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CSIR Foundation Day

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As CSIR celebrates its 85th Foundation Day, this Special Issue of CSIR TechConnect brings together a remarkable cross-section of technologies emerging from laboratories across the CSIR network. The 37 impactful technologies showcased in this special issue are contribution of each of the 37 laboratory of CSIR, making this edition a collective showcase of the breadth, diversity, and national relevance of CSIR's scientific and technological capabilities.

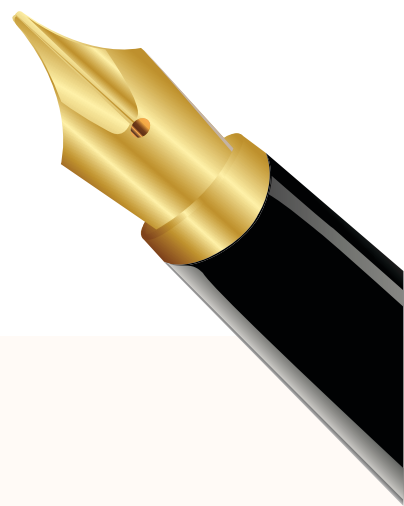
The technologies featured in this issue span an impressive range of areas — from advanced materials, healthcare and diagnostics to clean energy, environmental technologies, agriculture, infrastructure, water and sanitation, industrial processes, artificial intelligence and rural development. From X-ray shielding materials and fuel-cell technologies to smart villages, climate-friendly cooking solutions, rain gardens, PM_{2.5} detection, AI-powered diagnostics, seaweed-based applications, DME process technology and solutions addressing antimicrobial resistance, these stories demonstrate how research across CSIR is responding to challenges at different scales.

Beyond the individual technologies, this issue celebrates the collective spirit of innovation within CSIR. Each contribution represents years of scientific research, experimentation and collaboration, and reflects the commitment of CSIR laboratories to develop solutions that are relevant to the needs of society, industry and the nation.

The preparation of this Foundation Day Special Issue has also been a collaborative endeavour. Scientists and teams from CSIR laboratories across the country have worked closely with the Science Communication and Dissemination Directorate (SCDD) at CSIR Headquarters by sharing technical information, photographs, expert inputs and other relevant material. Their active participation has enabled us to bring these complex scientific and technological innovations to our readers in what we hope are engaging and relatable formats.

We hope this special edition inspires readers to discover the diverse technological capabilities within CSIR and appreciate the science, the people and the purpose behind them.

— Editorial Team
CSIR TechConnect



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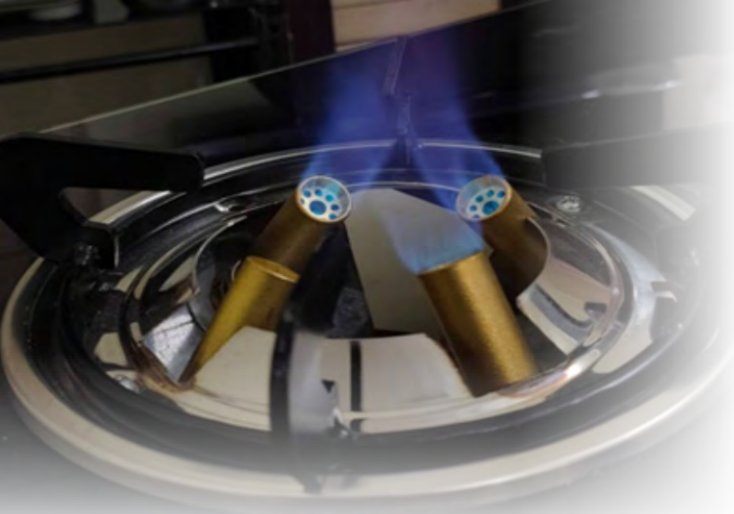
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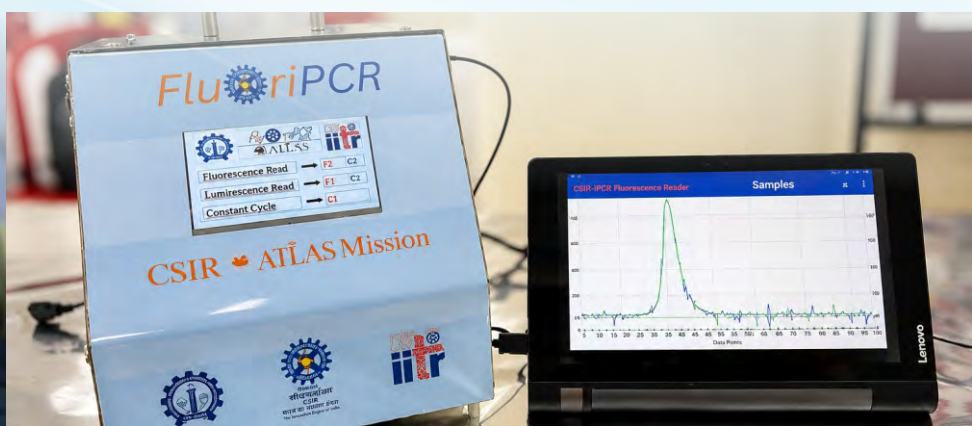
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TRIVIA TIME

CSIR at 85: From Scientific Foundations to the Frontiers of Viksit Bharat

- Dr. Jitendra Singh

Minister of State (Independent Charge), Ministry of S&T and Vice President, CSIR

CSIR belongs to a rare generation of national institutions that were conceived before Independence and subsequently became integral to the making of modern India. Its journey has evolved from building basic scientific capacity in the early years to addressing complex challenges in health, agriculture, industry, environment, strategic technologies and infrastructure in the recent years.

CSIR's mandate is more relevant than ever in realizing Hon'ble Prime Minister Narendra Modi's vision of *Atmanirbharta*, innovation-led growth and *Viksit Bharat 2047*. These national emphases have given renewed impetus to CSIR's efforts in developing indigenous technologies, research translation, technology transfer and capabilities that strengthen India's position in the global knowledge economy.



The very name of CSIR carries the word '*Industrial*' — a constant reminder that science must ultimately translate into economic value and national wealth. Today, CSIR is strengthening the lab-to-market journey, deepening researcher–industry collaboration and developing scalable, competitive and market-relevant solutions.

The spirit is evident in CSIR's efforts to strengthen India's technological self-reliance. For decades, critical chemicals like Hydrazine Hydrate, essential for pharmaceuticals, agro-chemicals and space applications, and the common drug Paracetamol were imported. Today, with CSIR's indigenous processes, commercial plants have been established in India, saving valuable foreign exchange and strengthening our chemical self-reliance.

From indigenous Hansa-NG trainer aircraft, now being produced commercially, to the world's first flight using Bio-Jet fuel made from used cooking oil, CSIR has led the way. Even the roads we travel on bear CSIR's imprint, with the innovative road technologies enabling infrastructure development using waste plastic and steel slag, making Bharat's infrastructure more sustainable and durable.

The Aroma Mission demonstrates how scientific innovation can drive self-reliance, rural prosperity and global competitiveness. CSIR's work on menthol mint, lemongrass and other high-value aromatic crops has helped transform India into a leading producer and exporter of essential oils and aroma products. The Purple Revolution through lavender cultivation in Jammu & Kashmir further shows how indigenous science can reach remote communities, creating livelihoods and enabling inclusive growth.

From indigenous atomic clocks to advanced materials, aerospace technologies, healthcare innovations, biotechnology and environmental solutions, CSIR's mandate today is increasingly shaped by the strategic needs of a confident India. Its research is being aligned not merely with what is scientifically possible, but with what the nation needs.

The partnership with Micro and Small Enterprises is particularly important. Through its engagement with *Laghu Udyog Bharati*, CSIR has sought to take indigenous technologies directly to MSMEs, with the objective of expanding market reach, promoting export and import substitution and enabling enterprises to adopt cost-effective technologies. This shift from research excellence to research with impact defines CSIR's present phase.

Equally important is the democratisation of science. A scientifically confident nation is not built only in research laboratories; it is built in classrooms, villages, start-ups, farms and industries. Initiatives such as CSIR Jigyasa, One Week One Lab and public technology showcases have helped bring the institution closer to citizens, particularly young people.

The world is entering an era in which technological sovereignty will increasingly influence economic and strategic



sovereignty. Artificial intelligence, quantum technologies, advanced materials, semiconductors, biotechnology, clean energy, blue economy and space technologies are rapidly redefining the global order. The national discourse on science and technology is consequently moving from catching up to leading, and from technology acquisition to technology creation.

This is where CSIR's role becomes even more significant. The next phase must see CSIR move with greater speed from laboratory to market, from patent to product, and from innovation to impact.

As India moves towards *Viksit Bharat 2047*, the meaning of development is evolving. It is no longer about building more or growing faster, but about building better, cleaner and smarter; ensuring inclusive and sustainable growth; and creating technologies that address both India's needs and global challenges.

CSIR has the scientific depth, institutional experience and national reach to contribute decisively to this transformation. Its future will be measured not only by papers and patents, but by technologies commercialised, enterprises created, jobs generated, lives improved and strategic dependencies reduced.

The first 84 years built the foundation; the 85th calls for acceleration. CSIR must become more agile, collaborative and globally connected, while remaining firmly rooted in the nation's developmental priorities.

Today, CSIR's scientific capability is a vital pillar of India's aspiration to become a developed, self-reliant and innovation-led nation. As CSIR enters its 85th year, its task is not merely to carry forward a proud legacy, but to create the next one.

For India@2047, CSIR must remain what it has always aspired to be at its best: science in the service of the nation, innovation in the service of society, and knowledge transformed into a stronger, self-reliant and globally confident India.

TechConnect: Connecting Technologies with Society

- Dr. N. Kalaiselvi, DG, CSIR

India's journey towards becoming a developed and technologically empowered nation will depend significantly on its ability to convert scientific knowledge into solutions that create value for society and the economy. At the Council of Scientific & Industrial Research (CSIR), this transformation has been central to our mission for more than eight decades.

Established in 1942, CSIR has evolved with the changing needs of the nation. Its network of laboratories, working across diverse disciplines, has contributed technologies and scientific capabilities in healthcare, agriculture, pharmaceuticals, energy, environment, aerospace, advanced materials, engineering, food, infrastructure and strategic sectors. These contributions represent not only scientific achievement, but also the growing capacity of India to develop, manufacture and deploy indigenous technologies.



The real measure of research, however, lies beyond the laboratory. A technology acquires greater significance when it reaches an industry, improves a manufacturing process, enables a farmer, creates a livelihood, strengthens healthcare or addresses a societal challenge. This is why CSIR is increasingly focused on strengthening the entire pathway from discovery and innovation to technology development, demonstration, transfer, commercialisation and adoption.

As India moves towards Viksit Bharat 2047, this principle becomes even more relevant. The technological landscape is changing rapidly, with artificial intelligence, quantum technologies, biotechnology, advanced materials, semiconductors, clean energy, precision medicine, critical minerals, climate technologies and digital systems creating new opportunities as well as new challenges. India needs research that is globally competitive while remaining responsive to its own developmental priorities.

CSIR's role in this emerging landscape is therefore evolving—from being primarily a generator of scientific knowledge to becoming an increasingly connected innovation ecosystem. Stronger engagement with industry, academia, start-ups, MSMEs, entrepreneurs and government agencies is essential to accelerate the translation of research into deployable technologies. Equally important is the creation of pathways through which promising technologies can be scaled, adapted to different contexts and taken to the people who need them most.

This is the context in which CSIR TechConnect becomes particularly significant.

A technology is meaningful only when its possibilities are understood beyond the laboratory. CSIR TechConnect seeks to make that connection visible by bringing together technologies developed across CSIR's laboratories and presenting them in a manner that highlights not only what has been developed, but also why it matters and where it can create impact.

This special issue offers a snapshot of the remarkable diversity of CSIR's technological capabilities, featuring an impactful technology from each CSIR laboratory. The range—from healthcare and agriculture to environment, energy, engineering, advanced materials and food—reflects the breadth of challenges that CSIR addresses and the depth of expertise available within its distributed research network.

The journey ahead will require not only new discoveries, but also stronger bridges between researchers and those who can transform research into products, services and solutions at scale. It will require a culture in which technology transfer is viewed not as the end of a research project, but as the beginning of its journey towards impact.

As CSIR enters its 85th year, its legacy provides a strong foundation, but its future will be defined by the impact it creates. The ambition must be clear: to advance science, develop technologies that matter, enable their wider adoption and contribute to an India that is technologically self-reliant, economically competitive and socially resilient.

The Villages of Tomorrow: How Science is Transforming Rural India

What if scientific innovations developed in laboratories could directly improve life in villages? Through the CSIR SMART Village Initiative, indigenous technologies are being deployed across rural India to address challenges ranging from water and sanitation to agriculture, energy, livelihoods, and skill development. The initiative offers a new model for building resilient and self-reliant communities.



Imagine a village where clean drinking water reaches every household. Solar panels power community facilities. Farmers use scientific tools to improve crop yields. Young people gain skills that help them find employment without leaving their communities. For many, this may sound like a vision

of the future. For the Council of Scientific and Industrial Research (CSIR), it is a vision already taking shape.

Under the CSIR SMART Village Initiative, villages are becoming living laboratories where science, technology, and community

participation come together to improve everyday life. Developed as a Mission Mode Project under the Ministry of Science and Technology, the initiative aligns with the national vision of Viksit Bharat @ 2047 and seeks to demonstrate how scientific innovations can contribute directly to rural development.



Vision of CSIR for Smart Village

Why Villages Need Integrated Solutions

Rural development is often discussed in separate sectors—water, agriculture, sanitation, energy, livelihoods, or infrastructure. But village life does not work in compartments. A farmer's productivity depends on water availability. Better roads improved access to markets and healthcare. Reliable electricity supports education and local enterprises. Sanitation influences public health. Employment opportunities determine whether young people stay or migrate. Addressing these challenges one by one can be slow and expensive. The SMART Village initiative adopts a different approach: solving multiple challenges together through an integrated framework of technologies and community-driven interventions.

Science Meets Rural Development

To demonstrate this model, six villages across five climatic zones of India have been selected for integrated development. What makes the initiative unique is the scale of scientific collaboration behind it. CSIR-Central Building Research Institute (CSIR-CBRI) is the nodal laboratory for the mission, coordinating the initiative and supporting the integration of technologies and expertise from across the CSIR network. Seventeen CSIR laboratories are contributing technologies and expertise, ensuring that solutions are tailored to local conditions and real-world needs. Rather than introducing technology for its own

sake, the programme focuses on practical interventions that can improve the quality of life of rural residents.

Building a Smart Village, Not Just Installing Technologies

A smart village is not built through a single innovation. A solar panel alone cannot transform a community. Neither can a water treatment unit, a new road, or a skill-development programme in isolation. The strength of the CSIR SMART Village initiative lies in bringing multiple solutions together. A farmer who has access to scientific farming practices and efficient water management can improve productivity. Reliable clean energy can power schools, health centres, and local enterprises. Better sanitation and wastewater management improve public health, while improved roads and community infrastructure enhance access to markets and essential services.

Equally important are the opportunities created beyond agriculture. Skill-development programmes, rural enterprises, and value-addition activities help generate local employment, enabling young people to find opportunities closer to home. Digital literacy and community engagement programmes ensure that residents are not merely beneficiaries of development but active participants in shaping it. Viewed individually, each intervention may seem modest. Together, however, they create something much larger: a resilient village ecosystem where economic

growth, environmental sustainability, and social well-being reinforce one another.

More Than Technology Deployment

One of the most important aspects of the SMART Village initiative is that its goal extends beyond installing new technologies. A water system is useful only if it can be maintained. A solar installation delivers value only if people know how to use and manage it. Infrastructure becomes sustainable only when communities participate in its upkeep.

For this reason, the initiative places strong emphasis on skill development, community ownership, and continuous engagement. The objective is not merely to solve today's problems but to build the capacity to address tomorrow's challenges as well.

A Blueprint for Rural India

India's villages are home to nearly two-thirds of the country's population. Their development will play a decisive role in shaping the nation's future. The CSIR SMART Village Initiative offers a compelling model for how science can contribute to that transformation. By combining technology, sustainability, and community participation, it demonstrates that rural development need not be viewed as a collection of isolated projects. Instead, villages can become centres of innovation, resilience, and opportunity.

From Village Growth to National Growth

The future of India will not be built only in cities, industrial corridors, or technology parks. It will also be built in villages—where scientific innovation improves livelihoods, strengthens resilience, and creates new opportunities for millions of people. The CSIR SMART Village Initiative is helping to build that future, one village at a time. Because when villages grow, the nation grows.

गाँव बढ़े, देश बढ़े।

Floating Power: India's Quest to Harvest Energy at Sea

India's strongest winds often blow far from land, where traditional offshore turbines cannot stand. Scientists at CSIR-SERC are developing floating platforms carrying wind turbines and solar panels designed for Indian seas. The technology could reshape how the country harvests clean energy from deep oceans.



An AI Illustration

Imagine standing on a beach during a windy evening. The breeze feels endless. Now imagine that same wind, much stronger and steadier, hundreds of kilometres offshore. Those offshore winds carry immense energy potential, enough to power cities if harvested efficiently. For years, this energy existed—but remained

unreachable as the ocean gets deep.

Traditional offshore wind turbines work like giant poles fixed into the seabed. These foundations perform well in shallow waters, roughly up to 50 metres deep. Beyond that, building becomes difficult and expensive. Yet the strongest offshore winds often lie farther out,

over deeper waters.

For a country like India, this matters enormously. India has nearly 11,000 kilometres of coastline and a vast Exclusive Economic Zone extending up to 370 km offshore. The energy potential is immense. But India's seas also bring cyclones, monsoon



Floating offshore hybrid energy platform configurations at CSIR-SERC

shifts, and turbulent conditions unlike those in Europe, where much offshore technology was originally developed. Designs successful elsewhere may not survive India's waters. This is where scientists at CSIR-Structural Engineering Research Centre (CSIR-SERC) entered the story not by forcing existing solutions into Indian seas, but by designing systems around Indian conditions. Their answer: make renewable energy platforms float.

Teaching Renewable Energy to Float

A floating offshore wind turbine sounds strange at first. Aren't turbines supposed to stand rigidly? Yet floating structures have an advantage: instead of resisting every force from waves, they can move in controlled ways. One platform studied by CSIR-SERC is called a semi-submersible platform. Part of it stays below water, using submerged mass and water resistance to reduce excessive movement. Think of it as a carefully balanced raft engineered to remain stable even under harsh conditions.

But floating introduces another challenge: vibration. Every structure has a natural frequency, a rhythm at which it prefers to vibrate. If waves match that rhythm, oscillations can grow stronger a

phenomenon called resonance. Push a playground swing at exactly the right timing and it goes higher; resonance in offshore structures can instead damage components over time.

To prevent this, scientists tested several solutions. Heave plates act like underwater parachutes, increasing resistance and slowing vertical movement. Tuned Mass Dampers (TMDs) work differently: they move opposite to the structure's vibration, absorbing energy before oscillations become dangerous. Researchers even used Real-Time Hybrid Simulation, combining physical testing with virtual simulations to examine how turbines behave under realistic forces. The work did not stop there. Scientists performed wind tunnel experiments to understand how moving platforms affect airflow around turbine blades. They also explored what happens if a mooring line—the structure's anchor system—fails. The aim was resilience: ensuring one failure does not trigger catastrophe.

Building Hybrid Energy Farms at Sea

Then came an even more ambitious idea. Why choose between wind and solar when both can share the same floating platform? This hybrid approach recognises a practical truth: renewable sources often

complement each other. Sunny days may favour solar generation, while stormier or cloudier conditions may strengthen wind output. Combining them can smooth fluctuations in electricity production.

The design goes further by rethinking how offshore farms use space. Large Horizontal Axis Wind Turbines (HAWTs) create turbulent wakes behind them, forcing wide spacing between turbines. Normally, those gaps become unused ocean. CSIR-SERC's concept fills them with platforms carrying Vertical Axis Wind Turbines (VAWTs) and solar panels. Because VAWTs recover from wake effects faster and have lower centres of gravity, they can fit more closely and remain inherently stable.

The result resembles a mosaic spread across the sea: large floating wind platforms surrounded by smaller wind-and-solar units, extracting more energy from the same area. Researchers validated these designs through wave-flume experiments simulating deep-water conditions, including depths of about 150 metres and extreme sea states.

Why Floating Renewables Could Shape India's Future

Why does all this matter beyond engineering? India aims for 500

GW of non-fossil energy capacity by 2030. Offshore renewables could support that transition while reducing pressure on land-based infrastructure. The technology also aligns with the country's Deep

Ocean Mission, linking energy security with deep-water capability. There is another possibility too: a new blue economy where energy generation coexists with shipping, fisheries, and marine ecosystems. For centuries, coastlines marked the

boundary between land and sea. Technologies like these suggest something different. The ocean may no longer be the edge of India's energy future. It may be where that future begins.



Wind tunnel testing of Floating Offshore Wind Turbines (FOWT)

Printing Precious Metals: Building India's Future in Gold powders for 3D printing

For centuries, jewellery began in the hands of skilled goldsmiths. Today, it can begin as a digital design and a cloud of microscopic gold particles. Scientists at CSIR-NML have developed India's first indigenous 22- and 18-karat gold alloy powders for metal 3D printing, opening new possibilities for jewellery manufacturing using additive manufacturing technologies.



Every piece of jewellery begins as an idea. In the hands of a skilled goldsmith, that idea slowly takes shape—gold is melted, hammered, soldered, and polished into an ornament that reflects years of craftsmanship and experience. For generations, this painstaking process has transformed precious metal into rings, bangles, and necklaces admired for their beauty and precision.

But what if a customised ornament could be created not on a workbench, but on a computer screen? What if intricate designs could be produced with microscopic accuracy while reducing material waste? This is no longer a futuristic vision. Thanks to a breakthrough by scientists at CSIR–National Metallurgical Laboratory (CSIR-NML), Jamshedpur, metal 3D printing is opening a new chapter in the art and science of jewellery making.

Printing Gold, One Layer at a Time

Most people are familiar with plastic 3D printers. Metal 3D printing works on a similar principle, but with far more sophisticated materials and equipment. One of the most widely used techniques is called **Selective Laser Melting (SLM)**.

In this process, an ultra-fine layer of metal powder is spread across a surface. A laser then selectively melts tiny regions according to a digital design. Another thin layer of powder is added, and the process repeats thousands of times until a complete three-dimensional object emerges. The technology allows manufacturers to create intricate lattice structures, lightweight components, and customized designs that would be difficult—or sometimes impossible—to produce using traditional methods. For jewellery designers, the possibilities



Typical 3D printed jewellery

are especially exciting. Complex geometries, personalized ornaments, and highly detailed designs can be produced with unprecedented precision.

The Missing Ingredient

Yet there was a problem. Metal 3D printers cannot work with just any powder. To function properly, they require particles that are nearly spherical, highly pure, and capable of flowing smoothly like a liquid. The ideal particle size is often between about 10 and 45 micrometres—roughly comparable to the thickness of a human hair divided several times over.

Until recently, India lacked both the infrastructure and the expertise needed to manufacture such high-

quality gold alloy powders domestically. The prevailing statutory regulations on import of precious metal powders further added additional challenges for India's growing additive manufacturing ecosystem.

Turning Gold into Powder

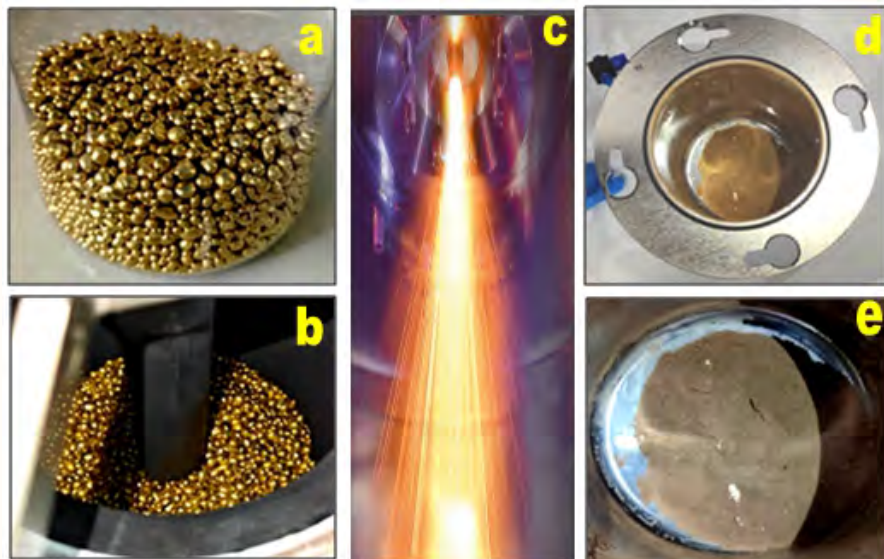
To address this challenge, CSIR-NML established a state-of-the-art Inert Gas Atomization (IGA) facility—the first of its kind in India, which can be used to produce precious metal powders, in addition to other metals. The facility

was inaugurated in 2024 and represents a major step toward self-reliance in materials for additive manufacturing. The process sounds almost magical.

Gold alloy is first melted into a liquid. This molten metal is then subjected to high-pressure inert gas jets that break the liquid stream into countless tiny droplets. As these droplets travel through the atomization chamber, they cool and solidify into microscopic metal spheres. The result is not gold dust in the ordinary sense, but a highly engineered material designed for precision manufacturing.

India's First Indigenous Gold Powders for 3D Printing

Using this facility, CSIR-NML successfully produced 22-karat and 18-karat gold alloy powders suitable for metal 3D printing. The powders were found to be highly



(a) 22k gold alloy nodules (b) Charging into graphite crucible in melting chamber (c) atomization in process (d) gold alloy powder in collecting jar (e) different batch powder



Charging the silvers granules into melt chamber by Dr. N. Kalaiselvi, Director General, CSIR & Secretary, DSIR, Govt. of India. at CSIR-NML

spherical and largely free from defects known as satellite particles—small attached particles that can affect powder flow and printing quality.

After sieving, the powders were separated into carefully controlled size ranges, including the critical 10–45 micrometre fraction required for Selective Laser Melting. For the first time, the essential raw material for 3D-printed gold jewellery could be produced within India.

A Golden Future

The development of indigenous gold alloy powders could help jewellery manufacturers reduce

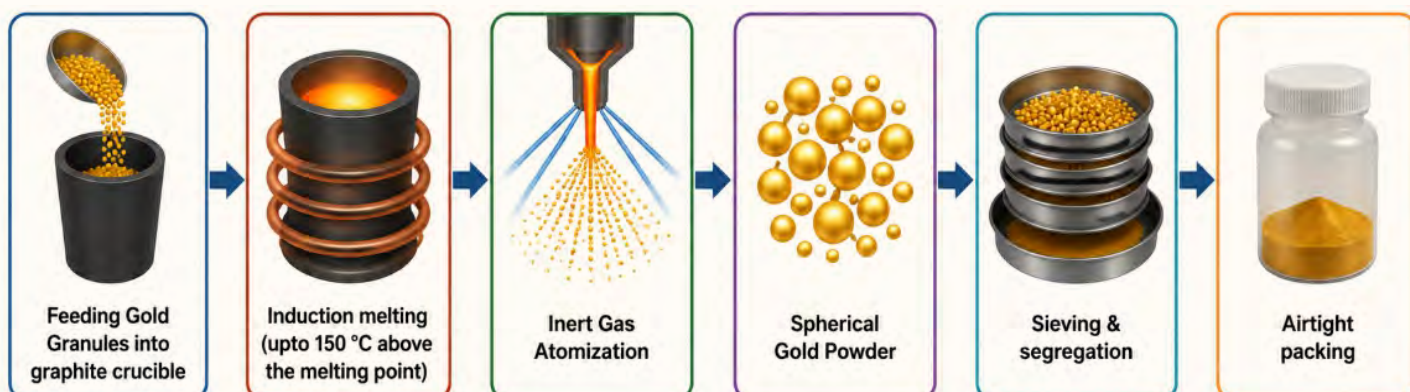
material wastage, shorten production times, and offer highly customized products to customers. Researchers at CSIR-NML are continuing efforts to develop new alloy compositions, improve powder quality, increase production efficiency, and support industries through technology transfer and specialized training.

While jewellery may be the most visible application, the significance of this achievement extends much further. The same atomization facility can also produce powders based on copper, silver, iron, and nickel alloys. Such materials are increasingly important for sectors

ranging from aerospace and defence to electronics and advanced engineering.

Looking ahead

From the hands of the goldsmith to the beam of a laser melting the gold powder layer by layer, the story of gold jewellery is sailing along with technology. What once began as glittering granules now emerges as a masterpiece of innovation. Powered by science, shaped by technology, inspired by tradition and curious scientists, the golden story continues... brighter than ever before.



Schematic diagram of various stages in inert gas atomization of gold alloys

The Pine Needle Revolution in Uttarakhand: From Source of Forest Fire to Clean Fuel

Every summer, pine needles carpeting the forests of Uttarakhand become fuel for devastating wildfires. But what if these same needles could become a source of clean energy, rural livelihoods, and women's empowerment? A pioneering initiative led by CSIR-IIP in Champawat is showing how an environmental challenge can be transformed into an economic opportunity.



An AI Illustration

The pine forests of Uttarakhand are beautiful, but they come with a challenge. Every year, chir pine trees shed enormous quantities of dry needles, locally known as Pirul. These needles accumulate on the forest floor, forming a thick carpet that suppresses vegetation growth and becomes highly vulnerable to

ignition during the dry season. A single spark can trigger a wildfire that spreads rapidly across the hillsides. For decades, pine needles were largely viewed as a nuisance—a forest residue with little practical value. Yet scientists saw something else hidden within this annual accumulation. They saw energy.

Seeing Opportunity in a Forest Hazard

Uttarakhand generates an estimated 1.33 million tonnes of pine needles every year. If utilized effectively, this biomass represents a substantial renewable energy resource. The challenge was not availability; it was finding a practical way to collect, process, and use it. To address this challenge, scientists at CSIR–Indian Institute of Petroleum (CSIR-IIP), Dehradun, with support from the Uttarakhand State Council for Science and Technology (UCOST), established a pine needle briquetting unit in Bhingrara village of Champawat district.

The idea was deceptively simple: collect pine needles from forests and convert them into dense biomass briquettes that can be used as a renewable industrial fuel.

Turning Needles into Fuel

The process begins in the forest. Women from local self-help groups collect pine needles while carrying out their routine activities such as gathering fodder and fuelwood. The



Participants of the “Ujjwal Mahila Samooh”, a women-led group, actively engaged in the operation of CSIR-IIP pine needle briquetting unit

collected material is brought to the briquetting unit, where it is processed into compact cylindrical briquettes.

The technology relies on a piston-press briquetting machine that compresses shredded biomass under high pressure. No chemical binders are required. The result is a dense, durable fuel that is easier to transport, store, and use than loose biomass. What was once considered forest waste now becomes a marketable energy product.

The Women Behind the Transformation

One of the most remarkable aspects of the initiative is who runs it. The briquetting unit is operated by Ujjwal Mahila Samooh, a women-led self-help group formed under the National Rural Livelihood Mission (NRLM). These women participate throughout the value chain—from collection and transportation to briquette production, packaging, and marketing.

This creates something more valuable than fuel. It creates livelihoods. The project provides additional income opportunities while strengthening women's participation in entrepreneurship and local decision-making. Technical training and operational experience further enhance their skills and confidence.

Preventing Fires Before They Start

Most wildfire management strategies focus on controlling fires after they occur. The Champawat project takes a different approach. By creating economic value for pine needles, it encourages communities to remove combustible material from forests before it can contribute to fire outbreaks. During 2024–2026, approximately 300 tonnes of pine needles were collected and converted into briquettes. Every tonne removed represents less fuel available for potential forest fires. In effect, the initiative transforms local residents into active partners in forest conservation. The forests become safer, while communities



Pine needle briquettes are being supplied to the user industry by the "Ujjwal Mahila Samooh", demonstrating their active involvement.

benefit economically.

Building a Circular Rural Economy

The briquettes are already finding applications in industries such as food processing and brick manufacturing, demonstrating their potential as an alternative fuel. The project has helped establish market linkages and create a sustainable value chain around a previously underutilized biomass resource.

Economic assessments indicate that a briquetting unit can become financially viable within a relatively short period, making the model attractive for wider adoption. The approach also aligns with Uttarakhand's broader efforts to promote pine needle utilization under its Pirul Niti and biomass-energy initiatives.

A Model Beyond Uttarakhand

The significance of the project extends beyond a single village. Many regions across the Himalayan belt face similar challenges of forest-fire risk, rural unemployment, and underutilized biomass resources. The "Bhingrara Model" demonstrates how these challenges can be addressed together through science, community participation, and local entrepreneurship. Recognizing its impact, the initiative received a prestigious SKOTCH Award in

2026 under the Rural Development and Renewable Energy category.

When a Problem Becomes a Resource

The story of pine needles in Uttarakhand is a reminder that waste is often a matter of perspective. What appears to be a forest hazard can become a source of renewable energy. What seems like an environmental burden can generate livelihoods. And what begins as a local solution can inspire broader change. In the forests of Champawat, fallen pine needles are no longer a potential fire hazard. They are helping power a more sustainable future.



Pine needle briquetting machine being operated by the trained women of "Ujjwal Mahila Samooh" under the guidance of CSIR-IIP

Measuring the Invisible: How Indian Scientists are Tracking the Air We Breathe

Every breath we take contains particles too small to see but capable of affecting human health. Measuring these particles accurately is essential for understanding air quality, their impact on health and developing effective pollution-control strategies. Through indigenous technologies developed and transferred to Indian manufacturers, CSIR-NPL is strengthening India's ability to monitor particulate pollution and support cleaner air.

Air pollution is often visible. A hazy skyline, smoke rising from vehicles, or dust hanging over a busy road can immediately signal poor air quality. But individual particles, the most harmful pollutants are completely invisible to the human eye. These tiny airborne particles known as particulate matter, or PM. These particles are so small that thousands of them could fit on the head of a pin. Yet they play a central role in determining the quality of the air we breathe and the health risks associated with it. Because of their importance, particulate matter has become one of the most closely monitored environmental indicators across the world.

Why Size Matters

Not all particles are equally dangerous. Scientists classify particulate matter according to its aerodynamic diameter. Two of the most important categories are PM₁₀ and PM_{2.5}. PM₁₀ refers to particles

with diameters of 10 micrometres or less, while PM_{2.5} consists of particles measuring 2.5 micrometres or less.

To appreciate how small these particles are, consider a human hair. The average human hair is about 70 micrometres of diameter. A PM_{2.5} particle is roughly thirty times smaller. Such particles can remain suspended in the atmosphere for long periods and travel deep into the respiratory system when inhaled. Some may even enter the bloodstream. If these particles carry toxic substances, they can contribute to respiratory illnesses, cardiovascular diseases, and other serious health problems. This is why air-quality standards across the world, including India's National Ambient Air Quality Standards (NAAQS), place special emphasis on monitoring PM_{2.5} and PM₁₀ levels.

The Challenge of Measuring the Invisible

Knowing that these particles exist is one thing. Measuring them accurately is another. Unlike sand or gravel, airborne particles cannot simply be separated using sieves. Their extremely small size demands specialized scientific instruments capable of sorting particles according to their aerodynamic behaviour.

This challenge has driven decades of research in aerosol science and environmental metrology. At CSIR-National Physical Laboratory (CSIR-NPL), New Delhi, scientists have established a state-of-the-art aerosol wind tunnel and chamber facility dedicated to developing, testing, and calibrating particulate matter measurement technologies. The facility supports Indian industries by providing services ranging from filter and mask testing to air-purifier evaluation and calibration of air-quality monitoring instruments.



State-of-the-art aerosol wind tunnel facility at Aerosol and Gas Metrology Section of Environmental Sciences and Biomedical Metrology Division, CSIR-NPL.



PM_{2.5} Technology transfer and MoU signing between CSIR-NPL, New Delhi, and M/s Engineering & Environmental Solutions Pvt. Ltd., Aligarh

Separating Particles with Science

One of the most widely used methods for classifying airborne particles relies on a simple principle: inertia. Larger particles tend to resist changes in motion more than smaller ones. Scientists exploit this behaviour using devices known as impactors and cyclones. An impactor works somewhat like a sharp bend in a road. As air changes direction, larger particles continue moving straight due to their inertia and collide with a collection surface, while smaller particles remain in the airflow and pass through. By carefully controlling airflow speed and geometry, scientists can selectively separate particles of specific sizes.

Cyclones use a different approach. Air is forced into a swirling motion, generating centrifugal forces that separate particles according to their aerodynamic characteristics. Although the principles sound simple, designing these systems to achieve precise size separation requires lengthy computations, sophisticated engineering and extensive testing.

Building Indigenous Solutions

Recognizing the need for reliable and affordable air-quality monitoring technologies, CSIR-NPL has developed several indigenous particulate matter sampling systems and transferred them to Indian manufacturers.

These technologies include PM₁, PM_{2.5}, PM₁₀, and bioaerosol sampling systems that support air-

quality monitoring across a range of applications. Such developments align with national initiatives such as Make in India and Atmanirbhar Bharat, reducing dependence on imported technologies while strengthening domestic manufacturing capabilities.

A New Generation of PM_{2.5} Monitoring

Among the recent achievements is the development of an indigenous High-Volume PM_{2.5} Impactor Sampler.

The system is designed to efficiently separate particles larger than 2.5 micrometres and collect finer particles on a large filter operating at a high flow rate. This allows scientists to gather sufficient material not only for routine monitoring but also for advanced chemical analysis and source-apportionment studies that help identify where pollution is coming from. Chemical analysis is also a key task for their health impact assessment.

Importantly, the technology can also be retrofitted onto existing Total Suspended Particulate Matter (TSPM) samplers, providing a practical and cost-effective pathway for expanding monitoring capabilities across India. The technology has now been transferred to an Indian MSME, further demonstrating the successful transition from laboratory innovation to industrial deployment.

Why Better Measurement Matters

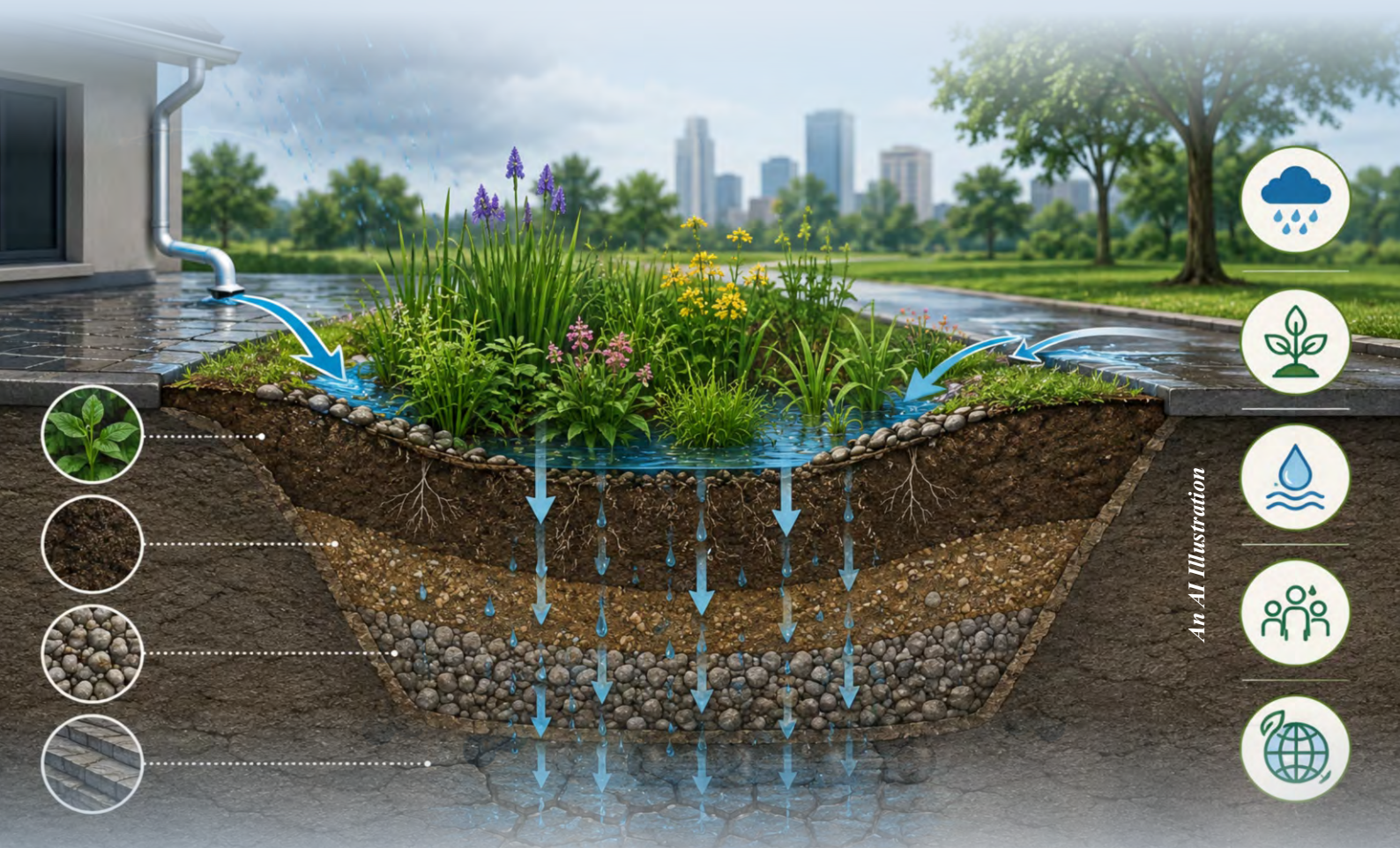
Air pollution cannot be managed effectively unless it is measured accurately. Every Air Quality Index reported to the public, every pollution-control strategy developed by policymakers, and every scientific study investigating health impacts ultimately depends on reliable measurements. By developing indigenous technologies and transferring them to Indian manufacturers, CSIR-NPL is helping build the scientific infrastructure needed to understand and address one of the country's most pressing environmental challenges.

Breathing Easier Through Better Science

Most of us rarely think about the air between one breath and the next. Yet hidden within that air are particles that influence public health, environmental quality, and quality of life. The ability to detect, measure, and understand those particles may seem like a technical challenge. In reality, it is much more than that. It is one of the essential foundations of cleaner air, better public health, and informed environmental decision-making. Sometimes, the first step toward solving a problem is simply learning how to measure it.

The Garden That Refills the Ground: How Rainwater Is Recharging Cities

Every monsoon, cities struggle with a paradox—streets flood during heavy rain, yet groundwater levels continue to decline. Scientists at CSIR-NGRI have developed an innovative rain garden system that turns stormwater into a resource, helping recharge aquifers, reduce flooding, and build climate-resilient cities.



Few urban problems seem as contradictory as this one. A city experiences flooded roads after a heavy downpour. Water rushes through drains, spills onto streets, and disappears within hours. Yet a few months later, the same city may face water shortages and declining groundwater levels.

How can there be both too much water and too little water at the same time? The answer lies in what happens to rain after it falls. In many cities, rainwater lands on rooftops, roads, parking lots, and paved surfaces. Instead of soaking into the ground, it is quickly channelled into drains and carried away. The result is a double challenge: increased urban flooding and reduced groundwater recharge.

Scientists of CSIR–National Geophysical Research Institute (CSIR-NGRI) have been searching for ways to address both problems together. One promising answer comes in the form of something surprisingly simple—a rain garden.

A Garden Designed for Rain

Unlike an ordinary garden, a rain garden is specifically designed to capture and absorb rainwater runoff. It is a shallow, vegetated depression that collects water flowing from surrounding areas such as rooftops, pavements, roads, and parking lots. Instead of allowing stormwater to rush into drains, the rain garden slows it down, temporarily stores it, filters it, and gradually allows it to seep into the ground. In effect, a rain garden acts like a natural sponge.

Water enters the garden through channels or drainage pathways, collects briefly in the shallow basin, and then begins a slower journey downward. Along the way, soil, plants, and microorganisms help remove sediments and pollutants.

Eventually, the water reaches deeper soil layers and aquifers, becoming part of the groundwater system.

Global Success Stories in Urban Water Management

Rain gardens are not entirely new to the world. Over the past two decades, cities across the globe have adopted them as part of sustainable urban water management strategies. Some of the most celebrated examples include Seattle's pioneering SEA Streets



are becoming less common.

Today, many cities experience short-duration, high-intensity rainfall events—sometimes resembling cloudbursts. Huge volumes of water arrive within a short period, overwhelming drainage systems and leaving little time for infiltration. Much of the water simply flows away.

Rain gardens are designed to respond to this challenge. By capturing runoff where it falls and allowing rapid infiltration, they help convert what would otherwise be a flooding hazard into a groundwater resource.

A Living Laboratory in Hyderabad

One of India's most significant demonstrations of rain-garden technology is located at the campus of CSIR-NGRI in Hyderabad. The initiative began in 2007 as an experiment in stormwater harvesting and groundwater recharge. The original system included nine recharge ponds, a rain garden, and natural stormwater collection pathways. The results were encouraging. The facility harvested about 200 cubic metres of water during each rainfall event and contributed to a groundwater rise of approximately 1.5 metres. Encouraged by these outcomes, scientists recently upgraded the facility to handle larger runoff volumes associated with increasingly intense rainfall events.

project and Portland's Green Streets programme in the United States, as well as Singapore's internationally acclaimed ABC Waters Programme and Bishan–Ang Mo Kio Park. These projects have demonstrated how thoughtfully designed landscapes can reduce urban flooding, improve water quality, and replenish groundwater. While rain gardens are still relatively new in India, growing concerns over urban flooding, groundwater depletion, and climate resilience are driving interest in their wider adoption.

Rain Gardens and Rainwater Harvesting

Rain gardens are often confused with conventional rainwater harvesting systems, but the two serve different purposes. Traditional rainwater harvesting primarily focuses on collecting and storing rainwater from rooftops in tanks or directing it into recharge wells for later use. A rain garden, on the other hand, is a landscaped infiltration system that captures stormwater runoff from a wider area, temporarily stores it, naturally filters pollutants through soil and vegetation, and gradually allows the water to percolate into the ground. In essence, rainwater harvesting collects water, while rain gardens manage, clean, and recharge water within the urban landscape itself.

Nature and Engineering Working Together

The plants are carefully selected for their deep roots, drought tolerance, and ability to support infiltration.

Beneath the surface lies an engineered mixture of sand, soil, organic matter, and gravel designed to maximise water absorption while preventing clogging. Special inlet and outlet structures regulate water flow during both normal rainfall and extreme storms.

Together, these components perform several jobs at once. They reduce flooding, improve water quality, support biodiversity, and replenish groundwater reserves. What appears to be a landscaped feature is actually a carefully designed water-management system.

The Challenge of a Changing Climate

Traditional groundwater recharge methods, such as soak pits, were developed for rainfall patterns that



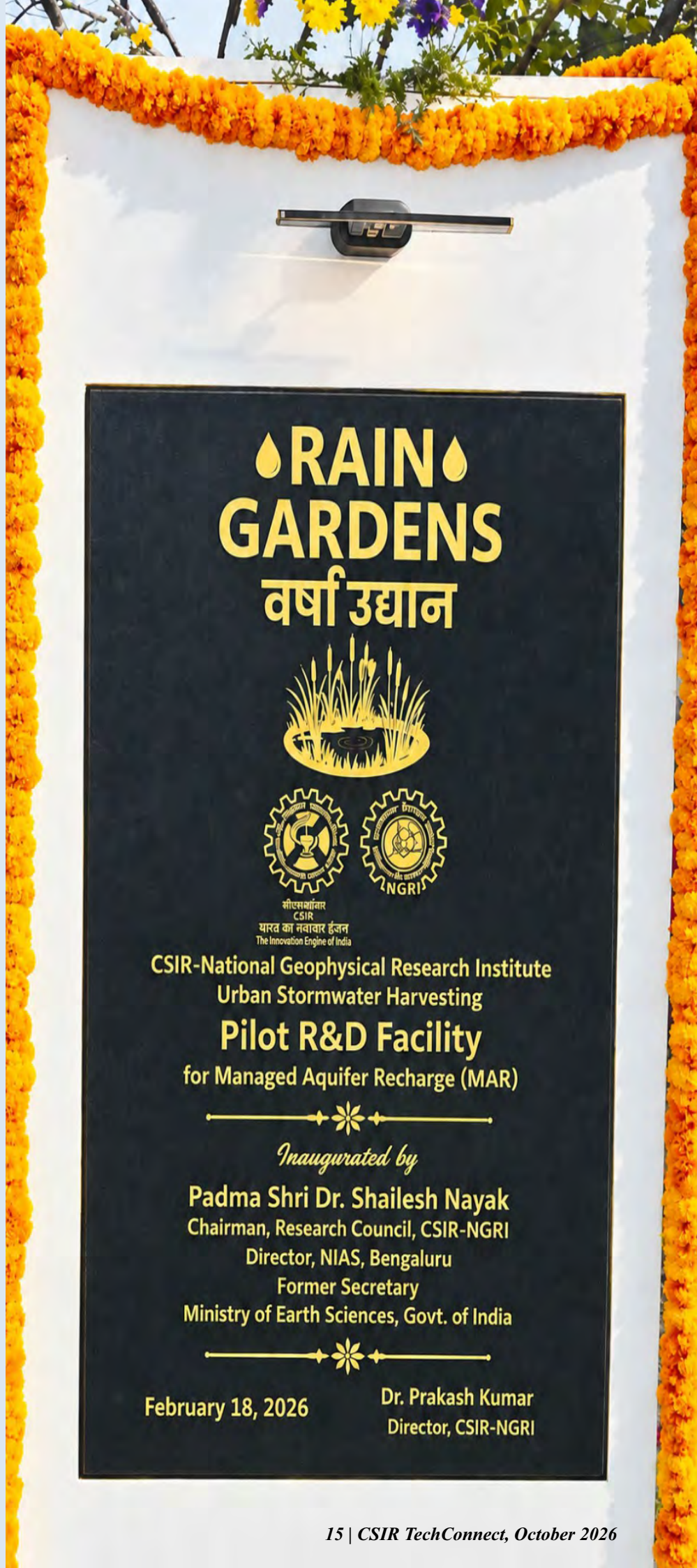
Making Rain Gardens Smarter

The upgraded Rain Gardens Pilot R&D Facility, inaugurated in February 2026, incorporates several scientific improvements. These include a redesigned hydraulic layout, optimised engineered soil media, strengthened inlet and outlet systems, and the integration of geological, hydrogeological, and geophysical information.

This last feature is particularly noteworthy. Rather than simply allowing water to infiltrate randomly, scientists use subsurface data to identify fractured rock zones and preferential recharge pathways. This helps direct infiltrated water more effectively toward groundwater storage zones. The results have been significant. Monitoring shows an average groundwater rise of about 2.3 metres, while the recharged water now supports approximately 46,000 litres per day for horticultural and landscaping needs on the campus.

A Blueprint for Smart Cities

The success of this pilot facility provides a scalable blueprint for the rest of urban India. As groundwater levels plummet and concrete surfaces expand, these low-maintenance, nature-based systems can easily be integrated into school campuses, public parks, residential colonies, and even major infrastructure projects like the new airport watersheds. By replacing flood-prone concrete with smart, absorbing landscapes, cities can defend themselves against flash floods while securing their own future water supply. The rain garden proves that the best way to manage the power of nature is to work alongside it.



BIRSA 101: India's Own Gene-Editing Cure for Sickle Cell Disease

A CSIR-IGIB breakthrough turns the promise of CRISPR into an affordable reality for India's tribal communities

In the tribal heartlands of Madhya Pradesh, Chhattisgarh, Odisha, and Jharkhand, a single misspelled letter in the human genetic code has quietly devastated generations. Sickle cell disease (SCD) bends red blood cells into rigid, crescent shapes that clog blood vessels, starve organs of oxygen, and trigger excruciating pain crises. In some tribal communities, as many as one in three or four people carry the faulty gene. Until now, the only cure available anywhere in the world was a bone marrow transplant — costly, hard to access, and dependent on finding a matching donor — or imported gene therapies priced at a staggering ₹20–25 crore per patient. For India's tribal families, both options were effectively out of reach.

That gap is now closing. Scientists at the CSIR-Institute of Genomics and Integrative Biology (CSIR-IGIB), New Delhi, are developing BIRSA 101, India's first

indigenously created CRISPR gene-editing therapy for sickle cell disease. Named in honour of the tribal freedom fighter Birsa Munda on his 150th birth anniversary, the therapy is not going to be a scientific milestone — it is a statement of intent: that India can build, and afford, its own genomic medicines.

Editing the Disease Out

Sickle cell disease is caused by a single error in the gene that codes for haemoglobin, the protein that carries oxygen in red blood cells. BIRSA 101 takes a “precise genetic surgery” approach. Blood-forming stem cells are first collected from the patient. Using a CRISPR-based molecular tool, scientists then edit these cells outside the body to correct the disease-causing defect. The corrected stem cells are infused back into the patient, where they take up residence in the bone marrow and begin producing healthy, round red blood cells instead of sickle-shaped ones.

Because the patient's own cells are used and corrected at the source, the approach offers the possibility of a one-time, lasting treatment rather than a lifelong regimen of pain management.

What makes BIRSA 101 distinctive is the molecular “scissors” at its heart. Most CRISPR therapies developed globally rely on a bacterial protein called Cas9 derived from *Streptococcus pyogenes*. The CSIR-IGIB team, led by Dr. Souvik Maiti and Dr. Debojyoti Chakraborty, instead engineered a different, naturally compact variant derived from the bacterium *Francisella novicida*, re-engineered in the lab to recognise the human genome efficiently and precisely. This indigenously engineered platform, called enFnCas9, was built from the ground up by Indian scientists, giving India intellectual ownership over a foundational gene-editing tool rather than dependence on licensed foreign technology.



Hon'ble Union Minister of State Dr Jitendra Singh launched India's first indigenous CRISPR based Gene therapy for Sickle Cell Disease (19 Nov. 2025)

From the Lab Bench to the Clinic

The journey from a laboratory concept to a therapy tested in patients took years of painstaking work: validating that the editing tool could find and correct the right spot in the genome with high accuracy, testing it extensively on patient-derived cells, and confirming safety before any human use. Backed by funding from the Department of Science and Technology and catalysed through the Ministry of Tribal Affairs, the programme reached a landmark stage in 2025 with an early-phase clinical trial. Three patients with sickle cell disease received the gene-edited therapy — an important first test of safety and feasibility in real patients, marking one of the first instances of indigenous CRISPR gene-editing technology entering human trials in India.

This achievement positions India among a small group of nations with the demonstrated capability to take a CRISPR therapy from concept to clinic entirely with home-grown science.

A Partnership for Scale

A discovery, however brilliant, only changes lives when it reaches patients at scale. Recognising this, CSIR-IGIB signed a technology transfer and collaboration agreement with the Serum Institute of India Pvt. Ltd. (SIPL), the world's largest vaccine manufacturer by volume, to scale up, manufacture, and deploy BIRSA 101 across the country. This public-private partnership mirrors the model that has made India a global hub for affordable vaccines, and the ambition here is identical: take a sophisticated genomic therapy and make it available at a fraction of global prices, potentially replacing treatments that elsewhere cost crores of rupees.



Union Minister of State for Science and Technology, Dr. Jitendra Singh, who formally unveiled the technology transfer, described the underlying gene-editing process as comparable to “precise genetic surgery”, and noted that the initiative directly supports the national vision of a Sickle Cell-Free India by 2047, alongside the broader push for Atmanirbhar Bharat in advanced healthcare technology.

Why it Matters

Sickle cell disease in India is not a peripheral health issue. It disproportionately strikes scheduled tribes, with the highest known carrier rates in the country, and contributes heavily to childhood illness, school dropouts, and reduced life expectancy in tribal districts. A successful, affordable indigenous cure has the potential to transform outcomes for some of India's most underserved populations — communities for whom imported gene therapies were never a realistic option.

Beyond sickle cell disease itself, BIRSA 101 demonstrates something broader: that the enFnCas9 platform developed at CSIR-IGIB is a versatile genome-editing toolkit — one that could, in time, be redirected toward other inherited blood disorders such as

thalassemia and haemophilia, and potentially a wider range of genetic diseases that have long lacked affordable treatment options anywhere in the world.

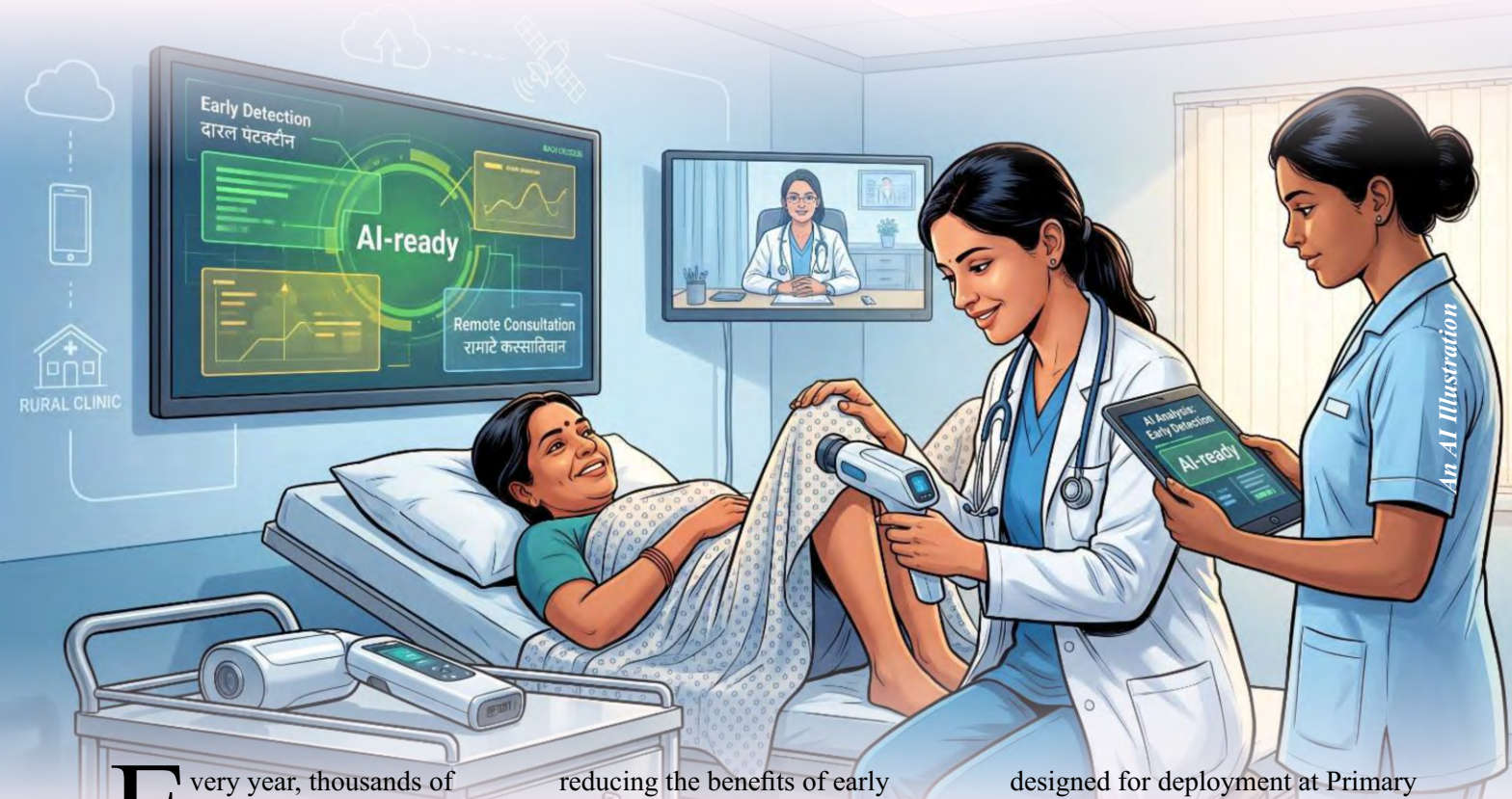
The Road Ahead

BIRSA 101 is still an early-stage of development. Following the initial trial in three patients which is going to begin in late 2027 or early 2028, larger and more extensive clinical studies will be needed to confirm long-term safety and effectiveness before the treatment can be made widely available. The technology transfer to Serum Institute of India is designed precisely to support this next phase — building the manufacturing capability needed to take BIRSA 101 from a handful of patients to thousands, and eventually, to every corner of the country where sickle cell disease takes its toll.

BIRSA 101 is going to be as a powerful proof of concept: that world-class genomic medicine — built entirely in India, for India's own most vulnerable communities — is no longer a distant aspiration but a reality already taking shape in patients' veins.

Spot it Early: How Technology Could Transform Cervical Cancer Screening

Cervical cancer is one of the few cancers that can often be prevented if detected early. Yet many women still miss timely screening because specialist healthcare is not always within reach. Scientists at CSIR-CEERI have developed an indigenous IoT-enabled colposcope that combines digital imaging, remote consultation, and AI-assisted analysis, helping bring early detection closer to communities and improving access to life-saving care.



Every year, thousands of women lose their lives to cervical cancer. The tragedy is that many of these deaths are preventable. Unlike many diseases that appear suddenly, cervical cancer usually develops slowly. Long before cancer forms, subtle changes begin to occur in the cells of the cervix—the lower part of the uterus. These changes can often be detected and treated early, preventing the disease from progressing further. In other words, cervical cancer offers something that many cancers do not: a valuable opportunity for early intervention.

The challenge is getting that opportunity to every woman. For women living in cities, specialized screening facilities may be relatively accessible. But for those in rural and remote regions, obtaining expert medical evaluation often means travelling long distances to larger hospitals. Delays in screening can delay diagnosis,

reducing the benefits of early treatment.

Recognizing this gap, scientists at CSIR—Central Electronics Engineering Research Institute (CSIR-CEERI), Pilani, have developed an indigenous IoT-enabled colposcope designed to support the early detection of pre-cancerous cervical conditions.

A colposcope is a medical device that allows doctors to closely examine the cervix using magnified images. Traditionally, such examinations often require specialist facilities and expertise. The new CSIR-CEERI-developed system aims to make this process more accessible.

From Innovation to Inclusion

Developing an advanced medical device is only part of the solution. Ensuring that it reaches the people who need it most is equally important. The CSIR-CEERI-developed colposcope has been

designed for deployment at Primary Health Centres (PHCs), which serve as the first point of healthcare for millions of Indians. By enabling screening closer to communities, the technology helps bridge the gap between rural healthcare facilities and specialist medical services. This approach shifts an important aspect of healthcare delivery. Instead of expecting patients to travel to specialists, the technology helps bring specialist support closer to patients.

Bringing Specialist Care Closer to Every Woman

One of the key strengths of the system lies in its connectivity. Healthcare professionals at PHCs can capture high-quality cervical images using the colposcope and securely share them with specialists through IoT-enabled remote consultation platforms. Experts located elsewhere can review the images and provide guidance without requiring the patient to travel.

This digital workflow can significantly reduce delays in diagnosis while improving access to specialist care. For many women, especially those living far from major healthcare centres, this could mean receiving timely medical attention without the burden of repeated long-distance travel.

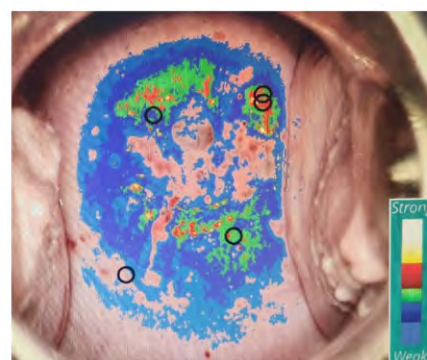
Smarter Technology for Earlier Detection

The device provides 55-times magnification, allowing healthcare professionals to examine cervical tissues in greater detail. Captured images can be stored on smartphones and cloud platforms, enabling easy sharing and long-term record keeping. The system also incorporates AI-ready software that assists clinicians in identifying suspicious abnormalities and prioritizing lesions that may require biopsy. This supports follow-up consultations and helps maintain continuity of care. The portable design also makes the device suitable for routine screening programmes across diverse healthcare settings, including resource-constrained environments.

AI ASSISTED COLPOSCOPE : BIOPSY GUIDANCE



Cervix with detected suspicious tissues of cervical cancer



Digital spectral map with annotated suspicious tissues

Think of it as an additional set of analytical eyes. The software does not make medical decisions on its own. Instead, it helps clinicians focus their attention on areas that may require closer examination, supporting more informed decision-making.

Connecting Primary Healthcare with Specialists

The technology creates a digital bridge between frontline healthcare workers and specialists. Trained healthcare personnel can perform examinations locally, while experts review images remotely and provide recommendations. This collaborative model helps shorten

diagnosis times and extends specialist expertise to areas where it may not otherwise be available. In effect, the system transforms healthcare delivery from a location-based service into a connected network of care.



AI ASSISTED COLPOSCOPE : TECHNOLOGY INNOVATION



AI ASSISTED COLPOSCOPE : PRIME USERS



Dr. Partha Basu, a world-renowned gynecology oncologist currently at "International Agency for Research on Cancer" at Lyon, France



Dr. P.G. Kumar of Sai Niwas Healthcare engaged in early detection & prevention of cervical cancer is a leading gynecology oncologist.



CEERI- Divine colposcope at 'Middle East Obstetrics & Gynecology Conference' in Dubai, UAE was displayed. Dr. Alla is one of the leading users at Dubai.

Creating Healthier Futures

The true value of medical technology lies in the lives it can improve. By combining digital imaging, IoT-enabled connectivity, remote consultation, cloud-based record management, and AI-assisted analysis, the CSIR-CEERI-developed colposcope has the potential to strengthen cervical cancer screening across India. More importantly, it represents a future where early detection is not limited by geography. A future where women can access timely screening, expert evaluation, and preventive care closer to home. Because when it comes to cervical cancer, early detection can make all the difference.

Millets Meet Modern Baking: Developing Healthier Millet-Based Buns for the Food Industry

Millets are often celebrated as "superfoods" for their rich nutritional profile and climate resilience. Yet incorporating these ancient grains into modern bakery products without compromising taste and texture remains a major challenge.

Scientists at CSIR–Central Food Technological Research Institute (CSIR-CFTRI), Mysuru, have successfully developed millet-based buns that combine the health benefits of multiple millets with the softness, appearance, and eating quality consumers expect. The innovation demonstrates how food science can help transform everyday foods into healthier and more sustainable choices.

A burger bun is probably the last place most people would expect to find millets.

For decades, bakery products have relied heavily on refined wheat flour to achieve the softness, volume, and texture consumers enjoy. Millets, despite being rich in dietary fibre, minerals, antioxidants, and bioactive compounds, have rarely found a place in mainstream bakery products because they do not behave like wheat. Their lack of gluten affects dough development, gas retention, loaf volume, and texture, making it difficult to create bakery products that meet consumer expectations.

Recognising both the nutritional potential of millets and the technological challenges involved, scientists at CSIR–Central Food Technological Research Institute (CSIR-CFTRI), Mysuru, collaborated with M/s Hardcastle Restaurants Private Limited, Mumbai, to develop nutritionally superior millet-based buns suitable for commercial production.

From Grain to Bun: A Scientific Journey

The project began with selecting suitable millet varieties and optimizing their processing. Five nutrient-rich millets, finger millet (ragi), sorghum (jowar), pearl millet (bajra), foxtail millet, and proso millet, were chosen to prepare a balanced millet flour blend. Each grain underwent carefully standardized processing involving cleaning, steaming, drying, dehusking, polishing, and milling to preserve its nutritional value while ensuring suitability for bakery applications.

Developing a successful millet bun required much more than simply replacing wheat flour. The research team systematically optimized every stage of the baking process. Both Straight Dough and Sponge-and-Dough methods were investigated to understand their influence on dough characteristics and product quality. Multiple formulations were then developed by varying millet incorporation levels, gluten supplementation, yeast concentration, fermentation time, hydration levels, dough

improvers, and functional additives.

Several Trials Towards Perfection

Creating the ideal millet bun required extensive experimentation. Each formulation underwent rigorous evaluation to determine how processing conditions and ingredient combinations affected product quality. Researchers assessed loaf volume, texture, crumb structure, colour, moisture retention, sensory quality, and shelf-life stability using both instrumental analyses and trained



Launch of Multi Millet Bun developed by CSIR-CFTRI at Mumbai during September 2024



Dr. Sridevi Annapurna Singh, Former Director CSIR-CFTRI and Mr Akshay Jatia, President and CEO, Westlife Foodworld Limited, (the master franchisee for McDonald's in West and South India) exchanging the Project Agreement

sensory panels.

The results revealed a clear trend. While higher millet incorporation enhanced nutritional value, it also increased hardness and reduced loaf volume. After extensive optimization, 22 percent millet flour incorporation emerged as the ideal level, providing an excellent balance between nutrition, texture, appearance, and eating quality.

Another important finding involved fermentation. Reducing fermentation time to 60 minutes produced buns with better volume, softer texture, improved crumb structure, and superior sensory acceptance compared to longer fermentation periods.

Nutrition without Compromise

One of the major achievements of the project was demonstrating that healthier bakery products need not compromise consumer appeal.

The optimized millet buns closely resembled conventional wheat buns



Multi Millet Bun with goodness of 5 millets

in appearance, softness, and flavour while offering enhanced nutritional benefits. Analysis confirmed higher dietary fibre content and improved mineral composition compared to traditional bakery products.

Shelf-life studies further showed that the buns remained microbiologically safe and organoleptically acceptable for up to seven days under ambient storage conditions when packed in polypropylene packaging, making them suitable for commercial production and distribution.

Benchmarking Against Industry Standards

An important component of the project involved comparing the optimized CSIR-CFTRI formulation with the commercial formulation provided by the industry partner.

Although both formulations incorporated 22 percent millet flour, the CSIR-CFTRI bun achieved comparable quality while using lower quantities of sugar, salt, oil, gluten, and processing additives. This resulted in a product with a cleaner ingredient profile and improved nutritional value without significantly affecting consumer acceptance.

The findings demonstrate that healthier bakery products can be developed through scientific optimization rather than simply

adding more ingredients.

Supporting India's Millet Mission

The development aligns closely with India's growing emphasis on millet promotion and nutritional security.

Millets have gained renewed recognition because of their exceptional nutritional value and environmental sustainability. However, increasing millet consumption requires integrating them into foods that people already enjoy and consume regularly.

By successfully incorporating millets into a popular bakery product, CSIR-CFTRI has demonstrated how scientific innovation can encourage healthier eating habits while creating new market opportunities for millet growers and the food industry.

A Successful Industry–Institute Partnership

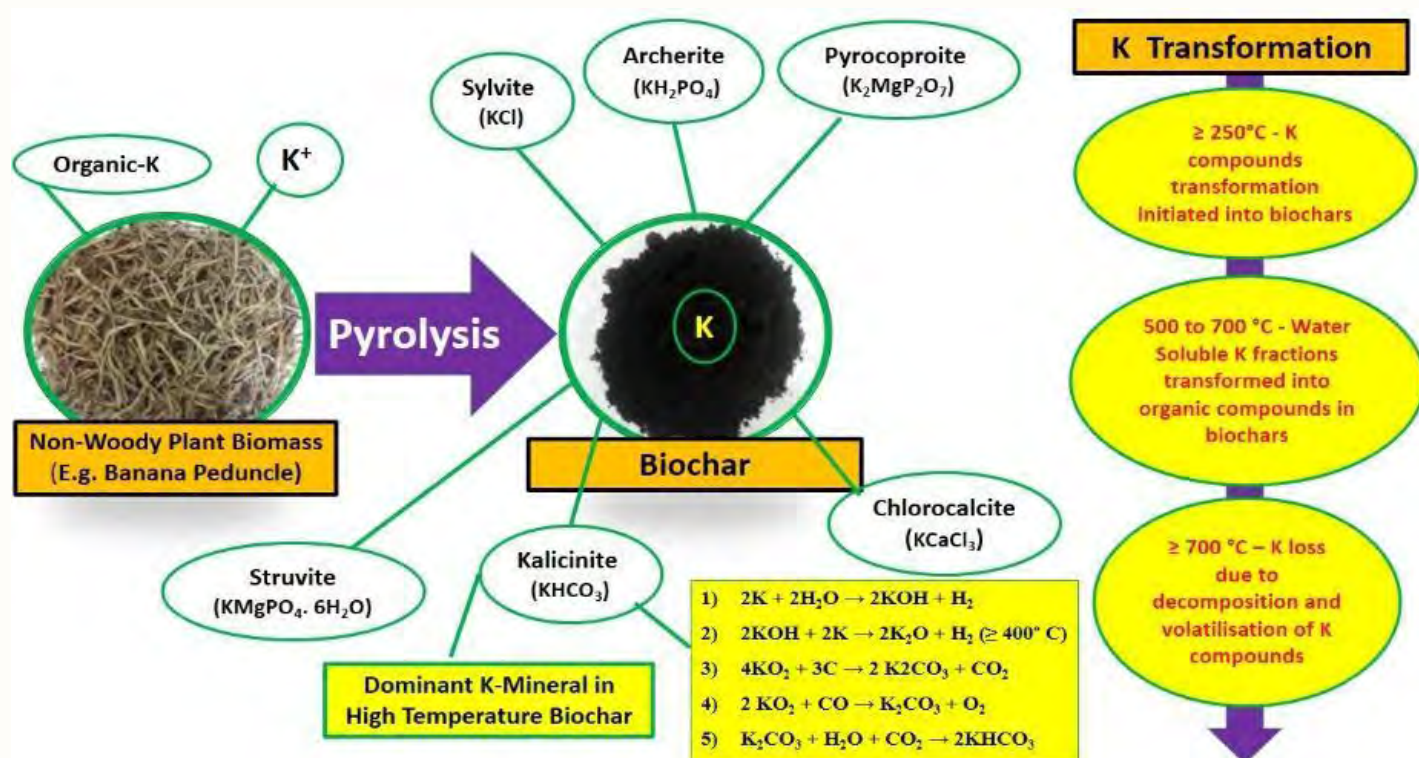
The project stands as an excellent example of collaboration between scientific institutions and industry. By combining CSIR-CFTRI's expertise in food science with the commercial experience of M/s Hardcastle Restaurants Private Limited, the team developed a product that is both technologically robust and commercially relevant. Beyond the bun itself, the project generated valuable knowledge on millet processing, dough optimization, and bakery product development that can support future innovations in functional foods.

Looking Ahead

The successful development of millet-based buns demonstrates how traditional grains can be reimaged for modern consumers. By overcoming long-standing challenges associated with millet incorporation in bakery products, CSIR-CFTRI has shown that nutritious, sustainable, and consumer-friendly foods can coexist. As demand grows for foods that combine health, convenience, and sustainability, innovations such as millet-based buns could help bring millets from farms and kitchens into everyday food choices across the country.

From Banana Waste to Black Gold: The Story of Potash-Enriched Biochar

Every year, millions of tonnes of banana waste are discarded across India, creating disposal challenges and environmental concerns. Scientists at CSIR-Institute of Minerals and Materials Technology (CSIR-IMMT), Bhubaneswar, have transformed one such overlooked waste—the banana peduncle—into a value-added product known as Potash-Enriched Biochar. The innovation supports sustainable agriculture, rural livelihoods, waste valorisation, and carbon sequestration, demonstrating how scientific research can convert an environmental problem into an economic opportunity.



Bananas are among the most widely cultivated fruits in the world, and India is its largest producer.

For generations, almost every part of the banana plant has found a use. Leaves serve as eco-friendly plates, fibres are woven into handicrafts, stems are used for food and fodder, and peels find their way into compost pits. In many parts of India, the banana plant is often called Kalpataru—the wish-fulfilling tree—because of its remarkable versatility.

Yet one part of the plant has largely remained neglected: the banana peduncle, the thick stalk that supports a bunch of bananas. After harvest, millions of tonnes of peduncle waste are discarded in fields and wholesale markets every year. As the waste decomposes, it releases greenhouse gases and contributes to local environmental

problems. What appears to be agricultural waste, however, hides an untapped resource. Scientists at CSIR-Institute of Minerals and Materials Technology (CSIR-IMMT), Bhubaneswar, saw an opportunity where others saw waste.

Looking for Potassium in an Unlikely Place

The journey began with a simple scientific observation. Banana plants are naturally rich in potassium, one of the most important nutrients required for healthy plant growth. Researchers discovered that the banana peduncle contains particularly high concentrations of this valuable nutrient.

This raised an intriguing possibility. Could this discarded biomass be converted into a soil amendment that not only improves soil health

but also returns valuable nutrients back to agriculture? To answer this question, CSIR-IMMT scientists developed a novel process for producing Potash-Enriched Biochar, eventually securing a patent for the technology.

What is Biochar?

Biochar is often described as a form of engineered charcoal. It is produced by heating biomass under controlled conditions in the absence of oxygen, a process known as pyrolysis. Unlike ordinary burning, pyrolysis converts biomass into a stable, carbon-rich material while retaining many of the beneficial mineral nutrients present in the original feedstock.

Biochar has attracted global attention because of its ability to improve soil properties, retain moisture, enhance nutrient availability, and store carbon for

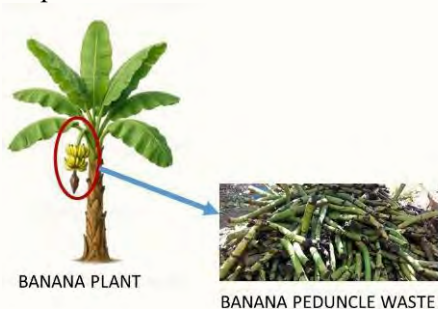


long periods. The challenge was finding a way to enrich biochar with additional agricultural value. The banana peduncle turned out to be an ideal candidate.

Turning Waste into a Soil Resource

At CSIR-IMMT, researchers explored multiple approaches to convert banana peduncle waste into biochar, including plasma pyrolysis, rotary pyrolysis systems, tubular furnaces, and drum kilns.

The resulting product was not ordinary biochar. During thermal processing, the naturally occurring potassium became concentrated within the biochar structure, producing a material containing between 5 and 15 percent potassium depending on the production process. Much of this potassium exists in forms readily available to plants.



BANANA PEDUNCLE WASTE

The final product is porous, alkaline, and rich in stable carbon. Its structure allows it to function simultaneously as a soil conditioner, a liming agent, and a source of potassium nutrition. Field trials demonstrated its potential to improve soil quality, particularly in acidic soils and degraded mining landscapes where fertility restoration is often difficult.

A Solution for Farmers and the Environment

The significance of Potash-Enriched Biochar extends beyond agriculture. When crop residues are left to decompose or are openly burned, carbon stored in the biomass rapidly returns to the atmosphere. Biochar offers a different pathway.

Because of its stable carbon structure, a substantial portion of that carbon can remain locked in the soil for years or even decades. This makes biochar a promising tool for carbon sequestration, contributing to climate-change mitigation efforts and supporting India's commitment to achieving net-zero emissions by 2070.



PYROLYSIS



POTASH ENRICHED BIOCHAR

At the same time, farmers benefit from improved soil health and nutrient availability. It is a rare example of a technology that simultaneously addresses waste management, agricultural productivity, and environmental sustainability.

Creating Livelihoods from Agricultural Waste

Perhaps the most compelling aspect of the technology is its impact beyond the laboratory. Over the past five years, CSIR-IMMT has licensed the technology to six entrepreneurs, startups, and MSMEs. One notable example is Jaydev Banana Farmers and Artisan Association (JBFAA) in Odisha.

Through this initiative, nearly one thousand farmers began earning additional income by supplying banana plant waste that would otherwise have been discarded. Farmers received payments for each plant supplied, while local enterprises generated new business opportunities through the production and sale of Potash-Enriched Biochar. The technology created value at multiple levels: for farmers, entrepreneurs, workers, and end users. What was once considered waste became part of a circular economy.

Scaling a National Opportunity

The success achieved in Odisha represents only a fraction of the technology's potential. India generates an estimated 4.25 million tonnes of banana peduncle waste annually, with major banana-producing states including Andhra Pradesh, Maharashtra, Tamil Nadu, Gujarat, Karnataka, and several northeastern states.

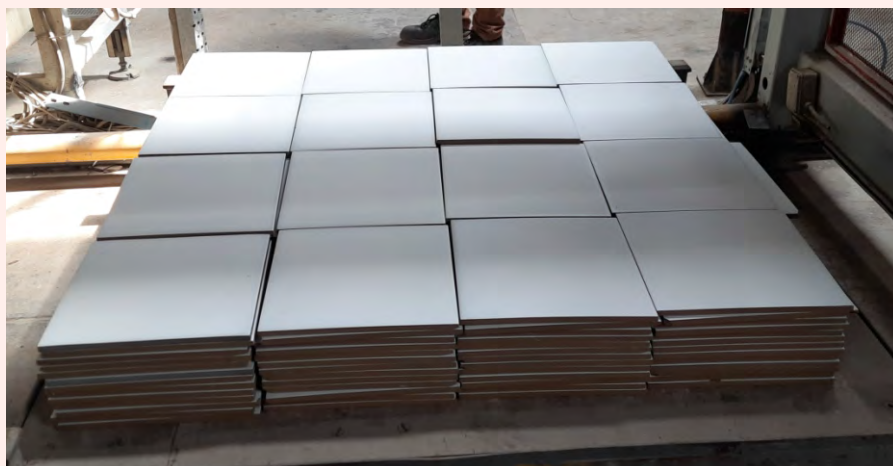
This vast biomass resource remains largely underutilized. Recognizing this opportunity, CSIR-IMMT continues to promote awareness, training, and skill-development programmes focused on biochar production and application. Technology-transfer initiatives and partnerships with industry organizations are helping expand the reach of the innovation beyond its initial deployment areas.

How Red Mud could Make Radiation Safer

Every day, hospitals, research laboratories, and nuclear facilities rely on radiation to diagnose diseases, treat cancer, and support scientific research. But protecting people from harmful radiation often depends on lead—a toxic metal with well-known health risks. Scientists at CSIR-Advanced Materials and Processes Research Institute (CSIR-AMPRI) have developed an innovative technology that transforms industrial waste called red mud into lead-free radiation shielding tiles and bricks, offering a cleaner, safer, and more sustainable alternative.

Radiation has transformed modern medicine. Every time an X-ray helps detect a fractured bone or a cancer patient receives radiotherapy, ionizing radiation is being used to save lives. Today, more than 60 percent of cancer treatments involve radiation therapy. Beyond hospitals, radiation also plays an important role in nuclear power plants, scientific research, defence, and industrial inspection.

But there is another side to this powerful technology. While radiation is invaluable when carefully controlled, excessive exposure can damage living tissues, leading to serious health problems ranging from cataracts and organ damage to genetic disorders and cancer. That is why every hospital X-ray room, radiotherapy bunker, and nuclear facility is surrounded by specially designed shielding materials that prevent radiation from escaping. For decades, lead has been the material of choice for this purpose. It is highly effective at blocking X-rays and gamma rays. Unfortunately, it is also one of the world's most toxic metals.



Production of RST tiles in pilot scale.

Why Look Beyond Lead?

Lead has served radiation shielding for generations, but it comes with significant drawbacks.

Workers handling lead-based shielding can be exposed to lead dust and tiny particles released through wear, corrosion, or mechanical friction. Long-term exposure to lead is known to affect the nervous system, kidneys, and several other organs. Concrete and brick walls are often used as alternatives, but they bring challenges of their own. To stop high-energy radiation, they must be

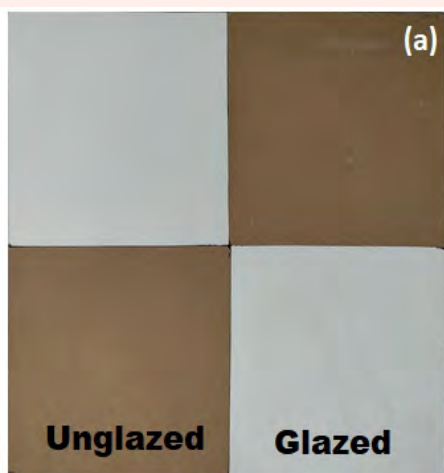
extremely thick, occupying valuable space. Cracks or poorly sealed joints may also become pathways through which radiation can leak.

Scientists have therefore been searching for safer, durable, and economically viable alternatives that offer effective protection without the disadvantages of lead. An unlikely answer emerged from a completely different industry.

A Second Life for Red Mud

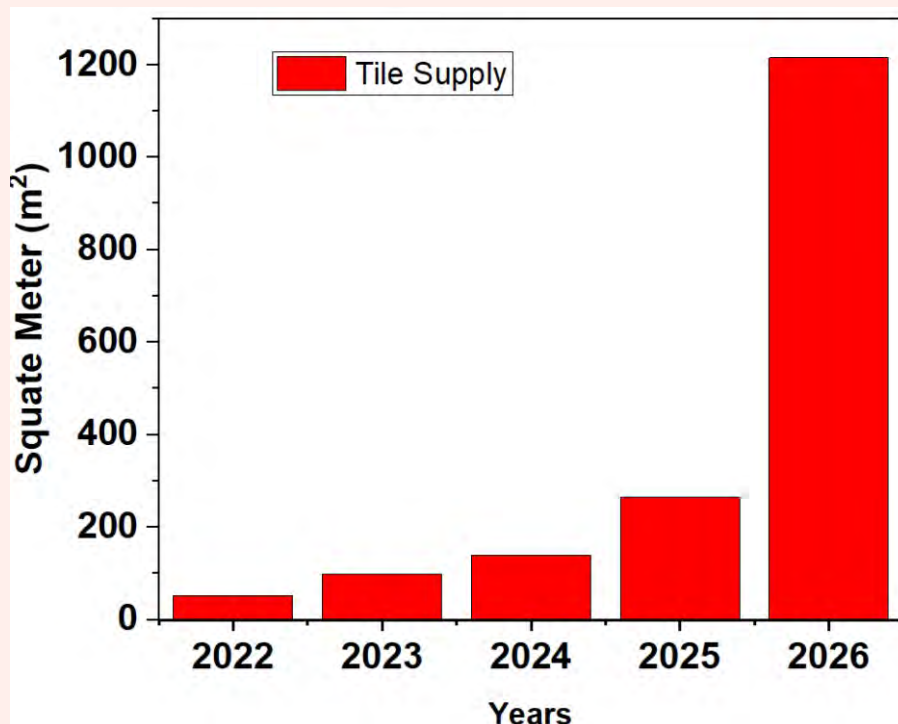
Every year, the aluminium industry generates nearly 170 million tonnes of red mud, a highly alkaline waste left behind during the extraction of alumina from bauxite ore. Despite decades of research, only a small fraction of this material is recycled. Most of it is stored in large disposal ponds, where it occupies enormous areas of land and poses environmental concerns. Heavy metals can gradually leach into soil and water, while dry red mud particles may become airborne, causing irritation to the eyes and skin.

To most people, red mud is simply an industrial waste. To scientists at



Glazed and unglazed X-ray shielding tiles available in the market





Year wise supply of radiation shielding tiles.

CSIR–Advanced Materials and Processes Research Institute (CSIR-AMPRI), Bhopal, it represented an untapped resource. Red mud naturally contains 35–54 percent iron oxide (Fe_2O_3). Because materials with higher density and atomic number are better at absorbing radiation, the researchers explored whether this industrial waste could become an effective radiation shield. The result was a classic example of turning waste into wealth.

From Waste to Radiation Shield

The research team developed a ceramic process that converts red mud into lead-free radiation shielding tiles suitable for X-ray rooms. To improve strength and radiation absorption, the red mud was combined with carefully selected binders and other high-density materials before being processed into ceramic tiles.

The finished tiles are not only mechanically strong but also highly effective at shielding radiation. A tile just 13.5 millimetres thick provides radiation protection comparable to a 2-millimetre lead sheet for diagnostic X-rays up to 140 kV. Unlike conventional brick walls, the tiles are joint-free, reducing the possibility of radiation leakage through gaps. They are durable, require little maintenance,

occupy less space, and eliminate the need for toxic lead sheets.

From Laboratory to Hospitals

Scientific innovation becomes meaningful only when it reaches society. In 2019, CSIR-AMPRI transferred the technology to M/s Prism Johnson Ltd., Mumbai. After overcoming manufacturing challenges such as cracking, glaze peeling, and firing defects, the company successfully commercialised the product in 2022 under the brand name Johnson Endura.

Today, the tiles are being used in more than 20 hospitals across India, including medical facilities operated by the Indian Navy, government hospitals, speciality institutes, and private healthcare providers. Their growing adoption demonstrates that environmentally friendly alternatives can successfully replace conventional materials in critical healthcare infrastructure.

Protecting the Future of Nuclear Energy

The technology does not stop with hospitals. As nuclear energy and advanced cancer treatment facilities expand, the demand for gamma-ray and neutron shielding materials is also increasing.

To address this need, CSIR-AMPRI has developed high-density radiation shielding bricks using hot compaction technology. This process removes microscopic pores that normally form during manufacturing, producing denser blocks capable of providing effective protection against both gamma rays and neutrons. A pilot plant has already been established, and efforts are underway to scale up production for wider applications.

More Than Better Building Materials

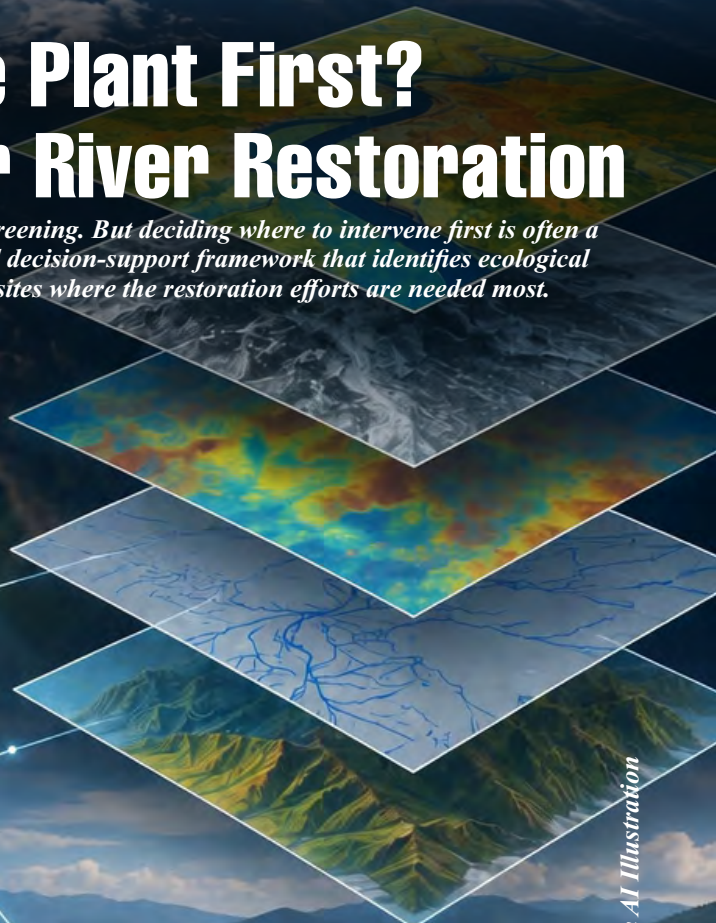
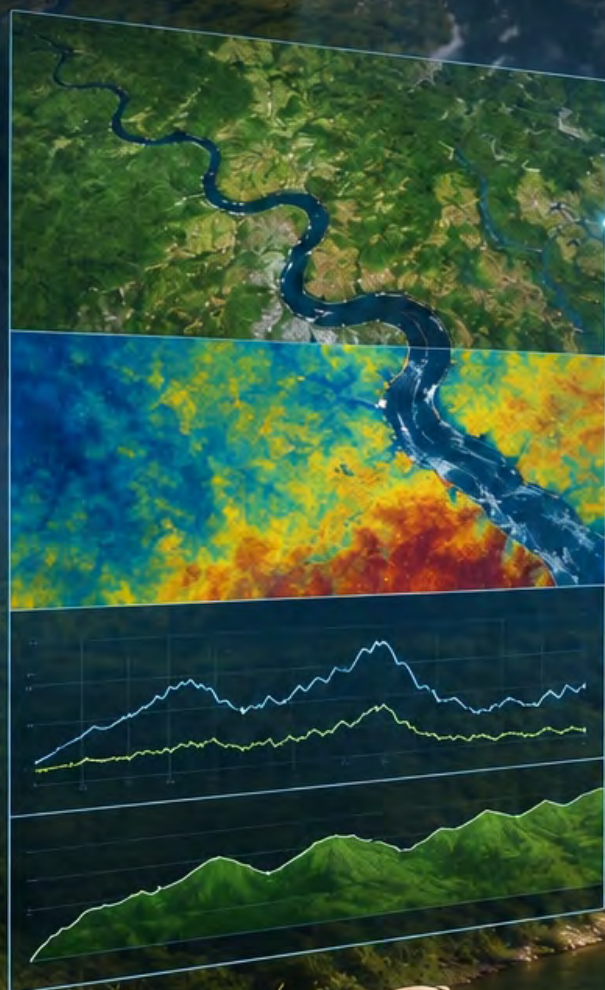
The significance of this innovation extends far beyond radiation shielding. Replacing imported lead-based materials could reduce India's dependence on expensive imports while creating new opportunities for domestic manufacturing. At the same time, large-scale utilisation of red mud offers a practical solution to one of the aluminium industry's biggest waste management challenges. The environmental benefits are equally important. Converting industrial waste into high-value construction materials helps reduce pollution, conserves natural resources, and supports a circular economy where waste becomes a valuable raw material.

The technology also aligns with several United Nations Sustainable Development Goals, including good health, clean water, sustainable industry, and climate action. Perhaps most importantly, it reminds us that some of tomorrow's most valuable technologies may not begin with new raw materials—but with finding new purpose for the waste we already produce.

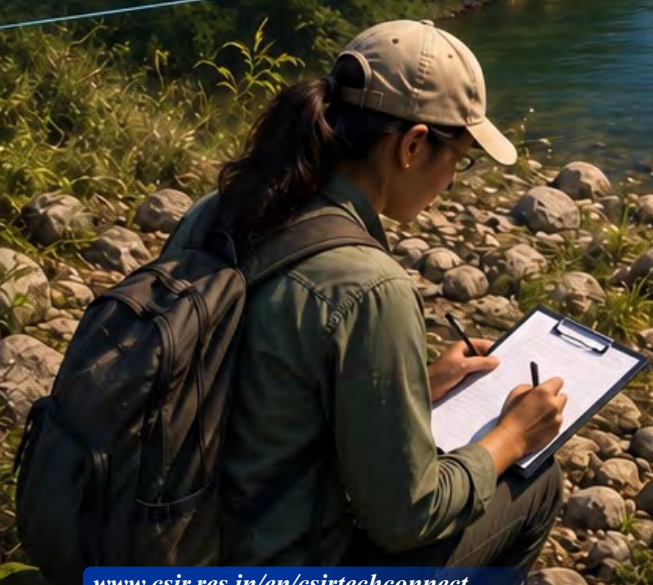


Where Should We Plant First? A New Tool for Smarter River Restoration

Cities across the world are investing in river restoration and urban greening. But deciding where to intervene first is often a challenge. Scientists at CSIR-NBRI have developed a satellite-based decision-support framework that identifies ecological stress hotspots along river corridors, helping planners prioritize sites where the restoration efforts are needed most.



An AI Illustration



No hospital would treat every patient with the same medicine regardless of their condition. A person with a fever, a fractured bone, and a heart problem would each require a different course of treatment. Applying the same solution to all would be inefficient, expensive, and ineffective. Yet this is how ecological restoration is frequently approached.

Cities invest in plantation drives, riverfront beautification projects, and greening initiatives, but often without a clear understanding of which locations need urgent attention and which are already functioning relatively well. Scientists at CSIR–National Botanical Research Institute (CSIR–NBRI), Lucknow, set out to develop a scientific method for identifying which stretches of a river corridor are ecologically healthy and which require urgent restoration. The goal was to create a comprehensive ecological assessment tool that could guide planners in making informed restoration decisions.

Taking the Pulse of a River

Rivers are much more than flowing water. Their banks, floodplains, vegetation, soils, and surrounding landscapes form a complex ecological system that supports biodiversity, regulates temperature, reduces erosion, and improves urban environmental quality.

However, rapid urbanization, expanding infrastructure, land degradation, and the spread of invasive plant species are placing increasing pressure on these ecosystems.

The Gomti River, which flows through Lucknow, offers a clear example of these challenges. While some stretches remain relatively healthy, others show signs of severe ecological stress. The difficulty lies in identifying these stressed areas accurately across large landscapes.

A Satellite-Based Ecological Diagnosis

To solve this problem, CSIR–NBRI scientists developed an Integrated Spatial Decision-Support Framework (ISDSF), a tool that

combines satellite observations, environmental data, and field surveys to assess the ecological condition of river corridors.

Think of it as a comprehensive medical examination for a landscape. The framework evaluates indicators such as vegetation health, soil condition, moisture availability, land-surface temperature, land-use changes, and signs of degradation.

Using freely available satellite data and geospatial information, the researchers generated a detailed picture of ecological conditions along a 500-metre-wide corridor on both sides of the Gomti River.

Creating a Restoration Priority Map

The various environmental indicators were combined into a single measure called the Composite Restoration Index (CRI). The CRI acts much like a report card. Areas receiving low scores are relatively healthy, while areas with high scores indicate ecological stress and a greater need for restoration.

The resulting maps classified the river corridor into five categories ranging from very low to very high restoration priority. The findings were striking. More than 36 percent of the studied river corridor fell within the high or very high restoration priority categories, indicating that over one-third of the landscape requires urgent ecological intervention.

These areas were characterized by sparse vegetation, degraded soils, elevated temperatures, lower moisture levels, and stronger impacts from urban development.

Confirming the View from Space

Satellite images can reveal a great deal, but scientists must always verify what they observe from above. To test the reliability of their findings, the researchers conducted field surveys across 47 locations along the river. The ground observations confirmed the patterns detected by the satellites. Areas identified as highly degraded contained fewer native plant species

and greater dominance of invasive plants such as *Parthenium hysterophorus* (carrot grass) and *Lantana camara* (common lantana). Native biodiversity declined significantly in these stressed zones, reinforcing the accuracy of the restoration-priority maps.

The study also revealed another important insight. Locations with richer native vegetation and denser tree cover were noticeably cooler than degraded areas, demonstrating how healthy riparian ecosystems can help reduce urban heat stress.

Why this Matters for Cities

Urban greening is often viewed as a simple exercise in planting more trees. In reality, effective restoration requires strategic planning. Resources are limited. Budgets are finite. The question is not whether restoration should happen, but where it should happen first.

The new framework provides planners, municipal authorities, riverfront development agencies, and conservation practitioners with a scientific basis for making those decisions. Instead of planting trees uniformly across an entire riverfront, they can identify ecological hotspots where interventions are likely to deliver the greatest environmental benefits.

A Tool Beyond the Gomti

Although the framework was developed and tested along the Gomti River, its significance extends far beyond Lucknow.

One of its greatest strengths is that it relies largely on freely available satellite datasets and open-source geospatial tools. This makes the approach affordable, scalable, and adaptable for cities across India.

Whether applied to the Yamuna, Mithi, Musi, Sabarmati, or other urban rivers, the framework can help guide restoration efforts using objective scientific evidence rather than visual assessment alone.

The Machine that Keeps Workers Out of Sewers

Every day, cities generate thousands of tonnes of wastewater that must travel through drains and sewers before disappearing from sight. Keeping this hidden infrastructure functioning is essential, but cleaning it has often come at a heavy human cost. Scientists at CSIR-CMERI have developed an indigenous mechanized drain cleaning system that can clean, inspect, and maintain sewers without requiring workers to enter hazardous spaces, offering a safer and more sustainable future for urban sanitation.

Most urban residents notice a drain only when it stops working. A blocked sewer quickly announces itself through overflowing manholes, flooded roads, foul smells, and disrupted daily life. Yet few people think about the workers responsible for restoring these systems. For decades, cleaning drains and sewers has remained one of the most hazardous sanitation jobs, exposing workers to toxic gases, infectious waste, and dangerous working conditions.

Despite laws prohibiting manual scavenging, the reality is that many sewer maintenance activities still depend on human intervention in difficult and risky environments. What if the job could be done without sending people into sewers at all?

That question led scientists at CSIR–Central Mechanical Engineering Research Institute (CSIR-CMERI), Durgapur, to develop an indigenous vehicle-mounted mechanized drain cleaning system that combines multiple cleaning and inspection functions into a single platform. The goal was not merely to build another machine. It was to redesign sewer maintenance around safety, efficiency, and dignity.

A Machine Designed for a Difficult Job

Cleaning a clogged sewer is more complicated than it appears. Waste



accumulates in different forms. Some blockages consist of sludge and sediment. Others involve plastic waste, grease deposits, or debris that become trapped inside pipelines. Damaged sewer lines may further complicate the situation. Traditionally, multiple tools and considerable manual effort are required to tackle these challenges. The CSIR-CMERI system brings together several operations in a single machine. It combines high-pressure jetting, suction, grabbing, filtration, and inspection technologies on a vehicle-mounted platform.

High-pressure water jets loosen accumulated waste. The suction system removes the dislodged material. Grabbing mechanisms help extract larger debris. Inspection systems verify the results after cleaning. Together, these functions allow comprehensive sewer maintenance without requiring workers to enter confined spaces.

The Water-Saving Innovation

One feature makes the system particularly distinctive. Conventional sewer jetting operations consume large quantities

of fresh water. Once used, the water is typically discarded along with the waste it carries. The CSIR-CMERI machine takes a different approach.

An onboard slurry water filtration system cleans the wastewater collected during operations and recycles it for subsequent jetting. In effect, the machine reuses its own cleaning water. This innovation significantly reduces freshwater consumption while allowing cleaning operations to continue for longer periods without interruption. In water-stressed urban environments, such savings can make a meaningful difference.

Built for Indian Cities

Engineering solutions are successful only when they work under real-world conditions. The drain cleaning system was designed specifically for Indian municipal requirements. All components are compactly integrated onto a BS-VI-compliant vehicle chassis, allowing easy mobility through urban environments. An automated hose reel guiding mechanism simplifies operation and reduces manual handling. An integrated disinfectant unit improves hygiene during cleaning activities. Pneumatically





More Than an Engineering Achievement

At first glance, the machine appears to be a sanitation technology. In reality, it addresses a much larger challenge. For cities, it improves sewer maintenance and operational efficiency. For municipal bodies, it reduces maintenance costs and downtime. For the environment, it conserves water through recycling. Most importantly, for sanitation workers, it removes the need to perform one of the most dangerous jobs in urban infrastructure management.

The true measure of technological progress is not only what machines can do, but what people no longer have to do. By combining indigenous engineering, environmental sustainability, and worker safety, the CSIR-CMERI-developed mechanized drain cleaning system demonstrates how technology can help build cleaner cities while protecting the people who keep them running.

operated systems enhance safety while making the machine easier to use. The machine also incorporates an operator feedback system, providing information that helps personnel perform cleaning operations efficiently and safely. These features ensure that advanced technology remains practical for everyday municipal use.

Looking Beneath the Surface

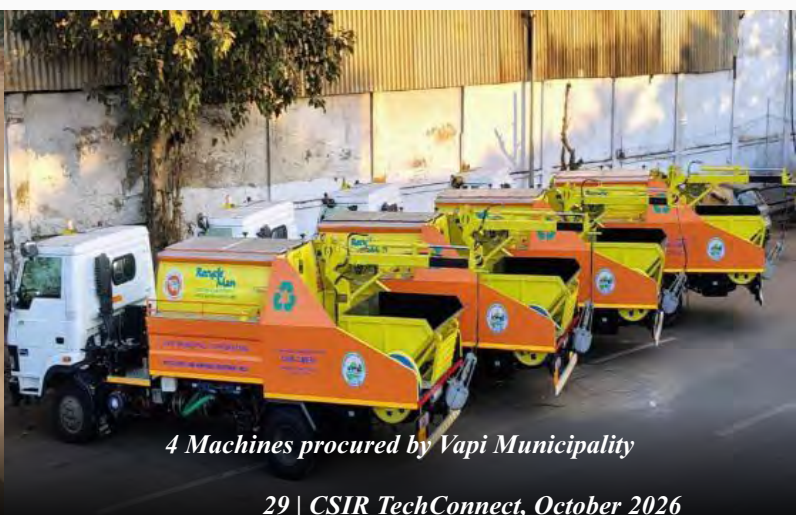
Cleaning a sewer is only half the challenge. Confirming that it has been cleaned properly is equally important. For this purpose, the machine includes an underwater camera-based inspection system. After cleaning is completed, operators can visually inspect drains and sewer pipelines without physically entering them. The camera helps identify remaining blockages, structural damage, or maintenance requirements that may otherwise go unnoticed. This capability transforms the machine from a cleaning tool into a complete sewer management system.

From Laboratory Innovation to Field Deployment

The technology has already moved beyond research laboratories. Following successful technology transfer, industry partners have developed commercial products based on the CSIR-CMERI innovation. These include Recycle Man, developed by M/s Maniar & Co., Ahmedabad, and Kamjet RGI, developed by M/s KamAvida Enviro Engineers Pvt. Ltd., Pune. The systems have been demonstrated in several municipalities, including Ahmedabad, Rajkot, Gandhinagar, Bengaluru, Coimbatore, Jaipur, and Chandigarh. Municipal authorities and sanitation workers have reported positive experiences, particularly regarding safety, ease of operation, and reduced dependence on manual intervention. The technology has also attracted attention from the Swachh Bharat Mission, urban development agencies, and municipal bodies seeking safer alternatives for sewer maintenance.



6 Machines procured by Vadodara Municipality



4 Machines procured by Vapi Municipality

Clearer Skies Ahead: How India Built its Own Smart Airport Weather System

Every safe flight depends on accurate, real-time weather information. For decades, India relied entirely on imported airport weather systems. Scientists at CSIR-NAL changed that by developing an indigenous Automated Weather Observing System (AWOS), now operating at major airports and ready for wider deployment. The technology strengthens aviation safety, reduces import dependence, and demonstrates how home-grown innovation can support India's expanding aviation sector.



Every time a plane takes off or lands, it relies on a hidden shield of technology. Weather dictates everything in aviation. Sudden crosswinds, heavy downpours, thick fog, or shifting air pressure can turn a routine flight into a high-risk situation. Because of this, global aviation bodies such as the International Civil Aviation Organisation (ICAO) mandate that airports monitor local weather in real time. For decades, India had a major vulnerability: every single one of its automated airport weather systems was imported.

Relying entirely on foreign technology drained the country's financial reserves. Worse, it trapped local airports in frustrating loops of software licensing issues, expensive spare part shipments, and long-term maintenance delays. To solve this, the scientists at CSIR-National Aerospace Laboratories (CSIR-NAL) in Bengaluru stepped up. They spent a decade designing, testing, and perfecting India's very own Automated Weather Observing System (AWOS).

Smart Weather Intelligence for Harsh Climates

Designing a weather system for airports sounds simple, but the

engineering behind it is incredibly complex. India is home to some of the most diverse and punishing climates on Earth. A reliable system must withstand the scorching heatwaves of central India, the heavy dust storms of the northern plains, the corrosive salt air of coastal regions, and the relentless downpours of the monsoon season.

The CSIR-NAL AWOS meets these challenges through a brilliant three-step architecture:

- **The Sensors:** High-precision, rugged instruments placed along the runway to measure wind speed, temperature, pressure, humidity, visibility, and rain.
- **The Brains:** High-reliability microprocessors that instantly clean, filter, and calculate the raw data right at the edge of the field.
- **The Network:** Secure, multi-layered, redundant communication lines that ensure the data flows safely from the runway to the control tower without a single second of interruption.

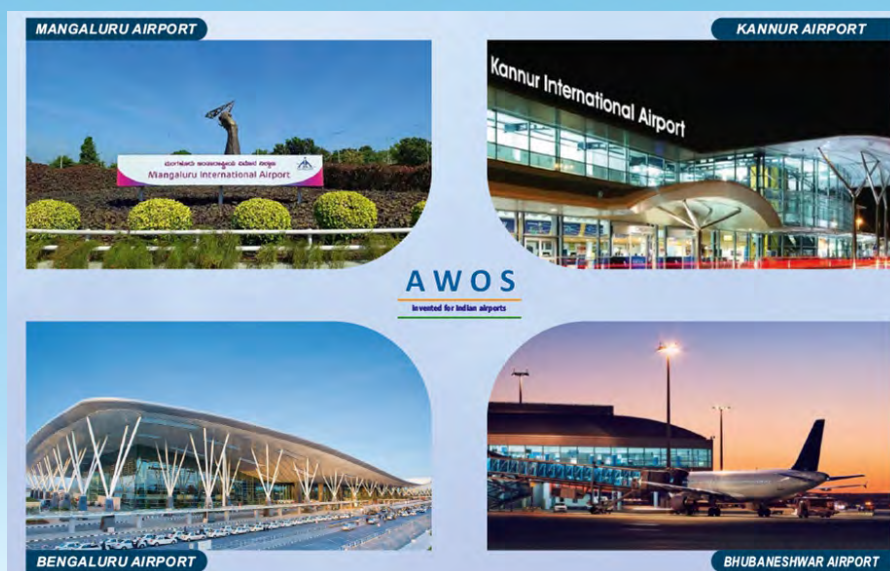
Once the data reaches the terminal, the AWOS software instantly translates raw numbers into

international aviation weather reports. Air traffic controllers and pilots use live visual dashboards to make split-second decisions that keep passengers safe. Because the system is built with a modular "plug-and-play" design, airports can easily upgrade or expand it as they grow.

From the Lab to the Runway: The Success Story

AWOS is no longer just a laboratory experiment; it is a proven commercial success story. Five fully certified units are currently operating 24/7 at four major international airports: Bengaluru, Bhubaneswar, Kannur, and Mangaluru. Years of flawless real-world operations have proved that this Indian innovation is technically superior to and much more cost-effective than foreign brands.

This operational success paved the way for a massive milestone in India's technology sector. On 14 May 2026, CSIR-NAL officially signed a Technology Transfer license with M/s Central Electronics Limited (CEL). This partnership hands over the blueprints to a trusted domestic



manufacturer capable of mass-producing the system at a commercial scale. This transition ensures that local inventions directly fuel national infrastructure, serving as a perfect example of self-reliance.

Why This Matters to Industry Leaders and Policymakers

The alliance between CSIR-NAL and CEL opens up an incredible domestic market. India currently has over 140 active commercial civilian airports, alongside dozens of military airbases, looking to modernise. AWOS offers these facilities complete immunity from foreign supply chain disruptions and significantly slashes equipment costs.

Furthermore, this affordable technology is the ideal engine for regional connectivity initiatives such as the government's UDAN scheme. UDAN aims to make flying accessible to the common citizen by connecting smaller towns and rural areas. However, building remote airstrips safely requires low-cost, high-reliability weather monitoring. AWOS fills this gap perfectly.

Beyond aviation, the modular nature of AWOS opens up lucrative avenues in other industries:

- **Offshore Energy:** Keeping workers safe by tracking violent storms on offshore oil and gas rigs.
- **Maritime Shipping:** Helping deep-water sea ports optimise cargo handling based on wind and wave conditions.
- **Smart Highways:** Creating national highway weather grids to alert drivers about dangerous patches of sudden fog or heavy rain.

A Lasting Impact on Everyday Society

At a macro level, AWOS acts as an economic multiplier for the entire country. Lowering the setup and maintenance costs for airport operators helps reduce the financial barriers to running regional flights. Over time, these savings can lead to more affordable ticket prices for regular travellers. This connects remote communities in the North-Eastern and Himalayan regions to major economic hubs, boosting tourism, commerce, and emergency medical access. Local manufacturing also creates highly

skilled jobs for young Indian engineers in electronics, software, and precision manufacturing.

The core technology behind AWOS also directly improves public safety and daily life. Municipalities can use these precise microclimate sensors to track urban heat islands and build smarter, cooler cities. Regional disaster management teams can plug this data into early warning networks to predict flash floods, cyclone paths, and severe lightning strikes with much greater accuracy, saving thousands of lives. Finally, streaming these hyper-local weather insights to digital farming platforms helps millions of rural farmers predict climate risks, protect their crops, and secure their livelihoods.

From protecting passengers in the sky to helping farmers on the ground, AWOS is a testament to what Indian science can achieve.

Blueprint for Next-Generation Aviation Meteorology: Introducing NaviMet

Building on the real-world success of AWOS, CSIR-NAL has developed NaviMet, a comprehensive, next-generation aviation weather monitoring platform. As India's aviation sector grows at a record pace, demand for more accurate weather predictions is higher than ever. To meet this need, NaviMet integrates cutting-edge innovations like intelligent edge-computing sensors, decentralised cloud data tracking, and artificial intelligence (AI) to help pilots and air traffic controllers make better decisions.

The journey from AWOS to NaviMet establishes a continuous pipeline of local innovation. It proves that India can independently design, scale, and maintain world-class, mission-critical technology. By strengthening both military airbases and civilian airports, this next-gen system secures the nation's airspace and guarantees safer skies for everyone.



What Colour will the World Wear in 2028?

Long before a new colour appears in shop windows, it has already been discussed, analysed, and selected by experts studying global trends. Scientists and designers look beyond fashion shows to understand society, technology, sustainability, and consumer behaviour. Through its association with the internationally recognised MODEUROP and Fashion Trend Pool, CSIR-CLRI helps bring this global fashion intelligence to Indian industry, enabling manufacturers to prepare for markets well before trends arrive.



An AI Illustration

Imagine walking into a shoe store in 2028 and finding shades of moss green, deep burgundy, metallic bronze or misty lavender everywhere.

Now imagine that those colours were predicted three seasons ahead i.e., one and half years earlier.

That is the science - and business - of fashion forecasting.

While most people think fashion begins with designers, the process actually starts much earlier. Global experts analyse social trends, culture, technology, sustainability, consumer behaviour and economics to anticipate what people are likely to buy years in advance. These forecasts help manufacturers decide what colours, materials and products to develop long before they reach the market.

India plays an important role in this global exercise through CSIR-Central Leather Research Institute (CSIR-CLRI), Chennai.

Recently, CSIR-CLRI released the MODEUROP and Fashion Trend Pool Colour Cards for the Autumn-Winter 2027/28 season - an internationally recognised forecast that guides the footwear, leather goods and accessories industries worldwide.

Predicting Fashion is Serious Business

Fashion forecasting is often compared to weather forecasting. Just as meteorologists analyse atmospheric data to predict tomorrow's weather, fashion experts study global developments to forecast tomorrow's consumer preferences.

Will buyers favour earthy natural tones or bold digital colours? Will handcrafted aesthetics return? Will sustainability influence materials and finishes?

These are not guesses. They influence billions of dollars of manufacturing and retail decisions worldwide. A footwear company designing products today needs to know what consumers are likely to prefer when those products finally reach stores two years later.

CSIR-CLRI: India's Gateway to Global Fashion Intelligence

MODEUROP and Fashion Trend Pool develops the global colour forecasts—but someone has to ensure they reach industry in different countries in a form that businesses can use.

Think of it this way: the World Health Organization (WHO) develops international health guidelines, but national agencies such as India's Ministry of Health or ICMR disseminate, interpret and help implement them within the country. Fashion forecasting works in much the same way.

CSIR-CLRI serves as India's bridge to the MODEUROP and Fashion Trend Pool network, enabling the Indian leather industry to

participate in global colour and trend forecasting. It guides industry stakeholders in developing and presenting colour proposals, while bringing the latest MODEUROP and Fashion Trend Pool Colour Cards to India and organising their release. By engaging manufacturers and designers and facilitating access to global trend intelligence, CLRI helps Indian businesses develop products aligned with future international markets.

Whether it is a footwear manufacturer in Agra, a leather exporter in Chennai, a handbag producer in Kolkata or a fashion start-up in Bengaluru, CSIR-CLRI helps businesses stay ahead of evolving consumer preferences and strengthen their competitiveness in global markets.

More Than Just Colours

The MODEUROP and Fashion Trend Pool Colour Cards are far more than a palette of attractive shades. Each colour is selected through extensive international collaboration and becomes a precise reference standard for designers, dye houses, leather processors and manufacturers across the supply chain.

Complementing the colour cards - a curated collection of mood boards, textures, materials, finishes and lifestyle themes that translate emerging social and cultural trends into practical product ideas. Together, they provide industry with a roadmap for future collections.

Where Science Meets Style

Fashion today depends as much on science as it does on creativity. Consumers increasingly expect

products that are durable, sustainable and environmentally responsible. Delivering these expectations requires advances in materials, manufacturing processes, testing methods and colour technologies.

This is another area where CSIR-CLRI has made internationally recognised contributions. The institute has long been a leader in leather science, footwear engineering, sustainable processing technologies, product testing, design innovation and advanced materials. Its scientific expertise enables Indian industry not only to anticipate future trends but also to develop products that meet global standards of quality, performance and sustainability.

Why it Matters

Fashion forecasting influences much more than clothing. It shapes footwear, handbags, furniture upholstery, automotive interiors, home décor, packaging and numerous lifestyle products.

When a particular colour or design suddenly appears across multiple products, it is rarely a coincidence. It is often the result of coordinated global forecasting carried out years earlier.

India's leather and footwear sectors support millions of livelihoods and contribute significantly to exports. Access to reliable global trend intelligence is therefore a strategic advantage.

By serving as India's gateway to global fashion intelligence, CSIR-CLRI equips Indian manufacturers, exporters and designers with the insights needed to anticipate international trends, develop globally competitive products and strengthen India's position in the world's leather and fashion industries.

The next time a new colour seems to appear everywhere, remember—it was probably envisioned years ago. And thanks to institutions like CSIR-CLRI, Indian industry is prepared well before the trend reaches the marketplace.



**MODEUROP and Fashion Trend Pool Colour Cards for the season
Autumn Winter 27/28**

Immune System's 'Troublemakers': A Hidden Driver of Chronic Inflammation

Inflammation protects the body from infection, but when it fails to switch off, it can become a cause of disease. Scientists at CSIR-CDRI have identified a unique subset of neutrophils that remains overactive and drives chronic inflammation. The discovery opens new possibilities for precision immunotherapies that target harmful immune cells while preserving the body's natural defence against infections.

Consider an army continuing to fire beyond the point of winning the battle. Rather than safeguarding the city, the incessant bombardment starts damaging the same streets and buildings they were intended to protect. A similar situation occurs within our bodies during uncontrolled inflammation. Just as an unchecked fire can cause damage, uncontrolled inflammation can harm healthy tissues in the body. Prolonged inflammation is recognized as one of the main causes behind rheumatoid arthritis, psoriasis, lupus, inflammatory bowel disease, non-alcoholic steatohepatitis, and severe viral infections like COVID-19.

Inflammation is one of the most potent defensive mechanisms. As

soon as there is any infection caused by microbes or any injury to the tissue, the immune system acts swiftly to destroy the pathogen and start repairing. One such response mechanism is provided by neutrophils; the most common kind of white blood cell found in blood. These cells rapidly reach the site of infection, eliminate the foreign invaders and remove the damaged tissues and then quietly disappear from there once they complete their task. However, it is interesting to know what happens in inflammatory disorders? Chronic inflammation may arise through several mechanisms, including overactivation of immune cells, failure to clear activated cells, or the expansion of inflammatory subpopulations that fail to switch off once the threat has passed.

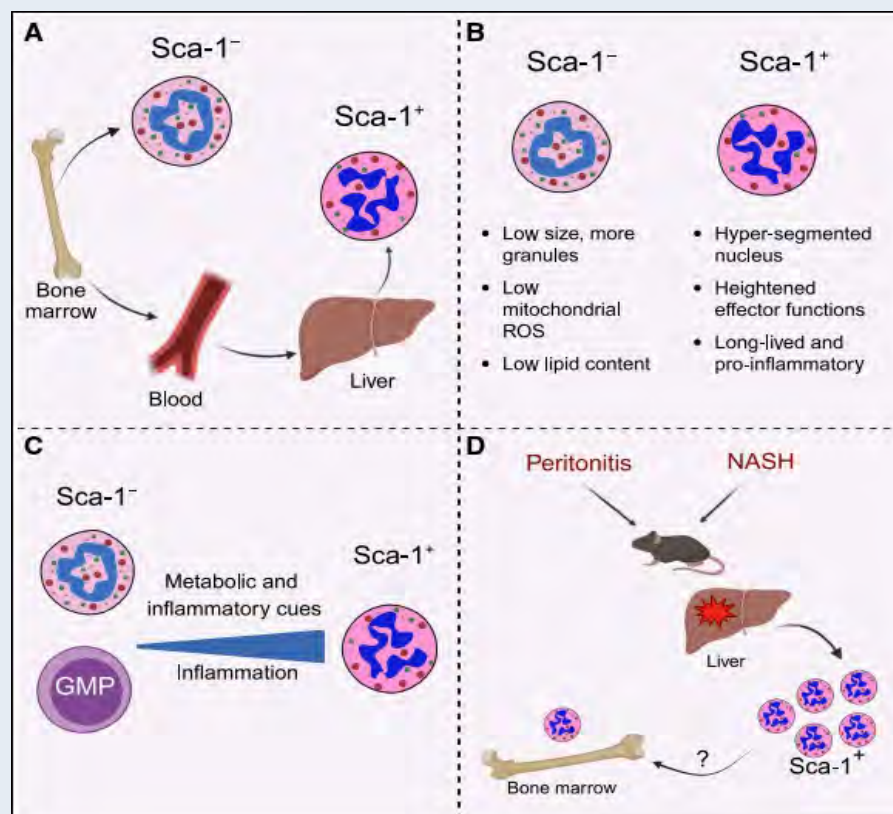
Seeking answers to these questions, scientists at the CSIR-Central Drug Research Institute (CSIR-CDRI), Lucknow, and their team have discovered a novel subset of neutrophils which remains active far beyond their supposed duration, thus causing inflammation instead of curbing it.

The Frontline Soldiers of the Body

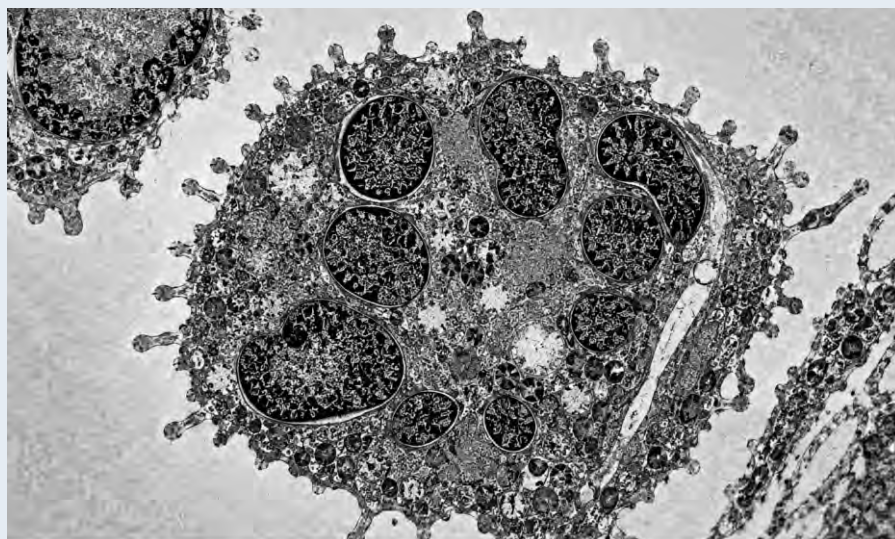
Human blood contains three main types of cells, i.e., red blood cells, white blood cells, and platelets. While red blood cells are responsible to transport oxygen, platelets for coagulation, and white blood cells help to fight any invading pathogen. Among these defenders, neutrophils are the most common. They make up nearly two-thirds of all white blood cells. These cells act very quickly. Within minutes of sensing an infection, they move towards the site of the injury, engulf dangerous pathogens, release antimicrobial chemicals, and call other immune cells to strengthen the attack. These cells are normally designed for short service, usually lasting for just a few hours or days before natural cell death so that no harm comes to the normal tissue from their activity.

Not All Neutrophils are the Same

When neutrophils remain active for a longer period, the body's protective response may become harmful. According to Dr. Kumar and team, a certain group of neutrophils is quite unique in terms of its nature when compared to the overall neutrophil population. Such neutrophils have a long-life span, remain highly active, and trigger a much stronger inflammatory response than normal neutrophils. The aforementioned neutrophils can be defined by Sca-1 protein and therefore called Sca-1^{pos} neutrophils. Most importantly, Sca-



The characteristics of Sca-1^{pos} neutrophils and relevance to inflammatory conditions. For more detail follow-
<https://www.sciencedirect.com/science/article/pii/S2211124725007661?via%3Dihub>



The troublemaker pro-inflammatory Sca-1^{pos} neutrophils with hyper-segmented nucleus and accumulation of lipid droplets.

1pos neutrophils are detected abundantly in the liver, and their accumulation is seen during acute and chronic inflammation, specifically in cases of experimental peritonitis and non-alcoholic steatohepatitis (NASH).

When Protectors Turn into Destroyers

To study these strange cells, the researchers used highly sophisticated methods, such as high-resolution microscopy, flow cytometry, and molecular analyses. It revealed that Sca-1pos neutrophils have all the tools that regular neutrophils have. They generate reactive oxygen species that destroy the microbes, release destructive enzymes, and form the web-like structures called neutrophil extracellular traps (NETs) that trap the invaders. What makes these cells different from regular ones is that they never turn off. Since they live longer and stay active, they keep producing the inflammatory substances even after the primary threat has been passed. This leads to excessive destruction of tissues and may contribute to chronic inflammatory conditions. The researchers also found that regular neutrophils can become these dangerous inflammatory cells when they are under continuous inflammation or metabolic stress.

Link Between Fat Metabolism and Inflammation

One of the most intriguing findings was that Sca-1pos neutrophils have higher levels of lipids than usual neutrophils. This is a unique

association of fat metabolism and immunity. Non-Alcoholic Steato-Hepatitis (NASH) is one of the diseases affected by both metabolism and inflammation. The existence of lipid-loaded Sca-1pos neutrophils provides an explanation of why there is chronic inflammation in these diseases. This is proof of the current understanding of the link between metabolism and immunity.

Silencing of the “Troublemakers”

One of the most encouraging parts of this study is that silencing of the Sca-1 protein resulted in a significant decrease in tissue injury and inflammatory reactions in animal models. This suggests that the Sca-1 protein does not only serve as an identifier of these cells but also plays an active role in making them behave in a harmful manner. Thus, by blocking this particular subset of neutrophils, it is possible to reduce unwanted inflammation without interfering with the beneficial effects of the immune system as a whole. In contrast to numerous current anti-inflammatory treatments, which generally inhibit immunity and create better conditions for infections, selective targeting of harmful neutrophil subpopulations may result in a safer and more beneficial treatment.

Future perspective

Though Sca-1 is exclusive to mice, human neutrophils express several associated proteins, including CD177 and Ly6E, that are being linked with infections and

inflammatory diseases. In future research, it would be interesting to look perspective to target these troublemaker neutrophil subsets in humans for therapeutic purposes. The identification of Sca-1pos neutrophils introduces a new aspect in the comprehension of immune regulation. Rather than viewing neutrophils as one uniform category, the research shows that there are specialized subgroups with different functions in disease processes. While the search for similar neutrophil subsets in humans is still ongoing, this research can lead to designing new types of targeted therapies for chronic inflammatory and autoimmune diseases that will suppress inflammation without compromising critical properties of the immune system.

A step forward in precision immunotherapy

The discovery of Sca-1pos neutrophils reveals that not all neutrophils behave the same way. While most help fight infections and then disappear, some remain active and continue to drive harmful inflammation. Although Sca-1 is found only in mice, related proteins in human neutrophils are already linked to inflammatory diseases, opening new avenues for future research.

Importantly, selectively targeting these "troublemaker" neutrophils could reduce chronic inflammation without weakening the body's normal immune defence. Such precision therapies may one day offer safer and more effective treatment options for chronic inflammatory and autoimmune diseases.

When Every Minute Matters: Giving Indian Drones the Power to Fly Longer

"A new indigenous hydrogen fuel cell technology developed by CSIR-Central Electrochemical Research Institute (CSIR-CECRI) is enabling unmanned aerial vehicles to remain airborne more than twice as long as conventional battery-powered drones, opening new possibilities for strategic surveillance, disaster response and precision agriculture while advancing India's Green Hydrogen Mission."



An AI Illustration

Picture a drone searching a flooded village for stranded families. Just as rescue teams identify survivors, the drone flashes a low-battery warning and heads back to base. Or imagine a drone monitoring hundreds of kilometres of India's border. After barely half an hour in the sky, it must land to replace its batteries, creating an unavoidable interruption in surveillance. For today's unmanned aerial vehicles (UAVs), endurance is often the biggest obstacle—not navigation, not artificial intelligence, and not sensors.

Scientists at CSIR-Central Electrochemical Research Institute (CSIR-CECRI), Chennai Unit, are addressing this challenge with an indigenous Open Cathode Proton Exchange Membrane (PEM) Fuel Cell technology that could redefine the future of long-endurance drones. Developed in collaboration

with Magic Myna Pvt. Ltd. and CSIR-National Chemical Laboratory (CSIR-NCL) under the National Green Hydrogen Mission (Research and Development Scheme) 2023 program funded by Ministry of New and Renewable Energy (MNRE) (Project Reference Number: MNRE/T/2024/2629), the technology combines advanced electrochemistry with lightweight fuel cell stack engineering to create a clean and efficient power source for next-generation UAVs.

Why Batteries can Take Drones Only So Far

Lithium-ion batteries store only a finite amount of energy. Increasing battery capacity inevitably increases weight, forcing the motors to consume more power. Eventually, engineers reach a point where adding more batteries produces very little improvement in flight time. For heavy-duty multirotor

UAVs, this typically limits endurance to around 25 minutes, regardless of continuous improvements in battery technology.

The question before scientists was simple: Could electricity be generated continuously during flight instead of storing it entirely inside a battery?

The Science of Flying on Hydrogen

The answer lies inside a hydrogen fuel cell powered drone. Unlike a battery, which stores electrical energy, a hydrogen fuel cell continuously produces electricity through an electrochemical reaction. Hydrogen stored inside a lightweight high-pressure cylinder reacts with oxygen from the surrounding air to generate electrical power. The only products of this reaction are electricity, heat

How a Hydrogen Fuel Cell Drone Works



and pure water. This clean conversion of chemical energy into electricity makes hydrogen one of the most promising energy carriers for future aviation.

A Simpler Fuel Cell for the Sky

Conventional fuel cell systems are heavy and complex as they often require compressors, humidifiers and liquid cooling systems to operate efficiently and hence not suited for Drones. To tackle this issue, CSIR-CECRI has adopted an compact and light weight Open Cathode System approach where ambient air works as reactant and coolant and makes it ideal for UAV applications.

More Than Double the Endurance

Hydrogen's greatest advantage is its exceptional energy density. While lithium-ion batteries typically deliver around 200–300 Wh/kg, hydrogen fuel cell systems can provide an effective energy density of 800–1000 Wh/kg. This difference fundamentally changes

how long a drone can remain airborne. For the hydrogen-powered hexacopter being developed under the project, flight endurance is expected to double from battery-powered platform to fuel cell powered system. By intelligently combining the fuel cell with a compact battery (additional power during take-off and rapid manoeuvres), the endurance can increase further increase by 20%.

Engineering Every Gram

Achieving long-endurance flight requires far more than replacing batteries with hydrogen. Every component of the fuel cell system must become lighter, smaller and more efficient. Researchers at CSIR-CECRI are developing indigenous Open Cathode Fuel Cell engines using advanced materials and innovative engineering. Computational Fluid Dynamics (CFD) is being used to optimize airflow distribution so that every cell receives adequate oxygen and cooling, even during demanding flight conditions. The membrane

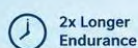
electrode assembly is being redesigned to improve oxygen transport, water management and catalyst utilization under the low-humidity operating conditions encountered in open cathode systems. Lightweight bipolar plates, ultra-thin current collectors and advanced composite end plates are being developed to significantly reduce stack weight while maintaining mechanical strength. At the same time, an intelligent Fuel Cell Control Unit continuously monitors hydrogen flow, temperature, voltage, pressure and power demand, ensuring safe, reliable and efficient operation throughout every mission.

Building India's Hydrogen Aviation Ecosystem

The project is about much more than developing a drone. It represents an important step towards building indigenous expertise in hydrogen fuel cells, lightweight stack engineering, advanced membranes, fuel cell control systems and UAV integration. The technology also complements the objectives of the National Green Hydrogen Mission, supporting India's vision of becoming a global leader in clean hydrogen technologies while reducing dependence on imported high-end fuel cell systems. By integrating innovations in electrochemistry, materials science, mechanical engineering and aerospace technology, CSIR-CECRI and its partners are laying the foundation for a new generation of sustainable aerial platforms.

Flying Longer. Flying Cleaner.

CSIR-CECRI's Hydrogen Fuel Cell Technology
Powers India's Next-Generation Drones



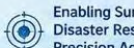
2x Longer
Endurance



Zero
Emissions



Indigenous
Technology



Enabling Surveillance,
Disaster Response &
Precision Agriculture



Understanding Resistance in Pathogens, through Wastewater Surveillance

Antimicrobial resistance is one of the world's fastest-growing health threats. A nationwide wastewater surveillance strategy developed by CSIR-CCMB scientists could help detect resistant pathogens early, enabling better clinical decisions and stronger public health interventions.

Who doesn't know of medicines like azithromycin and streptomycin? These are some of the commonly used antibiotics. Though they come under Scheduled-H drugs and are supposed to be sold with prescriptions, they find a way into most of our first aid boxes through over-the-counter sale for self-medication. Though through wrong measures, they reached our households because they are miracle drugs.

Though many of us think of them similar to paracetamol, they are very different kinds of drugs. Paracetamol rids us of disease symptoms. But antibiotics cure us from bacterial infections by killing the bacteria itself. Some puncture the bacterial cell wall, some stop the bacterial DNA replication or protein making machinery. But slowly and steadily with antibiotics' misuse, abuse and improper disposal, their efficacy reduced against infections. This situation in medical terms is called antibiotic resistance. And, this is a part of an overall problem called Antimicrobial Resistance (AMR).

How Bacteria Learn to Fight Back

AMR happened in bacteria because they evolved to resist the action of antibiotics. There are specific doses prescribed that annihilate a bacterial population. But when bacteria experience sub-par amounts of antibiotics, some of the stronger ones remain. Their genes differ from the sensitive ones. These can make tougher cell-walls around them such that antibiotics don't enter their cell. Some have proteins that don't allow antibiotics affecting their cells. Some even throw out antibiotics from their cells or destroy the antibiotics around them. Not only that, they can share these



Saving data from a PCR machine

AMR genes to other neighbouring bacteria.

This is a worrisome situation for medical practitioners and patients. Millions suffer and die globally due to AMR. And, a country like India with a heavy infectious disease burden is at the hot seat of the problem. When faced with AMR cases, doctors have to decide on a different antibiotic cocktail and/or dosage. The sooner they figure out an infection is AMR, better are the prospects for a patient. Longer infections are more painful as well as more expensive for the patient.

The Challenge of Detecting Antibiotic Resistance

Currently, doctors have to culture infection samples to know if it is AMR and which antibiotics work against it. This not only is time-consuming and takes days to reach a conclusion, it is also limited to hospitals that have the human resources and infrastructure to do these kinds of testing. Given that AMR infections are now known in every part of the country; it has become a public health crisis. And,

a crisis of that scale requires a mass-deployable solution.

Looking for Answers in Wastewater

One way of tracking AMR is also through surveilling wastewater from communities. We release microbes from our bodies through bodily fluids, which find their way into the community's wastewater. They can be identified by looking for their DNA.

Scientists from CSIR-Centre for Cellular and Molecular Biology (CSIR-CCMB) led a multi-institutional project that allowed them to identify prevalent bacterial pathogens from wastewater samples collected from various cities across India including Delhi, Hyderabad, Bengaluru, Pune, Shillong, Mumbai, Chennai and Kolkata. DNA data analyses from these samples helped in finding the prevalent bacterial pathogens contributing to AMR as well as their associated antimicrobial genes (ARGs). This discovery has now led them to devise a strategy to check AMR pathogens and associated ARGs across the country.

Building a Nationwide AMR Surveillance Network

The strategy is simple on paper – periodically collect wastewater from different parts of the country and check for the commonly found AMR pathogens and ARGs through a test called Polymerase Chain Reaction (PCR) as well as through genome sequencing. But in reality, PCR machines and genome sequencers, and human resources who can operate these are still found only in limited places in the country. A countrywide deployment of these tests also needs to be cost-effective.

The wider scientific community have resolved these problems. The National Centre for Disease Control have a network of public health workers who are equipped with collecting periodic samples. Initially designed for polio virus surveillance, they along with the Indian Council of Medical Research are now willing to participate in surveillance of pathogens of public health concern including AMR pathogens. Scientists have figured out protocols to store water samples at 4 oC for up to 2 days, within which the samples have to be transported from the point of collection to testing. Startups in Hyderabad and Bengaluru have designed indigenous and affordable PCR testing kits that make the project economically viable.

Turning Data into Better Healthcare

A countrywide deployment of this technology should lead to a database that tells the doctors which AMR genes are prevalent in their localities and which antibiotics have the best chances of working against such bacterial infections. It should also help the public health workers stop the misuse of those antibiotics against which a high number of AMR genes are found.

A silver lining in the AMR crisis is that it is a reversible problem. If antibiotics use is reduced through better regulations, the AMR genes also reduce in the environment. That is the future we need where the antibiotics are kept reserved for doctors treating bacterial infections. Not for us to hoard them in our first aid boxes.



Wastewater collection at a site



Preparing samples for PCR testing



How AI is Helping Farmers Spot Crop Diseases Earlier

A healthy paddy field can hide the first signs of disease remarkably well. By the time symptoms become visible, farmers may already be facing lower yields and higher pesticide costs. Scientists under CSIR's agricultural mission have developed an AI-powered decision support system that combines drones, smartphones, and machine learning to detect paddy diseases at an early stage, helping farmers take timely action and move towards more sustainable agriculture.

A healthy paddy field can hide the first signs of disease remarkably well. To the human eye, every patch of green may look the same. But long before a disease spreads across the field, subtle changes begin to appear on the leaves—changes that artificial intelligence can detect much earlier than conventional field inspections. For farmers, this early warning can make the difference between controlling a disease and losing a significant part of the harvest.

Paddy cultivation in India faces growing challenges from changing weather, emerging pests and diseases, rising input costs, and the need to produce more food with fewer resources. Among these, crop diseases remain one of the biggest threats. Once visible symptoms appear across a field, valuable time has often been lost, forcing farmers to use larger quantities of pesticides while still suffering reduced yields.

Recognising this challenge, CSIR-National Institute of Data Science and AI (CSIR-NIDSA), has developed an AI-based decision support system that detects paddy crop diseases at an early stage using aerial images captured by drones

and photographs taken with mobile phones.

Teaching AI to Recognise Diseased Crops

Artificial Intelligence learns much like a student—it improves by studying thousands of examples. To train the system, scientists created a pan-India geo-referenced image database of paddy fields using both UAV (drone)-based multispectral images and mobile phone RGB images collected from diverse agro-climatic regions across the country. Each image was carefully labelled using field observations recorded through a mobile-based disease scoring application.

This labelled dataset forms the foundation of the AI system. By analysing thousands of healthy and diseased crop images, deep learning algorithms learn to recognise disease patterns that are often too subtle for the human eye to detect during the early stages of infection. The strength of the technology lies in combining real field observations with computational intelligence, ensuring that the AI is trained on actual farming conditions rather than laboratory data alone.

Watching Fields from the Sky

Traditional crop monitoring depends largely on farmers or agricultural experts physically inspecting fields, a process that can be both time-consuming and labour-intensive. Satellite images, while useful, often lack the resolution needed to detect diseases early.

The CSIR-developed system overcomes these limitations through two complementary AI-driven tools. The first is an offline Android application that runs directly on a smartphone, allowing farmers and field workers to detect diseases even without internet connectivity.

The second is a cloud-based web platform that analyses high-resolution images captured by drones. As the drone flies over a field, it records detailed multispectral images that are stitched together into a single digital map known as an orthomosaic. The AI then examines different sections of this map to identify areas showing signs of disease or crop stress. This enables rapid assessment of entire fields that would otherwise take hours to inspect manually.

Built on Thousands of Field Images

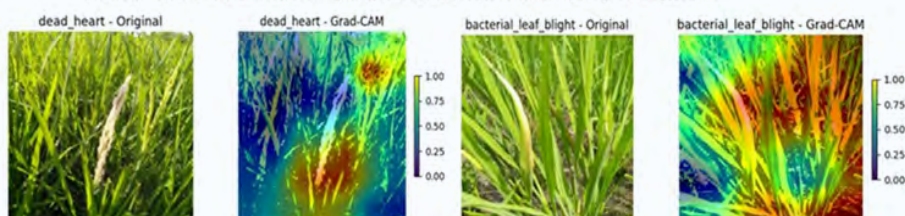
Behind every accurate AI model lies high-quality data. The platform has been trained using a carefully validated database containing around 20,000 images collected from paddy fields across India. This includes nearly 9,000 mobile phone images representing major paddy diseases and 15,000 high-resolution UAV images for large-scale crop monitoring.

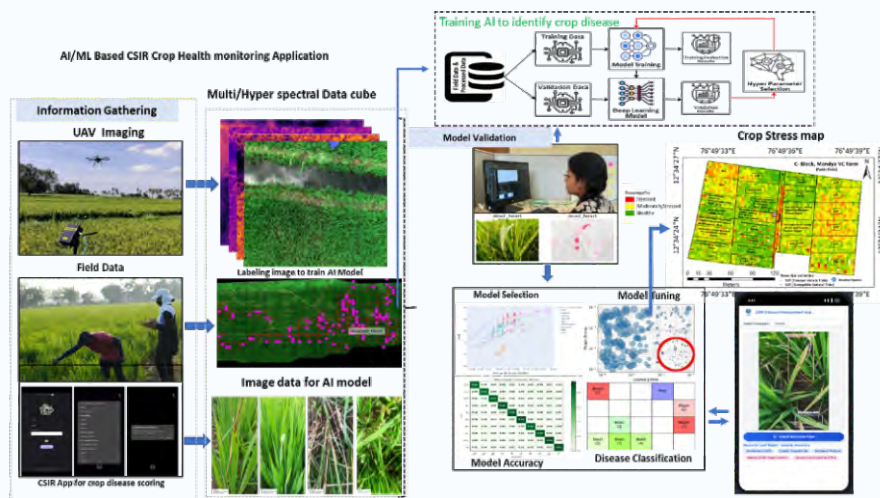
To make the system more reliable, scientists have also incorporated Explainable Artificial Intelligence

LIME - Highlighted areas in red indicate where the model focuses in the training image during prediction - BEIT Model



GradCAM - Visualizes the focus areas of image where last activation layer of ResNet is looking to make prediction





(XAI). Unlike conventional AI systems that simply provide an answer, explainable AI highlights the areas in an image that influenced its prediction. This helps agronomists and agricultural experts better understand and trust the AI's recommendations.

Designed for Farmers Across India

The technology has been designed with accessibility in mind. The offline mobile application brings AI-based disease detection directly to farmers' smartphones, while the cloud platform enables large-scale monitoring of agricultural fields using drone imagery.

To reach farmers across different regions, the application supports

English, Hindi, Kannada, Tamil, and Malayalam, making advanced crop diagnostics accessible to a wider farming community.

By combining mobile devices, drones, cloud computing, and AI into a single decision support system, the technology offers a practical solution that can be used from individual farms to large agricultural landscapes.

The disease diagnostic platform has undergone validation in pilot farmer fields across India and will undergo large area field trial during the second phase of CSIR Mission before transferring the technology to relevant stakeholders for real field application. Also, the unique dataset created for training the AI

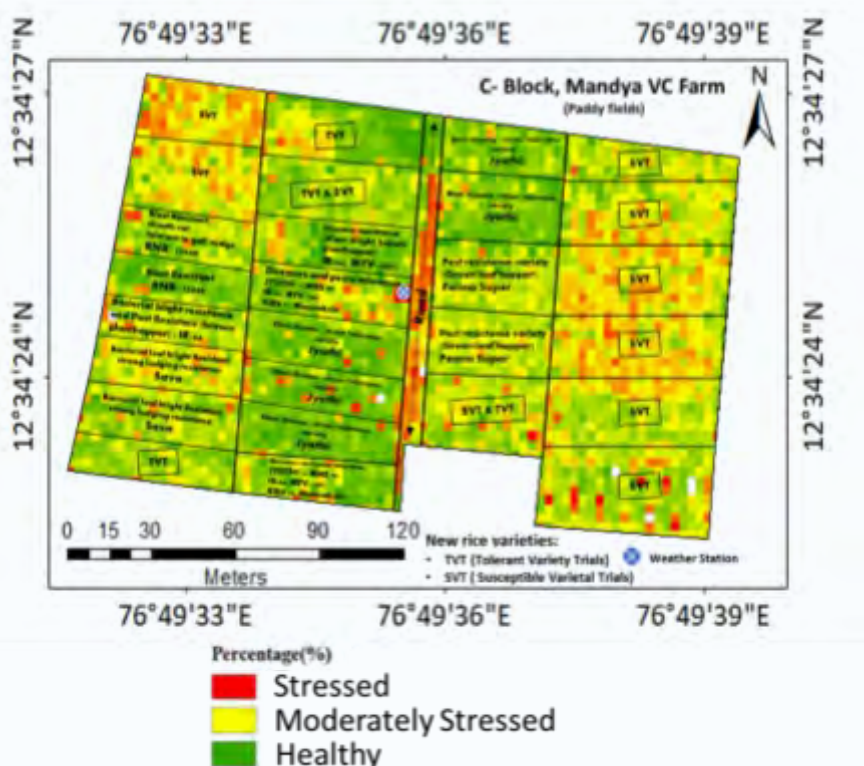
model will be made publicly available for research community after protecting IP at the end of the Mission.

Towards Smarter and Sustainable Farming

The greatest strength of this technology lies not simply in identifying diseases, but in helping farmers make better decisions. Early detection allows pesticides to be applied only where they are needed, at the right time and in the right quantity. This reduces unnecessary chemical use, lowers production costs, and minimises pollution of soil and groundwater. Optimised pesticide application can also reduce chemical residues in harvested crops, contributing to safer food for consumers.

Healthier crops, timely disease management, and improved yields ultimately support better farm incomes while strengthening food security. As agriculture faces the twin challenge of producing more food with fewer resources, technologies that combine artificial intelligence with field-based knowledge offer an important step towards precision farming. By helping farmers detect problems before they become widespread, AI is not replacing agricultural experience—it is giving it a powerful new set of eyes.

Paddy Crop Stress map derived from UAV image based



Meet PHYTOCHEM X: THE AI PLATFORM TRANSFORMING DRUG DISCOVERY

Discovering a new medicine is often a long and expensive journey, with scientists spending years searching for a single promising molecule. Researchers at CSIR-Central Institute of Medicinal and Aromatic Plants (CSIR-CIMAP) have developed PhytoChemX, an AI-powered web platform that brings together more than 20 computational tools, helping scientists identify promising drug candidates faster and more efficiently.



A single medicinal plant can contain hundreds of chemical compounds. Somewhere among them may lie the next treatment for cancer, an infectious disease, or a metabolic disorder. But finding that one promising molecule is a bit like searching for a needle in a haystack. Scientists may spend years examining thousands of compounds before identifying a handful worth testing in the laboratory. What if artificial intelligence could narrow that search dramatically? Scientists at CSIR-Central Institute of Medicinal and Aromatic Plants (CSIR-CIMAP), Lucknow, have developed PhytoChemX, an AI-powered web platform designed to make early-stage drug discovery faster, smarter, and more efficient.

Why Drug Discovery Takes So Long

Developing a new medicine is one of science's most challenging tasks. From identifying a promising compound to developing a safe and effective drug can take more than a decade and require enormous investment. One major reason is the sheer amount of information scientists must analyse. Every potential drug has to be evaluated for its chemical properties, biological activity, safety, possible side effects, and interactions with the human body. Traditionally, researchers often rely on multiple independent software tools to perform these analyses, making the process slow and fragmented. PhytoChemX was developed to simplify this complexity.

Many Powerful Tools, One Platform

Rather than forcing researchers to move between different software programs, PhytoChemX brings together more than 20 computational modelling tools within a single web-based platform. Researchers can use it to explore chemical databases, compare molecular structures, evaluate drug-like properties, predict toxicity, identify biological targets, investigate disease pathways, study drug interactions, support nanomedicine research, and even assist in designing next-generation therapeutic molecules. Instead of

replacing laboratory experiments, the platform helps scientists decide which compounds are most promising to test first, saving valuable time and research effort.

Where Artificial Intelligence Meets Medicinal Plants

One of the platform's unique strengths is its ability to combine knowledge from traditional medicinal plants with modern computational science. Medicinal plants have served as valuable sources of therapeutic compounds for centuries. However, identifying the biologically active molecules responsible for their medicinal properties has always been a difficult scientific challenge.

By combining artificial intelligence, chemical informatics, pharmacogenomics, and systems biology, PhytoChemX enables researchers to analyse phytochemicals more rapidly and identify candidates that may be useful for treating diseases such as cancer, infectious diseases, and metabolic disorders. The platform also incorporates pharmacogenomic approaches, helping scientists understand why the same medicine may produce different responses in different individuals—an important step towards more personalized healthcare.

Applications Beyond Drug Discovery

Although developed primarily for early-stage drug discovery, PhytoChemX has applications across several areas of biomedical research. The platform supports pharmaceutical research and development, herbal drug discovery, virtual screening of large chemical libraries, toxicity prediction, drug repurposing, precision medicine, nanomedicine research, and AI-assisted therapeutic design. Because it is entirely web-based, researchers can access these advanced computational tools without requiring expensive computing infrastructure, making sophisticated analyses more accessible to a wider scientific community.

Accelerating Research Through AI

The significance of PhytoChemX extends beyond computational convenience. By reducing the time required to identify promising drug candidates, the platform can help researchers focus laboratory experiments on the most suitable compounds. This has the potential to lower research costs, improve decision-making, and strengthen collaboration among chemists, biologists, pharmacologists, and data scientists. For pharmaceutical companies, this means faster lead identification. For academic researchers, it provides a single integrated workspace for analysing chemical and biological data. Ultimately, these advances could contribute to the development of safer and more effective medicines.

A Smarter Future for Drug Discovery

Artificial intelligence is rapidly becoming an important partner in biomedical research—not by replacing scientists, but by helping them make better-informed decisions. With PhytoChemX, CSIR-CIMAP has demonstrated how AI can simplify one of the most complex stages of drug discovery by bringing together more than twenty computational tools on a single platform. As AI continues to reshape healthcare and pharmaceutical research, platforms like PhytoChemX show how digital technologies can help scientists search smarter, accelerate discoveries, and move promising medicines from computer screens to laboratory benches more efficiently than ever before.

PhytoChemX Web Link:

<https://phytomedai.com/phytochemx/>

The Spice India Loved but Couldn't Grow

For centuries, Heeng (asafoetida) has been an indispensable ingredient in Indian kitchens, yet every pinch came from imports. Scientists at CSIR-IHBT have changed that by developing India's first indigenous cultivation technology and achieving the country's first successful harvest. The breakthrough promises new opportunities for Himalayan farmers while strengthening India's journey towards spice self-reliance.

Every Indian kitchen has a familiar ritual. A tiny pinch of Heeng, added to hot oil, releases a rich aroma that transforms a simple dal or vegetable curry. Although used in homes across the country for generations and valued in Ayurveda for its medicinal properties, there has always been one surprising fact about this beloved spice. India never grew it!

Despite being one of the world's largest consumers of asafoetida, the country depended entirely on imports from Afghanistan, Iran and Uzbekistan. Every kilogram travelled thousands of kilometres before reaching Indian kitchens. Today, that story is changing. Scientists at CSIR-Institute of Himalayan Bioresource Technology (CSIR-IHBT), Palampur, have achieved something once considered impossible—they have developed indigenous cultivation technology for Heeng and successfully completed India's first-ever harvest of raw asafoetida, opening a new chapter in the country's agricultural history.

Why Was Heeng So Difficult to Grow?

Unlike most spices, Heeng is not harvested from seeds, leaves or fruits. It comes from the oleo-gum resin that naturally oozes from the thick roots of a perennial plant called *Ferula assa-foetida*.

The plant grows naturally in the cold, dry landscapes of Iran and Afghanistan. Recreating those conditions in India proved extremely difficult. Farmers lacked suitable planting material, cultivation techniques, and scientific knowledge about the crop. To make matters more challenging, a Heeng plant takes nearly five years before it produces harvestable resin.

These obstacles kept India dependent on imports for decades.

A Scientific Mission Takes Root

Recognising the strategic importance of domestic production, scientists at CSIR-IHBT launched a long-term research programme to introduce and establish Heeng cultivation in India.

The journey began by importing 66 seed accessions from Iran through the ICAR–National Bureau of Plant Genetic Resources. Years of research followed, focusing on seed germination, nursery management, transplantation, nutrient management, irrigation and crop maintenance under Indian Himalayan conditions.

The researchers discovered that India's cold desert regions—including Ladakh, parts of Himachal Pradesh, Jammu & Kashmir, and Uttarakhand—closely resemble the natural habitat of the crop, making them ideal for cultivation.

Building the Foundation for Farmers

Developing a cultivation technique was only part of the challenge. To ensure future expansion, CSIR-IHBT established a dedicated Heeng Seed Production Centre along with a Quality Planting Material (QPM) Facility, ensuring a reliable supply of healthy planting material for farmers. The research soon achieved another

*Flowering in *Ferula assa-foetida* at CeHAB*



milestone. In 2025, Heeng plants cultivated at Palampur flowered for the first time in India, demonstrating that the crop had successfully adapted to Indian conditions. Flowering and seed production were later achieved at the institute's high-altitude research station in Lahaul & Spiti, paving the way for self-sustaining seed production.

The Harvest That Made History

Growing a perennial crop demands patience.

After five years of careful scientific management, the first Indian-grown Heeng plants finally reached maturity in 2026.

For the first time in the country's history, researchers extracted the aromatic oleo-gum resin from roots grown entirely in India. The carefully collected resin became raw asafoetida—the same spice that has flavoured Indian food for centuries.

This was far more than a successful harvest. It proved that India now possesses the scientific capability to cultivate one of its most valuable imported spices domestically.

Expanding Across the Himalayas

The success at Palampur did not remain confined to the laboratory.

Under CSIR-IHBT's technology dissemination programme, Heeng cultivation has expanded to 332 locations, covering more than 12 hectares with approximately 79,000 plants across Himachal Pradesh, Uttarakhand, Jammu & Kashmir and Ladakh.

These demonstration plantations

help evaluate crop performance under different environmental conditions while introducing farmers to the commercial potential of this high-value spice.



Benefits Beyond the Spice Box

For farmers living in cold desert and high-altitude regions, Heeng offers an attractive new livelihood opportunity.

The crop requires relatively little irrigation after establishment and is naturally suited to dry mountain ecosystems where few commercial crops thrive. Although it takes several years to mature, its high market value offers the potential for substantial returns.



At the national level, indigenous cultivation can gradually reduce dependence on imports, strengthen India's spice value chain, conserve foreign exchange, and create opportunities in nursery production, resin processing and value-added products.

A New Chapter for an Ancient Spice

The story of Indian Heeng is about much more than cultivating a new crop. It demonstrates how long-term scientific research can solve challenges once considered impossible.

From introducing seeds and developing cultivation techniques to establishing seed production systems and achieving India's first indigenous harvest, CSIR-IHBT has built the complete scientific foundation needed for commercial cultivation.

For generations, every pinch of Heeng in Indian kitchens came from another country. Thanks to this pioneering work, the next generation may increasingly find that this cherished spice is not only used in India—but proudly grown in India.

Seaweed: The Ocean Crop Powering India's Blue Economy

Seaweed may appear to be little more than floating marine vegetation, but it is emerging as one of the world's most valuable biological resources. Scientists at CSIR-CSMCRI have developed technologies that enable seaweed cultivation, processing, and value addition, creating new livelihood opportunities for coastal communities while supporting agriculture, industry, and India's growing Blue Economy.



For many people, seaweed is simply something that washes ashore after high tide. But beneath the waves lies a remarkable natural resource with the potential to reshape industries, strengthen coastal livelihoods, and support sustainable development. Rich in valuable natural compounds, seaweeds—or marine macroalgae—are finding applications in food, pharmaceuticals, cosmetics, biotechnology, agriculture, and even renewable energy. They also absorb carbon dioxide, recycle nutrients, and help restore fragile coastal ecosystems, making them an

important component of the emerging Blue Economy.

Recognising this enormous potential, CSIR-Central Salt and Marine Chemicals Research Institute (CSIR-CSMCRI), Bhavnagar, has developed a comprehensive technology ecosystem that spans seaweed cultivation, processing, value addition, technology transfer, and entrepreneurship development.

Building a Seaweed Economy
India's coastline stretches for nearly 11,100 kilometres, offering ideal conditions for seaweed farming. Yet

commercial cultivation remained limited for many years because of inadequate cultivation methods, poor-quality planting material, and weak value chains.

To overcome these challenges, CSIR-CSMCRI developed scientifically validated cultivation systems, including raft, tube-net, hanging-net, and bottom-net techniques, suitable for different coastal environments. The institute also standardised cultivation methods for edible seaweeds such as *Ulva* and *Monostroma*, ensuring a reliable supply of quality biomass throughout the year.



Source: Dream 2047

Through the CSIR Seaweed Mission and programmes under the Pradhan Mantri Matsya Sampada Yojana (PMMSY), the institute has supplied elite seed material, identified suitable cultivation sites, and provided technical support to farmers and entrepreneurs, enabling large-scale adoption of seaweed farming.

Creating Value Near the Coast
Growing seaweed is only the first step. Processing it quickly is equally important.

To minimise post-harvest losses, CSIR-CSMCRI introduced a decentralised cultivation and processing model in which local cultivation clusters are supported by nearby processing facilities. This reduces transportation costs, allows initial value addition close to the farms, and ensures industries receive better-quality raw material.

The model has encouraged

entrepreneurship while creating new livelihood opportunities for fishing communities and women self-help groups. Because seaweed farming requires no freshwater, no fertile land, and relatively little investment, it offers a sustainable source of supplementary income for coastal families. Experts estimate that nearly 400,000 families, representing about 1.6 million people, could potentially benefit from seaweed farming in India.

From the Ocean to Industry

Seaweed's true value lies in what it can become.

CSIR-CSMCRI has developed indigenous technologies to produce food-grade agar, bacteriological-grade agar, molecular biology-grade agarose, carrageenan, and alginic acid from Indian seaweed resources. These materials are essential for food processing, pharmaceuticals, biotechnology, microbiology, and tissue culture.

By developing these technologies domestically, the institute has helped reduce India's dependence on imported marine bioproducts while strengthening indigenous manufacturing under the vision of Atmanirbhar Bharat.

Today, more than 25 companies have licensed seaweed-related technologies developed by CSIR-CSMCRI, demonstrating how public-funded research can successfully translate into industrial growth.

Helping Farmers Beyond the Coast

Seaweed is proving valuable not only in the sea but also on land.

Scientists at CSIR-CSMCRI developed liquid seaweed biostimulants from brown and red seaweeds that improve nutrient-use efficiency, enhance tolerance to heat and drought, strengthen plant health, and increase crop productivity.

The technologies were evaluated through 164 multi-location field trials in collaboration with agricultural universities across almost every state in India. The studies consistently recorded 18–30% increases in crop yield across cereals, pulses, oilseeds, sugarcane, vegetables, and horticultural crops.

These innovations have now been commercialised by around 25 companies, including products marketed through licensees by IFFCO as Sagarika and KRIBHCO as Sivarika. Their widespread adoption has strengthened India's biostimulant industry while improving farm productivity and farmer incomes.

Growing Communities Along with Seaweed

Technology creates lasting impact only when people are empowered to use it.

Through training programmes, demonstrations, and technical support, CSIR-CSMCRI has trained thousands of farmers, entrepreneurs, students, and coastal youth in seaweed cultivation and



Source: Dream 2047



processing. These efforts have helped establish new enterprises and created skilled employment opportunities in India's growing marine bioeconomy.

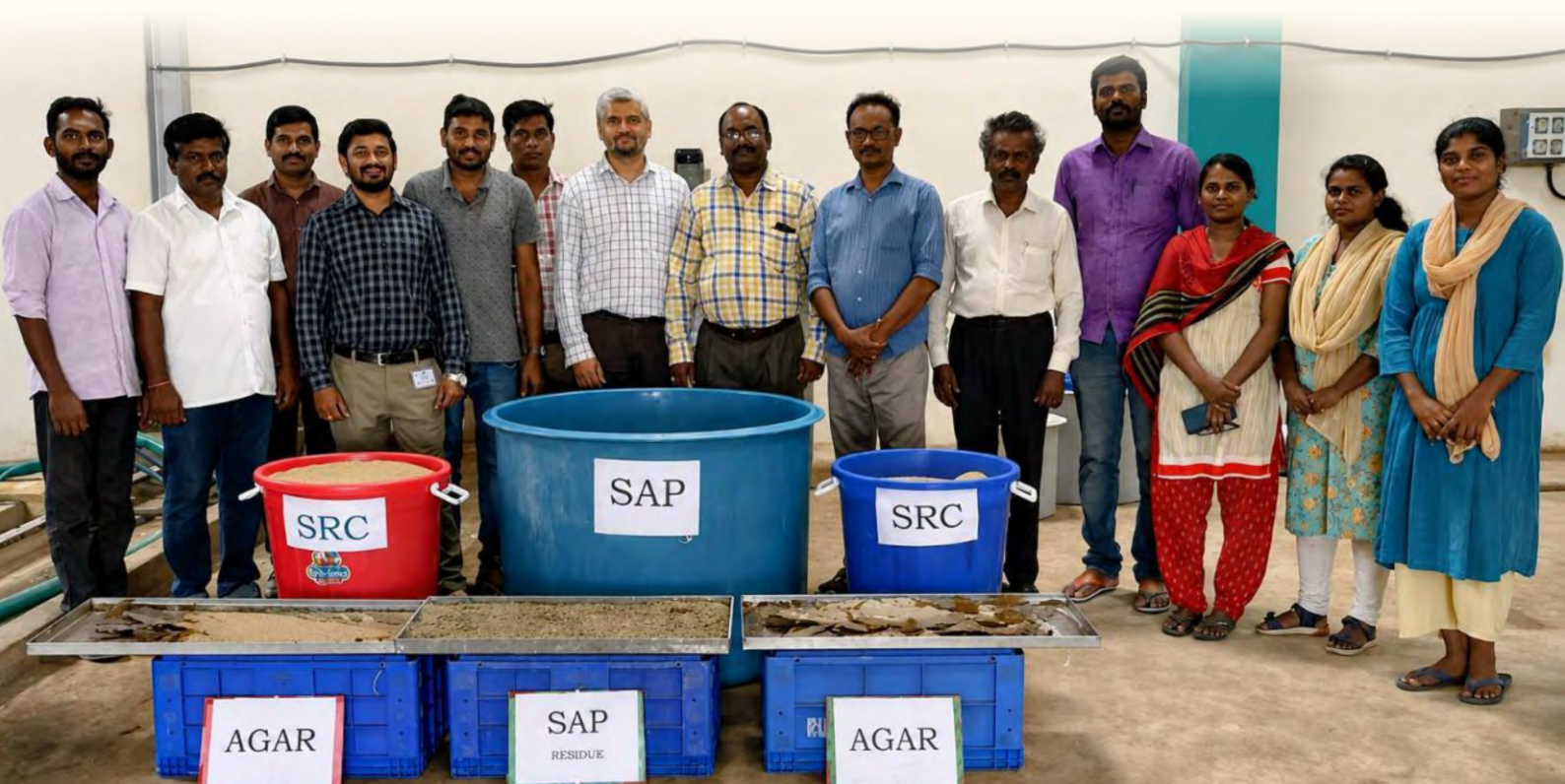
At the same time, seaweed farming delivers environmental benefits by absorbing carbon dioxide, removing excess nutrients from coastal waters, and requiring neither freshwater nor agricultural land.

The Future Lies Beneath the Waves

Seaweed is no longer just a marine resource—it is becoming an engine of sustainable development.

By integrating scientific research with technology transfer, entrepreneurship, industrial partnerships, and community participation, CSIR-CSMCRI has demonstrated how a simple marine plant can support livelihoods,

strengthen industries, improve agricultural productivity, and contribute to a cleaner environment. As India expands its Blue Economy, seaweed is poised to play an increasingly important role in building a future where economic growth and environmental sustainability go hand in hand.



The Pilot's Eye: Building India's Indigenous Head-Up Displays

What if a pilot could see critical flight information without ever looking down at the cockpit? That is the idea behind the Head-Up Display (HUD)—a technology that places flight, navigation and mission information directly in the pilot's field of view. For more than four decades, CSIR-CSIO has been developing and indigenising this critical aerospace technology for India's tactical aircraft.

A fighter pilot has to process an enormous amount of information while flying at high speed. Aircraft attitude, altitude, airspeed, flight path, navigation, target location, weapon status and threat warnings may all need attention within seconds.

Normally, checking such information requires looking down at cockpit instruments. Even a brief shift of attention can matter during demanding phases of flight. A Head-Up Display (HUD) addresses this problem by projecting important information onto a transparent glass panel positioned in front of the pilot. The pilot can see the outside world and essential flight information at the same time.

This is why a HUD is often described as the “pilot's eye.”

How Does a HUD Work?

The key idea behind a HUD is optical collimation.

In simple terms, the system uses a combination of display and optical components to make the projected symbols appear as though they are coming from a very distant point—effectively optical infinity. This allows the pilot to look between the outside scene and the displayed information without repeatedly changing focus.

The system uses a display source, projection optics, mirrors, collimating optics and a transparent combiner—the glass through which the pilot sees both the real world and the digital information.

The result is a single visual field containing the outside environment alongside flight, navigation and targeting information.



HUD installed in a cockpit with other displays

India's Indigenous HUD Journey

HUD technology was originally developed for military aviation and has evolved considerably with advances in optics, electronics and digital displays.

In India, CSIR-Central Scientific Instruments Organisation (CSIR-CSIO) has played a major role in developing indigenous HUD systems for tactical aircraft. The work has been carried out with stakeholders including the Aeronautical Development Agency (ADA), Hindustan Aeronautics Limited (HAL) and the Indian Air Force.

The technology developed by CSIR-CSIO has been used on platforms including LCA Tejas, HJT, Hawk-i and LCA Navy.

For decades, the conventional systems have relied on extremely high-brightness cathode ray tubes (CRTs) as display sources. However, advances in modern

display technologies are now opening the way for more compact and capable HUD architectures.

Engineering a HUD for a Fighter Aircraft

Making a HUD is far more complicated than simply placing a screen in front of a pilot.

The optical system must provide a wide field of view while remaining compact and lightweight. It must also deliver high brightness, accurate imagery and low distortion.

The mechanical structure has to survive the demanding environment of an aircraft, including severe vibration, shock, temperature extremes, humidity, sand and dust, salt fog and high-altitude operation.

The HUD must also communicate with several aircraft systems, including the mission computer, air-data computer, navigation systems, GPS, radar, flight-control computer

and weapon systems.

All these systems have to work together so that the information displayed to the pilot is accurate and available in real time.

Making the HUD Smarter—and Lighter

The future HUD may become more than a flight-information display.

With advances in artificial intelligence, sensor fusion and high-speed computing, it could present pilots with only the most relevant information at a particular moment.



HUD Symbology Through CSIR-CSIO Developed HUD on Beam Combiner

At the same time, AI-assisted engineering and additive manufacturing could help create lighter, more compact and structurally efficient HUD assemblies.

The integration of HUDs with Helmet Mounted Display Systems (HMDS), augmented reality and synthetic vision could eventually provide pilots with a seamless information environment even when they turn their heads.



CSIR-CSIO developed HUD systems

Testing Before It Takes to the Sky

Before a HUD can be installed on an aircraft, it must undergo extensive testing.

CSIR-CSIO has developed a HUD Test Evaluation Platform (HTEP) for design verification, performance evaluation, calibration, qualification and acceptance testing. The facility allows engineers to evaluate parameters such as optical performance, symbology accuracy, alignment, brightness and contrast under controlled conditions.

Such testing reduces development risks and helps minimise the need for repeated aircraft flight trials.

Building Self-Reliance in Critical Avionics

The development of indigenous HUD technology is about more than a display in a cockpit. It brings together precision optics, electronics, software, mechanical engineering, optical coatings, testing and aircraft integration.

According to the supplied information, more than 150 indigenous HUD systems are operational on Indian aircraft, demonstrating the maturity of the technology. Technology transfer and production partnerships with Indian defence industries have also enabled series production.

As aircraft become increasingly digital and connected, the HUD will continue to evolve. From a transparent screen displaying flight symbols, it is becoming a sophisticated interface between the pilot, the aircraft and the surrounding environment.



HUD Symbology during take-off (Day-Stroke Mode)



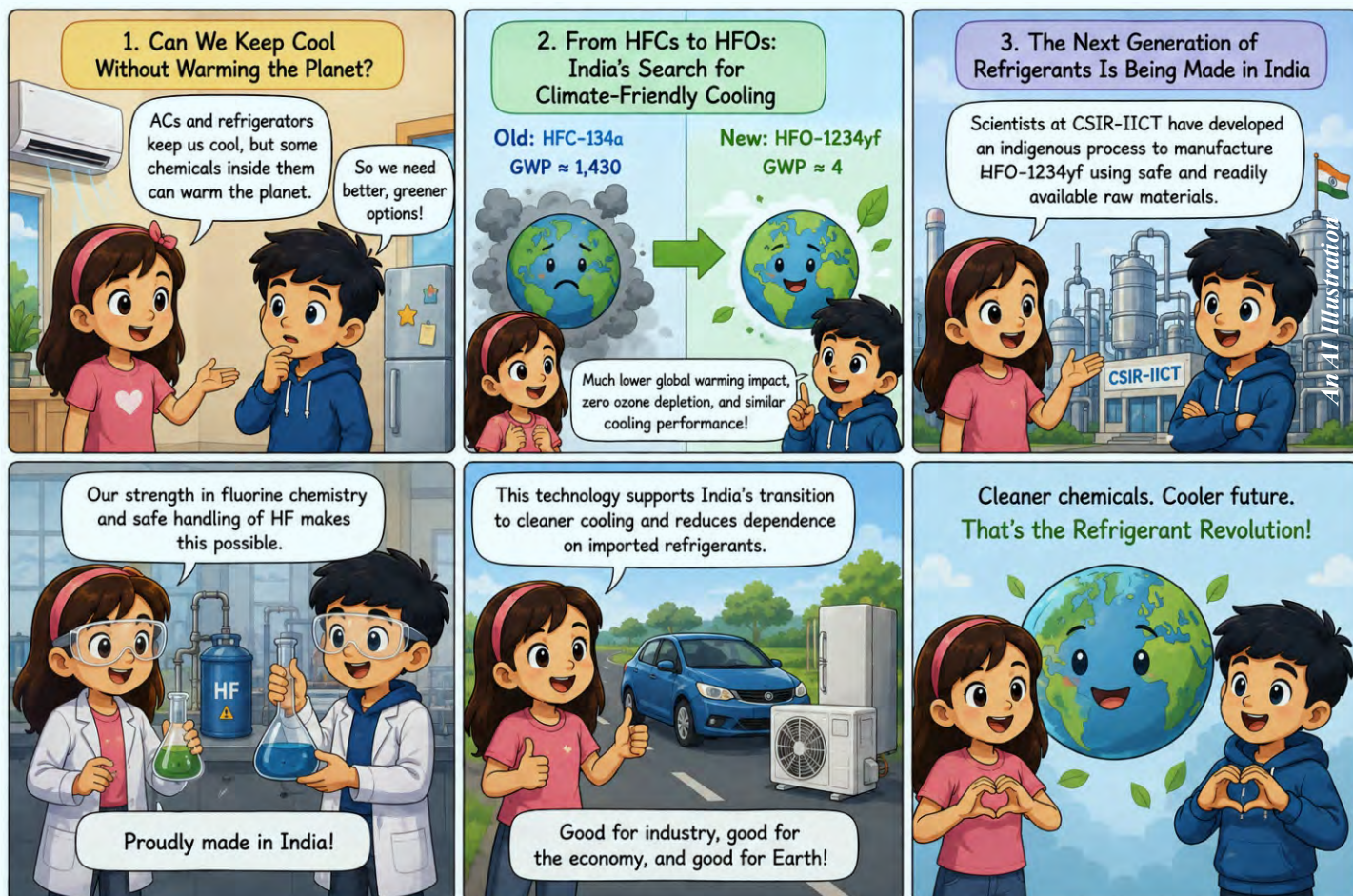
HHUD Symbology during take-off (Day-Stroke Mode)



HUD Symbology during Night-Stroke in Raster Mode

From HFCs to HFOs: India's Search for Climate-Friendly Cooling

Modern life depends on cooling, from refrigerators and air conditioners to vehicle cabins and hospitals. But some of the chemicals that make cooling possible can also warm the planet. Scientists at CSIR-IICT have developed an indigenous manufacturing process for HFO-1234yf, a next-generation refrigerant with far lower global warming potential, supporting India's transition towards cleaner and more sustainable cooling.



A refrigerator keeps food fresh. An air conditioner makes homes, offices and hospitals comfortable. A vehicle's air-conditioning system can turn a sweltering journey into a bearable one. Not long ago, however, such technologies were expensive luxuries available mainly to industries and wealthier households. As technology improved and costs fell, cooling became part of everyday life.

But cooling has another side. The cooling machines themselves may provide comfort, but the chemicals inside them can affect the climate. For many years, refrigerators and air conditioners relied on hydrofluorocarbons (HFCs). These refrigerants do not damage the ozone layer like some older

chemicals, but many of them are powerful greenhouse gases. When they escape through leakage or are released during improper disposal, they can contribute to global warming. Scientists are now working to change that equation.

The Problem Inside the Cooling System

One widely used refrigerant has been HFC-134a, particularly in automobile air-conditioning systems. It became popular because it provides effective cooling without harming the ozone layer. Its weakness, however, is its high Global Warming Potential (GWP), a measure of how strongly a gas contributes to warming compared with carbon dioxide.

The search for alternatives has

therefore focused on refrigerants that can deliver similar cooling performance while having a much lower GWP. This global transition received further momentum through the Kigali Amendment to the Montreal Protocol, which calls for the gradual reduction of high-GWP HFCs and encourages the adoption of more climate-friendly alternatives.

India's Cooling Transition

For India, moving away from HFCs is both an environmental challenge and a technological opportunity.

Under the Kigali Amendment, India has committed to gradually reducing HFC use, with reductions planned from 2032 onwards. Looking towards Viksit Bharat 2047, the transition will require



large-scale adoption of next-generation refrigerants.

A New Generation of Refrigerants

Researchers from CSIR–Indian Institute of Chemical Technology (CSIR-IICT) have developed an indigenous manufacturing process for a new-generation refrigerant designed to provide effective cooling with a much smaller climate impact. The technology developed at CSIR-IICT focuses on HFO-1234yf, a next-generation refrigerant known for its much lower climate impact.

Compared with HFC-134a, which has a GWP of about 1,430, HFO-1234yf has a GWP of about 4. That means its global warming impact is dramatically lower. It also has zero ozone depletion potential and breaks down relatively quickly in the atmosphere.

Importantly, its cooling performance is comparable to HFC-134a, which means it can potentially be adopted in automotive air-conditioning systems without major changes to existing cooling requirements.

From Fluorine Chemistry to Indigenous Manufacturing

Developing a promising refrigerant is only part of the challenge. It also

has to be manufactured safely, efficiently and at a scale suitable for industry. Drawing on decades of expertise in fluorine chemistry and the safe handling of anhydrous hydrogen fluoride (HF), CSIR-IICT scientists developed an indigenous manufacturing process for HFO-1234yf using readily available raw materials.

The research programme received support from the Ministry of Environment, Forest and Climate Change, the Department of Science and Technology, and CSIR. The result is more than a new chemical process. It represents the development of domestic capability in an advanced area of fluorochemical manufacturing that is increasingly important to the global cooling industry.

Why Indigenous Refrigerants Matter

The importance of this technology extends beyond replacing one refrigerant with another.

India's demand for cooling is increasing, and the transition away from high-GWP HFCs will require large volumes of suitable alternatives. Indigenous manufacturing can strengthen domestic capabilities, reduce dependence on imported refrigerants, and create

opportunities for advanced chemical manufacturing within the country.

At the same time, the shift towards lower-GWP refrigerants can help reduce the climate impact associated with the rapid expansion of cooling technologies.

Keeping Cool in a Warmer World

Cooling presents a fascinating challenge of the modern world: the technologies that help people cope with rising temperatures must themselves become more climate-friendly. The answer is not to stop cooling. It is to make cooling cleaner.

By developing an indigenous process for HFO-1234yf, CSIR-IICT is helping address that challenge at the chemical level—where the future of cooling begins. The refrigerator or air conditioner may look unchanged from the outside. But inside, a quieter revolution is underway: finding ways to keep the world cool without warming it further.

Dimethyl Ether: The Clean Fuel that could Flow through India's LPG Network

India's search for cleaner, more secure energy has led to an indigenous breakthrough in Dimethyl Ether (DME) technology. Scientists at CSIR-NCL have developed a complete methanol-to-DME process—from catalyst design to pilot-scale production—demonstrating how home-grown research can support cleaner cooking fuel, sustainable transportation, and greater energy self-reliance while strengthening India's transition towards a low-carbon future.



'ADITI URJA SANCH' burner for DME-LPG blends.

Every time we switch on an LPG stove, we rarely think about where that fuel comes from. Yet for countries like India, meeting the growing demand for clean cooking and transportation fuels depends heavily on imported fossil fuels. Global supply disruptions and rising energy costs have highlighted an important question: Can cleaner fuels be produced at home using indigenous technology? Scientists at CSIR-National Chemical Laboratory (CSIR-NCL), Pune, believe the answer is yes. Their work focuses on Dimethyl Ether (DME), a clean-burning fuel that could complement existing LPG supplies while reducing emissions and strengthening India's energy self-reliance.



CSIR-NCL's 250 kg/day Methanol-to-DME Pilot Plant, developed using a patented indigenous catalyst.

A Small Molecule with Big Potential

Dimethyl Ether may not be a household name, but it has attracted growing global attention as an alternative fuel. Unlike many conventional fossil fuels, DME burns cleanly. It produces no sulphur emissions and very low levels of particulate matter and nitrogen oxides—pollutants that contribute to poor air quality. Even more importantly, its physical properties are remarkably similar to those of Liquefied Petroleum Gas (LPG). This means DME can use much of the existing LPG storage, transportation and distribution infrastructure, avoiding the need to build an entirely new fuel network. Recognising this potential, the Indian standard IS 18698:2026 permits blending DME with LPG up to 8 percent by weight, making gradual adoption both practical and economically attractive.

At the CSIR-National Chemical Laboratory (CSIR-NCL), this potential has been translated from concept to technology. Over the past several years, researchers have developed an end-to-end process to produce DME from methanol, taking it from laboratory experiments to pilot-scale demonstration and early industrial collaboration. This journey exemplifies how fundamental

science can evolve into solutions of societal relevance.

Turning Methanol into Clean Fuel

Producing DME efficiently, however, is not straightforward. In 2017, under its Catalysis for Sustainable Development programme, CSIR-NCL began developing a single-step catalytic process to convert methanol into DME.

Catalysts are substances that accelerate chemical reactions without being consumed themselves. Designing the right catalyst is often the key to making an industrial process economical and reliable. The CSIR-NCL team developed a mixed-metal oxide solid acid catalyst that avoids expensive noble metals while delivering exceptionally high performance. Laboratory studies demonstrated more than 99.9% methanol conversion and greater than 99.99% selectivity towards DME. Equally significant, the catalyst remained stable for over 12,000 hours of continuous operation and could be regenerated without losing its effectiveness, an important requirement for commercial-scale production.

From Laboratory to Pilot Plants

The transition from laboratory

discovery to engineering reality began with small-scale reactor studies producing only a few litres of DME per day. These experiments provided crucial proof-of-concept validation. By 2019, CSIR-NCL had successfully established a mini pilot plant on campus, capable of producing approximately 12-15 litres of DME per day. This marked one of India's earliest demonstrations of an integrated methanol-to-DME process developed using indigenous catalyst technology. The scale-up generated valuable engineering data required for future commercial plants and demonstrated reliable long-term operation under continuous conditions, advancing the technology to Technology Readiness Level (TRL) 6-7.

Bringing Clean Fuel into Daily Life

A distinctive feature of DME programme at CSIR-NCL has been its focus on real-world application. Rather than limiting the work to laboratories, researchers actively tested how the fuel could be used in everyday settings.

A key innovation was the development of a specially designed “ADITI URJA SANCH” burner, capable of operating efficiently with DME-LPG blends as well as pure DME. Trials conducted in residential households within the CSIR-NCL campus and in the institute cafeteria demonstrated stable combustion, efficient fuel utilisation and reliable performance. These studies showed that DME-LPG blends could be used safely for domestic cooking without major modifications to existing LPG systems, significantly reducing barriers to adoption.

The Automotive Research Association of India (ARAI), Pune, also evaluated DME as a transport fuel. Vehicle trials, including tests in three-wheelers using DME-LPG blends, demonstrated favourable combustion and significantly lower particulate emissions than conventional fuels, further highlighting DME's potential for household, industrial and transport applications.



ARAI-tested DME-LPG three-wheeler at CSIR-NCL.

Industrial Interest and National Collaboration

As the technology matured, it attracted interest from major energy organisations, including Indian Oil Corporation Limited (IOCL) and Oil and Natural Gas Corporation (ONGC). The next milestone is even more significant. India's first indigenous 250–275 kg/day pilot-scale DME plant, jointly engineered by CSIR-NCL and M/s Texol Ltd., is expected to begin operations in 2026 at the site of industrial partner M/s Atrium Innovations Pvt. Ltd. Plans are also underway to establish a 2.5-tonne-per-day demonstration plant by the end of 2027. Supported by six granted patents and numerous scientific publications, the technology now stands on a strong foundation for future commercialization.

A Step Towards a Cleaner Future

The development of DME technology at CSIR-NCL represents a complete innovation continuum: from molecular-level catalyst design to pilot-scale engineering

and real-world testing. It also highlights how research institutions can contribute directly to national priorities such as energy security, environmental protection and industrial self-reliance.

What makes this journey particularly significant is its translational nature. A laboratory concept has been systematically transformed into a deployable technology with validated performance, industrial engagement and real-world applications.

As the world moves toward low-carbon and sustainable energy systems, technologies like DME offer a practical bridge between today's fossil-fuel-dependent infrastructure and tomorrow's cleaner future.

Lighting Up Living Cells: Smart Fluorescent Probes Transform Biomedical Research

What if scientists could watch the inner workings of a living cell without disturbing it? Researchers at CSIR-IICB have developed smart fluorescent probes that selectively illuminate individual cellular structures, enabling real-time imaging of disease processes while paving the way for next-generation diagnostic technologies.

Imagine trying to understand how a city works at night without switching on a single streetlight. Roads, buildings, traffic, and people would all disappear into darkness. Studying a living cell poses a similar challenge. Cells are packed with tiny structures that constantly communicate, store energy, manufacture proteins, and respond to disease, yet these activities occur on a microscopic scale that is impossible to observe directly.

To illuminate this hidden world, scientists use fluorescent molecules that glow under special light. However, many conventional probes fade quickly, stain multiple structures at once, or interfere with normal cellular activity, limiting their usefulness for long-term imaging.

Scientists at CSIR-Indian Institute of Chemical Biology (CSIR-IICB), Kolkata, in collaboration with National Institute of Pharmaceutical Education and Research (NIPER-Kolkata), have developed a new generation of organelle-specific

smart fluorescent probes that overcome many of these limitations. These probes enable researchers to visualize specific structures inside living cells in real time while preserving normal cellular function, providing powerful new tools to investigate health and disease.

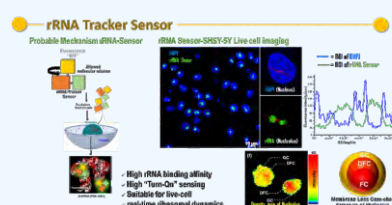
Lighting Up the Cell's Hidden Compartments

A living cell functions much like a miniature city, where different compartments, called organelles, perform specialised tasks. Some generate energy, others manufacture proteins, while some store nutrients or regulate metabolism. The newly developed fluorescent probes are designed to selectively illuminate individual organelles rather than the entire cell. This

targeted imaging provides exceptionally clear pictures of cellular architecture and allows scientists to monitor how these structures change during disease.

Among the most significant innovations is LipiK510, a fluorescent probe developed specifically for imaging lipid droplets. LipiK510 combines several features that make it particularly useful for watching living cells. It is photostable, meaning it does not quickly lose its brightness when exposed repeatedly to light during imaging. Its strong fluorescence produces clear, bright images, and helps produce cleaner images with less background interference. The probe can also easily enter living cells, a property known as cell permeability, and shows minimal toxicity, meaning it does not significantly harm the cells being studied.

Together, these properties allow researchers to observe cellular structures clearly for longer periods without significantly disturbing normal cell function. LipiK510 has



Smart fluorescent probes developed by CSIR-IICB and NIPER-K for organelle-specific live-cell imaging.

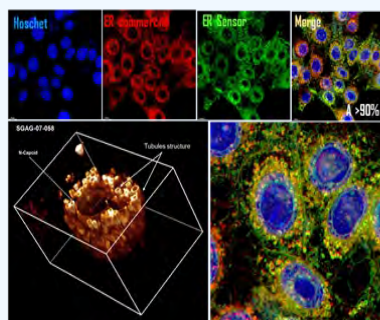
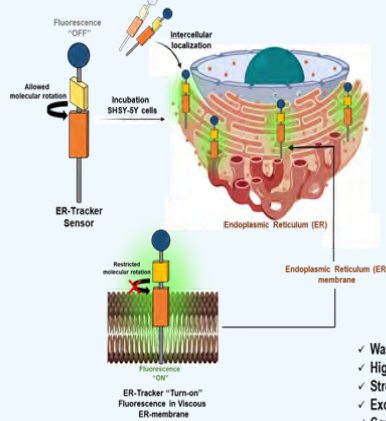


Technology transfer pathway illustrating translation of laboratory discoveries into commercial biomedical products.

ER-Tracker Sensors

Probable Mechanism ER-Sensor

SHSY-5Y Live cell imaging (Comparison with Commercial probe)



- ✓ Wash-free imaging capability
- ✓ High ER selectivity and retention
- ✓ Strong signal-to-noise ratio
- ✓ Excellent photostability
- ✓ Compatible with high-content imaging systems

been successfully tested in living cells and in the tiny model organism *Caenorhabditis elegans*, commonly known as a roundworm, which is widely used in biological research. These studies demonstrated that the probe can be used to study lipid droplets in different biological settings.

Beyond Lipid Droplets

The researchers did not stop at lipid droplets. Building on the success of LipiK510, the team developed additional fluorescent probes designed to highlight other important structures inside cells.

One of these probes targets the endoplasmic reticulum (ER)—an interconnected network inside cells that helps make, process, and transport proteins. By selectively lighting up the ER, the probe allows scientists to create detailed three-dimensional images and observe how this cellular network changes under disease conditions, including in studies using neuroblastoma cells.

Another probe targets ribosomal RNA (rRNA). Ribosomes are the

molecular machines that make proteins, while rRNA forms an important part of these machines. The new probe allows researchers to observe changes in the physical behaviour of rRNA inside both *Escherichia coli* bacteria and human cancer cells.

Together, these probes give scientists a clearer view of the cell's inner workings. They can help researchers watch how cellular structures change, communicate, and respond to disease—providing a more detailed picture of biological processes as they happen.

From Laboratory Discovery to Biomedical Innovation

The scientific value of these probes extends well beyond basic research. Recognising their translational potential, CSIR-IICB and NIPER-Kolkata have protected the underlying chemistry and applications through three Indian patent applications filed in 2023. Besides serving as advanced research reagents, these probes also show promise as early-stage diagnostic tools for diseases such as

cancer and neurodegenerative disorders, including Alzheimer's disease.

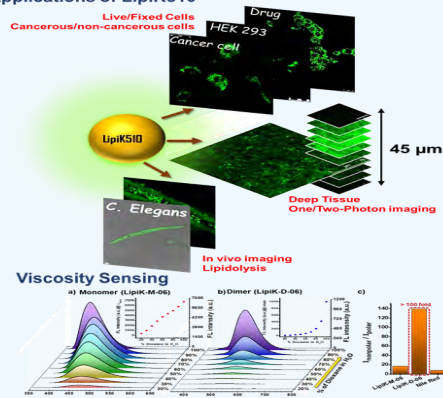
The technology reached an important milestone on 2 April 2026, when CSIR-IICB and NIPER-Kolkata signed a technology transfer agreement with Gene to Protein Pvt. Ltd. (G2P), Hyderabad, licensing the smart fluorescent probes for selective imaging of the endoplasmic reticulum and ribosomal RNA. This marks the successful translation of laboratory research into industrial application while strengthening India's capability in advanced diagnostic reagents and biomedical innovation.

Illuminating the Future

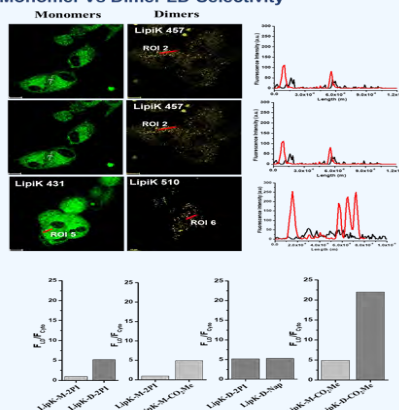
Modern biology increasingly depends on the ability to observe living cells as they function naturally. By combining chemistry, biology, and advanced imaging, the organelle-specific smart fluorescent probes developed by CSIR-IICB offer researchers an unprecedented window into the microscopic world of life.

As these technologies move from research laboratories toward commercial applications, they promise to accelerate biomedical research, improve our understanding of complex diseases, and support the development of future diagnostic tools. More importantly, they demonstrate how fundamental scientific research can be transformed into practical innovations that strengthen India's biotechnology ecosystem and contribute to better healthcare.

Applications of LipiK510



Monomer Vs Dimer LD-Selectivity



Lipid droplet imaging using Lipik510

Can Saffron Slow Brain Ageing? Inside a New CSIR Drug Discovery Effort

For centuries, saffron has been prized as the world's most expensive spice. Now, scientists at CSIR-IIIM, Jammu, are investigating its potential as a modern medicine for Alzheimer's disease and age-related cognitive decline. Their research on saffron-derived crocetin has uncovered effects on brain waste clearance, cellular energy, inflammation and ageing, with a clinical trial application now under regulatory review.

A pinch of saffron can transform the colour and aroma of a dish. For thousands of years, people have valued saffron, harvested from the delicate purple petals of the *Crocus sativus* flower, for its vibrant color, distinct flavor, and place in traditional medicine. But beneath its culinary charm lies a powerful secret. Today, scientists are turning this ancient kitchen staple into a cutting-edge medicine that could soon change how we fight Alzheimer's disease and brain ageing.

Researchers at the CSIR-Indian Institute of Integrative Medicine (CSIR-IIIM) in Jammu have spent years untangling the science behind saffron. Their goal? To transform raw tradition into rigorous modern science. The team has formally submitted an Investigational New Drug (IND) application to the Central Drugs Standard Control Organisation (CDSCO) seeking permission to begin Phase 1 clinical trials for IIIM-141, a standardised

phytopharmaceutical formulation derived directly from saffron. The research journey, however, began much earlier, with a closer look at one of saffron's important chemical components crocetin.

Helping the Brain Clean Up Its Waste

One of the major features of Alzheimer's disease is the accumulation of abnormal amyloid-beta ($A\beta$) proteins in the brain. These protein deposits can interfere with communication between nerve cells and contribute to inflammation and neuronal damage.

The brain has its own waste-management system for removing damaged or misfolded proteins. This process is called autophagy—essentially, a cellular recycling and cleaning mechanism.

Research published in *Autophagy* showed that crocetin can stimulate this self-cleaning process. The studies found that crocetin activates the LKB1-AMPK pathway, a

cellular signalling system involved in energy sensing and autophagy. Once this pathway is activated, microglial cells—the immune cells that reside in the brain—and neurons were able to clear toxic $A\beta$ peptides more effectively.

In Alzheimer's disease animal models, a one-month treatment with crocetin reduced soluble $A\beta_{40}$ levels by about 45% and $A\beta_{42}$ levels by up to 57%. The treatment also reduced inflammation and brain gliosis, and these changes were accompanied by improvements in learning and memory in behavioural tests.

Giving Ageing Brain Cells More Energy

The research has also explored another problem associated with brain ageing: declining energy production.

As the brain ages, changes in its microvascular network can reduce oxygen availability to tissues. Brain cells depend heavily on oxygen to produce ATP, the molecule that serves as the cell's main energy currency. When oxygen supply falls, the mitochondria—the cell's energy-producing structures—can struggle to keep up.

A study published in *ACS Pharmacology & Translational Science* found that crocetin can enhance oxygen diffusion into oxygen-deprived brain tissue.

In four-month ageing studies, crocetin increased the expression of several mitochondrial genes and restored aspects of cellular energy production. Brain ATP levels doubled, while NAD⁺, a molecule important for cellular metabolism, increased by around 50%.





The research also found changes in gene activity within the hippocampus, a brain region strongly associated with memory. After treatment, the gene-expression pattern of aged brains shifted towards a profile more closely resembling that of younger brains.

In preclinical models, treatment also improved physical strength, motor coordination and working memory, while increasing median lifespan by 17.7% without observed oxidative stress or organ toxicity.

Strengthening the Brain's Protective Barrier

Earlier work on saffron extracts provided another piece of the puzzle.

The brain is protected from many substances circulating in the blood by the blood-brain barrier (BBB), a

highly selective protective boundary formed by tightly connected cells lining blood vessels.

Research by the team found that saffron extracts strengthened this barrier by improving proteins involved in its integrity, including Claudin-5. The extracts also increased the activity of transport proteins such as P-glycoprotein (P-gp) and LRP1, which can help move toxic A β out of brain tissue.

At the same time, saffron components helped restore proteins associated with healthy connections between nerve cells, including PSD-95 and SNAP-25.

Together, these findings suggest that saffron-derived compounds may influence several mechanisms involved in neurodegeneration rather than acting through a single pathway.

From Spice to Standardised Medicine

Traditional saffron cannot simply be treated as a medicine. The amount of active compounds can vary between batches, and compounds in crude botanical material may not always be absorbed efficiently when consumed orally.

This is where IIIM-141 becomes important. The aim is to move from variable plant material to a standardised

phytopharmaceutical—a scientifically characterised medicine with controlled composition and defined active components.

The IND application submitted to CDSCO represents the next major step. If regulatory approval is granted, Phase 1 clinical trials can begin to evaluate the formulation in human volunteers.

Importantly, the promising effects described so far come from preclinical research. Whether IIIM-141 is safe and effective in humans remains to be established through clinical trials.

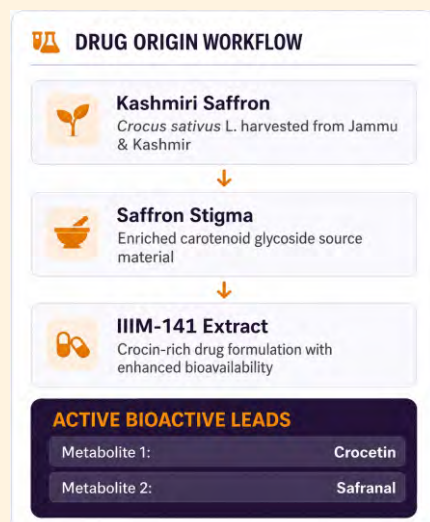
A New Chapter for an Ancient Spice

Saffron has spent centuries in kitchens and traditional medicine. Its next chapter is being written in laboratories.

The research at CSIR-IIIM suggests that crocetin may influence several biological processes linked to Alzheimer's disease and brain ageing, from clearing unwanted proteins to supporting cellular energy and protecting the brain's internal environment.

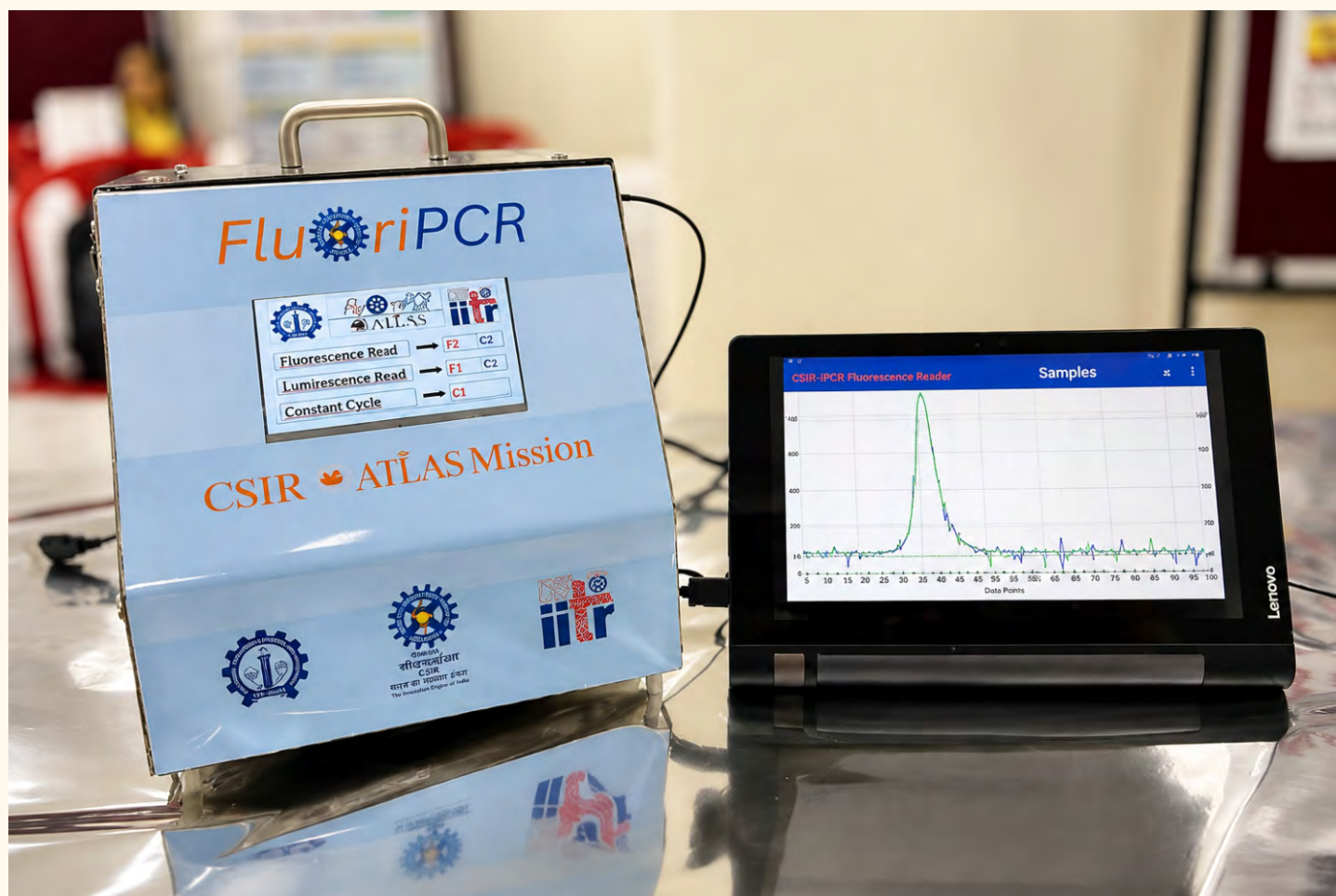
The journey from a laboratory discovery to an approved treatment is long, and the clinical stage will determine how well these findings translate to people.

But the idea itself is striking: a spice valued for generations is being examined with modern tools to understand whether it can help the brain protect itself.



From Four Machines to One: The Portable Lab Reshaping Science and Food Safety

What if a laboratory did not need four separate instruments to perform four different kinds of analysis? FluoriPCR®, developed by CSIR-IITR and CSIR-CEERI, brings multiple molecular and optical testing capabilities into one compact, portable platform. The technology could make advanced testing more affordable and accessible while taking laboratory analysis closer to farms, food facilities, clinics and field sites.



A laboratory can sometimes look less like a room and more like a crowded machine park. One instrument runs PCR, another performs real-time PCR, another measures fluorescence, and yet another analyses light passing through a sample. Each is useful—but each takes money, space, power and maintenance.

Now imagine replacing all four with one compact box. That is the idea behind FluoriPCR®, an indigenous platform developed by scientists from CSIR–Indian Institute of Toxicology Research (CSIR-IITR) and CSIR–Central Electronics Engineering Research Institute (CSIR-CEERI).

Four Jobs, One Platform

FluoriPCR® brings together four laboratory functions: PCR, real-time PCR, fluorescence measurement and UV-Visible analysis.

In simple terms, PCR helps scientists make millions of copies of a selected piece of DNA so that it can be detected and studied. Real-time PCR allows this process to be monitored as it happens. Fluorescence measurement detects substances that emit light, while UV-Visible analysis studies how samples interact with light.

Bringing these capabilities together means researchers can perform different kinds of testing on a single platform instead of moving samples

between several machines.

The system is designed for applications including molecular diagnostics, food authenticity, microbial contamination and environmental monitoring.

When the Laboratory Leaves the Laboratory

Scientific testing does not always happen inside a large research centre.

A food inspector may need to check a sample at a processing facility. A field team may need to investigate contamination. A diagnostic worker may operate far from a sophisticated laboratory.

FluoriPCR® has been designed with



such situations in mind. Its compact and portable format makes it easier to transport, while its ability to work with different testing methods allows analysis closer to where samples are collected. That can reduce the need to transport samples over long distances and help speed up decisions.

Already Tested on Food Samples

The technology has moved beyond the idea stage. FluoriPCR® has been tested for meat authenticity and unwanted mixing in meat products. The system has successfully helped identify four meat species in test samples, providing a way to check whether a product contains components that should not be present.

Its applications are not limited to meat. Because it works with DNA-based testing, the platform can also be adapted for other foods such as wheat and pulses, as well as for detecting bacteria, viruses, fungi and allergens such as gluten and soy, depending on the test being used. The device has also been tested by a NABL-certified laboratory.

Advanced Testing at a Fraction of the Cost

The most striking feature may be its affordability. According to the information provided, the

conventional instruments needed to perform these different analyses can collectively cost around ₹35 lakh. FluoriPCR® is estimated at around ₹1–1.5 lakh, making advanced testing potentially accessible to laboratories with much smaller budgets.

Its compact design also reduces space and infrastructure requirements. The platform is compatible with a wide range of reagents and kits, giving users flexibility rather than tying them to a single supplier. For universities, start-ups, teaching laboratories, diagnostic centres and research facilities, that difference could determine whether advanced testing is possible at all.

From Food Safety to Field Science

The possibilities extend beyond one laboratory or one industry. A portable, multifunctional system can support academic research, diagnostic testing, food safety inspections, environmental monitoring and skill development. It can also be used for hands-on training in schools, colleges and universities, giving students access to several basic molecular analysis techniques through a single platform.

The idea is simple: instead of building a laboratory around several

expensive instruments, bring several capabilities together in one adaptable system. FluoriPCR® is currently at Technology Readiness Level 4, with a working prototype successfully demonstrated and ready for know-how transfer. It also has Indian patent protection, trademark registration and copyright protection for the design.

A Laboratory in a Box

The most interesting part of FluoriPCR® may not be any single function it performs. It is the decision to rethink how laboratory science is packaged. A machine that is smaller, portable, multifunctional and far less expensive can take advanced analysis to places where large laboratory instruments may be difficult to install or afford. The laboratory of the future may not always be a room filled with machines. Sometimes, it may be one machine small enough to carry with you.

The Life-Saving Miracle from the Lab: “Clot-Buster” Revolutionized Indian Healthcare

When a heart attack strikes, every second counts. For decades, the life-saving drugs required to dissolve cardiac clots were prohibitively expensive for most patients in the developing world. By engineering an indigenous, highly cost-effective clot-buster, CSIR-IMTECH laid the foundation for affordable alternatives for cardiovascular healthcare.



The human heart is a tireless, rhythmic engine that beats some 100,000 times a day, pushing blood through a vast, intricate network of living canals. A myocardial infarction occurs when a blood clot, bound together by a tough net-like protein called fibrin, obstructs a coronary artery, cutting off the vital blood supply to the heart muscle. In emergency cardiac care, clearing this block quickly and effectively is the ultimate race against time.

From Bacterial Protein to Life-Saving Drug

The origins of this medical intervention trace back to a serendipitous discovery in 1933. Scientists William Smith Tillett and R.L. Garner, working at Johns Hopkins University, were studying a specific strain of *Streptococcus*, a group of microbes responsible for strep throat and similar infections. They observed that a substance secreted by these bacteria could rapidly dissolve clotted human plasma. Ironically, a protein used by a dangerous human pathogen to

achieve virulence and survival could be used to save human lives. It took over two decades of rigorous scientific effort to purify this protein, named streptokinase, for clinical use in the late 1950s.

Unlike other thrombolytic enzymes that act directly to dissolve blood clots, streptokinase operates through a unique, indirect mechanism. It is a specialized protein that binds to human plasminogen, a naturally inactive protein present in our blood. Once partnered, this complex converts the surrounding plasminogen into plasmin, the active enzyme that degrades the fibrin clots.

For decades, reliance on imported formulations kept the cost of this life-saving drug prohibitively high, limiting its accessibility for many patients across India and the developing world.

CSIR-IMTECH Builds an Indigenous Clot-Buster

Recognizing the urgent societal need for affordable cardiac care, a

dedicated team of researchers at the CSIR-Institute of Microbial Technology (CSIR-IMTECH) in Chandigarh, INDIA, took on the challenge. They developed a hyper-producing strain of the bacteria, specifically engineered to generate large amounts of streptokinase, and worked out an optimized method for its purification. This breakthrough enabled the extraction of clinical-grade, injectable natural streptokinase with an impressive process yield, and the technology was licensed and subsequently commercialized in 2002 by Cadila Pharmaceuticals Ltd. under the brand name STPase. The societal impact was immediate and profound. The introduction of this indigenous drug disrupted the market, providing a massive competitive advantage and bringing down the market price of streptokinase.

From Biosimilar to the Next Generation

In the realm of modern biopharmaceuticals, a “biosimilar” is a biologic product engineered to be highly similar to an already approved biological medicine. Never content to rest on their initial success, the CSIR-IMTECH team pushed the boundaries of molecular biology to enter this space. They used genetic engineering to manufacture a recombinant version of streptokinase, which proved to be roughly ten times more efficient than the natural production technology. The technology was transferred to Shasun Chemicals & Drugs Ltd. in 2002-03, and the product was launched in Indian markets in July 2009 under multiple brand names. This helped drastically lower manufacturing costs once again, translating into

CSIR



CSIR-IMTECH's Clot Buster, Streptokinase- A Wonder Drug

Significant price reduction, induced due to introduction of this CSIR drug in 2009, made it easily accessible to economically challenged sections in the country



even lower drug costs for end-users.

Bringing these drugs to the public, in addition to democratizing healthcare, also served as a vital stress test for the government research ecosystem. Historically, public laboratories excelled at basic science but struggled to bridge the gap between a successful laboratory prototype and a commercially viable product on pharmacy shelves. The journey of commercializing streptokinase helped shatter this barrier. It streamlined internal technology transfer protocols and proved the immense value of engaging industry partners early in the process. By navigating complex licensing agreements, CSIR-IMTECH demonstrated that government laboratories could successfully scale innovations and bring highly competitive products to the global market.

Beyond the Original Clot-Buster

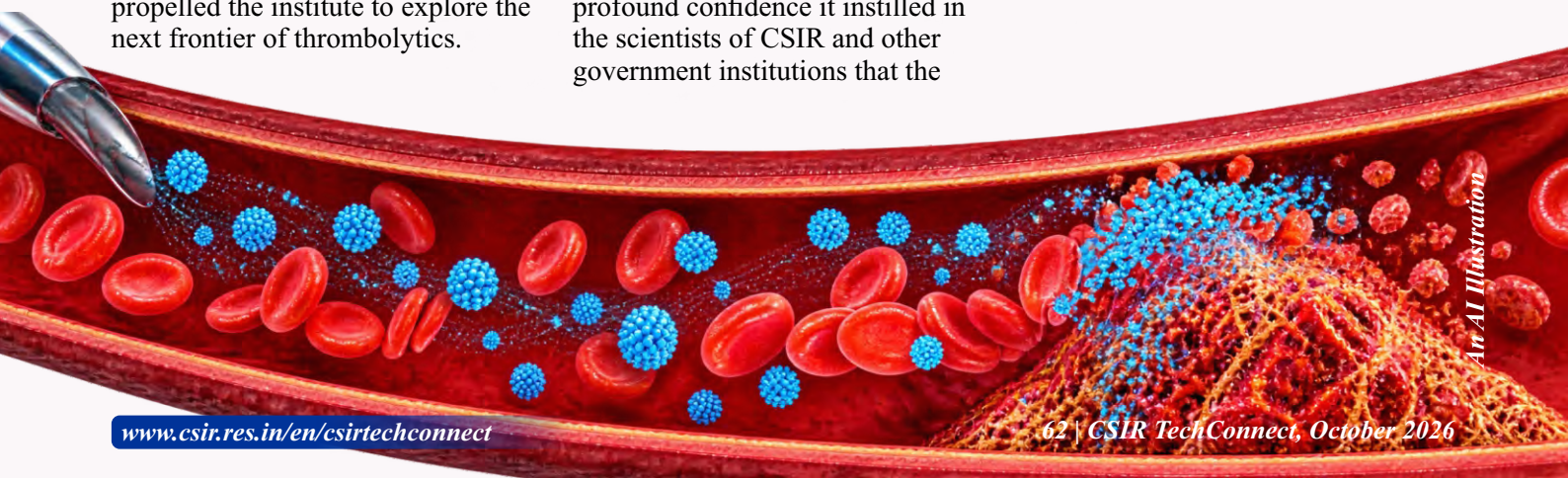
The monumental success of India's first indigenous clot-buster is inextricably linked to the vision of the late Dr. Girish Sahni (2 March 1956 - 19 August 2024), whose leadership, first as the Director of CSIR-IMTECH and then as the Director General of CSIR, propelled the institute to explore the next frontier of thrombolytics.

While biosimilars aim to replicate an existing drug to lower costs, a biobetter is a biologic intentionally engineered to possess superior clinical properties, such as increased efficacy, reduced side effects, or a longer lifespan in the body. The CSIR-IMTECH team pivoted from simply replicating the original protein to designing true biobetters. It is well known that both natural and recombinant streptokinase activate the plasminogen systemically, which carries a risk of unwanted bleeding. To mitigate this risk, CSIR-IMTECH researchers engineered next-generation clot-specific versions of this protein. These biobetters are designed to circulate in an inactive state and activate only upon binding to a pathological blood clot, thereby restricting plasmin generation to the site of the blockage. Furthermore, some variants of this protein are PEGylated, with a protective polymer attached to increase their lifespan in the bloodstream and reduce the body's immune response.

From Laboratory Bench to Bedside

Ultimately, the true legacy of the streptokinase journey is the profound confidence it instilled in the scientists of CSIR and other government institutions that the

path from the laboratory bench to the patient's bedside is entirely navigable. The CSIR-IMTECH streptokinase story stands as a beacon of what public science can achieve when oriented toward human welfare. By taking complex biological principles and refining them into reliable, mass-produced medicines, CSIR-IMTECH scientists turned a protein from a microscopic bacterium into a macro-level force for health equity and economic growth. As these emerging technologies progress from the lab toward commercialization, the ultimate hope remains unchanged that rigorous public science will continue to reach out, touch lives, and build a healthier, more equitable world for all.

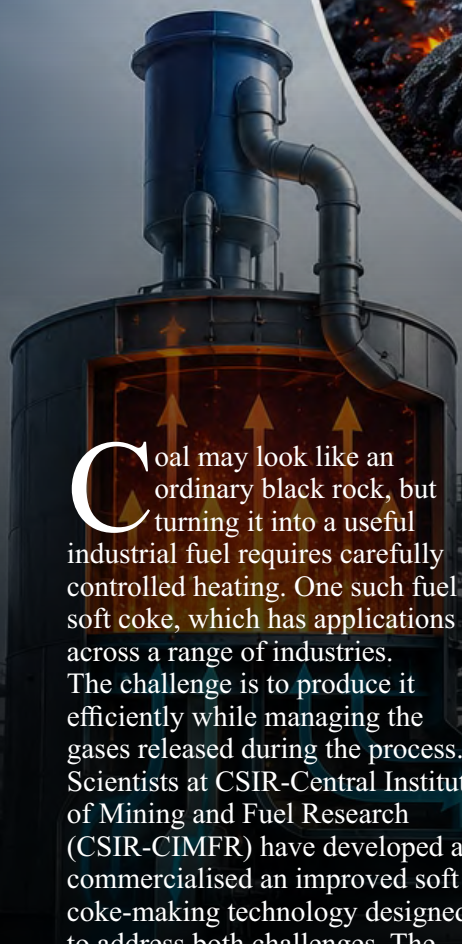


An AI Illustration

Turning Inferior Coal into a Better Fuel: The Science of Soft Coke

Making soft coke from coal requires careful control of heat and gases. CSIR-CIMFR has developed an improved soft coke-making technology that reduces coking time, increases productivity and improves combustion of volatile gases, helping lower pollution. Already transferred to 22 industries, the technology demonstrates how better process design can make an established industrial fuel-making process more efficient.

An AI Illustration



Coal may look like an ordinary black rock, but turning it into a useful industrial fuel requires carefully controlled heating. One such fuel is soft coke, which has applications across a range of industries. The challenge is to produce it efficiently while managing the gases released during the process. Scientists at CSIR-Central Institute of Mining and Fuel Research (CSIR-CIMFR) have developed and commercialised an improved soft coke-making technology designed to address both challenges. The

technology uses indigenous non-coking and inferior-grade caking coal and converts it into soft coke while reducing coking time and increasing productivity.

A Coke Oven That Uses Its Own Heat

At the heart of the technology is a specially designed soft coke oven made from standard refractory bricks. When coal is heated during carbonization, it releases volatile substances. Instead of allowing these gases to simply escape, the oven directs them through specially

designed passages. The gases burn inside the oven and generate additional heat, helping maintain the temperature needed for carbonization.

A specially designed oven sole creates higher temperatures at the bottom of the oven, helping burn unburnt components before the gases leave through the chimney. This creates an efficient cycle in which gases released from the coal help provide the heat needed for the process.

Controlling Heat and Air

Temperature control is essential because it influences both the speed of carbonization and the quality of the coke. The oven uses appropriately placed dampers to regulate the movement of air and gases. Secondary air helps burn unburnt hydrocarbons, producing additional heat while reducing pollution.

The oven doors are lined with refractory material to reduce heat loss, while the primary air entering the oven can be adjusted through openings in the doors. Mechanized rope-and-pulley arrangements are used for operating the oven doors and removing the coke. These systems reduce manual effort and make the operation more convenient for workers.

From Coal to Coke

Soft coke production involves five main stages: coal preparation, coal charging, carbonization, coke discharging and coke quenching. Coal larger than 50 mm is selected for carbonization and transported to the oven using charging trolleys. Each oven can hold approximately 2 tonnes of coal.

During the initial operation, the coal is ignited using materials such as jute, oil and small pieces of wood. Once the refractory walls become sufficiently hot, these additional materials are no longer required.

As the coal absorbs heat, carbonization begins. The volatile matter released from the coal burns above the coal charge, while hot gases move through the oven's



Which used for pulling the soft coke out from the oven through drag rod.



Soft Coke Plant showing Chimney, Winch and Drag Rod

internal passages. Controlled secondary air promotes further combustion. The hot flue gas then passes through the flue system. Additional controlled air helps burn any remaining unburnt components before the gas finally exits through the chimney.

Faster Processing, Lower Pollution

Once carbonization is complete, the oven door is opened and the hot coke is removed using a mechanized drag arrangement. The discharge process is completed within about five minutes to minimise loss of oven temperature.

The hot coke is immediately quenched with cold water. Approximately 0.5 tonnes of water is required for every tonne of coke. Some water is lost through evaporation, while the remaining water is collected for reuse.

The improved circulation of gases raises the oven's sole temperature, helping reduce coking time and increase productivity. At the same time, better combustion of volatile hydrocarbons reduces the amount of unburnt material released into the atmosphere.

From Innovation to Industry

The technology has already moved beyond development and into industrial use. According to the provided information, the Improved Soft Coke Making Technology has been transferred to 22 industries and has generated cumulative



Drag Rod for taking the soft coke out from the oven

royalty of ₹207.68 lakh.

A commercial soft coke plant based on the technology has also been transferred to M/s Ganpati Enterprises.

By using relatively inexpensive domestic coal and improving the control of heat, gases and air, the technology offers industries a more productive approach to soft coke manufacturing while reducing pollution from incomplete combustion.

The story demonstrates that industrial innovation does not always require an entirely new process. Sometimes, better control of an existing process can deliver meaningful gains in productivity, efficiency and environmental performance.

The Science of Silence: Engineering Quieter Cities

A patented, “frequency tuned noise barrier from CSIR-CRRI” is quietly reshaping how India's highways, metro lines and railway corridors deal with unwanted sound, cutting noise by up to 38 decibels by targeting the exact pitch that disturbs us most.

Stand beside a busy flyover, a metro viaduct, or a stretch of railway track cutting through a city, and the noise rarely feels like a single sound. It is a layered wall of pitches, the low rumble of heavy vehicles, the midrange hiss of tyres on tarmac, and the sharp, piercing screech of a train taking a curve or a driver leaning on the horn. Conventional noise barriers, however, are not built to tell these sounds apart. Whether the offending noise is a deep growl or a shrill screech, the same slab of rock wool and perforated aluminium is expected to muffle it all and, more often than not, it does the job only partially.

Scientists at the CSIR-Central Road Research Institute (CSIR-CRRI) asked a simple but often overlooked question: What if noise barriers were designed not for noise in general, but for the specific frequency doing the damage? The answer is a patented, frequency based composite noise barrier that has now moved out of the laboratory and onto real streets including a stretch of the Delhi Metro Rail Corporation (DMRC) network near Khan Market and along B. R. Ambedkar Road in Mumbai.



Field installations of the frequency based noise barrier on the DMRC network, New Delhi, and B. R. Ambedkar Road, Mumbai.



Frequency based noise barrier installed along an elevated urban corridor.

The Trouble with One-Size-Fits-All Barriers

Noise barriers, sometimes called sound walls or acoustic screens, exist to protect people living or working near busy roads, railways and industrial corridors from the well documented harms of chronic noise exposure such as disturbed sleep, elevated stress and blood pressure, impaired concentration, and long term risk to hearing and heart health. Around the world, though, these barriers are built the same way regardless of what they are meant to block. A rock wool core faced with perforated aluminium sheeting remains the industry default, with barely 40 percent of the panel surface actually open to let sound in and be absorbed.

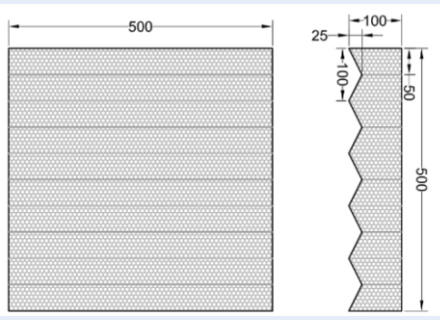
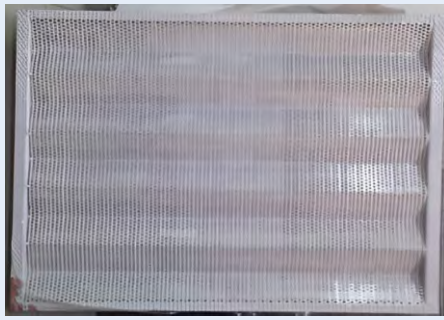
That design carries hidden costs. Over time, loosely packed rock wool settles and shifts, opening gaps at the top or sides of the panel through which monsoon rain seeps in, quietly degrading the barrier's performance. The material itself can irritate the skin of workers who install and maintain it, making it difficult for manufacturers to

guarantee a barrier for more than about a decade. And because so little of the panel surface is actually open, a large share of the noise simply bounces off rather than being absorbed.

Designing for the Pitch, Not Just the Volume

CSIR-CRRI's approach starts from acoustics rather than convention. Traffic and rail noise was broken down into three frequency bands: low (below 200 Hz), middle (200 to 1,000 Hz) and high (1,000 to 20,000 Hz), each associated with a different physical source of noise, from engine and structural vibration at the low end, to tyre and wheel rail interaction in the middle, to the sharp screech of wheels on curves and the blast of a horn at the high end. Instead of one generic panel, the team engineered three distinct composite barriers, each with its own combination of absorptive material, density and perforation pattern, tuned to soak up the frequency band it is built to fight.

The same base material, the researchers found, behaves very differently once its density is



Composite panels fabricated for frequency specific sound absorption, ready for laboratory and field testing.

changed, a property that became central to tuning each barrier to its target frequency band, rather than relying on a single, unchanging formulation.

Putting Numbers on Quiet

In laboratory and field trials, the payoff showed up clearly in the Noise Reduction Coefficient (NRC), the standard measure of how much sound a material absorbs. The three barriers cut overall noise levels by 21, 28 and as much as 38.4 decibels respectively, roughly double the reduction typically achieved by a conventional barrier at similar cost.

For context, a reduction in the high thirties of decibels is roughly the difference between standing next to a busy road and stepping into a quiet library, a meaningful shift for anyone living or working along a noisy corridor.

From the Lab to the Street

The real test of any infrastructure technology is how it performs once

it leaves the laboratory. CSIR-CRRI's frequency based barriers have already been installed at two demanding urban locations: on the DMRC metro network at Khan Market in New Delhi, where curve induced wheel rail screech is a constant challenge, and along B. R. Ambedkar Road in Mumbai, a busy arterial corridor. Both installations serve as live validation of the acoustic gains measured in the lab.

Beyond the acoustics, the technology is built to last: a minimum service life of 20 years barring accidental collision damage, materials that are reusable, and unlike rock wool based systems, no adverse health effects for the workers who install or maintain it.

Where India Could Put It to Work

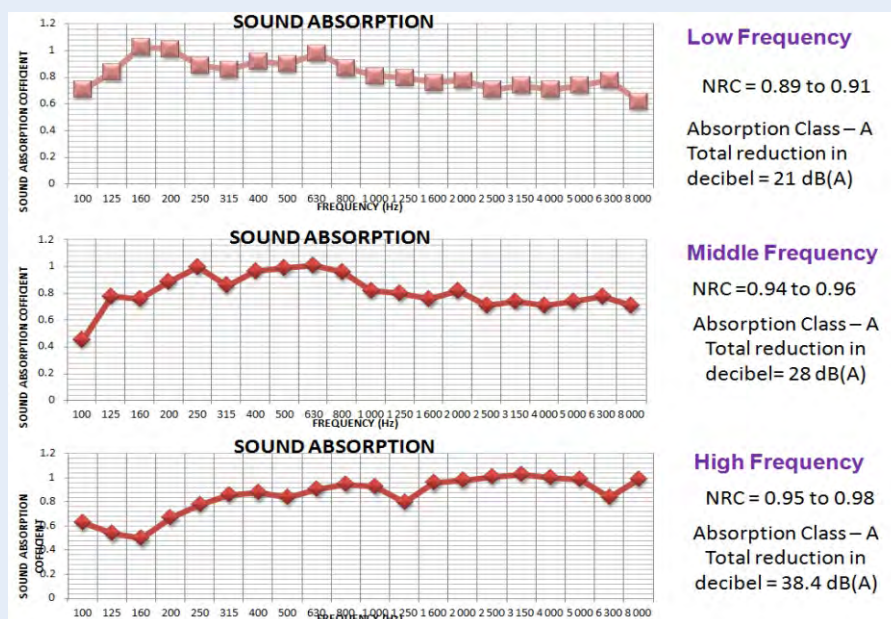
The barrier's natural constituency is anywhere fixed or semi fixed noise sources dominate: Indian Railways and Metro Rail Corporations grappling with curve-section screech, NHAI and state PWDs

managing highway and flyover noise, and urban development authorities from Mumbai's MMRDA and MSRDC to Hyderabad's HMDA, along with Pollution Control Boards (e.g. Goa, Rajasthan, Gujarat, Kerala) tasked with keeping city soundscapes within limits. It is especially suited to road intersections where honking dominates and to rail alignments cutting through forested or residential stretches, where both people and wildlife stand to benefit from a quieter corridor.

The technology is aligned with the Government of India's Innovate in India and Smart Cities missions, which call for home grown, environmentally sound solutions to the everyday costs of rapid urbanisation, of which noise, though often invisible on a balance sheet, is one of the most persistent.

A Quieter Blueprint for Growing Cities

CSIR-CRRI's frequency based noise barrier is a reminder that not every infrastructure problem needs a bigger or bulkier fix, sometimes it needs a more precise one. By designing barriers around the specific pitch of the noise they are meant to silence, rather than treating all sound as the same problem, CSIR-CRRI has built a technology that is simultaneously more effective, more durable and safer to install than what it replaces. With patents in place and field installations already running on the streets of Delhi and Mumbai, the frequency based noise barriers stands ready for wider deployment as India's railways, metros and highways expand, offering cities a practical, science driven way to turn down the volume without slowing down growth.



Sound absorption performance recorded across the frequency spectrum for the low, middle and high frequency barriers.

From Ceramic Science to Patient Care: The Story of India's Indigenous Ceramic Hip

A hip replacement's service life depends on two artificial surfaces moving smoothly against each other for millions of cycles under demanding loads. Scientists at CSIR-CGCRI have developed indigenous zirconia-toughened alumina (ZTA) ceramic components for total hip replacement, taking the technology from materials research to testing, regulatory approval and commercial clinical use in India. The innovation represents a major step towards advanced, homegrown medical-device manufacturing.



A hip joint looks simple from the outside, but inside the body it performs a remarkable mechanical job. Every step, turn and stretch requires two surfaces to move smoothly against each other, repeatedly and often under highly demanding loads.

When the natural hip is severely damaged, a total hip replacement can restore lost function of the joint by replacing it with artificial components. But the materials used in these implants must meet demanding requirements: biocompatible, resist wear, stable and tolerate repeated loading, and maintain highly precise surfaces during service.

For years, India depended on imported ceramic components for advanced ceramic-on-ceramic hip replacements. Scientists at the CSIR-Central Glass & Ceramic Research Institute (CSIR-CGCRI) set out to change that by developing the materials and manufacturing technology within the country.

From Ceramic Powder to Hip Implant

The journey began in 2005, when CSIR-CGCRI initiated the indigenous development of ceramic components using pure alumina.

This laid the foundation for initial technology licensing in 2010 and paved way for the development of advanced Zirconia Toughened Alumina (ZTA) technology between 2016 and 2022.

ZTA combines micro-sized zirconia particles into an alumina-rich ceramic matrix. In simple terms, the researchers combined two essential qualities: alumina's exceptional hardness to minimize wear, and zirconia's structural toughness to prevent cracking under heavy, repeated loads. The resulting composite material technology achieves high hardness, superior fracture toughness, and an ultra-precise surface finish and wear resistance—the exact mechanical properties required for durable, smooth-articulating ceramic components for artificial joint implants.

Engineering Every Microscopic Detail

The performance of an advanced ceramics depends not only on its composition but also on how the material is processed and how its microscopic structure is engineered and controlled.

To maximize these properties, CSIR-CGCRI optimized the ZTA

composition, processing route and microstructural design of ZTA achieving precise grain size control at the microscopic level. The developed material exhibits a hardness of about 21 ± 1 GPa and fracture toughness up to 9.5 ± 1 MPa $\sqrt{\text{m}}$, striking an ideal balance between wear resistance and structural integrity.

The licensed technology encompasses the two vital articulating components of a modular total hip replacement system: the ceramic femoral head (the ball) and the ceramic acetabular liner (the socket bearing). Together, they form a smooth, durable ceramic-on-ceramic articulating joint pair.

From Laboratory to the Hospital

Developing the material was only the beginning. Between 2016 and 2024, the technology progressed through a comprehensive development pipeline involving materials design, process optimization, prototype fabrication, mechanical and wear testing, preclinical validation, licensing, scale-up and regulatory approval.

Following this eight-year translational effort, the product entered the market in 2025. Today, the technology is commercially manufactured by M/s G Surgiwear Ltd. in Shahjahanpur, Uttar Pradesh. Having secured Central Drugs Standard Control Organization (CDSCO) and a manufacturing license, the implant system is now commercially available for clinical use across India.

A Technology Already Reaching Patients

The innovation has transitioned from development into active



Product Package and representative ZTA Ceramic Femoral Heads [Courtesy M/s G Surgiwear Ltd.]

clinical use. Reports from the licensee and feedback from surgeon and patients indicate that more than 400 total hip replacement surgeries have been performed using the technology across Indian hospitals since November 2025. Surgeons and patients report encouraging early outcomes, including post-operative pain reduction and satisfactory joint articulation. However, these reports represent observational feedback rather than findings from an independent, controlled clinical study. This distinction is crucial as long-term clinical evaluation and formal post-market evidence remains essential to fully establish technology's long-term efficacy and safety.

Building India's Ceramic Medical-Device Capability

The significance of this technology extends far beyond a single hip implant. It demonstrates how advanced ceramic science can be successfully translated into a sophisticated medical device—spanning material composition, microscopic structure, precision surface engineering, regulatory clearance, and commercial manufacturing.

By establishing an indigenous platform for advanced ceramic-on-ceramic hip components, this technology provides India with a domestic capability that expands patient access to high-end orthopedic solutions. Beyond its

current use, it serves as a foundational platform with strong potential for adaptation across other joint replacements and orthopedic applications. What began as a targeted search for improved ceramic materials has ultimately evolved into a complete, end-to-end journey from benchtop since to clinical application.

ENCOURAGING EARLY FIELD EXPERIENCE

— Positive feedback from surgeons and patients | Strong early adoption in real-world clinical use —



SURGEON OBSERVATIONS

Several surgeons have reported encouraging implant performance, patient compliance and post-operative performance based on clinical experience and follow-up examinations.



PATIENT FEEDBACK

Patients have reported substantial reduction in pain immediately following surgery.



ARTICULATING INTERFACE

Surgeon observations include robust ceramic liner-acetabular shell locking and anti-rotation performance.



FIELD ADOPTION

More than 400 THR surgeries have been performed since November 2025, demonstrating early adoption of the commercialized technology.



400+
THR SURGERIES



Since
November 2025
Across hospitals in India



Note: The above observations are based on information reported by the licensee and surgeon/patient feedback. They are not presented as results of an independent, controlled or statistically validated comparative clinical study.

When Trees Clean Wastewater: The Science Behind HRTS

What if wastewater could be treated not by machines, but by a carefully designed ecosystem of soil, microbes, and trees? The High-Rate Transpiration System (HRTS) developed by CSIR-NEERI uses natural processes to manage treated wastewater with minimal energy and chemicals, while creating green spaces, conserving freshwater, and offering a sustainable option for industries and communities.

Water treatment is usually associated with concrete tanks, pumps, pipes and large amounts of electricity. These systems can be highly effective, but they can also be expensive to build and operate, particularly for smaller towns, rural communities, and industries. There is another way to think about wastewater treatment: work with nature instead of relying entirely on machinery.

This idea lies at the heart of the High-Rate Transpiration System (HRTS), a nature-based technology developed by scientists at the Council of Scientific and Industrial Research–National Environmental Engineering Research Institute (CSIR-NEERI). Instead of depending on energy-intensive equipment and synthetic chemicals, HRTS combines soil, organic filter materials, naturally occurring microorganisms, and specially selected trees to manage treated wastewater.

A Treatment System Powered by Sunlight

The basic idea is surprisingly simple. An HRTS site is arranged as a series of parallel ridges and furrows. Treated wastewater is directed into the furrows, while suitable fast-growing, high-water-consuming trees such as Eucalyptus, Casuarina, and Bamboo are planted on the ridges. As the water moves through the soil and specially selected filter materials such as coconut husk, rice husk and rice straw, suspended particles are trapped. At the same time, naturally occurring microorganisms living around the plant roots break down organic pollutants.

The cleaned and nutrient-rich water is then absorbed by the trees. This is where the system's defining process, transpiration, comes into play. Trees absorb water through their roots and release much of it into the atmosphere as water vapour through their leaves. In this way, the plants act as a biological pump, using sunlight as their energy source.

Science Behind the Green Landscape

HRTS may look like a plantation, but it is actually a carefully designed environmental engineering system. Before implementing the technology, scientists assess factors such as soil properties, temperature, wind speed, solar radiation and the water-use capacity of the selected plants. These measurements help determine how much wastewater can be safely introduced into the system.

This calculation, or water budget, is important. The aim is to match the amount of wastewater entering the system with the amount of water that the vegetation and soil can process and remove. When properly designed, the system can prevent waterlogging while allowing the biological processes to operate effectively.

An Alternative for Industry

Industries that generate large amounts of wastewater face increasing pressure to manage their



HRTS implemented at Dana India Pvt. Ltd., Satara

effluents responsibly. For sectors such as food and beverages, textiles, paper, and chemical industries, conventional treatment and zero-liquid-discharge systems can require substantial infrastructure, energy, and operating costs.

HRTS offers a different approach, particularly for suitable smaller and medium-scale applications. By using biological processes rather than relying entirely on mechanical systems and chemical inputs, it can reduce operational complexity and energy requirements. The treated wastewater is not simply discarded. Instead, it becomes a resource that supports vegetation and biomass production.

From Wastewater to Green Wealth

One of the distinctive features of HRTS is that its output is not just cleaner surroundings. The trees growing within the system produce biomass that can potentially be harvested, while the vegetation creates a greener landscape and supports biodiversity. What was once a wastewater-management problem can therefore become part of a circular system in which water supports plant growth, plants generate biomass, and the surrounding landscape gains

ecological value. The approach also reduces the demand for freshwater for tree growth because the plants are sustained using treated wastewater.

A Nature-Based Solution in Action

The technology has moved beyond the laboratory and has been implemented at industrial sites including Dana India Pvt. Ltd., Satara, and Mahindra Vehicles Manufacturers Limited, Chakan.

These installations demonstrate how a biological treatment system can be integrated into real industrial environments.

Beyond wastewater management, the approach offers potential environmental benefits by creating green spaces, supporting biodiversity, and contributing to carbon sequestration through vegetation.

The broader idea is simple but powerful: wastewater does not always have to be treated as something that must simply be removed.

With the right design, it can become part of a living system.

Working With Nature

Modern environmental engineering often focuses on controlling nature with machines. HRTS takes a different route. It uses the natural abilities of soil, microorganisms and trees, carefully arranged and scientifically managed, to address a human problem.

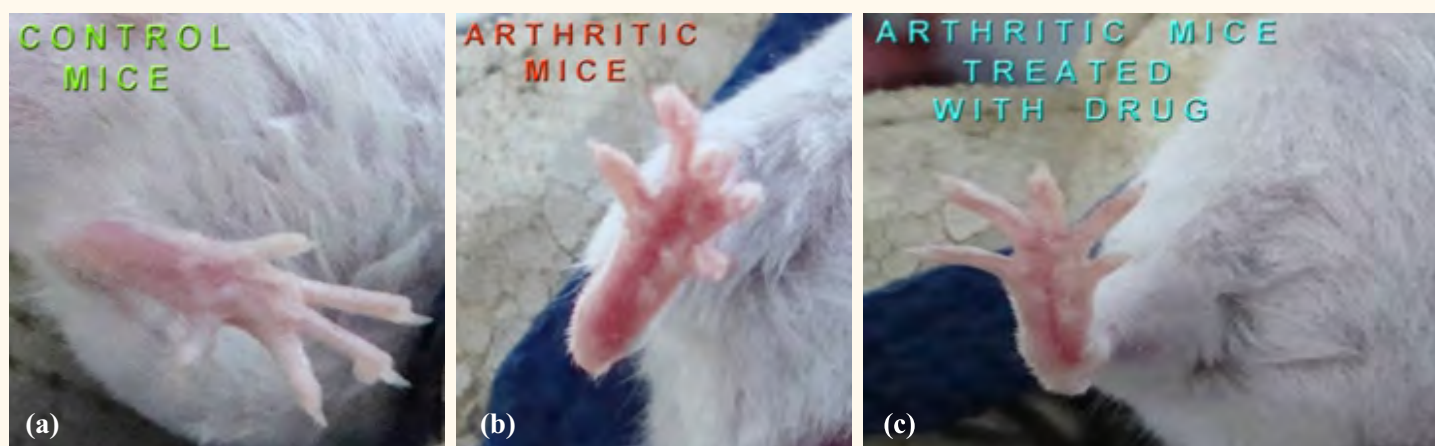
That is what makes the technology interesting. It is not simply about replacing a machine with a tree. It is about understanding how natural processes work, and designing an engineered system that allows those processes to do useful work. Sometimes the most sustainable technology is not the one that builds a bigger machine. It is the one that learns how to make nature work smarter.



HRTS implemented at Mahindra Vehicles Manufacturers Limited, Chakan

The Science of a Herbal Approach to Arthritis

A flight of stairs, a morning walk or simply holding a cup can become difficult when painful joints refuse to cooperate. Arthritis affects millions in India, creating a need for affordable ways to manage pain and inflammation. Scientists at CSIR-NEIST have developed a herbal anti-arthritis formulation using plant-derived ingredients from Northeast India, taking the innovation from laboratory research to commercial availability.



(a) Paw of normal mice, (b) Paw of Arthritic mice (inflamed and reddish), (c) Paw of mice treated with Herbal Anti-Arthritis formulation

A flight of stairs can seem surprisingly long when every step hurts. For someone living with arthritis, ordinary activities such as walking, climbing stairs or holding an object may become uncomfortable reminders of painful joints.

Arthritis is not a single disease but a broad term covering more than 100 joint and related conditions. Two of the most common forms are osteoarthritis and rheumatoid arthritis. In India, the burden is substantial: nearly one in six Indians experiences arthritis-related pain or other musculoskeletal disorders, while osteoarthritis affects more than 54 million people. Managing this burden requires treatments that are not only effective, but also affordable and accessible.

A Herbal Solution from the Northeast

Scientists at the CSIR–North East Institute of Science and Technology (CSIR-NEIST), Jorhat, developed a scientifically validated Herbal Anti-Arthritis Formulation using plant resources from the biodiversity of Northeast India.

Unlike medicines taken orally or through injections, the formulation is applied directly to the skin over affected joints. The essential oils in the formulation can penetrate the

skin rapidly, allowing the preparation to act at the affected site. The formulation contains active ingredients derived from edible plant sources and has been developed for both osteoarthritis and rheumatoid arthritis.

But how does a herbal formulation actually help with arthritis? The answer lies partly in inflammation (cause of pain). During an arthritic condition, the body's inflammatory response can become excessive, contributing to swelling, pain and tissue damage. Scientists therefore looked not only at whether the formulation reduced visible symptoms, but also at what was happening at the molecular level.

Looking Inside the Inflammatory Response

To study the formulation, researchers used a collagen-induced arthritis mouse model. In simple terms, they created controlled features of arthritis in laboratory mice so that the progression of the condition and the response to treatment could be studied systematically. The formulation and its major components were then tested in this model.

The researchers examined several inflammatory biomarkers—measurable substances in the body that indicate

how strongly an inflammatory process is taking place. Among them were TNF- α , interleukin-1 β (IL-1 β), interleukin-6 (IL-6), C-reactive protein (CRP), and matrix metalloproteinase-9 (MMP-9). In simple terms, these molecules act as indicators of inflammatory activity and, in some cases, are involved in processes that can contribute to tissue damage.

The arthritic animals showed increased levels of these markers compared with healthy animals. After treatment, the levels were reduced. The researchers also observed improvement in joint-related pathological changes. These findings provide biological evidence supporting the formulation's anti-inflammatory activity.

The study also examined gene expression, meaning whether particular genes were becoming more or less active. The expression of genes associated with inflammatory molecules such as TNF- α and IL-1 β was reduced after treatment, further supporting the observed effect on inflammation. In other words, the research suggests that the formulation does not merely provide surface-level relief; it is associated with changes in the biological pathways involved in inflammation.



Making an Affordable Product

Scientific research becomes more meaningful when people can access its outcomes. CSIR-NEIST established a Herbal Drug Production Centre on its campus and obtained the required drug manufacturing licence and statutory registrations. The anti-arthritis ointment was introduced on a no-profit-no-loss basis, keeping the product affordable while allowing licensed marketing partners a reasonable margin.

Commercial production began, and marketing rights were transferred through licensing agreements to five parties. The institute also distributed the ointment free of cost

through health camps, science and technology exhibitions, NGOs and individual requests, reaching rural, elderly and economically disadvantaged communities.

Anti-Arthritis ointment developed by CSIR-NEIST

From Laboratory to the Marketplace

The technology has now moved well beyond laboratory development. Commercial products based on the CSIR-NEIST formulation are available through technology licensees, both through retail channels and online platforms including Amazon, Flipkart, MyStore, Tata 1mg, Meesho and

IndiaMART. The work was also recognised with the CSIR Technology Award in the Life Sciences category for the development of the low-cost herbal formulation.

When Plant Science Meets Modern Validation

The story of the CSIR-NEIST formulation is not simply about finding useful plants. It is about taking plant-derived ingredients through formulation, experimental testing, biological analysis, manufacturing, technology transfer and market availability.

Patient, practitioner and licensee feedback collected over the years has reported relief from joint pain and interest in wider availability. The supplied material also records entrepreneurship and employment generated through commercialization.

The broader lesson is perhaps the most important one: natural resources can provide starting points for healthcare innovations, but their value grows when they are investigated scientifically, tested systematically and translated into usable products.

For millions living with painful joints, that journey, from plant biodiversity to a scientifically studied, affordable formulation, offers a compelling example of how indigenous research can connect nature, science and society.



Anti-Arthritis ointment developed by CSIR-NEIST

Meet C-Bot: India's Underwater Robot Tracking Coral Health

Coral reefs are among the first ecosystems to show the effects of rising temperatures, but monitoring them across large areas is difficult, costly and physically demanding. CSIR-NIO's C-Bot, an indigenous autonomous underwater robot, offers a new approach—using cameras, sensors and onboard intelligence to survey fragile reefs repeatedly, safely and at lower cost.



An AI Illustration



C-Bot during operations at Malvan and Grande island Goa

A coral reef may look still from the surface, but beneath the water it is a constantly changing ecosystem. Small changes in temperature can stress corals, causing bleaching—a whitening process that can eventually lead to their death. With nearly half of India's coral reefs reported to show signs of bleaching, monitoring their health has become increasingly important.

But there is a practical problem: how do you survey a large underwater ecosystem without sending divers everywhere? Scientists at CSIR-National Institute of Oceanography (CSIR-NIO), Goa, have developed an answer: an underwater robot called C-Bot.

Why Coral Reefs Need Continuous Monitoring

Corals are highly sensitive to environmental changes, making reefs useful indicators of climate stress. When conditions become unfavourable, corals can lose the organisms that live within their tissues, leading to bleaching.

Traditionally, reef surveys rely on trained divers who swim along fixed straight-line paths, known as transects, recording and photographing corals at selected locations. The method is effective, but it is demanding. A diver's underwater time is limited, and repeated surveys require considerable human effort.

As a result, current monitoring protocols may cover only a few transects in a month. For large and complex reef systems, scientists need a way to increase this coverage.

A Robot Designed to Swim with the Reef

C-Bot is a compact Autonomous Underwater Vehicle (AUV) designed specifically for coral-reef monitoring. Unlike a remotely operated vehicle that remains connected to a support vessel through a cable, C-Bot is a free-swimming robot. Two propellers provide forward movement, while two others control diving. This cable-free design is particularly

useful around fragile coral ecosystems, where a trailing cable could become a potential hazard.

The robot can follow straight-line transects, move across reef areas in a “lawn-mower” pattern, and hover in place like an underwater helicopter to capture detailed images. With an endurance of about six hours with its current payloads, C-Bot can remain underwater long enough to conduct extended surveys.

More Than an Underwater Camera

C-Bot is not simply a camera attached to a robot. It carries multiple sensors that help it understand where it is and what it is seeing. These include instruments that measure movement, depth, water properties, light conditions and underwater position.

An onboard computer processes this information and supports image-analysis tasks. Artificial intelligence and computer-vision tools are being used for tasks such as coral and fish segmentation—essentially helping the system distinguish organisms and features within underwater images. The robot can also use its navigation information to maintain planned survey paths and perform accurate hovering for high-resolution imaging.

From the Lab to the Reef

The technology has already been tested in the field. C-Bot has performed operations in the Malvan region of Maharashtra and around Grande Island in Goa, demonstrating its ability to work in real reef environments. Its compact design is approximately 1.12 metres long, 0.43 metres wide and 0.38 metres high, with a weight of around 45 kg and a depth rating of 200 metres.

The system is now positioned for wider deployment, with operations in Lakshadweep planned for December 2026. Longer-term development includes underwater docking and charging, which could allow the robot to remain in the water for much longer periods and reduce dependence on support vessels.

Why a Robot Could Change Reef Monitoring

The biggest advantage of C-Bot is the possibility of increasing the frequency and scale of reef surveys. At a cruising speed of about 0.5 metres per second, a low-flying reef AUV can cover a one-kilometre transect in roughly 33 minutes.

A conventional diver-based survey requires significantly more human effort and repeated dive cycles. More frequent monitoring means scientists can detect changes earlier and build better records of how reefs respond to temperature and other environmental stresses. Such information can help support conservation planning, restoration efforts, protected-area management and fisheries decisions.

A Platform Beyond Coral Reefs

Although C-Bot was designed for coral ecosystems, its modular design gives it wider potential. The platform can be adapted for seabed surveys, pipeline inspection, harbour surveillance, freshwater-dam inspection and environmental sampling. This expands its possible user base from marine scientists and conservation organisations to ports, infrastructure operators and other stakeholders. The technology has also moved towards commercialization. A technology transfer agreement with Krishna Defence & Allied Industries in December 2025 is intended to support serial manufacturing and greater indigenous production.

Watching the Ocean, One Reef at a Time

The future of ocean monitoring may not always involve sending more people underwater. Sometimes, it may involve sending a robot. By combining underwater mobility, sensors, imaging and onboard intelligence, C-Bot offers a way to monitor fragile ecosystems more frequently and with less human intervention. It also demonstrates how marine robotics can translate scientific research into practical tools for environmental protection. For coral reefs facing a rapidly changing climate, better observation is not the final solution—but it is an essential first step.

A Bottle Made from Plants: Rethinking Everyday Plastic Bottles

Plastic bottles are convenient, lightweight, and everywhere—but their persistence in the environment has made them a growing ecological concern. Scientists at CSIR-NIIST have developed a biodegradable bottle technology using plant-derived PLA-based polymer composites. The innovation combines renewable materials with existing PET bottle manufacturing technology, offering industry a practical pathway towards more sustainable packaging.



A plastic bottle may be used for only a few minutes, yet the material it is made from can remain in the environment for far longer. This mismatch lies at the heart of the global plastic-waste problem. Among the most widely used bottle materials is Polyethylene Terephthalate (PET), a strong and lightweight plastic used for products ranging from drinking water and soft drinks to edible oils and household goods. PET can be recycled, but not every bottle reaches a recycling facility. Many end up in landfills or waterways, adding to the growing burden of plastic and microplastic pollution.

The search for alternatives has therefore moved beyond simply

asking how to recycle plastic better. Scientists are also asking a different question: Can we make bottles from materials that are less dependent on fossil resources and can break down more easily? Researchers at CSIR–National Institute for Interdisciplinary Science and Technology (CSIR-NIIST) have developed a technology that takes an important step in that direction.

The Challenge of Making a Better Bottle

Replacing PET is not as simple as replacing one material with another. A commercial bottle needs to be transparent, strong, tough, dimensionally stable and easy to manufacture. Many biodegradable plastics have been developed over

the years, but matching the combination of properties offered by PET has remained difficult. The CSIR-NIIST technology addresses this challenge using Polylactic Acid (PLA)-based polymer composites.

PLA is produced from lactic acid obtained by fermenting sugars from renewable crops such as corn, sugarcane, cassava and sugar beet. Unlike conventional PET, which is derived from petroleum, PLA therefore begins with renewable plant-based resources. The researchers combine PLA with biologically derived additives in carefully controlled proportions to create a material suitable for bottle manufacturing.



A Greener Material Without a New Factory

One of the most practical features of the technology is not simply what the bottle is made from, but how it can be manufactured. Completely replacing existing production lines can be expensive for manufacturers. It can also slow down the adoption of new materials.

The CSIR-NIIST process has been designed to work with existing PET bottle manufacturing lines with minimal modifications. The processing conditions have been optimized so that the resulting bottles achieve the required mechanical strength, transparency and dimensional stability.

This compatibility could make the transition to biodegradable packaging considerably easier for manufacturers. Instead of building an entirely new production system, companies could potentially adapt infrastructure they already have.

From Water Bottles to Everyday Packaging

The potential applications extend across the packaging industry. The technology can be used to manufacture biodegradable bottles for drinking water, soft drinks, dairy products, edible oils, personal-care products, household cleaners and other FMCG applications.

This makes the innovation relevant not only to packaging manufacturers but also to beverage companies, dairy businesses and

consumer-goods industries looking for more sustainable alternatives to conventional plastic packaging.

Why This Matters

The environmental appeal of the technology comes from two directions. First, the bottles use renewable, plant-derived raw materials, reducing dependence on fossil-based resources. Second, their biodegradable nature offers an alternative for applications where collection and recycling of plastic waste remain difficult.

For manufacturers, the technology also offers an economic advantage by reducing the need for major changes to existing production infrastructure. That combination—renewable material, biodegradability and industrial compatibility—is what makes the approach particularly interesting.

Towards a Different Kind of Plastic Bottle

Plastic itself is not disappearing from modern life anytime soon. Packaging must still protect products, survive transportation and remain affordable. The challenge is to find materials that perform these jobs while creating a smaller environmental burden.

The CSIR-NIIST technology demonstrates one possible route: replace petroleum-derived plastic

with a biodegradable, plant-based material while keeping the manufacturing process familiar to industry. The transition to sustainable packaging will require many such solutions rather than a single universal replacement.

But the next time a bottle is produced using plants instead of petroleum, and manufactured on a line that already exists, it may represent something larger than a new packaging product. It may be a glimpse of how materials science can make everyday convenience more compatible with a cleaner future.



From Lab to Land: Measuring India's Readiness to Innovate

A promising laboratory idea does not automatically become a product on the market. Technology Readiness Level (TRL) assessment helps determine how close an innovation is to real-world use by examining evidence from prototype development, testing, validation and manufacturing. CSIR-NIScPR has been helping build a structured, sector-specific and nationwide ecosystem to assess technology maturity and accelerate the journey from laboratory to society.

Every year, Indian laboratories produce thousands of promising ideas: a new diagnostic kit, a disease-resistant crop variety, a water purifier, defense equipment, and so on. Some ideas remain in the laboratory, and a few become products that farmers, doctors, and industries actually use. What decides which path a technology takes?

Often, it isn't the brilliance of the idea. It is readiness. A technology that works beautifully on a lab bench may still be years away from a factory floor. Knowing exactly how far along that journey a technology has travelled, and what it still needs, is the job of Technology Readiness Level (TRL) Assessment. And CSIR-National Institute of Science Communication and Policy Research (CSIR-NIScPR) has quietly become one of India's leading institutions in making this assessment rigorous, evidence-based, and enabling nationwide adoption.

A Simple Ladder, A Powerful Idea

TRL is a nine-step ladder, originally devised by the National Aeronautics and Space Administration (NASA), that describes how mature a

technology is from TRL 1, where only a basic scientific principle has been observed, to TRL 9, where the technology is fully operational in the real world. In between lie the harder stages: building a prototype, testing it in realistic conditions, scaling it up, and proving it can be manufactured reliably.

Putting a Number to India's Technology Portfolio

CSIR-NIScPR's 'CSIR Compendium of Technologies 2021', a first-of-its-kind exercise that assessed technologies developed across CSIR's network of national laboratories and identified 313 of them as being at TRL 6 or above, meaning they were no longer just lab curiosities but genuinely close to, or ready for, the market.

These 313 technologies span eight broad sectors, from agriculture and healthcare to materials, energy, and strategic electronics. Agriculture, nutrition and biotechnology, together with mining, minerals and materials, turned out to be the biggest contributors. Around six in ten of these technologies were found to be "promising," needing further validation, while the remaining four in ten were assessed as genuinely market-ready.

Behind these numbers are real success stories. An improved, disease-resistant Samba Mahsuri rice variety with added benefit for diabetic consumers. Rapid RT-PCR kits that helped India respond to the COVID-19 pandemic. Atmospheric water generators that pull clean drinking water from humid air. A compact rotary engine for light aviation. Acoustic sensors that can detect gunfire. Each of these had to prove itself, evidence by evidence, before it earned its place on the list, which is exactly what TRL Assessment is designed to do: separate genuine readiness from promise on paper.

NETRA: From Assessment to Institutionalization

Doing a one-time exercise is useful, but India needed a standing facility that any innovator could approach. That is why, in 2023, CSIR-NIScPR partnered with the National Research Development Corporation (NRDC) to set up a TRL assessment facility, NETRA — National Establishment for Technology Readiness Assessment, at NRDC, New Delhi.

At NETRA, CSIR-NIScPR serves as the knowledge partner, bringing its expertise in TRL methodology to evaluate technologies brought in by researchers, startups, and industry. Rather than simply taking a developer's word for how mature their technology is, NETRA insists on structured evidence like test data, prototype performance, user trials, as well as manufacturing readiness, before certifying a TRL score. It also helps innovators with technology valuation and risk assessment, information that investors and licensees actively look for.

The TRL Ladder: From Idea to Impact



Figure 1: The nine-step TRL ladder, grouped into three phases of a technology's journey. The image is prepared using AI.

Inside the CSIR Compendium of Technologies, 2021

A snapshot of 313 selected and mature technology-ready CSIR innovations

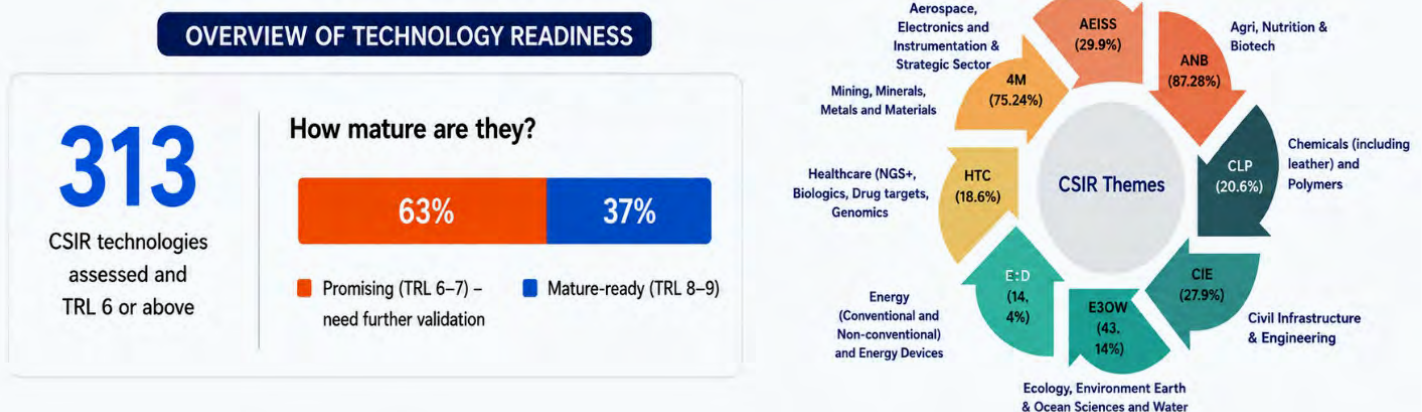


Figure 2: A snapshot of the CSIR Compendium of Technologies, 2021. The image is prepared using AI.

One Size Doesn't Fit All

A medical device, a food-processing technology, and a water-treatment system may all be called “technologies,” but the road each travels from lab to market looks nothing alike: different regulations,

different testing needs, different users. A single generic TRL scale struggles to capture this.

Recognizing this, CSIR-NIScPR has been developing and validating sector-specific TRL frameworks,

early organizations to develop and use the Technology Readiness Level (TRL) concept for assessing technologies. Recently, the Office of the Principal Scientific Adviser (PSA) has developed TRL Compass, a digital tool that allows researchers and innovators to self-assess the readiness level of their technology. CSIR-NIScPR will be a knowledge partner in this national initiative and will contribute its experience and sector-specific assessment frameworks. These frameworks will help TRL Compass assess technologies across different sectors in a more consistent and systematic manner.



Figure 4: CSIR-NIScPR's journey from a one-time study to a national assessment ecosystem. The image is prepared using AI.

tailored versions of the readiness ladder for food processing, medical devices, water technologies, agriculture, and pharmaceuticals, so that a “TRL 6” means something equally meaningful whether the technology is a vaccine or a solar

dryer.

Joining a National Movement

India is now working towards a common and transparent way of assessing how mature a technology is. CSIR-NIScPR was among the

From Readiness to Real-World Impact

As India works to develop its own technologies and become a strong and globally competitive innovation-driven country demanding new frontiers like semiconductors, drones, quantum technologies, clean energy, advanced medical devices, it is no longer enough to simply ask, “Have we developed a technology?” We also need to ask, “How ready is the technology to be used?”, “What evidence shows that it is ready?”, and “What more is needed to take it from the laboratory to people and the market?” These questions help ensure that useful technologies do not remain in the laboratory but reach society and make a real difference in people's lives.

Real Technologies That Made the List

A few of the 313 — each had to prove its readiness with evidence, not just promise



Figure 3: A few of the technologies from the Compendium, and the readiness they had to prove. The image is prepared using AI.

TRIVIA TIME

Q1. Which CSIR laboratory developed the radiation shielding technology?

- A) CSIR-NPL
- B) CSIR-CLRI
- C) CSIR-AMPRI
- D) CSIR-NEERI

Q2. Which CSIR lab is the nodal laboratory coordinating the CSIR Smart Village Initiative?

- A) CSIR-CMERI
- B) CSIR-NEERI
- C) CSIR-CBRI
- D) CSIR-NIIST

Q3. What additional feature does the IoT-enabled colposcope developed by CSIR-CEERI bring to cervical cancer screening?

- A) Automated cancer treatment
- B) Remote access to specialist support
- C) Blood pressure monitoring
- D) Surgical assistance

Q4. Which CSIR laboratory developed the mechanized drain cleaning system?

- A) CSIR-CEERI
- B) CSIR-CMERI
- C) CSIR-NGRI
- D) CSIR-CLRI

Q5. What makes the new noise barrier, developed by CSIR-CRRI, different from conventional barriers?

- A) It targets specific frequencies
- B) It uses thicker concrete
- C) It blocks all sounds equally
- D) It needs more maintenance

Q6. Which gold alloy powders did CSIR-NML develop for metal 3D printing?

- A) 10-karat and 14-karat
- B) 14-karat and 16-karat
- C) 20-karat and 24-karat
- D) 22-karat and 18-karat

Q7. What does the CSIR-NAL AWOS help airports monitor?

- A) Local weather
- B) Aircraft engines
- C) Passenger numbers
- D) Runway length

Q8. What is the main purpose of the CSIR-NGRI rain garden system?

- A) Store drinking water in tanks
- B) Recharge groundwater
- C) Increase road drainage
- D) Reduce rainfall

Q9. What does CSIR-NPL measure using its air-quality technologies?

- A) Particulate matter
- B) Rainfall levels
- C) Noise levels
- D) Wind direction

Q10. What can the CSIR-NIDSA AI system detect in paddy fields?

- A) Crop diseases
- B) Soil colour
- C) Water levels
- D) Weather changes

Q11. What banana waste does CSIR-IMMT use to make Potash-Enriched Biochar?

- A) Banana leaves
- B) Banana peels
- C) Banana peduncle
- D) Banana fruits

Q12. What powers the long-endurance drone developed by CSIR-CECRI?

- A) Hydrogen fuel cell
- B) Solar battery
- C) Diesel engine
- D) Petrol engine

Q13. What did CSIR-CGCRI develop for hip replacement surgery?

- A) Metal screws
- B) Plastic bones
- C) Surgical robots
- D) Ceramic components

Q14. What does CSIR-CSMCRI produce from seaweed for agriculture?

- A) Chemical pesticides
- B) Synthetic fertilisers
- C) Animal feed
- D) Seaweed biostimulants

Q15. What is the main climate benefit of the CSIR-IICT refrigerant technology?

- A) Lower global warming impact
- B) Higher cooling temperature
- C) Greater electricity use
- D) Longer refrigeration cycles

Q16. What does CSIR-CCMB wastewater surveillance help detect?

- A) Antimicrobial resistance
- B) Water temperature
- C) Air pollution
- D) Soil nutrients

Q17. Which CSIR laboratory discovered the Sca-1pos neutrophils?

- A) CSIR-NCL
- B) CSIR-CCMB
- C) CSIR-IICT
- D) CSIR-CDRI

Q18. Which percentage of millet flour was found suitable for the CSIR-CFTRI developed buns?

- A) 10%
- B) 15%
- C) 22%
- D) 30%

Q19. What does CSIR-CIMAP's PhytoChemX help scientists do?

- A) Grow medicinal plants
- B) Identify promising drug candidates
- C) Manufacture medicines
- D) Test medicines on patients

Q20. What technology does CSIR-IGIB use in BIRSA 101?

- A) MRI scanning
- B) CRISPR gene editing
- C) X-ray imaging
- D) Ultrasound therapy

Q21. What fuel is CSIR-NCL developing as an alternative to conventional LPG?

- A) Dimethyl Ether (DME)
- B) Hydrogen
- C) Methane
- D) Ethanol

Q22. Which CSIR lab achieved India's first harvest of raw Heeng in 2026?

- A) CSIR-CIMAP
- B) CSIR-IIIM
- C) CSIR-NBRI
- D) CSIR-IHBT

Q23. What does the CSIR-IICB fluorescent probe LipiK510 help scientists observe?

- A) Blood cells
- B) Lipid droplets
- C) Bones
- D) Nerve fibres

Q24. What brain-cleaning process does crocetin activate in CSIR-IIIM research?

- A) Digestion
- B) Blood clotting
- C) Autophagy
- D) Photosynthesis

Q25. What can FluoriPCR© developed by CSIR-IITR and CSIR-CEERI do on a single platform?

- A) Perform PCR, real-time PCR, fluorescence and UV-Visible analysis
- B) Perform microscopy, X-ray imaging, weighing and heating
- C) Perform DNA sequencing, MRI scanning, ultrasound and filtration
- D) Perform drying, grinding, mixing and chemical separation

Q26. Which protein did CSIR-IMTECH develop as an affordable indigenous clot-busting medicine?

- A) Insulin
- B) Collagen
- C) Streptokinase
- D) Haemoglobin

Q27. What does the CSIR-NBRI Composite Restoration Index (CRI) show?

- A) River water speed
- B) Number of trees in a city
- C) Restoration priority of different areas
- D) Amount of rainfall each year

Q28. What does a Head-Up Display help a pilot see?

- A) Flight path and navigation information
- B) Weather forecasts
- C) Fuel information
- D) Engine temperature

Q29. What is one major benefit of the improved soft coke technology developed by CSIR-CIMFR?

- A) Longer coking time
- B) Higher coal prices
- C) More manual work
- D) Reduce coking time and increase productivity

Q30. What does CSIR-IIP's pine needle technology convert forest pine needles into?

- A) Paper sheets
- B) Biomass briquettes
- C) Plastic products
- D) Liquid fuel

Q31. Which natural components work together in the HRTS developed by CSIR-NEERI?

- A) Plastic, metal and concrete
- B) Pipes, pumps and generators
- C) Sand, glass and chemicals
- D) Soil, microorganisms and trees

Q32. How is the herbal anti-arthritis formulation developed by CSIR-NEIST

applied?

- A) It is injected into the joint
- B) It is taken as a tablet
- C) It is applied directly to the skin
- D) It is added to drinking water

Q33. What is the main purpose of C-Bot developed by CSIR-NIO?

- A) To collect drinking water
- B) To monitor coral reef
- C) To catch fish
- D) To clean beaches

Q34. Which industries can benefit from the global trend information shared by CSIR-CLRI?

- A) Only the automobile industry
- B) Only the food industry
- C) Footwear, leather goods and accessories industries
- D) Only the construction industry

Q35. What plant-based material is used by CSIR-NIIST to develop its biodegradable bottle technology?

- A) Nylon
- B) Glass
- C) Aluminium
- D) PLA-based polymer composites

Q36. What does CSIR-NIScPR's NETRA facility help assess?

- A) Technology readiness
- B) Weather conditions
- C) Soil fertility
- D) Air pollution

Q37. What energy sources are combined in the CSIR-SERC hybrid platform?

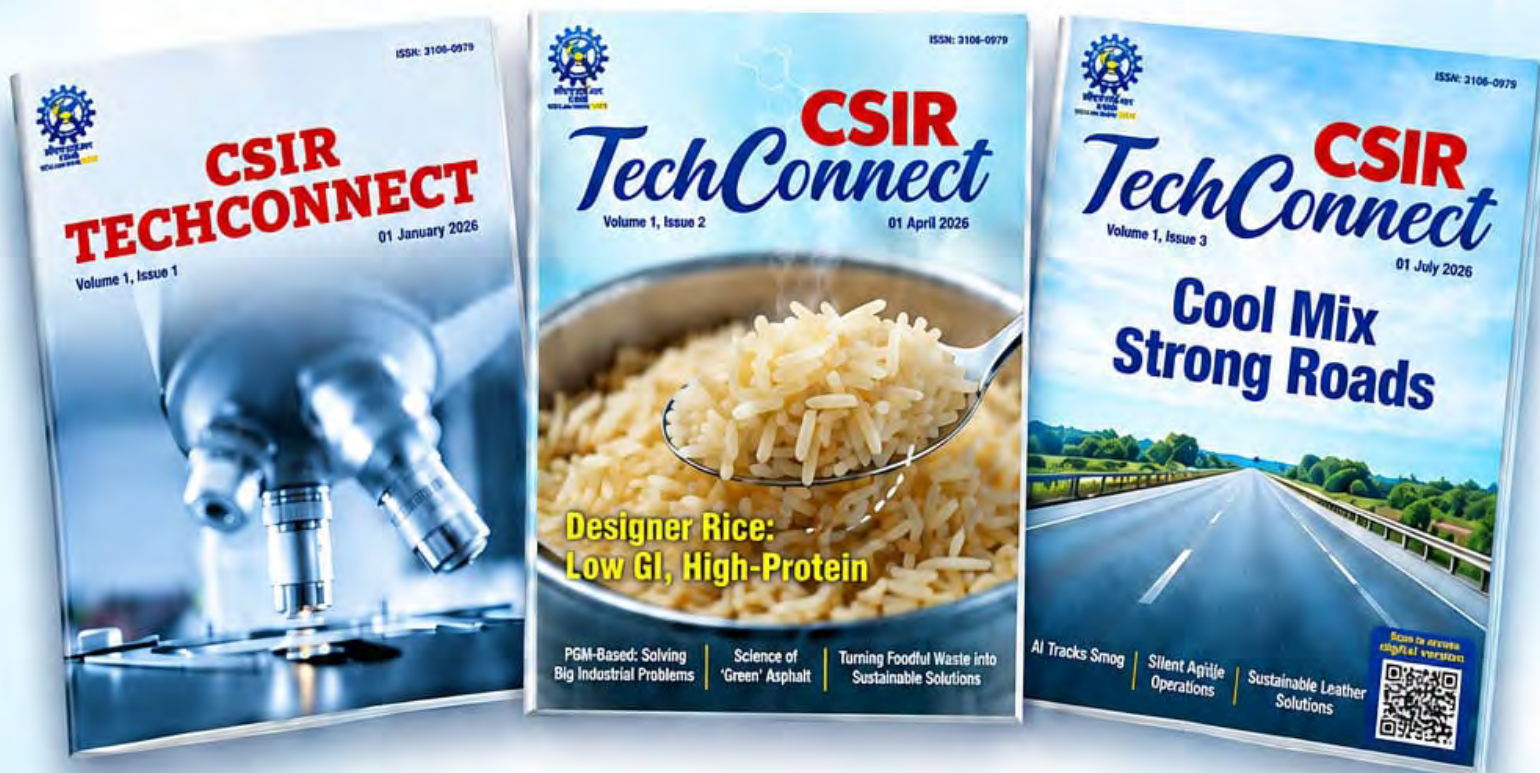
- A) Wind and solar
- B) Solar and tidal
- C) Wind and wave
- D) Tidal and geothermal

I) C, 2) C, 3) B, 4) B, 5) A, 6) D, 7) A, 8) B, 9) A, 10) A, 11) C, 12) A, 13) D, 14) D, 15) A, 16) A, 17) C, 18) D, 19) B, 20) B, 21) A, 22) D, 23) B, 24) C, 25) A, 26) C, 27) C, 28) A, 29) D, 30) B, 31) D, 32) C, 33) B, 34) C, 35) D, 36) A, 37) A

Answers

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*SciArt depicting Heliborne Geophysical Study of CSIR
Picture Credit: Prakash Kumar (CSIR-NGRI)*



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