Current Science Reports

Alpine Summit Flora
Assessment for monitoring

Alpine ecosystems contain a rich repository of endemic biodiversity, providing life-supporting ecosystem services. When the climate changes, how will alpine vegetation respond?

A team from the University of Kashmir are tackling the question in collaboration with scientists from ISRO. They set up a long-term biodiversity monitoring site at Apharwat Peak. To collect baseline data, they chose four spatially isolated summits, with altitudes ranging from the tree line at the lowest to the snowline at the highest. The researchers found that soil temperature decreases by about 2.4 degrees from lower to higher summits.

Image: Anzar A. Khuroo

From sampling sites at each summit, they recorded plants, small loose stones and surface rocks. Species diversity decreased with altitude. This, the scientists say, is related to the decrease in temperature.

There were more than 140 plant species in total. Herbs dominated in all summits. Most were perennial and their dominance increased with altitude. Plants with buds on the surface predominated in all summits and increased with elevation. Plants with buds below the soil's surface and very short-lived plants also increased with elevation

Plants species, only seen in this part of the Himalayas, become more common as we go up. The mountains support a wide variety of habitats, allowing speciation. Chances of dispersal are limited. Both factors lead to flora unique to the area, say the researchers.

Though the area has adequate soil moisture, differences in availability of sunshine between east, west, north and south aspects create a diversity of micro-climatic habitats. Thus, species assemblages along different directions on Himalayan alpine slopes are also quite varied.

The results show that species traits vary along elevation gradients. The difference in temperature along elevation in alpines can help predict changes in alpine vegetation. With continued monitoring of the sampling sites, we might identify traits for better adaptation or survival in harsh environments and the alpine ecosystem's responses to projected climate change.

DOI: 10.1007/s11629-019-5924-7

Prawn Shell for Sunscreen

Sunlight contains ultraviolet radiation in the range of 200 to 400 nanometres. The shorter wavelengths are absorbed by ozone but wavelengths from 280–400 reach us to harm our skin. Sunscreens designed to protect from these rays induce reactive oxygen species and often cause allergy. So, people prefer natural sunscreens: corn starch, mulberry and papaya extracts, green coffee oil...

When Komalakrushna Hadagalli and Saumen Mandal from the National Institute of Technology Karnataka came to know about mycosporine-like amino acids which absorb ultraviolet radiations found in marine-based mucus and fish lenses, they had an idea. Prawn shell too has such water-soluble mycosporine-like amino acids. Can it offer ultraviolet protection? In collaboration with researchers from the Indian Institute of Science, Bangalore they explored.

They collected shells of the Indian prawn, *Fenneropenaeus indicus*, from a local market, cleaned and dried the shells, and carried out morphological and elemental investigations. Prawn shell consists of layers of chitin-protein composite with proteins and spherical calcites in between, along with traces of calcium carbonates that go into the formation of crystalline calcites and magnesium oxide.

Spectroscopic analysis showed broad absorbance in the entire ultraviolet range, with peaks at 290 and 320 nanometres, suggesting an abundance of mycosporine-like amino acids with a central aromatic ring such as found in tryptophan, phenylalanine and tyrosine.

'Ultraviolet-absorbing protein from prawn shell can be used as sunscreen filter in cosmetics, textiles, food, pharmaceuticals and biodegradable packaging', says Komalakrushna, NIT Karnataka.
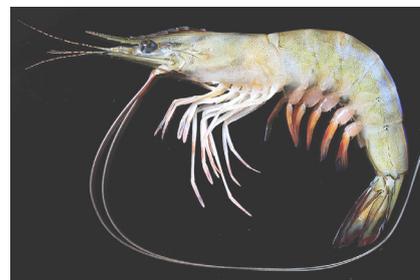
Image: MNHN via Wikimedia Commons

'Shells form about 40% of the weight of prawns. And about 40% of the shell is protein. The material is available in plenty', says Saumen, his mentor.

Chitin from shells has medical and agricultural applications and is already being extracted on a large scale. This finding can prove useful for industries to start producing low-cost, safe, and natural sunscreen filters.

DOI: 10.1016/j.matchemphys.2020.123002

Remedy for Alzheimer's
Ferulic acid analogues

Alzheimer's disease involves progressive loss of memory. Acetylcholine, a neurotransmitter, is involved in learning and memory. So drugs that target acetylcholinesterase, the enzyme which breaks down acetylcholine, have been developed. However, the treatment is ineffective in managing increased levels of reactive oxygen species, metal ions and neurofibrillary tangles of β-amyloid in the patients' brains.

Gyan Prakash Modi and team at IIT BHU have been exploring natural

compounds with antioxidant and neuroprotective activities to treat Alzheimer's. Ferulic acid, a phenolic compound in fruits, has antioxidant properties. But it does not cross the blood-brain barrier or interact very strongly with cholinesterases. Ferulic acid is hydrophilic. So they set about to make it more lipophilic and to interact more strongly with the cholinesterases.

The team synthesised derivative compounds, joining 2-amino-N-phenyl substituted acetamides with ferulic acid. Then they screened the compounds for capacity to inhibit the enzymes. Molecular docking studies in collaboration with researchers from the University of Mississippi confirmed improved binding efficiency by one of the molecules with the two cholinesterases. *In silico* pharmacokinetic studies also showed enhanced lipophilicity and predicted brain permeability for the molecule.

The 5-aminoindolyl substituted derivative showed effective free radical scavenging and metal chelation. The lead molecule interacted with the β-amyloid *in vitro* and reduced its fibrillar structure. It was more effective than the standard drug, donepezil.

The researchers then induced learning and memory dysfunction in a mouse model using scopolamine. The control group suffered learning and memory dysfunction. But in the group given the derivative daily for 7 days, alterations in the brain were reversed.

Now that the *in vitro*, *in silico* and animal studies are done, there is a need to follow up with clinical trials, before those who are at risk for Alzheimer's forget this report.

Brainwave Mapping
Gamma oscillation and aging

Brainwaves, electrical impulses of different frequencies, include gamma rhythms of 20 to 70 Hertz generated during attention and memory formation and alpha rhythms of 8 to 12 Hertz produced at relaxing states. An abnormality in these rhythms, especially in gamma, is noticed in autism, schizophrenia and Alzheimer's disease. But what happens in the elderly?

Recently, a team from various institutes in Bengaluru investigated how oscillations vary with age.

They selected young and elderly cognitively healthy people from IISc's longitudinal study on ageing. The people selected were shown images of continuous dark and white bars to induce brain oscillations. In more than 80 per cent, the gamma oscillations induced were either fast or slow, while both slow and fast gamma oscillations were induced in less than 60 per cent. The researchers found that the peak frequencies of both slow and fast gamma reduce with age.

The slow gamma power builds up gradually whereas fast gamma power decreases with increase in duration of the stimulus. Females had higher baseline slow gamma power than males. However, both gamma bands appeared to decrease with age.

Females had higher baseline alpha power than males. However, alpha suppression does not significantly differ between genders.

Alpha suppression was stronger in younger people than in the elderly. The researchers also found that age-related variations, including eye position, pupil size, and noise, do not significantly affect the baseline powers of fast and slow gamma.

To unravel the relationship between physical stimuli and brain activity, the subjects were shown flickering images on a screen. The natural responses at 32 Hertz in the gamma range decreased significantly with age.

'The results can help design cheap, non-invasive biomarkers, based on gamma rhythms, for disorders like Alzheimer disease and schizophrenia', says Murty Dinavahi, IISc Bengaluru.

Classifying Tomatoes
Automatic optical sorting

Many food processing industries benefit from overproducing tomatoes in certain seasons to make various packaged food products. The quality of these products depends on the quality of the tomatoes used. However, manual sorting of tomatoes at industrial scale is labour intensive and time-consuming.

Image via needpix.com

Researchers from three different institutions in Tamil Nadu have now developed a microcontroller for grading and sorting tomatoes, based on a multiclass support vector machine algorithm. A camera installed above a conveyor belt captures images of the tomatoes. The team used more than 20 features such as shape, colour, contrast, and texture to detect defective tomatoes in three stages.

In the first stage, they sorted tomatoes from apples and lemons with cent per cent accuracy. In the next stage, they used the algorithm to differentiate between ripe and unripe tomatoes based on fruit colour. This classification was also a hundred per cent accurate.

In the last stage, they tested for three types of defects – black spot, canker, and melanose. The researchers observed that the algorithm could classify defective tomatoes into the three groups with an accuracy of up to 92%.

'The multiclass support vector had more accuracy than the k-nearest neighbour algorithm', says S. Dhakshina Kumar, University College of Engineering, Ramanathapuram.

'We can reduce misclassification by adding more features and even extend the algorithm to detect other defects in tomatoes', says S. Bama from the Kalasalingam Academy of Research and Education, Srivilliputtur.

'We only considered external qualities such as colour, shape, size, and surface defects. But quality depends on flavour and taste too. But this will need other equipment like sensors and destructive testing. Our method is non-destructive and effective', says S. Esakkirajan, PSG College of Technology, Coimbatore.

To get the system up to industrial scale, entrepreneurs need to come forward.

Carcinogenic Smoked Food
Liquid smoking, a safe alternative

Masmin, from Lakshadweep, tuna fish cooked in seawater, smoked and dried, is famous. Smoke provides a typical flavour and preserves food. But the traditional process of multiple smoking and drying cycles can contaminate food with carcinogenic polycyclic aromatic hydrocarbons. And that creates problems in quality control for export.

There is a process for liquid smoking which makes it safer. But it needs optimisation. So, recently, research organisations under the Ministry of Commerce and Industry collaborated with two universities in Kerala to create guidelines for producing liquid smoked masmin.

There are three processes for using liquid smoke: spraying, soaking and mixing. For optimising spraying and soaking, the researchers used response surface methodology since there were many process variables: duration of exposure, salt content, dilution, flow rate, chamber temperature... The methodology was not applied to the mixing method as there was only one variable – the quantity of liquid smoke.

For the best flavour, the researchers suggest spraying cooked tuna with one part commercial liquid smoke diluted with three parts distilled water for ninety minutes at a flow rate of one litre per hour with nine grams of salt per hundred millilitres of water in a chamber maintained at forty-five degrees Celsius.

The cooked blocks of tuna should be soaked in one part commercial liquid smoke diluted with twelve parts distilled water, with seven grams of salt per hundred millilitres of water, for ninety minutes, say the researchers.

Masmin produced by mixing commercial liquid smoke at 0.5% level was best.

Sensory analysis by experts revealed that spraying gives higher sensory acceptance than soaking and mixing.

The team measured polycyclic aromatic hydrocarbons after the processes. Benzopyrene, the marker for carcinogenic polycyclic aromatic hydrocarbons, was not detected in commercial liquid smoked masmin. The other polycyclic aromatic hydrocarbons that come under export-import regulations were also well within limits.

The team also checked for fungal contamination and found the flakes microbiologically safe even after twelve months storage. Packaging with twelve micron polyester and three hundred gauge polyethylene improved shelf life.

This approach can be used to produce and export other smoked and grilled products, claim the researchers.

Though it's good news for exporters, it will be more sustainable if indigenous liquid smoke products are developed.

Biocontrol of Parthenium
Zygogramma bicolorata

Parthenium, native to the American tropics, was accidentally introduced in India. It quickly invaded forest, agricultural and urban areas. The Mexican beetle, *Zygogramma bicolorata*, was proposed as a biocontrol agent to manage the invasion. But does it really work? Which developmental stage of the beetle should we release for controlling parthenium?

Fazil Hasan, from the Aligarh Muslim University, collaborated with scientists from the ICAR-Indian Agricultural Research Institute, New Delhi and the King Saud University, Riyadh to investigate the biological suppression of parthenium by the beetle in natural field conditions.

They selected twelve locations in and around Aligarh with lush green growth of parthenium. Parthenium suppresses the growth of other plants and the locations had no crop cultivation for more than a year and half when they started the experiments.

In four locations, they released 12 adults per square metre and, in another four, they released the same number of 3rd instar larvae per square metre, leaving four as control.

The pattern of release was repeated four times every fifth day. The re-

searchers recorded the rate of defoliation by the beetle. The impact of infestation on plant fitness in terms of height, biomass, rate of leaf injury and soil seed reservoir was also recorded.

Image: Wikimedia Commons

On the 60th day after larval release, there was complete defoliation, while it took 80 days in locations where adults were released. *Z. bicolorata* defoliated the plants by up to 80–100% in all sites. After completely defoliating the plant, the beetle started to target flower buds for egg-laying.

Releasing adult beetles reduced the density of plants and affected various growth stages of the weed in the field. After hatching, the neonates fed on flowers to prevent seed production. Seeds were reduced 5 to 150 folds.

The Mexican beetle has the potential to reduce the density of parthenium population.

Though release of larvae has an immediate impact on parthenium, release of adults helps propagate new colonies and has longer term impact', suggests Al-Ghanim from the ICAR-Indian Agricultural Research Institute, New Delhi.

There are various methods to control parthenium. No single management practice is adequate. 'Recruiting Mexican beetles to fight parthenium is a good addition to the existing arsenal', adds Hasan Fasil, Aligarh Muslim University.

Tamarind Seed Polysaccharide
For anode in lithium batteries

Lithium-ion batteries are lightweight but have high power density. Hence, they are used in portable electronic gadgets. These batteries have good cycling stability even at high sweep rates. Nonetheless, high capacity batteries for robust use in electric vehicles still remain a challenge.

The electrochemical performance of batteries mostly depends on the electrodes used. Most lithium-ion batteries today use graphite as anode. During charging, lithium ions move into the graphite stacks and, during discharge, they return to the cathode through the electrolyte. Though cheaper and safer than lithium, the capacity of graphite is limited. Transition metal oxides, especially zinc ferrite, suggested as alternative, have higher capacity, but are not stable over multiple charge-discharge cycles.

Christopher Selvin, Bharathiar University, asked his team to try coating zinc ferrite with carbon. P. Perumal and P. Sivaraj have been experimenting with using biological polymers to create carbon coats on metal nanoparticles. They chose a carbohydrate polymer easily derived from tamarind seeds.

When making zinc ferrite nanoparticles, they added the polymer and then heated the nanoparticles formed to high temperatures, to convert the polymer into carbon.

They characterised the carbon-coated zinc ferrite and found that the nanoparticles formed are more spherical and did not aggregate as zinc ferrite grains usually do.

Impedance analysis showed that lithium ions can migrate easily through the carbon coat and there is no ionic blocking at the anode. Electronic conductivity was more than when pristine zinc ferrite was used. Specific capacity and cycling capability also improved to more than 200 milliamps per gram in multiple sweep rates.

The researchers say that this eco-friendly, low-cost and efficient electrode might play a vital role in future lithium-ion batteries for long term use.

Indoor Air Quality
Rural households

Rural households are badly ventilated and use open stoves that release particulate and gaseous matter. Such indoor air, containing microbes and particulates, can impact health. Researchers from IIT Hyderabad collected air samples from living rooms to assess bioaerosols and endotoxins in rural households in Kyasaram, Telangana.

They cultured the samples and used DNA for species identification. There were 79 different bacterial species. Some were agriculturally important bacteria found in soil and others came from the skin and gut of domestic animals. *Bacillus anthracis*, a pathogen, was abundant.

Since women spend more time indoors, they face a greater risk of bacterial infection. They estimated the concentration of the toxins and found that, for women, the probability of *B. anthracis* infection was up to 1% when exposed to the microbe for 12 hours every day.

Bacterial concentration indoors was greater than fungal concentration. There were 67 species of fungi including those belonging to the pathogenic Candida species. The other important phyla noted include the club fungi and mushroom group members and saprophytes. Aspergillus was dominant both indoors and outdoors.

Bacterial aerosols were higher indoors than outdoors. The scientists say that indoor temperature affects microbial growth and diversity. The building's age was also important. Older buildings were dustier, promoting bacterial growth.

Cow dung cakes, for cooking, increased particulate matter to which microbes bind. Domesticated animals also contribute to bioaerosol loads.

Clean fuel, better ventilation, keeping animals out and maintaining dust-free environments can reduce the threat, say the researchers.

Circular Economy
Testing the concepts

For sustainable development, a circular economy, where waste is converted to wealth, has been recognised as necessary. But does it really work?

Take the case of municipal solid waste management in a city like Bilaspur where it has become an environmental and public health issue. Pradeep Rathore and S. P. Sarmah from the IIT Kharagpur examined the potential of implementing a circular economy in municipal solid waste management. They analyzed the economic, environmental, and social feasibility. The team formulated a mixed-integer non-linear programming model to minimise the total cost – the sum of functioning, transportation, hiring, environmental, social, and penalty costs.

They evaluated and developed a model for two situations. First is the present situation, in which unsegregated municipal solid waste is collected from sources and disposed of in landfill, and thermal power plants only get fuel from coal mines. In the second, the organic municipal solid waste is sent to a biogas plant and the gas produced is transported to the thermal power plant as fuel.

The researchers used the model for both situations. Using waste as resource reduced the total cost of solid waste management by approximately 30 million rupees per day. It also drops carbon emission by 186 tonnes daily. The circular economy concept reconciles ecological and economic concerns.

The team then tested the model's suitability universally and its applicability in other cities by changing waste collection efficiency and thermal power plant capacity parameters. The model emerges as universally implementable – best suited to cities with low capacity thermal power plants. However, the need for investment makes the concept more practicable for economically developed countries, say the researchers.

Reports by: **Sanghamitra Deobhanj, Sushmitha Baskar, Shwetakshi Mishra, Swarnendu Roy, K. Sri Manjari, Ravi Mishra, D. C. Jhariya, Sudhir Verma, Pudi. Venkatesu** and **Pavithra P. Nayak**