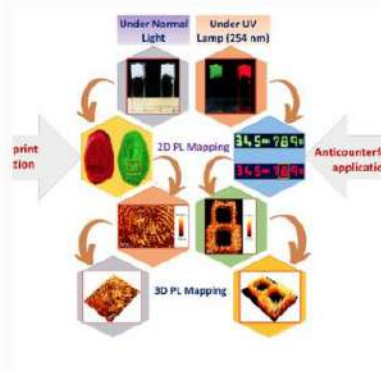
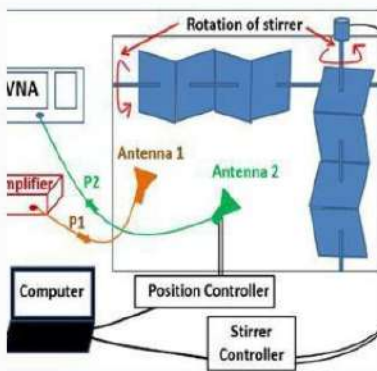


सीएसआईआर-एनपीएल CSIR-NPL



2023- 2024
ANNUAL
REPORT

Annual Report

2023-2024



सीएसआईआर - राष्ट्रीय भौतिक प्रयोगशाला
CSIR-National Physical Laboratory
(राष्ट्रीय मापिकी संस्थान)
(National Metrology Institute)
नई दिल्ली/ New Delhi



सी एस आई आर-राष्ट्रीय भौतिक प्रयोगशाला
(भारत का राष्ट्रीय मापिकी संस्थान)
CSIR-NATIONAL PHYSICAL LABORATORY
(National Metrology Institute of India)



डॉ. के. एस. कृष्णन मार्ग, नई दिल्ली - 110012, भारत / Dr. K. S. Krishnan Marg, New Delhi - 110012, India
www.nplindia.in

गुणवत्ता नीति : Quality Policy

अंतरराष्ट्रीय मानकों के अनुरूप सतत अनुसंधान और विकास के माध्यम से राष्ट्रीय मापन मानकों का प्रापण, स्थापना, रखरखाव व उन्नयन करना और भारतीय निर्देशक द्रव्य (बी एन डी) का विकास/उत्पादन करना।

आई एस/आई एस ओ/आई ई सी 17025 : 2017 की आवश्यकताओं के अनुरूप ग्राहकों को मापन की अनुमार्गणीयता बनाए रखने के लिए शीर्षस्तरीय अंशांकन/परीक्षण सेवाओं तथा मानकों का प्रसार निष्पक्ष और प्रभावी ढंग से प्रदान करना।

आई एस/आई एस ओ 17034 : 2016 की आवश्यकताओं के अनुरूप प्रयोक्ताओं हेतु अनुमार्गणीयता के प्रसार के लिए बी एन डी का विकास/उत्पादन करना और निर्देशक द्रव्य उत्पादकों (आर एम पी) को बी एन डी के विकास/उत्पादन में तकनीकी सहायता प्रदान करना।

To realize, establish, maintain and upgrade the national standards of measurement compatible to international standards and to develop/produce Bharatiya Nirdeshak Dravya (BND®), through continuous research and development.

To provide apex level calibration/testing services and dissemination of standards for maintaining the traceability of measurements to the customers fulfilling the requirements of IS/ISO/IEC 17025 : 2017, impartially and effectively.

To develop/produce BNDs for disseminating traceability to the users and to provide technical support to the Reference Material Producers (RMPs) in the development/production of BNDs, conforming to the requirements of IS/ISO 17034 : 2016.

उद्देश्य : Objectives

ग्राहकों/प्रयोक्ताओं की संतुष्टि के लिए निर्दिष्ट समय-सीमा में निष्पक्षता व सक्षमता से अंशांकन/परीक्षण सेवाएं और बी एन डी प्रदान करना।

अंशांकन, परीक्षण व बी एन डी विकास/उत्पादन से संबंधित सभी कर्मियों को गुणवत्ता प्रणाली प्रलेखन तथा नीतियों और प्रक्रियाओं के कार्यान्वयन से परिचित कराना।

To provide calibration/testing services and BND within the specified time, impartially, competently and to the satisfaction of the customers/users.

To familiarize all personnel concerned with calibration, testing and BND development/production with the quality system documentation and implementation of policies and procedures.

प्रो. वेणु गोपाल आचन्टा
निदेशक

Prof. Venu Gopal Achanta
Director

CSIR-NPL: Vision and Mandate



Shri Narendra Modi
Hon'ble Prime Minister
President, CSIR



Dr. Harsh Vardhan
Hon'ble Minister of State (I/C),
Ministry of S & T & Ministry of Earth
Sciences, MoS in the Prime Minister's
office, Ministry of Personnel, Public
Grievances & Pensions, Department of
Atomic Energy, Department of Space
Vice President CSIR



Dr. N Kalaiselvi
Director General,
CSIR and Secretary DSIR



Prof. Venugopal Achanta
Director, CSIR-NPL

Vision and Mission

“Accurate and precise measurement are essential to drive the growth engines of Indian Science & Industry as it removes chaos and prompts innovations, which in turn, would save precious lives, resources and time....

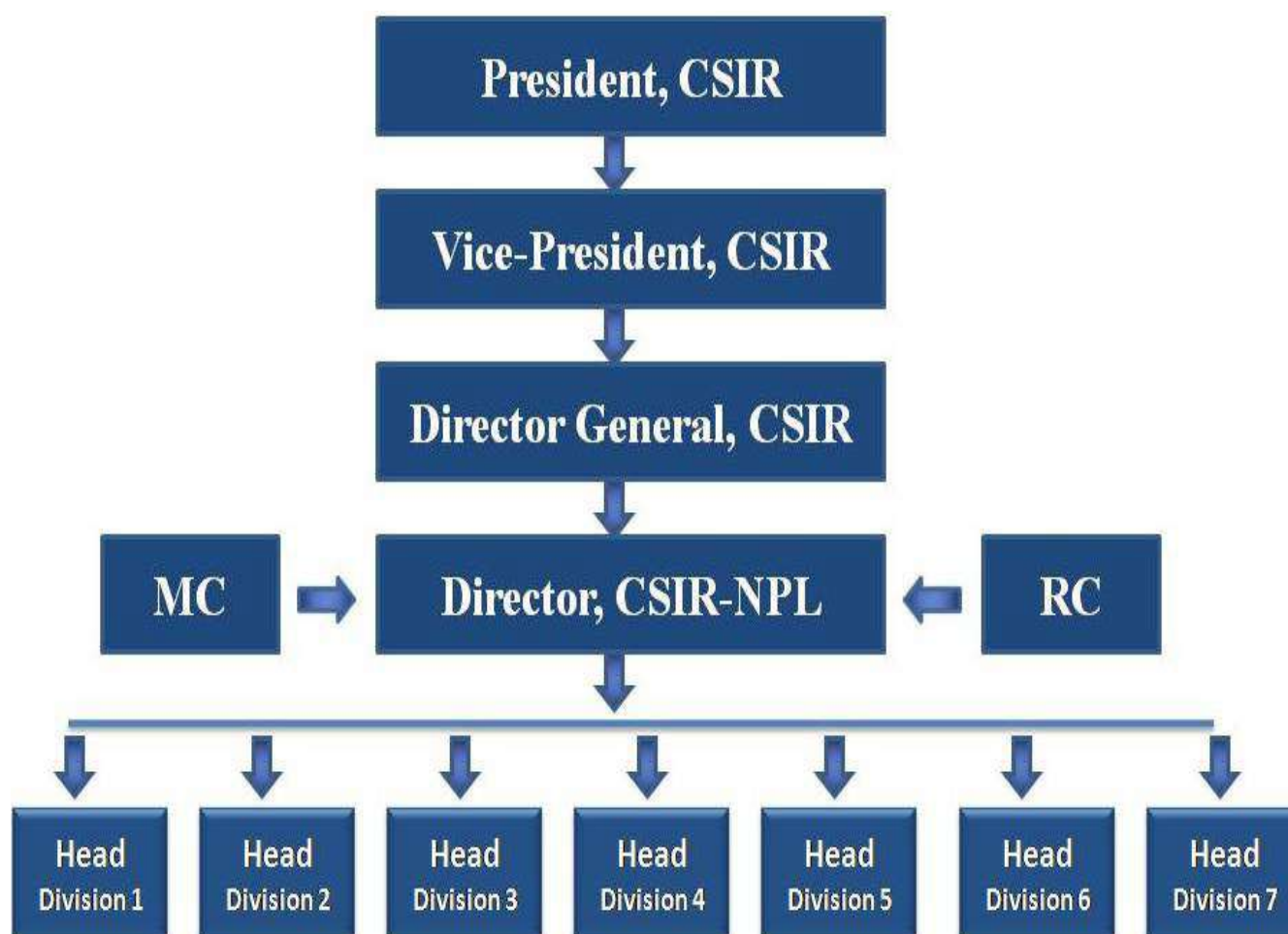
- a) *Developing India's measurement standards that are internationally accepted and disseminating the measurement capabilities to industry, government, strategic and academia that underpin the India's prosperity and quality of life.*
- b) *Conducting multidisciplinary R&D with a mission to establish the futuristic quantum standards and upcoming technologies so that India remains on par with international measurement laboratories.*
- c) *Developing sophisticated analytical equipments (i.e. import substitutes) under “Make in India” programme to cater the ever increasing demands of emerging India.*
- d) *Training of young scientists and industry personnel in the area of measurements under “Skill India” programme.*

Mandate

CSIR-National Physical Laboratory (NPL-India) is mandated to be India's “National Metrology Institute” (NMI) by the act of Parliament and is the custodian of “National Standards” with a responsibility of the dissemination of measurements to the needs of the Country.

Organizational Structure

CSIR-NPL: Assuring Quality of Life



- | | |
|---------------------------|--|
| <u>Division 1:</u> | Physico-Mechanical Metrology |
| <u>Division 2:</u> | Electrical & Electronics Metrology |
| <u>Division 3:</u> | Environmental Sciences and Biomedical Metrology |
| <u>Division 4:</u> | Advanced Materials and Device Metrology |
| <u>Division 5:</u> | Bharatiya Nirdeshak Dravya (BND®): Indian Reference Materials |
| <u>Division 6:</u> | Indian Standard Time Metrology |
| <u>Division 7:</u> | Directorate |

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Preface



It gives me immense pleasure to present the annual report of the CSIR–National Physical Laboratory (CSIR-NPL) for 2023–2024, a year marked by scientific ambition, purposeful innovation, and unwavering dedication to strengthening India’s measurement ecosystem. Recognized by an Act of Parliament as the National Measurement Institute (NMI) of India,

CSIR-NPL stands as the custodian of the national measurement standards. Our duty extends far beyond maintaining a set of international benchmarks. CSIR-NPL ensures that precision, reliability, and scientific integrity flow into every aspect of the nation’s quality of life- from industrial production and global commerce to healthcare, environmental monitoring, and the daily experiences of citizens. As a premier hub of research in the Physical sciences, CSIR-NPL not only advances the frontiers of scientific research but also metrological traceability for national standards, advances R&D in emerging areas and contributes significantly to national missions. As a social responsibility, it continues to foster scientific temperament through outreach activities, empowers youth through skill development, and translation of scientific technologies for societal benefits. These collective efforts not only strengthen the quality infrastructure of the nation but also fuel India’s economic ambitions, supporting the stride toward a USD 5-trillion economy. Our partnerships—with the Quality Council of India, the Bureau of Indian Standards, the Legal Metrology Department, and several other national bodies—remain central to our mission. Together, we work to embed reliability, traceability, and trust into every measurement that shapes India’s development.

The major highlights of public outreach activities in the year 2023–24 were the **One Week One Lab** (OWOL) Programme along with multiple hands-on training programs covering the relevance of Dimensional Metrology, Pressure, Vacuum, Ultrasonic Metrology and Non-Destructive Testing, Air Quality Measurement, Advanced Materials Characterization,

Biomedical Metrology, Laser Interferometry etc. Under the aegis of OWOL, different programmes included were Startup/MSME/Industry Meet, Metrology Conclave, R&D Conclave & Women in STEM, Skill Conclave. The event was inaugurated by Hon'ble Minister of State (I/c), S&T, Dr. Jitendra Singh and aimed to create awareness about CSIR-NPL's work and its role in supporting various sectors. The OWOL programme ended with the Skill Conclave having a keynote address by Dr. R. Chidambaram, (Padma Vibhushan), former Principal Scientific Advisor, Govt. of India. He emphasized the need to generate new knowledge, and the importance of skills to add on to the knowledge. The other dignitaries that graced the occasion included the guest of honour, Dr. Nagahnumaiah (Director, CMTI, Bengaluru), and chief guest of the event, Prof. T. G. Sitharam (Chairman AICTE). The guests delivered visionary speeches highlighting the need to keep pace with new upcoming technologies to make India a 'Vishwa-Guru'. CSIR-NPL welcomed students, researchers, industry collaborators, and international participants to the labs, events, and workshops. Events such as the Rashtriya Boudhik Sampada Mahotsav/National IP Festival, International Workshop on Advanced Materials Challenges and Standardization needs for Net Zero Technologies (AMCSNZT-2023), VAMAS Steering Committee Meeting (October 9-12, 2023), AcSIR India - RMIT University One-day Workshop, Stakeholder's meet, IISF 2023 outreach programme, and visits of foreign delegations added new depth to our national and global engagement. CSIR-NPL's participation in Bharat Parv, Technical Peer-Reviews, Quality Management System Training Programs on ISO/IEC 17025 & ISO/IEC 17011, and various science festivals helped foster the spirit of metrology among the common citizen. World Environment Day, with the theme 'Solutions to Plastic Pollution', was celebrated, and a Stakeholders Meet on 'Traceable PMU Usage to Enhance Power Grid Reliability' was held to discuss the adoption of traceable Phasor Measurement Units (PMUs) for enhancing power grid reliability. CSIR-NPL maintains copies of the Original Constitution of India kept in the Parliament Library in a controlled micro-environment for its long-term preservation. Dr. (Mrs.) N. Kalaiselvi, Secretary DSIR and DG CSIR, made a maiden visit to oversee the preservation activity, along with Prof. Venu Gopal Achanta, Director CSIR-NPL. The inaugural function of the Azadi Ka Amrit Mahotsav -IP Campaign was graced by Hon'ble Minister of State (I/c), S&T, Dr. Jitendra Singh at CSIR-NPL on June 30, 2023. A two-days Conclave for Metro officials on 'Noise and Vibration Conclave for Metro Rail Transit Systems' at CSIR-NPL was held on August 24 – 25, 2023. The year witnessed the signing of several crucial

agreements and MoUs, each aimed at empowering national capability in security, quality assurance, and scientific instrumentation. An Agreement for collaborative project for “Design and Development of Smart Noise Tracker for Noise Monitoring and e-Sound Limiter for Noise Control” was signed between CSIR-NPL and M/s DISTRONIX, 62/44, SATIN SEN SARANI, KOLKATA, WEST BENGAL. An MoU was signed between CSIR-NPL (NMI of India) and National Institute of Ocean Technology (NIOT, Chennai, Designated Institute of India for Underwater Acoustic) in January 2024 for five years, for providing guidance on quality system based on IS/ISO/IEC 17025 : 2017 and conducting peer review so that NIOT can publish CMCs on Underwater Acoustic in the BIPM KCDB. An Agreement with M/s Envirotech Instruments Private Limited, A-271 Okhla Industrial Area, Phase-1, New Delhi, licensing of know-how “Six-stage bioaerosol air sampler and sampling probe for BFE testing of mask” was signed on April 18, 2023, at CSIR-NPL. Another Agreement on Development and Fabrication of Bipolar Graphite Plates using Needle Coke was signed between CSIR-NPL and Research and Development Centre, Indian Oil Corporation Limited, Faridabad. During the year 2023-24, CSIR-NPL signed 7 MoUs with other academic institutes/Universities. These collaborations represent our shared commitment to indigenous technologies, closely aligned with the national missions of **Make in India** and **Atmanirbhar Bharat**. A broad spectrum of in-house and externally funded projects pushed forward innovation across various sectors, including healthcare, clean energy, advanced electronics, environmental safety, and national security. New testing and calibration facilities were established to address critical national needs.

Among the many achievements of the year, several are particularly noteworthy, such as Participation in International Key Comparison CCL- K11 (For Iodine Stabilized He-Ne laser frequency), Successful Installation of New Mechanical gauge block comparator and optical frequency comb, Establishment of IR Calibration facility upto -40°C, Establishing measurement equivalence with another NMI by performing Hybrid comparison with METAS Switzerland (APMP.PR-H1.2023), Installation of two new high-resolution DMP 41 digital indicators with 1 MN and 3 MN force machines for calibrating force proving rings and digital load cells, with calibration range capacities ranging from 100 kN to 3000 kN, Establishment of new facility for hardness calibration, Initiation of bilateral interlaboratory comparison between National Physical Laboratory, (NPL India), and the National Institute of Standards and Technology (NIST USA), in the pressure measurement range from 0.4

MPa to 4.0 MPa, in the pneumatic pressure region, Maintenance of the primary standard of sound pressure through absolute calibration of standard condenser microphones in coupler cavity by the reciprocity technique in the frequency range 1 Hz to 25 kHz with an expanded uncertainty of ± 0.17 dB, Maintenance of the primary standard of vibration amplitude through absolute calibration of standard accelerometer by Laser interferometer technique in the frequency range 0.1 Hz to 20 kHz with accuracy better than ± 1.2 %. Technical services projects were undertaken for various private manufacturers in the country to provide testing and calibration services for Acoustical materials in Reverberation chambers and sound impedance tube facility, International Key Comparison AFRIMETS.AUV.V-K5 pilot by NMI South Africa as Pilot laboratory with three other participating laboratories in March-April, 2023, Installation and commissioning of top loading calibration setup, Installation and commissioning of Rotary Positive Displacement (RPD) Meter calibration set-up for low frequency output, Inspection of Municipal Corporation of Greater Mumbai Water Meter Test Benches supplied by M/s. Nagman Flow-level Systems and Solutions LLP, Chennai and its suitability for use in testing of water meters, Participation in APMP Key Comparison (APMP.M.FF-K1.1.2022) on water flow, Range Extension of Gas Flow Calibration System from 1000 L/min to 2000 L/min, enhancing CSIR-NPL's capability to calibrate a diverse range of gas flowmeter, development of ultrathin films of WTe_2 (a type of Weyl semimetal) on flexible plastic (PET) substrates by FIB lab, Establishment of type testing, calibration & certification facility for OCEMS & CAAQMS Preliminary suitability test of AUM Air monitoring device (Pre-certification test), Development of Novel Lanthanide Coordinated Luminescent Hydrogels for Anticounterfeiting and Fingerprint Detection Applications, Demonstration of electronically triggered tunable terahertz signal in LPCVD grown single layer graphene. In the year 2023-2024, six new BNDs i.e. BND-5008, BND-5009, BND-5061, BND-5062, BND-5063, BND-5064 were released for cement and building materials along with the new batches of ongoing BNDs. Release of BNDs for Selenium standard solution (BND® 1034), Bromate Standard Solution (BND® 1035) and Conductivity Standard Solution (BND® 1041) on World Metrology Day – 2023, and CSIR-NPL Foundation Day-2024. Among other notable achievements were procurement of atomic clocks and related infrastructure, installation of Active Hydrogen Masers at DRC Bangalore, and advanced procurement of IT and power systems for the nation-wide IST dissemination project funded by MoCA,

Finalization of Jio's dark fiber link between CSIR- NPL and RRSL Faridabad, Development of CSIR-NPL disciplined oscillator, Revival of indigenously developed Primary Frequency Standard (NPLI-CsF1), Re-establishment of National Standards for Microwave Power at 50 GHz with improved uncertainty from $\pm 1.9\%$ to $\pm 1.3\%$. On the upgradation of national standards, the 7.0 mm Coaxial Microcalorimeter System, serving as the primary standard for microwave power at 18 GHz, has been re-established with enhanced accuracy, reducing the measurement uncertainty from $\pm 0.7\%$ to $\pm 0.4\%$. These advancements mark a pivotal step in improving the precision of microwave power measurements. The primary standard for Low Frequency (LF) Voltage and LF Current, based on Multi-Junction Thermal Converters (MJTC), has been evaluated for its AC/DC transfer difference at 2 V and 5 mA. Participation in intercomparisons has reinforced measurement capabilities and global collaboration APMP.EM.RF-K8.CL for Microwave Power and APMP.EM-S8 for LF Voltage and Current. The Electromagnetic Metrology section has a significant role in maintaining and upgrading National Standards related to electrical and magnetic parameters through continuous development, and providing calibration/test services (as per ISO/IEC guidelines) to more than 120 customers. Each of these achievements reflects months—sometimes years—of perseverance, collaboration, and scientific curiosity. Science thrives through collaboration. This year, we established and expanded partnerships with several technology innovators. These alliances ensure that the solutions we develop not only advance science but also touch the lives of ordinary citizens.

CSIR-NPL researchers also received notable recognitions during the year 2023-2024. Dr. Govind Gupta received the MRSI-Distinguished Lectureship Award from the Materials Research Society of India (MRSI) for the year 2023-24. Dr. Bhanu Pratap Singh received BD Bangur Award 2023 from the Indian Carbon Society in the field of carbon science and technology for encouraging and promoting research work in the field of carbon. Dr. Shibu Saha received the prestigious 'APMP Young Metrologist Prize for Developing Economies - 2023' in recognition of his efforts in Asia Pacific Metrology Program (APMP) activities among young metrologists in developing economies. Dr. Kriti Tyagi received the Young Scientist Award 2023 by the International Society for Energy, Environment and Sustainability (ISEES), constituted by IIT Kanpur. Dr. Anshul Varshney received the IEEE Power and Energy Society Outstanding Engineer Award for 2023.

I would also like to extend my heartfelt gratitude to DG-CSIR, CSIR Headquarters, the Research Council, the Management Council, our industry partners, and all funding agencies for their constant support and guidance. Most importantly, I acknowledge the unwavering commitment of the CSIR-NPL family—our scientists, staff, students, and collaborators—whose passion fuels the institute's success. As we move forward, I firmly believe that our collective pursuit of precision and excellence will continue to elevate India's standing on the global scientific stage. Together, we will continue to advance the nation's metrology landscape, along with R&D in cutting-edge areas, and strive to contribute to the nation's growth, fueled by innovation, trust, and scientific progress.

(Prof. Venu Gopal Achanta)

Director, CSIR-NPL

CSIR-NPL: Enabling Quality Infrastructure

Users availing the calibration and testing services from CSIR NPL.

Government/PSU

DRDO, ISRO, Election Commission of India, CPCB, Indian Railways, Indian Airforce, Air India, BSF, BIS, Legal Metrology, DAE, CPRI, HAL, BHEL, BEL, GAIL, ONGC, IOCL, HPCL, Indian oil, State Electricity Boards, NTPC, Delhi Jal board, MSME Testing Centres, Ordnance Factory, Steel Authority of India and Scientific Institutes/Labs, Universities etc.

Private Sector/Industries

Tata Steel; Mysore Paints & Varnish; CK Birla Group; GE power systems; ABB India; ACC; AIMIL Ltd.; Alstom India; Ambuja Cement; Adani Electricity; Binani Cement; Blue Star; Bureau Veritas; Casio India; Crompton Greaves Limited; Diesel Locomotive Works; Essar Oil Ltd.; Godrej & Boyce Mfg. Co. Ltd; Havells India; Honda Cars; J.K. White Cement; JK Lakshmi Cement; Kirloskar Brothers; Larsen & Toubro; Maruti Suzuki; Philips India; Rapid Metro Rail Gurgaon; Samsung India; Honda Sael; Surya Roshni, Wipro consumer care & lighting; Orient Electric; ITC, Halonix Technologies, Astra lighting; Bharat Forge; Tektronix India; Fluke Technologies etc.

SAARC Nations

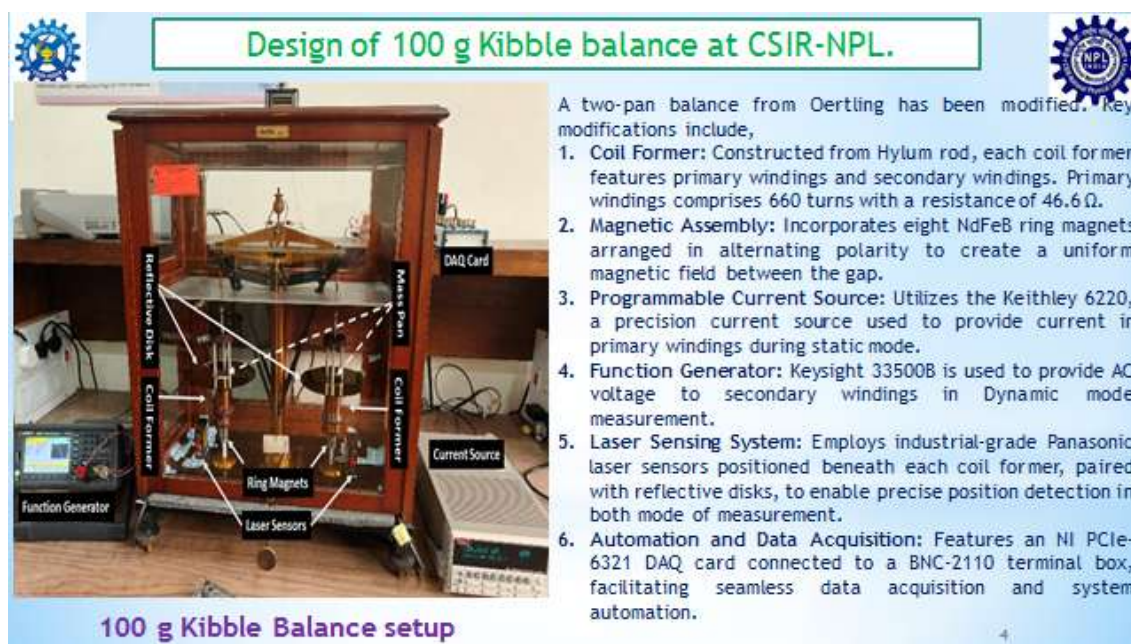
Nepal Bureau of Standards & Metrology (MBSM), Bangladesh Standards and Testing Institution (BSTI), Measurement Units, Standards and Services Department, Sri Lanka; National Physical and Standards Laboratory (NPSL), Pakistan; Bhutan Standards Bureau (BSB), Bhutan; Afghanistan National Standards Authority (ANSA), Maldives Standards and Metrology Unit



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Significant Contributions

Working Towards Upgradation of Two Pan Balance in to 100 g Kibble Balance under OLP-214832

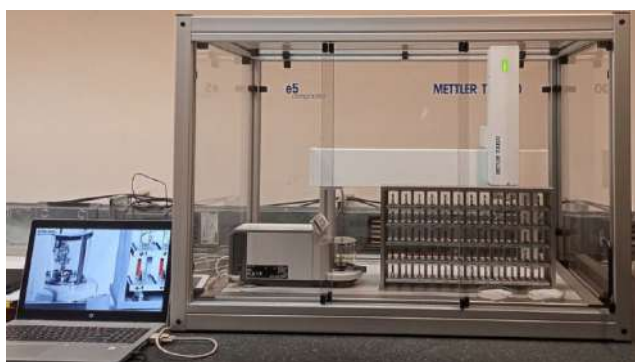


- A two-pan balance from Oertling has been modified. Key modifications include,
1. **Coil Former:** Constructed from Hylum rod, each coil former features primary windings and secondary windings. Primary windings comprises 660 turns with a resistance of 46.6 Ω .
 2. **Magnetic Assembly:** Incorporates eight NdFeB ring magnets arranged in alternating polarity to create a uniform magnetic field between the gap.
 3. **Programmable Current Source:** Utilizes the Keithley 6220, a precision current source used to provide current in primary windings during static mode.
 4. **Function Generator:** Keysight 33500B is used to provide AC voltage to secondary windings in Dynamic mode measurement.
 5. **Laser Sensing System:** Employs industrial-grade Panasonic laser sensors positioned beneath each coil former, paired with reflective disks, to enable precise position detection in both mode of measurement.
 6. **Automation and Data Acquisition:** Features an NI PCIe-6321 DAQ card connected to a BNC-2110 terminal box, facilitating seamless data acquisition and system automation.

Digital Alcoholmeters from U.P. Excise Department to be Supplied to Different Customers are Tested Continuously and Test Reports are Given



Robotic Mass Comparator has been Established at CSIR-NPL and the Operation has Commenced



Specifications

- Make: Mettler Toledo
- Name: e5 Robotic Mass Comparator,
- Maximum Capacity: 6.1 g,
- Readability: 0.1 μg
- Weight Handler: 3-axis robot
- Magazine position: 60 Automated Draft shield

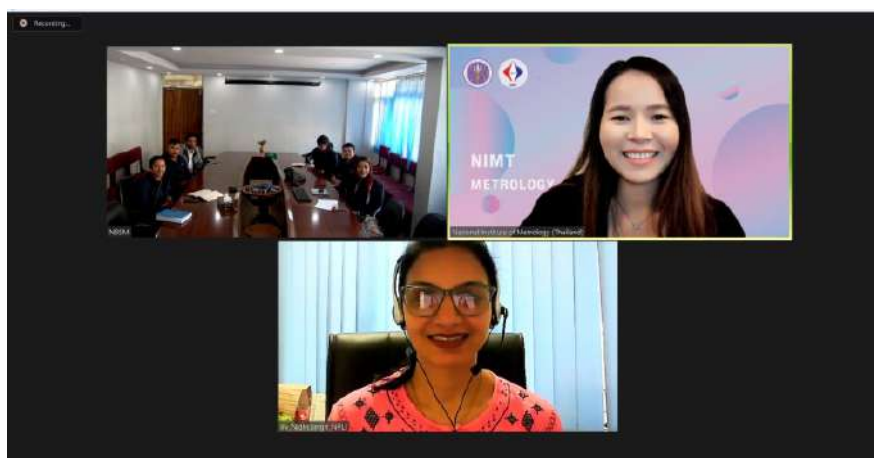
Using Up- graded **primary Solid density standard** from Manual to Semi-Automatic setup, reference hydrometers were calibrated which are being used to provide traceability.

Specifications of Automated System

- Bi directional honey comb bread board table with accuracy of 01 cm
- Imaging system with control unit & Camera with 20x mag. with display unit
- Cover with acrylic sheet on both sides
- Vibration free Granite surface plate for balance.
- Temperature controller unit with 0.01°C resolution
- Temperature bath with range: (10 - 80) °C

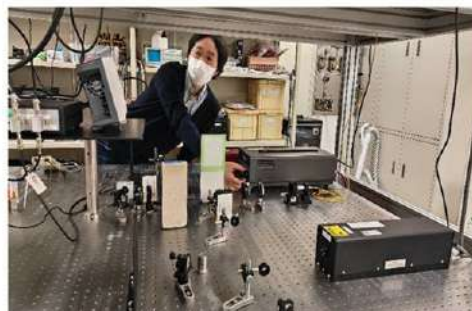
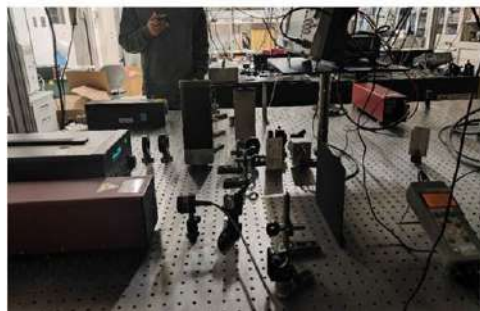
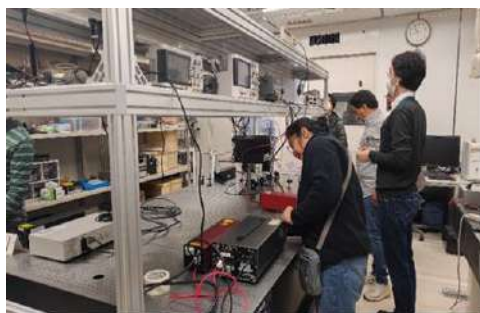


Participating in “APMP DEC CMC Task Force - Form of Evaluating the Status of the Laboratory” Meeting as Mentor of Mass for NBSM, Nepal and Co-mentor of Mass for Bangladesh Reference Institute for Chemical Measurements BRiCM. APMP DEC - CMC Task Force: Online Training on Mass Metrology, Calibration of Mass Standard, and Understanding of Calibration Certificate; Duration: (25 to 27) July, 2023; Three Invited Lectures; Trainees: Participants from APMP Region



International Key Comparison CCL- K11 (For Iodine Stabilized He-Ne laser Frequency)

International key comparison of Length Primary Standard is essential to prove our international equivalence, maintain our CMCs, and disseminate traceability down the line to ensure accurate and precise dimensional measurements. Six NMIs (CSIR-NPL India, NIM Thailand, SCL Hongkong, NMI Malaysia, SASO Saudi Arabia, and NMI Japan) participated in this intercomparison at the National Metrology Institute, Japan, from January 29-February 02, 2024. The draft A report for this comparison is under circulation.



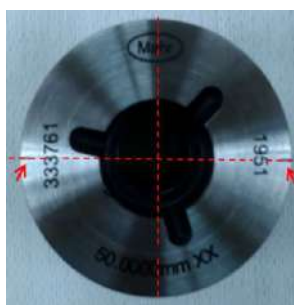
Measurements being taken at NMIJ Optical Frequency Measurement Lab

Draft A reports of the Key Comparisons EURAMET.L-K3.n01 (Angle Standards) and APMP.L-K4.n01.2021 (Diameter standards) have been Received, CSIR-NPLI Demonstrates Satisfactory Results in these Comparisons

CSIR NPL participated in the intercomparisons EURAMET.L-K3.n01 (Angle Standards) piloted INRIM Italy and APMP.L-K4.n01.2021 (Diameter standards), piloted by CMS/ITRI, Chinese Taipei. Draft A reports of the Key Comparisons have been received.



EURAMET.L-K3.n01 Artefact



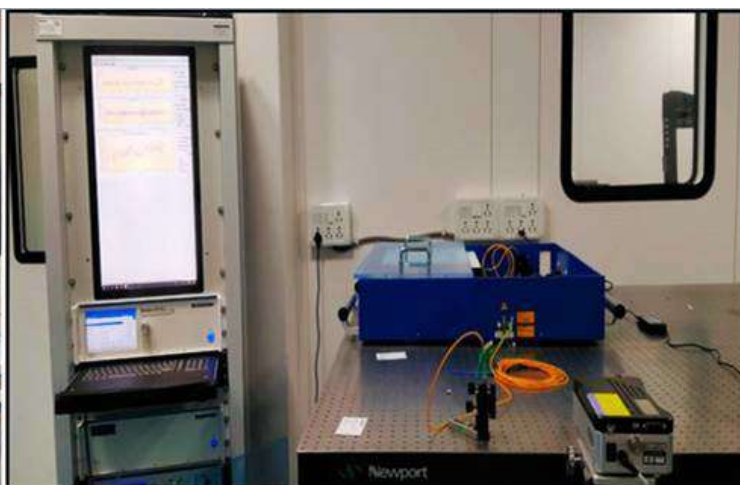
APMP.L-K4.n01.2021 Artefacts

Successful Installation of New Mechanical Gauge Block Comparator and Optical Frequency Comb



Mechanical Gauge Block Comparator

Measuring Range: 0.1 to 250 mm
Resolution: 0.001 μm
Measurement Uncertainty at $k=2$:
 $\pm(0.03+0.3L/1000) \mu\text{m}$, where L is
the length of the gauge block in
mm



Optical Frequency Comb

Optical Output Power: > 80 mW
Central Wavelength: $1560 \pm 20 \text{ nm}$
(original fibre laser)
Spectral Wavelength: 500 – 1000
nm
Second Harmonic Generation @
780 nm

Establishment of IR Calibration Facility upto -40°C



IR Thermometer and Thermal Imager Calibration Facility Down to -40 °C

We have established the calibration and testing facilities for temperature metrology in the range from -200 °C to 3000 °C, and humidity metrology in the range from 10% RH to 95% RH at -10 °C to 70 °C, Dew/frost point from -30 °C to 60 °C. Among these, the total radiation thermometry range was from 50 °C to 3000 °C and spectral radiation thermometry from 750 °C to 3000 °C, as per International Temperature Scale of 1990 (ITS-90). Recently, we have established the IR thermometry facility from -40 °C to 135 °C, to meet the increasing demand of calibration and testing in the field of non-contact thermometry in low temperatures, particularly for 8 m to 14 m total radiation thermometers and thermal imagers. The cylindrical metal cavity blackbody of 0.998

has been placed in the alcohol filled low temperature calibrator. The reference T90 temperature was assigned using SPRT calibrated on ITS-90 fixed points from Triple point of Ar (-189.33 °C to Freezing Point of Al (660.323 °C). The standard pyrometer (Heitronics, TRT IV.82 with spectral range 8 m to 14 m and temperature -50 °C to 1000 °C) was measured at various temperature points in the range from -40 °C to 135 °C. All the essential parameters such as emissivity, stability and uniformity of blackbody source, temperature drop, size-of-source, distance effect, emissivity setting on pyrometer, etc were measured and analysed, to compute the measurement uncertainty.

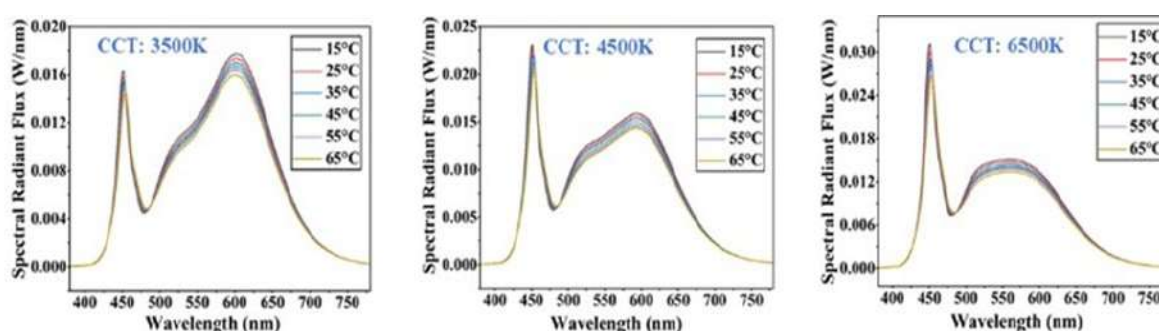
Hybrid Comparison with METAS Switzerland (APMP.PR-H1.2023)

In an attempt towards establishing measurement equivalence with another NMI, with a future goal of establishing Calibration and Measurement Capability (CMC) for photometric and colorimetric measurements of LED light sources by the systems established under the LED project, a comparison was conceptualised. Though, international key comparison has been the usual method for establishing the measurement equivalence, but owing to reasons like long time intervals between the inter-comparisons, lengthy process, etc., Asia-Pacific Metrology Programme (APMP) has established the process of Hybrid Comparison.

With the approval of Technical Committee on Photometry & Radiometry (TCPR) Chair, a Hybrid Comparison (APMP.PR-H1.2023) has been initiated with METAS, Switzerland.

Commissioning of Sphere Spectroradiometer

The Sphere Spectroradiometer is an important system in the LED Photometry laboratory. The system has the capability of carrying out temperature dependent photometric and colorimetric measurements. The system primarily measures total luminous flux of lamps and luminaires with a very short turn-around-time. Apart from this the system is capable of measuring a number of parameters like Total Radiant Spectral Flux, CCT, Color coordinates, Color Space Diagrams, etc. Measurements related to commissioning of the system were carried out. A sample of temperature dependent spectral profiling of a light source is presented in the following figure.



Temperature dependant Measurements of LED Light Emitting Spectra of different CCTs

Upgradation of 1 MN and 3 MN Machines

Two new high-resolution DMP 41 digital indicators have been installed with 1 MN and 3 MN force machines for calibrating force proving rings and digital load cells, with calibration range capacities ranging from 100 kN to 3000 kN.



1 MN Force Primary Machine is Up-gradated using a High Resolution DMP 41 Indicator



A High Resolution DMP 41 Indicator is Installed with 3 MN Force Standard Machine

Establishing New Facility for Hardness Calibration

A new Rockwell hardness machine has been installed for providing calibration in Rockwell hardness scales.



A Rockwell Hardness Machine

The calibration requirements within this range are in high demand due to numerous ongoing construction projects in major metropolitan areas, such as metro rail construction, high-rise residential building projects, bridges, flyovers, reservoirs, and dams.

Bilateral Comparison with NIST USA (APMP.SIM. M. P-K1c.2023)

A bilateral interlaboratory comparison between National Physical Laboratory, NPLI (India), and the National Institute of Standards and Technology (NIST), USA, was initiated in the pressure measurement range from 0.4 MPa to 4.0 MPa, in the pneumatic pressure region. The objective of the project was to compare the performance of pneumatic pressure standards in



Characterization of NPLI-4 (Transfer Standard) against NPLI-8A (Secondary Standard)

participating institutes in gauge mode using nitrogen gas as the pressure-transmitting medium. The transfer standard is a piston-cylinder assembly provided by NPLI, which was to be compared to the pressure standards of each of the participating laboratories.

During the period, the transfer standard was characterized using our secondary standard (NPLI-8A), and measurement data were collected in the range of (0.4 to 4) MPa and processed for further analysis.

Primary Sound Calibration System

The standard of sound pressure, vibration amplitude and power. The primary standard of sound pressure is maintained through absolute calibration of standard condenser microphones in coupler cavity by the reciprocity technique in the frequency range 1 Hz to 25 kHz with an expanded uncertainty of ± 0.17 dB. The primary standard of vibration amplitude is maintained through absolute calibration of standard accelerometer by Laser interferometer technique in the frequency range 0.1 Hz to 20 kHz with accuracy better than ± 1.2 %.



Primary Vibration Calibration System

The primary standard transducers are calibrated by absolute method while secondary and measurement transducers are calibrated by comparison and transfer standard method respectively. The latest international standard 16063-11 specifies three calibration methods based on laser interferometer viz., Fringe counting method (FCM), Minimum point method (MPM) and Sine approximation method (SAM). The FCM can be used for sensitivity calibration in the frequency 1 to 800 Hz. The MPM is intended for sensitivity calibration in the frequency range 800Hz to 10 kHz. The SAM covers the frequency range 1 Hz to 10 kHz and additionally makes it possible to measure the phase lag between the mechanical input and the accelerometer output voltage. The accuracy of transfer standards like sound level calibrator (± 0.15 dB) and vibration level calibrator (± 1.5 %) is determined with the help of transducers calibrated by absolute methods.

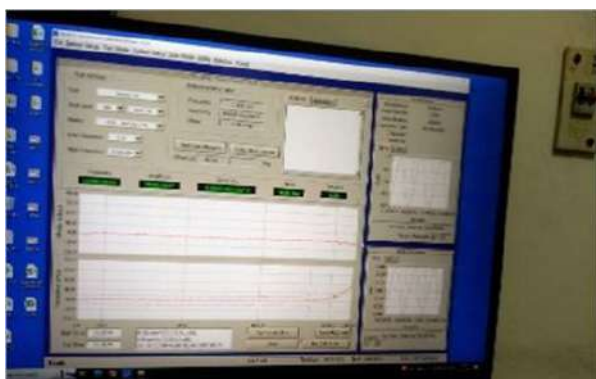


Building Acoustic Materials Testing

CSIR-NPL providing testing and calibration services for Acoustical materials in Reverberation chambers and sound impedance tube facility. Many technical services projects were undertaken for various private manufacturers in the country.



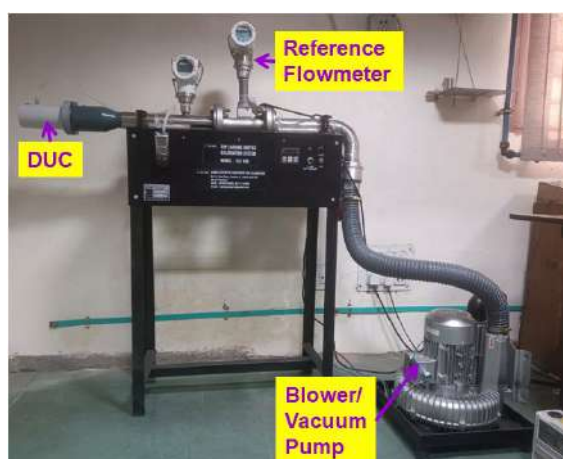
International Key Comparison AFRIMETS.AUV.V-K5 Pilot by NMI South Africa as Pilot Laboratory with 3 other Participating Laboratories in March-April, 2023



Artifacts circulated amongst various NMIs in the Key Comparison on Vibration Sensors

Installation and Commissioning of Top Loading Calibration Setup

A top-loading calibration setup has been successfully commissioned to support flow measurement in the range of 500 L/min to 2000 L/min. This advanced facility is designed to provide precise and reliable calibration services for high-volume air samplers, including High Volume PM₁₀ Samplers. By enabling accurate calibration across these critical flow ranges, the setup significantly strengthens measurement capabilities in air quality monitoring. This development will particularly benefit the environmental sector by ensuring enhanced reliability of data, improved compliance with regulatory standards, and greater confidence in environmental assessments, thereby contributing to better air quality management and policy implementation.



Top Loading Calibrator Setup

Installation and Commissioning of Rotary Positive Displacement (RPD) Meter Calibration Set-up for Low Frequency Output

A Rotary Positive Displacement (RPD) Meter Calibration system has been established, specifically designed for low-frequency output applications. RPD meters play a critical role in accurately measuring gas flow across various domains, including natural gas pipelines, compressed air networks, manufacturer's gas lines, and diverse environmental applications.



RPD Meter Calibration Set-up for Low Frequency & High Frequency Outputs

Inspection of Municipal Corporation of Greater Mumbai Water Meter Test Benches supplied by M/s. Nagman Flow-Level Systems and Solutions LLP, Chennai and its Suitability for Use in Testing of Water Meters

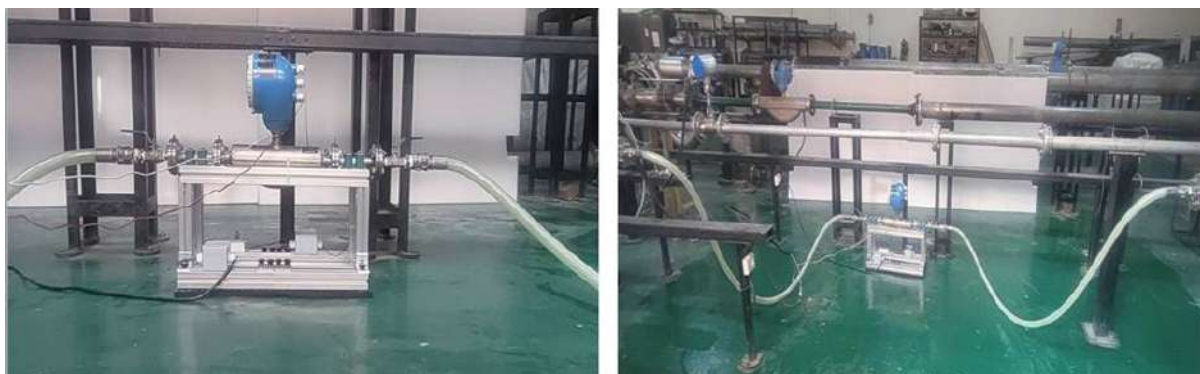
The technical service project titled “Inspection of Bulk Water Meter Test Benches of the Brihanmumbai Municipal Corporation (BMC)”, sponsored by M/s. Nagman Flow-Level Systems and Solutions LLP, Chennai, has been successfully completed in accordance with the agreed project plan. The request involved assessing a Bulk Water Meter Test Bench, Model WATCAL 80200C(S), supplied for BMC’s water meter testing facility in Mumbai. The system is intended for testing and calibration of bulk water meters ranging from DN80 to DN200 at nominal flow conditions. As part of their contractual commitment to BMC, M/s. Nagman engaged CSIR–National Physical Laboratory, New Delhi, to perform an independent inspection to evaluate the test bench’s suitability, performance, and compliance with required accuracy specifications.

Participation in APMP Key Comparison (APMP.M.FF-K1.1.2022) on Water Flow

The active participation in the APMP Key Comparison on Water Flow (APMP.M.FF-K1.1.2022) highlights our strong commitment to international metrology standards. The comparison, covering a flow range of 5 kg/min to 60 kg/min, involved eight National Metrology Institutes (NMIs): CMS/ITRI (Taiwan, Pilot Laboratory), KRISS (Korea), NMIM (Malaysia), NIMT (Thailand), NMJJ (Japan), NPLI (India), NMC (Singapore), and ITDI (Philippines).

For this exercise, we utilized a Coriolis Mass Flowmeter (DN15, Model: Promass F, Make: Endress+Hauser) as the artifact. The calibration was conducted at NPLI from May 1 to May 20, 2023, with measurements carried out at six flow points: 5, 10, 20, 30, 40, 50, and 60 kg/min.

Our contribution to this comparison not only validates the accuracy and reliability of our measurement capabilities but also fosters collaboration and knowledge exchange among leading NMIs in the Asia-Pacific region. Such initiatives strengthen global measurement frameworks, supporting industries, research, and regulatory compliance worldwide.



The Artifact i.e. Coriolis Mass Flowmeter installed in Primary WFCF

Range Extension of Gas Flow Calibration System

We've expanded the flow range of our Gas Flow Calibration Facility from 1000 L/min to 2000 L/min, enhancing CSIR-NPL's capability to calibrate a diverse range of gas flowmeters. This extension enables calibration of instruments with pulse/frequency output, including Mass Flowmeters, top loading calibrators, and root meters. To support this upgrade, a new air compressor system capable of delivering 2000 L/min has been installed, complemented by the procurement of a 1000 L/min sonic nozzle. With these enhancements, we're equipped to meet the evolving needs of industries reliant on precise gas flow measurement, further solidifying CSIR-NPL's position as a leader in metrology services.



Air compressor

Air Receiver

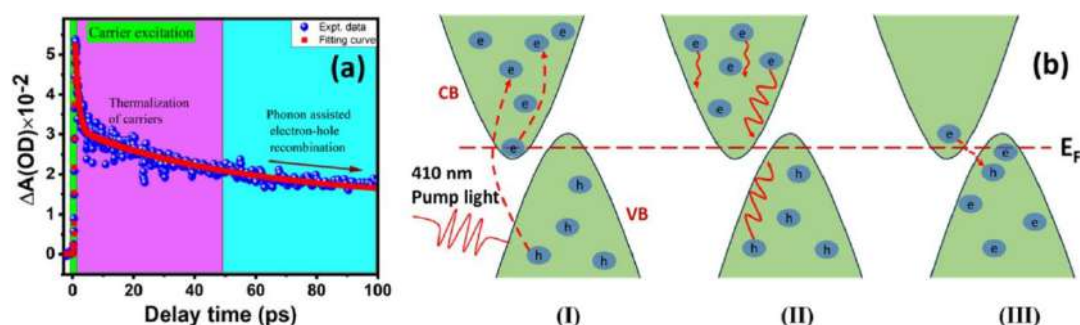
Fluke Sonic nozzles with Mass Flow Terminal

Gas Flow Calibration System for 2000 L/min

Ultrafast Carrier Dynamics in Flexible WTe_2 Thin Films

FIB lab has developed ultrathin films of WTe_2 (a type of Weyl semimetal) on flexible plastic (PET) substrates and studied how fast they respond to laser light. Using femtosecond laser pulses, they explored how electrons inside these films absorb light and lose energy over time. They observed three key steps in this relaxation process: (1) rapid electron-phonon interactions, (2) slower phonon scattering, and (3) the slowest

step—electron–hole recombination. Interestingly, thicker WTe_2 films retained the excited electrons for longer, showing better energy retention, which is vital for devices that rely on fast electrical responses. Unlike traditional semiconductors, WTe_2 can detect a broader range of light (from UV to infrared), and the flexible PET substrate makes the entire system lightweight, robust, and low-cost. These features make WTe_2 films ideal candidates for the next generation of ultrafast optoelectronic devices. It proves that combining quantum materials like WTe_2 with everyday plastics could transform future tech.



The above image shows how WTe_2 , a unique quantum material known as a Weyl semimetal, responds to ultrafast laser light. When a laser pulse of 410 nm hits the thin WTe_2 film, it excites electrons from the valence band (VB) to the conduction band (CB), creating mobile charge carriers (electrons and holes). This process, shown in part (b-I), starts the ultrafast dynamics. In the next step (b-II), the excited electrons quickly lose excess energy by interacting with atomic vibrations in the lattice—called phonons—a process known as thermalization. Finally, in step (b-III), the electrons recombine with holes, but in WTe_2 , this doesn't happen directly. Due to its special band structure, the electron and hole don't line up perfectly in momentum space, so phonons must help them meet, making the recombination non-radiative and slower. Part (a) shows how these processes unfold over time. The sharp rise at the beginning shows the instant the laser excites the carriers. This is followed by a steep drop (pink region), where the carriers rapidly lose energy through thermalization. After that, in the blue region, the signal decays more slowly due to phonon-assisted recombination. This three-step behavior—fast excitation, rapid cooling, and slower recombination—is characteristic of WTe_2 and is what makes WTe_2 ideal for ultrafast optoelectronic devices.

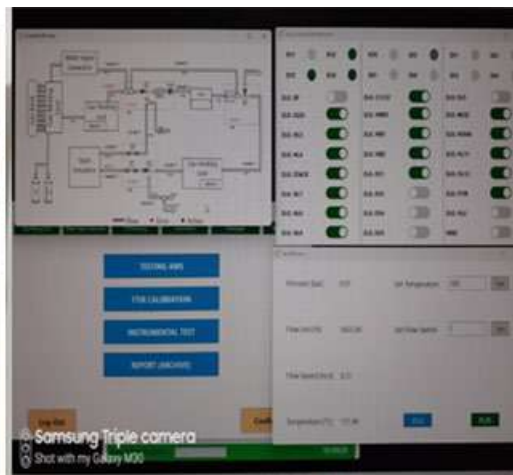
Successful Technical Peer Review was done on Feb 2024. Intra-RMO Review is Successfully Completed for 4 CMCs in Gases at KCDB



Establishment of Type Testing, Calibration & Certification facility for OCEMS & CAAQMS Preliminary Suitability Test of AUM Air Monitoring Device (Pre-Certification Test)



Stack Simulator



Control Unit

CSIR-NPL has set up India's first dedicated facility for type testing, calibration, and certification of Online Continuous Emission Monitoring Systems (OCEMS) and Continuous Ambient Air Quality Monitoring Systems (CAAQMS), including conformity tests of Air Monitoring Devices. This facility ensures that monitoring instruments undergo rigorous pre-certification evaluation under Indian environmental conditions, which differ significantly from those in countries where most devices are originally certified. By establishing this capability, CSIR-NPL provides a national framework for quality assurance, enabling industries, regulators, and researchers to rely on standardized, credible emission and ambient air quality data.



Novel Lanthanide Coordinated Luminescent Hydrogels for Anticounterfeiting and Fingerprint Detection Applications

CSIR-NPL has developed a new luminescent security ink based on Tb-BTC and Eu-BTC hydrogels which have attracted attention for anticounterfeiting and fingerprint detection applications. This innovative ink, synthesized using the trimesic acid (H_3BTC) as organic ligand and lanthanide ions (Tb^{3+} and Eu^{3+}), appears white under normal light but emits vivid green and red colours under UV light due to specific electronic transitions. The hydrogels' structure, morphology, chemical

composition, and photoluminescent properties have been thoroughly analysed through advanced techniques, confirming their unique features. This ink offers colour tunability, ranging from green to red, by adjusting the ratios of Tb^{3+} and Eu^{3+} and shows promising features for direct screen printing on various substrates, enabling enhanced security features. Additionally, the ink's ability to detect latent fingerprints on different surfaces further demonstrates its potential for forensic applications as shown in the figure. This breakthrough opens new possibilities in security printing and forensic science.

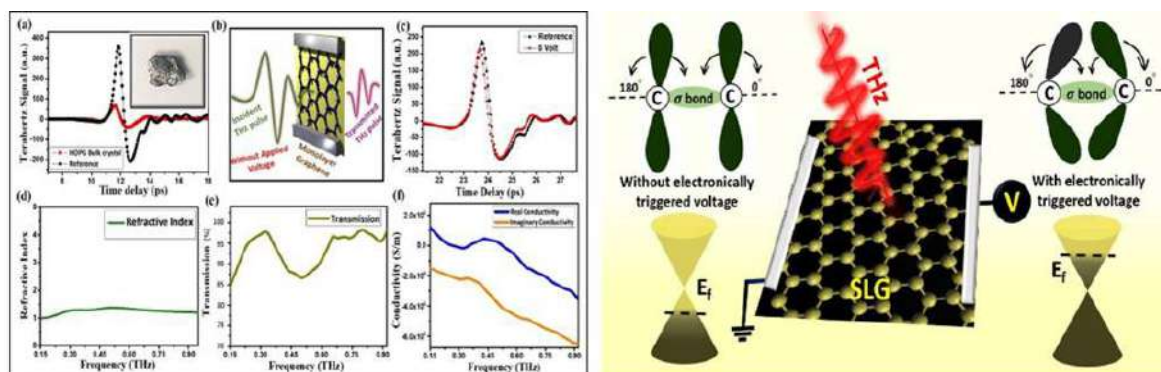


Eu-BTC and Tb-BTC Hydrogels for Detection of Fingerprint on Black Paper for Forensic Application and some Characters Printed on Black Paper by using Screen Printing Technique for Anticounterfeiting Applications

Demonstration of Electronically Triggered Tunable Terahertz Signal in LPCVD Grown Single Layer Graphene

CSIR-NPL has developed a successful strategy to synthesize a low-cost, highly reproducible high-quality SLG by an indigenously developed LPCVD setup for THz applications. In this perspective, the THz-TDS on LPCVD grown SLG at room temperature has been demonstrated to probe the accurate, rapid, and non-destructive response in the high frequency range (0.2 to 0.95 THz). This enables us to quantitatively analyse several frequency dependent optoelectronic parameters such as transmissions, refractive index, and sheet conductivity of SLG in the THz range. Moreover, a comparative THz study between SLG and its bulk equivalent (HOPG) is shown to validate the selectivity of SLG as compared to HOPG bulk crystal towards the proposed THz applications. The obtained THz signal intensity of SLG is four times higher as compared to HOPG bulk crystal, which clearly suggests the selectivity of SLG for THz applications. The estimated values of refractive index, transmission and conductivity of SLG have been found to be 1.4, ~95% and $\sim 10^6$ (in order of), respectively, without any electronically triggered voltage. Moreover, the interesting tuneable THz characteristics of SLG have been confirmed through electronically triggered applied voltages on SLG surfaces at room temperature. The achieved tuneable THz parameter values of refractive index, transmission and conductivity of SLG vary from 1.4 to 1, from ~95% to ~99% and from $-3.42 \times 10^6 \text{ S m}^{-1}$ to $-3.84 \times 10^6 \text{ S m}^{-1}$, respectively, under the triggering voltages. The observed tuneable characteristics of SLG on the light of delocalized π electrons as well as shift in Fermi levels are successfully proposed as

plausible mechanisms as shown in the following figure. Thus, the present investigations provide us with a new concept to create tuneable THz characteristics for SLG to design next-generation THz quantum devices.



Terahertz time domain spectroscopy (THz-TDS) of HOPG bulk crystal and as grown SLG on sapphire substrate at room temperature without application of voltage. (a) THz signal transmitted through HOPG bulk crystal; (b) schematic representation of THz-TDS of SLG; (c) THz signal transmitted through SLG transferred; (d) Refractive index of SLG; (e) Transmission of SLG; (f) Real conductivity and Imaginary conductivity of SLG; at zero voltage and plausible mechanisms

Bharatiya Nirdeshak Dravya: Strengthening National Quality Infrastructure

To achieve global competence across public, private, strategic, and societal sectors of any economy, more stringent metrological regulations in trade and commerce are essential. Partial compliance with an unbroken chain of measurements and associated traceability often weakens the quality infrastructure. As India is transiting rapidly from a developing to a developed economy, strengthening its quality infrastructure and manufacturing capabilities becomes critical. The availability of indigenous standards and certified reference materials (CRMs) plays a pivotal role in this endeavour. The indigenously developed certified reference materials (CRMs) have been trademarked as *Bharatiya Nirdeshak Dravyas* (BNDs) by Council of Scientific & Industrial Research (CSIR). CSIR-NPL has taken a step forward for the development of BNDs in collaboration with ISO 17034 accredited reference material producers (RMPs) in various domains. The easy availability of BNDs are poised to play a significant role in strengthening India's quality infrastructure by enabling accurate testing and calibration and enhancing the reliability of measurements across industries. They support the "Make in India" initiative by aligning domestic standards with international benchmarks, thereby boosting the country's manufacturing capabilities and global competitiveness. The BND Division at CSIR-NPL is involved in the development of BNDs in the areas of cement and building materials, petroleum products, water testing, high-purity chemicals and solutions, precious metals and pharmaceuticals etc. A total of 150 BNDs have been produced to date at CSIR-NPL and in-collaboration with ISO17034 accredited reference materials producers (RMPs). These BNDs are made available to both Indian as and international market at highly competitive prices and have played a pivotal role in opening of new jobs and entrepreneurship opportunities. In the fiscal year 2023-2024, BND division of CSIR-NPL has released six new BNDs i.e. BND-5008, BND-5009, BND-5061, BND-5062, BND-5063, BND-5064 in area of cement and building materials along with the new batches of ongoing BNDs. These BNDs have efficiently served the Indian testing laboratories & industries, and have penetrated the international market of

SAARC countries. Further, CSIR-NPL has developed in-house BNDs for FT-IR calibration, X-Ray diffraction calibration and also precious metal BNDs.



Launch of BND-5008 on 24th December, 2023,
during the Foundation Day of NCCBM

Strengthening National Time Dissemination Infrastructure

CSIR-NPL led the establishment of five secondary timing laboratories and a Disaster Recovery Centre to enhance the nationwide dissemination of Indian Standard Time (IST). During 2023–24, major milestones included the procurement of atomic clocks and related infrastructure, installation of Active Hydrogen Masers at DRC Bangalore, and advanced procurement of IT and power systems. Jio's dark fiber link between CSIR-NPL and RRSL Faridabad was finalized, and the CSIR-NPL Disciplined Oscillator was tested for deployment. The policy documents on IST legalization were discussed with LM for further action.

Maintenance and Dissemination of Indian Standard Time

CSIR-NPL continued to maintain the national time scale UTC (NPLI) with traceability to UTC and provided traceable time and frequency services to strategic users. A significant achievement was the ongoing contract with ISRO for traceability of NavIC system time scales IRNWT-I and IRNWT-II through Two-Way Satellite Time and Frequency Transfer (TWSTFT) and GNSS CV. The National NTP Service, strengthened as per CERT-In directives, ensured wide dissemination of IST, with a stratum-1 NTP server operational at NIC to support critical infrastructure.

Capacity Building, Collaboration, and Leadership

Numerous review meetings and stakeholder interactions were organized with the Ministry of Consumer Affairs, ISRO, Legal Metrology Department, and RRSLs to monitor and accelerate development of national infrastructure. Training on Time and Frequency Metrology was provided to project staff, and recruitment drives were conducted to expand technical capacity of Time and Frequency Metrology under Project TSP180932. CSIR-NPL represented India at APMP and BIPM forums, contributing to international discussions on UTC and time dissemination. Engagements with NIC, DoT, IIT Kanpur, Burdwan University, Reliance Jio, ONGC, and other agencies strengthened collaborative networks essential for national timing resilience.

National Metrological Services and Revenue Generation

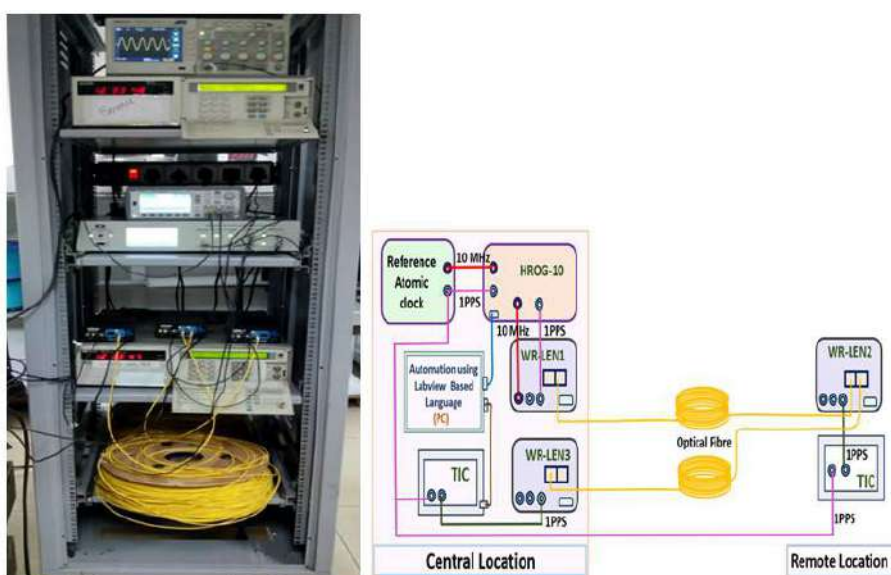
The Time and Frequency Metrology Section continued its role as the authorized national provider of traceable calibration services for high-precision frequency standards, GPS receivers, and timekeeping instruments. The section remained the highest-earning unit of CSIR-NPL, underlining its critical contribution to the laboratory's mandate.

Revival of Indigenous Primary Frequency Standard (NPLI-CsF1)

India's first and indigenously developed primary frequency standard has been operationalized. Efforts are ongoing to ensure its sustainable operation and evaluation. Due to the aging system, many of components have been repaired and upgraded. The whole optical design has been changed to achieve sustainable operation. Cold atoms are being obtained on daily basis and fountain is operational again after overhauled optical set-up. Efforts are underway to operate the fountain and evaluate its frequency along with detailed uncertainty analysis.

Precise and Secure Time (IST) Dissemination through Underground Optical Fiber of Telecommunication Sector

Optical fibre-based time transfer techniques provide excellent options for transferring precise and secure time over a distance of several hundreds of kilometers. Work in progress towards establishing an optical fibre link through underground optical fibre link of telecommunication sector utilizing White Rabbit Precision Time Protocol (WR-PTP) for precise and accurate transfer UTC(NPLI) to the RRSF Faridabad. In order to enhance the accuracy and stability of the optical fibre link, a feedback loop has been utilized for estimating as well as compensating dynamic phase variation, arises due to ambient variation around the link. About ~ 45 km long optical fibre link has been established between CSIR-NPL and Jio Telecom Center at Nehru Place, New Delhi for transferring precise and secure time with better than nanoseconds accuracy. After introducing active phase compensation, the time synchronization uncertainty remains within 150 ps even under varying temperature conditions.



Experimental setup of the underground Optical Fibre Link for Precise Transfer IST from CSIR-NPL to the Remote Location, Jio Telecom Centre, Nehru Place

Network Time Protocol (NTP) Services

A meeting chaired by the Joint Secretary of MeitY focused on enhancing NTP services to ensure Internet resilience and support for critical sectors.

Re-establishment of National Standards for Microwave Power with Improved Uncertainty

The National Standard for Microwave Power at 50 GHz has been re-established using a coaxial microcalorimeter system, achieving a significant improvement in measurement uncertainty from $\pm 1.9\%$ to $\pm 1.3\%$. Similarly, the 7.0 mm Coaxial Microcalorimeter System, serving as the primary standard for microwave power at 18 GHz, has been re-established with enhanced accuracy, reducing the measurement uncertainty from $\pm 0.7\%$ to $\pm 0.4\%$. These advancements mark a pivotal step in improving the precision of microwave power measurements.

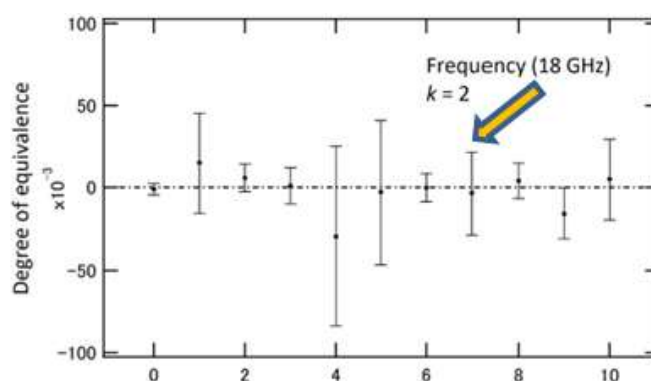
Evaluation of Primary Standards for LF Voltage and LF Current

The primary standard for Low Frequency (LF) Voltage and LF Current, based on Multi-Junction Thermal Converters (MJTC), has been evaluated for its AC/DC transfer difference at 2 V and 5 mA. The evaluation achieved a measurement uncertainty ranging from ± 5 ppm to ± 25 ppm across the frequency range of 10 Hz to 1 MHz.

Participation in Intercomparisons

Participation in intercomparisons has reinforced measurement capabilities and global collaboration:

- APMP.EM.RF-K8.CL for Microwave Power: Piloted by NMII, the final report was presented and accepted during the APMP TCEM 2024. The report concluded that the intercomparison was successfully executed, with results strongly supporting its reliability. The Degrees of Equivalence (DoE) between the calibration factors of the participants, the APMP Regional Value (RV), and the CCEM Key Comparison Reference Value (KCRV) can be confidently used to establish the calibration measurement capabilities of each participating institute. This outcome reinforces the robustness of regional and global calibration standards.
- APMP.EM-S8 for LF Voltage and Current: Piloted by NPLI, the final report has been successfully published in the BIPM KCDB and the Metrologia journal.



DoE between m(Li) and APMP RV (18 GHz, Sensor No. 1)

Maintaining and Upgrading National Standard Related to Electrical and Magnetic Parameters

Electromagnetic Metrology section has significant role in maintaining and upgrading National Standard related to the electrical parameters (including antenna factor, attenuation, electric field, power and shielding effectiveness) as well as the magnetic parameters (such as Magnetic flux Density, Magnetic flux, turn area of search coil, power loss measurement of electrical steel) through continuous development and providing calibration/test services (as per ISO/IEC guidelines) to more than 120 customers (MSME sectors, Large scale industries, Govt. organizations and R&D institutes like Indian Air Force, Air India, Power Grid, CPRI, IDEMI, ERTL, ETDC, ABB, Siemens, Samsung, GE Healthcare, L&T, Adani power, Genus Power, Secure Meters etc.) to improve the quality infrastructure of India.

Involvement in R&D Activities

The Design and analysis of large scale Reverberation chamber for frequency range 100MHz to 18GHz was achieved in the year. An anechoic chamber is also under development for providing the suitable environment for calibration and testing. The availability of these chambers supports the accuracy in measurements and performance of the material under test is examined carefully with minimum uncertainties. The section has started dielectric measurements for solids in X band along with uncertainty evaluation. Development of RIS (Reconfigurable intelligent surface) has already been initiated.

In the quantum metrology part, Rydberg atom based SI traceable and self-calibrating RF E-field sensor has been developed on optical table and experimental results are reported for Ku Band, K band and X band bolstering the candidature of Rydberg atoms as broadband potential antenna for Microwave E-field sensing. Also, Electromagnetically Induced Transparency (EIT) based Ultrabroadband sensing was achieved in this year with the claimed Uncertainty.

On the magnetic front, device development is at the focus of the team. Two miniaturized, low cost magnetometers have been developed in the lab. One is for weak DC magnetic field measurement and the other is for AC magnetic field measurements. The devices provide accurate and validated results for the value of magnetic field.

Represented CSIR-NPL in APMP GA 2023 (Asia Pacific Metrology Program 2023), in Shenzhen, China

Participation in APMP TCL (Technical Committee for Length) and DEC meetings contributes to knowledge enhancement and strengthening of the network in the metrology community for capacity building. The current status

of various intercomparisons was discussed in the TCL meeting, opening up the participation avenues for CSIR-NPL. Various issues related to the peer review were addressed.





**ANNUAL
REPORT**
2023-24

Glimpses of Events

One Week One Lab (OWOL) Programme of CSIR-NPL (April 17-21, 2023)

- Inauguration of OWOL (April 17, 2023)



- Startup/MSME/Industry Meet at OWOL (April 18-22 April, 2023)

Inauguration of Startup/MSME/Industry meet and Bio-aerosol sampler technology transferred to M/S Envirotech Pvt. Ltd. Delhi on 18.04.2023 (now available commercially) during the Startup/ MSME/ Industry meet



- **Metrology Conclave at OWOL (April 19, 2023)**



- **R&D Conclave & Women in STEM at OWOL (April 20, 2023)**



- **Skill Conclave at OWOL (April 21, 2023)**

The conclave was open to the public, and about 400 persons from various academic institutions, business, students, and members of the general public from a range of societal vocations were present. Prof. Achanta spoke about the nation's need for demand and supply of skilled labour during the Skill Conclave. The guest of honour, Dr. Nagahanumaiah, Director, CMTI, Bengaluru, discussed the problems faced by our education system. The Chief gGest of the event, Prof. T. G. Sitharam (Chairman of AICTE), delivered a visionary speech. The keynote speaker Dr. R. Chidambaram, (Padma Vibhushan), former Principal Scientific Advisor, Govt. of India emphasized

the need to generate new knowledge, and the importance of skill to add on to the knowledge.



Celebrations of World Metrology Day 2023 (May 19, 2023)



Celebrations of World Environment Day with the theme 'Solutions to Plastic Pollution' (June 05, 2023)



Stakeholders Meet on 'Traceable PMU Usage to Enhance Power Grid Reliability' (June 08, 2023)

The Stakeholders Meet brought together experts, policymakers, and industry leaders to discuss the adoption of traceable Phasor Measurement Units (PMUs) for enhancing power grid reliability. The event highlighted the critical role of accurate Synchrophasor data in ensuring grid stability and fostering sustainable energy solutions.



Celebrations of Rashtriya Boudhik Sampada Mahotsav/National IP Festival (June 30, 2023)

The inaugural function of the Azadi Ka Amrit Mahotsav -IP Campaign was graced by Hon'ble Minister of State (I/c), S&T, Dr. Jitendra Singh Ji at CSIR-NPL.



Training Program on Biomedical Metrology under Skill Development Program (July 10-11, 2023)

A training program under the Skill India program was organized on Biomedical Metrology. This program includes sharing the knowledge on medical devices, their classification, operation and calibration of Medical Devices. Professionals from startup, testing and calibration laboratories, research and organization and students from universities attended the program.



Training Program on 'Pressure, Vacuum, Ultrasonic Metrology and Non-Destructive Testing' (August 16-18, 2023)



A Collaborative Workshop between NIT Delhi and CSIR-NPL (August 17, 2023)



Air Quality Measurements Training (August 23-25, 2023)

A three days training program on 'Air Quality Measurements Training' was organized under the Skill initiative STP6 and certificates were distributed to all participants.



Two Days Conclave for Metro Officials on 'Noise and Vibration Conclave for Metro Rail Transit Systems' at CSIR-NPL (August 24 - 25, 2023)



Training Program on Force, Torque and Hardness Metrology (September 21-22, 2023)



CSIR Foundation Day 2023, Technology Demonstration at Bharat Mandapam, New Delhi [September 26, 2023]



Demonstration of luminescent security pigments indigenously developed by CSIR-NPL to prevent from counterfeiting of currency notes, passport, stamp papers and many important documents.



Demonstration of CSIR-NPL Technology of PM_{2.5} High volume sampler.



IR thermometer testing facility of CSIR-NPL was exhibited at Bharat Mandapam, CSIR-NPL Pavellion and won the Award.

Celebrations of 82nd CSIR Foundation Day at CSIR-NPL (October 04, 2023)

Prof. Ajay Kumar Sharma (Director, NIT Delhi) was the Chief Guest



CSIR-NPL Open Day 2023 (October 04, 2023)



International Workshop on Advanced Materials Challenges and Standardization Needs for Net Zero Technologies [AMCSNZT-2023] and VAMAS Steering Committee Meeting in CSIR-NPL (October 9-12, 2023)



Temperature, Humidity and Moisture Metrology Training (November 01-03, 2023)

This skill training programme was attended by 25 participants from Industry and Academia.



Skill Training Program on Advanced Materials Characterization Techniques (STP-15) (November 09-10, 2023)

Skill training programme on Advanced Materials Characterization technique was organized by In-House BND Group of BND Division. Faculty members, research scholars and students from various academic institutions have participated in the programme.



Delegates from Indian Air Force Station, Tughlaqabad, Delhi (November 14, 2023)

Delegates came to witness the various pneumatic pressure facilities available at CSIR-NPL, as well as the newly established 100 MPa high-pressure standard, on November 14, 2023.



APMP TCM Meeting (24th TCM Meeting -APMP 2023) Shenzhen, China, hosted by the National Institute of Metrology (NIM), China. Presented-Design and Fabrication of Kibble Balance-Feasibility Study at CSIR-NPL, and Country Report, CSIR-NPL (November 27 – December 03, 2023)



APMP-24th meeting of TCM, 29th November 2023.



This presentation covers highlights of recent activities at NPL, India in the areas of ...

Updates on 100 g Kibble Balance at NPLI

Dr. Nidhi Singh
Sr. Pt. Scientist
Mass Metrology Sub-division,
Physico Mechanical Metrology Division
CSIR-National Physical Laboratory
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Mass Metrology



Pressure Metrology



Force & Hardness Metrology

CSIR-NPL AcSIR India - RMIT University One-day Workshop on "Creating Intellectual Infrastructure for Mentoring Young Graduates" at CSIR-NPL (December 05, 2023)



Peer Review of Time & Frequency Metrology Sub-Division (December 13-14, 2023)



Dr. Dai-Hyuk Yu (Technical Expert, KRISS Korea) & Mr. SC Huria (Quality Expert, Ex GM NCCBM India) conducted peer review.

IISF 2023 Outreach Programme at CSIR-NPL (December 14, 2023)

Dignitaries from National Institute of Electronics & Information Technology, New Delhi and Indraprastha Vigyan Bharati graced the occasion.



51st Shanti Swarup Bhatnagar Memorial Tournament (SSBMT-2023) (December 20-22, 2023)



Celebrations of 78th Foundation Day of CSIR-NPL (January 04, 2024)

Prof. Ashutosh Sharma (President INSA and Ex-Secretary DST), Dr. Ranjana Aggarwal (Director CSIR-NIScPR), Dr. Viswajanani J. Sattigeri (Head, CSIR-TKDL), Prof. Venu Gopal Achanta (Director, CSIR-NPL) graced the occasion.



IIFS 2023, Faridabad Event (January 17- 20, 2024)

CSIR-NPL Technology of Bio-aerosol sampler was demonstrated to DG-CSIR at IISF 2023.



Scientific Collaborative Workshop between CSIR-NPL and NIT Delhi (January 18, 2024)



Two Days Measurement Uncertainty Training Program (January 23-24, 2024)

CSIR-NPL is involved in the NMCG-PTB Namami Ganga project under NAMAMI GANGA Mission and supporting to the State, Regional Pollution Control Board labs for their capacity building for quality-assurance. Two days measurement uncertainty training was organized by PTB and conducted by the Technical Experts of CSIR-NPL at Lucknow.



Bharat Parv Event at Lal Quila, New Delhi (January 26, 2024)

CSIR-NPL demonstrated PM_{2.5} technology at Lal Quila



Visit at Gas Laboratory of BIPM and Gas Analysis Symposium, Paris (January 29 – February 01, 2024)

Gas Metrology staff visited Gas Laboratory BIPM France on 29th Jan 2024 and presented three posters at Gas Analysis-2024 Symposium from 30th Jan – 1st Feb 2024 at Paris, France.



Skill Training Program on 'Metrology in Chemistry (MiC)- Practical Training on ICP-MS to determine Mass Fraction of Measurand' (February 12-14, 2024)

A training program on 'Metrology in Chemistry (MiC)- Practical Training on ICP-MS to determine mass fraction of measurand' was organised to disseminate detail knowledge on the basic principle of Chemical Metrology for the accurate quantification of chemical parameter in particular matrix using analytical technique especially ICP-MS.



Technical Peer Review of Gas Metrology (February 22-23, 2024)

Gas Metrology activity was successfully peer reviewed without any non-conformance. Prof. Jinsang Jung (Head, Gas Metrology, KRISS, NMI of Korea) was the Technical expert.



Quality Management System Training Programs on ISO/IEC 17025 & ISO/IEC 17011 (February 26 - March 01, 2024 & March 04 - 08, 2024)

The Quality Management System (QMS) Training Program, jointly organized by BSI-UK and CSIR-NPL, featured advanced and introductory training sessions conducted by BSI-UK expert Dr. Zacharias Ioannidis:

- Advanced Training on ISO/IEC 17025:2017: Focused on conformity assessment and the general requirements for the competence of testing and calibration laboratories, this session was held from February 26 to March 01, 2024.
- Introductory Training on ISO/IEC 17011:2017: Highlighting the requirements for accreditation bodies accrediting conformity assessment bodies, this session took place from March 04 to 08, 2024.

These programs provided in-depth insights into international standards, enhancing participants' proficiency in quality assurance and accreditation processes.



Training Program on Popular Science Writing (March 05, 2024)

CSIR-National Physical Laboratory, the National Metrology Institute of India, organized an online training program on popular science writing, under the aegis of CSIR Integrated Skill Initiative. The topics covered were Conceptualizing and writing popular science books and publication ethics.



Two Days Training Program for CPCB Officials on 'Noise Pollution Control and its Management in Urban Area' at CSIR-NPL (March 12 – 13, 2024)

The workshop was having eminent national experts from Delhi and Patalia. The workshop discusses about the basics of noise pollution, noise pollution strategies, noise mapping, control, mitigation methods and computational modelling. 20 CPCB and State Pollution Control Board officials from different parts of India attended the training.



Dr. K.S. Krishnan Memorial Lecture at CSIR-NPL (March 14, 2024)



सीएसआईआर-एनपीएल में 'पर्यावरण और मानव स्वास्थ्य:वर्तमान चुनौतियाँ' विषय पर एक दिवसीय सम्मेलन (March 15, 2024)



Training Programs Conducted under Integrated Skill Initiative (Project NWP-100)

In line with Prime Minister's vision for self-reliance and "vocal for local", Government of India is making all possible efforts to support various skill initiatives to strengthen the manufacturing segment. In manufacturing, Quality Control can be obtained by accurate and dependable measurement. Thus, metrology enables the manufacturing of components for strict adherence with desired design specifications and functional requirements. To enhance productivity, achieve customer satisfaction and endorse fair trade; precise, accurate and traceable measurements are essential. In India, there are more than 8000 accredited and calibration laboratories and there are many more unaccredited laboratories in government and private sectors. These laboratories essentially need a substantial number of skilled manpower to cater ever growing industrial needs and CSIR-NPL being the pioneering institute in metrology, is catering the work force with specified training programmes on basic metrology, calibration and testing and measurements uncertainty evaluation etc. Additionally, we have provided trainings in diverse fields such as; Training programme on Mass, Volume, Density & Viscosity Metrology and Fluid Metrology, Length & Dimension Metrology and application of Interferometry, Training Programme on IS/ISO/IEC17025:2017 (General Requirements for the Competence of Testing and Calibration Laboratories), Advance Spectroscopy, Materials Characterization and Scientific Communications etc.



Training Programme of Fluid Flow Metrology



Training Programme on AI in Healthcare & its applications



Training Programme on Material Characterization



Training Programme on IS/ISO/IEC 17025 : 2017
(General Requirements for the Competence of
Testing and Calibration Laboratories)



Training Programme on Dimensional its applications in Dimensional Metrology



Training Programme on Advanced Materials Characterization Techniques



Training Programme on Force, Torque & hardness Metrology



Training Programme on Timing & Frequency



ANNUAL
REPORT
2023-24

Divisional Activities

Physico-Mechanical Metrology

The Physico-Mechanical Metrology Division (PMMD) of CSIR-NPL is mandated to establish, maintain, disseminate and continuously upgrade through research, the physico-mechanical standards such as Mass; Length & Dimensions; Temperature & Humidity; Optical Radiation; Force and Hardness; Pressure, Vacuum & Ultrasonic; Acoustic & Vibration, and Fluid Flow Metrologies. Establishment of four out of seven SI base units, viz. kilogram, metre, kelvin and candela are part of the divisional activity, for which state-of-the art R&D facility are established. Continuous research is in progress for realization of the units based on fundamental constant. Sub-divisions of PMMD continuously participate in the inter-comparisons at international level for the establishment of measurement equivalence and to get globally competitive calibration measurement capabilities for various parameters. This enables the international harmonization with international bodies and precision in dissemination of measurements to the clients of NPLI, which in turn supports the robust quality infrastructure required for missions such as Aatmanirbhar Bharat.

A glimpse of activities of some of our subdivisions is presented below.

Mass Metrology

Mass measurements are essential for trade, technology, fundamental research etc. Reliable measurements of mass and its derived parameters which include volume, density, force, pressure, hardness, etc. are indispensable to support many diverse areas. Mass Metrology section maintains the apex level standards for Mass, Volume, Density and Viscosity and provides traceability to the various sectors such as Legal Metrology, Space, Atomic Energy, MSMEs, Delhi Jal Board, Indian Oil Corporation, CPCB, various industries, etc. One of the important sectors is pharmaceutical industries which are making drugs and medicines. During the year 2023-24, the section has continued its efforts for unceasing upgradation of the national standards and providing traceability to the whole nation. Mass metrology is undergoing three international inter-comparisons in volume currently to enhance the range of CMCs organized by APMP.

Length, Dimension, and Nano-metrology

Dimensional metrology is an essential element of a nation's quality infrastructure, for the industrial and economic development of a country. Reliable dimensional measurements play vital roles in various aspects of social life and significantly empower numerous scientific and technical fields such as; manufacturing, aerospace, automobile, defense and semiconductors, etc. This section provides apex-level calibration services for various dimensional measurement instruments to maintain an unbroken chain of traceability across the nation and the SAARC countries. Length, dimension, and nano-metrology section fulfills the parliamentary mandate to maintain the primary standard of length for the realization of SI unit "meter" through Iodine stabilized He-Ne laser, wavelength 633 nm. This section has various state-of-the-art facilities such as a coordinate Measuring Machine, Length

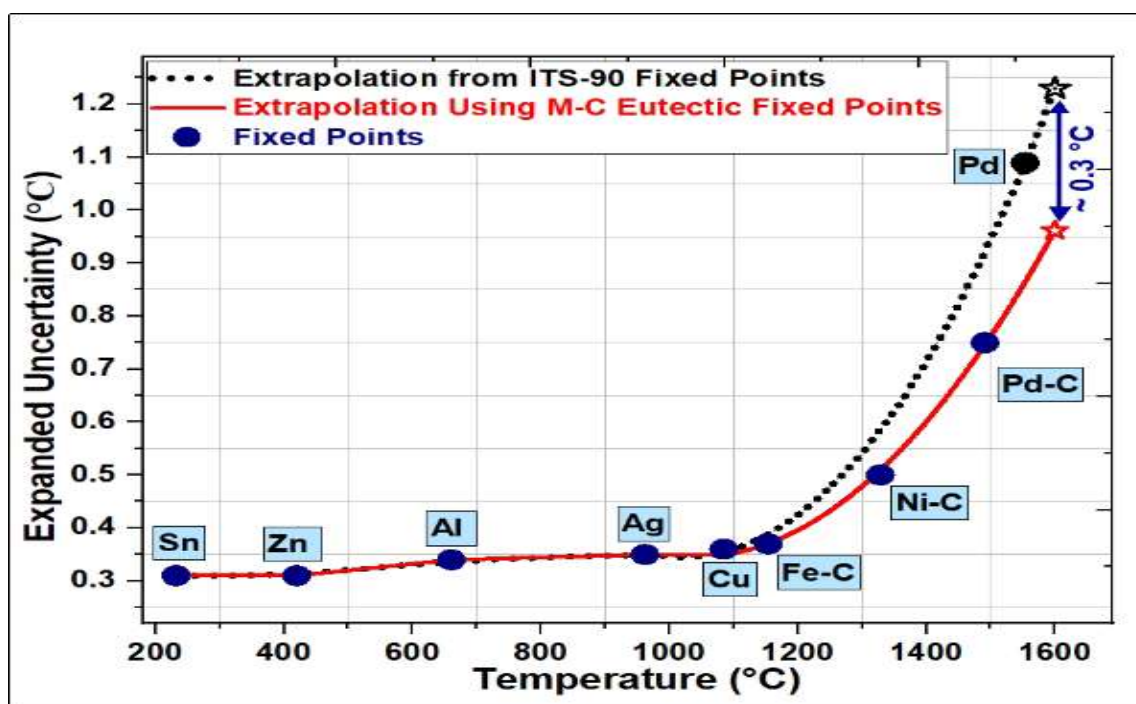


Primary standard of length at
CSIR-NPL

Measuring Machine, 3D Optical Profiler, Roughness and Contour Measuring Machine, Flatness Measuring Interferometer, Linear Displacement Measuring Interferometer, Gauge Block Interferometer and Roundness Tester, etc., to cater the ever-increasing demands of various industrial and R&D segments. Additionally, continuous research and development in the field of precision dimensional metrology for advanced measurement techniques/ standards/ instruments is one of the prime objectives of the section. This group is involved in R & D activity for augmenting and upgrading the standards at par with other leading National Metrology Institutes (NMIs) and continuously participates in international inter-comparisons to establish international equivalence to the international measurement system. Furthermore, we conduct technical workshops, training programs and provide consultancy services to various industries for capacity building across India.

Temperature and Humidity Metrology

The subdivision maintains the primary standard of temperature and humidity parameters from -200 °C to 3000 °C and 10 % RH to 95 % RH. Apex level calibrations and traceability to SPRTs, RTDs and various resistance sensors, LIGTs, Thermocouples, pyrometers, blackbodies, thermo-hygrometers, dew/frost measurements, moisture measurements and mercury-free (electrical and IR based) clinical thermometers to NABL accredited Labs, SAARC NMIs and the government sectors lies in the mandate of division. During this year our research activities include: (i) Development of microwave measurement facility for Acoustic Gas Thermometry for the realize new kelvin based on Boltzmann constant (ii) Development of Ni-C fixed point blackbodies and Pd-C fixed point for high temperature thermometry, and improved the thermocouple realization uncertainty, (iii) development of IR calibrator for the IR thermometer and Thermal Imager calibration down to -40 °C temperature.



Comparison of thermocouple calibration uncertainty at 1600 °C, when extrapolated using ITS-90 fixed points and using in-house developed metal-carbon eutectic fixed points

CSIR-NPL maintains the copies of the Original Constitution of India kept in Parliament Library in a controlled micro-environment for its long-term preservation, in which an active role is played by the sub-division. Dr. (Mrs.) N. Kalaiselvi, Secretary DSIR and DG CSIR made a maiden visit to oversee the preservation activity, along with Prof. Venu Gopal Achanta, Director CSIR-NPL. DG-CSIR, Director-CSIR-NPL, along with their team members can be seen with the original constitution in the below picture. Prof. Venu Gopal Achanta, Director CSIR-NPL is also seen in the picture, describing the preservation technique developed for the original copy of the Constitution of India on Sansad TV on the occasion of Republic Day 2024.



Optical Radiation Metrology

Optical Radiation Metrology section of CSIR-NPL establishes, maintains and disseminates optical radiation standard, which includes Visible Range, UV and NIR range of the electromagnetic spectrum. The section has established a number of photometric and radiometric parameters for disseminating measurement services. In the present scenario of the advent of energy efficient lighting, an apex level testing and calibration facility for photometric measurements of LED lights and luminaires is being established. During the year 2023-24, the section has continued its efforts for expanding its capabilities in the direction of LED photometry and providing traceability to its clients.

Force, Torque and Hardness

Precise measurement is the foundation of innovation and technological advancement. Without traceable and accurate measurements, no new technology or research can achieve reliability or global acceptance. CSIR-NPL, as the National Metrology Institute of India, plays a pivotal role in this regard by ensuring traceability and providing apex-level calibration facilities nationwide.

Our group serves as a critical pillar in this mission by specializing in the calibration of force, torque, and hardness measurements essential parameters for the design and development of high-performance equipment, structures, and technologies. Esteemed organizations such as NABL-accredited laboratories, ISRO, DRDO, HAL, and RAFALE rely on these services to uphold their operational precision and safety standards.

From Apr. 2023 - Mar. 2024, the team has successfully completed 652 calibrations. This substantial impact reflects both the scale of demand and the trust placed in our expertise. Each calibration helps industries identify and correct instrument errors by benchmarking them against national standards, directly contributing to the creation of more accurate, robust, and globally competitive systems and infrastructures.

Beyond delivering calibration services, we actively contribute to the maintenance, upgradation, and establishment of primary standards for force, torque, and hardness. These efforts strengthen India's measurement infrastructure and enable advancements in cutting-edge sectors, reinforcing the nation's position as a leader in science and technology.



Force



Torque



Hardness

Pressure, Vacuum and Ultrasonic Metrology

The primary objective of the Pressure, Vacuum and Ultrasonic Metrology Section is to realize, maintain and disseminate the derived SI unit of pressure and vacuum – the pascal (Pa) as well as ultrasonics. We have standards for measurements from 10^{-6} Pa to 10^9 Pa. The group has been providing apex-level calibration services in pressure, vacuum, and ultrasonic measurements and maintains traceability of these parameters at par with international levels. We maintain the national primary and secondary standards, which continuously evolve through further research and development. Over the years, the group has achieved the global status of compatible measurement standards and calibration facilities through participation in International key comparisons. In addition, the section also provides consultancy and technical services to support the industries. Our patented technologies have also been commercialized. At present, the group is also engaged in the development of a new primary standard based on universal constants as well as testing of automated and non-automated sphygmomanometers.

Acoustics and Vibration Metrology

Acoustics and Vibration Metrology, CSIR-NPL maintains primary standards, viz. the standard of sound pressure, vibration amplitude and power. The primary standard of sound pressure is maintained through absolute calibration of standard condenser microphones in coupler cavity by the reciprocity technique in the frequency range 1 Hz to 25 kHz with an expanded uncertainty of ± 0.05 to ± 0.30 dB. The primary standard of vibration amplitude is maintained through absolute calibration of standard accelerometer by Laser interferometer technique in the frequency range 0.1 Hz to 20 kHz with the measurement uncertainty of ± 1.0 %. The accuracy of primary standards is verified periodically through participation in Key-comparison exercises with leading NMIs in the world.

The primary standard transducers are calibrated by absolute method while secondary and measurement transducers are calibrated by comparison and transfer standard method respectively. The latest international standard 16063-11 specifies three calibration methods based on laser viz. Sine Approximation Method (SAM). The SAM

covers the frequency range 1 Hz to 10 kHz and additionally makes it possible to measure the phase lag between the mechanical input and the accelerometer output voltage. The accuracy of transfer standards like sound level calibrator (± 0.20 dB) and vibration level calibrator (± 1.5 %) is determined with the help of transducers calibrated by absolute methods. The working standards like measurement microphones and accelerometers are calibrated with the help of transfer standards with an overall expanded uncertainty of ± 0.3 dB for microphones and ± 2.0 % for accelerometers. The field / in – situ measurements are carried out with the help of sound and vibration level meters which themselves are calibrated with the help of transfer standards. The sub-division also undertake technical services projects, consultancy and external funded projects in the setting up of the acoustic facility, noise and vibration abatement, building acoustics, environmental noise mapping and control. The sub-division introduced many calibration and testing activities as required by the industry notably for Testing of Noise barriers as per EN 1793 standards, Testing of Hanging baffles, Auditorium chairs, Extended measurement range in 80 Hz to 10 kHz; Acoustic Louvers and Diffusers; On-site vibration testing of Machines and Vibration shakers and Validation of Anechoic and Semi anechoic chambers.

Fluid Flow Metrology

The Fluid Flow Metrology Section provides comprehensive testing, calibration, and standardization services to diverse user groups, including water flowmeter and water meter manufacturers, State Water Boards, industries, environmental pollution monitoring equipment manufacturers, Pollution Control Boards, biomedical laboratories, R&D institutions, and testing and calibration laboratories. By delivering these services, the section enables its stakeholders to improve product quality, ensure compliance with regulatory standards, and foster innovation in their respective domains. Its activities include testing of water meters that are widely used in industries, households, and offices for tariff assessment and water conservation, as well as calibration of oil and gas flow instruments critical to strategic sectors such as HPCL, ONGC, IOCL, atomic plants, pharmaceuticals, biotechnology, aviation, and R&D laboratories. Presently, the section undertakes calibration services for gas flowmeters, water flowmeters, infusion pumps, syringe pumps, infusion device analyzers, dialysis meters, and other biomedical flow devices. The Gas Flow Calibration Facility caters to instruments such as Mass Flow Controllers, Mass Flow Meters, Rotameters, Dry Gas Meters, Air Flow Calibrators, Ventilator Testers, Gas Flow Analyzers, Digital Flowmeters, Rotary Piston Displacement (RPD) meters, Piston Provers, and Orifice Flowmeters, thereby ensuring accurate measurement of gas quantities for applications in tariff calculations, R&D, biomedical systems, and environmental monitoring. To address evolving requirements, the section has introduced a top loading calibrator setup for the calibration of high-volume air samplers and PM10 samplers in the range of 500 L/min to 2000 L/min, and has also developed an RPD meter calibration setup capable of handling low pulse outputs for applications in natural gas pipelines, compressed air lines, industrial gas networks, and environmental monitoring. These initiatives highlight the section's commitment to advancing calibration technologies for industrial efficiency, environmental protection, and public welfare. The Gas Flow Calibration Facility primarily serves manufacturers of pollution monitoring instruments, Pollution Control Boards, biomedical laboratories, NABL-accredited laboratories, and R&D organizations such as NPL engaged in environmental research. In parallel, the Water Flow Calibration Facility has been upgraded to provide calibration for high-accuracy water flowmeters, including electromagnetic, ultrasonic, coriolis, and differential pressure types, with

capability to calibrate meters up to 250 mm diameter at flows up to 650 m³/h, along with testing of bulk water meters up to 200 mm diameter in compliance with ISO 4064 standards. Through these integrated activities, the Fluid Flow Metrology Section continues to play a pivotal role in delivering precision, reliability, and innovation in fluid flow measurement across sectors of national importance.

Electrical and Electronics Metrology

The Electrical and Electronics Metrology Division (EEMD) mainly involves in establishing, maintaining, disseminating, and upgrading the standards of electrical and electronics parameters based on the continuous research and indigenous development of quantum standards. The electrical parameters include voltage, current and resistance; low frequency and high frequency impedance-related quantities such as capacitance, inductance, and AC resistance; DC high voltage; and AC high voltage & current; AC power & energy; and quantum standards such as Josephson voltage standard (JVS), quantum hall resistance (QHR), quantum current (QC) and quantum nanophotonics (QN). The traceability of the above-said parameters are based on Programmable Josephson Voltage Standard (PJVS), QHR standard, and frequency standards (time). The measurements are disseminated through an unbroken chain of calibrations at par with other leading NMI's to the industries, strategic sectors, regional calibration and testing laboratories and support the robust quality infrastructure required for various ongoing government missions such as Make-in-India and Vocal-for-local. The metrological services of the division are internationally recognized by the International Committee for Weights and Measures through mutual recognition arrangement (CIPM-MRA) and follow the quality system as per ISO/IEC 17025:2017. The division is unceasingly putting major efforts to upgrade and maintenance of existing facilities for various electrical and electronics parameters to cater to the mandate and requirements of the industries. EEMD also contributes to recognizing the international notch of equality in calibration measurement capabilities for various parameters through international inter-comparisons. Along with maintenance and dissemination of above, EEMD also works on various quantum materials such as graphene, 2D materials, topological insulators, superconductors, and nitrides-based thin film towards development of quantum standards like Quantum Hall resistance, single photon detection, and quantum current. Glimpses of activities of subdivisions are described below.

LF, HF Impedance and DC Metrology

LF, HF Impedance and DC Metrology Laboratory is maintaining the national standards of DC and Impedance parameters at par with international level for the parameters such as DC voltage, current, resistance, DC voltage ratio, AC capacitance, resistance, inductance and inductive voltage ratio. This laboratory is disseminating the traceability and providing calibration services to the industries, research institutions and secondary laboratories all over the nation.

Relevant Science & Technology Development(s):

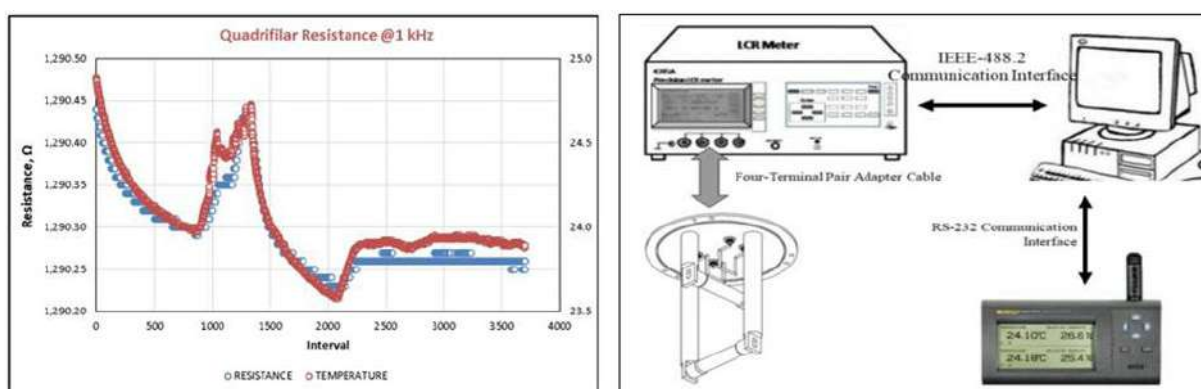
Towards the mandate of the institute, the following up-gradation in the measurement capabilities has been completed.

- DC reference voltage (Zener) has been upgraded to 100 mV, 1 V and 10 V range.
- Multifunction calibrator with trans-conductance amplifier capability for current range has been upgraded from 20 A to 100 A, and resistance range from 1 M Ω has been upgraded to 100 M Ω .

- 8.5 Digital Multi-meter capability for current measurement has been upgraded from 20 A to 30 A, and resistance measurement range has been upgraded from 1 G Ω to 10 G Ω .
- Inductive voltage dividers (IVDs) and reference transformers are designed and developed in-house for impedance metrology applications.
- A facility for measuring the dielectric constant of solid and soft dielectric materials using contact and non-contact techniques up to 10 MHz has been established.
- The facility for the calibration of high frequency resistance standards (10 Ω to 100 k Ω) has been established from 10 kHz to 1 MHz using electrical equivalent circuit model.
- Electrolytic conductivity (0.147 mS/cm and 1.41 mS/cm) of KCl solutions with different molalities using parallel plate method has been established.
- Establishment of low value capacitance standard from 50 fF to 1 pF using guarded electrode method is in progress for audio to radio frequencies.

Ongoing Projects:

- **Establishment of DC Low Current from 100 fA to 1 μ A and DC Charge from 100 pC to 2 μ C** is in progress under facility creation project (FCP)- MLP231932, "Establishment of DC low current and charge measurement facility at CSIR-NPL", with the fund support from CSIR and CSIR-NPL. The objective of the project is to establish traceability of low current measurement/source and low charge measurement facility at CSIR-NPL with a scope of enhancing our calibration and measurement capability in the targeted range. Using well known techniques like $I=V/R$ and $I= C dv/dt$ for current and $Q=CV$ for charge measurement, analysis and measurement is in progress.
- **Design and Fabrication of Quadrifilar Reference Resistance Standards** have been completed. The characterization of these standards is currently in progress, as illustrated in the following Figure.



Quadrifilar measurement setup and preliminary results

AC High Voltage and Current Metrology

AC High Voltage and Current Metrology sub-division is actively maintaining the National Standards of AC High Voltage Ratio measurement up to 100 kV, High Voltage Capacitance & Tan δ facility up-to 200 kV and AC High Current Ratio measurement up to 5 kA. The sub-division has 8 CMCs for AC High Voltage and High Current parameters at par with International level. It is providing Apex Level Calibration Services for Voltage Transformers (VT's), Voltage Transformers Test Sets, AC High Voltage Sources, HV

Break Down Test Sets, HV Dividers, HV Probes, kV Meters, Capacitance & Tan δ Bridges, VT Burdens, Current Transformers (CT's), Current Transformer Test Sets, AC High Current Sources, Clamp Meters, Current Coil, Current Probes, CT Burdens, etc., to various Power Utilities, Electrical Equipment Manufacturers and Electrical Testing and Calibration Laboratories.



Measurement set-up for AC High Voltage (left) and AC High Current (right)

Meanwhile, the sub-division is planning to enhance the calibration facilities for AC high Voltage up to 300 kV and for AC High current side up to 10 kA respectively in order to cater the calibration, and measurement requirements from Power industries, Electrical Manufacturers, Electrical Testing and Calibration Laboratories, etc., across the country.

Relevant Science & Technology Development(s):

Towards the mandate of the institute, the following calibration and traceability, up-gradation in our measurement capabilities has been completed.

- Creation of facility for the evaluation of AC Dielectric strength in Insulating oil/Insulating materials upto 100 kV

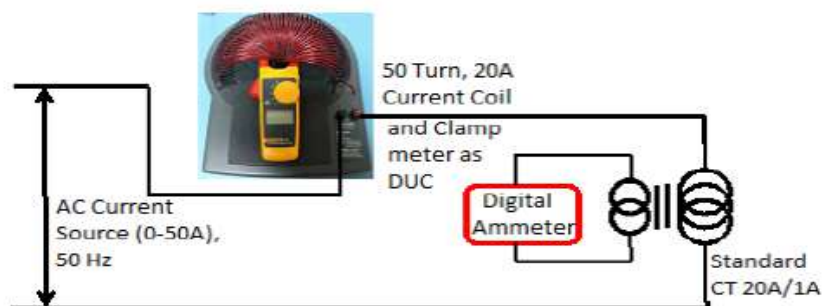
To align the lab into the digital transformation, the division has taken up a project under *Metrology for Digital Transformation in International Cooperation (M4DT-IC)* which is a collaboration between CSIR-NPL India and PTB Germany. The main aim of the project is

- Development of DCC for AC high voltage and current metrological parameters. Parameters to be analyzed: ratio error and phase error.

Ongoing Projects/Research & Developments:

- **Uncertainty Evaluation in 50-Turn, 20A Current Coil using a Digital Clamp Meter** - The research work presents the uncertainty evaluation of a 50-Turn, 20A current coil using digital clamp meter. Based on the literature studies, it is proven that the clamp meter calibration can be effectively more accurate with the help of a current coil. In this work, AC current source (20A) has been injected with 50-Turn current coil to measure the range up to 1000A using a digital clamp meter ($\pm 0.2\%$) as a display unit at 50 Hz frequency. The current comparator of 20A/1A ($\pm 0.0045\%$) with standard digital ammeter ($\pm 0.05\%$) has been used as a reference standard for comparing with the device under calibration (DUC). The basic circuit has been shown in the following Figure. The expanded uncertainty in

measurements has been done at a coverage factor, $k = 2$ which has a coverage probability of approximately 95% for a normal distribution. Hence, it is observed that the expanded uncertainty for the current coil from 100A-1000A is $\pm 0.25\%$ and at 20A is $\pm 0.55\%$ respectively.

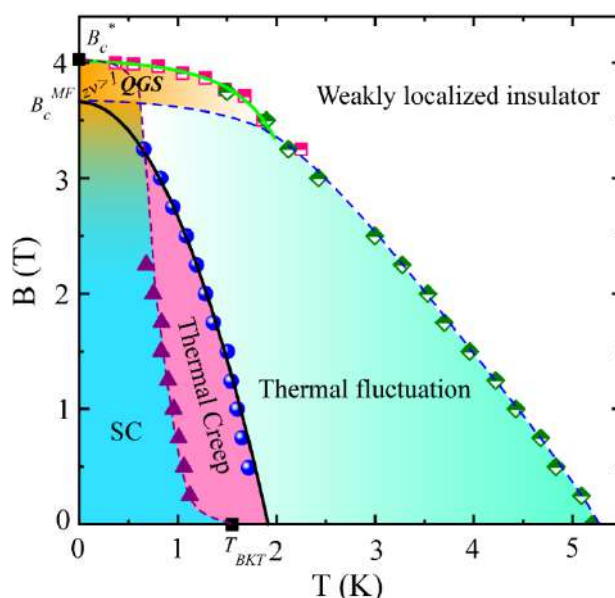


Basic Circuit for 50-Turn, 20A Current Coil

- Absolute Calibration of AITTS for Ratio and Phase Errors** - Accuracy of AITTS substantially affects the resulting accuracy of the measuring devices. Therefore, regular calibration of the AITTS is important for the precise and accurate measurements. It demonstrates the absolute calibration of AITTS using standard PTs/CTs by computing the ratio differences of REs and PEs for standard PTs/CTs. The technique is much simpler than the existing technique used for AITTS calibration at CSIR-NPL. The major uncertainty components are repeatability in measurements and the resolution of the AITTS display. The uncertainty achieved with proposed techniques for PTs ratios is $\pm 0.00016\%$ & ± 0.002 min for Ratio Error and Phase Error respectively, which is well within the uncertainty range of AITTS standards for PT calibration. The method is simple and precise, which can be conveniently used for the calibration of AITTS and PTs at various calibration and testing labs.
- Development of DCC for AC High Voltage and Current Metrological Parameters** - It is well known that CSIR-NPL provides calibration services to several industries and SAARC countries on various parameters. The reports of calibrations are mostly either paper based or manually PDF generated documents, which is laborious, time-consuming, cumbersome and prone to human errors. The aim is to develop certified framework for machine readable calibration information to assure traceability to national measurement standards and further to SI units. A project has been initiated in technical collaboration with PTB Germany in which digital calibration certificates will be generated for AC High Voltage & Current Metrology parameters. For the better functioning, a homepage, comprising of buttons for Administration, Technical and Customer users, are developed with both sign-in and sign-up options. Certificates are generated for providing the information on organization, certificate details, environmental conditions, standards used, customer details, results and calibration methodology. An automated framework based on HTML markup language has been developed for generation of uncertainty budget in a structured A4 format. A sample certificate has been generated on the potential transformer burden test results. In addition to this, a Monte Carlo based algorithm has been developed to analyze the propagation of uncertainties.

Quantum Nanophotonics Metrology

- Experimental Demonstration of Quantum Griffiths Singularity (QGS) in Disordered TiN Thin Films** - In recent years, the quantum current (QC) lab has developed a novel substrate mediated nitridation method to fabricate disordered transition metal nitrides that serve as disordered superconductor suitable for quantum phase slip (QPS) studies. Titanium nitride (TiN) is one of the nitrides which has been grown and studied extensively in our QC lab. The experimental observation of quantum Griffiths singularity (QGS) associated with field induced quantum phase transitions (QPTs) in disordered TiN thin films has been demonstrated. TiN is one such premiere superconducting material which provides a model platform to study the quantum criticality, quantum phase transitions and many other intriguing quantum phenomena for decades. Our QC lab demonstrated the emergence of QGS for the first time in TiN thin films that are not highly crystalline or epitaxial grown along with the robustness of QGS with respect to temperature and disorder strength.

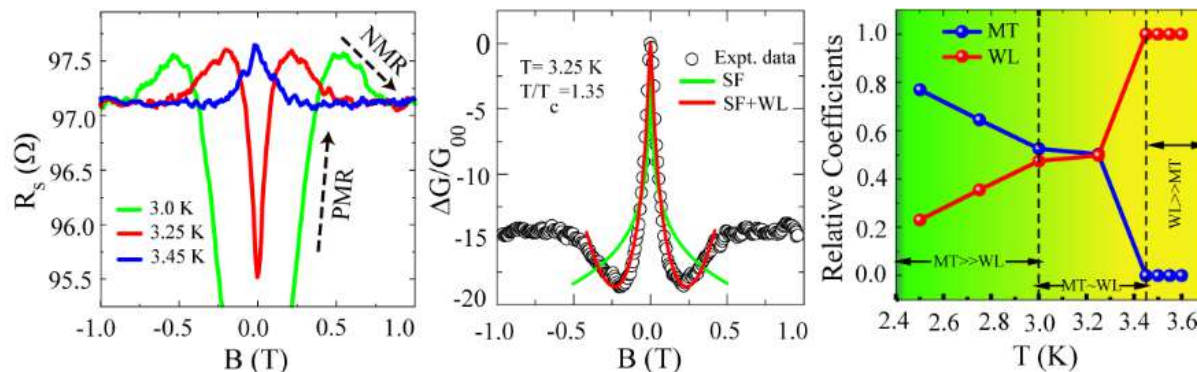


Magnetic field-Temperature (B-T) phase diagram constructed from the measured magnetic field and temperature dependent sheet resistance $R_s(B,T)$ measurements for a TiN sample of thickness about ~ 2 nm)

- Direct Probing of the Interplay between Superconducting Fluctuations and Weak Localization in Disordered TiN Thin Films** - The research work demonstrates the coexistence of both positive and negative magnetoresistance (MR) in different field range at temperature above the critical temperature T_c for disordered TiN in 2D. With temperature variation, a crossover from positive to negative magnetoresistance is also observed.

A crossover from positive to negative MR has been observed and reported in materials having high spin-orbit coupling. However, for a conventional superconductor like the case here with TiN, in weak disorder regime and at temperature above T_c , there is hardly any report of similar results. **The QC team has shown that the quantum corrections to the conductivity (QCC) and magnetoconductivity from superconducting fluctuations (SF) and weak**

localization (WL) convincingly follow the experimental observations provided the major quantum correction terms [Maki-Thompson (MT) term from SF and WL] are associated with individual coefficients that describe their strength and contribution to the observed magnetoresistance. This leads to a generic approach for comparing and studying the interplay between superconducting fluctuation (SF) and weak localization (WL) in similar type of electronic systems.



Crossover from positive magnetoresistance (PMR) to negative magnetoresistance (NMR) by varying temperature for disordered TiN thin film of thickness ~ 7 nm is shown in the left most panel. The middle panel represents the experimental data along with the theoretical fitting with SF and WL for normalized magnetoconductivity (G , inverse of magnetoresistivity). The right most panel displays the comparison of the coefficients from the SF and WL contributions and their variations with the temperature. Here, MT corresponds to Maki-Thompson contribution which is considered as the major SF contribution.

- **Activities of Quantum Voltage Metrology:**

Quantum standards are the measurement systems based entirely on the fundamental properties. These have been used for a variety of metrology applications because of their highest accuracy and error free measurement capabilities. At CSIR-NPL, one of such Quantum standards has been established as 'Programmable Josephson Voltage Standard' system, which is the primary standard of voltage. It is based on inverse 'Josephson effect' based Quantum phenomena which relies on fundamental constants only. This system plays an important role in electrical metrology as it is used to disseminate unit 'volt' throughout nation to maintain traceability. The measurement of electrical dc voltage is of enormous economic importance as the equipment used every day should be calibrated in an uninterrupted calibration chain, at the end with the primary voltage standard. This system has been



Established PJVS system at CSIR-NPL India for quantum DC voltage metrology

used for dissemination of unit 'volt' in India through calibration of national standards (bank of Zener-diode based dc reference standard) at 1.018 V and 10 V. These Zener standards further link all dc instruments to this primary standard.

Superconducting Nanowire Single Photon Detectors (SNSPD) and Microwave Kinetic Inductance Detectors (MKID) - The division is engaged with activities related to the SNSPD development as well as MKID development. Recently, bi-layer superconductor systems such as NbGe/NbTiN were studied to evaluate them for both applications. We have installed a 2K cryostat with optical and MW lines for light shining and microwave experiments related to both MKID and SNSPD. Sample holder modification was done to accommodate both optical fibres and MW lines up to the sample. The figure shows the images of the 2K cryostat and the sample probe for the cryostat.



2K Cryostat for SNSPD experiments
and the sample probe for the same

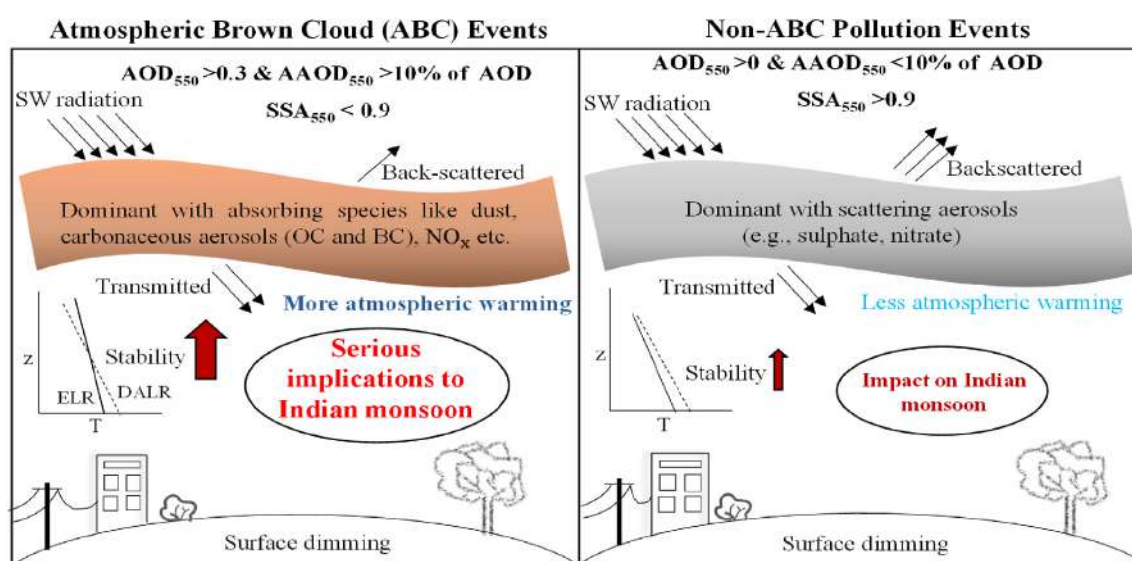
Environmental Sciences & Biomedical Metrology

The Environmental Sciences & Biomedical Metrology division strives to serve the nation through its scientific research & development capabilities in the area of Atmospheric Science and metrology, Gas metrology, Biomedical metrology and Sensor devices for atmospheric applications by developing best practices for accurate measurements and quality research to serve the nation. Overall, the division generates huge data on various aspects of atmospheric components like, GHGs, Trace gases, Aerosol physics, chemical and optical properties, Solar radiation in UV, short and long wave, different kinds of biomass and fuel inventories that contribute to climate change activities. We also provide primary calibration and traceability for gas standards, calibration facility for surface Ozone measurements; testing calibration and certification of OCEMS and CAAMQS; characterization of the ionized and non-ionized atmospheric media over Indian Latitudes, Polar Regions and development of light weight pollution measuring instruments. We are also engaged in establishment and realization of National Standards for biomedical metrology and providing calibration facility services to various stakeholders. At the same time, we also focus on the development of smart sensors for the detection of electromagnetic radiations (UV, Visible, NIR) and atmospheric pollutants. Thus, we have been consistently contributing towards the development of science, technology, training and nation building.

Atmospheric Science and Metrology

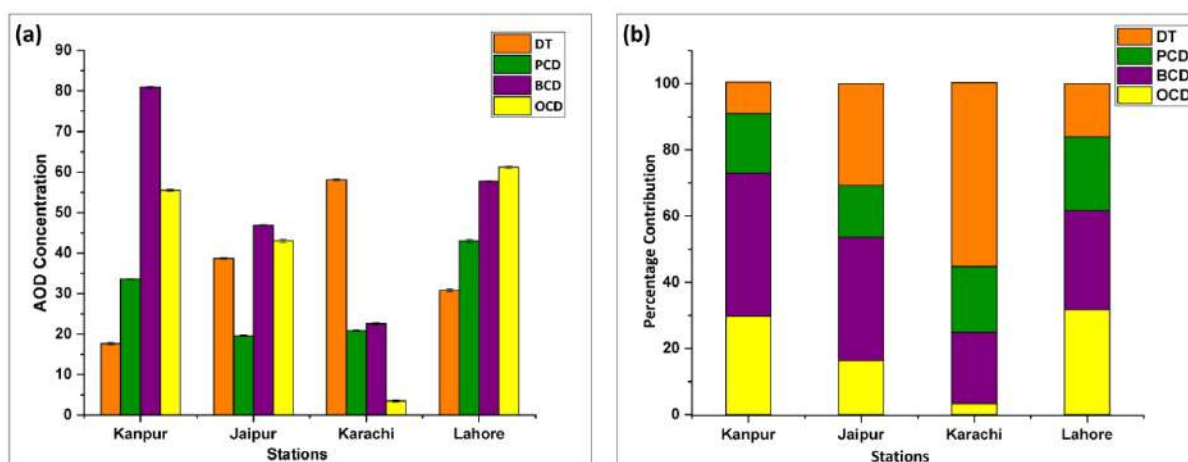
The Environmental Sciences and Biomedical Metrology Division (ESBMD) is committed to comprehensive monitoring of atmospheric pollutants, encompassing greenhouse gases (GHGs), particulate matter, and emerging contaminants such as microplastics. Its primary objective is to investigate the chemical and physical properties of these pollutants and to assess their ecological and health impacts using advanced instrumentation and modeling frameworks. The division is actively developing standardized methodologies for accurate measurement of atmospheric trace species and aerosols, intended for adoption by national agencies and institutions engaged in air quality monitoring. This work is vital, as improved measurement techniques directly inform evidence-based policymaking for air quality enhancement and climate change mitigation. In parallel, ESBMD is advancing the design of cost-effective indigenous monitoring equipment and establishing a national facility for type testing, calibration, and certification of automated Air Monitoring Systems, particularly Online Continuous Emission Monitoring Systems (OCEMS) and Continuous Ambient Air Quality Monitoring Systems (CAAQMS). Beyond pollutant monitoring, the division undertakes frontier research on ionized and non-ionized atmospheric conditions across Indian latitudes, polar regions, and planetary environments. These studies address critical aspects such as radio propagation for communication and navigation, atmospheric coupling processes in the lower and upper atmosphere, ionospheric precursors to earthquakes, and other societal and strategic applications. Additionally, ESBMD provides global users with ionospheric forecasting services through the Space Weather Regional Warning Centre (RWC, NPL-India), reinforcing its role as a national and international leader in atmospheric sciences and metrology. The following section highlights the recent research contributions of the Atmospheric Sciences and Metrology group.

- Atmospheric Brown Cloud and its Effects in IGP:** Atmospheric brown clouds (ABCs) are widespread hazy accumulation of particles and gases dominant with absorbing nature impacting the air quality, hydrology and climate. The presence of absorbing components such as black carbon (BC), brown carbon (BrC), mineral dust, fly ash along with oxides of nitrogen in ABCs makes its appearance as a brownish haze in the sky. ABCs cause significant regional surface dimming by blocking the incoming solar radiation resulting in a cooling effect on the surface while warming of the atmosphere. The Indo-Gangetic plain (IGP) being an ABCs hotspots is prone to extreme pollution episodes due to anthropogenic activities. However, there is a limited study that specifically compares episodes of absorbing aerosols (ABCs) and comparatively non-absorbing aerosols (non-ABCs) along with their respective radiative impacts over the IGP. We have used ground-based remote-sensors' retrieved datasets from AERosol RObotic NETwork (AERONET) to study spatio-temporal variation of ABCs' frequency and associated radiative properties across the IGP region during 2001–2019. The shortwave aerosol radiative effect (ARE) during ABC and non-ABC episodes is estimated using Santa Barbara DISORT Atmospheric Radiative Transfer (SBDART) model. Our results show significant spatial variability in the frequency of ABC episodes across the IGP stations with $\sim 17 \pm 5\%$, $\sim 19 \pm 11\%$ and $\sim 18 \pm 13\%$ average occurrence during winter, pre-monsoon and post-monsoon seasons, respectively. ARE estimations show enhanced surface dimming (ARESRF) and atmospheric warming (AREATM) during ABC episodes as compared to non-ABC episodes. A general increasing trend for ARE is observed as we move from west to east across the IGP due to the meteorological and geographical variations in the region. Our results show day-time averaged ARESRF varying between -142.46 ± 25.13 and $-56.66 \pm 6.88 \text{ W/m}^2$ while AREATM ranging from 58.07 ± 2.58 to $132.69 \pm 7.43 \text{ W/m}^2$ for ABC episodes. Though ABC episodes show lower aerosol loading as compared to non-ABC episodes in our study, we found higher atmospheric heating during ABC episodes mainly due to distinct chemical composition (lower single scattering albedo) of absorbing aerosols. The upper bound of the difference between atmospheric heating rate during ABC and non-ABC episodes is found to be $0.48 \pm 0.27 \text{ K/day}$.



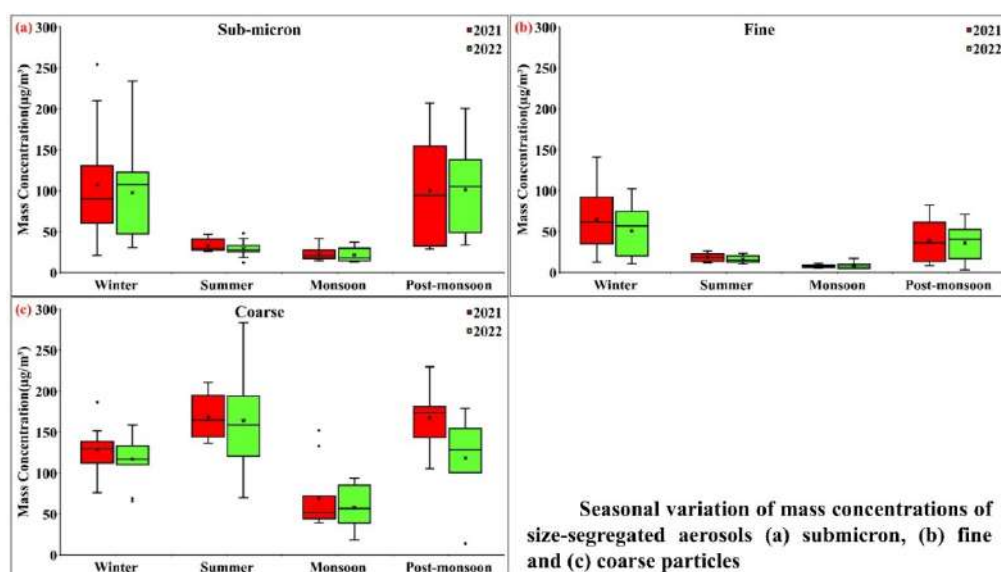
A schematic illustration of the difference aerosol characteristics and its climatological impacts between ABC and non-ABC episodes

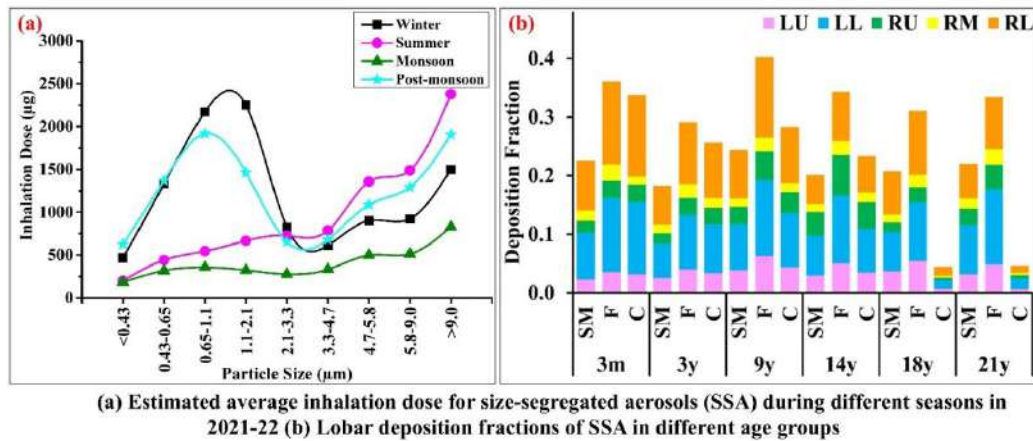
- Impact of Aerosol types on UVR:** Atmospheric aerosols play a crucial role in the scattering and absorption of solar radiation, directly influencing the UV flux reaching the Earth's surface. We have investigated the impact of different atmospheric aerosol types on the ultraviolet (UV) flux at four stations over the Indo-Gangetic Plain (IGP), namely Kanpur, Jaipur, Karachi and Lahore. For this, high-resolution $1^\circ \times 1^\circ$ UVA and UVB data were obtained from Clouds and the Earth's Radiant Energy System (CERES). Various aerosol types present in the atmosphere were categorized based upon their optical properties and their quantitative influence on UVA and UVB flux was examined. Ground-level aerosol products were obtained from the NASA-based Aerosol Robotic Network (AERONET) at four stations in the IGP. Based on the optical properties of aerosols (fine mode fraction, single scattering albedo, aerosol optical depth and angstrom exponent), four distinct atmospheric aerosol types were inferred, namely dust-dominant (DT), polluted-continental dominant (PCD), black-carbon-dominant (BCD), and organic-carbon-dominant (OCD). The DT shows a higher contribution over Karachi and Jaipur at 55.48% and 30.80%, respectively, while a lesser contribution is seen at Lahore and Kanpur, with 16.01% and 9.45%, respectively. This large concentration of DT is due to dust deposition over the IGP region, which is transported from the western region (i.e., the Thar Desert). Due to high anthropogenic activities (i.e., mining, industrial wastes, vehicular emission) the PCD were found to be maximum at Lahore, with 22.31%, whereas there was 17.98% at Kanpur, 19.92% at Karachi and 15.60% at Jaipur. From a regional perspective, at Kanpur the most-contributing aerosol type was BCD (43.32%), the second highest OCD (29.73%) and then PCD (17.98%) and DT (9.45%). At Jaipur, BCD (37.32%) had the highest contribution, followed by DT (30.80%), OCD (16.28%) and PCD (15.60%). At Karachi, DT showed the highest contribution, with 55.48%, followed by BCD (21.55%), and OCD the showed minimum with 3.34%. At Lahore, OCD with 31.74% shows the highest concentration, then BCD (29.95%), followed by PCD (22.31%) and DT (16.01%). It is observed that the AOD of different aerosol types when separated do not seem to have made significant effects on UVA/B radiation (except at Kanpur), possibly due to the statistically smaller data set. For the entire combined AOD, the effects on UVA/B became quite significant at all the stations, which shows that a unit rise in AOD leads to a reduction of $5\text{--}7 \text{ Wm}^{-2}$ in UVA and $0.14\text{--}0.23 \text{ Wm}^{-2}$ in UVB.



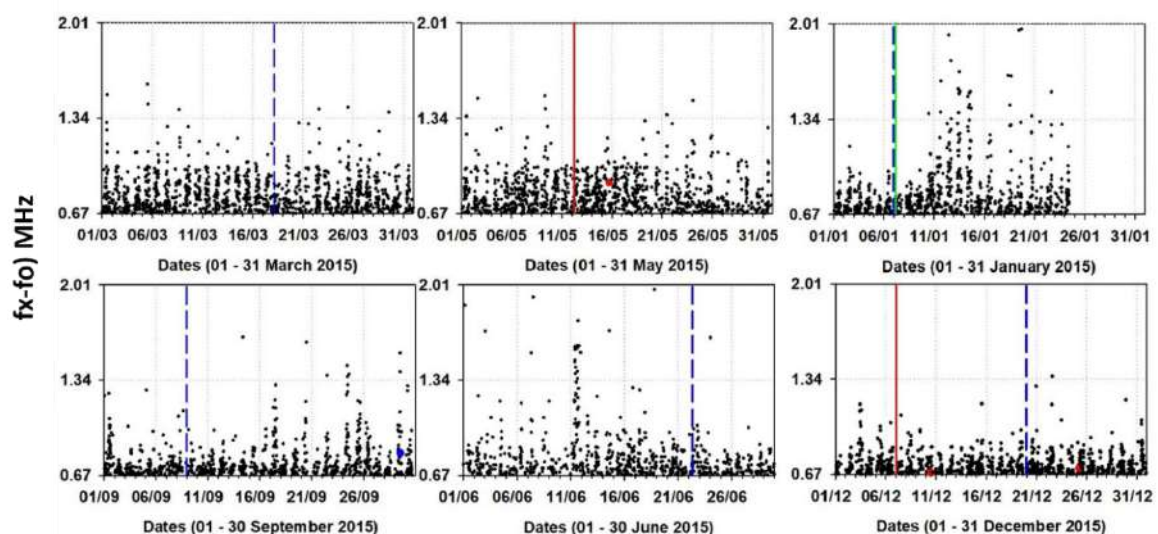
Annual AOD concentration of each aerosol type (a) and annual percentage contribution of each

- Seasonal Variation of Size-Segregated Aerosols in Central Delhi and their Deposition Patterns in Human Respiratory System** - Seasonal patterns and potential exposure of size-segregated particulate matter (PM) were studied in central Delhi from January 2021 to December 2022. A total of 79 samples were collected using an eight-stage Andersen cascade impactor. The samples were categorized as submicron ($PM_{<0.43-1.1}$), fine ($PM_{1.1-2.1}$), and coarse ($PM_{2.1-9}$) fractions of PM. During 2021, average mass concentrations of submicron, fine, and coarse PM were 67.2 ± 10.7 , 33.6 ± 5.7 and 124.1 ± 9.1 $\mu\text{g}/\text{m}^3$ respectively. During 2022, the corresponding average mass concentrations were 55.1 ± 7.5 , 25.8 ± 3.6 and 117.2 ± 8.9 $\mu\text{g}/\text{m}^3$ respectively. The submicron and fine particles were more prevalent during the post-monsoon and winter seasons, while coarse particles were more pronounced during summer. The log-normal mass-size distribution displayed a bimodal pattern during the winter and the post-monsoon seasons of 2021 and 2022. Conversely, summer and monsoon seasons exhibited unimodal distributions. The inhalation dose was calculated for all seasons, found in the order post-monsoon > winter > summer > monsoon. Total, regional and lobar depositions of size-segregated PM in respiratory airways of various age groups were also quantified using the multiple-path particle dosimetry model. The right lung is divided into three lobes, i.e., the right lower lobe (RL), right middle lobe (RM), and right upper lobe (RU). In contrast, the left lung has two lobes namely the left lower lobe (LL) and left upper lobe (LU), to accommodate space for the heart. It was observed that lower lobes had higher depositions compared to upper/middle lobes, while the middle lobe had the lowest depositions in all three size fractions. The different path lengths and lobes' volumes were responsible to the observed differences in particle depositions. Lower lobes with higher volumes exhibited higher depositions, whereas middle lobes with lower volumes had lower depositions. Among different age groups, the deposited concentrations ranged from 35-51% for inhaled submicron particles, 57-68% for fine particles, and 89-96% for coarse particles, respectively. The deposited mass in respiratory airways was maximum for coarse particles in summer, while maximum in winter for submicron and fine particles in all age groups.



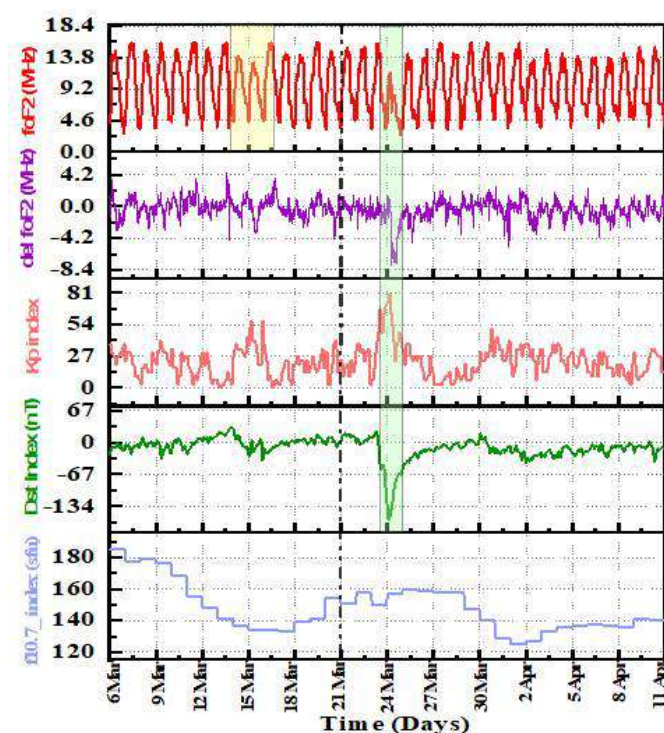


- Investigation of Junction Frequency Separation in Vertical Incidence Ionogram Traces at a Low-Mid Latitude Indian Station, New Delhi: Ionosonde Observations** - Ionogram traces in the F-layer split into two modes—ordinary (O) and extraordinary (X)- due to magneto-ionic splitting, where a transmitted pulse propagates in two distinct ways under Earth's magnetic field. This magnetic influence also causes ionogram traces to exhibit double-hop echoes, where an echo reflects off the ground and is then re-reflected by the ionosphere, highlighting the ionosphere as a doubly refracting medium. We analyzed the separation in Junction frequencies (JFs) of the O and X modes in vertical incidence ionogram traces over a seven-year period (2014–2020), covering the declining phase of the solar cycle from maximum to minimum. At the low-mid latitude Indian station in New Delhi (28.6°N, 77.2°E), the expected mode-splitting difference is 0.67 MHz. However, anomalous JF separations exceeding 21% were observed. Further, analysis revealed that over 30% of JFs exhibited anomalies across different seasons, with the highest occurrence in summer, followed by equinox and winter. JFs displayed a diurnal variation, with greater fluctuations during solar cycle maxima and reduced variation during minima. Additionally, we identified a correlation between JFs and ionospheric perturbations caused by phenomena originating from both the lower and upper atmosphere.



Plot showing separation in critical frequency O- and X- mode for the year 2015 (Summer – June, Equinox – September, Winter – December) for $f_x - f_o > 0.67$ MHz

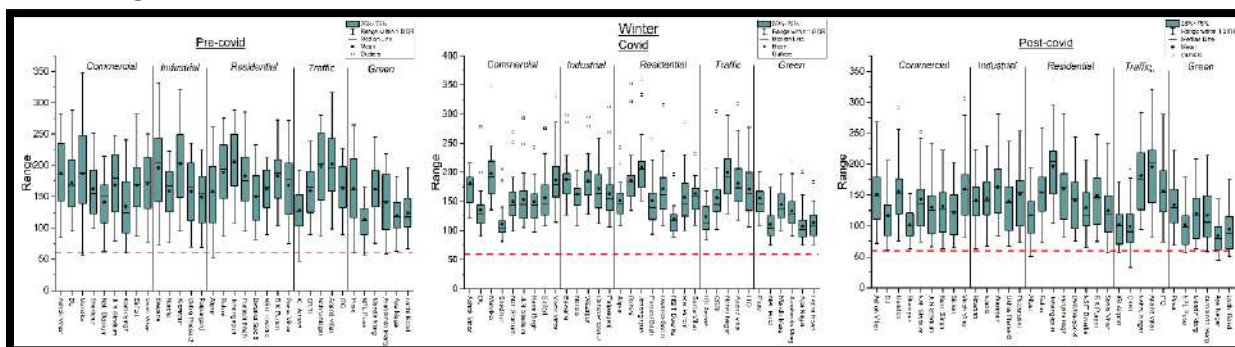
- Investigation of Anomalous Ionospheric Signature as Precursor to Earthquakes at Low-Mid Latitude Indian Station, New Delhi** - We have examined the ionospheric response to a magnitude 6.6 earthquake that occurred in the Hindu Kush region of Afghanistan on March 21, 2023. This seismic event impacted the ionosphere in the Indian region. Our analysis utilized critical parameters of the F2 layer (foF2, hmF2), obtained through Digisonde measurements from a low-mid latitude Indian station located in New Delhi (28.6°N, 77.2°E, 19.2°N geomagnetic latitude, 42.4°N dip). The routine day-to-day fluctuations in the ionosphere are removed by computing variations in the critical frequency and peak height of the F2 layer (Δ foF2, Δ hmF2) in comparison to its standard normal behaviour during quiet periods. We observe noteworthy disturbances in the ionospheric F2 region over Delhi about 5 days before the earthquake event, leading to a substantial variation in peak electron density of approximately 120%. These observed perturbations suggest the potential existence of seismo-ionospheric coupling, given the solar and geomagnetic indices remained relatively quiet and stable during the period. Notably, the precursory impact of the earthquake was observed beyond the designated earthquake preparation zone, as outlined by Dobrovolsky et al. (1979).



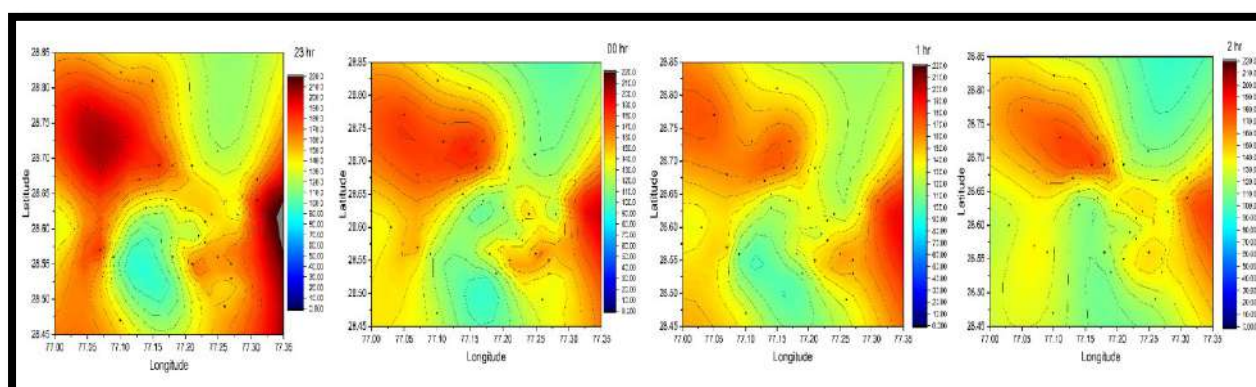
Plot of solar, geomagnetic, and ionospheric parameters for fifteen days prior and twenty days after the seismic event of 21 March 2023

- Seasonal and Diurnal Variability of PM_{2.5} Concentration along with the Role of Wind Patterns over Different Locations of Delhi during the Years 2018 to 2022** - The study assesses the seasonal and diurnal variability of PM_{2.5} concentrations across five distinct locations of Delhi—industrial, commercial, residential, traffic, and green areas—using CPCB CAAQMS data from 2018 to 2022, with a focus on the role of wind patterns. PM_{2.5} concentrations were highest during the post-monsoon and winter seasons (up to 300-350 $\mu\text{g}/\text{m}^3$) due to low mixing heights, cold temperatures, and agricultural residue burning emissions. In contrast, monsoon season concentrations were lowest (<100 $\mu\text{g}/\text{m}^3$) due to rain-induced washout. Diurnal patterns revealed consistent morning and night peaks

caused by traffic, cooking emissions, and boundary layer dynamics. Spatially, industrial areas recorded 25% higher PM_{2.5} concentration than green areas and 8% higher than commercial areas, with pollution hotspots identified in North and East Delhi. A significant negative correlation between PM_{2.5} concentrations and wind speed highlighted the dispersive role of wind. Additionally, a decreasing trend of approximately 15% in PM_{2.5} concentrations was observed from the pre- to post-COVID period, reflecting the impact of reduced anthropogenic activities and stricter pollution controls. These findings underscore the need for targeted mitigation strategies such as reducing industrial and vehicular emissions, expanding green cover, and incorporating meteorological data into air quality management efforts in Delhi.



Box plots of PM_{2.5} concentration over different locations during the winter season

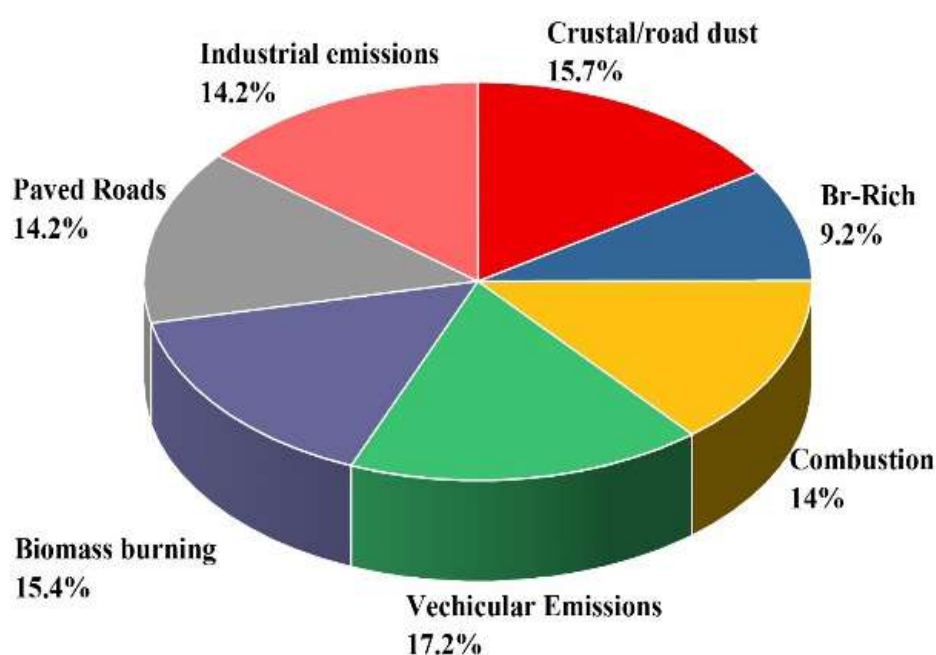


Diurnal variation of PM_{2.5} concentration during nighttime in October

- Long-term Characteristics of Ambient Trace Gases Delhi-** The study examined the long-term characteristics and relationship of atmospheric ammonia (NH₃) with other trace gases (NO, NO₂, SO₂ and CO) at highly polluted urban agglomeration of Delhi, India. Measurements of ambient trace gases (NH₃, NO, NO₂, SO₂, and CO) and meteorology were recorded at the observational site of Delhi from 2011–2022. Overall mean levels of NH₃, NO, NO₂, SO₂ and CO were 18.9±5.0 ppb, 19.9±4.8 ppb, 19.1±5.3 ppb, 2.15±0.38 ppb, and 1.47±0.42 ppm, respectively during 2011–2022. During study, a significant diurnal and seasonal variation in levels of NH₃, NO, NO₂, and CO were monitored except SO₂ level. During all the seasons, the levels of trace gases were observed higher during night time and lower during day time. Correlation analysis reveals that the higher loading of NO, NO₂ and CO influenced the level of NH₃ at the study site. To improve the ambient air quality of the Delhi the pollution control authority had planned to reduce the concentration of particulate matter (PM_{2.5} and PM₁₀) up to 40% by the year 2024 when compared with base year 2017 under the National Clean Air Program

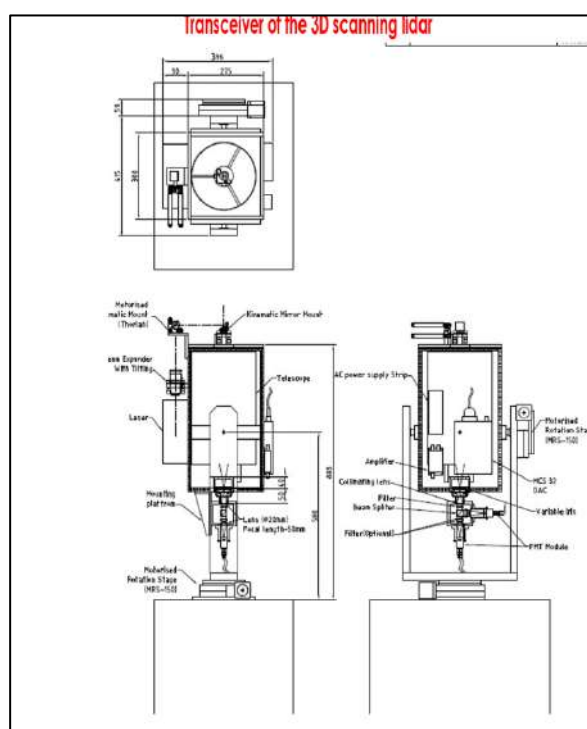
(NCAP) initiative. The ambient NH_3 , NO , NO_2 and SO_2 are the precursors gases of secondary aerosol formation through gas-to-particle conversion. It shows that the overall reduction in (from 2017 base year) NH_3 , NO , SO_2 and CO as -10.2% , -16.5% , -5.3% and -21.9% , respectively except NO_2 . The reduction in concentrations of these trace gases indicated the possibility of reduction in particulate matter ($\text{PM}_{2.5}$ and PM_{10}) in Delhi after 2017.

- Sources and Health Risks Assessment Trace Elements of $\text{PM}_{2.5}$ in Delhi, India-**
 The study investigated the concentrations, seasonal variations, sources, and human health risks associated with exposure to heavy elements (As, Al, Pb, Cr, Mn, Cu, Zn, and Ni) of $\text{PM}_{2.5}$ at an urban location of Delhi, from January 2013 to December 2021. The average mass concentration of $\text{PM}_{2.5}$ throughout the study period was estimated as $127 \pm 77 \mu\text{g m}^{-3}$. The heavy elements, Al ($1.24 \mu\text{g m}^{-3}$), Zn ($0.50 \mu\text{g m}^{-3}$), Pb ($0.23 \mu\text{g m}^{-3}$), Cr ($0.21 \mu\text{g m}^{-3}$), Cu ($0.17 \mu\text{g m}^{-3}$), Mn ($0.07 \mu\text{g m}^{-3}$), and Ni ($0.01 \mu\text{g m}^{-3}$) exhibited varying concentrations in $\text{PM}_{2.5}$, with the highest levels observed in the post-monsoon season, followed by winter, summer, and monsoon seasons. Six primary sources throughout the study period, contributing to $\text{PM}_{2.5}$ were identified by Positive Matrix Factorization (PMF), such as dust (paved/crustal/soil dust: 29.9%), vehicular emissions (17.2%), biomass burning (15.4%), combustion (14%), industrial emissions (14.2%) and Br-rich sources (9.2%). Health risk assessments, including hazard quotient, hazard index, and carcinogenic risk, were computed based on heavy elements concentrations in $\text{PM}_{2.5}$. Elevated hazard quotient values for Cr and Mn linked with adverse health impacts in both adults and children. High carcinogenic risk values were observed for Cr in both adults and children during the winter and post-monsoon seasons, as well as in adults during the summer and monsoon seasons. The combined hazard index value exceeding one suggests appreciable non-carcinogenic risks associated with the examined elements.



Annual (2013-2021) source profiles and % source contribution of $\text{PM}_{2.5}$ extracted by PMF

- Design and Development of 3D Scanning Lidar for Airport Application is Under Progress-** Information on the atmospheric condition is very critical in aviation field for the safe landing and take-off of the aircraft. The real time data on the structure, position and composition of cloud, pollution layers, volcanic ash, and fog layers are necessary for safe movement of aircrafts. The data on vertical and slant visibility also an important parameter for the aircrafts. The clouds with huge vertical extend, clouds contain ice crystals etc. create problem for the communication though radio signals by the aircraft. In order to cater to this need we are working on the design and development of a 3D scanning lidar as part of a CSIR sponsored project FBr010302. The optical components design, and lidar control software is completed. The assembling of the lidar system will be completed in due course of time. The figure shows the transceiver (transmitter and received part of the 3D scanning lidar system).

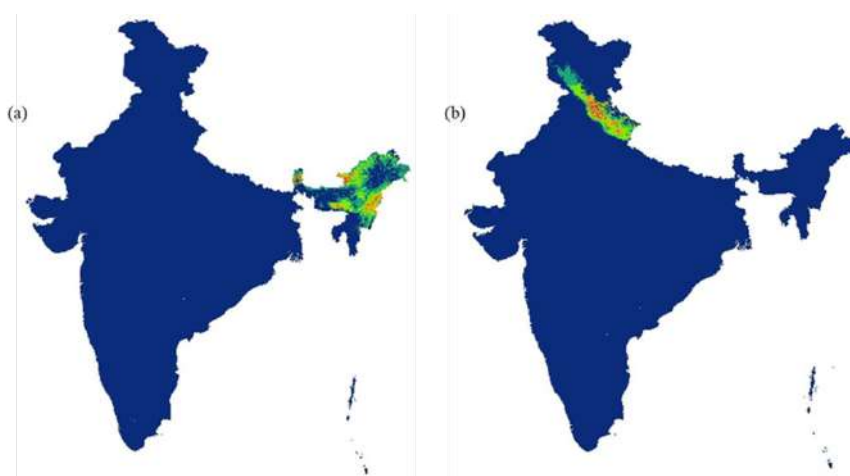


- Assessment of Impact of Climate Change on Endangered Taxus Species in the Indian Himalayan Region**

A study was conducted to assess the potential distribution of *Taxus* species (*Taxus contorta* and *Taxus wallichiana*) within the Indian Himalayan Region (IHR), utilizing species distribution models MaxEnt for different climate change scenarios. The study used geocoordinates of existing populations of *Taxus* species from field surveys, scientific literature and the Global Biodiversity Information Facility (GBIF) web portal, and environmental predictors from WorldClim web portal (Shared Socioeconomic Pathways - SSP126, SSP345, SSP370, SSP585) to run the models. The Jackknife test was performed to identify the most influential parameters.

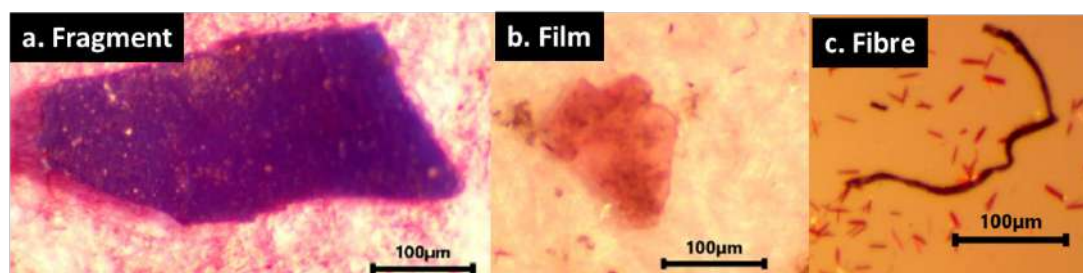
The projections identified the IHR as the current distribution area for both the species. However, by the 2050s, highly potential area of *T. wallichiana* under SSP126 shrinks to 4,960.4 km², while *T. contorta* sees the largest decrease under SSP345 (6,866.7 km²). However, by the 2070s, range of *T. wallichiana* increases to

14,693.5 km² under SSP585, and *T. contorta* grows by 11,060.69 km² in the 2100s under SSP126. Furthermore, Srad 5 and BIO17 were identified as the most influential predictors for *T. wallichiana* and *T. contorta* respectively. Overall, the findings of current study will be essential for guiding future conservation and management efforts in the region.



Potential distribution of (a) *T. wallichiana* and (b) *T. contorta* in the IHR in under current climatic scenario (Source: Rajlaxmi et al. 2024, Predicting the current and future potential habitat of *Taxus* species over Indian Himalayan Region using MaxEnt model)

- Microplastics as Emerging Contaminants in Urban Street Dust of Delhi, India**
 - Microplastics have emerged as environmental contaminants recently due to the extensive use, durability, and cost-effectiveness of plastic. The study was performed to observe the spatial distribution and characterization of microplastics in urban street dust across distinct locations of Delhi, a city experiencing high level of pollution. Sampling was carried out across diverse land use types, including industrial, commercial, landfill, and institutional zones. This was followed by systematic pretreatment and extraction procedures, along with advanced characterization techniques. The analysis confirmed the presence of microplastics in the street dust of Delhi, with varying morphologies indicative of heterogeneous sources. Morphological characterization revealed a predominance of fibres, fragments, and films shaped microplastics. These findings highlight the widespread contamination of urban environments by microplastics and emphasize the urgent need for targeted mitigation strategies. Also, the study contributes to the growing body of research by supporting the achievement of Sustainable Development Goals (SDGs) by contributing to targets related to good health and well-being (SDG 3), sustainable cities (SDG 11), responsible consumption and production (SDG 12), and the protection of terrestrial and aquatic ecosystems (SDGs 14 and 15).



Stereomicroscopic images of various microplastics types identified in street dust

Gas Metrology

Gas Metrology is disseminating SI traceability through measurement services in area of calibration, testing and primary reference gas mixtures (Gas-BNDs) to its stakeholders who are gas industries, accredited laboratories, regulatory bodies like CPCB/SPCB, academic institution, CSIR-Sister laboratories etc. These indigenously prepared SI traceable reference gas standards are saving the outflow of foreign currency. Following are the gas metrology achievements in year 2023-24:

- **Gas Metrology International Peer Review - PEER REVIEW** of Gas metrology was completed successfully without any Nonconformance on 22nd and 23rd Feb 2024 for both its technical and quality system as per **ISO/IEC 17025:2017 and ISO 17034: 2016** and applied for **04 nos of CMCs in gases**. Technical Expert was Dr. Jin Sang Jung, Head of Gas Metrology Group from KRISS (Korea Research Institute of Standards and Science; NMI of Korea). Mr S. C. Huria was the Quality Expert from India.
- **Technology Transfer- “Six-stage Bioaerosol Sampler and Mask Testing Setup”** technology developed during 2022-2023 under project MLP 201232 is transferred to M/s Envirotech India Pvt. Ltd., Delhi on 18th April 2023.
- **Patent Granted-** One patent titled “Design and development of a high-volume PM_{2.5} impactor” granted in India on 1st November 2023 (**Indian Patent Application No. 201711013523**; Filling Date: 17.04.2017; Patent no: 464709). Name of Inventors are **Aggarwal Shankar G**, Patel Prashant, Tsai Chuen Jinn, **Soni Daya**, **Singh Khem**, Kotnala Ravinder Kumar, Tomoaki Okuda , Gupta Prabhat Kumar, Ojha Vijay Narain, Aswal Dinesh Kumar
- **Traceability Dissemination Services through Gas-BNDs, Calibration & Testing-** Traceability is disseminated to the customers through Gas-BNDs, Calibrations and testing and 24 numbers of certificates were issued.
- Following Technical Service Projects (TSPs) are started in the year 2023 which will be continued till 2025.
 1. Testing of high flow air purifiers (to be installed at new parliament building): M/S Siddhivinayak Tradelinks, Mumbai
 2. Testing of air monitoring instruments: M/S Kenteck India Pvt. Ltd. New Delhi.

Biomedical Metrology

- **Biomedical Metrology Section at CSIR-NPL Developed an Automated Calibration System and Calibration Setup** - Researchers at the Biomedical Metrology Section of CSIR-NPL have developed an automated system for calibrating flow using the gravimetric method. This system is capable of calibrating infusion device analyzers and infusion devices with volumes ranging from 10 mL to 900 mL. Additionally, the section has established a calibration setup for occlusion pressure of infusion device analyzers in accordance with the DKD-R 6-1 Guideline.

The automated flow calibration system utilizes a high-precision balance to measure the mass of fluid delivered by the infusion device. This method ensures accurate and reliable calibration results. The calibration setup for occlusion pressure measures the pressure required to occlude the flow path of an infusion

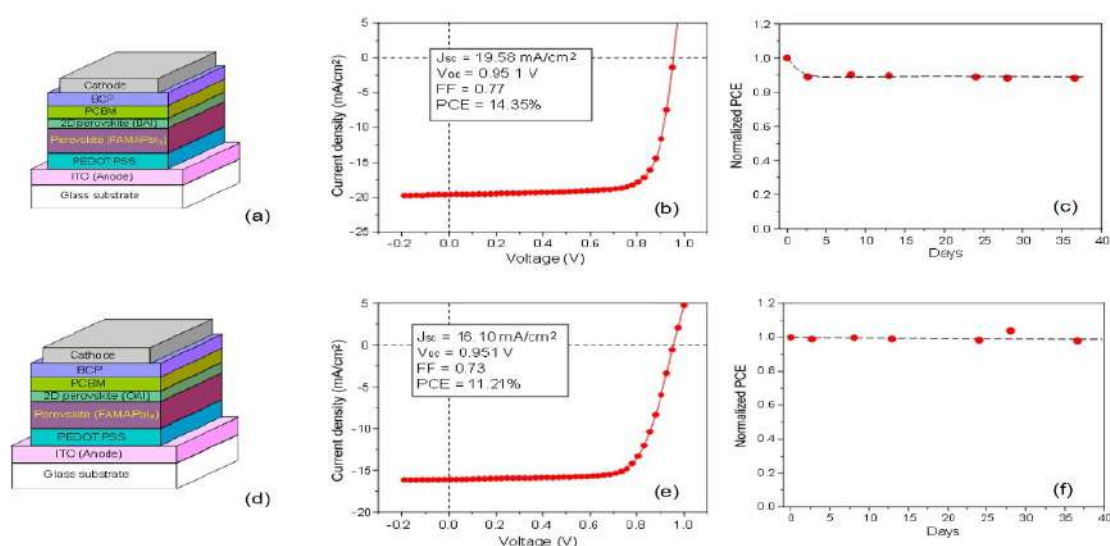
device analyzer. This calibration is essential for ensuring the safe and effective operation of these devices.

The development of these calibration systems is a significant contribution to the field of biomedical metrology. They will help to ensure the accuracy and safety of infusion devices, which are critical for the delivery of medications and other fluids to patients.

Advanced Materials & Device Metrology

The highlights of different sub-divisional research activities for the year are as below:

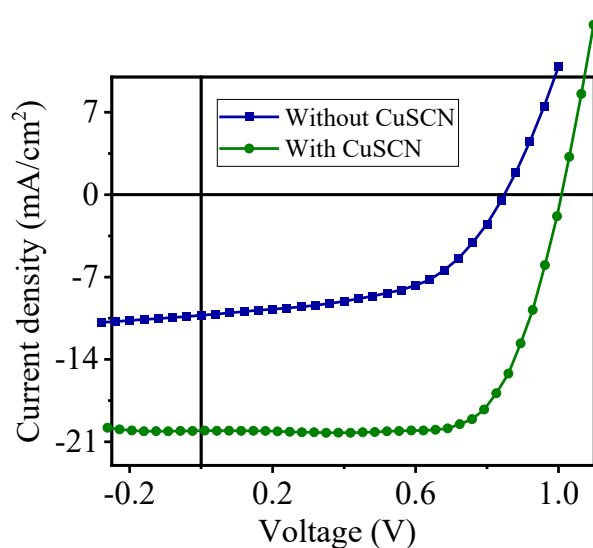
- Development of Printable Perovskite Solar Cells** - CSIR-NPL investigated in details the effect of in-situ substrate heating on the growth of perovskite crystals towards getting high performance printed PSCs. All the layers like electron transport layer (ETL), perovskite layer and hole transport layer (HTL) were printed by slot die method. Perovskite layer was printed via two step method, where first PbI_2 film was printed and then methyl ammonium iodide (MAI) ink was printed to convert it into methyl ammonium lead iodide (MAPbI_3) perovskite. The crystal growth and nano-scale morphology of printed PbI_2 films is observed to affect the growth of perovskite crystals thereafter. It was difficult to convert the compact PbI_2 film completely into MAPbI_3 via subsequent printing of MAI, therefore we came up with an idea of multiple print cycles of MAI on PbI_2 . The optimized print cycles of MAI led us to achieve complete conversion of PbI_2 into high quality MAPbI_3 crystals, which resulted in PSCs having power conversion efficiency (PCE) up to 11.99%.



(a) Schematic structure, (b) J-V characteristics and (c) degradation profile of the spin coated solar cell with BAI capping layer stored in air without encapsulation. (d) Schematic structure, (e) J-V characteristics and (f) degradation profile of the spin coated solar cell with OAI capping layer stored in air without encapsulation

- Thermally Deposited Hole Transport Layer in Perovskite Solar Cells: CuSCN** - CSIR-NPL developed solution-processable deposition of copper (I) thiocyanate (CuSCN) thin films which could be widely used as hole transport layer (HTL) in optoelectronic applications, namely perovskite and organic solar cells. We have grown CuSCN thin film via thermal evaporation as an efficient, eco-friendly and scalable HTL in inverted perovskite solar cells as an alternative and solvent free approach to the conventional solution-processed methods. The structural, electrochemical, optical, and morphological properties of the CuSCN films have been characterized. The long-term electrochemical and optical stability of thermally deposited CuSCN films were examined. The effect of CuSCN film

thicknesses (20, 30, 40, 60, and 100 nm) and annealing temperatures (RT, 50, 100, 150, and 200°C) of CuSCN films on the photovoltaic performance were also investigated. The optimized device configuration ITO/CuSCN/MAPbI₃/PC₆₁BM/BCP/Ag with 30 nm thick CuSCN film annealed at 100°C for 10 min exhibits the maximum power conversion efficiency (PCE) of 15.71% with $V_{oc} = 1.01$ V, $J_{sc} = 20.2$ mA/cm², and FF = 0.77. For reference, perovskite solar cells without HTL have been also fabricated simultaneously. Importantly, the thermally deposited CuSCN based devices show excellent reproducibility and stability up to 240 h with ~89% retention of the initial PCE. It demonstrates a new methodology for obtaining better CuSCN film by thermal deposition technique for efficient, sustainable and scalable electronic device applications.



J-V characteristics curve of fabricated devices.

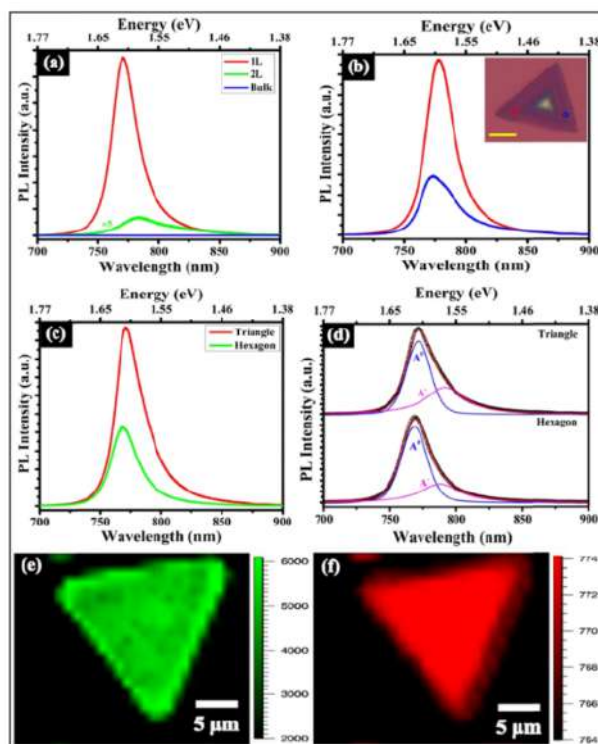
- Recycling of Plastic Wastes** - We have developed a single-step delamination and demetallization process for multilayer plastic waste via exploiting a strategic combination of aqueous alkali and liquid organic medium, making the process safe, scalable, environment-friendly (no solvent fume hazard or disposal issues) and economically viable (due to cheap liquid medium and its regeneration and subsequent reuse). Similarly, work related to the waste pharmaceutical blisters (WPBs) is completed to identify the optimized conditions, ultimately affecting the delamination of aluminium and plastic fractions of WPBs by selective etching/dissolution of the binder layer sandwiched between the two, thus ensuring very high recovery rates, reduced loads on materials reserves, energy savings, waste to wealth realization, maintenance of circular economy and reduced carbon foot prints.



Recovered polymer from multilayer plastic waste using single-step delamination and demetallization process

Recovered polymer and aluminum foil from waste pharmaceutical blisters

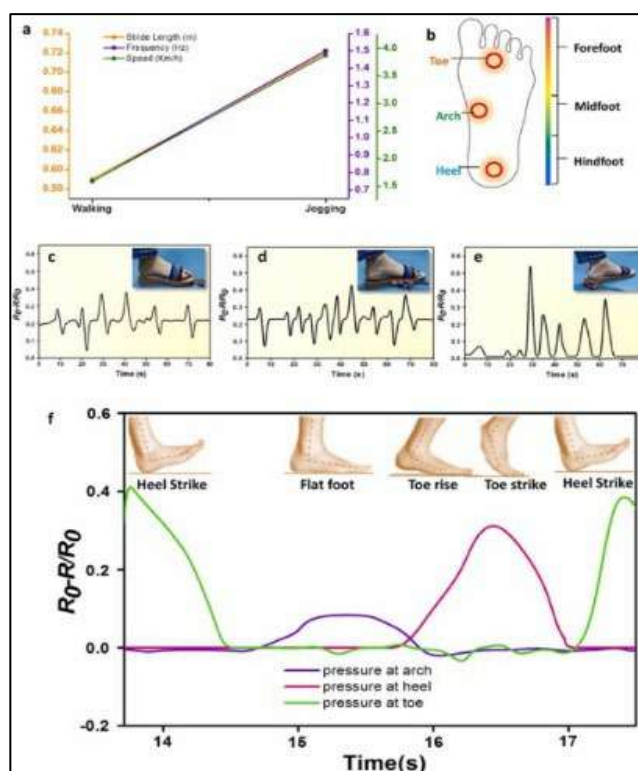
- Spectroscopic Studies on CVD-grown Monolayer, Bilayer, and Ribbon Structures of WSe₂ Flakes** - CSIR-NPL demonstrated a lab-built CVD setup used to synthesize different 1L, 2L, shapes (triangles and hexagons of the synthesis and spectroscopy of WSe₂ flakes along hexagons), and stacking morphologies of WSe₂ flakes. The morphologies of the WSe₂ flakes were examined using different growth parameters, such as the growth temperature, promoter (KBr) mass, H₂ gas flow rate, and deposition time, confirming that these parameters play a crucial role in obtaining the different nanostructures. In addition, the synthesis pathway of WSe₂-RS was elucidated comprehensively on the basis of droplet motion. The features of the layer-stacking patterns were investigated using optical microscopy, SEM, Raman, PL, TEM, XPS, and AFM, confirming that the WSe₂ flakes are of good quality. Raman and PL spectroscopies were used principally to examine the quality of the as-synthesized WSe₂ flakes (1L and 2L) and their RS. Furthermore, the spatial distribution of the as-synthesized WSe₂ flakes, including different vertical stacking of triangles, hexagon, and varying the RS, was examined through Raman mapping of the E_{12g} (in-plane) mode, which confirmed that the flakes are uniform in nature. Moreover, PL spectra and mapping also confirmed that the obtained monolayers are of high quality. Hence, these results offer a platform for the synthesis of new emerging 1D-on-2D structures and the design of optoelectronic devices.



(a) Comparison of PL spectra for 1L, 2L, and bulk WSe2 over the Si/SiO₂ substrate. For clarity, the PL spectrum of 2L WSe2 is magnified, as indicated. (b) PL spectra of WSe2 -RS deposited on the Si/SiO₂ substrate, where the inset shows an optical image of the WSe2-RS (scale bar, 5 mm). (c) PL spectra of triangle and hexagon shapes of 1L-WSe2 obtained at the center of the flake. (d) Peak analysis of the A exciton peak in both flake shapes, where the peak is fitted with two Voigt functions. The different line types of circular dots (black), red, blue, and magenta traces represent the experimental data, fitted data, A0 exciton, and A- trion, respectively. (e) and (f) PL mapping with respect to the A exciton peak in the WSe2 triangle shape, for the peak intensity map (e) and the peak position map (f). The notation has the usual meanings

- Development of Three-dimensional CNT-rGO/PDMS Porous Scaffold Derived Super compressible Lightweight Body-mounted Piezoresistive Force Sensor for Human Motion Monitoring** - CSIR-NPL successfully demonstrated a 3D porous scaffold-based sensor which is integrated with high piezoresistive force sensitivity and super-compressibility. A porous PDMS sponge is synthesized via facile method, infused with dual conductive networks of carbon nanotubes (CNTs) and reduced graphene oxide (rGO) that synergistically improve the electrical and sensing properties. In present investigations, the parameters that influence the efficiency of the piezoresistive sensor are accurately optimised. Hybrid sponges with varying rGO, CNT concentrations were prepared to determine the best composition. The drop-by-drop solution casting of nanomaterial ink allowed control of the microstructure. The sponge with ~60 wt% CNT and ~40 wt% rGO is the optimised composition that creates an efficient piezoresistive transduction mechanism. Dropping cycles also play a vital role in affecting the piezoresistivity of the sensors has been observed. After proper analysis 4–5 dropping cycles (1 mg/ml) of hybrid ink is considered ideal to generate a viable piezoresistive sponge as small number of dropping cycles were insufficient to form conducting paths, whereas more dropping cycles caused agglomeration of nanomaterial and show a percolation threshold thereby increasing the mass. A comparative

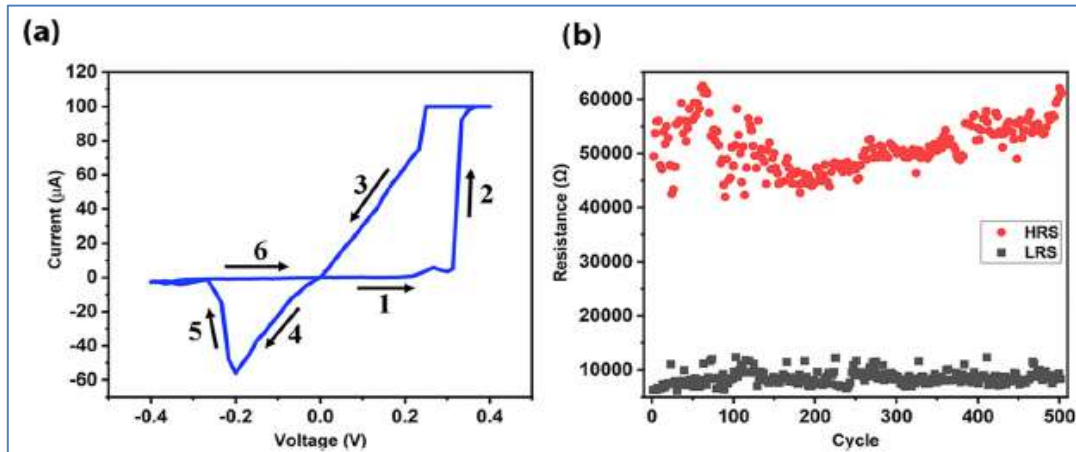
piezoresistive force study shows that hybrid/PDMS show better linearity, wide sensing range and better sensitivity as compared to pure CNT/PDMS and pure rGO/PDMS sponges. It is attributed to the better interfacial contacts, high electron/phonon transfer, low intertube slippage and reduction in phonon scattering between CNTs and rGO. The sensor shows super compressibility upto 90%, durability for 2000 cycles and 38 ms/32 ms response/recovery time. The sensor is capable to detect flexion generated while joint movements of finger, wrist, elbow and knee as shown in the following figure. It can also measure different gait patterns while walking, jogging, squatting, sitting, standing and analyse gait speed, stride length when integrated on a shoe sole thereby revealing its potential application in personal health monitoring, soft robotics and wearable electronics.



(a) Stride length, Stride frequency and gait speed while walking and jogging, (b) Illustration of key pressure on foot; Gait pattern as a function of the relative resistance response of sensor when pressure is at the (c) toe area, (d) arch area, (e) heel are, (f) the relative resistance response of sensor during a complete gait cycle (heel strike, flatfoot, toe rise, toe strike)

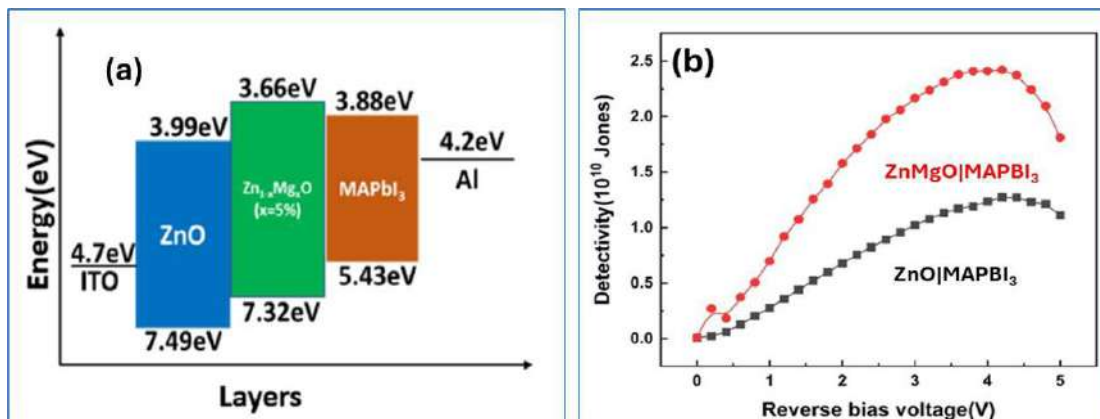
- Developments of AgBiS₂ Quantum Dot-based Multilevel Resistive Switching Device-** The quantum dot of metal sulfide has been developed for low power electronics. AgBiS₂ QDs have been synthesized with a particle size of 5.9 ± 1.4 nm. These are used to fabricate an Al/AgBiS₂/ITO memristive device which exhibits electroforming-free bipolar RS behaviour at very low switching voltages of +0.3 V/-0.25 V for sweep signals. The device also shows a high endurance for 500 cycles of +0.7 V/-0.7 V (set/reset) pulse signals. The RS behaviour of the device is mainly derived from the accumulation and depletion of the Ag⁺ ions and sulfur vacancies under an external applied field. The device can be set to 5 different conductance levels of 1G0, 1.5G0, 3G0, 4G0 and 5G0. This is primarily because of the atomic size of the conducting filament. The absence of electron scattering in

the atomic size range leads to ballistic transport of the electrons and eventually results in the quantization of conductance.



(a) Bipolar switching I-V characteristics of the AgBiS₂ memristor device. (b) LRS and HRS state of the device up to 500 cycles with a pulse width of 100 ms at read voltage of 0.01 V

- Development of Solution-processed Metal Oxide Electron Transport Layer for MAPbI₃ Optoelectronic Device Applications** - A stable and solution-processed Mg-doped ZnO thin films was fabricated for MAPbI₃ based photodetectors (PD). The highest responsivity for ZnO devices and Mg-doped ZnO PDs devices is 40 mA/W and 609 mA/W in the UV region of Illumination. The multiple ON-OFF cycles of both devices at different wavelengths of light illumination show good stability and reproducibility. The LDR of the Mg-doped ZnO photodetector is three times higher than ZnO photodetectors for white light.

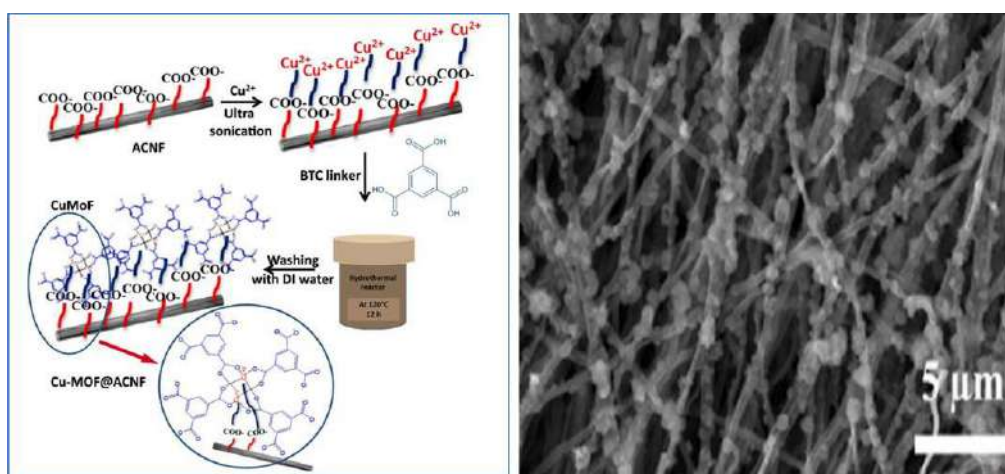


a) The Schematic energy diagram of PDs device (b) The specific detectivity of ZnO and Mg doped ZnO ETL PDs under the illumination of white light at different reverse bias voltages.

Advanced Carbon Products and Metrology

- Carbon Nanofibers Decorated Cu-MOF as Free-standing and Flexible Electrode for Robust Electrochemical Energy Storage**

The development of green and renewable materials for energy storage and conversion technologies promises humankind a dependable hope for a clean and green future that is decoupled from the use of conventional fossil fuels. Among existing energy storage devices, super capacitors are emerging as a credible candidate owing to their superior characteristics, such as rapid charge-discharge rate, high stability, long cyclability, and economical cost. In the present work, one of the most prevalent biopolymers, Kraft lignin, is employed as a precursor to synthesize activated carbon nanofibers (ACNFs). The use of naturally sourced Kraft lignin to develop ACNFs makes the process not only affordable but also environment-friendly. The free-standing ACNFs are decorated with copper-metal-organic frameworks (Cu-MOFs).



Schematic for the synthesis of Cu-MOF@ACNF and FESEM images of Cu-MOF@ACNF

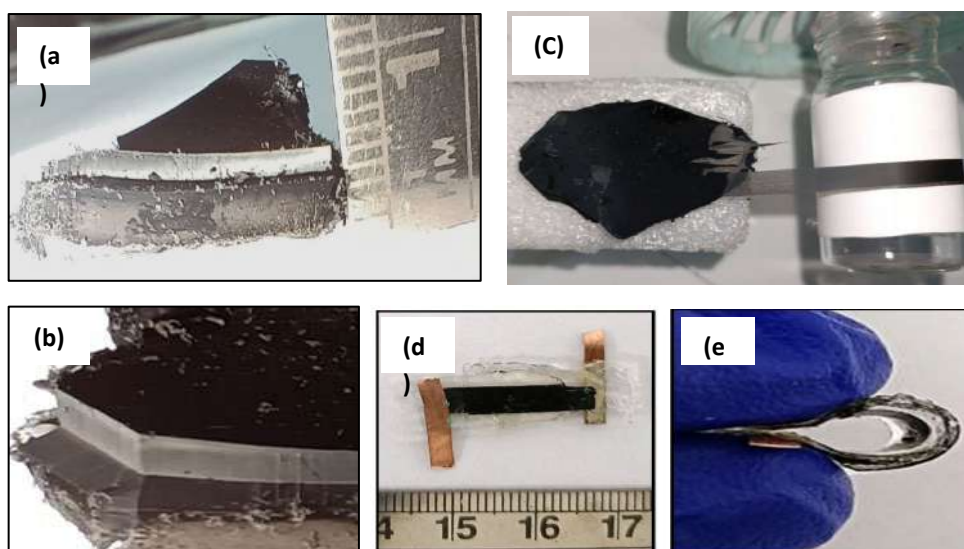
The Cyclic Voltammetry (CV), Electrochemical Impedance Spectroscopy (EIS), and Galvanostatic Charge-Discharge (GCD) studies were performed to compare the electrochemical performance of the Cu-MOF, ACNF, and Cu-MOF@ACNF as electrode materials for supercapacitors. Among three electrodes, the Cu-MOF@ACNF sheet reveals a higher specific capacitance of 303.2 F/g compared to ACNF (203.3 F/g) and Cu-MOF (68.2 F/g) at the same current density of 1 A/g. Based on the higher performance of Cu-MOF@ACNF two types of symmetrical devices, i.e., aqueous (using electrolyte-impregnated filter paper) and solid-state devices (using a polymeric gel electrolyte), were fabricated. The all-solid-state supercapacitor device was found to feature high flexibility, stand-alone characteristics, and excellent performance as an electrode with a working potential window of 0–2.0 V. The device demonstrates a high energy density of 78.71 Wh/kg and a power density of 1050.0 W/kg, along with high coulombic efficiency (99.8 %) after 10,000 cycles. The achieved performance is superior to many published reports, revealing that the developed composite materials hold prospect for applications in green and high-performance flexible energy storage devices.

- Petroleum Coke Derived Reduced Graphene Oxide as an Electrocatalyst for Water Splitting** - One of the by-products produced in the petroleum refinery industry is Petroleum coke or pet coke (PC). To make its use in the development of high-cost value-added carbon products apart from electrodes in steel and aluminum extraction is one of the areas of research interest among the scientific community. The PC is a feedstock of carbon sources and has the potential to produce more valuable carbon products such as graphite, pitches, graphene etc. It reported heat treatment of PC at high temperature (2200°C) and its conversion in to graphene oxide (GO) and reduced graphene oxide (rGO). The synthesized rGO was investigated as an electrode material for water splitting, utilizing Nickel foam (NF) as a substrate. The rGO obtained from PC heat treated 2200°C shows remarkable electrocatalytic performance by showing lower over-potentials 169 mV (vs. RHE) for HER @10 mA/cm² current density and the Tafel slope of 108.23 mV/dec. For OER, the obtained over-potential of 400 mV (vs. RHE) @10 mA/cm² current density and Tafel slope 104 mV/dec provides insight into using PC-derived rGO application towards water splitting. This shows, PC derived rGO can be used for the improvement of electrocatalyst performance in terms of stability, efficiency, and large-scale production of green hydrogen as a clean & sustainable fuel.
- Torrefied Waste Rice Husk Biomass for Co-firing with Coal in Thermal Power Plant** - India is an agriculture-based economy with over 70% population sustaining their livelihood from agricultural practices. Rice is one of the most important food crops and feeds more than 66 % population of India. India is the second largest producer of rice after China. The rice plant at the end of crop it consists of straws and rice seeds. The rice seed consists of rice grain and rice husk which is the hard-protective coverings of rice grains. The rice husk is separated from the grains during milling process. Rice husk is an abundantly available waste biomass material and it contains about 40–50% of organic carbon. In India, there is ~30-40 million ton of rice husk available, it is a waste material and therefore required effective management. Only a fraction of this residue is used as feed for ruminants and for other uses like manure, in brick kilns and boiler, etc. Rice husk biomass is renewable source and it can be utilized to produce heat and energy. But the raw rice husk possesses high moisture content, poor grindability, high oxygen content, and low calorific value that makes it unsuitable.

CSIR-NPL team worked towards improvement of the physico-thermal properties of rice husk biomass to compose it as a useful renewable source material for the energy generation. In this direction, the rice husk torrefaction is carried out on an electrically preheated rotating screw reactor without any carrier gas up to a temperature of 300 °C. It is observed that volatile matter decreases, and fixed carbon increases with increasing torrefaction temperature. The calorific value increases from 15.27 to 19.16 MJ/kg and bulk density from 110 to 270 kg/m³ at temperature 300°C. On pulverization of torrefied product, bulk density is improved to 550 kg/m³. The hard grove grindability index, which is an essential property of the biomass when used with the combination of subbituminous coal for co-firing, for rice husk is 15, and it was increased to 37 after the torrefaction at 300°C.

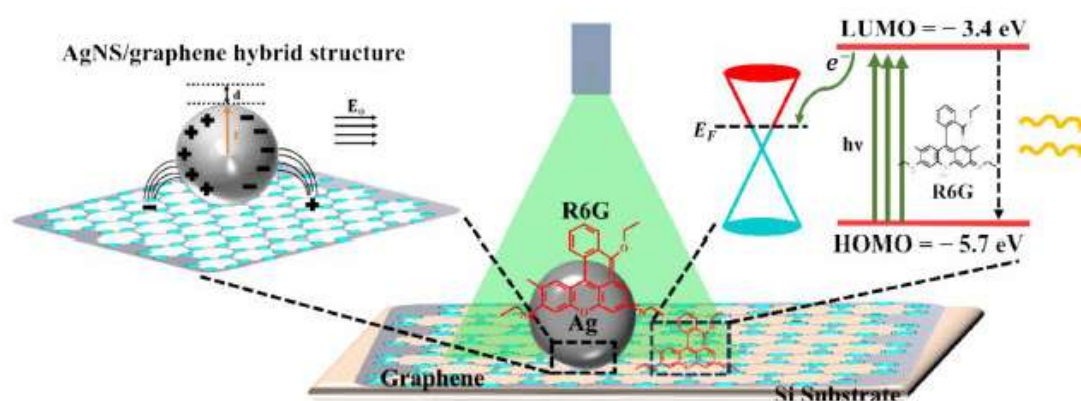
The torrefied rice husk can replace fossil fuels in cookstoves, rural industries, industrial boilers, furnaces and in thermal power plant with co-firing with coal, which can significantly reduce greenhouse gas emission.

- Development of Aligned CNTs Forest and its Application in Energy Storage and Generation-** The long length CNTs yarn and sheet have been developed from a highly drawable and spinnable vertically aligned CNTs forest with millimeter scale array height based on a practically viable single-step CVD growth process. The NMP-treated CNTs sheet employed to develop Flexible hybris solid state supercapacitor (FHSC) devices.



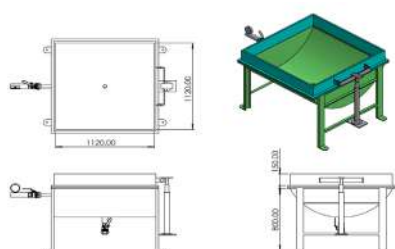
Vertically aligned carbon nanotubes (VACNTs) forest (a &b), Drawing of aligned CNTs sheet (c), Flexible hybrid solid state supercapacitor (FHSC) (d&e)

- Development of Hybrid SERS Substrate based on Graphene for its Application in Sensing-** The hybrid substrate based on silver nanostructures (AgNS) and graphene have been devised to understand the role of pristine CVD grown graphene on SERS signal and its possible mechanism. The developed hybrid SERS evaluated for sensing of rhodamine 6G (R6G). The graphene with its ability to modulate the electronic structure and tune it relative to the highest occupied molecular orbital-lowest occupied molecular orbital (HOMO-LUMO) levels of R6G molecules resulted in improved SERS signal by about an order for graphene-AgNS hybrid structure as compared to bare AgNS.



Schematic diagram representing the underlying SERS phenomenon in R6G/AgNS/graphene/Si substrate and R6G/graphene/Si

- **Under the FTT project entitled "Development of a Process Technology for Preparation of Carbon Nanotube-based Flexible Paper of Size 1 Meter x 1 Meter,"** - A dedicated setup for producing CNT paper of this size has been successfully designed and established. The prepared CNT paper has been thoroughly characterized for its electrical conductivity, tensile strength, BET surface area, and pore size. This innovative meter scale CNT paper holds tremendous potential for various applications, including energy storage systems, flexible thermoelectrics, electromagnetic interference (EMI) shielding, ballistic resistance materials, structural composites, and water purification.



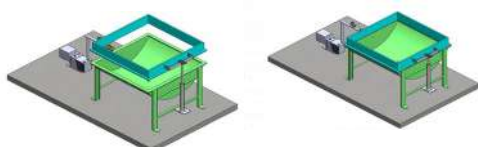
Designs of Fabrication set-up of meter scale flexible CNT paper



Fabrication set-up



Flexible CNT Paper of 1m x 1m



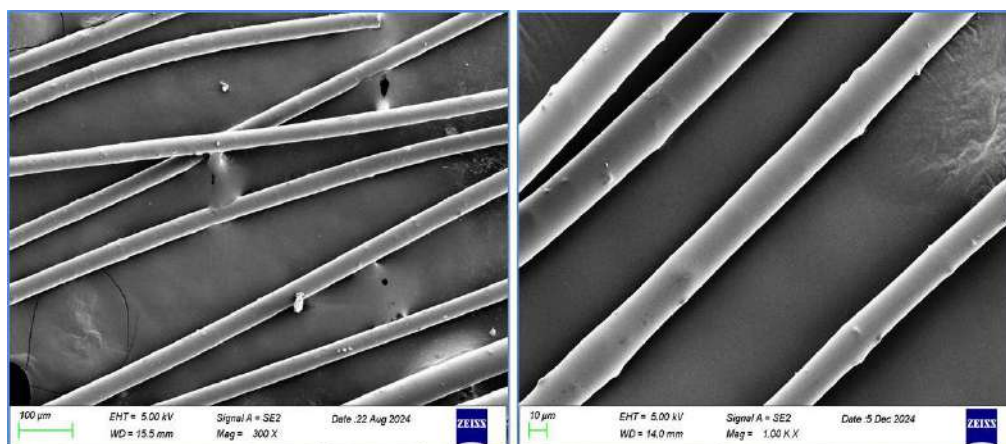
Flexible CNT Papers

Design, Establishment and Fabrication of 1m x 1m CNT Paper

Carbon fibers have gained considerable attention due to their exceptional properties, including lightweight, superior mechanical strength, excellent chemical resistance, and outstanding durability. These characteristics make them indispensable across a broad range of industries, such as aerospace, sports equipment, medical devices, defense, energy sectors etc. As the demand for carbon fibers continues to increase across these sectors, the development of cost-effective precursors and production methods has become increasingly critical. Pitch based precursors such as isotropic and mesophase pitch, have emerged as promising precursors for production of carbon fibers.

A Research Project in this area has been sanctioned by the **National Technical Textiles Mission (NTTM), Ministry of Textiles, Government of India**. In this project, the research is focused on synthesis of spinnable isotropic coal tar pitch and mesophase pitch and fabrication of carbon fibers therefrom. The production process involves several critical steps: starting from synthesis of precursors, melt spinning to transform pitch precursors into pitch fibers, stabilization in an oxidative environment to prevent pitch fibers from melting during subsequent heat treatment, and subsequently carbonization at 1000 oC to convert stabilized pitch fibers into carbon fibers with a carbon content exceeding 90%. Each of these stages plays a pivotal role in determining the final properties and overall cost of the carbon fibers. The spinnable pitch precursors and high-quality carbon fibers can only be achieved through systematic integration of all steps. Each step is associated with certain parameters which have to be optimized to make the process effective and efficient. We are systematically optimizing these steps to

streamline the process, reduce cost, and enhance the properties of the resulting carbon fibers. It underscores the critical impact of modifications in precursor processing, along with fine-tuning stabilization and carbonization parameters, on enhancing fiber performance. It reveals that the carbon fibers with diameters ranging from 18 to 25 μm have achieved tensile strength of 0.8 GPa and 1.40 GPa for isotropic pitch and mesophase pitch, respectively. It further establishes the viability of producing high-quality carbon fibers through a cost-effective and scalable approach, addressing the increasing industrial demand for advanced materials.



Images of (A) isotropic pitch and (B) mesophase pitch-based carbon fibers

Bharatiya Nirdeshak Dravya (BND®)

BND Division works under four verticals namely:

1. In-House BND
2. Chemical and Food BND group
3. Outreach RMP
4. BND Management

In-House BND

The In-House BND Section of CSIR-NPL plays a crucial role in developing Indian Reference Materials for instrument calibration and works closely with Reference Material Producers to create BNDs in sectors such as petroleum, pesticides, and precious metals, ensuring high-precision measurement standards across the country. Several advanced analytical capabilities have been established to support the preparation and dissemination of indigenous reference standards. This group also focuses on developing reference materials for sophisticated instruments, offering cost-effective solutions that are fully comparable with internationally accepted standards.

Chemical and Food BND group

This group is involved in Chemical Metrology and development of CRMs/BNDs targeting chemical parameters in various matrices like food, water, and building materials. These BNDs are used by Testing Laboratories as a primary standard for calibration of instrument, and development of methods. The BNDs developed by Chemical and Food BND section are easily available to the stakeholders on competitive prices enabling the calibration of their instrument on routine basis. During the fiscal year 2023-24, three new BNDs and thirty six successive batches of BNDs had been disseminated to the market that were developed in collaboration with RMP. The photo given below shows the Selenium standard solution (BND® 1034), Bromate Standard Solution (BND® 1035) and Conductivity Standard Solution (BND® 1041) which have been released on World Metrology Day – 2023 and Foundation Day-2024.



Outreach RMP

Outreach is involved in Coordinating efforts with external reference material producers for seamless development.

BND Management

The BND management and BND outreach collaboratively identify the niche areas where the indigenously developed CRMs are required. Further, to it they identify the competent RMP to produce the BNDs at commercial level as per the criteria laid down by CSIR-NPL quality system and BND management. Furthermore, BND management team also organizes various stakeholder meetings time to time for creating awareness and educating the industry partners to fulfill their requirements of CRMs. The BND management team has established the necessary logistics for the registration, certification, and dissemination of BNDs, as well as related activities to support production which is a continuous exercise.

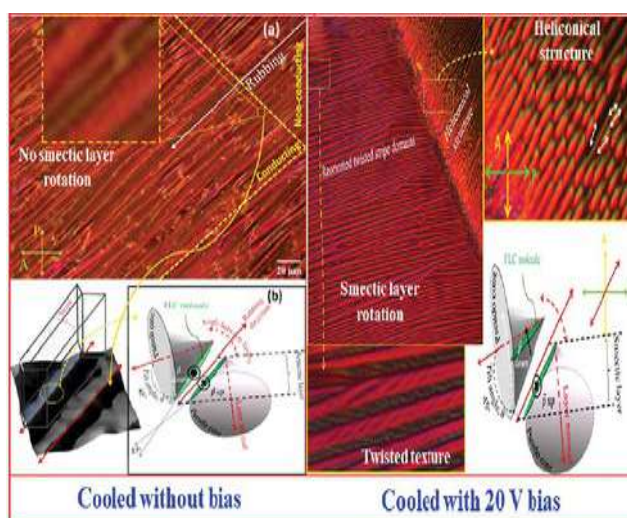
Research & Development Activities:

The BND Division of CSIR-NPL is actively engaged in cutting-edge research spanning both fundamental science and metrology. The BND division contributes to nationally significant areas through diverse and advanced research activities. The division's expertise covers biosensors, liquid crystals, electrochemical energy devices, magnetic sensors, water purification technologies, magnetic materials, thin-films, polymer-based materials, quantum materials, spintronics and the growth of high-quality single crystals. In addition, we play a pivotal role in the development, preparation, and dissemination of Bharatiya Nirdeshak Dravyas (BNDs), supporting India's measurement standards and ensuring quality at par with international standards for Indian industry and academia.

A brief outcome of research activity in the form of scientific papers is given below.

- **Smectic Layers Reorientation with Stripes and Heliconical Structure in Surface Stabilised Ferroelectric Liquid Crystal:**

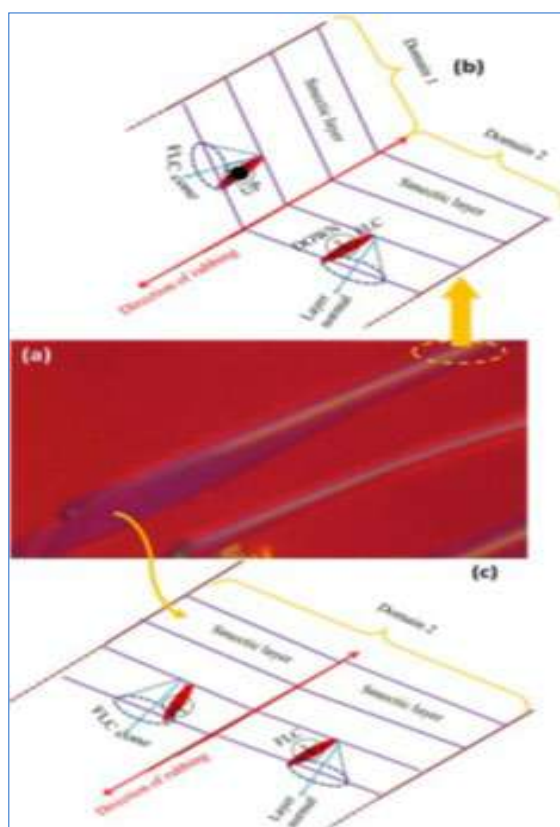
High-tilt angle ferroelectric liquid crystal material in surface stabilised geometry (SSFLC) is investigated for the smectic layer reorientation and its molecular dynamics by electro-optical and dielectric spectroscopy techniques. The first observation of Smectic layer reorientation (5° to 45°) is by controlled cooling rate and applying an electric field in the vicinity of transition temperature from chiral nematic (N^*) to chiral smectic C (SmC^*) phase, stripe domain textures along the rubbing direction are detected with quasi-bistable states. A dielectric relaxation process at a lower frequency than Goldstone mode with an increase in DC bias up to 2 V is observed in the sample cooled without any bias, it may have originated from the heliconical structure within the stripes which is seen in the optical textures recorded at the time of the dielectric scan.



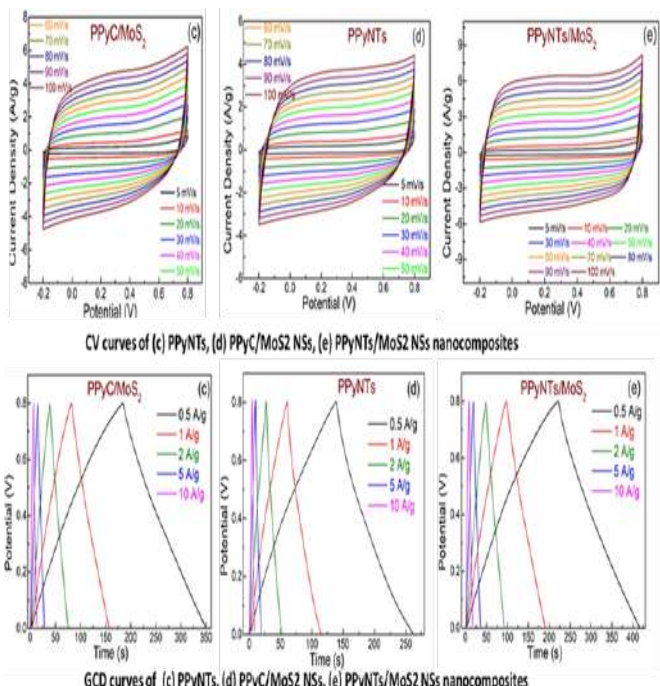
However, this increment is not observed in the sample cooled under DC bias. This indicates that there exist different phenomena in the high-tilt angle SSFLC sample cooled in different conditions of DC bias; stripe domains, smectic layers reorientation, heliconical structure and twisted structure within stripes which are significant to explore deeply in high-tilt angle ferroelectric liquid crystals. The results have found a place on the cover page of the Journal [*Liquid Crystals*, 34 (2023) 182–189]



- Domain Reorientation due to Smectic Layer Instability in High Tilt Angle-based Surface Stabilized Ferroelectric Liquid Crystal Cell** - High tilt angle (45°) ferroelectric liquid crystal (FLC) in surface stabilized geometry, having no chiral smectic A (SmA^*) phase, has been studied for the reorientation of the smectic layers near the transition temperature (T_c). The electro-optical studies have shown the stripe domain formation in which the liquid crystal molecules are aligned along the rubbing direction, but the smectic layers are tilted away from the rubbing direction at room temperature. In such high tilt angle FLCs, the molecular alignment and smectic layer formation start from bottom and top rubbed grooves at T_c . The domain formation of the FLC takes place in the middle of the top and bottom surfaces due to the frustration of the dipolar interaction. The smectic layer switching is observed by optical microscopy and confirmed by the dielectric spectroscopy method near T_c of SmC^* and chiral nematic phases. Domain switching has shown a larger switching angle than the molecular tilt angle within the smectic layer. These studies are expected to be significant for understanding the smectic layer structure and the domain switching process, which may pave the way for large optical switching devices.



- High-performance Flexible Supercapacitor based on Morphology-tuned Polypyrrole/Molybdenum Disulfide Nanocomposites** - Polypyrrole (PPy) is the most studied material among the conducting polymers for high-performance supercapacitors. However, due to morphology collapse, polypyrrole exhibits poor cycling ability and lower charge storage capacity, limiting its real-world applications. To address these issues herein, the binary nanocomposites of PPy with MoS₂ (molybdenum disulfide) NSs (nanostructures) in two different morphologies, have been prepared through in situ polymerization technique. The rational design of PPyNTs/MoS₂ nanocomposite consisting of dense wrapping of PPyNTs on MoS₂ leads to high specific capacitance (Csp) up to 481 F/g at 0.5 A/g. After 2000 charge-discharge cycles, a decline of 5.6% in the specific capacitance of PPyNTs/MoS₂ nanocomposite was observed. This outstanding performance of PPyNTs/MoS₂ nanocomposite resulted in designing futuristic flexible supercapacitors.

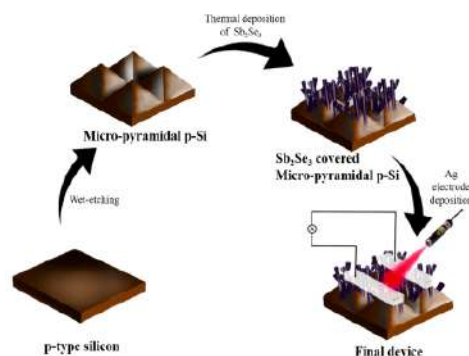


CV curves of (c) PPyC/MoS₂, (d) PPyNTs, (e) PPyNTs/MoS₂ nanocomposites

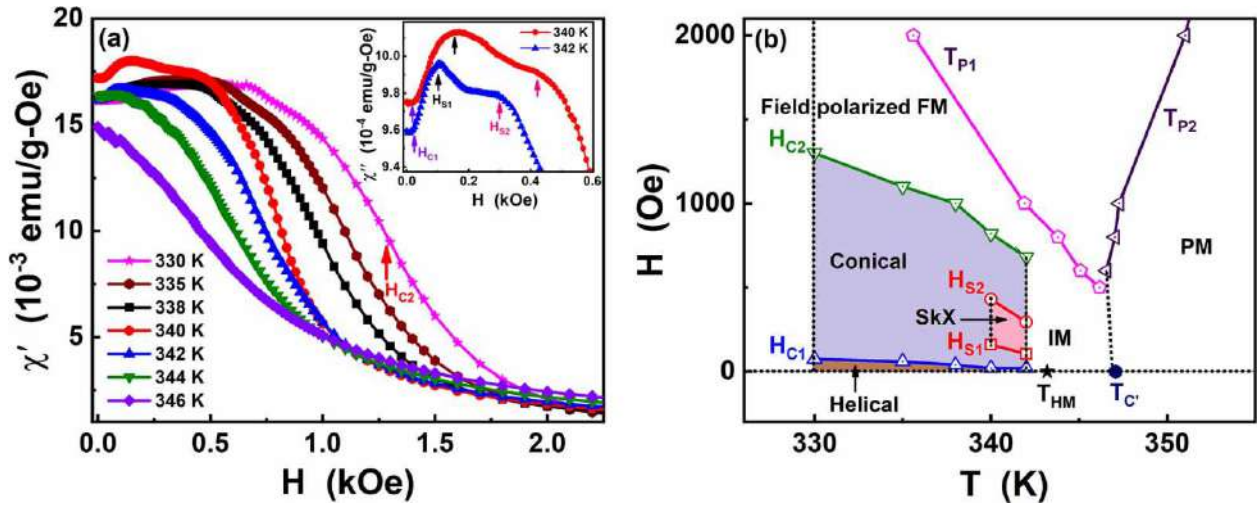
GCD curves of (c) PPyC/MoS₂, (d) PPyNTs, (e) PPyNTs/MoS₂ nanocomposites
- Optimizing the Fly Ash/Activator Ratio for a Fly Ash-Based Geopolymer through a Study of Microstructure, Thermal Stability, and Electrical Properties** - Fly ash (FA)-based geopolymer was prepared using sodium hydroxide and sodium silicate (in 2.5 ratio) as an alkali activator liquid (AL). The condition of FA/AL was optimized for achieving 1.00, 1.25, 1.5, and 1.75 ratios by varying the alkali concentrations, which are referred to as GP1, GP2, GP3, and GP4, respectively. The influence of slight variations in the FA/AL ratio on microstructure, morphology, functional groups, and composition was investigated by X-ray diffraction (XRD), field emission scanning electron microscopy (FESEM), X-ray fluorescence (XRF), and Fourier transform infrared spectroscopy (FTIR). FESEM detected a homogeneous fused matrix of fly ash and alkali activator solution up to 1.5 ratios; GP3 showed a dense morphology. FTIR confirmed that the formation of aluminosilicate gel induced a shift in the T-O (T = Si or Al) asymmetric stretching band, nearing a lower frequency. XRD showed an amorphous structure with phases, including quartz, mullite, hematite, and sodalite. The thermogravimetry and differential thermal analysis (TGA-DTA) indicated that the geopolymer samples were thermally stable. From this study, we understood that the geopolymer possessed insulating properties.
- Growth of Potential Nonlinear Optical Single crystal of Ammonium Penta Borate by inexpensive slow evaporation solution growth method**-Slow evaporation solution technique (SEST) was employed to grow bulk size single crystal of Ammonium Penta Borate (APB). Commercially available raw salt of ammonium pentaborate tetrahydrate (NH₄B₅O₈·4H₂O) with high purity was used

for the above said purpose. The solubility was examined using various solvents out of which deionised water was found as most suitable solvent for the single crystal growth. The saturated solution was prepared by taking raw salt of APB with deionised water as solvent at ambient conditions with the help of magnetic stirrer. The nucleation in the prepared solution was observed after 40 days and continuous recrystallization was performed to improve the purity of the material. The growth of bulk size single crystals was achieved after 45 days. The grown single crystals of APB were found optically transparent and without any visible inclusions. The grown single crystals were useful for lasing and optoelectronic applications.

- Preparation of SnSe Thin Films-** SnSe has been made in-house using the solid state reaction route and thin films have been deposited by thermal evaporating it. These thin films have been characterized for their optoelectronic and gas sensing properties. The effect of thickness on the p-n switching in $\text{SnSe}_2/\text{SnO}_x/\text{SnSe}$ Heterojunction-based NO_2 Gas Sensor as well as Photodetector has been reported. Similarly Sb_2Se_3 thin films have been deposited and a highly responsive near infrared $\text{Si}/\text{Sb}_2\text{Se}_3$ photodetector via surface engineering of Silicon has been reported. Sb_2Se_3 nanosheet film-based devices have found its application in UV photodetection and resistive switching. Using the Sb_2Se_3 thin films $\text{Sb}_2\text{Se}_3/\text{CdS}$ -Based Solar Cell has been made and its experimental and theoretical analysis has been carried out. Various configurations of Sb_2Se_3 thin films have been studied theoretically for its solar cell applications. Also, SnO_2 -based NO_2 gas sensor with outstanding sensing performance at room temperature has been reported.

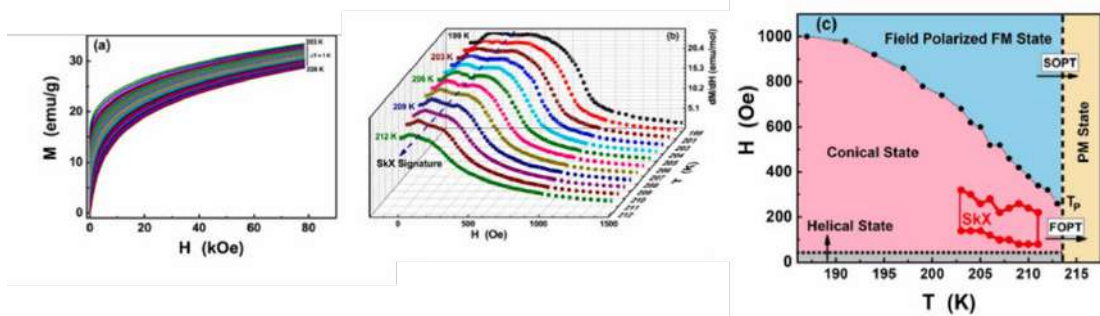


- Chiral-fluctuations Mediated Helical to Paramagnetic Phase Transition and Scaling Study in β -Mn type $\text{Co}_8\text{Zn}_8\text{Mn}_4$ Chiral Magnet-** The magnetization and ac susceptibility studies on a chiral cubic β -Mn type $\text{Co}_8\text{Zn}_8\text{Mn}_4$ alloy near the onset of magnetic ordering temperature. The $\text{Co}_8\text{Zn}_8\text{Mn}_4$ alloy undergoes a complex series of temperature-driven transitions from paramagnetic (P_M) to helimagnetic phase through an intermediate inhomogeneous chiral fluctuations phase. The Gaussian-shaped peak in χ' (T , $H = 0$ Oe) at $T_{HM} \sim 343.19$ K is analogous to that of the zero-field transition to the long-period modulated helical state. Moreover, a pronounced field-induced anomaly in $\chi'(T, H \geq 500$ Oe) rises quickly with field above T_{HM} like a fingerprint, evidence of a field-induced crossover into a precursor region. The in-field critical behavior characterizing a ferromagnetic-PM phase transition in the vicinity of ordering temperature confirms that $\text{Co}_8\text{Zn}_8\text{Mn}_4$ chiral magnet belongs to the 3D-Heisenberg universality class. The existence of a precursor region and the sizable expansion in the transition temperature, T_C , can be explained by the Landau equation.



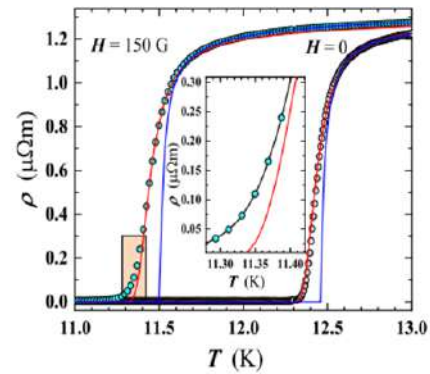
(a) Magnetic field dependent real part of ac susceptibility (for $h = 10$ Oe and $f = 9984$ Hz) at selected temperatures for $\text{Co}_8\text{Zn}_8\text{Mn}_4$ alloy. Inset shows field dependent imaginary part of ac susceptibility showing skyrmion phase boundary at $T = 340$ K and 342 K. (b) Temperature-magnetic (T - H) phase diagram for $\text{Co}_8\text{Zn}_8\text{Mn}_4$ alloy constructed using magnetic ac susceptibility, $\chi(H, T)$ data. The abbreviations used are: F_M : ferromagnetic, IM : intermediate, P_M : paramagnetic, and H_M : helimagnetic and the black dotted lines are guides for the eyes.

- In-field Critical behaviour of -Mn type CoZnMn Skyrmion-host** - An elaborate in-field critical behaviour study based on magnetic isotherms measured in the vicinity of ordering temperature of a polycrystalline cubic β -Mn type $\text{Co}_7\text{Zn}_7\text{Mn}_6$ alloy is presented. The Rhodes-Wohlfarth analysis suggests the itinerant character of this chiral magnet. The critical exponents β , γ and δ for spontaneous magnetization, initial magnetic susceptibility and critical M-H isotherm, respectively are evaluated through the modified Arrott plots, Kouvel-Fisher method and critical isotherm analysis. The estimated critical exponents $\beta = 0.382(1)$, $\gamma = 1.386(2)$ and $\delta = 4.628(1)$ corroborate that the critical behaviour of the $\text{Co}_7\text{Zn}_7\text{Mn}_6$ system is akin to that of a three-dimensional (3D) Heisenberg ferromagnet. Based on the renormalization group theory predictions, the magnetic moments in the $\text{Co}_7\text{Zn}_7\text{Mn}_6$ chiral magnet are found to interact through the attractive extended-type short-range interactions between spins.



(a) Magnetic isotherms in the vicinity of T_c . (b) Isothermal magnetic susceptibility (dM/dH) plot obtained from the derivative of $M(H)$ data at different temperatures. (c) Magnetic phase diagram extracted by isothermal susceptibility for a polycrystalline $\text{Co}_7\text{Zn}_7\text{Mn}_6$ alloy. FOPT: first-order phase transition, SOPT: second-order phase transition and T_c : tri critical point. Helical to conical phase transition ($H = 35$ Oe) is shown by dotted straight line

- Berezinskii-Kosterlitz-Thouless to BCS-like Superconducting Transition Crossover Driven by Weak Magnetic Fields in Ultra-thin NbN Films** - The Berezinskii-Kosterlitz-Thouless (BKT) transition in ultra-thin NbN films is investigated in the presence of weak perpendicular magnetic fields. A jump in the phase stiffness at the BKT transition is detected up to 5 G, while the BKT features are smeared between 5 G and 50 G, disappearing altogether at 100 G, where conventional current-voltage behaviour is observed. Our findings demonstrate that weak magnetic fields, insignificant in bulk systems, deeply affect our ultra-thin system, promoting a crossover from Halperin-Nelson fluctuations to a BCS-like state with Ginzburg-Landau fluctuations, as the field increases. This behavior is related to field-induced free vortices that screen the vortex-antivortex interaction and smear the BKT transition.



Indian Standard Time Metrology

Indian Standard Time Division is responsible for the realization, establishment, custody, maintenance, dissemination and upgradation of the national standards for Time & Frequency, LF & HF Voltage, Current, Microwave and Magnetic parameters. The Time & Frequency Metrology Section is responsible for the highest level of time and frequency measurements in India using ultraprecise satellite links. As one of the mandates, CSIR-NPL maintains the Indian Standard Time (IST) based on atomic timescale consisting of bank of Cesium (Cs) atomic clocks, Hydrogen masers, precision measurement devices and ultraprecise satellite links. The traceability of CSIR-NPL timescale generating IST with respect to coordinated Universal Time (UTC) maintained by BIPM is at the level of few nano-seconds (ns). Dissemination of IST via satellite links and network is provided to users as per time synchronization accuracy requirements. Calibration services are provided for atomic clocks, oscillators, stop watches etc. to strategic and industry users as per requirement. In addition, research and development on primary atomic clocks is carried out. India's first Cs fountain clock, with an accuracy of a few parts in 10¹⁵, became operational in 2011 and is being improvised for better stability. A second Cs Fountain is under development. Recently, development of a more accurate clock ($\approx 10^{-17}$) at optical wavelengths based on a single trapped Ytterbium ion (project STIOS) has been initiated. LF & HF Voltage, Current and Microwave Metrology section maintains LF & HF Voltage, Current, Microwave Power and Phasor Measurement Unit (PMU) parameters of electrical metrology. To maintain the international traceability, a number of international & bilateral intercomparisons under the umbrella of BIPM and APMP have been carried out. At CSIR-NPL, PMU-CAL system traceable to its national standards carries out a comprehensive calibration and testing of PMU as per IS/IEC/IEEE 60255 118-1:2018 standard. It plays a vital role in power distribution sector through the PMU calibration and measurement system. Electromagnetic (EM) Metrology section comprises of various measurement facilities in frequency range from 1 Hz to 110 GHz of electromagnetic spectrum for devices from household electronic appliances to advanced strategic communication and instrumentation. The section maintains and disseminates various parameters such as attenuation, impedance, insertion loss, microwave power, E-Field and specific absorption rate (SAR), Shielding effectiveness, and dielectric measurements along with advanced Quantum E-Field measurements traceable to Planck Constant, Magnetic flux Density, Magnetic flux, turn area of search coil, power loss measurement of electrical steel.

Time and Frequency Metrology

The CSIR-NPL project "Strengthening of Network Time Dissemination Services for Nation-Wide Dissemination of IST" was approved and funded by CSIR, highlighting CSIR-NPL's commitment as the Time-Keeper of the Nation and emphasizing the importance of precise time dissemination from CSIR-NPL. Project supports the government's sovereign functions by ensuring national security, economic stability, and the synchronization of critical infrastructure through accurate time dissemination and timekeeping.

As part of the international cooperation, the Time and Frequency Metrology Section of CSIR-NPL engaged in a collaborative project with Taiwan within the framework of the Asia Pacific Metrology Program (APMP). During this period, CSIR-NPL's satellite receivers underwent rigorous comparison with internationally calibrated and accepted counterparts from Taiwan.

Significant Achievements of the work is as follows:

- **Enhanced Traceability:** The comparison of satellite receivers has significantly strengthened the traceability of Indian Standard Time (IST) and UTC(NPLI) to the international standard time, UTC.
- **Improved Accuracy:** This collaboration has ensured that the timekeeping standards maintained by CSIR-NPL are in close alignment with global standards, thereby improving the accuracy and reliability of time dissemination in India.
- **International Recognition:** Participation in APMP and successful comparisons with Taiwan's metrology standards have reinforced CSIR-NPL's position in the international metrology community, showcasing our commitment to maintaining high precision in time and frequency measurements

LF & HF Voltage, Current and Microwave Metrology

- **Low Frequency Voltage & Low Frequency Current Metrology** - Banks of Multi-Junction thermal converters (MJTC) are used for assigning AC DC transfer difference to the primary standard (MJTC) at 2 Volt and 5mA with the best uncertainty of ± 5 ppm. Therefore, the thermal transfer standard or thermal converters are designed to cover voltage range of 1mV volts to 1000 volts in the frequency range 10 Hz to 1 MHz with an uncertainty of $\pm (7 \text{ to } 1000)$ ppm and current range of 1mA to 20 A in the frequency range of 40 Hz to 10 kHz with an uncertainty of $\pm (10 \text{ to } 92)$ ppm.



50A current shunt calibration setup

- **High Frequency Voltage Metrology** - High frequency (HF) voltage primary standard at NPLI has been realized using a twin resistance coaxial power mount in the frequency range of 1 MHz to 1000 MHz. The rf/dc transfer difference has been assigned at the input reference plane of the primary standard. The overall uncertainty in assigning RF DC transfer difference has been estimated to be within $\pm 0.50\%$ in the frequency range up to 1 GHz. With the establishment of the RF voltage primary standard, one can calibrate and assign the RF DC transfer difference to the transfer standard thermal voltage converters. HF Voltage standard is used to calibrate the RF Voltage meters, high frequency thermal converters using the well-established technique.



HF Voltage Calibration setup

- Microwave Power Metrology** - Coaxial Microcalorimeter system in 2.4mm connector, established as the primary standard of Microwave Power in the frequency range of 1 MHz to 50 GHz is an absolute method based on thermocouple principle for the determination of effective efficiency to the thermocouple sensor. This section provides **apex level calibration services** in microwave power parameter to the industry & user organizations of the country. In order to meet the growing demand for calibration of microwave equipments in this era of continuously growing technology, CSIR-NPL disseminates the traceability of microwave power from 1MHz up to 50 GHz. The absolute value of the effective efficiency has been assigned to the microwave power standard from 1 MHz to 50 GHz using coaxial microcalorimeter and Vector network analyzer. The expanded uncertainty of microwave power primary standard at 50 GHz is $\pm 1.9\%$.



50 GHz Coaxial Microcalorimeter System

- Phasor Measurement Unit Calibration Metrology** - Today's smart grid relies on phasor measurement units (PMUs) to deliver real-time critical data on the voltage, current, frequency and phase mainly within the power grid. It is mandatory that PMUs must be calibrated from a traceable calibrator system to ensure its consistency, accuracy and reliability. The CSIR-NPL Phasor Measurement Unit Calibration System (PMU-CAL) is capable of providing perfect solutions for PMU users, manufacturers, electrical power utilities and organizations associated with electrical power transmission. The automated PMU-CAL system fully complies with the IEC/IEEE 60255-118-1:2018 standard. The compliance testing of Phasor Measurement Unit (PMU) from 50V to 150V and 1A to 5A at 50 Hz with a frame rate of 10, 25 and 50 frame/seconds has become possible with the establishment of PMU-CAL system serving the nation through power sector. The CSIR-NPL PMU

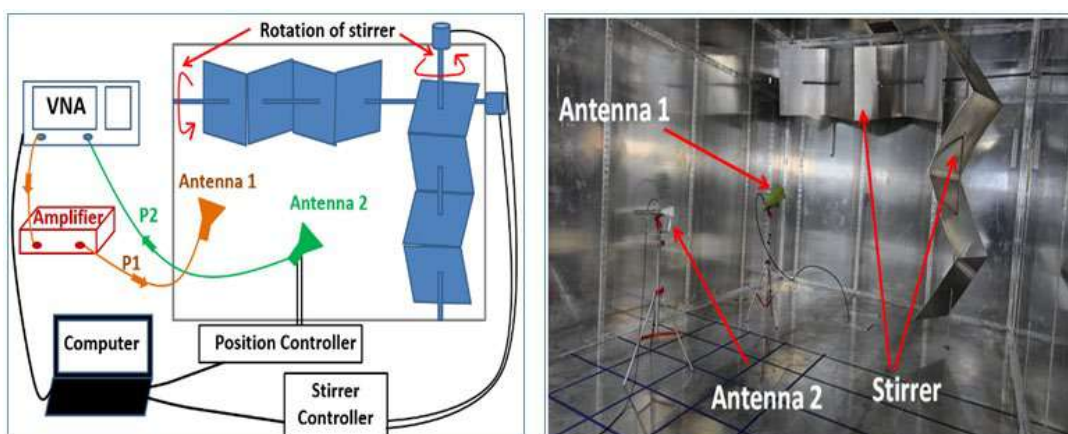
calibration system has an uncertainty of $\pm 0.005\%$ to $\pm 0.010\%$. We use PMU-CAL system to generate a wide variety of complex signals, including flicker, harmonics. This feature gives us flexibility to calibrate PMUs by different manufacturers.



PMU Calibration System and multi-vendor PMUs under calibration

Electromagnetic Metrology

- Design and Establishment of a Large-scale Reverberation Chamber** - A large-scale reverberation chamber for the frequency range of 100 MHz to 18 GHz and the internal dimension of the antenna $4.0 \text{ m} \times 7.5 \text{ m} \times 3.16 \text{ m}$ with two stirrers for E and H plane is designed at CSIR-NPL. All the essential factors for characterization of the chamber are evaluated and measured sequentially for the environment of Rayleigh scatterer that can be used for further characterization of the RF and microwave devices used in mobile communication. The work is carried out to establish the standards for mobile communication assessment at CSIR-NPL.

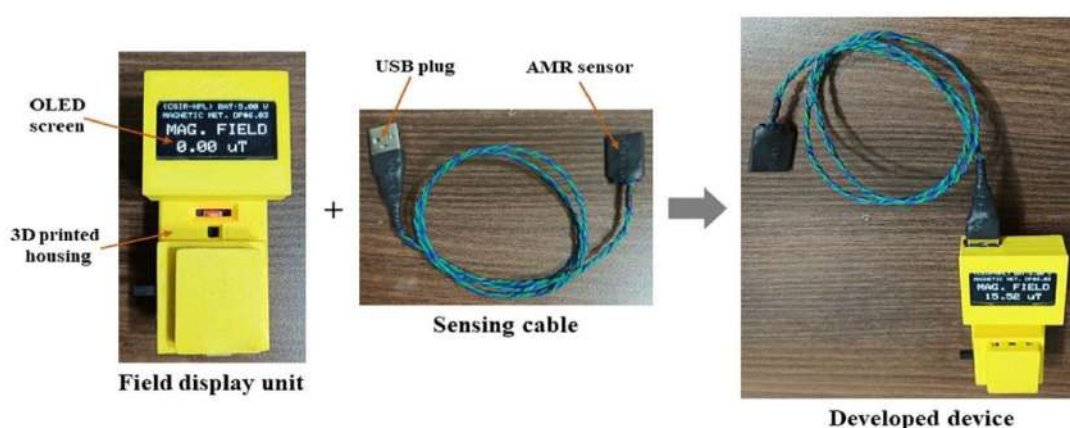


Block diagram of reverberation chamber and experimental setup of the chamber

The measurement facility is developed considering the emerging wireless devices that will operate in a wide range of multipath communication (based on Rayleigh environment). The test facility works based on the interest of direct and indirect

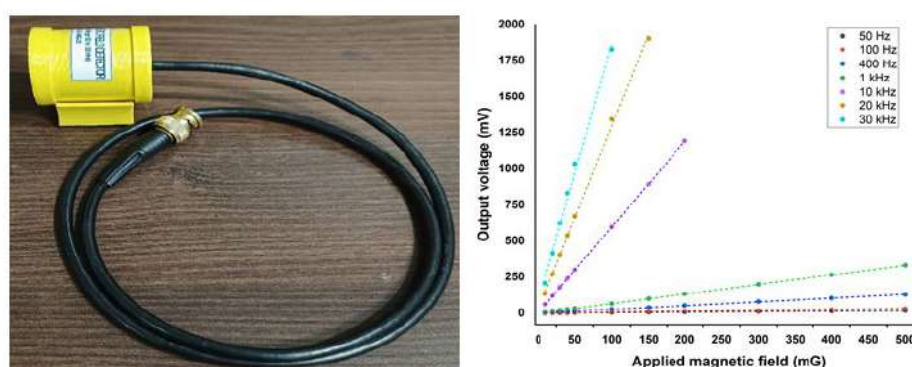
path components; therefore, certain factors need to be evaluated for the measurements (i.e. effective volume, Rician K-factor, quality factor of chamber, etc.). There are several reverberation chambers that are well established to measure and calibrate different devices; however, in India there is no facility available that uses reverberation chamber for RF and microwave measurements. Therefore, this work is carried out for establishment and standardization of this facility at CSIR-NPL. The quality factor calculated for the chamber of the order of 10^4 for GHz frequency range.

- **Development of Low-cost, Pocket-sized Device for Measuring the Weak Magnetic Fields** - Developed and validated a low-cost, pocket-sized device for measuring the weak magnetic fields in the range of $\pm 800 \mu\text{T}$ with permissible accuracy of less than 1.5%. The device can have significant applications in aviation, space, data handling & storage, geological surveys, and healthcare sectors. The device can also be used as a reference standard in calibration/testing laboratories.



Detailed description of the developed magnetic field measuring device

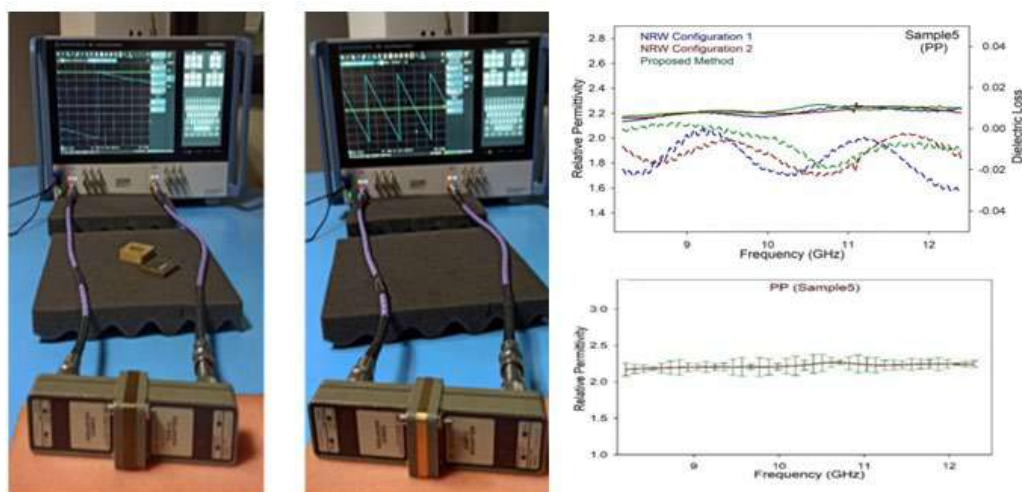
- **Portable AC Magnetic Field Measuring Device** - Development of a portable AC magnetic field measuring device (from 10-500 mG) in the frequency range of 50 Hz to 30 kHz. A detector has been developed and validated for measuring magnetic fields in different frequency range. A portable device with a display unit for the same is under development stage.



Developed detector coil and its obtained calibration curves at different frequencies

- **Dielectric Characterization for Solids** - An improved NRW-based procedure for dielectric property retrieval utilizing two port T/R measurements in an X-band waveguide (8.2–12.4 GHz) is established. The method reduces the number of steps in traditional NRW method by employing direct measurement at air-material

interface. The method makes use of specialized sample holders and utilizes cascading of these sample holders to achieve different lengths of line. The method also works well for different sample lengths. A major advantage of this approach is that it enables proper and precise placement of MUT sample in the line and easy removal and replacing of the sample for multiple measurement. The method can also enable the user to better address the error introduced due to air-gap and uncertainty in sample length. The biggest advantage of the method is that it allows to makes uncertainty evaluation less complex compared to the traditional NRW method. We have written a MATLAB based code for the improved method, which directly provided dielectric properties from raw S-parameters measured, without any data smoothening or statistical manipulation. The comparison of traditional NRW method and method reveals no significant difference between the extracted dielectric properties using either method, while the proposed method is simpler for user to perform and repeat, and also leads to simpler uncertainty evaluations with lesser number of contributing variables.



Measurement setup for dielectric measurement using the proposed method and the results obtained



**ANNUAL
REPORT**
2023-24

Directorate

Directorate

This division encompasses Planning, Monitoring Evaluation and Outreach; Industrial Liaison Group; Centre for Calibration & Testing; Workshop; International Science and Technology Affairs Group; Human Resource Development Group; Administration; Quality Management System; Rajbhasha Unit; Knowledge Resource Centre; Finance & Accounts Store; Purchase Section; Works & Services.

Planning, Monitoring Evaluation and Outreach

CSIR-NPL undertakes projects sponsored by various external agencies such as Ministry of Science & Technology, MNRE, DST, etc. The department is involved in the planning, monitoring and evaluation of the various type of GAP, FTT, FCP, HCP, MLP & Mission Mode projects. The details of External Cash Flow i.e., money received from these agencies to carry out specified project is regularly recorded and monitored by PME against the target established by the Institute. Registration of all projects and allotment of specific identity in terms of a Project No. is made at PME, soon after the money for the project is received along with in-principle approval. Projects are registered in different modes viz FTT, FCP, HCP, Mission Mode and Grant-in-Aid. The total number of projects registered in different modes during 2023-24 is 41. In the year 2023-24, twelve new GAP projects have been started worth Rs. 10.36 Crores, while five new CSIR Funded projects have taken off, costing Rs. 100.94 Crores. A grant of Rs 33.08 Crores in the twenty two continuing GAP projects was received.

Apart from this, PME also attends to technical queries, Parliament Questions and technical audit as well as assist Director in liaisoning with CSIR-HQ, Management Council (MC) and Research Council (RC) on project related matters. In 2023-24, PME has successfully conducted 02 Research Council, and 15 Scientific/Project Review Meetings. PME has processed 1227 indents worth Rs 92.67 Crores.

Business Development Group (BDG)

The Business Development Group (BDG) serves as an interface between CSIR-NPL and Government/Public/Private Organizations/Industries/Universities, etc. BDG facilitates the utilization of CSIR-NPL knowledgebase by licensing the technologies/knowhow to the Industries and other stakeholders. BDG plays an active role in show-casing technologies and know-how developed by CSIR-NPL to the stakeholders on various platforms including the CSIR-NPL website. BDG also facilitates consultancy, technical and research services to the clients in time-bound project mode for utilization of expertise available within CSIR-NPL regarding the development of new products/processes and for improvement of the Quality System in the country. Apart from this, BDG also processes the registration of the new Bharatiya Nirdeshak Dravya (BNDs) along with the handling of traceability and dissemination charges. One of the important roles of BDG includes the execution and signing of MoUs/Agreements/NDAs with the clients (Indian Industries, Institutes, Research Organizations, Reference Material Producers (RMPs), etc) for the purpose. In addition, BDG is highly involved in the management of S&T outputs including the generation of various reports to be sent to various stakeholders including CSIR-Head Quarters.

The details of the technology/know-how licensed, MoUs/agreements signed, projects undertaken, registration of new BNDs and traceability and dissemination charges received during this period are as follows:

Technical Services Projects (TSP)

Sl No	Project Title	Client	Money Released by client (Rs) including GST@18%
1	Synthesis of MWCNTs and their Dispersion in Polymer Matrices	M/s DDEV Plastiks Industries Limited, 168/151-158, Dabhel Industrial Co-Operative Society Ltd, P.O-Dabhel-396215, Daman, Dadra and Nagar Haveli and Daman and Diu	Rs. 10,39,875/-
2	Evaluation of Sound Absorption Coefficient and Sound Absorption Class of Acoustical Materials	M/s Anutone Acoustics Ltd., 3A Visvesvaraya Industrial Area, Mahadevapura, Bangalore-560048, Karnataka	Rs. 5,90,000/-
3	Development of timing laboratories of Legal Metrology Department (LM) traceable to National Time Scale generating IST at five locations and creation of one disaster recovery center	Legal Metrology Department, Ministry of Consumer Affairs, New Delhi, Govt of India	Rs. 2,40,80,000/-
4	Acoustical Evaluation in Reverberation Chambers of Sandwich window glazing's for noise control	M/s Saint-Gobain India Private Limited, 18/3, Sigappi Aachi Building, Rukumani Lakshmipathy Road Egmore, Chennai, Tamil Nadu 600008	Rs. 5,90,000/-
5	Noise Mapping, Analysis and Devising Mitigation Plans for Noise Pollution Control in Delhi	M/s Acoem Ecotech Industries Pvt. Ltd, Plot No. 57, Sector II, Pithampur Industrial Area, Dhar, Madhya Pradesh-454775	Rs. 24,78,000/-
6	Fabrication of high electrical conductive graphite composite bipolar plates for fuel cell application	M/s Virayaa Green Energy Systems Private Limited, 1-9-292/7, Ramalayam Street, Vidyanagar, Hyderabad, Telangana-500044	Rs. 7,37,500/-
7	Evaluation of sound insulation and absorption characteristics of acoustical materials in Reverberation Chambers for noise control as per ISO 354, ISO 717 and EN	M/s Envirotech Systems Limited, 346-347, Ecotech 1 Extension, Kasna, Gautam Buddha Nagar, Uttar Pradesh-201308	Rs. 7,08,000/-

	1793 standards		
8	Sound Absorption and Sound Transmission Loss Measurements in Reverberation Chambers and Sound Impedance Tube Facility	M/s Saint Gobain India Pvt Ltd., 5th Level, Leela Business Park, Andheri Kurla, Andheri (E), Mumbai-400059	Rs. 4,72,000/-
9	Testing of a high-flow air purifier	M/s Siddhivinayak Tradelinks, 5 B/8, Good Earth CHS Ltd, Sindhi Society, Chembur, Mumbai Suburban, Maharashtra-400071	Rs. 6,01,800/-
10	Inspection of Bulk Water Meter Test Benches of Municipal Corporation of Greater Mumbai	M/s. Nagman Flow-Level Systems and Solutions LLP, No. 168/7, Chennai-Bangalore National Highway, Chembarambakkam, Chennai, Tamilnadu-600123	Rs. 1,97,650/-
11	Fabrication, and establishment of testing and calibration facility for clinical thermometers (liquid-in-glass, electrical, and IR) with the maximum device for the five RRSLs laboratories	Legal Metrology Division, Department of Consumer Affairs, Ministry of Consumer Affairs, Food and Public Distribution, Govt of India, New Delhi-110001	Rs. 2,17,27,104/-
12	Fabrication of sphygmomanometer testing kits to be used for calibration and testing of sphygmomanometers and automatic blood pressure measuring devices	Legal Metrology Division, Department of Consumer Affairs, Ministry of Consumer Affairs, Food and Public Distribution, Govt of India, New Delhi-110001	Rs. 1,66,46,024/-
13	Establishment of reference standard for length at Five Regional Reference Standards Laboratories (Ahmedabad, Bhubaneswar, Faridabad, Guwahati & Varanasi) using laser interferometers	Legal Metrology Division, Department of Consumer Affairs, Ministry of Consumer Affairs, Food and Public Distribution, Govt of India, New Delhi-110001	Rs. 1,04,77,740/-
14	Evaluation of sound insulation and sound absorption characteristics of acoustical membranes and rubber based acoustical products for	M/s Soprema Private Limited, Third Floor, Unit No. 303, Suncity Business Tower, Sun City, Sector-54, Gurgaon, Haryana-122002	Rs. 5,90,000/-

	noise control		
15	Performance Testing of Air Monitoring Devices	M/s Kentek Environment Technology India Pvt. Ltd, 15th Floor, Block-G, Tower 5, Jaypee Green, Jaypee Green Residential, Greater Noida, Gautam Buddha Nagar-201306, Uttar Pradesh	Rs. 24,33,750/-
16	On-site Performance Evaluation of Anechoic Chambers as per ISO 3745 Standard for Air Conditioners Acoustical Testing and Evaluation	M/s Josts Engg. Co. Ltd, C-7, Josts Engineering Company Limited, Road No 12, Wagle Industrial Estate, Thane, Maharashtra – 400604	Rs. 7,08,000/-

Collaborative Services Project (CLP)

Sl No	Project Title	Client	Money Released by client (Rs) including GST@18%
1	Design and Development of Smart Noise Tracker for Noise Monitoring and e-sound Limiter for Noise Control	M/s Distronix, 62/44, Satin Sen Sarani, Kolkata-700054, West Bengal, India	Rs 11,32,800/-
2	Development and Fabrication of Bipolar Graphite Plates using Needle Coke	Research & Development Centre, Indian Oil Corporation Limited (IOCL), Sector-13, Faridabad, Haryana-121007	Rs 14,16,000/-

Registration Charges for Bharatiya Nirdeshak Dravya (BND) from Reference Material Producers (RMPs)

Sl No.	Client	Project Title	Money received (Rs) (including GST)
1	M/s Aashvi Technology LLP, E-14, Madhavpura Market, Shahibaug, Ahmedabad, Gujarat-380004, India	Registration of Two New BNDs for BND 1028 (5th Batch) and BND 1042 (2nd Batch)	Rs. 23,600/-
2	M/s Jalan and Company, C- 16, Lajpat Nagar -II, New Delhi, Delhi-	Registration charges for BND 4101 (2nd Batch)	Rs. 11,800/-

	110024		
3	M/s Aashvi Technology LLP, E-14, Madhavpura Market, Shahibaug, Ahmedabad, Gujarat-380004, India	Registration of Twenty BNDs (successive batches of Twelve BNDs) i.e. BND 1005 (14th, 15th and 16th Batch), BND 1006 (14th, 15th and 16th Batch), BND 1007 (9th Batch), BND 1008 (7th and 8th Batch), BND 1011 (3rd Batch), BND 1016 (4th Batch), BND 1019 (5th Batch), BND 1022 (6th and 7th Batch), BND 1023 (5th Batch), BND 1026 (2nd Batch), BND 1028 (6th and 7th Batch) and BND 1042 (3rd and 4th Batch)	Rs. 2,36,000/-
4	M/s Aashvi Technology LLP, E-14, Madhavpura Market, Shahibaug, Ahmedabad, Gujarat-380004, India	Registration Charges for BND 1030 (3rd Batch)	Rs. 11,800/-
5	M/s National Concil for Cement and Building Materials (NCCBM), 34 Km Stone, Delhi - Mathura Road (Nh-2), Ballabgarh 121004, Faridabad, Haryana	Registration Charges for BND 5061, BND 5062, BND 5063, BND 5064, BND 5008 and BND 5009 (ALL NEW BNDs-1st Batch)	Rs. 70,800/-
6	M/s Global PT Provider Pvt. Ltd., E-44/12, Okhla Industrial Area, Phase-II, New Delhi, Delhi-110020	Registration Charges for BND 2223 (Total 1 No.- NEW BND)	Rs. 11,800/-
7	M/s Aashvi Technology LLP, E-14, Madhavpura Market, Shahibaug, Ahmedabad, Gujarat-380004, India	Registration Charges for BND 1029 (6th Batch), BND 1029 (7th Batch), BND 1029 (8th Batch) and BND 1018 (5th Batch)	Rs. 47,200/-
8	National Council for Cement and Building Materials (NCCBM), 34 Km	Registration Charges for BND 5002 (3rd Batch), BND 5003 (3rd Batch), BND 5006 (3rd Batch), BND 5007 (3rd Batch) and BND 5091 (3rd	Rs. 59,000/-

	Stone, Delhi	Batch)	
9	M/s Aashvi Technology LLP, E-14, Madhavpura Market, Shahibaug, Ahmedabad, Gujarat-380004, India	Registration Charges for BND 1009 (6th Batch), BND 1009 (7th Batch), BND 1009 (8th Batch), BND 1021 (9th Batch) and BND 1021 (10th Batch)	Rs. 59,000/-

Traceability and Dissemination Charges for Bharatiya Nirdeshak Dravya (BND) from Reference Material Producers (RMPs)

Sl No.	Client	Project Title	Money received (Rs) (including GST)
1	M/s Global PT Provider Pvt. Ltd., F-89/22, Okhla Industrial Area, Phase-I, New Delhi, Delhi-110020	Traceability & Dissemination charges received from stock sale of BNDs @10% of BND Sale as per CSIR-NPL invoice no NPL/BND/RMP/GPTP/Sale/2023-24/02 dt. 31-05-2023	Rs. 5,338/-
2	Indian Government Mint, 134-E, Shahid Bhagat Singh Rd, Kala Ghoda, Fort, Mumbai, Maharashtra-400001	Payment towards CSIR-NPL share: 0.5% of turnover of services for BND Sale as per CSIR-NPL invoice no NPL/BND/IGM/Sale/2023-24/01 dt. 25-04-2023	Rs. 32,680/-
3	M/s Jalan and Company, C- 16, Lajpat Nagar -II, New Delhi, Delhi-110024	Traceability & Dissemination charges received from stock sale of BNDs for the period 01/04/2021 to 31/03/2022 @10% of BND Sale as per CSIR-NPL invoice no NPL/BND/RMP/Jalan/Sale/2023-24/04 dt. 25-09-2023	Rs. 2,006/-
4	M/s Jalan and Company, C- 16, Lajpat Nagar -II, New Delhi, Delhi-110024	Traceability & Dissemination charges received from stock sale of BNDs for the period 01/04/2022 to 31/03/2023 @10% of BND Sale as per CSIR-NPL invoice no NPL/BND/RMP/Jalan/Sale/2023-24/05 dt. 25-09-2023	Rs. 77,006/-
5	National Council for Cement and Building Materials (NCCBM), 34 Km Stone, Delhi	Traceability & Dissemination charges received from stock sale of BNDs for the period 01/04/2022 to 31/03/2023 as per CSIR-NPL invoice no NPL/BND/RMP/NCB/Sale/2023-	Rs. 12,40,972/-

		24/03 dt. 22-09-2023	
6	M/s Aashvi Technology LLP, E-14, Madhavpura Market, Shahibaug, Ahmedabad, Gujarat-380004, India	Traceability & Dissemination charges received from stock sale of BNDs for the period 01/04/2022 to 31/03/2023 as per CSIR-NPL invoice no NPL/BND/RMP/Aashvi/sale/2023-24/06 dated 29/11/2023	Rs. 21,54,479/-

Licensing of Technology/Know-How

Sl. No.	Name of the technology/Know-how	Name of the client	Date of licensing
1	A know-how "Six-stage bioaerosol air sampler and sampling probe for BFE testing of mask"; Lumpsum : Rs 5.60 Lakh including GST@12%; Non-Exclusive; Duration: 5 years; Royalty : 2% on sales proceeds	M/s Envirotech Instruments Private Limited, A-271 Okhla Industrial Area, Phase-1, New Delhi - 110020	18-Apr-2023
2	A know-how "High Volume PM-2.5 Impactor Sampler", Scientific MoU, Lumpsum: Nil; Non-Exclusive; Duration: 5 years; Royalty: 5% on sales proceeds	M/s Environmental Solutions, A3/508, Tower-4, Silvercity, Sector-93, Noida (UP)	08-Nov-2023

Royalty Received

S.No.	Name of the technology/Know-how	Name of the client	Money Received
1	Royalty for Licensed Technology/know-how titled "High-Volume PM 2.5 Sampler"	M/s Environmental Solutions, C-24, First Floor, Sector-85, Noida, Distt. Gautam Buddha Nagar, Uttar Pradesh-201305	Rs 25,960/-

Agreements/MoUs/NDA etc signed by CSIR-NPL

Sl. No.	Name of the company/Industry/Organization	Signing date
1	Agreement with M/s DISTRONIX, 62/44, Satin Sen Sarani, Kolkata – 700054, West Bengal, India for collaborative project for "Design and development of Smart Noise Tracker for Noise Monitoring and e-Sound Limiter for Noise Control"	18-Apr-2023
2	Agreement with M/s Envirotech Instruments Private	18-Apr-2023

	Limited, A-271 Okhla Industrial Area, Phase-1, New Delhi -110020 licensing of know-how “Six-stage bioaerosol air sampler and sampling probe for BFE testing of mask”	
3	Agreement with Research and Development Centre, Indian Oil Corporation Limited, Sector 13, Faridabad – 121007, Haryana, for sponsored project “Development and Fabrication of Bipolar Graphite Plates using Needle Coke”	04-Sep-2023
4	Agreement with M/s Environmental Solutions, A3/508, Tower-4, Silvercity, Sector-93, Noida (UP) for “High Volume PM2.5 Impactor Sampler”	08-Nov-2023
5	Agreement with National Institute of Ocean Technology, Chennai-600100, Tamil Nadu for “Proposed Designated Institute for Underwater Acoustics”	15-Jan-2024

Centre for Calibration and Testing Centre

CFCT acts as an interface for connecting metrological activities of NPLI to Industries & Govt. Agencies for National Growth, Quality Control & Trading. Currently, CFCT is supporting more than 4000 clients from industries, national laboratories, and government organizations from all over the country and abroad including SAARC nations. CFCT supports all the customer care related queries and deal the customers with utmost care to serve the Nation. CFCT plays an important role in creating awareness about the importance of metrology related activities. Also, at CFCT we have provided most of the information online so that our esteemed customers can freely accessible to it. These services include CTBR Form, Calibration and Testing Charges, Specimen Copy of Calibration & Test Certificates, and Payment Related Information with terms and conditions of instruments handling etc.

The below Table, shows the list of some of the users availing the calibration and testing services from CSIR-NPL through CFCT.

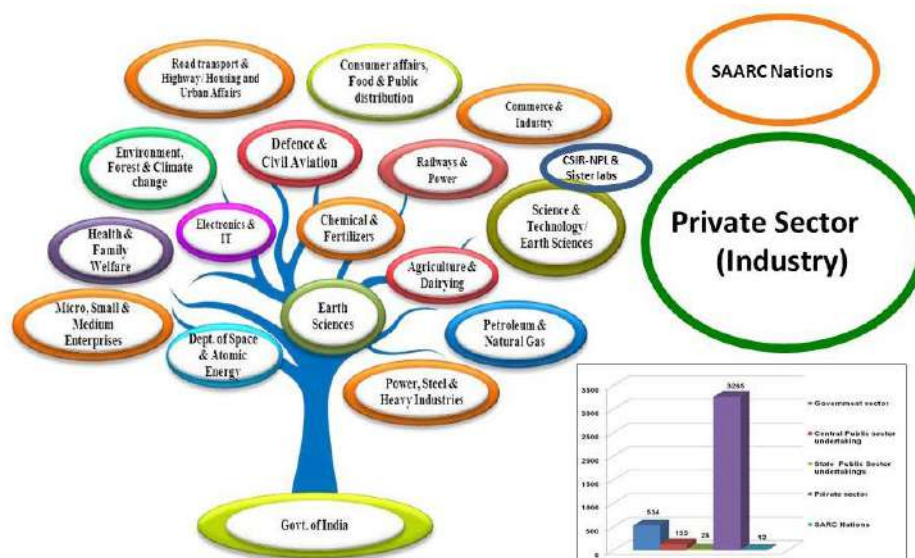
S.No	Organization	List of users/clients
1	Government/ PSU	DRDO, ISRO, Election Commission of India, CPCB, Indian Railways, Indian Airforce, Air India, BSF, BIS, Legal Metrology, DAE, CPRI, HAL, BHEL, BEL, GAIL, ONGC, IOCL, HPCL, Indian oil, State Electricity Boards, NTPC, Delhi Jal board, MSME Testing Centres, Ordinance Factory, Steel Authority of India and Scientific Institutes/Labs, Universities etc.
2	Private Sector/Industries	Tata Steel; Mysore Paints & Varnish; CK Birla Group; GE power systems; ABB India; ACC; AIMIL Ltd.; Alstom India; Ambuja Cement; Adani Electricity; Binani Cement; Blue Star; Bureau Veritas; Casio India; Crompton Greaves Limited; Diesel Locomotive Works; Essar Oil Ltd.; Godrej & Boyce Mfg. Co. Ltd; Havells India; Honda Cars; J.K. White Cement; JK Lakshmi Cement; Kirloskar Brothers; Larsen & Toubro; Maruti Suzuki; Philips India; Rapid Metro Rail Gurgaon; Samsung India; Honda Siel; Surya Roshni, Wipro consumer care & lighting; Orient Electric; ITC, Halonix Technologies, Astra lighting; Bharat Forge; Tektronix India; Fluke

		Technologies etc.
3	SAARC Nations	Nepal Bureau of Standards & Metrology (MBSM), Bangladesh Standards and Testing Institution (BSTI), Measurement Units, Standards and Services Department, Sri Lanka; National Physical and Standards Laboratory (NPSL), Pakistan; Bhutan Standards Bureau (BSB), Bhutan; Afghanistan National Standards Authority (ANSA), Maldives Standards and Metrology Unit

The following Table shows the outcome of the calibration and testing services from CSIR NPL through CFCT for the past 10 years.

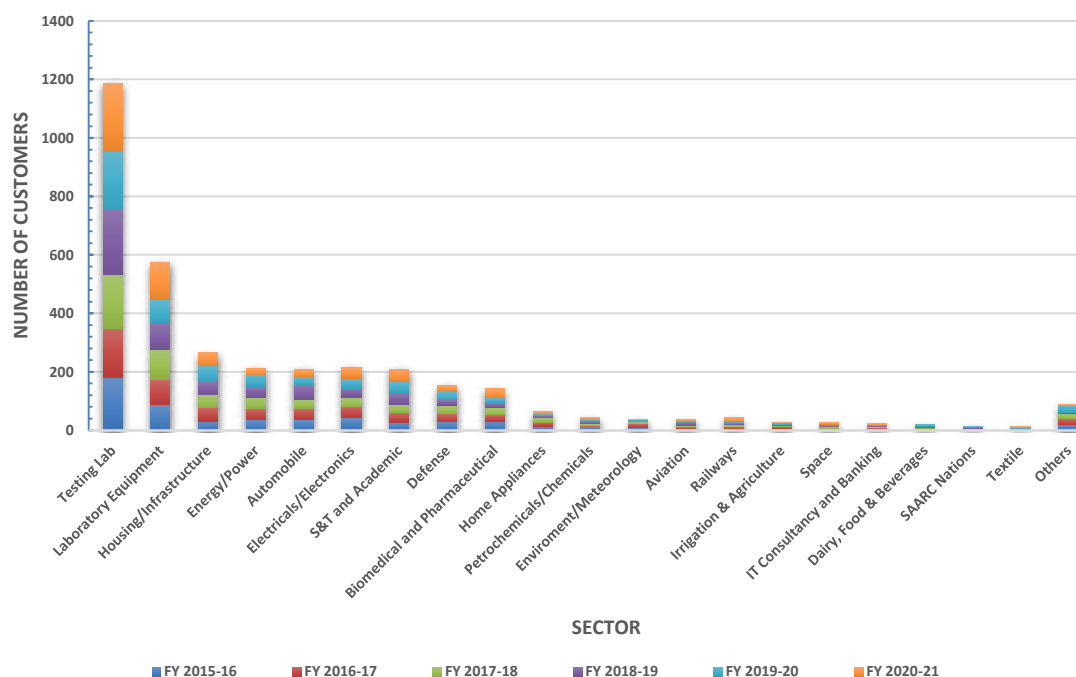
S.No	Financial Year	Total Earnings in Rs. Crores	Certificates Issued	Cases Generated
1	2014-15	7.1	2760	1267
2	2015-16	7.2	2758	1284
3	2016-17	7.4	2539	1172
4	2017-18	7.6	2638	1098
5	2018-19	11.1	2601	1264
6	2019-20	11.4	2348	1145
7	2020-21	10.2	2014	1126
8	2021-22	11.3	2151	1241
9	2022-23	13.6	2741	1390
10	2023-24	10.16	2790	1429

The following Figure shows metrological services provided by CSIR-NPL through CFCT to various organizations and sectors. The beneficiaries of these metrological services include government ministries, regulatory bodies, public sector undertakings, private industries, MSMEs, strategic sectors, S&T organizations, etc. In addition, CSIR-NPL has been supporting the NMLs of neighbouring countries, especially those belong to South Asian Association for Regional Cooperation (SAARC) nations.



CSIR-NPL provides Calibration and Testing Services through CFCT to several Stake Holders

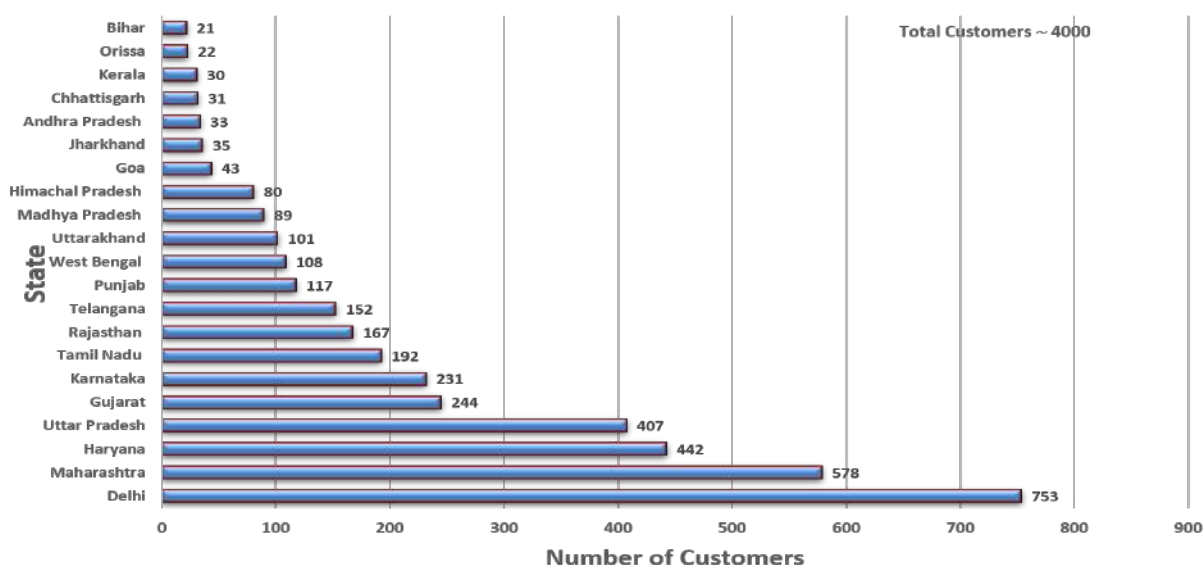
The following Figure shows sector-wise distribution of metrological services of CSIR-NPL through CFCT for 2015-16 to 2020-21. CFCT data analysis in terms of metrological services provided to vital sectors, which contribute to the knowledge economy and knowledge society. These are categorized into following twenty sectors: automobile, aviation, biomedical and pharmaceutical, dairy, food & beverages, defense, electrical/electronics, energy/power, environment metrology, home appliances, housing/infrastructure, irrigation & agriculture, IT consultancy & banking, laboratory equipment, petrochemicals & chemicals, railways, S&T and academic, space, testing laboratories, textile, SAARC nations and others.



Sector-wise distribution of Metrological Services of CSIR-NPL for 2015-16 to 2020-21

The “other” category includes data that could not fit into the above-mentioned specialized categories. The testing labs and laboratory equipment are the top sectors. This is quite expected because the NABL accredited laboratories across the country, need to obtain the mandatory metrological traceability to SI units through CSIR-NPL. It is understood that, most of the government ministries have their own secondary testing and calibration laboratories to ensure the conformity assessments for their regulations as well as for products manufactured in India or imported. Since these secondary laboratories are spread across the country, the state regulators approach these local laboratories for calibration and testing. These secondary laboratories have their traceability to the SI units through CSIR-NPL.

The other major sectors which obtain measurement traceability to SI units from CSIR-NPL through CFCT are automobiles, biomedical and pharmaceutical, defense, home appliances, housing/infrastructure electrical and electronics, energy/power, S&T and academic, aviation, railways and space. The measurement traceability to sectors like dairy, food & beverages, environment/ metrology, IT consultancy & banking, textile etc. though not significant at present in availing the facilities of CSIR-NPL, but possibilities exists that they may be using secondary calibration and testing laboratories. However, it must be ensured that all sectors utilize measurement *values traceable to SI units* for quality assurance.



Sector-wise distribution of Metrological Services of CSIR-NPL

As measurement traceability is linked to economic growth, organizations in the various states of India, availing the CSIR-NPL facilities are plotted. A total of 21 states data was analysed. New Delhi is frontrunner, which is expected as most of the government bodies and industries approach CSIR-NPL due to its proximity. The case with Haryana also, being an adjoining state. Otherwise, the ranking in measurement traceability to SI units through CSIR-NPL and the industrial growth appears to be correlated well. According to RBI's recent report, states like Maharashtra, Tamil Nadu, Gujarat, Utter Pradesh and Karnataka have high rate of industrial growth while north-eastern states have lowest industrial growth. Therefore, to improve the economy of the country, among many other parameters, the respective state governments

should be encouraging industries and MSMEs to ensure the measurement traceability for industrial growth through manufacturing of products of international quality.

Central Workshop

Central Workshop at CSIR-NPL is actively engaged in both technical and engineering services that require different DU R&D projects like Quantum materials and metrology, Solar photovoltaic, Advanced carbon products, Fuel cells, Batteries and Thermoelectric materials & Devices related activities. Central Workshop has developed various design & fabrication of high-precision components and repair and maintenance of existing sophisticated instruments and calibration facilities used by the various DU/DP of the Laboratory.

The central workshop has a FANUC-controlled CNC DECKEL FP4A machining center. The machine has the capability of 4-axis automated machining X, Y, Z and C- axes to fabricate various precious components that require different DU R&D projects. Several automatic controlled precision turning and machining centers, power hacksaws, surface grinders, welding equipment and accessories are used to fabricate/repair for advanced R&D and R&D support activities. During the year 2023-2024, the fabrication and Job work of ~ 493 were accomplished with the in-house available resources.



Fabricated/Machined Components at the Central Workshop

International Science and Technology Affairs Group (ISTAG)

International Scientific Collaborations are assisting the scientists to share their ideas & papers for developing new technologies & bridging the gap between them for the service of mankind. ISTAG group facilitates the overseas visits of scientific and technical personnel of the laboratory to get acquaintance & learn new techniques. It advises the scientists to participate in International Conferences, Seminars and Summer Schools. It helps the scientists to get prestigious international fellowships. This group also advises the scientists to avail bilateral exchange program. The total numbers of visits conducted by the CSIR-NPL scientists/technologists were 36 during 2023-24. ISTAG also conduct PRC meetings for foreign deputations of Regular Staff. This year 12 PRC Meetings were organized. The group also encourages and facilitates the visits of young students to abroad. This year 32 students visited abroad for attending International conferences/seminars/ workshops and others for research oriented program. It also organizes the visit of foreign delegations at CSIR-NPL. International experts are also invited to deliver talks and lectures at CSIR-NPL. The total numbers of foreign visitors visited CSIR-NPL were 44 during 2023-24. One International Conference was organized during 2023-24. The scientific staff is motivated to avail sabbatical leave/study leave. Arranging training program for international candidates is also the job of this group. International collaborative projects, bilateral exchange program and MOU are also handled by this group.

Human Resource Development Group

- **Ph.D. Registration and other Support to Research Fellows:** One of the most prominent activities of CSIR-NPL is to provide help and support to Research Fellows (JRFs / SRFs), starting from the time they join CSIR-NPL till the time they leave the institute. This includes their placement in a suitable Division / Group and helping them in getting Hostel accommodation, if required. This also includes their Ph.D. registration, assessment for continuance /up-gradation, deputation to attend conferences, etc.

During the period from 1st April, 2023 to 31st March, 2024, 46 research fellows (JRFs/SRFs) joined CSIR-NPL and AcSIR Ph.D. Programme, resulting in a total strength of Research Fellows (JRFs+SRFs) in CSIR-NPL is 292 as on 31.03.2024. Total Ph.D. degree awarded 63.

- **Organization of Student's Training at CSIR-NPL:** CSIR-NPL provides training to students pursuing M.Sc./M.Tech./MCA, or their equivalent degree programmes, at different educational institutions spread all across the country, in the areas of research activities being carried out at CSIR-NPL. The basic objective is to provide the students a feel and importance of the various activities, as well as to motivate them towards scientific research as the career.

During the period from 1st April, 2023 to 31st March, 2024 total 168 students were provided training oriented towards the fulfillment of their academic degree requirements in different areas of research under the guidance of senior scientists.

ECF Generated : 7,92,960/-

- **Deputation of NPL Staff Members to Attend Conferences / Similar Events:** CSIR-NPL encourages and supports its staff members, including the floating members like JRFs, SRFs, PAs, RIs, RAs, SRAs, etc., to attend and present papers at national / international conferences / symposia / seminars / workshops, organised by different agencies in areas relevant to research activities being carried out at CSIR-NPL. This is primarily meant to enable the staff members to put forward their views and research results before the leading national / international experts and interact with them on the latest developments in their research areas.

During the period from **1st April, 2023 to 31st March, 2024** , total **186** cases of CSIR-NPL scientists and other staff members including research scholars, were nominated to participate in various conferences / similar events and different Training Courses held across the country.
- **Skill Development Programme in CSIR-NPL:** Under Skill Development Programme total training programme **23** total participant **484**.
ECF Generated : 11,16,430/-
- **Jigyasa programme with Kendriya Vidhyalaya Sangathan:** During Year 2023-24, CSIR-NPL has organized **15** Programmes under Jigyasa . Total **4253** Students and **334** Faculty members has participated.
- **Institutional Visits:** During the Year 2023-24, CSIR-NPL has organized **13** visits for various colleges/schools . Total **521** visitors explored various facilities of laboratory.
- **MoU Signed with other Institutes/Universities :** During the Year 2023-24, CSIR-NPL has signed **7** MoU with other institutes/Universities .

Quality Management System

The Quality Management System (QMS) is responsible for implementing and fulfilling the requirements of IS/ISO/IEC17025 : 2017 and IS/ISO 17034 : 2016 standards at CSIR-NPL (NPLI). At present, there are 29 sub-divisions covered under QMS. QMS coordinated the annual internal audits of the various sub-divisions, followed up corrective actions taken by the respective sub-divisions for closure of non-conformances raised, if any, as well as conducted the annual Steering Committee meeting for ensuring the continuous suitability, adequacy and effectiveness of policies and objectives of the quality system.

QMS provided the necessary inputs and information as required by the Asia Pacific Metrology Programme (APMP) Technical Committee for Quality System (TCQS) from time to time. QMS representatives attended and presented (online) Annual Report (November 2022 - October 2023) of NPLI in the APMP TCQS meeting on the QMS related activities, including conducting peer reviews, participation in international

inter-comparisons, etc., at 39th APMP General Assembly (GA) held in November-December 2023.

Time & Frequency and Gas Metrology Sections have gone through the peer review for publishing Calibration and Measurement Capabilities (CMCs) in the International Bureau of Weights and Measures Key Comparison Database (BIPM KCDB). An MoU signed between CSIR-NPL (NMI of India) and National Institute of Ocean Technology (NIOT, Chennai, Designated Institute of India for Underwater Acoustic) in January 2024 for five years, for providing guidance on quality system based on IS/ISO/IEC 17025 : 2017 and conducting peer review so that NIOT can publish CMCs on Underwater Acoustic in the BIPM KCDB.

QMS has imparted training on IS/ISO/IEC 17025 : 2017 to approx. 20 participants from various organizations, organized at CSIR-NPL from 4th to 7th July, 2023.

QMS has organized training programs at CSIR-NPL on ISO/IEC 17025 : 2017 for Scientists and Technical Officers (30 Nos.) from 26th February to 1st March 2024 and on ISO/IEC 17011 : 2017 for Scientists (15 Nos.) from 4th to 8th March 2024 in collaboration with the British Standards Institution (BSI), UK.

Knowledge Resource Centre

In CSIR-NPL, the umbrella term 'Knowledge Resource Centre (KRC)' comprised of Library and IT related activities under its domain.

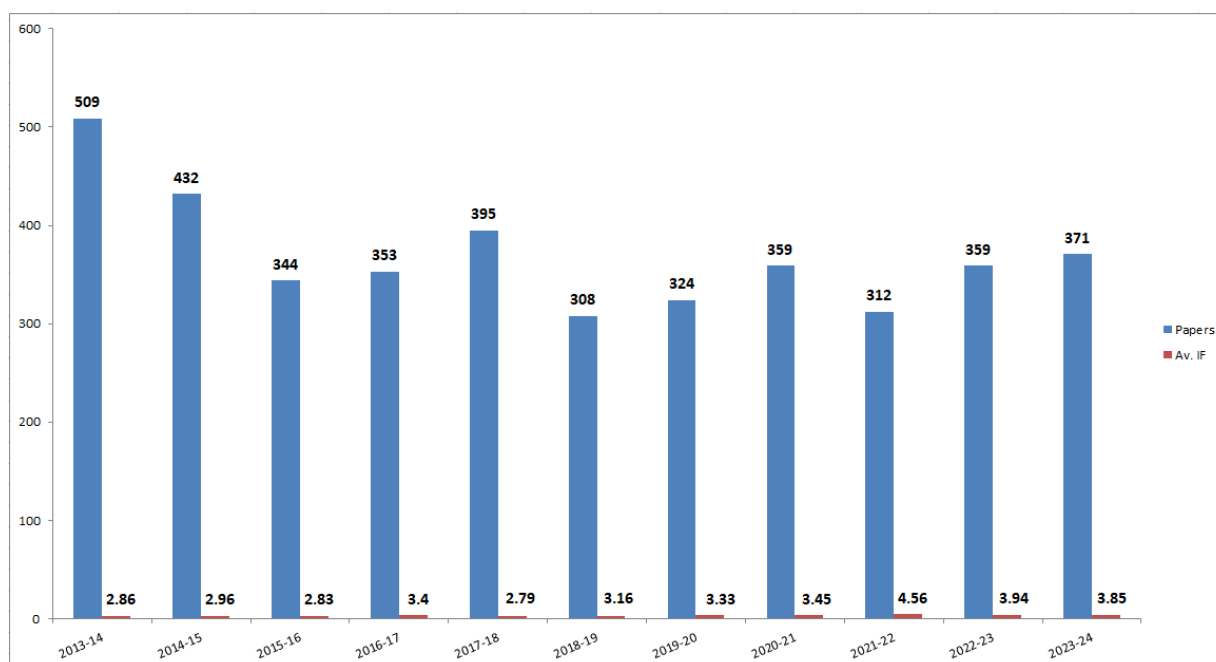
As far as library and information support is concerned, KRC over the years has developed a rich collection of scholarly books and journals, especially in the field of physics and related sciences. During the current year, KRC subscribed to numerous scholarly journals and added a variety of books both in English and Hindi languages to enrich its textual collection. Regarding the services offered, KRC serves the CSIR-NPL community with services like Electronic Document Delivery service, Inter Library Loan service, Reference service, Literature Search service etc. Further, towards improving the quality of science produced by the lab in terms of research publications, NPL-KRC offers content similarity check with the help of the recommended software 'iThenticate'. In addition to the printed content, the centre also offers online access to full text journals from distinct publishers through the National Knowledge Resource Consortium (NKRC). The NKRC facilitates access to the electronic content from publishers like ACS (American Chemical Society), AIP (American Institute of Physics), APS (American Physical Society), IOP (Institute of Physics), OSA (Optical Society of America), IEEE, RSC (Royal Society of Chemistry), Springer, Taylor & Francis etc. KRC has also acquired the recommended Standards to support research, and provides access to Indian Standards.

The shift in technology achieved with the automation of KRC activities and installation of improved routers helped in attracting the R & D personnel in large number to optimize the use of the available resources. Further, to promote free worldwide access to the intellectual outputs of CSIR-NPL in form of journals articles, research papers, conference papers, technical reports, preprints, and other scholarly communication, NPL-KRC has established the Institutional Repository (IR@NPL) <http://npl.csircentral.net/>. Further, library provides the services of specialized academic writing tools such as Grammarly and iThenticate. Additionally, the library is

actively engaged in the maintenance of the CSIR-NPL website and manages the institute's social media presence. Also, with the renovation of its Reading Hall, the Library attracts users by offering a welcoming and comfortable reading environment.

Apart from the library related activities, NPL-KRC also provides IT facilities to cater to the computing and communication needs of the laboratory. Data Center services are running 24x7 with in-house set up of various Linux based servers. Internet connectivity has been implemented through National Knowledge Network (NKN). A gigabit fiber optics backbone network solution is running at various locations across the CSIR-NPL campus and providing CAT6 based ethernet LAN to connect approximately one thousand network based devices i.e. computers, servers, laptops, IP cameras, attendance machines. The gateway security solution has been setup, which includes a Unified Threat Management (UTM) system for multi-level firewall, anti-virus etc. Email services of the laboratory are facilitated using NIC mail services at email.gov.in

Papers Published by the CSIR-NPL in SCI Journals



राजभाषा यूनिट

राजभाषा यूनिट दिन-प्रति-दिन के सरकारी कार्यों में राजभाषा हिन्दी के प्रगामी प्रयोग को बढ़ाने का कार्य करती है। राजभाषा यूनिट का मुख्य उत्तरदायित्व संघ सरकार की राजभाषा नीति, राजभाषा अधिनियम के उपबंधों तथा आदेशों से प्रयोगशाला के वैज्ञानिकों/अधिकारियों/कर्मचारियों को अवगत कराना, अनुपालन कराना एवं अनुपालन हेतु सहायता प्रदान करना है।

राजभाषा यूनिट के उत्तरदायित्व :

1. कार्यान्वयन:

- संघ सरकार की राजभाषा नीति, राजभाषा अधिनियम के उपबन्धों तथा आदेशों से प्रयोगशाला के वैज्ञानिकों/ अधिकारियों/कर्मचारियों को अवगत कराना, अनुपालन कराना एवं अनुपालन हेतु सहायता प्रदान करना ।
- प्रत्येक तिमाही में निदेशक, एन पी एल की अध्यक्षता में राजभाषा कार्यान्वयन समिति की बैठक का आयोजन, कार्य सूची एवं कार्यवृत्त तैयार करना। बैठक में लिए गए निर्णयों पर अनुवर्ती कार्रवाई करना ।
- हिन्दी दिवस/ हिन्दी मास तथा प्रत्येक तिमाही में हिन्दी कार्यशालाओं/व्याख्यानों का आयोजन करना ।
- राजभाषा विभाग, गृह मंत्रालय, भारत सरकार से प्राप्त वार्षिक कार्यक्रम में निर्धारित लक्ष्यों को प्राप्त करने हेतु निरंतर प्रयास व उचित कार्रवाई करना।
- संसदीय राजभाषा समिति के निरीक्षण सम्बन्धी कार्य तथा समिति को दिए गए आश्वासनों को पूरा करने हेतु कार्रवाई करना।
- प्रत्येक वर्ष विज्ञान विषयों पर हिन्दी में राष्ट्रीय संगोष्ठी का आयोजन।

2. प्रशिक्षण एवं प्रकाशन:

- हिन्दी प्रशिक्षण (प्रबोध, प्रवीण एवं प्राज्ञ पाठ्यक्रम) ।
- हिन्दी टंकण/आशुलिपि एवं कम्प्यूटर पर हिन्दी में कार्य करने का प्रशिक्षण दिलाना ।
- प्रत्येक छःमाही में हिन्दी समीक्षा पत्रिका का प्रकाशन ।
- प्रयोगशाला की वार्षिक रिपोर्ट तथा अन्य महत्वपूर्ण प्रकाशनों में हिन्दी अंश का संपादन ।

3. अनुवाद:

- प्रयोगशाला में प्रयुक्त सभी प्रपत्रों (फार्मों), मानक मसौदों का द्विभाषीकरण ।
- हिन्दी अनुवाद कार्य ।
- राष्ट्रीय भौतिक प्रयोगशाला के वार्षिक प्रतिवेदन के महत्वपूर्ण अंशों का हिन्दी अनुवाद ।
- प्रयोगशाला की वेबसाइट का हिन्दी अनुवाद ।

कार्मिक :

- | | |
|---------------------------|----------------|
| • श्री जय नारायण उपाध्याय | हिन्दी अधिकारी |
| • श्री विजय सिंह | निजी सचिव |
| • श्रीमती विद्यावती | एमटीएस |

प्रयोगशाला द्वारा राजभाषा की प्रगति के लिए उठाए गए कदम एवं प्रयास

- प्रत्येक तिमाही में निदेशक, एन पी एल की अध्यक्षता में राजभाषा कार्यान्वयन समिति की बैठक में वार्षिक कार्यक्रम में निर्धारित लक्ष्यों को प्राप्त करने हेतु चर्चा एवं उनकी समीक्षा की जाती है तथा बैठक में लिए गए निर्णयों पर अनुवर्ती कार्रवाई की जाती है ।
- संघ सरकार की राजभाषा नीति, राजभाषा अधिनियम के उपबन्धों तथा आदेशों से प्रयोगशाला के वैज्ञानिकों/अधिकारियों/कर्मचारियों को अवगत कराया जाता है, अनुपालन कराया जाता है एवं अनुपालन हेतु सहायता प्रदान की जाती है ।
- हिन्दी दिवस/हिन्दी पखवाड़ा/मास मनाया जाता है। इस दौरान विभिन्न प्रतियोगिताओं का आयोजन किया जाता है, जिसमें प्रयोगशाला के सभी अधिकारी/कर्मचारी भाग लेते हैं और उन्हें नकद पुरस्कार द्वारा प्रोत्साहित किया जाता है ।

- प्रत्येक तिमाही में प्रयोगशाला के अधिकारियों/कर्मचारियों हेतु हिन्दी कार्यशालाओं/व्याख्यानो का आयोजन किया जाता है। इन कार्यशालाओं के माध्यम से स्टाफ सदस्यों को हिन्दी में अधिक-से-अधिक कार्य करने हेतु प्रेरित एवं प्रोत्साहित किया जाता है। टेबल-वर्कशाप के माध्यम से व्यक्तिगत रूप से चर्चा की जाती है एवं कठिनाइयों का समाधान किया जाता है।
- प्रत्येक वर्ष विज्ञान विषयों पर हिन्दी में एक/दो दिवसीय राष्ट्रीय संगोष्ठी का आयोजन किया जाता है। वैज्ञानिकों द्वारा शोध पत्र हिन्दी में प्रस्तुत किए जाते हैं। राष्ट्रीय संगोष्ठी की सारांश पुस्तिका हिन्दी में प्रकाशित की जाती है, जिससे विज्ञान शोध सम्बन्धित जानकारी हिन्दी में आम जन तक पहुंचती है।
- प्रयोगशाला के अधिकारियों/कर्मचारियों को केन्द्रीय हिन्दी प्रशिक्षण संस्थान से हिन्दी प्रशिक्षण (प्रबोध, प्रवीण एवं प्राज्ञ पाठ्यक्रम) दिलाया जाता है। कम्प्यूटर पर हिन्दी में कार्य करने का प्रशिक्षण दिलाने हेतु कार्यक्रम आयोजित किए जाते हैं।

स्वच्छता पखवाड़ा

(09 मई, 2023 से 15 मई, 2023 तक)

भारत सरकार द्वारा जारी दिशा—निर्देशों के अंतर्गत प्रयोगशाला में दिनांक 09 मई, 2023 से 15 मई, 2023 तक 'स्वच्छता पखवाड़ा' का सफल आयोजन किया गया। दिनांक 04 मई, 2022 को निम्नलिखित दो वाद - विवाद एवं काव्य पाठ प्रतियोगिताओं का आयोजन किया गया :—

i वाद - विवाद प्रतियोगिता :-

- डा. मनोज कुमार, वरिष्ठ वैज्ञानिक ने प्रथम पुरस्कार प्राप्त किया।
- सुश्री आरती भारद्वाज, शोध छात्रा ने द्वितीय पुरस्कार प्राप्त किया।
- सुश्री शिखा श्रीवास्तव, शोध छात्रा ने तृतीय पुरस्कार प्राप्त किया।

ii काव्य पाठ प्रतियोगिता :-

- श्री गौरव वर्मा, शोध छात्र ने प्रथम पुरस्कार प्राप्त किया।
- सुश्री शिखा श्रीवास्तव, शोध छात्रा ने द्वितीय पुरस्कार प्राप्त किया।
- श्री अंकित गुप्ता, शोध छात्र ने तृतीय पुरस्कार प्राप्त किया।

इन दोनों प्रतियोगिताओं में कुल 45 स्टाफ सदस्यों (वैज्ञानिक/अधिकारी/कर्मचारी) व शोध छात्रों ने भाग लिया।

'स्वच्छता पखवाड़ा' के समापन समारोह में विजेता प्रतिभागियों को निदेशक महोदय द्वारा नगद पुरस्कार एवं प्रमाण पत्र प्रस्तुत किया गया।

प्रयोगशाला के वैज्ञानिक/तकनीकी अधिकारियों/स्टाफ सदस्यों के लिए कार्यशाला

स्वस्थ जीवनशैली पर एक दिवसीय कार्यशाला : 28 जून, 2023 को स्वास्थ्यचर्या के संदर्भ में स्वस्थ जीवनशैली पर एक दिवसीय कार्यशाला का आयोजन किया गया। आमंत्रित अतिथि वक्ता डा. श्रवण कुमार साहू, आयुर्वेद अनुसंधान अधिकारी, सीएआरआई, पंजाबी बाग, नई दिल्ली ने 'आहार ही औषधि है' विषय पर सारगर्भित व्याख्यान दिया।

कार्यक्रम

- | | |
|--------------------------------------|---|
| 1. स्वागत: | श्री जय नारायण उपाध्याय |
| 2. कार्यक्रम शुभारंभ/संबोधन: | निदेशक महोदय |
| 3. आमंत्रित अतिथि का परिचय व संबोधन: | श्रीमती वीना जैन, वरिष्ठ प्रशासन नियंत्रक |
| 4. मुख्य अतिथि द्वारा व्याख्यान: | डॉ श्रवण कुमार साहू, आयुर्वेद अनुसंधान अधिकारी
(विषय: आहार ही औषधि है) |
| 5. धन्यवाद प्रस्ताव: | श्री जय नारायण उपाध्याय |

आमंत्रित अतिथि वक्ता डा. श्रवण कुमार साहू, आयुर्वेद अनुसंधान अधिकारी, सीएआरआई, पंजाबी बाग, नई दिल्ली ने 'आहार ही औषधि है' विषय पर सारगर्भित व्याख्यान दिया। इस व्याख्यान के कतिपय महत्वपूर्ण बिन्दु निम्नवत हैं :

आहार का सीधा मतलब है आपका खानपान और यह हमारे जीवित रहने के लिए सबसे ज़रूरी चीजों में से एक है। हमारे वेदों में आहार को ही जीवन कहा गया है।

त्रयः उपस्तम्भाः इति आहारः स्वप्नो ब्रह्मचर्य इति।। (चरक सु. ११/१३)

आहार (भोजन), निद्रा (नींद) और ब्रह्मचर्य (ब्रह्मचर्य) आयुर्वेद में बताए गए त्रय उपस्तंभ (त्रयोपस्तंभ) हैं।

त्रय उपस्तम्भ का अर्थ है 3 उपस्तंभ या 3 सहायक स्तंभ। यदि मानव शरीर एक घर है, तो आहार, निद्रा और ब्रह्मचर्य महत्वपूर्ण सहायक स्तंभ हैं, जो हमारे शरीर को संतुलित करते हैं और जीवन का संचार करते हैं।

तीन स्तंभों में से, आहार या भोजन एक प्रमुख सहायक स्तंभ है, जो जीवन-निर्वाह और स्वास्थ्य के रखरखाव में मदद करता है। भोजन के बिना कोई जीवित रहने की कल्पना भी नहीं कर सकता।

कहते हैं "तन स्वस्थ तो मन स्वस्थ"। ऐसा आहार जो हमारे तन के साथ-साथ हमारे मन को भी प्रभावित कर स्वस्थ व सुखी रखे, वही पूर्ण प्राकृतिक आहार है। प्राकृतिक अपक्व आहार में पूर्णरूप से मिनरल, माइक्रो-मिनरल, फाइबर, विटामिन, शर्करा, नमक व जल जो हमारे शरीर के लिए आवश्यक हैं, वो सभी तत्वों की पूर्ति हो जाती है। प्रकृति ने हमें कई प्रकार के खाद्य पदार्थ दिये हैं, जो प्राकृतिक रूप से स्वादिष्ट व पौष्टिक हैं - स्वस्थ रहने के लिए पौष्टिक आहार की आवश्यकता होती है। हरी सब्जी, दाल और मौसमी फलों का संतुलित आहार से हम जीवन में स्वस्थ रह सकते हैं। फल, सब्जी, फूल, पत्ती, बीज यहां तक जड़े भी जिन्हें हम खाकर कई प्रकार की बीमारियों से अपने आपको सुरक्षित रख सकते हैं, प्राकृतिक आहार हमारे जीवन की कुंजी है।

हिन्दी दिवस तथा हिन्दी माह समापन समारोह- 2023

राजभाषा विभाग, गृह मंत्रालय, भारत सरकार द्वारा जारी हिन्दी पखवाड़ा/ माह आयोजन संबंधी दिशा- निर्देशों को ध्यान में रखते हुए प्रयोगशाला में 17 अगस्त, 2023 से 14 सितम्बर, 2023 तक 'हिन्दी माह' मनाया गया। प्रयोगशाला के सभी स्टाफ सदस्यों को अपना अधिक से अधिक कार्य हिन्दी में करने के लिए प्रेरित एवं प्रोत्साहित करने के उद्देश्य से निम्नलिखित प्रतियोगिताएं आयोजित की गयी।

क्रम सं.	प्रतियोगिता का नाम	दिनांक
1	लोकोक्ति पल्लवन प्रतियोगिता	17.08.2023
2	आशु भाषण प्रतियोगिता	22.08.2023

3	वाद विवाद प्रतियोगिता	24.08.2023
4	हिन्दी टंकण प्रतियोगिता	29.08.2023
5	सरकारी कामकाज में टिप्पण /आलेखन मूलरूप से हिन्दी में कार्य/डिक्टेसन	01.09.2023
6	काव्य पाठ प्रतियोगिता	04.09.2023
7	सामान्य ज्ञान-विज्ञान प्रतियोगिता	06.09.2023

दिनांक 04.09.2023 को काव्य पाठ प्रतियोगिता /कवि सम्मेलन हेतु प्रसिद्ध हास्य कवि श्री महेंद्र शर्मा को आमंत्रित किया गया था। संस्थान के प्रतिभागी कवियों के साथ-साथ श्री महेंद्र शर्मा जी की कविताओं का श्रोताओं ने भरपूर आनंद लिया।

दिनांक 14.09.2023 को हिन्दी दिवस तथा हिन्दी माह समापन समारोह-सह-कार्यशाला का आयोजन किया गया। कार्यकारी निदेशक महोदय ने कार्यक्रम का शुभारंभ आशीर्वचन से किया। उन्होंने हिन्दी दिवस के अवसर पर उपस्थित स्टाफ सदस्यों को दैनिक सरकारी कामकाज में हिन्दी का प्रयोग करने के लिए प्रेरित एवं प्रोत्साहित करते हुए ज्ञान-सृजन विषय पर अत्यन्त सारगर्भित व्याख्यान दिया।

एनपीएल में राजभाषा गतिविधियों के बारे में **श्रीमती वीणा जैन**, वरिष्ठ प्रशासन नियंत्रक महोदया ने संक्षिप्त ब्यौरा प्रस्तुत किया। साथ ही, उपस्थित स्टाफ सदस्यों को दैनिक सरकारी कामकाज में हिन्दी का प्रयोग करने के लिए प्रेरित एवं प्रोत्साहित किया।

डॉ. राजेश ,मुख्य वैज्ञानिक ने अतिथि वक्ता का परिचय प्रस्तुत किया तथा अपने सम्बोधन में कहा कि जन-जन की भाषा हिन्दी सहित भारतीय भाषाओं में सर्वसुलभ वैज्ञानिक उपलब्धियों तथा ज्ञान-विज्ञान से जुड़ी मूलभूत बातों को आम जन तक पहुंचाने के लिए सार्थक प्रयासों की आवश्यकता है ।

इस पावन अवसर पर मुख्य व्याख्यान अतिथि वक्ता **प्रसिद्ध हिन्दी विज्ञान संचारक व लेखक श्री सुभाषचन्द्र लखेड़ा,पूर्व वरिष्ठ वैज्ञानिक,डीआरडीओ** ने **‘हिन्दी में विज्ञान लेखन: वर्तमान स्थिति,समस्याएँ और समाधान’** विषय पर दिया। उन्होंने अपने विस्तृत ज्ञानकोश/अनुभवकोश से अनेक उदाहरण के द्वारा भारतीय भाषाओं /साहित्य और हिन्दी के सम्बन्धों के साथ विज्ञान साहित्य की रचना हेतु प्रेरित व प्रोत्साहित किया। विज्ञान, साहित्य,इतिहास आदि अनेक क्षेत्रों से उदाहरण देकर यह बताया कि हिन्दी भाषा में विज्ञान साहित्य सृजन की अपार संभावनाएं हैं।

समारोह के अंत में हिन्दी माह के दौरान आयोजित की गयी प्रतियोगिताओं में भाग लेने वाले **42 विजेता प्रतिभागियों को माननीय कार्यकारी निदेशक महोदय व मुख्य अतिथि के करकमलों से पुरस्कार व प्रमाण-पत्र प्रदान किए गए।**स्वागत, कार्यक्रम का संचालन व धन्यवाद ज्ञापन श्री जय नारायण उपाध्याय, हिन्दी अधिकारी, एनपीएल द्वारा किया गया।



डॉ. संजय रंगनाथ धकाते, कार्यकारी निदेशक संबोधित करते हुए



मुख्य अतिथि को सम्मानित करते हुए कार्यकारी निदेशक एनपीएल



मुख्य अतिथि श्री सुभाषचन्द्र लखेड़ा जी व्याख्यान देते हुए



काव्य पाठ करते हुए आमंत्रित कवि श्री महेंद्र शर्मा

विजेता प्रतिभागियों को पुरस्कार प्रदान करते हुए मुख्य अतिथि व अधिकारीगण





प्रयोगशाला के वैज्ञानिक/तकनीकी अधिकारियों/स्टाफ सदस्यों के लिए कार्यशाला 'मानक मापन' पर कार्यशाला

भारत सरकार के दिशा निर्देशों का अनुपालन सुनिश्चित करते हुए हिन्दी के प्रगामी प्रयोग में उत्तरोत्तर वृद्धि हेतु प्रयोगशाला के वैज्ञानिकों/तकनीकी अधिकारियों/कर्मचारियों/शोध छात्रों के लिए प्रत्येक तिमाही में हिन्दी कार्यशाला आयोजित की जाती है।

उपर्युक्त के संदर्भ में प्रयोगशाला के सभी वैज्ञानिक/तकनीकी अधिकारियों/स्टाफ सदस्यों के लिए "मानक मापन" विषय पर दिनांक 22 नवम्बर, 2023 को हिन्दी कार्यशाला आयोजित की गयी। इस हिन्दी कार्यशाला में "मानक मापन" विषय पर व्याख्यान दिए गए। इस हिन्दी कार्यशाला में लगभग 40 वैज्ञानिकों/तकनीकी अधिकारियों एवं 50 शोध छात्र/छात्राओं ने भाग लिया।

अतिथि वक्ता **श्री प्रमोद कुमार तिवारी (IAS, महानिदेशक, BIS, नई दिल्ली)** ने "मानक मापन" विषय पर महत्वपूर्ण एवं ज्ञानवर्धक व्याख्यान दिया।

अतिथि वक्ता श्री प्रमोद कुमार तिवारी के व्याख्यान के कतिपय महत्वपूर्ण बिन्दु निम्नवत् हैं :-

- **सोने की शुद्धता** :- 22 कैरेट का सोना बताकर कम कैरेट का सोना ग्राहक को देकर ठगने वाले हेरा-फेरी नहीं कर पाएंगे क्योंकि भारतीय मानक ब्यूरो ने जुलाई, 2021 से 6 डिजिट हॉलमार्क वाले आभूषण की बिक्री को अनिवार्य कर दिया है। इसका उल्लंघन करने पर भारी जुर्माना भरना या जेल जाना पड़ सकता है। सोना खरीद से पहले आप इंडिया बुलियन एंड ज्वैलर्स एसोसिएशन लिमिटेड (IBJA) की वेबसाइट पर जाएं, IBJA द्वारा जारी गोल्ड-रेट देशभर में सर्वमान्य हैं। गोल्ड ज्वेलरी पर भारतीय मानक ब्यूरो (BIS) अपने 6 डिजिट हॉलमार्क में शुद्धता की गारंटी देता है। साथ ही BIS Care app पर सोने की हालमार्किंग से संबंधित 6 डिजिट वाली HUID को तत्क्षण जांच सकते हैं।
- **पानी की शुद्धता** :- पानी की शुद्धता को TDS में मापते हैं। एक रिपोर्ट में BIS के मुताबिक अगर एक लीटर पानी में TDS की मात्रा 500 मिलीग्राम से कम है तो ये पानी पीने योग्य है।
- **उत्पाद प्रमाणन** :- उत्पाद प्रमाणन कार्य के लिए भारतीय मानक ब्यूरो (BIS) अपनी प्रयोगशालाओं में रसायन, खाद्य पदार्थ, इलेक्ट्रिकल और मैकेनिकल क्षेत्र से संबद्ध परीक्षण सुविधाएं करवाता है।
- विशेष तौर पर शोधार्थियों को संबोधित करते हुए उन्होंने कहा कि दैनिक जीवन में उपयोगी विभिन्न वस्तुओं/सेवाओं के मानक निर्माण/उन्नयन हेतु अनुसंधान प्रोजेक्ट लिखने व BIS में जमा कराने को कहा, ताकि भारतीय जनमानस गुणवत्तापूर्ण जीवन यापन कर सके।
- BIS Care app के बारे में बताते हुए श्री तिवारी ने कहा कि यह app बहुत ही उपयोगी है, जिसे सभी लोग अपने मोबाइल में अवश्य इंस्टॉल करें। कोई वस्तु भारतीय मानक ब्यूरो के मापदण्डों के अनुकूल निर्मित है अथवा नहीं, इसकी जांच तत्क्षण BIS Care app के माध्यम से कर सकते हैं।

उद्देश्य :-

- मानकों के सामंजस्यपूर्ण विकास के लिए समय पर सक्षम सेवा उपलब्ध कराना।

- BIS की प्रमाणन योजनाओं के संचालन के माध्यम से ग्राहकों की वस्तुओं और सेवाओं की गुणवत्ता एवं सुरक्षा जरूरतें पूरी करना।
- सेमिनारों, जागरूकता कार्यक्रमों और प्रचार अभियानों के माध्यम से मानकों, मानक अंकों और सुरक्षा एवं गुणवत्ता उत्पादों के प्रति जागरूकता पैदा करना।

हिन्दी कार्यशाला के अंत में धन्यवाद प्रस्ताव श्री जय नारायण उपाध्याय, हिन्दी अधिकारी ने किया। "मानक मापन" विषय पर आयोजित कार्यशाला में दिए गए व्याख्यान की वैज्ञानिकों/ तकनीकी अधिकारियों/कर्मचारियों को प्रेरित एवं प्रोत्साहित किया।

विश्व हिन्दी दिवस, 2024

राष्ट्रीय भौतिक प्रयोगशाला में राजभाषा यूनिट द्वारा विश्व हिन्दी दिवस, 2024 (दिनांक 10 जनवरी, 2024) का आयोजन किया गया। प्रयोगशाला में स्टाफ सदस्यों को हिन्दी में अधिक से अधिक कार्य करने के लिए प्रोत्साहित एवं प्रेरित करने के उद्देश्य से दिनांक 05 जनवरी को दो प्रतियोगिताओं का आयोजन किया गया।

क्रम सं	प्रतियोगिताएं	दिनांक
1	आशु भाषण प्रतियोगिता	08.01.2024
2	काव्य पाठ प्रतियोगिता	09.01.2024

इन सभी प्रतियोगिताओं में प्रयोगशाला के स्टाफ सदस्यों/शोध छात्र-छात्राओं ने अत्यधिक रुचि प्रदर्शित करते हुए उत्साहपूर्वक भाग लिया।

'विश्व हिन्दी दिवस' कार्यक्रम

- | | |
|--------------------------------------|--|
| 1. स्वागत: | श्री जय नारायण उपाध्याय |
| 2. कार्यक्रम शुभारंभ/सम्बोधन: | निदेशक महोदय |
| 3. विश्व हिन्दी दिवस के बारे में: | श्रीमती वीना जैन, वरिष्ठ प्रशासन नियंत्रक |
| 4. आमंत्रित अतिथि का परिचय व संबोधन: | श्री जय नारायण उपाध्याय |
| 5. मुख्य अतिथि द्वारा व्याख्यान: | प्रो. श्रीनिवास त्यागी, गार्गी कॉलेज, दिल्ली विश्वविद्यालय
(विषय: हिन्दी की वैश्विकता के मायने) |
| 6. धन्यवाद प्रस्ताव: | श्री जय नारायण उपाध्याय |

हर साल 10 जनवरी को 'विश्व हिंदी दिवस' के रूप में मनाया जाता है। इस दिन को विश्व में हिंदी भाषा के प्रचार-प्रसार के लिए जागरूकता फैलाने के उद्देश्य से मनाया जाता है। इस वर्ष की विश्व हिन्दी दिवस की थीम थी, 'हिन्दी - पारंपरिक ज्ञान और कृत्रिम बुद्धिमत्ता के बीच सेतु'। इस थीम का मकसद, भारत के पारंपरिक ज्ञान और आधुनिक तकनीक के बीच हिन्दी की भूमिका को दिखाना था।

अंग्रेजी के मशहूर समीक्षक और निबंधकार ईएम फास्टर ने अपनी पुस्तक आस्पेक्ट्स ऑफ नॉवेल में बड़ी बात कही है। उन्होंने साहित्य के बारे में कहा है कि जिस साहित्य की जड़ें जितनी स्थानीय होंगी, वह उतना ही अंतरराष्ट्रीय हो सकता है।

इस पावन अवसर पर कार्यकारी निदेशक डॉ संजय रंगनाथ धकाते महोदय ने विश्व हिन्दी दिवस की अनेक हार्दिक शुभकमनाएं दीं। उन्होंने कहा कि आज फीजी, मॉरीशस, गयाना, सूरीनाम, यूरोप, अमेरिका, नेपाल आदि देशों में हो रही हिन्दी-सेवा से वैश्विक परिदृश्य में हिन्दी का एक नया व प्रबल चित्र उभर रहा है। हिन्दी भाषा देश-विदेश में आधुनिक चुनौतियों को लांघते हुए विश्वव्यापी बन रही है। स्टाफ सदस्यों को दैनिक सरकारी कामकाज में हिन्दी का प्रयोग करने के लिए प्रेरित एवं प्रोत्साहित करते हुए ज्ञान-सृजन विषय पर अत्यन्त सारगर्भित व्याख्यान दिया। सम्बोधन के अंत में विश्व हिन्दी दिवस के अवसर पर आयोजित की गयी

प्रतियोगिताओं में भाग लेने वाले 10 विजेता प्रतिभागियों को माननीय कार्यकारी निदेशक महोदय ने हार्दिक बधाई दी।

श्री सुशील कुमार यादव, प्रशासनिक अधिकारी ने बताया कि विश्व में हिंदी का विकास करने और एक अंतरराष्ट्रीय भाषा के तौर पर इसे प्रचारित-प्रसारित करने के उद्देश्य से विश्व हिंदी सम्मेलनों की शुरुआत की गई और प्रथम विश्व हिन्दी सम्मेलन 10 जनवरी 1975 को नागपुर में आयोजित हुआ था। इसीलिए इस दिन को विश्व हिंदी दिवस के रूप में मनाया जाता है।

आमंत्रित अतिथि प्रो. श्रीनिवास त्यागी, गार्गी कॉलेज, दिल्ली विश्वविद्यालय ने “हिन्दी की वैश्विकता के मायने” विषय पर अपने सम्बोधन में कहा कि वर्तमान परिदृश्य में हिन्दी सहित भारतीय भाषाओं को विज्ञान/प्रौद्योगिकी तथा वाणिज्य-व्यापार आदि सहित तकनीकी शिक्षण हेतु भाषायी माध्यम बनाया जाना आवश्यक है।

समारोह के अंत में विश्व हिन्दी दिवस के अवसर पर आयोजित की गयी प्रतियोगिताओं में भाग लेने वाले 10 विजेता प्रतिभागियों को मुख्य अतिथि /मंचासीन गणमान्य माननीयों ने हार्दिक बधाई दी व पुरस्कार प्रदान किए।

स्वागत,कार्यक्रम का संचालन व धन्यवाद ज्ञापन श्री जय नारायण उपाध्याय, हिन्दी अधिकारी,एनपीएल द्वारा किया गया।



एक दिवसीय राष्ट्रीय सम्मेलन

' पर्यावरण और मानव स्वास्थ्य : वर्तमान चुनौतियाँ '

सीएसआईआर – राष्ट्रीय भौतिक प्रयोगशाला के पर्यावरण विज्ञान एवं जैवचिकित्सा मापिकी प्रभाग द्वारा आज 15 मार्च 2024 को एक दिवसीय सम्मेलन का आयोजन किया गया जिसका विषय था " पर्यावरण और मानव स्वास्थ्य : वर्तमान चुनौतियाँ "।

उद्घाटन सत्र में **प्रोफेसर वेणु गोपाल आचंडा** (निदेशक, सीएसआईआर-राष्ट्रीय भौतिक प्रयोगशाला) ने अपने स्वागत भाषण में कहा कि प्रयोगशाला में पर्यावरण विज्ञान एवं जैवचिकित्सा मापिकी से संबंधित अंशांकन व परीक्षण कार्य शीघ्र ही शुरू होगी।

पर्यावरण विज्ञान एवं जैवचिकित्सा मापिकी प्रभाग के विभागाध्यक्ष **डॉ. सच्चिदानंद सिंह** ने अपने उद्बोधन में इस प्रभाग के गठन व राष्ट्रीय/अंतरराष्ट्रीय महत्त्व की ऐतिहासिक उपलब्धियों की जानकारी दी।

डॉ. शंकर गोपाल अग्रवाल (मुख्य वैज्ञानिक, एनपीएल व सचिव, मेट्रोलॉजी सोसाइटी ऑफ इण्डिया) ने एमएसआई के बारे में बताया।

डॉ. अखिलेश गुप्ता (वरिष्ठ सलाहकार, विज्ञान एवं प्रौद्योगिकी विभाग, भारत सरकार) ने अपने व्याख्यान में प्रदूषण, पर्यावरण और मानव स्वास्थ्य के अंतर्संबंधों पर विस्तृत ज्ञानवर्द्धक जानकारी दी।

डॉ. सुमित कुमार मिश्रा (प्रधान वैज्ञानिक, सीएसआईआर- एनपीएल) इस सम्मेलन के संयोजक ने धन्यवाद ज्ञापन प्रस्तुत किया।

दिन भर चले इस महत्वपूर्ण सम्मेलन में विभिन्न विषयों पर कई तकनीकी सत्रों का भी आयोजन किया गया था। इसमें पर्यावरण विज्ञान संस्थान, जवाहरलाल नेहरू विश्वविद्यालय, मैकेनिकल इंजीनियरिंग विभाग, आईआईटी दिल्ली, संयुक्त राष्ट्र पर्यावरण कार्यक्रम, अखिल भारतीय आयुर्विज्ञान संस्थान (एम्स), गंगाराम अस्पताल, पर्यावरण अध्ययन विभाग, दिल्ली विश्वविद्यालय, राष्ट्रीय उच्च अध्ययन संस्थान, बंगलुरु, इंडियन एसोसिएशन ऑफ एयर पॉल्यूशन कंट्रोल आदि संस्थानों के विशेषज्ञों सहित अन्य क्षेत्रों के गणमान्य चिकित्सक व प्रबुद्धजनों ने अपने अनुभवों को साझा किया तथा मानव कल्याण के लिए विषयानुकूल समाधान प्रस्तुत किया।

Major R & D Projects during 2023-24

The major projects of value >50 Lakhs are listed below

Sl. No	Project Title	Funding Agency	Contract Value (in lakhs)	Amount Received during 2023-24
1	Study of seasonal variation of ozone precursor in relation with surface ozone over Delhi, a mega city	Physical Research Laboratory (A Unit of Dept. of Space, Govt. of India)	144.97	9.65
2	Seasonal variation of column aerosol properties, aerosol radiation forcing and the assessment of the impact of absorbing (BC) and desert dust aerosols in the mega-city of Delhi	Vikram Sarabhai Space Centre	86.00	NIL
3	Implementation of IST service using NPL controlled remote oscillator system for national knowledge Network at National Informatics Centre	National Informatics Centre Services Inc. (NICS)	94.36	NIL
4	Carbonaceous Aerosols Emissions, Source Apportionment and climate effects	Ministry of Environment, Forest and Climate Change (MoEF)	362.672	103.00
5	National Primary Standard facility for cell calibration	Ministry of New and Renewable Energy (MNRE)	2677.331	325.00
6	Megacity Delhi atmospheric emission quantification assessment and impacts (Delhi Flux)	Ministry of Earth Sciences (MoES)	198.28	NIL
7	Creation of Testing and Calibration Facility for LED and LED based Lighting at NPL India as per National/International Standards	Bureau of Energy Efficiency (BEE)	2224.00	NIL

9	Studies of stabilization of ferromagnetism in MnX(X=Al,Ga) binary alloy thin films by ion beam irradiation	DST	80.49	NIL
10	Production of Certified Reference Materials-Bharatiya Nirdeshak Dravya (BND)	Ministry of Commerce & Industry, Department of Commerce	1627.00	NIL
11	Establishment of type testing calibration and certification facility for online continuous Emission Monitoring System (OCEMS) and Continuous Ambient Air Quality Monitoring System (CAAQMS)	Ministry of Environment, Forest & Climate Change (MoEF) Govt. of India	4736.99	2000.00
12	Bulk preparation of p-type and n-type materials for excitonic solar cells	DST	58.24	19.42
13	Design and Development of flexible large area(156x156 mm ²) modified perovskite mini modules	DST	98.83	NIL
14	GCRF South Asian Nitrogen Hub (SANH)	UK Centre for Ecology and Hydrology (UKCEH)	153.13	28.27
15	Establishment of receptacles for the preservation of the original constitution of India in New Parliament Building	Lok Sabha Secretariat Parliament House	56.00	NIL
16	Dissemination of Time from RRSL Faridabad using a disciplined oscillator and R & D on optical fibers from NPL to Faridabad	Legal Metrology Division Department of Consumer Affairs	149.5	146.51
17	High output power emitters and sensitive detectors based on AlGaIn nano-heterostructures for deep-ultraviolet radiation towards biological application	DST (International Cooperation Division)	100.70602	14.14

18	Development of NavIC based IST traceable Primary Reference Time Clock (PRTC) for telecom sector	C-DOT (Centre for Development of Telematics)	275.000	41.00
19	Coal tar pitch-based fibers and its conversion into carbon fibers	Ministry of Textile	242.79872	222.60
20	Development of Indigenous PID-resistant Technology for Solar Cells	Central Power Research Institute (CPRI)	82.65	NIL

Awards & Achievements

Distinguished National/ International Award

- Dr. Govind Gupta received the MRSI- Distinguished Lectureship Award from the Materials Research Society of India (MRSI) for the year 2023-24.
- Dr. Bhanu Pratap Singh received BD Bangur Award -2023, from The Indian Carbon Society in the field of carbon science and technology for encouraging and promoting research work in the field of carbon.
- Dr. Shibu Saha received the prestigious 'APMP Young Metrologist Prize for Developing Economies-2023' awarded by APMP (Asia Pacific Metrology Programme) in recognition of his efforts in APMP's activities among young metrologists in developing economies.
- Dr. Anshul Varshney received the IEEE Power and Energy Society Outstanding Chapter Engineer Award for 2023.
- Dr. Kriti Tyagi received Young Scientist Award 2023 by the International Society for Energy, Environment and Sustainability (ISEES), constituted by IIT Kanpur.

Fellowship/ Grants

- Dr. Monika Kulshreshtha was awarded as a Fellow of Indian Geophysical Union
- Dr. Bhanu Pratap Singh received Raman Research Fellowship 2023-24 to visit the Aalto University, Finland during 16-03-2024 to 15-07-2024.
- Dr. Komal Bapna was awarded with 'CSIR-Raman Research Fellowship for 2023-2024' on 'Realization and Dissemination of the Thermodynamic Scale based on Acoustic Gas Thermometry' to work with Dr. Roberto Gavioso, Head of Physical Thermodynamics Group, National Institute of Metrological Research (INRiM) Italy, for a period of 06 months from 29th March 2024 to 28th Sept. 2024.
- Dr. Kriti Tyagi received the prestigious SERB International Research Experience (SIRE) fellowship 2023 to work at Northwestern University, Chicago.
- Dr. Anuj Krishna awarded with DST-SERB-ITS (Young Scientist) grant for attending and presenting poster at ICCGE-20 at Naples during 2023.
- Ms. Saloni Sharma was awarded with prestigious Mehta Rice Engineering Scholar Program (MRSEP-2023) fellowship during (Sept. – Dec. 2023)

Best Paper/ Poster Award

- Aarti received Best Poster Award at International Workshop on Advanced Materials Challenges and Standardization need for Net Zero Technologies, AMCSNZT-2023 at CSIR-NPL (9-12 Oct. 2023).
- Chinky Kochar received Best Poster Award for the poster on Reduced graphene oxide supported Zn/Al double layered hydroxide for adsorptive removal of lead,

arsenic and cadmium: Experimental and statistical analysis in MSA-ISPT 2023 Conference, Perth Australia (03-07 Dec. 2023).

- Urvashi Varshney received Best Poster Award in the AcSIR-RMIT workshop held at CSIR-NPL (05 Dec. 2023).
- Leeza Dutta received Best Poster Award in CSIR-NPL & RMIT Australia joint International One-day workshop on 'Creating Intellectual Infrastructure for Mentoring the young Graduates' at CSIR-NPL (05 Dec. 2023).
- Neha Yadav, Amit Choudhary, S. P. Singh, Rajesh, and A.M. Biradar received Best National Level Poster Presentation Award titled "Smectic layer reorientation in Ferroelectric liquid Crystal" in the India International Science Festival (IISF-2023) at CSIR-CRRI (13 Dec. 2023).
- Ankur Rana received Best Poster Award at International Conference on Atomic, Molecular, Material, Nano and Optical Physics with Applications (ICAMNOP-2023) at Department of Applied Physics, Delhi Technological University Delhi (20-22 Dec. 2023).
- Rahul Kumar, V. Aggarwal, S. Gautam, Aditya Yadav, B. Singh, G. Gupta, and Sunil S. Kushvaha received Best Poster Award at International Conference on Thin Films and Nanotechnology-Knowledge, Leadership and Commercialization (ICTN-KLC 2023) at IIT Madras, Chennai, for the paper entitled, "MoSe₂/n-GaN Hybrid Structures for Enhanced UV & NIR Photodetector" (6-8 Jul. 2023).
- Leeza Dutta received Best Poster Award at International Conference on Advances in Spectroscopic Techniques and Materials (ASTM-2024) at IIT(ISM) Dhanbad (18-20 Jan. 2024).
- Kumar, V., Khatkar, A., and Ahmad, S received Best Poster Award for "A comprehensive overview of synchrophasor technology in phasor measurement unit-based wide area monitoring system" in International Conference on Science and Technology for Sustainable Future, MDU University, Rohtak, Haryana (7-8 Feb. 2024).
- Bheem Singh, G. C. Behera, Bipul K. Pradhan, Sudhanshu Gautam, Rahul Kumar, Vishnu Aggarwal, Jai S. Tawale, M. Senthil Kumar, R. Ganeshan, Somnath C. Roy, and Sunil S. Kushvaha received Best Poster Award at National Science Day, CSIR-NPL, for the paper "PtSe₂ flakes decorated TiO₂ nanotubes for photoelectrochemical water splitting" (28 Feb. 2024).
- Gaurav Gupta, J.K. Sahu, S. N. Naik, and D.D. Shivagan received Springer Best Paper Award at AdMet 2024, Gurugram University for the Paper entitled "Dissimination of the Metrological Traceability to Field Level Food Grain Moisture Meters by Developing Reference Materials". (7-9 Mar. 2024).
- K. Alang, S. G. Aggarwal, Khem Singh, D. Soni, and P. Hegde received Best Poster Awards for poster "Light absorption characteristics of different polarity brown carbon fractions in Delhi aerosols", presented at National Science Day Poster Exhibition (28 Feb. 2024).
- Kiran, N. Vijayan, Divyansh Joshi, Jyoti, and Chetan received Best Poster Award for the poster entitled "Line Position and Line Shape Standard for Powder Diffraction

(Lanthanum Hexaboride Powder) BND 2025-P” in National Science Day celebrations at CSIR-NPL (28 Feb. 2024).

- Komal, Annu Verma, Pallavi Kushwaha, Jaidev, J. S. Tawale, Nidhi Singh, and H. K. Singh received Best Poster Award for the poster entitled “Structural, Transport and magnetic properties of Mn-Ni-Sn melt spun ribbons” in National Science Day celebrations at CSIR-NPL (28 Feb. 2024).
- Leeza Dutta received Best Poster Award in the National Conference on Chemical Physics (NCCP-2024) at Assam University, Silchar (19 Mar. 2024).
- Pukhraj Prajapat received Best Poster Award in National Conference on Environment and Human Health: Current Challenges organized by CSIR-NPL (15 Mar. 2024).
- Riya Malik received Best Poster Award (second prize) in the National Science Day - 2024 celebration at CSIR-NPL (28 Feb. 2024).
- Saloni Sharma received Best Poster Award (second prize) in the National Science Day - 2024 celebration at CSIR-NPL (28 Feb. 2024).
- Stuti Srivastava received Best Poster Award in the National Science Day Poster Competition at CSIR-NPL (28 Feb. 2024).
- दया सोनी, शंकर जी. अग्रवाल, खेम सिंह और आभा शुक्ला received Best Poster Award at Hindi Conference 'पर्यावरण और मानव स्वास्थ्य:वर्तमान चुनौतियाँ' at CSIR-NPL (15th March 2024).

Editorial Board of Reputed Journals

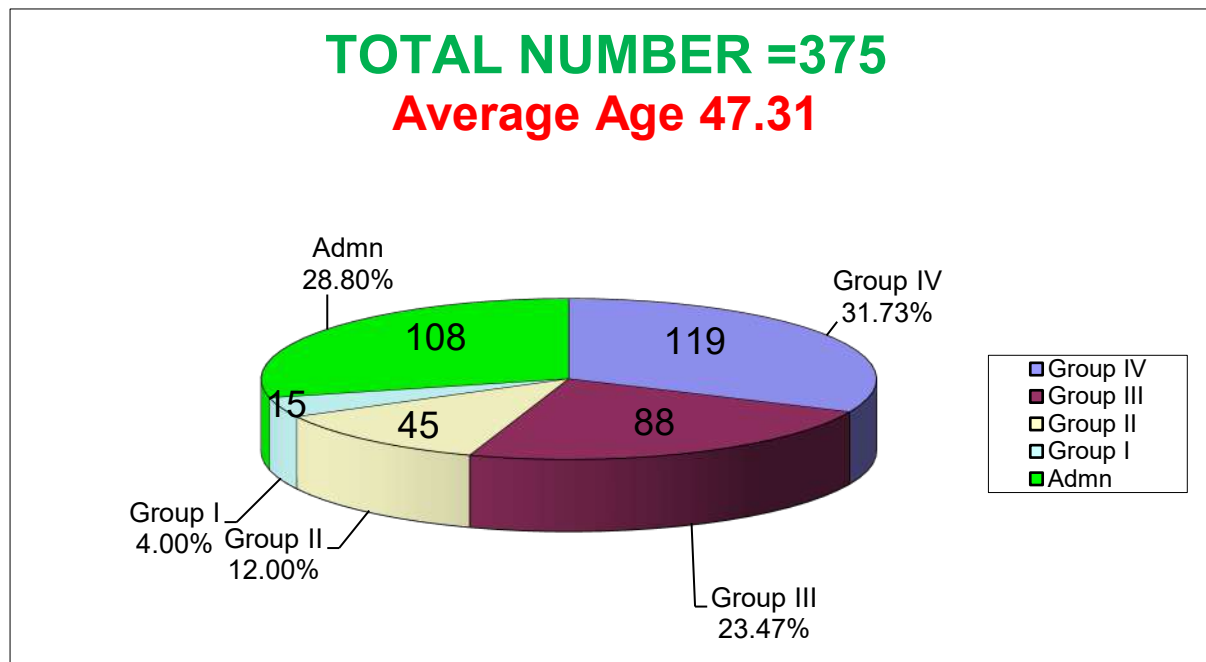
- Dr. Monika Kulshreshtha performed as a Member of Editorial Board, Journal of Indian Geophysical Union.

Other

- Shubhendra K. Jain received Prof. Baldev Raj Memorial Award for Best PhD Thesis under AcSIR-RMIT University Joint PhD Program at AcSIR (Oct. 2023).
- Dr.Ashish Agarwal was nominated a member from India on BIPM CCTF working group on Moon Reference Time.
- Dr Poonam Arora has been added as member to represent India at BIPM CCTF Task-force on Redefinition of SI Second.

Staff, Patents, Reports & Financial Outflow

Regular Staff in Position as on 31.03.2024



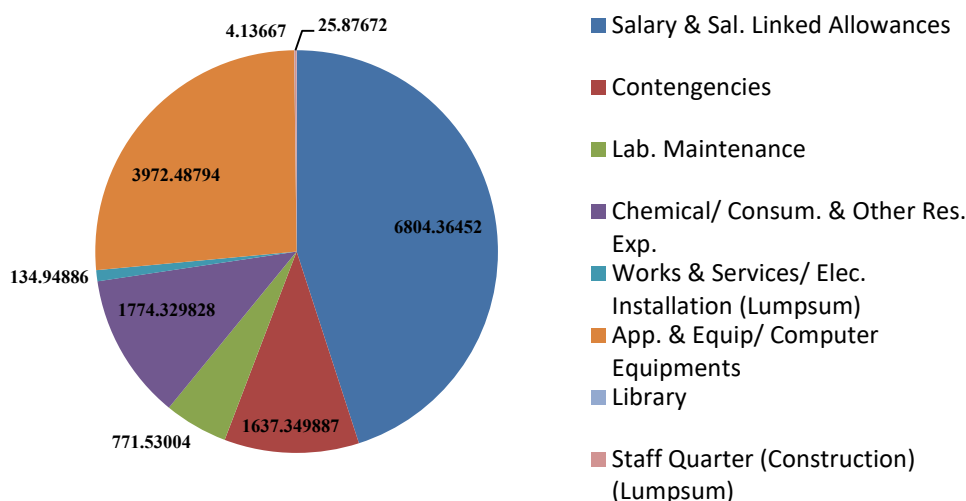
New Recruitments (2023-24)

S. No.	Name	Designation	Date of Joining
NIL			

Patents & Reports

- Patents Applications filed in India:03
- Patents Granted in India:10
- Copyrights filed in India: 02
- Copyrights registered in India: 01

Budget flow (in Lakh)



Patents & Copyright list

Filed in India

SNo	Title	Inventors	Prov. Filing Date	Comp. Filing Date	Application No.
1	A GREEN PROCESS FOR THE RECYCLING OF PHARMACEUTICAL BLISTER PACKAGING VIA METAL/ POLYMER DELAMINATION	PARVEEN SAINI, ANUJ, NEHA, RAHUL SAHA, SUSHIL KUMAR	---	26-Jun-2023	202311042898
2	A HIGHLY SENSITIVE LOW-COST, SMALL-SIZED DEVICE FOR MEASURING WEAK MAGNETIC FIELDS	ALOK PRAKASH, PRACHI TYAGI, ANURAG KUMAR KATIYAR, SATYA KESH DUBEY	---	04-Sep-2023	202311059463
3	A SINGLE STEP PROCESS FOR THE RECYCLING OF METAL/POLYMERS LAMINATES	PARVEEN SAINI, NEHA, ANUJ, RAHUL SAHA, SUSHIL KUMAR	23-Jan-2024	---	202411004790

Granted in India

SNo	Title	Inventors	Prov. Filing Date	Comp. Filing Date	Application No.	Grant Date	Patent No.
1	LIGHT WEIGHT CARBON FOAM AS ELECTROMAGNETIC INTERFERENCE (EMI) SHIELDING AND THERMAL INTERFACE MATERIAL FOR AEROSPACE APPLICATIONS	SANJAY RANGNATH DHAKATE, RAJEEV KUMAR, RAKESH BEHARI MATHUR, PARVEEN SAINI	26-Nov-2012	26-Nov-2013	3615DEL2012	17-May-2023	432074
2	LOW COST AND HIGH YIELD ELECTROSPUN POLY(VINYL ALCOHOL) BASED CARBON NANOFIBERS	SANJAY RANGNATH DHAKATE, ASHISH GUPTA, ANISHA CHAUDHARY, RAKESH BEHARI MATHUR	---	06-Aug-2014	2227DEL2014	25-May-2023	432876
3	DESIGN AND DEVELOPMENT OF A HIGH-VOLUME PM2.5 IMPACTOR	AGGARWAL SHANKAR G, PATEL PRASHANT, TSAI CHUEN JINN, SONI DAYA, SINGH KHEM, KOTNALA RAVINDER	17-Apr-2017	06-Apr-2018	201711013523	01-Nov-2023	464709

		KUMAR, TOMOAKI OKUDA, GUPTA PRABHAT KUMAR, OJHA VIJAY NARAIN, ASWAL DINESH KUMAR					
4	HIGH PERFORMANCE LIGHT WEIGHT CARBON FIBER FABRIC - ELECTROSPUN CARBON NANOFIBERS HYBRID POLYMER COMPOSITES	SANJAY RANGNATH DHAKATE, ANISHA CHAUDHARY, ASHISH GUPTA, RAKESH BEHARI MATHUR	---	26- Aug- 2014	2417DEL2014	01- Dec- 2023	476159
5	MAGNETIC NANOPARTICLES DECORATED ACTIVATED CARBON NANOCOMPOSITES FOR PURIFICATION OF WATER	SAINI PARVEEN, ARORA MANJU, KOTNALA RAVINDER KUMAR, BARALA SUNIL KUMAR, PANT RAJENDRA PRASAD, PURI CHANDNI	30- Sep- 2013	30- Sep- 2014	2891DEL2013	05- Dec- 2023	477069
6	LOW COST AND HIGH SENSITIVITY POLAR- RESISTIVE HUMIDITY SENSOR	ASHOK KUMAR, RAVIKANT, SHESHAMANI SINGH, HITESH BORKAR, GAURAV GUPTA, SHASHANK SINGH, SANJAY YADAV, PREMSHANKAR KEDARNATH DUBEY, VIJAY NARAIN OJHA	---	15- Nov- 2017	201711040726	06- Dec- 2023	477343
7	A PROCESS FOR THE PREPARATION OF CARBON FIBER- CARBON NANOTUBES REINFORCED POLYMER COMPOSITES FOR HIGH STRENGTH STRUCTURAL APPLICATIONS	SINGH BHANU PRATAP, TEOTIA SATISH, DHAKATE SANJAY RANGNATH	25- Oct- 2016	25- Oct- 2017	201611036488	14- Dec- 2023	482344
8	A METHOD FOR NUMBER COUNT EFFICIENCY CHECKS OF PARTICULAR COUNTER BASED ON CORRESPONDING PARTICLE MASS COLLECTED IN PARALLEL	SHANKAR GOPALA AGGARWAL, BIGHNARAJ SARANGI, SUDHANSHU KUMAR, KHEM SINGH, PRABHAT KUMAR GUPTA, ANIL KUMAR	---	30- Jul- 2015	2336DEL2015	04- Jan- 2024	494720
9	ELECTROMAGNETIC	DUBEY P K, OJHA	01-	23-	201611041059	15-	499085

	ACOUSTIC TRANSDUCER EXCITATION SOURCE WITH PROGRAMMABLE TONE BURST GENERATOR	V N, SINGH SHASHANK	Dec- 2016	Nov- 2017		Jan- 2024	
10	A PROCESS FOR THE PREPARATION OF ELECTROMAGNETIC FOAM INCORPORATES WITH FLY ASH	DHAWAN SUNDEEP KUMAR, KUMAR AMIT	---	07- May- 2015	1273DEL2015	29- Jan- 2024	504335

Copyrights filed in India:

SNo	Title	Diary No	Date of Filing	Registration No	Date of Registration
1	TIME TAG DATA PROCESSING SOFTWARE	5452/2024- CO/SW	19-Feb- 2024	SW- 18588/2024	03-04-2024
2	PC BASED CONTROL AUTOMATION AND ANALYSIS SOFTWARE FOR SWEEP FREQUENCY ULTRASONIC INTERFEROMETER	18856/2023- CO/SW	18-Jul- 2023	SW- 17268/2023	20-Sep-2023

Copyrights registered in India:

SNo	Title	Diary No	Date of Filing	Registration No	Date of Registration
1	PC BASED CONTROL AUTOMATION AND ANALYSIS SOFTWARE FOR SWEEP FREQUENCY ULTRASONIC INTERFEROMETER	18856/2023- CO/SW	18-Jul- 2023	SW- 17268/2023	20-Sep-2023

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