

## Science Last Fortnight

### Low-Level Jets

*Friend or foe?*

The meteorologist's fascination with low-level jets stems from their role in transporting moisture. These fast moving tunnels of air in the troposphere are crucial for the Indian monsoon. Events of extreme rainfall and drought are correlated with the low level jets.

Balaji and colleagues from the IITM, Pune, examined the monsoon oscillations associated with the low-level jet over the Western Ghats. They collected data from the 2015 monsoon to analyse the thermodynamic parameters and wind structure over the region. Using a wind profiler, the team structured the height and depth of the low-level jet. They found that low level jets were weaker in 2015. This explained why monsoon was deficient with poor moisture distribution in that year.

The team then conducted microwave radiometer experiments to study the moisture flux over the stretch. These experiments map the diffusion of energy by profiling humidity distribution. The results of the experiments showed poor convective activity. Poor moisture distribution coupled with a weaker low-level jet resulted in a below average monsoon in the region, the team claims.

The scientists theorise that, in 2015, the moisture flux drifted eastward from the Indian sub-continent due to prevalent El Niño conditions over the Pacific. The study further provides evidence that low-level jets are a crucial component of monsoon dynamics. Factoring them into our weather models will allow accurate predictions.

This study, funded and supported by the Ministry of Earth Sciences, will help 'nowcast' weather. We can draw imminent weather patterns due to short-term changes in the atmosphere. Dynamic phenomena, like electrical storms, which occur due to shear instabilities, can now be tracked with more certainty using data related to low level jet streams and local vertical winds.

*Atmos.*, **194**: 17–26

### Selecting Satellite Products

*Soil nutrient management*

Soil nutrient management, the best practices to optimize crop yield and quality, aims to minimize fertilizer input costs and to protect soil and water. In smallholder farms, soil nutrient deficiency is common. Landscape features such as vegetation cover, land use, soil organisms and soil parent material affect soil nutrient distribution.

It is not easy to generate such data for each farm. However, satellite data can be used to model and predict soil health. But which satellite data is most appropriate, with respect to cost and processing time?

S. P. Wani from the International Crops Research Institute for the Semi-Arid Tropics, Hyderabad, in association with researchers from the USA and China, collected soil samples and ancillary site data from two smallholder farms in Telangana and Karnataka. They analysed the samples to get exchangeable potassium – one of the nutrients. Next, they modelled and calculated this data to get the data from un-sampled areas. Then, they correlated this data with satellite derived data and analysed which satellite data gives best results.

According to the scientists, there is no perfect remote sensing product for soil mapping. They found that satellite data from WorldView-2, Pleiades-1A and GeoEye-1 can provide field-specific soil management suggestions to smallholder farmers. However, such data are costly. Satellite image data from Landsat 8, on the other hand, is free. Besides, soil prediction models from Landsat 8 data have good accuracy. Thus, they have potential to be widely applied in large scale soil prediction models, in a cost effective manner. The report suggests empirical guidelines for using satellite data for research in other agro-ecosystems.

Using satellite data can help policy makers and agricultural extension workers. Enlarging the scope of this study will help farmers adopt appropriate soil management practices.

*J. Environ. Manage.*, **200**: 423–433

### Global Warming Mitigation

*Using leaves in ruminant diet*

Many, in India, depend on livestock, especially ruminants, for a livelihood. Ruminants produce greenhouse gases such as methane and carbon dioxide as a by-product of digestion. According to a FAO 2006 report, ruminants emit 27% of the greenhouse gases that contribute to global warming.

Last fortnight, researchers from the Loyola College, Chennai, in collaboration with Mexican universities, reported a method to reduce greenhouse gas emission from ruminants. They checked *in-vitro* gas production by the lumen of ruminants in response to the leaves of nine plants: water hyacinth, chaya, neem, pistachio, black rosewood, Mexican calabash, West Indian elm, Uvalama and moringa. The scientists found that incorporating these leaves in feed, instead of the currently used alfalfa hay, reduced methane production by 77% and carbon dioxide by 80%.

Leaves contain secondary metabolites – phenolics, flavonoids and saponins – that inhibit the emission of greenhouse gases, and improve animal digestion. Secondary metabolites in leaves modify food fermentation by suppressing rumen bacteria. Besides reducing greenhouse gas emissions, these metabolites improve nutrient availability. Now, farmers can contribute to reducing greenhouse gas emissions while improving the health of their livestock.

*J. Cleaner Production*, **162**: 1192–1199

### Pregnancy Test for Buffaloes

*Early biomarkers*

Given the high demand for milk, buffaloes are artificially inseminated, at regular intervals, to ensure high production throughout their life cycle. It is important to detect pregnancy early to avoid repeated and unwarranted insemination. Early diagnosis also helps prevent miscarriages and ensures proper nutrition to pregnant buffaloes. However, current methods, such as palpation, ultrasound, progesterone and estrone sulphate tests, are accurate only 30 days after insemination.

Last fortnight, researchers from the Indian Veterinary Research Institute, Uttar Pradesh reported that pregnancy can be tested as early as 18 days post insemination. Now, we know that the interferon tau is secreted in high quantities during pregnancy. The team studied the expression of four genes, stimulated in response to this molecule during pregnancy. They found that, in pregnant buffaloes, the expression of three is significantly higher, 18 days after insemination. They cloned these genes and purified their proteins.

Given the high embryonic mortality in Indian buffaloes, these proteins may serve as ideal biomarkers for early detection of pregnancy, claims Mihir Sirkar, a scientist from the institute. The new pregnancy strip is a boon to improve the reproductive management of buffaloes.

*Theriogenology*, **100**: 50–58

### Natural Prebiotics

#### Fructans from foods

Fructans are plant fibres that encourage the growth of good bacteria in the colon and act as prebiotics. These fructo-oligosaccharides act as ideal substrates for probiotic bacterial strains. Many studies report the effects of commercial fructo-oligosaccharides on lactic acid bacteria. However, there are also many natural sources of prebiotic fructans.

Last fortnight, researchers from the Anna University, Chennai reported the prebiotic activity of fructans from the Nendran banana, and country and hill garlic cultivars. They tested the prebiotic activity of these on four bacterial strains: *Lactobacillus casei*, *Lactobacillus acidophilus*, *Lactobacillus plantarum* and *Bacillus amyloliquefaciens*.

The team discovered that the pH of garlic and banana fructans was lower than that in commercial varieties. Low pH is conducive for the utilization of fructans by bacterial strains. The scientists observed that the bacterial strains grew better in the extracted fructans than in commercial fructo-oligosaccharides and inulin. They also noted that the growth of *Escherichia coli*, in the banana and garlic substrates, was reduced.

Garlic contains a mixture of fructo-oligosaccharides and inulin. The Nendran banana has more fructo-oligosaccharides. So the prebiotic activity score is higher in Nendran banana. The researchers observed that fructans from the Nendran banana had greater prebiotic efficacy and supported the growth of all four probiotic strains. They found that *Lactobacillus casei* and *Lactobacillus plantarum* strains showed maximum growth rate.

The scientists report that garlic and Nendran banana fructans are good substrates for probiotics and produce more lactic acid than commercial fructo-oligosaccharides. The food industry can now use these as prebiotic ingredients.

*LWT—Food Sci. Technol.*, **83**: 68–78

### Liquid Active Ingredients Reducing wastage in medicine

Active pharmaceutical ingredients are that part of the medicine which exerts the desired curative action. Dosage forms like tablets, capsules, syrups, ointments, sprays, injections are decided mainly based on the chemical nature of the active ingredients and patient compliance. Many active ingredients pose problems of solubility, are less curative and are cleared off from the body as waste. Now, K. Prasad from the CSIR-CSMCRI, Bhavnagar, and scientists from the University of Leicester, UK collaborate to tackle these issues.

The team developed a liquid concentrated form of active ingredients to address solubility issues, especially in amphiphilic ingredients – active ingredients with a dual chemical nature, water soluble and water insoluble, due to polar and nonpolar moieties in the chemical structure. The team used the principle of deep eutectic solvent to prepare a liquid concentrated formulation. Deep eutectic solutions are a mixture of two components in a particular ratio, heated in a sealed environment. The resultant liquid has freezing and melting temperatures lower than those of the individual components. One of these two components should be a hydrogen bond acceptor – generally a quaternary ammonium salt – and another should be a hydrogen bond

donor. The scientists used two methods to make deep eutectic solutions: a first, where the active ingredients are hydrogen bond donors and, a second, where they are hydrogen bond acceptors. Ingredients such as aspirin, paracetamol, and salicylic acid showed better miscibility and stability in eutectic rather than in their regular solutions.

The study provides a useful method to handle solubility issues in the various dosage forms. Especially for complex polymorphic crystals which affect the drug's metabolism in the body. Good news for patients as less frequent dosing is required. Moreover, drug manufacturers will not have to worry about the differential behaviour of the drug in patients.

*Fluid Phase Equilibria*, **448**, Spl Issue: 2–8

### Hydroxyapatite from Fish Artificial bone

Hydroxyapatite, a form of calcium phosphate, resembles natural bone in both structure and chemical composition. Biocompatible, anti-inflammatory, with high osteo-conductivity, and anti-immunogenicity, this compound is used in orthopaedic implants and in dentistry. Interestingly, recent research suggests using fishbone to synthesize hydroxyapatite.

Fisheries discard fishbone. Though this smelly waste is an environmental problem, fishbone is fragrant news for scientists. It contains calcium phosphate, collagen fibre, calcium carbonate and hydroxyapatite.



Image by Mitch Ames, via Wikimedia Commons

Now, a team of scientists from the IEST, Howrah and the Central Glass and the Ceramic Research Institute, Kolkata have synthesized hydroxyapatite from the bones of *Lates calcarifer*, the Asian sea bass. They washed and

boiled the bones to remove organic compounds. Then the researchers dried the bones in an oven. Next, they calcinated them at different temperatures to synthesize biogenic hydroxyapatite powder.

The team identified the phases and functional groups of the powder using X-ray diffraction and Fourier transform infrared spectroscopy. They found phosphate and hydroxyl peaks. And noted that other groups, corresponding to carbonates and collagen, were not present. The researchers observed that the degree of crystallinity and the crystal size of fish bone derived hydroxyapatite powder increased with calcination temperature.

They conducted *in vitro* biocompatibility studies to prove the non-cytotoxicity of these powders. The sinterability of fish bone hydroxyapatite powder was significantly higher than that of chemically synthesized powder. This is due to the smaller crystal size, explains the research team.

Hydroxyapatite has high demand in dentistry and medicine. The use of fishbone, as source, will reduce the production costs of hydroxyapatite, and reduce environmental problems caused by fishbone waste.

*Mat. Lett.*, **203**: 89–92

### Contaminated Water

#### *Sintered brick as solution*

Heavy metal, non-metal and metalloid contamination of aquatic ecosystems is causing high morbidity and mortality. Yet, with increased human activity, these severe contaminants continue to enter drinking water.

Thousands suffer from arsenic and fluoride toxicity. Arsenic causes skin discoloration, cardiovascular disorders and cancer while fluoride is associated with bone and skeletal deformities. Existing methods for the removal of such contaminants include ion exchange, reverse osmosis, chemical reduction, electro dialysis and adsorption. Adsorption is favoured as most effective and is, therefore, a thrust area in research.

Last fortnight, researchers from the Indian Institute of Technology Roorkee, examined three different types of adsorbents – thermally treated laterite, acid-base treated laterite and alumin-

ium oxide/hydroxide nanoparticles – for the removal of arsenic and fluoride from water. After adsorption, the team stabilized the spent adsorbents into sintered clay bricks. Based on the analysis of the characteristics of these sintered bricks, the researchers claim that these bricks effectively immobilized the contaminants from water.

The study results reveal that the leaching back of arsenic and fluoride from the sintered bricks was in the range of 510 µg/l and 2.1 mg/l – less than that of the standard USEPA range. Given this claim, immobilization of spent adsorbents in the form of sintered bricks may prove useful for industries to avoid releasing contaminants into water ecosystems.

*J. Environ. Manage.*, **200**: 160–169

### Killing the Killer Colour

#### *In situ phytoremediation*

Textile dyes pose a threat to the environment. Hence, it is imperative to treat these effluents before discarding them into the environment. Govindwar and team from the Shivaji University, Kolhapur now report a low cost, eco-friendly and sustainable method for dye wastewater treatment. They grew two aquatic plants, *Typha angustifolia* and *Paspalum scrobiculatum*, together, at a high rate transpiration system. The arrangement involves a soil system in close conjunction with plants.

The team treated the effluents *in situ* using a *T. angustifolia*, *P. scrobiculatum* and a combination of the two plants. These two plants have excellent dye removal potential. The scientists observed significant reduction in biochemical oxygen demand, chemical oxygen demand, colour value, total dissolved solids, total suspended solids and heavy metals, after phytoremediation. The results showed that the combination of the two was more efficient for treating textile dyes than the individual plants alone.

After treatment with the consortium, seeds, to which the dye solution was applied, showed better germination than untreated dye-watered seeds, indicating reduced toxicity. Anatomical studies of the roots revealed phyto-transformation of dye in the epidermal and cortical regions. Metabolite analy-

sis showed that both plants have potential to convert complex dyes into simpler metabolites.

The team suggests that co-planting *T. angustifolia* and *P. scrobiculatum* could be a wise approach for future wastewater clean-up programs.

*J. Haz. Mat.*, **338**: 47–56

### Treating Waste Methylene Blue

#### *With lady's finger seeds*

Dye-handling industries – textile, paper, rubber, plastic, leather, paint, cosmetics, pharmaceutical – release large volumes of toxic reactive dye contaminated wastewater that find its way into surrounding water bodies. Methylene blue, a popular dye, is one such effluent. Discharged from textile industries, it forms a coloured residue, obstructing photosynthesis in aquatic plants as it blocks light and prevents microbial growth. Direct contact with or ingestion of methylene blue is harmful for us too: it can cause gastritis, vomiting, diarrhoea and headaches.

Recently, a research team from the Indian Institute of Technology, Kharagpur, reported an efficient way to remove methylene blue from polluted water. They used lady's finger – *Abelmoschus esculentus* – commonly cultivated and consumed in many tropical countries.



Image: Wikipedia Commons

The team separated, cleaned, dried and finely powdered the seeds, kernels and outer shells of lady's finger seed-pods for investigation. They employed a response surface methodology approach to develop a central composite design model. This design model was applied as input for an artificial neural network approach to further analyse interactive term effects between significant process parameters, on maximum biosorption capacity.

Out of the three powdered parts, they found that seed powder is the best and adsorbs about 65–80% of methylene blue – as efficient as commercially available activated carbon but seven times cheaper. The scientists also report that the seed powder can be efficiently employed for three consecutive cycles to remove methylene blue effluent.

Existing methods such as membrane filtration, ion-exchange and chemical precipitation are inadequate for large scale applications. They produce toxic sludge and use a lot of chemical reagents and energy. The report from Kharagpur now offers a cost-efficient and eco-friendly way to treat methylene blue dye-bearing industrial wastewater – seed powder from the humble lady's finger!

*J. Environ. Manage.*, **200**: 145–159

### Spotted Ground Thrush *Endangered forest specialist*

Forest specialists, as a species, have very specific habitat requirements. As forest areas shrink, their habitats are under threat. The Spotted Ground Thrush – *Zoothera guttata* – is one such endangered forest specialist. Scattered over the tropical and subtropical forests of Africa, five distinct populations and races of this bird inhabit the deep leaf-litter strewn floors of deep shaded forests. The IUCN records its world population as less than 2500 and decreasing. However, there exists little understanding of its habitat requirements and the reasons for its decline.



Image: Eric Gropp, via Wikimedia Commons

Last fortnight, a team from SACON, Coimbatore and the University of KwaZulu-Natal, South Africa reported

results from camera-trap surveys to identify the habitat requirements and conservation status of the Spotted Ground Thrush in the critically endangered Indian Ocean Coastal Belt Forest of southern Africa. They took 5796 trap-days in 82 forest patches of various sizes in the area during winter 2014–2016. They got 72 photographs of the bird from more than 40 locations.

The team reports that 70% of the Indian Ocean Coastal Belt Forest has been lost due to agriculture and other human activities. Forest areas have become fragmented. These are among the factors to which the researchers attribute the decrease in the Spotted Ground Thrush population of the Indian Ocean Coastal Belt Forest. Their study shows that small and isolated forest patches are unsuitable for the bird. Such patches fail to conceal nests and expose them to predation. The team also claims that changes in population structure and fragmentation result in low breeding success and low genetic vigour. However, in herbaceous and large tree patches, they note that the population appears healthy.

The scientists believe that recognizing the Spotted Ground Thrush as a flagship species will help conserve the bird and the remaining forest area.

*Forest Ecol. Manage.*, **400**: 523–530

### Superhydrophobic Cotton Fabric *Durable and self-cleaning*

Self-cleaning coatings have become part of our lives: they are used on glass, cement, paints and textiles. Existing superhydrophobic coatings for cotton textiles pose a problem: the coating is lost under acidic, alkaline and salty conditions. Boiling water, ultraviolet irradiation and mechanical abrasion also reduce hydrophobicity. So, the search for better alternatives is high priority in scientific circles.

Last fortnight, scientists from the Indian Institute of Technology, Kanpur reported developing a new anti-sticking, anti-contamination and self-cleaning superhydrophobic coating for cotton fabrics. They leveraged their research on the brochosomes found on the surface of leafhopper wings. Leafhoppers secrete these intricately struc-

tured microscopic granules to keep their cuticle dry. Existing literature is vivid with descriptions of the super hydrophobicity of brochosomes.

The scientists fabricated durable super-repellent surfaces on cotton fabric using zirconia particles embedded into a siloxane material. They used a simple sol-gel dip coating method to make the fabric. Then, using a field emission scanning electron microscope, they examined the surface morphology and elemental composition of the coated cotton fabric. They tested the stability of the coating by measuring the contact and sliding angles of various liquids with surface tensions ranging from about 45 to 70 mN/m. The team found that the surface resembled leafhopper brochosome. They also discovered that the super-repellency is due to the formation of continuous rough surfaces and the very low surface energy of the coated cotton fabric.



Image: Wikipedia Commons

The team suggests that the durable super-repellent zirconia-siloxane coated fabric can be used in many anti-wetting, self-cleaning applications and as support for aquatic floating devices. It can also act as filtration material for rapid and continuous oil-water separation, under all conditions.

*Appl. Surf. Sci.*, **416**: 639–648

**Reports by: Manish Kumar Tekam, G. Sharath Chandra, P. Venkatesu, Neeta Shrivastava, P. Vijisha, Sanghamitra Deobhanj, Mahadeva Swamy, Monika Jaggi, D. Kavya, K. Siranjothi, Biraja Kumar Sahu and Aditi Jain.**

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scienceandmediaworkshops@gmail.com