

Current Science Reports

Exoplanet Hunting

Direct imaging

So far, more than 4200 planets have been discovered around stars. Most were detected from typical changes in the star's radial velocity and the movement of the planets across the stellar disc. But planets far away from the star often go undetected.

Recently, quite a few supermassive planets, far from their young host stars, have been detected by direct imaging. These planets are hot and self-luminescent, making them amenable to spectral characterisation. Spectral analysis helps us understand the elemental composition of planets. And this, in turn, allows us to test theoretical models of planetary formation.

Out of about 50 directly imaged planets, researchers from the Indian Institute of Astrophysics, Bengaluru, and TIFR Mumbai selected 18 such planet hosting stars – those with publicly available spectra.

'The spectrum helps uncover not only the mysteries of the planets but also those of their parent star,' explains Mayank Narang, TIFR Mumbai.

'The elements which create a planet are commonly found on the parent star too,' adds C. Swastik, Indian Institute of Astrophysics. So the metallicity measured by the ratio of iron to hydrogen content of the parent star can tell us about the type of planet likely to be formed around the star.

Out of 18 such planet hosting stars, 12 had higher metallicity than our sun. Planets that are up to five times or more massive than our Jupiter are generally found around metal-rich stars. However, with more massive planets, the relationship breaks down.

This, the researchers say, may reflect two possible pathways of planetary formation: one due to core accretion from the planetary disc and the other due to gravitational fragmentation of the disc.

Super massive planets that are only a few million years old, far away from their young host stars are slowly help-

ing us refine our theories of planet formation.

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Seismic Risk in Guwahati

Microzonation of metropolitan areas

Guwahati, the largest metropolitan city in north eastern India, has contrasting geological foundations – a few hilly terrains enclosing the Brahmaputra alluvium. Alluvial soils are vulnerable to wave motion triggered by earthquakes. But hills with rocky basements may not be so easily swayed.

Can microzonation maps assess seismic susceptibility to urban structures? I. D. Gupta, an independent researcher from Pune, along with researchers from the US recently created a microzonation map of Guwahati region, using IndiaEQRISK, a computer program.

They superimposed cells of uniform size over the map of the North East and the Burmese region, assuming that the impact of the earthquakes within each cell would be uniform. Then they calculated the probability of earthquake occurrence in each cell based on 10 and 50 years data of earthquakes. They also factored in the recurrence time of earthquakes of different amplitudes. Almost two-thirds of earthquake risks are on alluvial sediments rather than on rocky and intermediate geological sites, they found.

Seismic risk is strongly dependent on earthquake likelihood and epicentre. Even earthquakes caused by the slipping of plates in the far away Burmese region can generate ground tremors with amplified effects in alluvial soils, creating risks to urban structures. So they further refined their calculations by including attenuations of spectral amplitudes of earthquakes from different regions.

Some earthquakes from the north-east had similar magnitudes and overlapping hypocentral distances with earthquakes in the Burmese region. The team decoupled the earthquake effects of both regions on Guwahati. Short period spectral amplitudes are

mainly from the local north east seismicity. The intermediate and long period spectral amplitudes get significant contributions from the high magnitude Burmese earthquakes. Burmese earthquakes enhance the hazard spectrum amplitude ratio by a factor of up to 1.36, say the researchers. Thankfully, high magnitude earthquakes in the Burmese regions are not frequent.

The microzonation map of the Guwahati metropolitan area can now be used to make informed decisions while constructing urban structures.

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Environment and Fishery

Impact on landings

Recently, scientists from the Central Marine Fisheries Research Institute, Kochi and the Kerala Agricultural University teamed up to explore how environmental changes impact fisheries on the Kerala coast. They collected fishery data from landing sites and environmental parameters from remote sensing. Then they tested the effects of 36 environmental parameters on five major fishery resources – Indian mackerel, lesser sardines, anchovies, scads, and penaeid prawns.

They analysed the parameters that influence the catch most, and identified 13. The team tested the effects of these parameters on the fish landings.

Fish catch was the maximum when sea surface temperature hovered around 25–27°C. Catch, for all fish groups, decreased along with increase in sea surface temperature. Similarly, increase in degree cooling month favours fish catch.

'Decrease in catch with increase in sea surface temperature shows that the warming of coastal waters harms fishery,' says P. Punya, Central Marine Fisheries Research Institute, Kochi.

Changes in current direction may decrease catch for the Indian mackerel, but increase penaeid prawn landing. Besides change in current direction, chlorophyll, salinity and rainfall also favoured penaeid prawn catches.

Rainfall tended to increase scad fish landing. But lesser sardine and anchovy fishery decreased with increase in rainfall.

Monitoring these parameters can provide fishers daily tips on potential catch.

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Groundwater in Kozhikode *Recharged by rain?*

Kozhikode is the second largest urban settlement in Kerala. Large scale urbanisation has reduced surface area for groundwater recharge.

There are many ponds and lakes in the area and two rivers that join the Arabian Sea. So, surface water could be a potential source for groundwater recharge. The area gets rain from both the southwest and the northeast monsoon. The rain could also be a source of the water underground. How can we understand the contributions from these sources?

Researchers from the Centre for Water Resources Development and Management, KUFOS, Kerala investigated using isotopes of hydrogen and oxygen in water. The hydrogen isotope with one extra neutron and the oxygen isotope with two extra protons are heavier. So water containing these atoms evaporates more slowly. Slowly, the isotopes get enriched in the sea. Both isotopes have long half-lives and are stable in time.

The researchers collected water samples from all potential sources of groundwater as well as rainwater and analysed isotope ratios. There was a higher percentage of heavier isotopes in summer monsoon rainfall than in November–December rainfall.

‘This is because the initial rain is from moisture from the sea enriched in isotopes and, later, it is from moisture evaporated from land,’ explains T. R. Resmi, CWRDM.

Analysis of isotopic composition confirmed a close association between rainwater and groundwater in the area. Surface water contribution to groundwater is very low. The variations in the contributions to groundwater recharge were due to geological factors.

The team found significant changes in land use and land cover from 2008

to 2018. Urban settlement area increased more than threefold, along with decrease in vegetation and water bodies.

‘To restrict the polluting of water, high surface water recharge areas need monitoring,’ says Girish Gopinath, KUFOS.

‘Areas with high groundwater recharge from rainfall need greater free surface. We must pay attention to groundwater recharge processes during infrastructure development,’ says N. P. Jesiya, CWRDM, Kerala.

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Managed Aquifer Recharge *Groundwater improvement*

Groundwater depletion and frequent floods are major concerns in the Ganges Basin. Can we use floods to recharge groundwater?

Sunil Kumar Jha and team from the Central Soil Salinity Research Institute, Lucknow collaborated with researchers from the International Water Management Institute to investigate.

They chose Jiwai Jadid village, Uttar Pradesh, serviced by the Krishi Vigyan Kendra at Rampur. The soil there is clayey with poor water infiltration. The area has many mostly dry community ponds. The team decided to use these to improve water infiltration.

They constructed 10 groundwater recharge wells in the dry ponds into which they diverted flood water from the Pilakhar minor canal through a desilting chamber. The team monitored siltation, water level and flood and groundwater quality. To monitor groundwater flow direction, they used modelling software.

Recharge rates initially increased about two and half fold in 2017. But to about two fold in 2018. The researchers attribute this reduction to the clogging of the recharge wells by siltation.

The chemical parameters of the groundwater were within permissible limits. So, the water is suitable for drinking and irrigation.

The techniques can be applied in similar hydrogeological conditions in the other parts of the Gangetic plains

to minimize flood impact and improve groundwater, say the researchers.

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Ionome Profiling of Jackfruit *Geographical identification*

Jackfruit, indigenous to the humid tropics, is a nutritionally rich fruit crop. Most popular jackfruit varieties are identified by the names of the growing region with specific names which indicate fruit quality.

Jackfruit is rich in minerals like calcium, zinc, potassium, iron and sodium. Can we use mineral content, or the ionome, to identify the jackfruit variety?

Nadia Debbarma and her team from the Sikkim University collaborated with ICAR-Indian Institute Spices Research, Kozhikode, the Central University of Tamil Nadu and the Dr YSR Horticultural University, Tadepalligudam to profile jackfruit ionome and to test its use as a marker for geographical origin.

They selected fruit and soil samples from seven locations in five states to explore the ionomes of different jackfruit germplasm. Using inductively coupled plasma mass spectrometry, they identified the total ionic content in the samples. There were 24 elements with significant differences in both soil and fruits.

The team found that each region has significant differences in soil nutrient content and fruit nutrient profile in all the nutrients analysed. They also found correlations between soil and fruit ionome, indicating the major influence of germplasm and other locational factors.

‘The ionome of the fruit is a good indicator of geographical origin,’ says Nadia Debbarma, Sikkim University.

‘The elemental signature from each genotype would be useful in breeding biofortified jackfruit,’ adds Subramanian Manivannan, Central University of Tamil Nadu.

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Detecting Natural Mango Ripening *Furaneol polymer sensor*

The tempting aroma of naturally ripened mangoes comes from furaneol, an organic molecule. Can furaneol be

used as biomarker for detecting ripening in mangoes, wondered Barnali Ghatak and her team from the Jadavpur University, Kolkata.

They collaborated with IIT Bombay and the GLA University, Mathura, to design a sensor using poly-methacrylic acid which has high affinity for furaneol. The team used molecular imprinting to create micro-holes in the polymer to bind the furaneol.

To check the sensor's selectivity, they exposed it to a solution of furaneol and other compounds in mangoes. The sensor was highly selective to furaneol, showing 85% specificity.

Often, mangoes are artificially ripened. Calcium carbide is commonly used to hasten the process. Consuming mangoes thus ripened can cause headaches, memory loss, cerebral oedema and seizures. Such artificially ripened mangoes have hardly any furaneol. Could the sensor discriminate between naturally and artificially ripened mangoes?

To find out, the team used the sensor on Amarapally, Himsagar and Langda mangoes. They allowed one group of mangoes to ripen naturally. For another, they used calcium carbide. The sensor accurately identified natural ripening in pulp from both groups.

The analytical performance of the sensor was very high and accurate. And Fourier-transform infrared spectroscopy revealed that the polymer sensor has a stable structure.

'Our sensor is cost effective for distinguishing naturally ripened mangoes,' says Barnali Ghatak, Jadavpur University, Kolkata.

'Mango processing industries may find it useful to control the quality of raw materials,' says Panchanan Pramanik, GLA University, Mathura.

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Proteins from Pumpkin Seeds *Source of essential amino acids*

Though proteins are abundant in plants, some essential amino acids are often missing in plant products. Lentils, the major source of protein in traditional Indian vegetarian diets, for example, do not have adequate amounts of all essential amino acids. This nutri-

tional deficiency affects development in children and predisposes adults to various diseases.

Prasanna Vasu and S. Vinayashree, from CSIR-Central Food Technological Research Institute, Mysuru have now come up with a solution to the problem: pumpkin seeds.

Pumpkin refers to three different species, each with distinct varieties. The variety Kashi Harit, of *Cucurbita moschata*, has become popular in many parts of India in recent decades. But the nutritional value of the seeds has not been investigated.

So the team isolated total protein from the seeds of Kashi Harit and found high protein content. The proteins were easily digestible and all essential amino acids were present. Except for one essential amino acid, all were high enough to satisfy the essential amino-acid percentage recommended by the WHO.

Antinutritional factors, if present in the seeds, can reduce the nutrient uptake by the body. So the team investigated further. And found that protein inhibitors were absent. However, antinutrients such as tannins and phytic acids were present, in low amounts. Heating the seeds or fermenting them can reduce the antinutritional factors, say the researchers.

The seed proteins had high emulsifying activity. This keeps the protein stable during processing for food applications. So Kashi Harit seeds, a good vegan protein source, can be included in health food formulations, to meet the daily requirements of essential amino acids for children and adults.

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De-bittering Giloy *Using ultrasonics*

Giloy, *Tinospora cordifolia*, is highly valued for its medicinal properties. But diterpenoids in the herb make it bitter, hindering its use in food products.

Heena Sharma and team from the National Dairy Research Institute, Karnal took up the challenge of eliminating the herb's bitterness without altering its bioactivity.

After peeling the bark, they processed the herb into powder, extract

and juice. Efforts to de-bitter giloy powder and extract were unsuccessful. So the team focused on the juice.

Beta-cyclodextrin, a polysaccharide, lowers bitterness in bitter gourd. Beta-cyclodextrin has a hydrophobic conical cavity, which accommodates diterpenoids, masking their bitter taste. So the researchers added some to giloy juice.

Stirring the mixture with a magnetic stirrer to aid the reaction turned out to be slow. Use of a sonicator bath to mix the juice reduced the time from 12 hours to 30 minutes. So to speed up the process, they used ultrasound to reduce the debittering time to 10 minutes.

Sensory experts then tasted the juice. The bitterness was reduced, but still detectable.

Turmeric is used traditionally to reduce the bitterness of bitter gourd. So Heena Sharma tried treating peeled giloy stem with minimal amounts of turmeric when preparing the juice.

She repeated the entire process. It worked!

Combining turmeric powder, beta-cyclodextrin and ultrasonication helped mask the juice's bitterness completely.

They analysed changes in pH, acidity, total solids and colour but found no significant difference. Testing the juice at different temperatures, the researchers found it thermally stable for food application.

However, there was significantly high phenolic and flavonoid content in the sample.

'This can be due to the release of bound phenolics in the juice,' explains Gaurav Kumar Deshwal, ICAR-NDRI, Karnal.

'Food industries can use ultrasonication to make giloy-based food products more palatable and flavonoids increase the nutraceutical value,' adds Heena Sharma, his colleague.

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Depression and Carbon Metabolism *A study in Haryana*

Depression, the second leading cause of disability, is complex. Though causative mechanisms are poorly understood, recently some important biomarkers have been identified: low

levels of homocysteine, folate and vitamin B12.

Gurjinder Kaur from the Panjab University teamed up with researchers from the University of Delhi to understand how these impact depression in Palwal district, Haryana.

They selected 800 individuals, aged 30 to 70, from the largely vegetarian population in 15 villages there. The prevalence of depression was higher among females, the illiterate and those with low socioeconomic status.

'Increased economic opportunities especially for women, can reduce the incidence of depression in rural communities,' says Mamta Kumar Thakur, University of Delhi

The team measured homocysteine, folate and vitamin B12 levels in the sample.

'Vitamin B12 and folate deficiency posed increased risk for severe depression in our sample,' says Gurjinder Kaur, Panjab University.

An increase in folate plays a compensatory role for vitamin B12 deficiency in depressed individuals. 'Nutritional intervention can play an important role in reducing depression in the district,' says Rajan Gaur, Panjab University.

Mutations in the gene that codes for the enzyme that breaks down homocysteine and folate are also associated with depression. But the team did not find any such mutations in the sample population.

'Cases of depression in the district have no genetic basis. However, interventions to overcome social stigma related to mental health are needed to facilitate understanding of the nutritional and social causes of depression in Palwal district,' adds K. N. Saraswathy, Delhi University.

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Clean Electricity

Cutting pollutants from power-plants

Energy use has doubled since the last two decades. In India 60 per cent of power is generated from coal. Coal-based power plants emit harmful gases such as sulphur dioxide, nitrogen oxides, carbon monoxide and fine particulate matter into the atmosphere.

And that impacts public health, especially in winter, when pollution mixes with fog to create smog.

To study how coal-based power generation impacts air pollutant concentrations and associated mortality across India, Sri Harsha Kota from the IIT, Delhi collaborated with universities in China and the USA.

The researchers simulated models to test three pollution controlling scenarios. In scenario I, emission control regulations proposed by the government are implemented across coal-based power plants. This led to a reduction of all pollutants and up to 9 micrograms per cubic metre particulate matter in all seasons.

Emission control regulations were implemented only in under-construction power plants. In scenarios II and III, the team assumed that new coal based plants were cancelled. In both, there was an increase in pollutant concentrations.

The simulations predicted that implementing emission control regulations in existing plants can save around 73 thousand lives and increase human lifespan by about 1.7 years.

Implementing pollution control technology in power plants could increase the cost of coal-based electricity. But the cost on public health is far greater, if stringent regulations are not implemented, say the researchers.

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Tumbling into Tagore Tunes

Figuring fractals

Tagore's songs, Rabindra Sangeet, have been sung and listened to for more than a century. What makes some songs survive and evolve? What are the characteristics of such songs? Researchers from Jadavpur University, IIT Kharagpur and Canada investigated.

They chose four popular Tagore songs sung by five singers from different generations. Splitting the songs into phrases, they selected a 45-second segment from each song sung by different artists.

Music exhibits self-similar patterns or a fractal structure. So does literature. When combined, we must expect

a multifractal structure. So, the team measured changes in the fractal dimensions of the segments.

'From the analysis, we calculated the multifractal width of the spectrum for each segment. As the width increased, so did the multifractality of the acoustic signals,' says Shankha Sanyal, Jadavpur University.

The singers' styles in the first two parts were similar as deduced from the small width. The song's rendering in the end showed larger width, signifying variations in the song through generations.

The team also noticed smaller width in complex notes among singers from different generations: complex musical structures are transmitted with more fidelity.

How do the songs affect the brain – another fractal structure? The researchers selected two songs sung by different artists and used electroencephalography to check neural responses in five volunteers.

Segments with similar spectral width aroused emotions to the same extent. Signals from the frontal and temporal lobes for both songs sung in similar style showed the same brain response. The team could also detect distinct asymmetry between left and right lobe responses.

Lyrical imagery provoked elevated response from the brain's occipital lobe. Responses to song segments by different vocalists remained the same.

'Understanding the relation of music and literature to brain responses may help create artificial neural networks to detect long lasting aesthetic structures,' says Archi Banerjee, IIT Kharagpur.

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Reports by: Iqra Rahim, D. C. Jhariya, G. Sharath Chandra, Ravi Mishra, Sileesh Mullasser, K. Sri Manjari, Shwetakshi Mishra, Manish Kumar Tekam, Nadiya Manzoor, Tahera Arjumand, Aradhana L. Hans and Pushpsen Satyarthi

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scienceandmediaworkshops@gmail.com