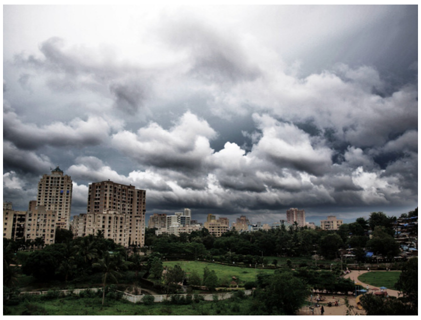
Current Science Reports

Monsoon Microphysics

Rain in Chennai and Mumbai

Mumbai is pounded by the southwest monsoon from June to September. From October to December, Chennai gets drenched by the northeast monsoon. How does rainfall differ in these cities?



Sachin Jadhav via flickr

Kaustav Chakravarty from IITM Pune collaborated with researchers from three other institutions in India to investigate. They used disdrometers, which provide raindrop size distribution, and data from weather stations in both cities.

Raindrops form, evaporate and re-form by condensation, accumulation and collision. During the southwest monsoon, Mumbai had the smallest drops. Chennai had mid-sized raindrops.

During the northeast monsoon, however, the cities trended differently at different rain rates. At lower rates, drops were larger in Chennai. In Mumbai, drops were larger at higher rates.

The northeast monsoon in Mumbai comes from continental clouds drifting in from the southeast. As continental clouds travel over land, they accumulate vapour. This increases the diameter of cloud droplets.

During the southwest monsoon, Chennai witnessed more convective rain – intense due to the accumulation of water vapour over the vertical region of convection, covering a small area. And it was more than Mumbai's share.

This is because Chennai has higher surface temperature, say the researchers.

Chennai received larger drops in the afternoon during the southwest monsoon. More surface heating around noon leads to rapid evaporation, generating sufficient water vapour in the atmosphere from June to September.

In October, there were sharp rainfall peaks over Mumbai. The daytime-specific variations were associated with continental rainfall.

Thus, there are key differences in the rain microphysics. These microphysical properties are useful inputs in earth system models for mapping urban rainfall patterns, say the researchers.

DOI: 10.1016/j.atmosres.2020.105313

Mariculture in India

Suitable sites in Gujarat

Mariculture, cultivating organisms in the open sea using cages or tanks, is popular given the increasing demand for seafood. The estimated marine production capacity in India is 4–8 million tonnes. But current production is negligible.

To identify the best locations, many constraints need to be considered. Wind, waves, currents and tides determine suitability. Mariculture should also not clash with traditional fishing, maritime traffic and offshore pipelines. It is in such situations that geographic information-based multi-criteria tools can be of help.

Recently, researchers from the ICAR-CMFRI and the K. L. University, Guntur developed a geographic information system-based decision support model and a spatial framework for selecting cage farm sites in the offshore waters at Gujarat.

They divided the coast, based on landforms and oceanography. Then came the laborious process of collecting data on suitability parameters, including remote sensing data from oceanographic parameters and secondary data from scientific literature. The team double-checked secondary data with *in situ* data. Social and infrastructural data were collected with a field survey and from national marine fisheries census data.

The researchers input the data into the model builder in ArcGIS, a geographic information system that generates site suitability maps, by eliminating constraint areas.

More than a fourth of the 24,000 square kilometres of open sea in the territorial waters of Gujarat has suitable sites and another fourth is moderately suitable.

'The most potential sites are along the Saurashtra region. The Gulf of Khambhat has the least,' says D. N. Divu, CMFRI.

'Structural stability levels for the culture system, topographic and socio-infrastructural unsuitability are major hurdles,' says A. Gopalakrishnan, CMFRI.

The method can now be used to find suitable mariculture areas in other coastal regions. Cooperative mariculture can reduce risk for fishers, lifting millions in coastal regions from poverty. And it can make Indian fisheries sustainable.

DOI: 10.1016/j.jclepro.2020.124760

Teesta River Valley Project

Sub watershed-treatment

The Teesta River starts in Sikkim and flows through West Bengal. The river basin has unstable slopes and endures high intensity rainfall. Unwise land use also contributes to high soil erosion in the region. This poses a serious threat to the agriculture-driven economy there.

Hulksr51 via Wikimedia Commons

To tackle the issue, the state government drafted the Teesta River Valley Project in 1977. To prioritize sub-watersheds requiring rapid treatment on the basis of sediment yield per unit area, reconnaissance surveys were carried out in Darjeeling and adjacent Sikkim. And the State Forest Department developed infrastructure to minimise soil erosion. The Department undertook agronomic and engineering measures to reduce runoff, allowing soil cover to evolve slowly.

In 2013, a researcher from the University of Delhi conducted ground surveys to study the impact of sub-watershed treatment and on-farm soil conservation measures on agriculture to compare farm profits between treated and untreated sub-watersheds. Sub-watershed treatment increased profits marginally in high and medium-erosion prone areas. However, the change in on-farm profits was insignificant in very high erosion-prone sub-watersheds. This could be because farmers did not put in optimal efforts to conserve soil on their plots.

'Restricted land area under the State Forest Department, pre-existing private property rights in agricultural lands and limited participation of farmers impeded efforts,' says Chandan Singha, University of Delhi.

Farmers find it hard to bear the costs of afforestation and stone-fencing on their plots, especially when the government does not provide financial incentives for these measures.

DOI: 10.1016/j.landusepol.2020.105089

Foliar Nitrogen and Carbon

Mapping spatial variability in sal

For sal trees, nitrogen content in canopy foliage increases from bottom to top and carbon stock increases as the trees mature and then declines. Foliar nitrogen and carbon are important parameters that indicate forest health.

In sal forests, spatial variation in foliar nitrogen and carbon occurs due to phenological conditions, site and soil quality and pest infestations. So, mapping this spatial variability can help monitor and manage sal forests. Remote sensing with machine learning algorithms is used to map the spatial variability of the biophysical and biochemical properties of vegetation.

Recently, Vaishali Vasudeva and colleagues from the Indian Institute of Remote Sensing, ISRO, Dehradun investigated the applicability of various machine learning algorithms to map the spatial variability of foliar nitrogen and carbon in sal.

They took Sentinel-2 data of a sal forest in the northwest Himalayan foothills and sal leaf samples to analyse the percentage of nitrogen and carbon. They established empirical relationships between satellite data-derived spectral indices, band reflectance and ground measured foliar nitrogen and carbon. And found a strong relationship between foliar nitrogen, the shortwave infrared-1 band, and the normalized difference red edge index. However, foliar carbon was strongly related to the shortwave infrared-1 band and other indices.

Then they tried to predict nitrogen and carbon content for a larger area using random forest, artificial neural networks and support vector machines. Random forest models performed better than artificial neural networks and support vector machine models.

The model can now be tested on sal forests in other regions and even be adapted to map the spatial variability of foliar nitrogen and carbon in other types of tropical forests using the broad bands of Sentinel-2.

DOI: 10.1080/01431161.2020.1823043

Papaya Leaf Curl Disease

Through chilli virus

Begomovirus in papaya causes leaf curl disease, leading to significant loss for farmers. The virus can be bipartite with DNA-A and DNA-B or monopartite with only DNA-A and beta, alpha and delta satellites. The smaller satellite DNAs influence pathogenesis and symptom development.

Abhinav Kumar, Institute of Integrated Learning in Management, Greater Noida studies how beta satellites act when these viruses infect crops.

But why is the infection so severe in papaya, he recently wondered.

The level of leaf curling shows high viral infection. So his team collected curled papaya leaves from and around New Delhi.

They isolated DNA from the leaves to amplify viral and satellite DNA sequences.

There was some DNA-A but they could not amplify any DNA-B. So the virus was monopartite. They amplified satellite DNA. But only found a distorted beta satellite.

Then, they matched the amplified DNA-A sequences with available sequences of viruses using bioinformatic databases. And found two sequences showing 97% similarity with the chilli leaf curl virus.

The recombination of viral genomes can happen in mixed infections. So they checked. And found recombination events in both isolates, confirming why papayas get infected with a chilli virus. The distorted beta satellite still manages to influence infection intensity.

Another insight into the evolution of plant pathogenic viruses.

DOI: 10.1080/14620316.2021.1874837

Fungal Infection in Peanuts

Pipecolic acid prevents

Some years back, a group of researchers identified a rhizobacterium which gives peanut seeds resistance against *Aspergillus flavus*, a common fungal infection. Now, they have identified the mechanism. The results could give help farmers protect crops from the fungus.

AhaaRuchi via pixabay

Sandeep Sharma and team from BHU, Varanasi collaborated with the CSIR-Central Salt and Marine Chemicals Research Institute, Bhavnagar and researchers from China and Germany to profile metabolites in peanut seeds. Thus, they could identify compounds and genes that provide resistance against the infection.

The team infected one set of peanuts with the fungi while another was infected and treated with rhizobacteria. Comparing metabolites from both sets, they found that the levels of pipecolic acid, a non-protein amino acid, consistently differed in both sets. In seeds treated with the rhizobacterium, levels were higher than those in infected but untreated seeds.

Pipecolic acid, a metabolic product of lysine, an amino acid, plays a role in immunity against diseases in plants and animals. So the team applied pipecolic acid externally to peanut seeds.

'This reduced chances of *Aspergillus* infection by almost 70 per cent,' says Sandeep Sharma, BHU.

'We looked at the genes involved,' adds Babita Choudhary, his colleague.

Genes that regulate pipecolic acid levels and pathways responsible for immunity could be targeted to provide resistance to seeds against different kinds of diseases. With genetic engineering, we can breed crops with better immunity against diseases.

DOI: 10.1016/j.jhazmat.2020.124155

Coffee Pulp Waste

Pectin extraction and treatment

Coffee seed extraction generates pulp. Though packed with macronutrients and bioactives, the pulp is difficult to dispose of.

Sam Faulkner via Flickr

Vallamkondu Manasa and team from the CFTRI, Mysuru decided to recover the nutrients in coffee waste.

So, they analysed coffee pulp samples and found saccharides and polyphenols.

The researchers also extracted pectin, a polysaccharide fibre, from the pulp using acids. To optimize pectin extraction, they tried ethanol and got better results than with salts and acids.

The team found that pectin from coffee pulp has higher equivalent weight than commercial pectin, which may be due to physical bonding with polyphenols.

The method could recover pectin and polyphenols simultaneously with minimal processing. But the pulp still remains. And the wastewater still contains materials that increase the oxygen demand of surface waters it may meet.

Can we treat coffee pulp wastewater with plant material, wondered Ancy Jenifer and her team from the Mother Teresa Women's University, Tamil Nadu.

Ricin, a highly toxic glycoprotein, acts as a natural coagulant. It can inhibit pollutants. And castor seed protein contains ricin.

The team added different doses of castor seed coagulant to the wastewater samples. The process removed three-fourths of dissolved coffee pulp solids and four-fifths of the colour.

Due to its cationic nature, ricin protein coagulates sugar binding sites and creates hydrogen bonds between molecules. This waste aggregate is then dissolved by amide groups in the ricin.

The castor-ricin treatment removed total dissolved solids in wastewater samples.

'Castor seed protein can be a cheap alternative to chemical coagulants to efficiently manage coffee waste,' say the researchers.

DOI: 10.1016/j.jwpe.2020.101742;
DOI: 10.1016/j.wasman.2020.10.045

Smartphone-based Tool

Measuring soil pH

Soil health is determined by pH. However, pH estimation is laborious or requires sophisticated, bulky, high-computing tools. Can we use smartphones for the purpose, wondered Priyanka Das, Tezpur University. Smartphones today pack as much computing power as desktops. So, with colleagues, she started working on a smartphone-based tool.

They collected soil samples and estimated pH, using a pH meter. To study the optical response, they treated the samples with pH-sensitive dye and prepared a setup for a smartphone camera sensor.

A beam of parallel light passes through a collimator and interacts with the treated soil sample. The beam is focused by a cylindrical lens. The transmitted light passes through a grating. To obtain the best spectrum, the diffracted light is deviated at 47 degrees. Finally, the light spectrum is displayed on the mobile screen through the camera.

Now, the challenge was to determine the relation between light and matter. To calibrate the sensor, the team recorded the spectrum of green and red light and determined their pixel positions. They established a linear relation between pixel position and the wavelength of the diffracted light. Based on this relation, they generated a scale of pH values from 4 to 10.

To visualise the relation between pixels and wavelengths of transmitted light, they correlated transmittance intensity with change in sample pH. The values obtained matched initial pH measurements.

'We can now easily estimate the pH of soil samples. It's as good as spectrometer results,' announces Priyanka Das, Tezpur University.

'We are planning to develop an application that will convert spectrometric data directly into readable format,' adds Pabitra Nath, her mentor.

Another app in the making for agripreneurs!

DOI: 10.1109/JSEN.2020.3027587

Measuring Uranium Isotopes

Compact instrumentation

Uranium naturally occurs as isotopes 234, 235 and 238. But only uranium-235 is used for nuclear fission to produce energy in nuclear power plants. To distinguish between uranium isotopes, a thermal ionization mass spectrometer is used.

A current beam under vacuum is passed through a uranium sample. Uranium ions get accelerated and move with the current. This ion beam then passes through a magnetic sector where it gets dispersed, based on the mass to charge ratio of the ions. The separated beams are collected and converted to voltages. A comparison of the voltages reveals isotope ratios in the sample.

The method is precise. But the instrumentation is bulky. Can we improve on it, wondered S. Das and K. Sreeramulu from the Raja Ramana Centre for Advanced Technology, Indore.

They collaborated with researchers from the Bhabha Atomic Centre, Mumbai to design an improved compact thermal ionization mass spectrometer.

The team targeted the magnetic sector for size reduction. Reducing the magnetic sector radius from a conventional radius of 30–20 cm improved the precision from 0.1% to 0.05%.

However, reducing size will also reduce the dispersion of beams. So, the team used variable dispersion zoom optics: an ion-optical arrangement, facilitating the dispersion of closely separated adjacent ion beams.

Tests revealed that the compact thermal ionization mass spectrometer had better performance.

'Sensitivity increased one and a half times,' says S. Das.

'The design helps achieve a 35 per cent reduction in overall footprint,' says R. K. Bhatia, BARC, Mumbai.

The system can be used for measuring isotope ratios of other elements too.

DOI: 10.1002/rcm.8963

Laser Tweezers and Holograms

3D rendering of cells

Manipulating biological cells without physical contact can help unravel their mechanical properties. Observing specimens in the real environment can change our view of microscopic life. A group from the University of Baroda has now found a cheap and simple way to do this.

With collaborators from IIT Delhi and the USA, the team designed optical tweezers coupled with a holographic microscope. These imaging devices use a laser beam to physically hold and move microscopic objects. The micron-sized particles can be plastic beads or biological cells. The sample is trapped by shooting a laser beam. The sample settles at the centre of the beam, where the electric field in the laser is strongest.

The sample now acts as a tiny lens changing the momentum of the light. This rate of change of momentum creates an equal but opposite force that moves the particle from the centre. The force applied to the object depends linearly on its displacement from the centre, like a spring system.

'Our optical tweezers are made from recycled DVD burners,' explains Nimit Patel, University of Baroda.

DVD burners have key components for optical tweezers: powerful laser, collimator lens, photo-diodes and focusing mechanism.

The team examined two types of polystyrene beads using this setup. They could measure the physical and optical properties of both samples.

Now, the group wanted to observe the structure of the samples. So, they added a silica glass plate to the setup to produce holograms of the specimen. The laser beams passed through the object create a digital hologram. An image sensor records a hologram from which a 3D image is constructed by a numerical hologram reconstruction algorithm.

These interference patterns created by the laser create a more complete and deeper view of objects. This interference pattern complements optical tweezers, as source lasers can be used for creating holograms.

The team observed red blood cells under their prototype.

'We got images of membrane fluctuations,' says Arun Anand, University of Baroda.

Their next step is to study changes in cells with time, using their prototype – a four dimensional microscopic digital hologram.

DOI: 10.1016/j.optlaseng.2020.106397

Rasgulla Shelf Life

Enhanced by pineapple pulp

Rasgullas are tasty and nutritious. But shelf life is about five days. So, confectioners use chemical preservatives.

Runu Chakraborty and Tanmay Sarkar from Jadavpur University, Kolkata have been experimenting with various fruits for some years now. They knew that pineapples are rich in antioxidants. Can those antioxidants help increase rasgulla shelf life?

The duo and their team collaborated with researchers in Malaysia to see how pineapple pulp can improve shelf life.

Vashisthapathak2015, via Wikimedia Commons

They used hot air, freeze, microwave, and microwave-convective dried pineapple pulp and treated rasgullas with raw as well as the differently dried pineapple pulp.

Then, they analysed the nutritional value and *in vitro* digestibility as well as the phytochemistry of the products. Pineapple-fortified samples were rich in alkaloids, flavonoids, polyphenols and tannins.

Microwave-convective dried pulp was best for most parameters. Rasgulla shelf life, when stored at 4°C, increased from five to seven and a half days. And, of course, the nutraceutical value also is increased.

DOI: 10.1111/jfpp.15233

Reports by: **Manish Kumar Tekam, Asma Sultan, Shwetakshi Mishra, Tejinder Singh Chechi, Archana Singh, Khuban Buch, Iqra Rahim, Tahera Arjumand, Ishrat Nazir, Sileesh Mullasseri, Jauhar Rafeeq** and **Aradhana L. Hans**

ACKNOWLEDGEMENT: IISER Pune for access to scientific databases.

scienceandmediaworkshops@gmail.com