit 10% of the disputed tax as 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 thesubmission, the Hon'ble Tribunal has directed NCESS to deposit 10% of the disputed tax amount within 4 weeks and report compliance on11.04.2016. 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 thecase is awaited
*Provision for probable liability was not created since Society was following Cash basis of accounting during the relevant Financial Year.				
2	WP © No: 32888 of 2017 filed by Rajesh P and others before theHonourable High Court of Kerala	Consider placing the petitioners in PB 2 i.e. 9300-34800 with GP 4200/- and for other reliefs.	Counter Affidavit filed.	Not Known
3	WP © No: 23371 of 2018 filed by Anju K Sand others before the Honourable High Court of Kerala	Consider placing the petitioners in PB 2 i.e. 9300-34800 with GP 4200/- and for other reliefs.	Counter Affidavit filed	Not Known
4	WA No.269 filed by P.Girija before the before the Honourable High Court of Keralain 2020	Requesting promotion as Scientist B from July 2008 and permit to continue till attaining 60 years of age ie 31.03.2011	Judgement awaited	Not known
5	WPC 2181/2019 filed by M/s Summer Cabs before the Honourable High Court of Kerala.	To stay the retender process and to award the vehicle contract to M/s Summer Cabs	Counter Affidavit filed	Decisionawaited

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6	WA No.2259 of 2019 filed by Smt.Sreelekshmi and others before Hon'ble High Court	Quash the direction dated 26th August 2019 and extention of contract engagement beyond 30.06.2019 and regularization in the services of NCESS.	Judgement awaited	Not known
7	WPC no.36390/2022 filed by Dr.K.K.Ramachandran and others -	6 Staff members retired during the period between 08.03.2019 and 31.07.2022 had filed the case requesting gratuity without limit.	Counter affidavit filed	Not known
8	WP(C) No.33232/2023 K.J. Mathew Vs NCESS	Shri.K.J.Mathew who had retired during in 2012 (Pretakeover period) had filed the case requesting gratuity without limit as provided in KSCSTE rules.	Counter affidavit filed	Not Known

m) Income and Expenditure Account:

Income and Expenditure account shows summary of expenses of NCESS on accrual basis and Grant received as Income on cash basis. The surplus is the unspent balance on grant amount received (total grant received is credited to Income and Expenditure account) for recurring and non-recurring purpose.

3. Notes to Accounts:

a) Society is having 10(23C) Registration under Income Tax Act as per order No. AACAN1437HA20206 dated 09-07-2021.

b) During the year, the entity acquired assets totaling ₹6,77,17,403. Additionally, assets amounting to ₹14,43,313 were transferred from external projects.

c) A certain portion of surplus from CONY (Consultancy) projects are transferred to MACIS (Marine and Coastal Information) Project division and the remaining portion is transferred to Corpus Fund.

d) Grant amount received and its related expenditures of Operations and Maintenance (OPMA) of NCESS is only routed through Income and Expenditure Account. Grant receipts and expenses relating to Research and Development Programs and Major Works are routed only through Unspent Balances GOI - MoES (Schedule-5) of Financial Statements.

e) As per the General Financial Rules (GFR), any interest earned from funds related to government grant-utilizing projects must be refunded to the Consolidated Fund of India. During the year, a total interest amount of ₹41,94,246. was refunded to the government in compliance with these rules.

f) The allocation of Research and Development (R&D) grants, may vary from the Sanction Orders due to adjustments made by the Programme Division (PD) of MoES through the Central Nodal Agency (CNA) model on the PFMS platform. However, the data for OPMA and Major Work funds should align with the Sanction Orders as these funds are routed through the conventional PFMS system.

During the year, the grant amounts received were as follows:

OPMA Grants	: ₹16,00,00,000
R&D Grants	: ₹4,08,55,687
Major Works Grants	: ₹1,00,00,000