

Science Last Fortnight

Studying the Past for a Safer Future *Proximity warning about earthquakes*

In 2001, on Republic Day, the Bhuj earthquake jolted the nation. It was the strongest contemporary seismic event recorded in India. The Kachchh is a very seismically active intra-continental region, documenting more than 13,000 shocks since 2001. Scientists from Gujarat and Jharkhand collaborated with scientists from Chile to do a post mortem of the sequence of the Kachchh rift, post the Bhuj earthquake.

Spatial and magnitude distribution of the seismicity are acknowledged to have scale invariant properties and present multi-fractal dynamics. Earlier studies show that there is a strong and reliable multifractality in the spatial distribution of epicentres and the magnitude fluctuations of earthquakes.

So the scientists scrutinized the Kachchh region earthquake dataset, of magnitude 3 and higher, from 2001 to 2012. They performed a fractal analysis of the entire dataset to derive the fractal dimension spectrum. For better accuracy, they derived equations for the seismic sequence analysis using the epicentre distribution of earthquakes, and not the depth. They used the method of correlation-integral partitioning to provide relative changes accurately.

The scientists studied the behaviour of generalized fractal dimensions preceding the occurrence of a large earthquake and subsequent moderate shocks. Their calculation showed a relatively lower fractal dimension. This corroborates earlier studies and the calculations seem consistent and reliable.

Interestingly, their analysis also shows that the multi-fractal dimension spectrum exhibits remarkable minima before the main shock. The researchers say that this indicates increase of clustering and reflects an accumulation of energy within the tectonic domain.

They found that the multi-fractal dimension spectrum decreased with increasing clustering of events in time before a moderate magnitude earthquake. The multi-fractal dimension

spectrum then increased to a maximum at the time of the main shock, releasing the energy suddenly. These evidences suggest that the spatial distribution of epicentres is not random, and shows self-organized criticality.

Such studies can be used to develop a warning system for seismic events. Timely warning may aid better earthquake preparedness.

Physica A, 17: 30663–30665

Aerosols over Northern India *Biomass burning is culprit*

Aerosols, minute particles suspended in the atmosphere, affect the earth's energy budget and climate directly by scattering sunlight directly back into space. Aerosols also modify cloud particles in the lower atmosphere. The Indo-Gangetic Plain is an aerosol hotspot, due to high loading of aerosols – natural dust, black carbon, organic matter, sulphates, nitrates and ammonium. This high content affects monsoon onset, duration and intensity, especially over northern India and the Himalayas. It introduces uncertainty in weather forecasts.

To overcome this problem, researchers from the Aryabhata Research Institute of Observational Sciences, Nainital in collaboration with researchers from Greece and China studied the role of relative humidity on aerosol properties. They measured aerosol optical and physical properties in Nainital. They considered aerosols of less than 1 micrometre and those that were more than 10 micrometres to understand the effect of aerosol size on weather modification.

They traced the origin of the air mass reaching Nainital to biomass-burning areas of north-western India and polluted air masses from the Ganges Valley. They found that local smoke plumes are later coated with industrial aerosols from northern India. This makes the aerosols larger and more hygroscopic.

In November–December, biomass-burning is greater. This, too, makes the aerosols coarser, less absorbing and more hygroscopic. Their hygroscopicity is a major factor in introducing errors in weather predictions.

These preliminary results are not adequate to improve weather prediction accuracy. Sophisticated instrumentation and systematic measurements of aerosol properties and their dynamics in the atmosphere may generate the data needed.

Sci. Total Environ., 605–606: 124–138

Fluoride-free Water *Bioremediation by bacterium*

Excessive fluorides in drinking water cause mottled teeth, skeletal fluorosis, and neurological complications. In India, groundwater receives fluorides from naturally occurring fluoride-bearing rocks or industrial operations such as phosphate mining. According to the Health ministry's estimates, this problem affects more than eleven million Indians. Current methods of fluoride removal – electro dialysis, ion exchange, and adsorption – are expensive and create waste disposal issues.

Recently, researchers from the National Institute of Technology, Durgapur used a bacterium, *Providencia vermicola*, to remove fluoride from water. They isolated the bacterium from a hand-pump at Madhabpur, West Bengal where the concentration of fluoride is 18 mg per litre, twelve fold more than the safe limit for fluoride consumption (1.5 mg/l) in drinking water.

The researchers hypothesized that the fluoride ions attach themselves to the cell wall of this bacteria via ion-binding molecules. The fluoride diffuses into the bacterium cell, forming complexes with other ions. The team analysed the changes in the bacterium before and after fluoride uptake.

They used electron microscopy to examine changes in the surface structure of the bacterium. Using X-ray analyses, they studied its elemental composition. To achieve maximum fluoride removal efficiency, the scientists optimised various parameters for bacterial growth. They found that, when *P. vermicola* was grown with dextrose and nitrogen sources at pH-7 and 37°C, maximum fluoride removal of 82% can be achieved when the fluoride concentration of water was 20 mg/l.

The team believes that *P. vermicola*'s mechanism to bioaccumulate fluorides can be used to remediate fluoride contaminated water.

J. Environ. Manage., **204**: 413–423

Cotton Leaf Curl Disease

Micro RNA to the rescue

Cotton is an important cash crop, vulnerable to cotton leaf curl disease. Symptoms include darker and thicker veins and cup-like structures below leaves. The disease leads to growth stunting and reduction in flowering and boll formation. This is a major threat to cotton production. Begomovirus, causing the disease, undergoes frequent changes in its genome, making it difficult to breed cotton varieties resistant to the virus.

Researchers led by Jawaid Khan from the Jamia Millia Islamia, New Delhi examined the genome of the virus and plant response. Based on *in silico* target prediction analysis, they homed in on two cotton microRNAs – miR398 and miR2950 – as the gene silencers of begomovirus. This indicated multiplicity of miRNA targets within the viral genome, a sign of good antiviral defence.

So the researchers developed transgenic plants with precursors of miR398 and miR2950 genes. They used HS6, a high yielding variety of cotton. The transformed plants appeared phenotypically normal. There seemed to be no side effects of the miRNAs on the morphology or development of the transformed cotton plants. In fact, the number of flower buds/bolls was higher in transgenic lines!

The team developed a total of ten cotton plants and subjected them to biological and molecular analyses. They confirmed the presence of the miRNA precursors using polymerase chain reaction and Southern blotting. Expression levels of the miRNAs were assessed by semi-quantitative Real Time-PCR, Real-Time quantitative PCR and northern hybridization in the PCR-positive lines.

Southern hybridization revealed that multiple copies of the T-DNA were integrated into the genome of the transformed plants. Remarkably, expression of pre-miRNAs was seen to be nearly six fold higher in the transgenic plants.

The researchers inoculated the transgenic cotton lines with an insect vector, the whitefly, *Bemisia tabaci*, carrying begomovirus. Four of the transgenic plants remained symptom-free. Though a very low titer of viral DNA could be detected by the most sensitive assay, the symptoms could not be detected in any of the transgenic plants. Most encouragingly, beta-satellite, the part of the viral genome generally associated with symptoms of the disease, was not detectable in the transgenic plants.

The study is a boon to cotton farmers. Identifying plant miRNA targets that inhibit or suppress viral activity, using software, can help develop virus resistant crops.

J. Biotechnol., **263**: 21–29

Increasing Plum Shelf Life

Coating with chitosan

Plums, grown in hilly Himachal Pradesh, Jammu and Kashmir, Uttarakhand and Uttar Pradesh, are minor fruit crops of great importance. They are rich in sugars and vitamin A. However, as they ripen, they rapidly soften, leading to short shelf life. So, they are stored at 0°C. But this may lead to chilling injury symptoms: flesh translucency and internal breakdown that affect quality and reduce consumer acceptability.



By Fir0002 Wikipedia via Wikimedia Commons

To overcome the problems associated with cold storage, a team led by Shruti Sethi from the Indian Agricultural Research Institute, New Delhi, has now produced an easy solution – coating plums with a non-toxic polysaccharide, chitosan.

They selected healthy mature 'Santa Rosa' plums from Kullu and divided them into two lots. The scientists then prepared a chitosan solution, dissolving it in distilled water containing glacialacetic acid and

Tween 80. They maintained an acidic pH of 5.0, adding sodium hydroxide. One lot was coated with this chitosan solution and the other, with distilled water. The team then air dried both lots and packed them in plastic punnets, to be stored in cold conditions.

The scientists observed the stored fruits at 7-day intervals for 35 days. And found that coating plum with chitosan helps in a 50% reduction in weight loss, as chitosan prevents evaporation of water content. They also observed that the fruits retained more glossiness and firmness than non-coated plums.

'We observed the lowest level of soluble solids content in chitosan-coated fruits throughout the storage period, resulting in the slow ripening of plums' says Manish Srivastav.

In plums, the pectin methylesterase enzyme is responsible for softening. Coating with chitosan inhibits carbon dioxide production and results in the suppression of pectin methylesterase enzyme activity.

Exporters can use this finding to extend plum postharvest shelf life. Agricultural extension workers would do well to popularize this technique for the benefit of farmers.

Sci. Hortic., **226**: 104–109

Jamun Wine

Effect of yeast and seeds

Jamun is a nutritious seasonal fruit rich in vitamins and minerals. The jamun fruit, seeds, bark and leaves have medicinal properties. As jamun fruits are highly perishable, processing them into various non-alcoholic and alcoholic beverages helps preservation. The fruits and wine are known to be astringent. But there is a need to enhance the sensory qualities for balancing the bitterness.

It is known that, in winemaking, seeds have a major role. Polyphenols from the seeds, contribute to wine astringency and stabilization of the colour. And jamun seeds have a variety of medicinal effects. So researchers from the CSIR-CFTRI, Mysuru investigated the role of jamun seeds and yeast strains on the vinification of jamun.

They used *Saccharomyces cerevisiae* and *Pichia gummi-guttae* strains for fermentation. Jamun wine produced from different isolates did

not show variation in chemical and sensory properties.

Principal Component Analyses of the components of the wine revealed anthocyanins in younger wines imparting redness to jamun wines. However, wines produced with seeds are found to be prone to browning. The scientists say that this may be due to the interaction of phenolics with other components like anthocyanins and polysaccharides during ageing.

The researchers observed high phenolic content of wines fermented with the seeds. However, these phenolics decreased during ageing. Correlation of sensory attributes with phenolic components by cluster analysis indicated that the organoleptic properties are influenced by phenolic composition. However, there was a negative correlation between overall taste and ethanol index, colour and polymeric anthocyanins. The malic acid content, which contributes to the sour taste in wine, was significantly reduced in the presence of seeds during fermentation.

Both yeast and seeds have an impact on the chemical properties of wine. However, seeds have a dominating influence on the overall quality of the wine, say the scientists. Incorporating jamun seeds during jamun wine fermentation balances astringency and enhances the organoleptic attributes of the wine. The team hopes that this would be useful to produce jamun wine with acceptable sensory attributes and bring down the shortcomings of the product.

Food Chem., **237**: 693–700

Smartphone as Glucometer Testing diabetes

According to the WHO, the number of diabetics has risen from 108 million in 1980 to 422 million in 2014. The common method of diagnosis involves testing blood from a finger prick. However, this is painful. Thus, saliva, tears and urine have emerged as alternatives in the form of electrochemical biosensor devices. But then, sensor fabrication involves expensive, complex procedures and costly reagents.

Recently scientists from the IIT and the AIIMS Delhi reported developing a smartphone-based glucose detection method. They fabricated filter

paper-based test strips containing glucose oxidase which react with saliva and change colour according to the glucose concentration. The filter paper is protected by lamination films on both sides. One of the lamination films has a small opening where a saliva sample can be dropped into the filter paper. The test strip has a nylon mesh cover.

The team used spiked saliva samples to calibrate the biosensor. A saliva sample is applied to the strip through the nylon mesh. The colour changes are scanned on the other side of the strip using the smartphone application, designed to estimate glucose levels with respect to changes in RGB pixel intensity.

The researchers validated the biosensor on both healthy and diabetic subjects, aged 20–80, at the IIT Delhi hospital. The procedure is painless and can be performed even by non-professionals with limited training. Moreover, the cost of the overall analytical performance and sensor test strip is lower than those in existence. The scientists plan further development of this sensor by automating strip manufacturing and look forward to commercializing the product.

Anal. Chim. Acta, **996**: 54–63

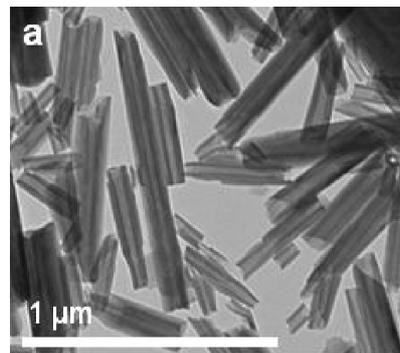
Ciprofloxacin Bioavailability Halloysite nanotubes as drug carrier

Antibiotic bioavailability is a major issue in treating bacterial infections. Some antibiotics, such as ciprofloxacin, tend to bind to iron reducing their solubility and, hence, absorption. Encapsulating antibiotics onto a nano-matrix alleviates such interactions and aids in their controlled release.

Scientists from the Gujarat Forensic Sciences University and the Gujarat Environment Management Institute Gandhinagar, recently used halloysite nanotubes as drug carrier for ciprofloxacin, a broad-spectrum antibiotic with bactericidal properties against clinically important pathogens. Halloysite, an aluminosilicate clay mineral with tubular nanostructure, is biocompatible and has been tested as delivery system for many pharmaceutical products.

The researchers incorporated an amino functional group into halloysite

nanotubes. They loaded ciprofloxacin into the nanotubes and examined the structure using a transmission electron microscope. They confirmed the presence of ciprofloxacin in the halloysite nanotube by looking at the Fourier transform infrared spectra with specific absorption bands corresponding to ciprofloxacin.



By VA Vinokurov via Wikimedia Commons

The team performed antibacterial assay against *Escherichia coli* and *Staphylococcus aureus* and confirmed reduction in the bactericidal activity of ciprofloxacin on complexation with iron. Using an *in vitro* drug release assay, they confirmed the controlled release of ciprofloxacin from the halloysite nanotubes.

The scientists have been experimenting with halloysite nanotubes with different functional groups that show better interaction with target molecules and improved loading capacity. They claim that the presence of the amino group in the halloysite nanotubes makes them more effective than other nanoparticles in terms of ciprofloxacin release and iron binding.

Halloysite nanotubes are nontoxic, low cost, eco-friendly and versatile. And the raw material is easily available. It is worth optimizing the drug delivery in *in vivo* systems. The problem of interference with metal particles is seen in many other pharmaceutical products and such nanoparticles may also be useful delivery platforms for other drugs.

Appl. Clay Sci., **150**: 293–302

Delicious and Healthy Breads Pomelo fortified

Bread is a staple. Though nutritional properties may be compromised to entice consumers, bread can still be an

inexpensive vehicle for essential nutrients.

Recently, a team from the CFTRI, Mysuru enriched the nutritional quality of bread by fortifying it with pomelo, *Citrus maxima*. Though pomelo has high nutritive and medicinal value, its bitterness makes it unpalatable. The team considered incorporating it into bread. The challenge was to retain the nutritional property of pomelo after baking.



By Stacy via Wikimedia Commons

The team optimized the level of fresh and dried pomelo segments in bread. And found that the ratio of fresh over dry segments resulted in better quality bread. They noted increased phenolic, flavonoid and carotenoid contents in pomelo supplemented bread. These compounds are antiallergic, antioxidant, antiviral, anticancer and antimicrobial.

The researchers also observed a high level of naringin, a compound that can reduce glucose absorption from dietary carbohydrates in the intestines. It inhibits the carbohydrate digesting enzyme, reducing the glucose level. This lowers the glycaemic index. The team confirmed this by hydrolysing bread samples and found a delayed glucose release.

The scientists say that pomelo enriched bread is a promising nutritional food for all – not only for diabetics.

Food Chem., **273**: 957–965

Solid Waste Management

Facility location model

Municipal solid waste management is an environmental concern. The increase in waste generation due to the rapidly increasing population and the lack of proper disposal sites are some of the major factors causing environmental pollution. Near human

settlements, these untreated wastes impact human health.

Scientists from IIT Bombay and the National Institute of Science and Technology, Odisha tackled the problem by analysing the transfer station between waste generation and waste disposal. A transfer station has a number of small and big vehicles for waste collection – the smaller vehicles come in to dump the collected garbage and the larger vehicles transport it to landfills or composting sites, sometimes kilometres away from the city. In urban areas, a properly chosen transfer station is critical to the economy of solid waste management.

The team developed an algorithm to solve the facility location problem of transfer stations. They considered four factors – collection of segregated wastes from households and commercial establishments, transportation to transfer stations by small vehicles, transportation of the compacted waste to composting site, transportation of composting residuals to landfill site. The amount of waste generated varies widely. So the scientists used a fuzzy mathematical logic to deal with the uncertainties.

The model is written in a mathematical programming language. The scientists used KNITRO 5.2, a software package for solving optimization problems. Various factors like amount of waste to be transported, size and capacity of the vehicle carrying waste, number of road networks from the source to transfer station etc. were incorporated into the model.

They also conducted a case study to test this model. They considered a hypothetical city, and identified ten potential locations for transfer stations. Applying the facility location model, they could choose the best location for a transfer station.

The scientists claim that using the facility location model to identify the best location for a transfer station can minimize the overall cost of municipal solid waste management.

Sci. Total Environ., **603**: 760–771

Solar Cell Efficiency

Performance analysis

Temperature affects solar cell power conversion efficiency. Minimizing temperature can improve efficiency.

Now, K. S. Reddy, from the IIT, Chennai, in collaboration with a team from the United Kingdom have come out with an analytical expression that provides correlation between solar cell performance and operating conditions for the theoretical analysis of efficiency.

Various factors are involved in altering the temperature of solar cell surface: wind direction, wind velocity, tilt angle of panel and solar radiation intensity. The scientists examined the effect of these parameters on temperature and compared the efficiencies of silicon, perovskite and dye-sensitized solar cells. They found that increase in angle of wind direction and solar radiation intensity increases temperature irrespective of solar cell type.

Although temperature decreases the performance of solar cells, increase in solar radiation improves efficiency due to increase in incident photons. The team also observed the temperature of the cell tends to decrease with increase in panel tilt angle and wind velocity, enhancing efficiency. The change in efficiency of the dye-sensitized solar cells was least, compared with silicon and perovskite solar cells, irrespective of parameters considered.

The team claims that this work can help pre-evaluate solar cell performance, to suit each location's specific weather conditions. Researchers and manufacturers can use the data to plug into the properties of the different layers of solar cells.

Appl. Therm. Eng., **127**: 559–565

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