Science Last Fortnight

Tremor-free Interferometers
Detecting gravitational waves

Gravitational wave detectors rigorously probe the universe to reveal phenomena that have remained mysteries. But these instruments are highly sensitive. Scientists say that even earthquakes of magnitude four on the Richter scale could interfere with the detector's functions.

Last month, Nikhil Mukund of IUCAA in collaboration with institutes in Italy, the United States, and the United Kingdom reported a technique for dealing with earthquakes[1]. They took archival data on seismic events and, using machine learning algorithms, devised ways to predict the impact of earthquakes and take appropriate measures. Using algorithms, they can now switch control configurations, such that the interferometers remain locked even under excessive ground motions.

Though measures have been taken to isolate these detectors from large magnitude earthquakes, small magnitude tremors still posed a problem.

Last fortnight, Nikhil Mukund and Sanjith Mitra from the IUCAA, Pune and Surendra Nadh Somala from the IIT Hyderabad collaborated with the Laser Interferometer Gravitational-Wave Observatory in Livingston, USA to develop a model to understand the effects of these small magnitude earthquakes[2].

They found that the major source for such earthquakes is the hydro-mechanical drilling carried out by oil industries in the surrounding region. Such drilling exposes the underlying fault lines to high pressure, resulting in tremors. Though these seismic events cannot cause any structural damage, they affect gravitational wave detectors.

However, the algorithms created to deal with large earthquakes cannot deal with small tremors caused by nearby industries. The team stresses the need to curb such activities by oil industries in the vicinity of the detectors. They also call for highly sensitive seismometers that can detect low magnitude tremors precisely and rapidly.

With many countries aiming to build both above ground and underground detectors, such contributions make Indian scientists leaders in this area of research, even before gravitational detectors are built here.

Debris Flow in the Gangotri Glacier
Evolution and triggering

In 2017, there was a massive flow of debris from the Meru Bamak stream at the Gangotri glacier, Garhwal Himalaya. The debris flow emptied large amounts of sediment from the Neela Taal region, modifying its topography and changing the course of the river Bhagirathi.

In recent decades, many such disasters have been reported in the Indian Himalayan region. Such events pose a high risk to life and infrastructure.

Gangotri Glacier Debris. Image: Amit Kumar

Amit Kumar, Rakesh Bhambri, Sameer Kumar Tiwari and Akshaya Verma from the Wadia Institute of Himalayan Geology, Anil Kumar Gupta from the IIT Kharagpur and Prashant Kawishwar from the Chhattisgarh Council of Science and Technology, investigated the July 2017 Gangotri glacier debris flow.

They analysed remote sensing data in combination with field data and found that the retreat of the Gangotri glacier was crucial in the debris flow event.

Gangotri, the largest glacier in the Garhwal Himalaya, retreated by about two kilometres in the last two centuries. Significant mass thinning of the glacier snout is also observed from 2000 to 2017. From 2006 to 2017, it receded by more than 200 m.

The researchers focused on the evolutionary history of debris flow since 2012. After the retreat of the Gangotri glacier, the parallel ridges of debris deposited along the sides of the glacier became unstable. Meltwater from the Meru Bamak was draining from the left side of the moraine. So this part was more affected. Meru Bamak gradually widened by about 10 m in September 2014. By 2016, it increased to about 50 m.

The 2017 debris flow event enlarged the stream by about 220 m and deeply eroded the Gangotri glacier's left lateral moraine. This is what could have triggered the event, say the researchers.

The Himalayan region can experience more debris flows in the future as glacial retreats appear to be on the increase. Such studies can help predict and reduce natural hazards in the region.

Fungal Endophytes
Hope for better malaria control

Fungal endophytes – fungi that coexist within plants – are often seen to borrow traits from the plants. A well-known classical case is that of endophytes from taxus trees producing taxol, an anticancer drug. More recently, scientists from the CSIR-NCL reported an endophytic entomopathogen that acquired stronger insecticidal traits from trees such as neem.

Dinkar Sahal of the International Centre for Genetic Engineering and Biotechnology, New Delhi wondered whether he could find antimalarials among endophytes. In Cameroonian traditional medicine, the soursop or *Annona muricata* is a plant well known in the treatment of malaria. Will there be endophytes in *Annona muricata* that can produce antimalarials?

Dinkar Sahal collaborated with Cameroonian scientists to find out. The team first isolated 157 endophytic fungi from the various plant parts. Did these endophytes have medicinal properties like those of the plant?

Image: Fpalli, via Wikimedia Commons

To test, they used a chloroquine-sensitive strain and two chloroquine-resistant malaria parasite strains.

The researchers used ethyl acetate extracts of all the fungi individually to test for antimalarial activity. Out of the extracts of 157 fungi, 28 were effective on chloroquine-sensitive strains and 27 worked even on chloroquine-resistant strains.

The team reports that, out of the 28 endophytic fungal extracts, seven were highly potent, inhibiting the growth of the parasite by 50% at a concentration of two micrograms per millilitre.

They identified one of the endophytes, *Neocosmopora rubicola*, as most potent inhibitor of both chloroquine-sensitive and -resistant strains. The concentration needed to inhibit the parasites by 50% was in the range of 0.4 micrograms per millilitre. The team observed inhibitory activity after four hours. Total clearance of the parasite took 32 hours of treatment.

Using a gas chromatographic analysis of the *Neocosmopora rubicola* extract the scientists identified many volatile metabolites. Cis-vaccenic acid methyl ester was the most abundant. The team says that more investigations are needed to understand the active metabolite. A deeper exploration of these endophytic fungi may reveal a rich repertoire of antiplasmodial molecules, says Dinkar Sahal.

The extracts showed limited cytotoxicity on HEK 293T cell lines indicating that the extracts are not harmful to normal body cells.

Annona muricata is known to have anticancer properties also. Perhaps further testing of the isolated endophytes may help identify fungi that produce anticancer compounds. The study may also be a tipping point for research on endophytes among ethnobotanically important plants.

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Energy Audit in Farming
Reducing carbon footprint

Given the impending climate change mitigation strategies, how do we reduce energy inputs and improve carbon sequestration in farming systems?

Zero tillage practices reduce the energy inputs required for growing crops. But how do they influence the need for nutrient inputs? What production strategies can we use to make agricultural practices productive and sustainable?

Last fortnight, scientists from ICAR institutes reported the results of their long-term field-based study on maize based systems. The team conducted trials on different combinations of crop rotations with maize: maize–mustard–mungbean and maize–wheat–mungbean.

The team found that retaining agricultural residues in the plots led to a 12% increase in system productivity and gross return. They say that cultivating maize–wheat–mungbean was less advantageous than cultivating maize–mustard–mungbean. The benefit to cost ratio was higher in maize–mustard–mungbean than in maize–wheat–mungbean.

The researchers noted higher generation of biomass in permanent beds with residues. They noticed higher carbon inputs in maize–wheat–mungbean than in the maize–mustard–mungbean system.

The scientists found that in both maize based systems, out of the total energy inputs, renewable crop residue accounted for more than 68%. Chemical fertilisers amounted to nearly 20%. In both cropping sys-

tems, chemical fertilisers used contributed to higher carbon footprints on a special scale.

The researchers combined diverse sources of nitrogen as fertilizer. They found that plots treated with neem-coated urea had higher productivity and lower carbon footprints than plots treated with prilled urea or sulphur-coated urea. And the prilled urea treatment proved costlier than using a one-time application of coated fertilisers.

C. M. Parihar, from the Indian Institute of Maize Research, says that the results provide policymakers evidence that conservation agriculture based on maize–mustard--mungbean rotation with nitrogen management through neem coated urea is environmentally safe and energy efficient. It can reduce carbon footprints while ensuring food security.

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Tannery–sludge Contamination
Geranium cultivars remediate

Tannery effluents contain heavy metals, bleaching agents and organic matter. Such effluents, when not treated properly, percolate through soil entering groundwater and ultimately, the food chain. The hexavalent chromium in these effluents is toxic. It causes dermatitis, ulcers and even cancer.

It is expensive to treat such metal-contaminated soils. Phytoremediation, on the other hand, is eco-friendly and cost effective, employing plants *in situ*. Many plants grow well in soils contaminated by tanneries. But would it not be better if they have economic benefits, besides the ecological one? And if the heavy metals do not come into the parts used, would it not be even better?

Recently, researchers from the CSIR-Central Institute of Medicinal and Aromatic Plants, Lucknow and the Academy of Scientific and Innovative Research, New Delhi, selected geraniums for this purpose. The plant is reported to be useful in remediating chemically laden soils and they are adaptable to environmental stresses. They compared the performance of two geranium cultivars,

Bourbon and CIM-Pawan, in soils with various concentrations of tannery sludge.

They applied dried tannery sludge in different concentrations to plots, moistened the plots and left them to incubate for 50 days. After the 50-day incubation, they observed an increase in pH, electrical conductivity, organic carbon, nitrogen, phosphorus, chromium, nickel, lead, iron, copper, zinc and manganese. And they found that applying composted tannery sludge to soil increased plant yield and improved soil physicochemical properties.

Then, the team planted 40-day-old uniform rooted cuttings of the two geranium varieties. In both cultivars, they noted high enzyme activities after 85 days. In both, the team observed increased urease and β-glucosidase activities in plots with 50 tonnes per hectare of dried sludge and maximum soil dehydrogenase and phosphatase activities at 100 tonnes per hectare.

Image: via Wikimedia Commons

They noted that a tannery sludge concentration of 50 tonnes per hectare increased urease activity but further increase in sludge reduced the activity. This, they interpret, may be due to the denaturation of protein.

Shoot height increased with increase in sludge treatments for up to 50 tonnes per hectare and further increase in sludge concentration decreased it. Both chlorophyll *a* and *b* decreased with increase in sludge. They observed similar trends with root length and leaf area. The scientists say that this decrease may be due to metal toxicity on plant metabolism and a reduction in photosynthesis.

They analysed the concentration of heavy-metals in plant shoots and roots using spectrometry and found maximum metal uptake in the roots of cv. Bourbon. They also found that heavy metals are translocated from root to shoot more easily in cv. Bourbon. Chromium was taken up more easily in the roots of both cultivars followed by lead and then cadmium. The team noted a bio-concentration factor < 1 for all the heavy metals in the soil.

In the postharvest soil, they observed a decrease in heavy metal concentrations, organic carbon, nitrogen and potassium. Again, cv. Bourbon proved more efficient than CIM-Pawan in all experimental parameters tested.

In order to test the oil quality and yield, the scientists hydro-distilled the cultivars' fresh leaves and inflorescence and extracted essential oil. They obtained good quality oil at 50 tonnes per hectare of sludge application and noted higher oil yield in cv. Bourbon than in CIM Pawan.

They conclude that geranium can phytostabilize tannery sludge-treated soil and that cv. Bourbon is best for the purpose. The results show that tannery sludge can help improve soil fertility and that geranium cultivars quickly and efficiently remove heavy metals from soil.

Socially responsible tanneries may take up geranium cultivation and, while ecologically improving the soil, economically benefit from the sale of the sweet scented oils. By switching to this aromatic crop, farmers can avoid food chain contamination.

Active Coagulant in *Nirmali* Seeds
Protein or polysaccharide?

Strychnos potatorum is known for its medicinal value. The seeds of the plant, locally called *Nirmali* seeds, are natural coagulants. They are traditionally used to clarify turbid water. They contain lipids, alkaloids and polysaccharides.

A 1994 study reported that a polysaccharide moiety in *Strychnos potatorum* seed is responsible for coagulation activity. However, the active coagulation component in another well-known natural coagulant, *Moringa oleifera* seed, is a protein. Lipids and polysaccharides in crude extracts of Moringa seeds are known to deter coagulation. So, what is the active coagulation component in *Strychnos potatorum* seeds? Is it really a polysaccharide?

Image: Vinayaraj via Wikimedia Commons

P. Arunkumar, V. Sadish Kumar, S. Saran, Harsha Bindun and Suja P. Devipriya, from the Pondicherry University decided to characterise the active agents in the seeds of *Strychnos potatorum* and establish the chemistry behind the process of coagulation. The researchers first defatted the seed powder to eliminate lipids. They then isolated the protein and polysaccharides from the seed and characterised them. The purified protein and polysaccharide extracts were used in the coagulation assay.

The researchers used synthetic turbid water prepared with kaolinite particles for the assay. Coagulation activity was measured by the proxy of optical density in a UV spectrophotometer. The data shows that the seed extracts have more than 80% coagulation activity.

The scientists found that the purified protein fraction from *Strychnos potatorum* seeds show better coagulation activity than the polysaccharide fraction. This is in contrast to the earlier report which ascribed the coagulant activity to the polysaccharide moiety.

Though they have been able to identify the coagulant fraction as a molecule of 12 kilodaltons, characterisation of the molecule is necessary to create a cheap and simple method of water purification.

Coagulation is perhaps through an electrostatic process, say the researchers. The kaolinite particles are charged negative. So they adsorb

to the positively charged cationic polyelectrolytes present in the protein and form aggregates.

The active coagulant agent in *Strychnos potatorum* seeds also needs to be compared with other plant-based coagulants from moringa seeds, beans, mustard etc. to assess their relative values in water treatment, say the researchers.

Bengal Gram Husk
Adsorbing organic dyes

If water is polluted, it often acquires colour. If there are water soluble dyes, even in trace amounts, the colour changes. Toxic dyes that cause cancer can, therefore, be easily detected even by a layperson. The colour reduces the transmission of light through water and affects aquatic ecosystems.

To adsorb the dyes from water, lignocellulosic agricultural waste such as rice, wheat straw, bamboo, seeds, sugarcane bagasse, and coconut shells have been used. Unlike these, bengal gram husk has no nutritional or commercial value. So Kanika Gupta and her team from the Indian Institute of Petroleum, Dehradun and the Academy of Scientific and Innovative Research, Ghaziabad checked the potential of using bengal gram husk to deal with dyes.

The scientists prepared graphene-like porous carbon nanostructures using bengal gram husk via alkali-activation. They converted the husk into a carbonaceous material and chemically activated it to obtain high surface area activated carbon. Using a surface area analyser, they found that it had high pore volume and surface area – essential attributes of a good adsorbent.

To confirm its adsorbent capacities, the researchers applied methylene blue and methyl orange dye. Using Fourier-transform infrared spectroscopy, they confirmed that both the dyes were adsorbed. These adsorbents could efficiently scavenge dye from industrial waste water.

Many types of agricultural wastes have been used to prepare activated carbon. However, none matches the adsorption capacity of bengal gram husk. This is due to its high porosity and graphene-like structure, say the researchers.

Identifying the Leader
Fireflies show the way

We are social animals. Our decision making is directly or indirectly influenced by others. People on online platforms, for example, congregate to exchange thoughts, and opinion leaders influence people. Such opinion leaders are easy to observe and study using algorithms. This can help make decisions in various instances – marketing, political and religious propaganda, to name a few.

The algorithms proposed till date to identify the leaders are complex or have limited scalability due to the large number of parameters to be considered. Can we use nature-inspired algorithms like the firefly algorithm to minimize these limitations and capture such electronic word-of-mouths better?

Lokesh Jain and Rahul Katarya, from the Delhi Technological University chose the firefly algorithm as it used both local and global optimization to solve the problem, whereas most algorithms use only one type. The algorithm results in faster computation and more coherent solutions than other algorithms can provide.

Just as a firefly flashes its light to attract another firefly, an opinion leader also flashes ideas to a large group of users. And, just as attractiveness decreases with distance for fireflies, the attractiveness of the leader to the user also fades, creating smaller local groups of users.

The team set about deriving a mathematical expression to rank the top opinion leader based on the ability to attract other users in an online community.

For this they first identified communities on online platforms based on the communication of the members or nodes within a group. Then they chose the top five opinion leaders based on dummy data from 2500 users and 20 nodes using the firefly algorithm with various permutations. The top opinion leaders were selected based on attractiveness, and distance and prominence values.

Next, they implemented the algorithm on a real dataset. They also compared results with another social network analysis algorithm, the Louvain method, and found that the firefly algorithm gave faster and better results in terms of accuracy, precision, and recall.

Unlike the case with other algorithms, the firefly algorithm uses both large and small groups to predict the top optimal leaders, says Rahul, Delhi Technological University.

However, the algorithm only solves a static case. Not a dynamic dataset. In online communities, there are constant changes, says Lokesh Jain, IIT Delhi.