Science Last Fortnight

Assessing Earthquakes

Making Kolkata safer

Kolkata stands on a seismically active zone. Old buildings rub shoulders with new structures, housing a dense population, amplifying the risk during earthquakes. The buildings here are constructed on thick deposits of the Bengal Basin's soft soils. These sedimentary deposits tend to liquefy under seismic stress. This liquefaction intensifies the degree of shaking and exposes the buildings to greater stresses. Thus, site-specific methods are required to understand soil behaviour under seismic conditions.

Scientists at the Jadavpur University, Kolkata recently developed a model for ground response analysis. This model estimates peak ground accelerations accurately for an earthquake at bedrock and surface level by simulating ground motions.

The team studied 144 locations across Kolkata and categorized them under 8 seismic subzones. They applied an artificial neural-network-based attenuation relationship model to analyse the seismic hazard of each subzone. And they used a response spectrum to report the interaction between ground acceleration and structure. The scientists included these spectral accelerations into the suggested model for analysis.

Specifications in the Bureau of Indian Standards, 2002, do not consider these local factors for designing buildings. Thus, structures constructed as per existing codes may undergo severe damage during an earthquake. Many Indian megacities are situated in the Ganga Basin. Such models can help reassess the risk of seismic damage to these areas as well.

J. Geophys. Eng., **14**(3): 466–477

Fly Ash in Embankments

Ticking seismic bomb

Fly ash is utilized as an alternative to natural soil for the construction of embankments. In a potential seismic zone, it can be risky as its dynamic properties are amplified during an earthquake. 'Pond ash mainly consists of noncohesive fine sand and silt. The material is vulnerable to liquefaction-induced failure', says Prishati Raychowdhury from the IIT, Kanpur.

Last week, his team of scientists reported the dynamic response analysis of a pond ash embankment near the Renusagar power plant in Uttar Pradesh, a Seismic Zone III, with moderate level of seismicity. The team experimentally validated and calibrated nonlinear material models of pond ash using finite element modelling.

They experimented with the dynamic characterization of the embankment in terms of mode shapes, natural period, acceleration amplification, horizontal and vertical displacement profile, nonlinear stress–strain behaviour, cyclic stress ratio, pore pressure generation and liquefaction potential. The researchers also characterized the pond ash using various laboratory tests, such as specific gravity test, sieve analysis, hydrometer analysis, standard Proctor test, consolidation test, and static consolidated undrained triaxial tests. They noticed a large amplification in horizontal as well as vertical displacement in pond ash.

In India, coal fuel based thermal power plants are a major source of power. And a large quantity of fly ash is produced. The researchers hope that 'policy interventions will be done by the Indian government regarding the disposal of fly ash for construction of embankments in seismically active areas'.

Int. J. Geomech., **17**(6): 04016141

Using Iron Ore Waste

To remove arsenic from water

Water is naturally contaminated with arsenic, a component of the earth's crust. Arsenic is mobilized into groundwater through the geochemical weathering of soil and biological actions. Chronic exposure to any form of arsenic leads to skin lesions and skin cancer. Existing techniques to remove arsenic from groundwater have inherent limitations. Nanofiltration membranes are attractive alternatives, but have high operating cost and fouling problems.

Last fortnight, Chatterjee and De from the Indian Institute of Technology, Kharagpur used inorganic additives in membranes to enhance selectivity for arsenic removal from groundwater. They took iron ore slime from steel industries and used it to impregnate a mixed matrix hollow fibre membrane made of polysulphone–polyvinylpyrrolidone.

The scientists assessed stability of the membrane using surface characterization, equilibrium studies and the dynamics of cross flow ultrafiltration of the membrane. Then they evaluated the arsenic removal efficiency of the membrane using groundwater from West Bengal, India.

Chemically treated iron ore slime decreased the permeability and porosity of the membrane, and improved the hydrophilicity as well as the arsenic removal capacity. Exhausted membrane was regenerated and used thrice. The dynamic filtration capability estimated for arsenic removal was reduced from 28 hours to 22 hours in the second regeneration and to 14 hours after the third cycle regeneration.

The membrane was also able to remove microorganisms and iron from real life feed solutions to below WHO approved permissible levels. Another example of how science finds ways to make industrial waste useful.

Sep. Purif. Technol., **179**: 357–368

Stopping Grain Drain

Gaining from plant peptides

The pulse beetle and the red flour beetle play havoc with stored grains causing heavy losses. Plants have evolved various mechanisms to fight insect pests. One of the primary strategies is to produce inhibitors of digestive enzymes such as amylase. If insects eat such plants they get indigestion because they are then unable to digest food.

But insects also evolve. Insects with a slightly different amylase that is not affected by the inhibitor survive and thrive on plants. And the plants respond by adjusting their inhibitor to the new amylase. Thus, there is now a diversity of inhibitors and amylases in the war between plants and insects.

This fight for survival using alpha amylase has gone on for millions of years. And *Amaranthus hypochondriacus* may have evolved the right inhibitor to throw the spanner into the digestive systems of the pulse beetle and the red flour beetle.

Scientists from the CSIR-NCL Pune, the Shivaji University and the North Maharashtra University, have now isolated the inhibitor gene coding for a peptide with 32 amino acids. Their studies show that it is cleaved out from a pro-peptide that is 75 amino-acids long in the golgi complex. The seeds of *Amaranthus* do not produce the peptide. It seems it is transported from leaves into the seeds and ultimately there is high concentration of the inhibitor in the seeds.

Thus, *Amaranthus* seeds or the inhibitory peptide can be used to develop products that deter insects from attacking our grains. Scientists find that *A. paniculatus*, *Celosia argentea* and *Achyranthes aspera* also have identical amylase inhibitors.

Their paper published last week provides important clues about the structure and function of the peptide. The first step to appropriate the plant's defenses to our purposes.

Plant Mol. Biol., **94**: 319–332

Mass Propagation of Soapnut Tree

Somatic embryogenesis

Long used as a traditional shampoo, the soapnut has now come into prominence as an environment friendly detergent. The fruits of the *Sapindus* tree are rich in bioactive compounds called saponins. The tree also yields other bioactive compounds. So products from this plant have been used to treat diseases like asthma, cholera, etc. Dye from the shell of the seed is used to colour shoe-creams, textiles and polishes. However, the high demand from the soap, dyeing and medical industries for soapnut remains unmet due to the slow growth of the plant and poor seed viability.

Last fortnight, P. Asthana and team, from the Banaras Hindu University, designed a new protocol for the mass propagation of the *Sapindus* plant through somatic embryogenesis. Using the sepal of the flower bud as explant, they developed embryos of the plant. The team studied the response of the explant on MS medium supplemented with varying concentrations of sugars and L-glutamine. And they observed a maximum number of embryos and secondary embryonic structures when the medium was supplemented with 200 mg l^{-1} of L-glutamine.

The scientists reported that 90% of the embryos they developed were acclimatized in the field. They claim that the technique is promising for the large scale production of *Sapindus* trees to meet industrial demand.

Ind. Crops Prod., **100**: 228–235

Contamination in Milk

Detecting kanamycin residue

Though milk has always been popular, there is increasing concern over the presence of contaminants. Antibiotics used in the dairy industry often surface as residue in milk. Kanamycin is one such antibiotic. Residual kanamycin in milk and other dairy products causes serious side effects, such as hearing and balance problems; it damages the kidneys.

Existing methods to detect kanamycin in milk, though sensitive and reliable, are time consuming and require high volumes of reagents. There is a need for simpler, faster, more robust, selective and specific methods to detect kanamycin.

Last fortnight, a research team from the Birla Institute of Technology & Science, Goa, the Université de Perpignan Via Domitia, France and the COMSATS Institute of Information Technology, Lahore, reported devising a simple, portable aptasensor, for the quantitative determination of kanamycin in milk.

The biosensor uses an aptamer, a short sequence of oligonucleotides with high affinity for kanamycin. The team used a kanamycin binding single strand DNA sequence to fabricate the sensor. This aptasensor was label free: it did not have any radioactive or fluorescent dye, metal complexes or nanoparticles.

The scientists claim that it is the first disposable and label free aptasensor for the detection of kanamycin without interference from competitive analogues. This kanamycin–aptasensor showed excellent recovery and the limit of detection was about 0.1 ng ml^{-1} kanamycin, meeting the requirement of regulatory standards. The results show that the sensor is simple and easy to use.

Sens. Actuat. B, **245**: 507–515

Reducing Salt Intake in Infants

Prevention is better than cure

Salt is ever present in food. Unfortunately, too much salt can result in hypertension, a major health problem worldwide. Though this health issue can be hereditary, bad food habits can predispose us to hypertension.

Researchers from the Institute for Indian Mother and Child, Kolkata collaborated with scientists in Italy to carry out studies in areas where hypertension is highly prevalent in both children and adults. They collected data from the mothers of more than five hundred infants aged 0–6.5 months. And information on the addition of salt in diet together with body weight from questionnaires filled by the mothers. They found that 90% of the mothers were breastfeeding and had healthy infants. However, most added salt in baby food after six months which resulted in low body weight and height. The team suggests that this high intake of salt is the reason for the higher incidences of hypertension in the population.

These results stress the need to educate mothers of the importance of breastfeeding and of postponing the use of salt in a baby's diet.

Int. J. Food Sci. Nutr., **68**(4): 467–472

Acacia Gum

Hydrogel for wound dressing

The gum of the acacia plant has been used medicinally for centuries. It acts as a demulcent, soothing mucosa. Thus, it is often applied to treat minor wounds.

Last fortnight, a research team from the Himachal Pradesh University, Shimla, used gum acacia to design a hydrogel for wound dressing. They prepared a hydrogel with acacia gum and polyvinylpyrollidone/carbopol. The team says that the rough surface morphology of the hydrogel film may help adherence to the healing tissue and allow cellular activity that promotes wound healing.

The researchers investigated the swelling behaviour of hydrogels and

report that swelling increased with increase in *N*-vinylpyrollidone content and then decreased. These trends may be due to increase in hydrophilicity initially. Later, increase in crosslinking reduces this effect. However, swelling increased with increasing carbopol content in the polymer matrix.

The hydrogel film is hemocompatible. The materials of the hydrogel are all highly hydrophilic and biocompatible. Hydrophilic surfaces show lesser adherence to the RBC membrane and therefore, less disruption of the cells. Thus, these hydrogel dressings can be regarded as safe for wound applications.

Gum acacia is known for anti-inflammatory properties. The oxygen permeability study for the hydrogel film showed that these films were permeable to oxygen. The antioxidative capacities of gum acacia can help scavenging excess free radicals. The polymer films showed antioxidant activity and absorbed wound fluids.

Using the microbial permeability test, the researchers showed that the hydrogel allows no microbial contamination. These wound dressings form a good barrier against microbes and prevent secondary infection during the wound healing.

Folding endurance test results show that hydrogel films are flexible and suitable for wound dressing applications.

The researchers tested the release of an antibiotic, moxifloxacin, from the hydrogel dressing and observed that it followed a non-Fickian diffusion mechanism. The results of the drug release studies indicate that these hydrogel dressings can deliver antibiotics in wound dressing applications.

Carbohydr. Poly., **165**: 294–303

Easy screening of *E. coli*

Mumbai. A hot Thursday morning. Mrs Sharma picks up the paper. The headline reads: *Cold shock: E. coli bacteria found in 92% ice samples in Mumbai*[1]. Would it not be nice if Mrs Sharma, like the billions who eat ice cream and enjoy a chilled drink, had an affordable, easy, and rapid method to detect faecal *E. coli* in the comfort of their homes?

Traditional methods of testing for *E. coli* contamination are long-drawn. In 2011, as part of the search for more rapid methods, Spanish scientists reported using nanoparticles modified by the antibiotic, colistin, to detect bacteria[2]. However, the method of synthesis of these nanoparticles is multistep – a major limitation in applicability.

Recently, S. K. Sahu from IIT Dhanbad and colleagues in Midnapore succeeded in achieving a ten-fold reduction in the number of steps required[3]. They used a new single-step pyrolysis method to synthesize colistin-modified carbon dots for the selective labelling, and thereby detection, of Gram-negative bacteria such as *E. coli*.

Briefly, they ground the carbon precursor for the carbon dots, diammonium hydrogen citrate, with varying amounts of the antibiotic, colistin sulphate, using a mortar and pestle. The obtained powder was then heated for an hour in a hot air oven. The final product was obtained by centrifugation and dialysis. Then, they tested their product for bacterial detection in urine and tap water samples.

Interestingly, the scientists also found that the synthesized carbon dots could be used to selectively detect Fe^{3+} in water, another issue that is garnering much attention.

These results are not just promising but also timely and have wide ramifications from in-time diagnosis of urinary tract infections to convenient detection of impure water using a simple kit. Mrs Sharma thinks that it's time to bring this technology to the market.

[1]*The Hindustan Times*, 2 June 2016
[2]*Biosens. Bioelectr.*, **26**(11): 4368–4374
[3]*Sens. Actuat. B*, **245**: 835–844

Microfluidic Chip
For blood analysis and cell sorting

Complete blood count is commonly required for various diagnostic and prognostic purposes. Currently, a flow cytometric instrument, with costly optics and electronic components, is used for these tests. Such equipment occupies significant laboratory space. Lots of blood is required for processing. All this increases cost and time.

To tackle these issues, scientists from IIT Hyderabad, in collaboration with the Michigan University, developed a portable device: a centrifugal microfluidics chip. They mixed blood with ficoll in the central microchannel on a chip. On single centrifugation of 10 min, ficoll separates different cells from blood according to their density gradient. The separated cells get sorted into microchannels positioned to collect the specific cells at their point of separation. This process provides recovery and purity rates >95% for peripheral blood mononuclear cells and a viability rate of 98% for recovered WBCs.

These isolated cells can be used for downstream culture applications and single cell analysis. *In situ* fluorescence staining and 4-colour immunostaining can also be done. Multicolour imaging and analysis of the sorted immune cells can be done in minutes. The device also provides clean cell free plasma for various biomarker analyses.

This chip requires as little as 250 microlitres of blood, far less than the currently used volume. The device also requires mere nanolitres of reagents, reducing cost per run. Further, miniaturization lowers sample processing time, and cuts down on manual errors associated with earlier methods. This compact and ready-to-use 'lab-on-a-chip' is a boon for point-of-care blood-based diagnostics and prognostics testing. It would also benefit cell biology and biomedical researchers. High precision, simplicity of design, and cost effectiveness for blood cell sorting and *in situ* analysis, make this portable device an asset to your lab.

Sens. Actuat. B, **245**: 1050–1061

Gold Nanoparticles
Treating breast cancer

Chemotherapy remains the major treatment for breast cancer. Antioxidants and cytotoxic drugs target cancerous cells in this therapy. However, it is expensive and damages healthy cells too. Recently, metal nanoparticles, including gold nanoparticles, were mooted as alternatives for cancer therapy. However, chemically synthesized gold nanoparticles are not biocompatible.

Recent reports show that biomolecules, such as proteins, phenols and flavonoids from plants, can be used for capping metal nanoparticles to reduce toxicity. Plant-based nanoparticle synthesis is cost-effective and the products are biocompatible. Last fortnight, Ramkumar and team from the Periyar University, Salem used non-toxic gold

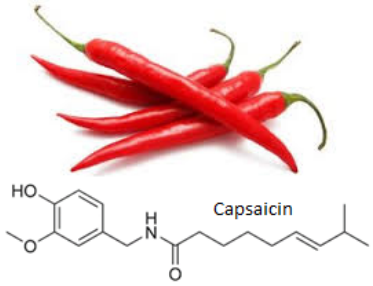
nanoparticles from a common weed, *Lantana camara*.

They found that root extracts from the plant can be used to encapsulate gold particles. Capped with the plant extract, the nanoparticles showed significant antioxidant and cytotoxic properties. These biologically synthesized nanoparticles proved more effective than chemically synthesized nanoparticles and can be low-cost alternatives as anticancer drugs.

Artif. Cells Nanomed. Biotech., **45**(4): 748–757

Seasonal Allergy
A chilli cure

We all have experienced the pungency of chillies. Capsaicin is the chemical which makes chilli pungent. Capsaicin binds to the pain receptors of the tongue and causes a burning sensation which the brain interprets as hot and spicy. Though we use chillies every day, few know of its use as medicine. It also enhances the curative effect of other medicines. A team of scientists led by Bedada from the Kakatiya University, Warangal studied this unique property.



They used capsaicin with fexofenadine, used for seasonal allergies, to examine the bioavailability of the drug for producing a curative effect. When given orally, the bioavailability of this drug is poor. Bedada and team used animal experiments to show that, when fexofenadine is administered in the presence of capsaicin, its absorption and concentration in the body is enhanced 2–3 fold.

This drug–diet interaction can help doctors tailor dosage to food to enhance cure.

Capsaicin, as chilli, is part of our daily diet. This may alter the effects of medicines. More research on drug–diet interaction is required for other drugs as well. However, for seasonal allergies, it is a chilli cure!

Drug Dev. Ind. Pharm., **43**(6): 932–938

Spice Nanoemulsions
Safer antimicrobials

Fresh fruits and vegetables top the list when it comes to healthy eating. Paradoxically, they can cause food-borne illnesses since they are vulnerable to microbial contamination. Preserving fresh produce for longer has always been a challenge in the food industry. A common method for preservation consists in washing with a solution of chlorine bleach in water to kill germs. However, toxic chlorine by-products raise issues related to safety for health.

Recently, researchers from the Pondicherry Central University came up with a solution: cumin and pepper oil nanoemulsions. To create nanoemulsions of the spice oils, they mixed essential oil, a detergent solution and water. And homogenized the mixture using ultrasonication.

When the researchers tested the spice oil nanoemulsions against *E. coli* and *Salmonella* species from fresh fruits and vegetables, they found that the nanoemulsions exhibited inhibitory effects on bacterial growth and motility. The emulsion could also affect the bacteria's ability to form biofilms. That means they become less pathogenic!

The researchers then checked whether these nanoemulsions could affect quorum sensing in bacterial populations. Quorum sensing is a bacterial collaboration mechanism where the cells collaborate to bring about a certain action, such as pathogenicity. The researchers found that the nanoemulsions are potent quorum quenchers!

Overall, the cumin oil nanoemulsion proved a better antimicrobial agent than the pepper oil nanoemulsion. But what the study truly demonstrated is that the potential of spice oil nanoemulsions as a natural alternative to chemical antimicrobial agents warrants further investigations.

LWT-Food Sci. Technol., **79**: 152–159

Castor stalk
Source for cellulose fibres

Cellulose, the most available organic matter on earth, is a major source of fibre for textile applications. Globally, farming generates tonnes of agricultural wastes containing substantial amounts of cellulose in fibrous form. Farmers would benefit economically if we could extract fibres from such waste.

The most well-known plant-based fibres are cotton, flax and hemp. Fibres from bamboo, banana and ramie are also popular, readily available and inexpensive. Now, a research team from the Jyothy Institute of Technology and SKSJTI, Bengaluru suggests the use of castor plant residues as a source for fibres.

The research team used an alkaline approach to extract castor fibres. Treating with alkali removes most non-cellulosic substances leaving only fibre bundles. The team found that, morphologically, individual castor fibres show convolutions and fibrillar architecture similar to cotton. The tensile property of castor fibres is similar to that of other natural fibres. These fibres have high fineness and low resistance to bending. So fabric from castor fibre will be less stiff.

Elongation of the fibres at 5% was higher than for common bast fibres such as jute and flax. As fibre fineness increases, torsional rigidity reduces proportionally. Fibres can be twisted easily during spinning. Thus, castor can be processed as textile fibres.

The researchers reinforced castor fibres with polypropylene and made composite fibres. They found that castor fibres are suitable as reinforcement for composites. Fibres and composites developed using castor are similar to, or better than, cotton and jute fibres. Thus, castor has potential in the production of bio-composites also.

Ind. Crops Prod., **100**: 126–131

Reports by: **Nivedita Mishra, Pinky Raychaudhuri, Shama Aphale, Pudi Venkatesu, Savitha Sekhar, Neeta Shrivastava, H. M. Mahadeva Swamy, Aditi Jain, Jinsu Varghese, R. Baskar, V. Subashini** and **P. Vijisha**
scienceandmediaworkshops@gmail.com