Science Last Fortnight

Predicting from Precursors
Earthquakes from electron content

Researchers from the Indian Institute of Remote Sensing, Dehradun, North Eastern Space Applications Centre and IIT Dhanbad, reported last fortnight that perhaps the total electron content of the ionosphere can be used to predict earthquakes.

Total electron content is an important parameter for ground to satellite communication and satellite navigation. The change in the path and velocity of radio waves in the ionosphere has a big impact on the accuracy of satellite navigation. Neglecting changes in the ionosphere total electron content can introduce tens of metres of error in position calculations. So the electron content of the ionosphere is regularly monitored.

The trick is simple. Radio waves are affected by electrons. The more the electrons in the path of the radio wave, the more the radio signal will be affected. We can thus get a measure of the total electron content between a radio transmitter and receiver. The researchers took data from ground-based global navigation satellite systems as well as from the UNAVCO, a consortium of universities interested in earth sciences.

The team observed that total electron content increased dramatically in the ionosphere vertically above four earthquake events in 2015: 1st April, Pipalkoti; 25–26 April and 12th May, Nepal. These changes could be seen almost eight days before the earthquakes. The team reports that significant low total electron content values were also observed 13–14 days prior to the first two events.

Ionospheric perturbation is seen even in low magnitude earthquakes whenever the recording station lies very close to the epicentre. Interestingly, their analysis shows total electron content increases as the distance to the epicentre decreases. Therefore, it is inferred that observed total electron content variations are seismogenic in nature. And are not related to geomagnetic storms caused by solar winds – especially since perturbations of the electron content by solar eruptions could be ruled out.

As the Himalayan region has a long history of frequent strong earthquakes causing significant loss of life and property, perhaps it is time to set up more continuous monitoring stations for ionospheric electron content.

Quat. Int., **462**: 65–74

Strain Accumulation
Himalayan earthquake signals

Microearthquake networks play an important role in earthquake prediction research. They provide information on changes in local stress fields. Scientists estimate earthquake probabilities from the history of large earthquakes in a specific area and the rate at which strain accumulates in the rocks.

Scientists from the Wadia Institute of Himalayan Geology, the National Centre for Seismology and the CSIR-National Geophysical Research Institute recently conducted a study using a Continuous Global Positioning System. This system has been useful for measuring crustal deformation in Garhwal-Kumaun Himalaya. Five continuous GPS sites have been installed in the region. In addition, there is a continuous GPS site at Delhi.

The rate of long-term convergence is generally equal to the slip deficit rate, as only less than 10% of this rate contributes to permanent deformation and the rest of the deformation is recoverable. Small and moderate earthquakes of the Himalayan seismic belt do not contribute much towards the convergence. Further, the slip rates across the plate boundaries are stationary over periods of a hundred to a thousand years.

The last great earthquake in the Garhwal Kumaun region probably occurred in 1505. And the one before that was probably in the thirteenth century. If the current rate of strain accumulation applies over the past 700 or even 500 years, then sufficient slip deficit has accumulated in the region to be released in a great earthquake.

The scientists analysed continuous GPS measurements from the region and found evidence for active deformation and strain accumulation for future major earthquakes in the region. The strain accumulation in this region corresponds to a slip deficit rate of 18 mm/year.

Other than the evidence of strain accumulation, these measurements also show seasonal variations, largely caused by atmospheric and hydrological variations. However, there seem to be other factors contributing to this variability. Further studies are required with better measurement techniques and analytical methods to ensure that there are no major earthquakes to be expected in the region.

Quat. Int., **462**: 124–129

Save Urbanized Herons
By protecting roadside trees

Herons, long-legged, non-swimming water birds, feed on a variety of live aquatic prey. Usually, they prefer to construct heronries near wetlands. Now, researchers from the Central University of Kerala report urbanization of the heron's habitat.

'It was interesting to see these wetland birds coming to urban areas for nesting. So we thought of studying the characteristics of the trees selected for nesting. We also looked into the species of trees and the herons nesting there' says Roshnath.

Initially, they used previous bird census data and observations from North Kerala to identify and count the bird population. They successfully identified more than 50 heronry sites in and around Kannur and Kasaragod districts. They measured the height of the trees and average canopy spread of tree where herons nested. They also studied the number of nests per tree and effect of urbanization on nest construction.

They found nine species of waterbirds in the heronries of North Kerala. Four of them – Little cormorant, Indian cormorant, Black-crowned night-heron and Indian pond-heron – constructed more heronries near cities than in wetlands.

The highest number of nesting trees was recorded along roadsides followed by residential areas and non-residential areas. The trees along the National Highway and other major roads had the maximum recorded nests. Rain tree, copper pod tree, as well as mango, jackfruit and banyan trees were favourites for heronries.

'We have proposed these heronry sites to be declared as heritage sites. We also proposed continuous monitoring of these sites during the breeding season, involving the public in such monitoring. Put up awareness posters near these trees', advises Roshnath.

Image: Roshnath Ramesh

Since most nesting trees are located along roadsides, priority should be given for conserving nesting sites. Saving and planting of trees along the roadsides will increase the heron populations.

Cur. Zoo., **63**(6): 599–605

The Case for Castasterone
Heavy metal stress-tolerant plants

Heavy metal contamination by industrial effluents is a global problem. Agricultural soil with heavy metals leads to poor crop productivity. Food crops from such soils bioaccumulate high levels of heavy metals. Consuming such food has adverse effects on health. As a large area of agricultural soil is already contaminated with heavy metals, it is necessary to breed plants resistant to heavy metals in soil and less able to accumulate them.

Last fortnight, a team from the Guru Nanak Dev University, Sri Guru Granth Sahib World University, DAV University and Punjabi University demonstrated that seeds pre-soaked in a chemical, castasterone, were able to better withstand heavy metal stress.

Castasterone is the end product of the brassinosteroid biosynthetic pathway in plants. Brassinosteroids are known to act as plant hormones.

Castasterone is activated in response to stresses such as salinity, heavy metal and drought. It increases the levels of antioxidants and helps the plant to combat stress.

The scientists hypothesized that supplementing seeds with castasterone prepares the plant for future stress conditions. They found that, in the presence of copper, mustard seeds treated with this chemical showed better growth than untreated seeds. Spectroscopic examination showed that these plants accumulated copper to a lesser degree.

Treated seeds also showed low levels of hydrogen peroxide and superoxide anion radicals which are directly correlated with stress in plants. The expression of genes, such as ascorbate peroxidase, glutathione reductase, glutathione peroxidase and glutathione-s-transferase, which help alleviating stress, was also high in treated seeds.

The researchers recommend using brassinosteroids to improve the performance of crop plants in metal contaminated soils.

Ecotoxicol. Environ. Saf., **147**: 725–734

Salt Tolerance Mechanism
Beet root – a model plant

Salinity stress affects the growth, development, and productivity of plants. It is known that the over-expression of certain genes is involved in the synthesis of osmoprotectants that confer salt tolerance to plants. Vandna Rai from the National Research Center on Plant Biotechnology, IARI, New Delhi in collaboration with Japanese scientists, examined the role of osmoprotectants in the salt stress mechanism using genes from salt tolerant sugar beet.

Glycine betaine is an osmoprotectant. The availability of serine, a betaine precursor, increases its biosynthesis, leading to elevated salt tolerance. Serine is synthesized from 3-phosphoglycerate in the presence of 3-phosphoglycerate dehydrogenase. The team isolated two genes, -a and -b, for D-3-phosphoglycerate

dehydrogenases, from salt-tolerant sugar beet and expressed them in *Escherichia coli*. The expression of phosphoglycerate dehydrogenase-*a* increased under salt stress, underlining its vital role in salt tolerance.

This provoked the scientists to study the kinetic properties of these proteins. They found that D-3-phosphoglycerate dehydrogenase-*a* has higher affinity for 3-phosphoglyceric acid than -*b*, under salt stress. They also found that phosphoglycerate dehydrogenase activity was increased in leaves, petiole, as well as in lateral and storage roots after salt stress. However, the petiole showed maximum activity.

Therefore, D-3-phosphoglycerate dehydrogenase-*a* expression in other plant species may help us understand the molecular events underlying plant salt-tolerance.

Protoplasma, **254**(6): 2305–2313

Farmers Grow Fuel
Agro-industry opportunity

Fossil fuels are limited. Thus, the global focus has been to find alternatives. Though researchers have suggested the use of biodiesel in internal combustion engines, biofuels also lead to the emission of greenhouse gases.

Last fortnight, Ashok Kumar and K. A. Subramanian from the IIT, Delhi, reported their explorations into the factors contributing to reduction in emission of CO_2, CH_4 and N_2O from a diesel engine. They compared the use of *Pongamia pinnata* oil and Bharat stage-IV diesel in an automotive diesel engine.

Biodiesel has a high cetane number, reflecting its faster ignition. As it has low sulphur content and no aromatic substances, it has lesser emissions and provides high performance in a compression ignition engine. Although CO_2 emission is less due to the lower carbon content of biodiesel, the scientists thought that they could boost engine efficiency by increasing compression ratio, thus bringing down greenhouse gas emissions further.

First, they connected a diesel engine with a dynamometer, to control the engine's speed and torque. They used an air flow meter to measure

intake and a mass flow meter to measure fuel consumption rate. The exhaust gas emissions were fed into a gas analyser to be measured. The analyser works on a non-dispersive infrared principle, which allows infrared energy to pass through the sampling chamber. The researchers used piezoelectric transducer sensors to measure the pressure in cylinder. A crank angle encoder was employed to deliver a signal when there was one degree rotation in the crankshaft.

Using this experimental set up, the scientists found that, in both biofuels and fossil fuels, there was an increase in brake thermal efficiency with increase in compression ratio. This is attributed to the higher temperature and pressure of reactants in the cylinder, when the compression ratio is increased. As biodiesel has high oxygen content, it leads to complete combustion and generates high temperature.

The scientists also found that increase in compression ratio led to decrease in CO_2, CH_4 and N_2O emission in both types of fuels. Thus, use of biodiesel will help further reduce GHG emissions.

The scientists say that redesigning engines for higher compression ratio will enhance the role of biodiesel in the automobile industry. Farmers can now grow these inedible seeds to tap into the raw material market for biodiesel.

Appl. Therm. Eng., **127**: 95–105

Piglet Mortality due to Diarrhoea
Desi pigs as remedy

Escherichia coli cause diarrhoea in young piglets accounting for heavy mortality. The adhesion of diarrhoeagenic *E. coli* to the epithelial cells of the small intestine, an essential prerequisite of diarrhoea susceptibility is differentially expressed in certain piglets owing to presence or absence of certain receptors genes reported to be mapped to SSC13q41 genomic region. *MUC13* gene, a potential candidate gene mapped at the same location is expected to influence the adhesion of *E. coli.* The DNA polymorphism as well as expression of the gene is influenced genetically and may be different in various genetic groups/breeds.

Last fortnight, Rebeka and team from the Indian Veterinary Research Institute, Uttar Pradesh, studied *desi* pigs in terms of *E. coli* adhesion pattern and MUC13 expression. They collected tissue samples of small intestine from 80 different slaughtered native pigs. A specific portion of the samples – brush border epithelial cells – was carefully processed for the Microscopic Adhesion Test using an Indian isolate of diarrhoeagenic *E. coli* to have field utility.

The team incubated the suspension mixture having equal volumes of brush border cell suspension and fresh *E. coli.* Finally, they examined for adhesion pattern and categorized the animals as adhesive, non-adhesive and strongly adhesive depending on the adherence of the bacteria. They did a PCR analysis and found that MUC13 mRNA expression was highest in a sample where bacteria were adhesive although the result was not statistically significant.

By ILRI, via Wikimedia Commons

They found that one-third of the samples expressed a non-adhesive pattern. This finding implies that there is scope for breeding programmes within the *desi* pig against diarrhoea. This study also signifies the importance of genetic resources conservation, so that they can be used to address a future crisis.

J. App. Anim. Res., **46**(1): 107–111

Targeting Mycobacteria

Mycobacterium tuberculosis, the bacterium responsible for tuberculosis, develops resistance to antibiotics, making it difficult to control. Interestingly, the bacteria have more phosphorylated proteins than other microbes.

Last fortnight, scientists from the CSIR-Institute of Microbial Technology, Chandigarh, reported the effect of phosphorylation on a nucleotide biosynthesis enzyme, guanylate kinase. Enzymes for nucleotide biosynthesis are crucial proteins for the survival and growth of organisms. They are potential antibiotic targets for the inhibition of infections.

The researchers used another well-characterized eukaryotic-type serine/threonine kinase from *M. tuberculosis* to carry out the phosphorylation on guanylate kinase. They began with cloning and purifying the guanylate kinase and eukaryotic-type serine/threonine kinase. Then, they performed an *in vitro* kinase assay and confirmed phosphorylation by detecting radiolabelled phosphate groups using autoradiography. Phosphorylation of guanylate kinase occurred *in vivo* when co-transformed with the serine/threonine kinase in *Escherichia coli*.

With the help of mass spectroscopy, the researchers confirmed phosphorylation on threonine residues. They further conclude threonine at position 169 in guanylate kinase to be crucial, and which, upon phosphorylation, has a major impact on enzyme functionality and substrate binding. By doing molecular simulations on available guanylate kinase structure, they noted the influence of phosphorylation on the overall protein conformation.

M. tuberculosis adapts and survives even during stress. The two component kinase–phosphatase system efficiently handles such situations. Serine/threonine kinases from *M. tuberculosis* have been studied now for more than a decade. The current study throws light on the impact of phosphorylation in modulating enzyme activity. Guanylate kinase is critically important for the nucleotide biosynthesis pathway and, hence, bacterial survival.

Biosci. Rep., **36**: BSR20171048

Controlled Drug Release
By cellulose acetate nanofibres

Anti-inflammatory drugs used for treating arthritis often affect healthy cells. This creates an additional burden for patients. To overcome this, a controlled drug delivery system is needed, especially for low half-life drugs.

Last fortnight, a team of scientists from IIT Hyderabad and Exeter University, UK, came up with the solution for sustained drug release. The scientists coated diclofenac sodium, a popular anti-inflammatory drug onto the cellulose acetate nanofibres.

The team used electrospinning technology to produce patterned nanofibres with diverse surface wettability. Such surface tuning is imperative. Since the drug is hydrophilic, the surface of the carrier must be hydrophobic to prevent uncontrolled drug release. They achieved this by electrospinning the cellulose acetate using nylon mesh templates of different pore sizes. And the optimized nanofibre was ready for testing.

The team observed the drug releasing pattern in the simulated diffusion cell, a model transdermal system. This is made up of two chambers separated by a multipore membrane. They found that the patterned nanofibre exhibited controlled drug release due to the reduced solid–liquid interface. Interestingly, the nanofibres obtained through a 50-micrometer nylon mesh showed a sustained drug release of up to 12 hours in a controlled manner.

The scientists conclude that this micro-patterned nanofibre will reduce the undesirable adverse effects of conventional arthritis treatments. The technology can be applied for other drugs with low half-life.

However, the scientists have to experiment with this technology *in vivo* to authenticate their efficiency. This promising technology can be applied for other drugs with reduced half-life.

Appl. Surf. Sci., **426**: 755–762

Digital Writer for Musical Scores
Retaining staff lines for recognition

There are many devices that recognize handwritten text and image documents. However, musicians find the use of such digital writers problematic. Musical scores come with staff-lines. Existing digital writers process the documents after removing staff lines. In aged documents, due to degradation of foreground and background, some text or symbol information such as clefs and accidentals may also be removed in the process.

Researchers from the IIT Roorkee, the Indian Statistical Institute and the Institute of Engineering & Management, Kolkata, now report a method for music score identification without removing staff lines. Their model for the identification of musical scores is an improved model of their previous work on handwriting recognition which uses block line segmentation.

To digitize musical score documents, they adopted the Hidden Markov Model. Partha Pratim Roy from the IIT Roorkee says 'Sliding window features are extracted from musical score-lines and used to build writer-specific Hidden Markov Models'.

Roy and team used the Principal Component Analysis method in the Hidden Markov Model for the feature selection process. A sliding window is moved from left to right in an overlapping fashion for feature extraction. They checked musical notes with vertical projection of line image at each sliding window position.

'We also used a Factor Analysis-based feature selection technique in sliding window features to reduce the noise appearing from staff-lines' says Umapada Pal, ISI Kolkata.

Besides recognition of musical notes without removing staff lines, the model identifies areas without any notes and silent zones, containing only staff lines without musical notes. They removed all silence zones and retained musical notes, using a Hidden Markov Model based framework.

An experiment was performed at line and page levels. The device recognized the number of writers required at each level. Using this information, the team designed algorithms to meet the requirements for writer identification tasks.

The researchers also confirmed that the Hidden Markov Model is efficient as it recognizes continuous as well as discrete data. They claim that they have tested the Hidden Markov Model on 'CVC-MUSCIMA', a music dataset, with thousands of musical scores. This method was repeated ten times, and each time it succeeded in identifying musical score documents without removing staff lines.

Expert Syst. App., **89**: 222–240

Children's Science Congress
Sustaining development

The 25th Children's Science Congress organised in Ahmedabad from 25 to 31 December 2017, had participation from nearly 750 children from various parts of India as well as representations from the ASEAN, the Middle East and, for the first time, from Russia. The theme for the Congress was Sustainable Development.

The child scientists presented their projects which covered Natural Resource Management, Food and Agriculture, Energy, Health, Hygiene & Nutrition, Lifestyles and Livelihoods, Disaster Management and Traditional Knowledge Systems. Special focus was on the differently abled.

Some of the projects that were presented were testimony to the fact that children can also do rigorous science, if adequate guidance is given. This reporter could not help feeling that sustaining and developing the interests of the children present can be done only if more scientists come forward to support the Congress.

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