Current Science Reports

Lightning in the Himalayas
Forecasting occurrence

The Himalayas are prone to lightning. Researchers from the Tripura University and the North Eastern Space Applications Centre, Meghalaya joined hands with researchers from Nepal recently to investigate lightning flash patterns in the Himalayan belt.

Jan Bambach via Wikimedia Commons

They collected data from various satellites and found that, in the eastern Himalayas, most lightning occurs in April. But, in the middle Himalayas, most were in May and, in the western Himalayas, in July.

The team investigated the relationship between meteorological parameters and lightning density. They found that relative and specific humidity are high in July and August in all three Himalayan regions.

The eastern Himalayas had the highest amounts of specific and relative humidity. The researchers attribute this to evaporation from a large number of water bodies in the eastern parts.

Pre-monsoon, surface air temperatures and the potential energy to develop thunderstorms are higher in the eastern and middle Himalayas, say the researchers. The potential energy available to develop thunderstorms is higher in the eastern Himalayas and least in the western Himalayas. In the western Himalayas, surface air temperature correlates with lightning flashes.

The team also examined the influence of aerosol particles on lightning. They found that aerosol concentrations were higher in winter when lightning events were lowest.

Terrain height difference, abundance of water and aerosols, and differences in vegetation are known to influence lightning. Data about these parameters is slowly accumulating to enable machine learning-based lightning forecasts. This may reduce damage to property and lives in the Himalayan regions.

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Faster Evapotranspiration
Fuelling extreme rainfall

Tree rings provide a record of past environmental changes. Trees can live for thousands of years. So it is possible to reconstruct past climates using tree ring width, relative density and tree ring reflectance. Stable carbon, hydrogen and oxygen isotopes in tree rings provide a powerful suite of additional climate proxies.

Nilendu Singh from the Wadia Institute of Himalayan Geology, Dehradun recently collaborated with researchers from other national institutes and from Germany to investigate tree-ring cores from Dokriani, a representative glacier valley of the central Himalayas.

The team analysed isotopes of carbon and oxygen in century-scale tree-ring cellulose from different plant species. The records indicated 1954 as a year of change in isotopic composition.

The team assessed decadal-scale dynamics of greening, changes in vegetation and increment in primary production by carbon dating pollen and analysing geochemical soil profiles. They found that plant communities were increasingly dominated by species from warmer regions and thus better adapted to a locally warming climate.

'The broadleaved plants were favored over conifers. This enhanced evapotranspiration,' says A. P. Dimri, JNU.

The researchers also analysed regional trends in vegetation and seasonal greening at the valley-scale using satellite remote sensing data. There were increasing trends in greening and seasonal expansion of evaporative surfaces.

Warming induced an increase in water and nutrient availability from melting glaciers and thawing permafrost. The concurrent rising of carbon dioxide levels enhanced processes such as assimilation, stomatal conductance and evapotranspiration, explain the researchers. Additional amounts of water vapour would enhance the total amount of precipitation, magnitude and frequency of extreme rainfall events.

'Frequent erratic rainfall events may be a consequence of carbon-dioxide-induced physiological activation and expansion of broadleaf vegetation,' explains Jayendra Singh, Wadia Institute of Himalayan Geology, Dehradun.

'Assessing changes in the ecophysiological behaviour of tree species could help us understand how regional hydrology changes with vegetation change,' adds Reet Kamal Tiwari, IIT Ropar.

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Groundwater Quality Assessment
Using machine learning

Arang, the town of temples in Chhattisgarh, has reasonable amounts of groundwater. But the groundwater is susceptible to pollution due to human activities. To take steps to control water pollution and to improve water management in the region, we need to predict water quality with high accuracy.

Recently, researchers from IIT (ISM) Dhanbad, CMPDIL, Bilaspur and CGWB, Patna used machine learning to predict groundwater quality in Arang. They collected 226 groundwater samples from dug and bore wells there and measured total dissolved solids and pH. Back in the lab, they measured other chemical parameters.

Usually, to develop a water quality index, experts have to provide weights for each of these factors based on their subjective understanding of how each factor impacts quality. To avoid such subjective estimates, the team decided to use the information entropy-based water quality index.

In this method, the higher the degree of dispersion of a measured value, the higher the information entropy. The entropy forms a network of information that can evaluate indirect relationships between the parameters. Unlike the case with the traditional

water quality index, the index calculated using information entropy represents the amount of disorder or more contamination. Thus, if the groundwater quality index is below 50, it is deemed excellent for drinking. From 51 to 100 it is considered good. It is moderate, if it ranges from 101 to 150. Above 200, the groundwater is unsuitable for drinking.

The computed groundwater quality index value in Arang varied from 14 to 232. Most areas had good to moderately good water quality indices. But the central, south-eastern and north-western parts of Arang had moderate to very poor quality.

'Groundwater quality deterioration is mainly due to the shallow groundwater levels and high agricultural activity there,' says Srinivas Pasupuleti, IIT (ISM) Dhanbad.

The researchers then used a deep learning algorithm, machine learning that uses multiple layers of neural networks to predict groundwater quality. The team used 82% of the data on water quality to train the model and validated it with the remaining data. They compared the prediction accuracy of their model against three other traditional machine learning models: random forest, XG boost and artificial neural network. The deep learning model achieved the highest accuracy.

The only limitation is that a single monsoon dataset is considered. Multiple season data could lead to greater insights, say the researchers.

Information entropy-based weightage of water quality parameters combined with the deep learning model can provide helpful insights for administrative steps to provide safe water.
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Dragon Fruit
A low-calorie superfood

Dragon fruit has recently become popular in India. The exotic fruit is reported to have high nutritional value. But which variety has better nutrition and which one should the farmer consider for good yield?

M. Arivalagan, G. Karunakaran and a team of researchers from the ICAR-Indian Institute of Horticultural Research, Bengaluru investigated seven popular clones cultivated in India – two had fruits with white pulp and five had red pulp.

Dragon fruit belongs to the cactus family and is propagated through stem cuttings. The researchers planted the clones in the Institute's experimental farmyard. Flowering started in 12–15 months and fruits were ready to be harvested 30–35 days after fruit set.

Fruits per pole ranged between 51 in Hirehalli White to 96 in Andaman Red. But Andaman Red yield per pole was about 10 kilos whereas Hiriyur Round Red yielded more than 30 kilos. Per hectare yield of Hiriyur Round Red was more than double that of Andaman Red.

The prices that various varieties fetch is a factor for farmers when they choose clones for cultivation. And that depends on the taste and nutritional qualities of the fruits. The researchers analysed the biochemical and nutritional constituents of dragon fruits with white and red pulp.

Pulp from red varieties had higher amounts of phenolic acids. It is also loaded with vitamins C, E and K, besides betacyanins, known to have many health benefits. Total soluble solids, including dissolved sugars and organic acids, were also higher.

'The combination of total soluble solids and acidity gives it better taste and flavour,' says Karunakaran.

Fruits with white pulp had high dietary fibre and low sugar content.

'It can be ideal for weight reduction and for diabetic patients,' says Arivalagan.

Considering fruit quality in terms of both yield and biochemical parameters, Hirehalli White was superior among the white pulped dragon fruit clones, and Hiriyur Round Red, among the red clones, say the researchers.

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Menopause Symptoms
Systematizing for better intervention

Menopause symptoms – hot flashes, vaginal drying and discomfort – are usually treated with hormones. For cases where hormonal treatment is contraindicated and for those who prefer not to use hormones, non-hormonal medications are needed. However, randomized clinical trials with such drugs, carried out in different parts of the world, are difficult to compare for drawing valid conclusions.

To systematize the approach, a project was launched in 2016 to collate a core outcome set describing a minimum dataset to be collected routinely in all treatments. Project COMMA, Core Outcomes in Menopause, included researchers from various countries including India.

They formed a steering group comprising of researchers, clinicians and postmenopausal women to examine different health issues that surface after menopause.

Recently, two such steering groups collected randomized trial outcomes related to vasomotor symptoms and genitourinary infections. The two groups assessed the data and merged any overlaps. The list contained 49 vasomotor and 48 genitourinary outcomes.

Was it comprehensive? Were there other outcomes to be included? The team conducted a survey. But most suggestions were related to psychological symptoms, say the researchers.

The steering group circulated the outcomes, with clear definitions and plain language explanations, for a second round of surveys among a wider range of stakeholders, including clinicians, researchers, academicians and postmenopausal women. In each round of survey, participants were asked to scale each outcome from 1 to 9 signifying 'not important' to 'of critical importance'. Outcomes where more than 70% scored 'of critical importance' and less than 15% scored 'not important' were considered as agreed.

When 70% thought that an outcome was 'not important', it was taken as not agreed, even if some felt it was 'of critical importance'.

The remaining outcomes in the list were taken up for further discussion among stakeholders via a virtual meeting. Finally, six vasomotor and eight genitourinary symptoms were included in the core outcome set.

The vasomotor outcome set included frequency and severity of symptoms as well as impact on sleep.

Genitourinary symptoms included vaginal dryness and discomfort, pain during urination and sex, and variation in symptoms over time.

Both categories included satisfaction and side-effects of the treatments as outcomes to be considered in clinical trials.

'If the core outcome set is followed by all treatment interventions, improved treatment options can be identified easily,' says Sunila Khandelwal, Fortis Escort Hospital.

Fish Gut Bacteria
Producing anticancer bacteriocin

Last year, Sarita Bhat and her team, from the Cochin University of Science and Technology, isolated a bacterial strain from sardine fish gut. They were delighted to find that the bacteria, *Bacillus safensis*, had high probiotic competence. Studies show that *B. safensis* is safe for pharmacological applications.

Most bacteria produce bacteriocins, peptides that restrict the growth of other bacteria. They can be promising antibacterial agents.

Some bacteriocins are also recognized anticancer agents. To check *B. safensis* bacteriocins for anticancer properties, the team from CUSAT teamed up with scientists from the Regional Cancer Centre, Thiruvananthapuram. They optimized the production medium to harvest bacteriocins from the bacteria.

The researchers then tested the cytotoxicity and anti-cancer activity of the bacteriocin on cell lines from the National Centre for Cell Science, Pune. About 100 samples with different concentrations of bacteriocin were incubated for one, two and three days.

The team found that 80 micrograms per milliliter restricted cancer cell proliferation but normal cell growth was not affected.

The researchers then conducted molecular simulation and docking studies with the bacteriocin and two receptors, Death Receptor 5 and Transforming Growth Factor-β, popular targets for anti-cancer therapy. The bacteriocin was found to be capable of inducing programmed cell death – the property of self-destruction of malfunctioning cells – a property that cancer cells generally lack.

'The bacteriocin has many positively charged amino acids. So, it can specifically target negatively charged cancer cell surfaces,' says Sarita Bhat, CUSAT.

Pharmaceutical companies now have a candidate for an anticancer drug.

Nano-powders for Forensics
Anti-counterfeiting and fingerprinting

Fingerprints are essential evidence that helps catch culprits. To make invisible fingerprints visible, special powders are sprinkled over surfaces and dusted with fine brushes. However, commonly used nano-powders are costly. And the prints developed are of low-resolution.

Advances in forensics have revealed that doping luminescent material with rare-earth metals can form powders yielding higher resolutions.

Researchers from Bengaluru and Tumkur teamed up recently, to prepare a nano-powder by doping the rare metal, terbium, with a green luminescent strontium aluminate.

To varying ratios of terbium and strontium aluminates, they added papaya plant latex as surfactant. The latex contains many bioactive compounds which help enhance the visibility of fingerprints.

The mixture was kept in a muffle furnace to make it into powder form. The team analysed the structural properties of the powder using various techniques. As the amount of papaya latex increased from 5% to 30%, the team observed a change in structure from an agglomeration to rods and then to more ordered flower-like structures.

'The strontium particles doped well with terbium,' exclaims Daruka Prasad, BMS Institute of Technology and Management, Bengaluru.

Using a fluorimeter, the team examined the luminescence properties of the powder.

'Strontium aluminate, doped with terbium to a seven mol per cent level, showed highest luminescence,' says Prasant S. Chandra, East West Institute of Technology, Bengaluru.

The material absorbed light of various frequencies between 300 to 400 nanometres and had strong emission at 545 nanometres which to us appears green. It has potential for application as LEDs, say the researchers.

Not satisfied with only one application, the researchers went on to test the material for application in visualizing fingerprints on various types of surfaces and compared the results with the fingerprints revealed using conventional powders.

'Using our nano-powder, we developed fingerprints with high-resolution and high luminescence,' says H. Nagabhushana, Tumkur University.

The researchers explored yet another application with the nano-powder: invisible ink. The team dispersed the prepared nano-powder in gold media of polyvinyl alcohol, an emulsifier, to make invisible ink. Using this ink, they made symbols over different surfaces.

'The symbols become visible as green fluorescence when 254 nanometre UV light falls on the surfaces. And the invisible ink remained on the surface for over three months without fading,' says H. B. Premkumar, M.S. Ramaiah University of Applied Sciences, Bengaluru.

Such inks can be applied to currency notes, tickets, or legal documents to reduce forgery and increase security, suggest the researchers.

'With the same starting material, we have three applications: Invisible ink, powder for fingerprinting and material for optical displays,' beams K. R. Ashwini, BMS Institute of Technology and Management, Bengaluru.

Intelligent Transport
Energy efficient network

In the last five years, motor vehicle accidents in India killed 7 lakhs and around 24 lakhs were injured. Speeding, drunken driving and breaking other traffic rules are major causes of accidents. To reduce accidents, we need an intelligent transportation system.

Researchers from Anna University and the SRM Institute of Science and Technology, Chennai, in collaboration with a university in the UK, recently proposed such a system. They installed sensors and tamper-proof devices in vehicles to collect and sort encrypted data. The data is generated only after the vehicles are registered.

A certificate authority for a vehicular ad hoc network then issues a secure ID to each vehicle. Roadside units collect personal IDs and generate end-to-end encrypted group IDs for vehicles in the same area. The collaborative network provides navigation and safe driving tips.

But sharing this information sometimes threatens the location privacy of vehicles – malicious drivers may use the information to launch attacks and cause accidents.

To overcome the problem, the researchers developed a private collaborative intrusion detection system, using roadside units and software-defined vehicular networks. If a malicious vehicle sends misinformation to another vehicle in the group, the roadside unit verifies the information with information from other vehicles.

If the information is not correct, the certificate authority revokes the malicious vehicle's ID and disconnects it from the network. The certificate authority also alerts all roadside units about any malicious vehicle activity. Then a network is re-established with other vehicles in the group by generating a new group ID.

The researchers say that the system consumes less energy and data than the current centralized network system. The system establishes localized connections with roadside units and does not store information it learns by collaboration among vehicles in the group.

'The system helps navigate traffic and reduces accidents,' says Sudha Anbalagan, SRM Institute of Science and Technology, Chennai.

But sharing information requires internet connectivity, difficult to achieve during fast mobility on highways with inadequate coverage by mobile network towers.

'Our collaborative network system can also be implemented in railways and air transport systems,' says Gunasekaran Raja, Anna University, Chennai.

Catalyst for Hydrogen Fuel
Hybrid cobalt sulphide

As per a Greenpeace report, pollution due to fossil fuels costs the world 60 thousand crore rupees every day. Hydrogen fuel is a clean alternative to fossil fuels. Hydrogen can be produced by electrolysis of water – a cheap raw material. The platinum group of metals used as electrocatalysts for the purpose works well in acidic medium but is costly. And catalysts useful in alkaline medium are not durable.

To improve efficiency, C. Manjunatha from the Centre for Hydrogen and Green Technology Research, Bengaluru and colleagues from Norway and Saudi Arabia decided to look for a catalyst that can withstand high currents and temperatures.

Cobalt is a transition metal and its compounds with elements from group 6a of the periodic table are extensively studied for use as electrocatalysts. Such materials show good conductivity, mechanical and thermal stability. The team took cobalt sulphide as their primary material.

As particle size reduces, surface-to-volume ratio increases and catalytic sites per gram of the substance increase, the researchers reasoned.

Doping nanoparticles is known to impact their performance. So the researchers added cobalt selenide in various proportions to create hybrid nanoparticles, using the hydrothermal process – chemical reactions in water at high temperature.

Cobalt sulphide particles ranged from 30 to 80 nanometres and cobalt selenium particles from 20 to 90 nanometres.

'But the hybrid had nanoparticles and nanoflakes,' says S. Laxmikant, RV College of Engineering, Bengaluru.

The team then tested the nanocomposites using the oxygen evolution reaction.

'The best result was with a hybrid containing a hundred parts of cobalt sulphide and 85 parts of cobalt selenium,' says L. Shreenivasa, Dayananda Sagar University, Bengaluru.

'When deposited on one square centimetre of stainless steel, the hybrid nanocomposite had an electrochemically active surface area of 210 square centimetres,' says B. W. Shivraj, RV College of Engineering.

Recording current with time showed that the cobalt sulphide–selenide hybrid composite had excellent stability at high current density. The hybrid catalyst was stable even after a 30-hour testing. Thus, the synergistic chemical coupling of cobalt sulphide and cobalt selenide overcomes the cost and durability limitations of other catalysts.

Materials with such properties are potential replacements in batteries, supercapacitors, and fuel cells, says C. Manjunatha, Centre for Hydrogen and Green Technology Research, Bengaluru.