Current Science Reports

Predicting Low-Pressure Zones

Formation mechanism

Low-pressure systems play a vital role in monsoon rainfall. Besides local conditions, there are long distance connections behind the formation of low-pressure systems. For example, we now know how El Niño and La Niña, originating in the Equatorial Pacific Region, impact the monsoon. Recently, researchers have pointed to conditions in the North-West Pacific as yet another factor.

Researchers from IIT Delhi and IISER Pune have now figured out a connection between typhoons in the North-Western Pacific region and low-pressure systems in the Indian subcontinent.

The group collected the occurrence of typhoons from the Joint Typhoon Warning Centre in Hawaii. Using normalised distribution, they tallied typhoon data with monthly counts of low-pressure systems. Over the last four decades, occurrences of North-western Pacific cyclones were fewer in June, but active from July to September.

The team also extracted Rossby wave data from outgoing longwave radiation and compared them with sea level pressure. Transfer entropy, which depicts the flow of information between the variables, showed a causal relation between Rossby waves and sea level pressure at the Bay of Bengal.

Using the mixture regression model, the researchers then visualised the trajectories of the typhoons. They divided the trajectory of the typhoons into six geographical clusters in the North-Western Pacific. Three of the clusters move towards landmasses, creating atmospheric disturbances.

From the Eastern China coast, tropical cyclones trigger disturbances towards the west, thus, initiating the formation of low-pressure systems. Interestingly, it is only after two or more typhoons occur within 10 days that low-pressure systems are created. This means one can predict their presence at least a week earlier.

Based on these findings, the group is developing an automated technique to predict low-pressure systems in the Indian subcontinent using deep learning models.

Yet another piece of the puzzle is now in place for understanding the Indian summer monsoon.

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Pollution at Paradip Port

Water quality and phytoplanktons

At Paradip port on the east coast of India, exchanges of cargo such as petroleum products, coal, fertilisers and chemicals take place on a regular basis. As a result, there is a risk of toxic materials spilling into the marine ecosystem.

In such ecosystems, phytoplankton can potentially be used as bio-indicators of water quality. So, scientists from the Institute of Minerals and Materials Technology, Odisha investigated relationships between the water quality index and phytoplankton diversity, community structure and their spatio-temporal variations along 10 locations in the port.

In 2017 and 2018, the team observed slight seasonal variations in the water quality index. The values were in a moderate range. The quality deteriorated post-monsoon and some locations, such as the East quay, recorded poorer water quality.

There were about 40 species of phytoplankton. Centric diatoms and dinoflagellates were abundant, followed by pennate diatoms. Interestingly, chlorophyll-*a* measurements and phytoplankton abundance did not show strict correspondence. Turbidity, pH, dissolved oxygen and biological oxygen demand had insignificant impact on phytoplankton growth.

Phytoplankton diversity was higher pre-monsoon than in other seasons. However, phytoplankton growth was maximum in winter due to favourable physical conditions and optimum nutrient availability.

Nutrients, temperature and salinity were the main environmental variables affecting phytoplankton growth. Some species of centric and pennate diatoms grew in abundance in areas polluted by nitrates, ammonia and phosphates. A few species of centric diatoms and dinoflagellates showed lower affinity to high concentration of nutrients.

The runoff from land during the monsoon and activities in the port seemed to contribute to the variations in phytoplankton growth and diversity.

The study pinpoints sources of pollution and of the release or spillage of materials in the Paradip port area. Port authorities must take necessary steps to maintain a healthy sustainable ecosystem.

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Neem – Synthetic Seeds

For in vitro *propagation*

Propagating neem trees using seeds is difficult. The seeds produced in summer quickly lose viability and, if rains are delayed, show poor germination. Moreover, neem is cross-pollinated. So variants are produced in each generation and this poses a problem for maintaining genetic integrity.

To overcome the issue, Abdul Kader and team from the University of Kalyani, West Bengal used tissue culture. They took shoot tips from a 15-year-old tree and cultured them to produce plantlets.

The team excised shoot tips from the plantlets grown *in vitro* and added them to a sodium alginate solution to form hydrogel, a commonly used encapsulation method. They dropped these encapsulated tips in calcium chloride solution and, after continuous shaking, the shoot tips were trapped in calcium alginate beads. This protects the seeds from damage and helps in germination by providing nourishment. The beads could now be used as synthetic seeds.

To find optimum storage temperature, the researchers stored the beads at 4°C and 24°C for brief periods and germinated the seeds.

'Seeds stored at 24°C showed better germination frequency,' says Sankar Narayan, University of Kalyani, West Bengal.

The team transferred the lab-grown plants to varying combinations of soil, sand, vermiculite and organic manure to acclimatise the tissue culture plants slowly before transplanting them in a field.

It is now recognised that plants from tissue culture undergo somatic mutations and epigenetic modifications. To confirm the genetic stability of the plants

from the synthetic seeds, the researchers generated a molecular fingerprint of the plants. To get the fingerprint, they used inter-simple sequence repeats, molecular markers which detect specific repeat sequences in the DNA. Plants propagated using the synthetic seeds produced a similar molecular fingerprint as their donor mother plant.

Horticulturists can use these synthetic seeds for large scale commercial propagation of neem trees and for seed conservation.

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Response to Drought

In two rice genotypes

Rice crops cultivated in highlands adapt to lower amounts of water whereas lowland varieties are adapted to more water. What are the adaptive mechanisms of rice root structures to drought tolerance?

Jitender Giri from the National Institute of Plant Genome Research, New Delhi collaborated with researchers from the US and Thailand to find out. They selected two rice varieties: Azucena, a variety adapted to highlands and IR 64, favoured for lowland cultivation. The team grew both rice varieties under well-watered and drought conditions in a greenhouse. They observed the effects of water stress on shoot growth and root architecture.

Azucena had 9 times the number of deep roots in well-watered condition and 3 times more in drought conditions. IR64 had smaller roots in both conditions. Root cross sectional and living tissue area impact respiration rates. Azucena also had larger root diameter and living tissue area.

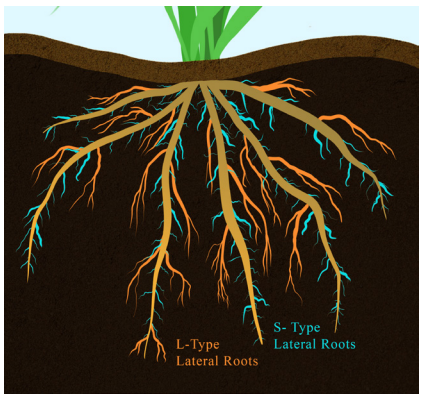

Image: Anoop Kumar V

L-type lateral roots which play a major role in water and nutrient uptake continued to grow at the frontal tip segments of older deeper roots. S-type lateral roots which primarily provide anchorage, besides absorbing water and minerals, had reduced density under drought conditions compared to IR64.

In Azucena, the metaxylem, the xylem that continues to grow, had a larger area. The metaxylem vessel in both shallow and deep roots had greater flexibility.

As soil phosphorus availability impacts the development of root systems, the researchers measured root respiration in a high and low phosphorus solution medium as well as in solid medium. Azucena had 17% higher respiration rates in low rather than in high phosphorus solutions.

'Root development in response to drought is dynamic and root response is the key to drought tolerance,' says Jitender.

Azucena roots had greater flexibility to grow under changing soil conditions and to maintain productivity. The team suggests that, to avoid yield loss, rice farmers use varieties with efficient roots like those of Azucena, for stress conditions such as drought.

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Macroalgal Proteins

Adapting to ocean acidification

Macroalgae may adapt efficiently to growing ocean acidity. But genomic and biochemical studies indicate that not all macroalgae respond in the same way. Can profiling proteins coded by their genes tell us more?

Amit Kumar, Sathyabama Institute of Science and Technology, Chennai worked with researchers from Italy to investigate.

The Ischia island coast in Italy has a carbon dioxide vent where the pH of the water goes down to 6.7, the pH projected for global oceans by 2300. The researchers collected samples of *Sargassum vulgare*, a brown macroalgae, from the acidified site and, for comparison, from a nearby control site unaffected by the vent.

They extracted proteins from the samples and analysed the total protein concentration. To get a clearer profile, the team broke the proteins down into smaller peptides and analysed them using mass spectrometry. The peptide spectra were fed into an online database to identify the proteins and their functions.

Of the total proteins identified, 111 were higher or exclusively present in the acidified samples. In the control group, 120 proteins were lower or exclusive.

In samples from the acidified site, proteins for translation and post-translational processes were reduced. However, proteins responsible for photosynthesis, glycolysis and oxidation-reduction increased.

Increased photosynthesis helps fix carbon dioxide at acidified sites, explain the researchers.

To adjust to the stress of acidic conditions, oxidation–reduction increased. Increasing glycolysis fulfilled the energy requirement of redox processes. How do these adjustments in protein synthesis impact the profiles of metabolites?

The team extracted sugars, fatty acids, amino acids and polyphenols and measured them using chromatography. There was an overall decrease in metabolites in samples from the acidic site. So, though macroalgae may adapt to increasing ocean acidification, they may lose their nutritional value in the bargain.

Industries investing in marine macroalgae for food, biofuel or other commercial products may be hit hard in that case.

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Host–Parasite Coevolution

Sex-specific local adaptation

Parasites evolve to survive in local environments within hosts by undergoing a selection process. Hosts, in turn, evolve mechanisms to reduce the harm that parasites inflict. The host–pathogen coevolution system helps us understand the local adaptation of both hosts and pathogens.

Usually, pathogens evolve faster than the host due to shorter generation time and larger populations. The adaptation of the host is usually longer and may be sex specific.

To investigate, Neetika Ahlawat and team at N. G. Prasad's lab, IISER, Mohali selected the fruit fly, *Drosophila melanogaster*, as host and *Pseudomonas entomophila* as pathogen.

Image: Hanna Davis via Wikimedia Commons

Neetika recorded the death rates in flies infected with the pathogen in four different sets of populations of host and pathogen. They isolated the pathogens from dead flies and used those to infect the next generation of flies in the corresponding population. This process was continued for 19 cycles to facilitate host–pathogen coevolution.

To study differences due to local adaptation, the team infected fruit flies from each population with pathogens from the other three populations. Hosts of the pathogen belonging to the same population had the highest survival. Pathogens from other populations led to higher mortality.

The researchers checked for sex specific patterns and assessed changes in the reproductive capability of infected female flies from each group. Though both male and female flies were locally adapted, male flies were more susceptible to pathogens from non-local populations. There was no change in fertility rates in female flies when infected with local or non-local pathogens.

Though the study is based on fruit flies, biomedical researchers and epidemiologists need to consider the implications of this information for better understanding infectious diseases as well as for prevention and treatment.

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Stillbirths during Pandemic

Higher due to lockdown?

Stillbirths – baby loss during pregnancy or labour – increased in India during the pandemic. Dr Nuzhat Aziz and team from Fernandez hospital, Hyderabad wondered if this was due to the disruption in planned antenatal care due to lockdown or whether it was due to SARS-CoV-2 infections.

The researchers collected the incidence of stillbirth rates from the hospital records. They compared the rate of stillbirths during the first and second waves of the pandemic with that of the previous years. There was an increase in total stillbirth rates. But there was no correlation between stillbirth rate and COVID infection status during both waves.

An examination of the electronic medical records database of antenatal registrations and obstetric visits by pregnant women revealed a significant reduction in the number of new antenatal registrations and obstetric visits before and during the lockdown period in the first COVID-19 wave.

The COVID-19 pandemic and lockdowns resulted in reduced access to healthcare facilities. Regular medical care facilities for emergency cases were restricted. Fear of infections could also have inhibited women from going for routine antenatal care.

During the first wave, there was a 50% higher incidence of stillbirth rates than in the second wave. Even though there were more COVID cases during the second wave than in the first, stillbirth rates reduced as there were no restrictions on health care facilities which were open.

Regular check-ups and baby monitoring are important during pregnancy. to prevent preventable stillbirths. Continuity of planned antenatal care should be ensured under all circumstances.

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Oral Cancer

Role of HOX genes

Homeobox (*HOX*) genes are genes with DNA sequences of 180 base pairs that control the differentiation of cells. Humans have 39 *HOX* genes. Some of them may play a role in regulating cancer and other diseases. So, understanding the *HOX* gene network may throw light on cancer.

Sanjiban Chakrabarty and Raghu Radhakrishnan from the Manipal Academy of Higher Education collaborated with scientists from the UK to investigate the role of *HOX* genes in oral cancer. They retrieved oral cancer gene expression datasets from the publicly available Gene Expression Omnibus. And downloaded the set of all RNA transcripts in oral cancer tissues from the Genomic Data Commons.

Using the interactive web tool, GEO2R, they analysed the datasets. There was greater expression of *HOX* genes in oral cancer tissue. The researchers analysed the expression patterns and regulation of *HOX* genes in oral cancer-derived cell lines.

Across all the cell lines screened, there was lower expression of *HOXB2* and *HOXB4* genes. Using CMap, they mapped connections between cancer drug targets and the expression of genes. Four homeobox genes, *HOXB2*, *HOXA10*, *HOXC10* and *HOXD11*, were differentially expressed in oral tumours.

These genes and gene products could be drug targets for treating oral cancer, say the researchers.

Translation researchers can now use this information for drug development.

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Adulteration in Sunflower Oil

Easy detection technique

Sunflower oil, popular for cooking, contains high unsaturated fatty acids. Palm oil is high in saturated fatty acids but cheaper. So it is often used to adulterate sunflower oil. There are several methods to detect such adulteration but they are expensive, time-consuming and inefficient.

Researchers from BITS Pilani and the CSIR Central Electronics Engineering Research Institute, Rajasthan collaborated to find a simpler and cheaper alternative. Esters and fatty acids in oils have distinct signature peaks in the mid-infrared region of the electromagnetic spectrum. So, the team reasoned that infrared spectroscopy would help identify the two oils and detect adulteration.

They analysed sunflower and palmolein oil samples using an attenuated total reflection spectrometer. Using machine learning algorithms, they cross-checked the accuracy of the fatty acid profiles from the spectra. Analysing the principal components in the spectra of the oils, they confirmed that the distinct components could be used to identify the oils.

To check for adulteration, the team mixed the oils in varying proportions of 5–75%. As the quantity of palm oil added to sunflower oil increased, the spectra leaned more towards the palm oil spectrum. Using modelling algorithms, the team could categorise samples as pure or adulterated with 100% accuracy.

'A spectrometric analysis provides good resolution without any pre-processing,' says K. Srinath, BITS, Pilani.

'The method is simple, rapid and accurate. It can detect even 5% of palm oil in sunflower oil,' adds P. C. Panchariya, CSIR-Central Electronics Engineering Research Institute, Rajasthan.

Scientific equipment manufacturers may take note of this development to mass produce such devices for oil industries.

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Ripe Banana Powder

Using freeze drying

Ripe banana powder can act as an essential value-added product for food, bakery, pharma and even cosmetics. However, the drying process for making a powder from ripe bananas causes loss of several nutrients. What is the most efficient way of drying bananas?

Safreena Kabeer, N. Govindarajan and team from the SRM Institute of Science and Technology, Chennai collaborated with researchers from USA and Oman to find out. They used the Nendran variety of bananas. This variety of bananas, though delicious, is very large and is not a snack, but a meal. The team tried tray drying, freeze-drying and spray drying the ripe bananas.

In tray drying, the bananas were sliced, dried at 50°C, and powdered after complete drying. The researchers prepared banana paste and freeze-dried the paste at –45°C. For spray drying, a nozzle atomizer made fine droplets of the paste which were dried in a chamber.

The team then analysed the mineral, vitamin and macronutrient content of the dried powders from the different drying techniques. They found that freeze-drying retained most of the minerals and vitamins. Freeze-dried powder had significantly higher potassium, iron and vitamin levels than the tray and spray-dried powders. It also had higher carbohydrate, protein and fibre content than the other powders. It retained most of the fat content, an essential component for preservation and for enhancing shelf life.

The team tried to compare the internal stability of the banana powders by visualizing their microstructure. The tray and spray dried powder had irregular structures due to heat treatments which caused cell breaks.

The well-organised structure of the freeze-dried powder helped retain nutrients and minerals, say the researchers.

A team of trained panellists then assessed sensory attributes like colour, texture and taste. The freeze-dried powder was most accepted. Freeze-dried powder retained the natural sweetness and soft texture of ripe bananas.

Food industrialists and entrepreneurs can exploit freeze-drying to make ripe banana powder. This could be a more productive approach than using conventional spray-dried powders. It would also help banana cultivators sell the large nendran bananas to industries and reduce losses due to banana spoilage.

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Baking Sandwich Bread

Impact of overhead pressure

Consumers judge the quality of bread by its softness. The softness of bread depends on its porosity which, in turn, depends on mixing, kneading, the action of yeast and baking processes.

Traditionally, bakers mix and knead dough under atmospheric pressure. But, today, new-fangled machines undertake the task to produce large quantities of bread. The machines allow us to control pressure inside the mixing chamber. Can modulating overhead pressure help make bread softer?

Piyush Kumar Jha and Ashish Rawson from the National Institute of Food Technology, Entrepreneurship and Management, Tamil Nadu collaborated with researchers from France to investigate.

They put bread dough ingredients in a closed bowl mixer and varied overhead pressure from below to above atmospheric pressure. And they examined the porosity, specific volume and crumb size of the final products.

At lower pressures, the resulting bread had lower porosity. The fermentation time to get the desired specific volume was longer. But mixing at high overhead pressures led to a higher void fraction and specific volume in lower fermentation time. The bread became softer and looked more inviting.

Bakers and mixer manufacturers can now modify their baking tools to produce good quality loaves.

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