

## 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*

Hérons, 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<sub>2</sub>, CH<sub>4</sub> and N<sub>2</sub>O 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<sub>2</sub> 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<sub>2</sub>, CH<sub>4</sub> and N<sub>2</sub>O 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 remov-

ing 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.

*Reports by:* **H. M. Mahadevaswamy, Sileesh Mullasserri, Khushbu K. Birawat, N. Padmaja, Aditi Jain, K. V. Srividhya, P. K. Udham, K. S. Nitin, S. Balaji, S. Suresh Ramanan and K. Venkatesh**

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scienceandmediaworkshops@gmail.com

## Science Last Fortnight

### Regeneration of Cardiac Cells

Cardiovascular diseases are a major cause of death worldwide, of which coronary heart disease is most common. In coronary heart disease, the coronary artery that supplies blood to the heart is blocked and due to insufficient supply of blood, cardiac cells suffer death.

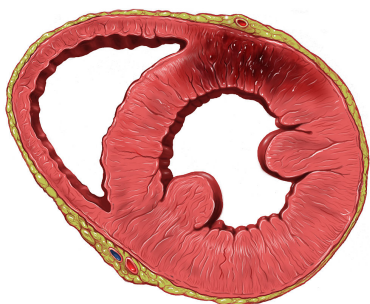


Image: Patrick J. Lynch, via Wikimedia Commons

Earlier, it was believed that cardiac cells cannot be regenerated. Now it is demonstrated that cardiac cells can indeed be regenerated, if provided with a suitable scaffold that can render appropriate physical, chemical and mechanical cues for cardiac cell regeneration. Regenerative medicine focuses on the restoring of pathologically altered tissues by transplantation of cells, in combination with supportive scaffolds of synthetic or natural materials.

Recently, Indian researchers from the Ton Duc University, Vietnam, the University of Malaysia, Bharath University, Chennai, the Sri Sakthi Institute of Engineering & Technology, Coimbatore and the Indian Institute of Space Science and Technology, Thiruvananthapuram reported a nanocomposite synthetic polymer as suitable scaffolding material. The new scaffold contains carotino plant oil incorporated into tecoflex EG80A, a polyether-based medical grade polyurethane polymer.

The polyurethane-carotino membrane had lesser fibre diameter, than that made of pure polyurethane. The new material had smaller pore size and high surface area, and could be used as scaffolding. The team reports that the nanocomposites show compatibility with RBCs.

They suggest that the physico-chemical properties and blood compatibility of this nanocomposite make it appropriate for use in the regeneration of cardiac and graft tissues.

*J. Appl. Polym. Sci.*, **135**(3), 45718

### DNA on Microchip Nanoparticle-based DNA extraction

Globally, waterborne organisms transmit diarrhoeal diseases. To identify the causative organism accurately, DNA is essential. The present methods of DNA extraction take hours and require costly equipment.

Now researchers from the Agharkar Research Institute, Pune report an improved method of DNA extraction: microchip-based cell lysis. The method is capable of lysing cells, as well as extracting and isolating DNA, in a single step.

The method uses positively charged chitosan-coated magnetic nanoparticles. The nanoparticles act as projectiles during mechanical vibrations, triggering controlled cell lysis. The magnetic nanoparticles make it easier to separate DNA from other cellular components.

The researchers imparted mechanical vibrations to the chip using an embedded vibration device. As they increased the frequency of vibrations, the intensity of the DNA band extracted increased. The team could achieve complete cell lysis at a vibrational frequency of 180 Hz.

The researchers extracted the DNA from six waterborne pathogens and quantified the extracted DNA using Nanodrop. Then, they assessed the integrity of genomic DNA using gel electrophoresis. The team achieved an extraction efficiency of nearly 100%.

The team compared the quality of the extracted DNA with DNA obtained by the conventional method. The absorption ratio of the DNA obtained using microchip is comparable to that of the conventional method, confirming the quality of the extracted and isolated DNA. The researchers also checked the quality of the extracted DNA based on 16S rRNA amplification using polymerase chain reaction. The

results confirmed the integrity of the DNA extracted.

Microchip technology is easier, more efficient and robust than conventional methods. The scientists claim that magnetic nanoparticles with positively charged polymeric coating material yield high quality DNA. These nanoparticles make centrifugation and/or packed columns unnecessary. The total time required for the complete process was ~15 min as against >2 h with the conventional method.

Though a small step for genomic studies, the innovation can become a giant stride in pathology labs and clinics, if the technology is developed for commercial exploitation.

*Biosens. Bioelectron.*, **99**: 62–69

### Oral Cancer An early diagnostic tool

Oral submucous fibrosis is a premalignant condition caused by tobacco chewing. In some cases it may develop into oral cancer. The procedure for the early detection of oral submucous fibrosis by tissue biopsy is painful. Hence, there was a need to develop a better diagnostic tool.

A group of researchers from the Indian Institute of Technology, Kharagpur in collaboration with the Midnapur Medical College and Hospital, West Midnapur and the Awadh Dental College and Hospital, Tata Jamshedpur have now reported the development of an early diagnostic tool for oral submucous fibrosis, to prevent oral cancer.

They used Fourier Transform Infrared Spectroscopy – FTIR – in combination with chemometric techniques, to distinguish the metabolic differences in serum samples of patients. The researchers observed wavelength peaks typical of increased collagenase which is responsible for tumour formation. The FTIR spectra showed abnormal concentrations of amino acids, carbohydrates, proteins and lipids. The team also found RNA ribose, at  $1171\text{ cm}^{-1}$ , an indication of carcinoma.

The researchers conclude that FTIR in combination with chemometric techniques can be used as an early



diagnostic tool for oral cancer. It is easy to handle, and gives accurate and rapid diagnosis. Using this method will help us detect oral cancer early enough to save lives.

*Spectrochim. Acta A: Mol. Biomol. Spectrosc.*, **189**: 322–329

### Skin Care Products

#### Value addition by excipients

To act on the skin, the active ingredients of a product require lipophilicity. But to reach the target, it requires hydrophilicity. Excipients – inert material used to increase solubility, flowability, and bioavailability – are often used to create the hydrophilic and lipophilic balance. However, finding a suitable excipient with active ingredients of natural origin is a challenging task, as natural products are complex in nature.



Image: Eric Hunt, flicker.com

Tea tree oil – essential oil from *Melaleuca alternifolia* – is one such natural product. It is toxic on ingestion but is a highly potent and popular ingredient in skin care products owing to its broad-spectrum antibacterial and anti-inflammatory properties.

To enhance the efficacy of tea tree oil in aqueous medium, Ganguly and colleagues from the Bhabha Atomic Research Centre, Mumbai used a non-ionic surfactant, pluronic P123. Pluronic P123 is a solubilizing agent for various lipophilic compounds due to its self-assembling, thermogelling behaviour. Pluronics also have spherical, globular or elliptical micellar structures such as those formed by lipids.

The scientists used various pluronic P123 concentrations to solubilize tea tree oil at room temperature. However, they did not get useful results due to the slow rate of micelle formation and incomplete solubilization. A complete solubilization of tea tree oil and proper micelle formation took

place on heating the pluronic P123 and tea tree oil in aqueous medium, to 100 degrees C and then cooling the mixture to room temperature. The team found that 1.2% tea tree oil in 10% pluronic P123 gives uniform micelle formation with complete solubilization of the oil along with required viscosity.

Tea tree oil in pluronic P123 retains its antibacterial and cytotoxic activity. The scientists say that the complete solubilization of tea tree oil in aqueous medium is possible with pluronic P123 making it a good candidate for skin care products.

*Colloids Surf. A Physicochem. Eng. Asp.*, **537**: 478–484

### Healthy Sex Life

#### With tamarind extracts

Sexual dysfunction among men is a serious health and psycho-social problem. In the quest for remedies, a few drugs were developed. However, side effects eliminate them from long-term consumption and necessitate the search for alternatives.

Recently, a team led by Amita Rai from the Ecron Acunova and the Manipal College of Pharmaceutical Science found a natural remedy for sexual dysfunction from tamarind fruits. In Africa, *Tamarindus indica*, a tropical tree, is traditionally used for treating sexual disorders. This clue prompted them to inquire into the potential active components.



Image: Petr Kratochvil

They collected fruits from Udupi and authenticated them before testing. They then macerated the fruits with chloroform-water. This softens the tissue to enable easy extraction of the compounds. The researchers dried the extracts in a lyophilizer, a freeze-drying machine.

The team found various proportions of bioactive compounds, such as phenolics, flavonoids and saponins, in

the extract. They used gas chromatography-mass spectrometry to analyse unknown compounds from the mixture and separated 40 different compounds. Their results resembled those from previous studies, where some of these compounds were found to improve sexual dysfunction.

The team went on to test the extracts on male rats. As a comparison, they used sildenafil citrate, a commonly used drug for sexual inabilities, and water, as control. They observed increased sexual desire in male rats treated with the extract. Using histopathological studies, they observed that prolonged treatment with the extracts did not alter the physiology of rat testes. The team checked the safe dose level of the extract on rats and found no significant toxicity even up to 2000 mg/kg.

The scientists noted that rats consuming the extracts had improved productivity and quality of sperm. They suggest that, perhaps, saponins could be behind this effect.

This finding may help improve sex life by natural means. However, further clinical trials are needed to authenticate the reliability of the activity of tamarind on humans.

*J. Ethnopharmacol.*, **210**: 118–124

### Sperm Motility in Cattle

#### Binder of sperm protein as marker

Advances in reproductive technologies have made gamete propagation possible and affordable. However, cryopreservation methods affect sperm motility and, hence, decrease fertilization rates. Frozen bull semen samples tend to have sperms with reduced motility. Although binders of sperm proteins in seminal plasma help in sperm maturation and fusion with oocytes, their role in sperm motility has not been addressed.

Last fortnight, Divyashree and Roy from the ICAR-National Institute of Animal Nutrition and Physiology and the Jain University, Bangalore have reported the role of binder of sperm-5, a protein associated with sperm motility. They collected semen samples twice a week from a total of eighteen Murrah buffaloes, eight Jersey and eight Holstein cattle bulls maintained at the Nandini Sperm Station, Bengaluru.

They separated sperms from seminal plasma and scored them for their motility using a computer assisted semen analyser and categorized samples into normozoospermic (>70% motility) and asthenozoospermic (<40% motility). They confirmed the presence of the binder of sperm-5 from seminal plasma using chemiluminescence coupled antibody-based antigen detection. The asthenozoospermic samples showed lower expression of the binder of sperm-5 than the normozoospermic samples. The binder of sperm displayed five isoforms in two-dimensional polyacrylamide gel electrophoresis. Using fluorescence microscopy, the team confirmed the localisation of the protein to be dominant in the mitochondria rich region of sperm.

In the last three decades, binders of the sperm family of proteins have been studied extensively. They are ubiquitous in mammals and are multifunctional. To improve conception rates and avoid pregnancy loss, during artificial insemination, normozoospermic samples are always preferred. This study highlights the importance of binders of the sperm-5 protein in bull semen for sperm motility and function.

*Theriogenology*, **106**: 279–286

#### **Urea Briquettes in Paddy** *Reducing greenhouse gas emission*

Urea is the cheapest, most commonly used fertilizer in paddy cultivation. Application of urea raises soil pH and increases  $\text{NO}_x$  and  $\text{CH}_4$  emissions. Slow release forms of urea and different application techniques were tried out to increase efficiency. Top dressing or surface application is less laborious but not as effective as a basal application. Deep placement or basal application of urea as briquette saves 35% of urea but it is labour intensive.

Last fortnight, thirteen scientists from the ICAR-National Rice Research Institute, Cuttack tried a comparison of basal application and top dressing of urea in lowland rice. They experimented in both wet and dry seasons. The team made urea briquettes with rice husk and karanj oil as additional materials. They also

compared the manual against the mechanized application of urea.

The team measured  $\text{CH}_4$  and  $\text{N}_2\text{O}$  using the manual closed chamber method at 3–7 day intervals throughout the year. They found that  $\text{N}_2\text{O}$  emission flux was higher in the dry season whereas  $\text{CH}_4$  was lower. The trend reversed in the wet season.



Image: McKay Savage, Flickr.com

Irrespective of the season, gas emission from plots where mechanized urea briquette application was used, was minimum and closer to the levels of the control plot. The team attributed the reduction in gas flux to the reduction in reactive surface area of the urea briquettes which slowed the enzyme-catalysed processes.

Mechanized application of urea briquettes proved effective in terms of yield also. The mechanical sub surface application of urea briquettes before flooding rice fields reduces the loss of nitrogen as gases and can thus be recommended to farmers. On the one hand, the technique reduces greenhouse emissions and, on the other, reduces urea usage.

*Agric. Ecosyst. Environ.*, **252**: 78–190

#### **Urban Biodegradable Waste** *Enhancing pigeon pea productivity*

Pigeon pea has good nutritive value. Since it is a legume crop and fixes nitrogen, it also improves soil fertility. Pigeon pea does not require heavy irrigation, and is drought tolerant. However, due to poor organic matter and degraded soil, the average yield is only about 7 quintals per hectare. There is potential to increase yield by 75–200% if organic matter is supplied.

Ansari and Mahmood from the Aligarh Muslim University undertook research on pigeon pea under improved soil conditions using rhizobium, a

bacterium that fixes nitrogen, in combination with municipal waste, goat manure and poultry manure separately.

Rhizobia colonize plant roots as nodules and convert atmospheric nitrogen into ammonia. They fix 15–20 kg of nitrogen per hectare and enhance soil attributes by up to 20%.

The scientists conducted a field experiment in pigeon pea for two years from 2012 to 2014. They evaluated the performance of bio-organics such as *Azospirillum brasilense* and *Pseudomonas fluorescens* and organics such as *Parthenium hysterophorus*, *Ageratum conyzoides*, along with municipal waste, and goat and poultry manure. The team recorded plant height, fresh and dry weight, pollen fertility, nodule density, number of pods and primary branches per plant. They monitored the nitrate reductase activity, peroxidase activity and chlorophyll in the plants as well as nitrogen, phosphorus and potash in the soil. The load of soil microbial biomass carbon, microbial population of fungi, actinomycetes bacteria, and beta-glucosidase were also evaluated.

Using statistical software, such as R i386, Duncan's multiple range test, multivariate and principal component analyses, they analysed two years data of all the 16 experimental plots.

The researchers found that the combination of rhizobium with municipal waste markedly improved the growth and yield attributes of pigeon pea over the untreated control. The maximum number of root nodules was recorded in this treatment. It also markedly improved nitrate reductase activity, peroxidase activity and chlorophyll. Nitrogen, phosphorus and potash in soils also improved. Maximum microbial population was recorded in the rhizobium and municipal waste treated plants. While rhizobium in combination with both goat and poultry manure showed considerable improvement in bacterial populations, nitrate reductase and other parameters, these combinations were not to the extent achieved by the rhizobium and municipal waste combination.

This study suggests that a good source of soil nutrients to enhance

agricultural yield in rural areas lies as waste in urban areas.

*Sci. Hortic.*, **226**: 1–9

### **Electro-mechanical Technique To determine concrete ageing**

Concrete starts gaining strength with hydration of cement. Therefore, it is important to monitor the early part of hydration to predict the strength and cracking patterns of the structure to be formed.



Image: Wikimedia Commons

Last fortnight, scientists from the Indian Institute of Technology and the Bennett University in Delhi proposed a mechanism to monitor the early hardening of concrete. They used an electro-mechanical technique to study the structural impedance offered by the structure. In the process, they identified a non-dimensional parameter to determine hydration in concrete.

The researchers used sensors and piezo-impedance transducers to determine the stiffness of the steel-bars inside the concrete. They analysed the parameter under different signal frequencies for 28 days. The results showed that the non-dimensional hydration parameter is very effective in monitoring the early stage hydration of cementitious materials.

Besides strength monitoring, the scientists say that the model can also be employed in numerous applications such as determining the system's power and energy consumption. This technique can also be applied to the construction industry, as the model can help decide the suitable time for removing the moulds used to shape and structure concrete.

*Mech. Syst. Signal Proc.*, **99**: 129–141

### **Desalination of Seawater Pervaporation for separation**

More than 90% of the Earth's water is too salty to drink. To overcome this shortage of potable water, most desalination plants use reverse osmosis. However, reverse osmosis wastes water in the form of brine and also consumes electrical energy.

On the other hand, partial vaporization by passing water through a dense membrane to produce ultrapure water – pervaporation desalination – economises on both water and energy.

The water flux through the membrane, used for pervaporation desalination, is usually hydrophilic. As salts are non-volatile and non-diffusive, they do not pass the membrane.

Scientists from the Central Salt & Marine Chemicals Research Institute, Gujarat, have now developed an efficient material for desalination: poly(vinyl alcohol)–silica film on porous polysulfone hollow fibre. They cross linked the silicon and the poly(vinyl alcohol) to fabricate an active membrane.

The team used an automatic dip coating machine to prepare polysulfone hollow fibre composite membranes, reinforced with the highly water-permeable but continuous barrier of poly(vinyl alcohol)–silica film.

This composite material was successful for salinity feeds of up to 50,000 ppm NaCl. The membranes exhibited 99.9% salt rejection when the pervaporation experiment was operated between 26–60 degrees Celsius. Above 60°, the per cent salt rejection was found to decrease.

The thickness of the active layer of the material is lesser than existing membranes. The scientists attribute this to the free volume of the poly(vinyl alcohol)–silica film. This technology promises to be useful for desalination of sea water and to solve the scarcity of water in the future.

*J. Appl. Polym. Sci.*, **133**(3): 45718

### **Remote Sensing Imagery In fisheries and aquaculture**

The vantage viewpoint of satellites to map marine and associated resources is being rapidly adopted for the benefit of fisher people and

coastal dwellers. The Second International Symposium on Societal Applications in Fisheries and Aquaculture using Remote Sensing Imagery (SAFARI-2) was held in CMFRI, Cochin, from 15th to 17th of January 2018 to share the advancements made in the field by countries across the world.

From the initial attempts at deducing fish resources by examining the oceans for the presence of chlorophyll the field seems to have exploded. What are the best places in Maharashtra for crab culture and for fin fish farming? How can we do sustainable agriculture in the river estuaries of Karnataka, especially for clam and crabs? What are the best locations for seed nurseries of fin fish and shell fish? How can we extend the areas for prawn culture? What are the best fishing zones in the Bay of Bengal? Where can we find yellow fin tuna in the coasts of Andhra Pradesh? And which locations can be developed as tourist spots in an eco-friendly manner?

How can we optimize on the harvesting of wind, wave and solar energy in the coastal areas? How can we leverage on communication technologies to provide early warning systems for coastal disasters? The questions that are tackled by scientists looking at the seas from space have grown to encompass many societal issues including reduction of conflicts in marine resource sharing between different stakeholders.

This reporter was overwhelmed by the diversity of issues being discussed in SAFARI-2, but could not help wondering how these scientific and technological advances can be understood and assimilated by fishers, traders, fisheries managers and consumers.

**Reports by: Mridula Vellore, H. M. Mahadeva Swamy, D. Kavya, S. Neeta Shrivastava, S. Balaji, K. V. Srividhya, S. Suresh Ramanan, J. Srinath, Ashwathy Nair, Sileesh Mullasserri and P. K. Udham.**

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scienceandmediaworkshops@gmail.com



## Science Last Fortnight

### Downy Mildew in Maize Detecting pathogens in seeds

Maize is the third most important cereal crop in India. However, the crop is often infected by downy mildew. This disease affects growth and, consequently, production.

The pathogen involved, *Peronosclerospora sorghi*, reproduces both sexually and asexually. It survives as oospore in soils and infects seedlings. It is also dispersed as airborne conidia, an asexual, non-motile spore, which infects seeds. When infected seeds are sown in a plot, the pathogen spreads. To prevent the spread of the disease to other plots, it is important to detect the pathogen in seeds. Existing tests for the pathogen require expertise, time and costs.

Sireesha and Velazhahan from the Tamil Nadu Agricultural University now report a simple, rapid and reliable technique to detect the pathogen. The team collected 20 isolates of *P. sorghi* from sorghum and maize and extracted DNA from each. Then they randomly amplified polymorphic DNA markers. They identified a reproducible and prominent band from the genomic DNA in all the strains of the pathogen. Next, they identified a Sequence Characterized Amplified Region – a nucleotide sequence that can serve as a marker for the pathogen. Thus, they identified a 305 base pair DNA, unique to the pathogen.

To test this marker, they collected seed samples of 28 downy mildew infected field grown maize plants from different parts of India. The researchers also selected 15 healthy plants as control. Using the 305 base pair DNA as marker, they could easily distinguish between infected and non-infected seeds. Even with very small, femtograms of DNA, the scientists could detect *P. sorghi*.

The team then tested the method with another 12 well-known fungal phytopathogens. Since they observed no cross reaction, they report that the test is very specific and that the method is more rapid, sensitive and less laborious than traditional methods.

The real-time polymerase chain reaction technique has increased sensitivity, specificity and reproducibility for detecting low concentrations of pathogen DNA. It might prove useful in detecting other fungal pathogens also. Now, it is up to scientifically-oriented entrepreneurs to market this idea as a diagnostic kit for farmers.

*Eur. J. Plant Pathol.*, **150**(2): 521–526

### Producing Monosex Tilapia Alternative to synthetic steroids

Tilapia is a widely cultured fish – second only to carp in global production. It is easy to spawn, grows rapidly and is less vulnerable to disease. It has high consumer acceptance and gives high returns to the fish farmers.

Tilapia females reproduce when still small and show stunted growth when the fish density is high. The males, on the other hand, grow faster and bigger. To get an all-male tilapia harvest, farmers use synthetic steroids. However, synthetic steroids pose many ecological and health hazards.

Recently, to culture monosex tilapia, researchers from the University of Calcutta and the Kaposvár University, Hungary used eco-friendly natural compounds: seeds of the Bengal velvet bean – *Mucuna pruriens* – and roots of shatavari – *Asparagus racemosus*.

They extracted plant metabolites with water, ethanol and methanol. And they administered these extracts to mixed-sex tilapia juveniles, as dietary treatment. The team found that extracts, with different solvents of both plants, had steroids/terpenoids, saponins and flavonoids. They observed that the extracts of Bengal velvet bean seeds produce a higher percentage of males than treatments with shatavari root extracts.

The scientists found that, in a dietary administration of methanol extract of Bengal velvet bean seeds, a concentration of 0.2 g/kg in the feed was best for producing all-male tilapia. However, further studies are required to establish an ideal treatment regime using plant materials.

The report might prove useful to develop an eco-friendly aquaculture technique, replacing synthetic hormones and chemotherapeutics with biodegradable natural compounds.

*Turk. J. Fish. Aquat. Sci.*, **18**: 267–275

### Cross-country Virus Transmission Threat to Tilapia



Image: Wikimedia Commons

Tilapia, the second largest group of farmed fish worldwide, is a commercially important protein source. However, this species, relatively resistant to infections, suffered an extensive viral epidemic in 2014. This first outbreak of the Tilapia lake virus resulted in high mortality and impacted the economics of aquaculture. Since then, there have been many outbreaks across the globe.

Last fortnight, a team from different ICAR organizations across the country reported incidences of tilapia virus in Indian aqua farms from West Bengal and Ernakulum. They analysed a total of 15 virus infected tilapia fishes from the West Bengal farm, using skin discoloration and detached scales as morphological features of the infection. They performed histopathological analyses and observed necrosis of liver hepatocytes as well as haemorrhages in brain cells – characteristic effects of the virus infection.

Next, they isolated viral genome from organ tissues and confirmed it to be closely related to a virus outbreak from Israel. They then infected a clinically healthy set of 25 tilapia with virus isolated from infected organs. The researchers found internal lesions in liver and brain cells of the test set after 10 days, showing that the virus can spread in a population.

Tilapia viral outbreaks could impact production worldwide and pose a threat to food security. The FAO has even issued a biosecurity alert against the virus. There is an urgent need for an effective method to contain the spread of the virus and to overcome infections in aqua farms.

*Aquaculture*, **484**: 168–174

### **Preventing Heart Failure** *Is oolong tea the answer?*

The WHO estimates that 31% human deaths are caused by cardiovascular disorders. More than three-quarters of heart disease-related deaths take place in low and middle income families who cannot afford expensive treatments. The expenses associated with treatment continue to soar. Under such conditions, prevention is indeed better than cure.

Last fortnight, researchers from the Bharathiar University, Coimbatore, in collaboration with medical universities in Taiwan, identified cardioprotective properties in semi-fermented oolong tea. They extracted the oolong tea by partial oxidation and fermentation of freshly harvested young tea plant shoots. This extract contained higher levels of polyphenols, caffeine, and total catechins than green and black tea. Moreover, the extract also contained a powerful antioxidant, epigallocatechin-3-gallate, that effectively neutralized the reactive oxygen species present in female embryonic rat heart fibroblast cells.

The researchers found that oolong tea extracted at low temperature steaming offers better and longer protection against cardiovascular disorders. They claim that the cardioprotective effect is due to the suppressing of a signalling pathway that induces hypoxia and causes cellular damage under oxidative stress conditions. Oolong tea enhances cell survival by suppressing apoptosis – a cell self-destruction programme which generally occurs to prevent the spread of disease to healthier cells.

Cardiovascular disorders, according to the American Heart Association, pose a 20% risk at 24. The risk is more than double at 45. And, at 80, the risk is 90%! Surely, it is easier to lower the

risk by simply drinking oolong tea – affordable protection against cardiac diseases.

*Environ. Toxicol.*, **33**(2): 220–233

### **Nano-bioglass Ceramic** *For bone tissue engineering*

Ceramic materials have been extensively used in bone grafts, as their composition is similar to that of the mineral part of bone. Also, they are bioresorbable. However, ceramic materials have poor mechanical strength and a faster dissolution rate.

Bone tissue engineering is a better alternative to the conventional use of bone grafts, due to the unlimited supply of materials: the repair process uses the patient's own tissue. One of the challenges in bone tissue engineering is fabricating scaffolds with mechanical, structural, surface-chemical, topographical and biological properties suitable to regenerate critical size cortical bone. In recent times, bioactive glass ceramic has attracted attention in this regard. It is widely applied as a material for bone tissue regeneration.

Last fortnight, scientists from the Chettinad Academy of Research and Education, Kelambakkam, the Madras Institute of Technology, Chennai and the SRM University, Kattankulathur, reported developing a bio-active glass ceramic with better bone forming abilities. They focused on treating bone defects, with biomaterials in combination with a homeopathic remedy.

They synthesized nano-bioactive glass using a sol-gel method and doped it with *Calcareo phosphorica*, a homeopathic prescription for bone related diseases.

The scientists analysed the surface topography, morphology and particle size of the nano-bioactive glass and the *Calcareo phosphorica* doped nano-bioactive glass ceramic using Scanning Electron Microscopy. They found calcium ions deposited over the crystalline structure, indicating the aggregation of *Calcareo phosphorica* on the surface of the nano-bioactive glass ceramic. Instead of the rod-shaped crystals of bioactive glass ceramic, the doped material showed more spherical shapes.

The researchers tested the toxicity of the particles by colorimetric quantification and found that a concentration of up to 0.1 mg/ml had no toxic effects. They found that the material leads to an 18% increase in proliferation of osteoblasts *in vitro*.

They claim that their findings may pave the way for new insights into developing the biomaterials with potential bone formation capability. The material needs further testing *in vivo*, for bone tissue engineering.

*Mater. Sci. Eng. C.*, **83**: 202–209

### **Self-Cleaning Cotton Fabric** *Superhydrophobic, superoleophobic*

Apart from looking good, clean clothes help keep away unpleasant body odours. They also protect us from harmful microorganisms, which, otherwise, make dirty clothes their home and cause skin infections.



Image: Wikimedia Commons

Every day, people working in industries, hospitals, warehouses, shops, and garages struggle to keep their clothes clean. In a climate like ours, cotton clothes are preferable. But they are difficult to maintain.

To overcome the issue, a team from the NIT, Rourkela and the IIT-ISM, Dhanbad, recently reported developing a liquid repellent coating on cotton fabric, with excellent self-cleaning and oil-water separation properties, like that of the lotus leaf. Silicon tetrahydride, and its derivatives, where hydrogen is replaced by other atoms or groups of atoms, commonly known as silanes, are used for corrosion protection, adhesion promotion and other surface modification applications. The researchers fabricated superhydrophobic and superoleophobic coating on cotton fabric using two fluoroalkyl silanes – trichloro

(octadecyl) silane and (pentafluorophenyl) triethoxysilane.

The researchers used commercial white cotton fabric as substrate in tests for different capabilities. They placed droplets of different solutions, with different surface tensions, on the coated fabric surface to test wettability. The coated cotton fabric showed superhydrophobicity with hot water and repelled liquids like ethylene glycol and glycerol.

The scientists observed optical images of water, glycerol and ethylene glycol droplets on the coated fabric after immersion with different solvents for four days and confirmed chemical stability. They also annealed coated fabric in an oven for one hour at an elevated temperature of 50°C to 160°C. The fabric showed no change in colour or damage, proving its thermal stability.

The team also conducted a water jet impact test on the superhydrophobic and superoleophobic coated fabric. The water jet bounced off in opposite directions, showing the mechanical stability of the coating. The researchers observed negligible stains on the silane-coated fabric after annealing at 40°C for 15 minutes with coloured droplets. This confirmed stain resistance. The coated fabrics also showed excellent stability after exposure to UV irradiation for 35 hours.

When the scientists poured water on the silane-coated fabric, it rolled off, carrying away dust particles and leaving a cleaned surface, evidencing excellent self-cleaning behaviour. Then, they prepared a mixture of oil (kerosene/benzene/petroleum ether) and water, and poured it on the coated fabric. The team also found that they could efficiently collect oil and water separately from the fabric.

They conclude that the superhydrophobic and superoleophobic silane coatings are suitable for many industrial and engineering applications. The textiles are also useful for making fire retardant, waterproof clothing, stain resistant surgical and other household products, they claim. The solution immersion technique they used is simple, single-step and cost-effective.

*Carbohydr. Polym.*, **181**: 1052–1060

### Anti-bacterial Filter Paper Water purification made easy

Water-borne diseases spread like wild-fire, and possess the strength to wipe out an entire population. In India, access to hygienic drinking water is limited to locations in and around water treatment plants. With the advances in technology, today we have microfiltration, ultrafiltration and even nanofiltration. But these are either time consuming or cost intensive. We need a mobile and economical solution.

Last fortnight, researchers from the Guru Jambheshwar University of Science and Technology in collaboration with scientists from Canada and the Republic of Korea reported developing an anti-bacterial filter paper, for water purification. Neeraj Dilbaghi and team focused on two aspects of the cellulose foam filter paper – wet strength and antimicrobial activity.

First, they prepared a cellulose foam paper by diluting, disintegrating and refining a softwood pulp suspension. They used surfactants to stabilize the structure of the cellulose paper. Next, they converted the cellulose foam paper into antibacterial water filter paper by immersing the foam paper into a glutaraldehyde solution and heating it. Glutaraldehyde is a potent disinfectant, regularly used for sterilization. To enhance linkages between the fibres, the scientists used a butanetetracarboxylic acid solution, a cross linking polymer. Thus, they increased the wet strength of the paper.

The team found that the fibres rapidly absorbed water and were, thus, not strong enough. Hence, they added polyacrylamide, along with glutaraldehyde, during the manufacturing process. Polyacrylamide introduced hydrophobic groups and increased the strength of the paper further. Thus, they have developed a new porous cellulosic filter paper, which can, potentially, be used for water filtration.

The scientists tested wet strength performance using a vertical tensile tester. They found that adding glutaraldehyde along with polyacrylamide enhanced the filter paper's wet strength and that rinsing time did not

affect the strength of the filter paper significantly.

The team then tested the antimicrobial activity of the filter paper using a turbidimeter against five test cultures, including both Gram-negative and Gram-positive bacteria. They found that the filter paper was an effective microbial growth inhibitor.

The photographs of the filter paper, taken using a scanning electron microscope, showed that its structure is non-uniform. This increases the probability of particles, including bacteria, getting stuck to the paper.

The research community can explore and study the effects of the antimicrobial filter paper and collaborate with industry to scale-up this invention to provide potable water in remote villages.

*Carbohydr. Polym.*, **181**: 1086–1092

### Transparent Conducting Oxides For solar cell applications

Solar cell applications call for materials with lower band gap energy, high transmittance and greater carrier concentration. Attempts to increase conductivity usually end up reducing transparency. So, scientists have been doping transparent conducting oxides with suitable materials, hoping that a combination of metal and metal oxide will produce materials with high transmittance and low resistivity.

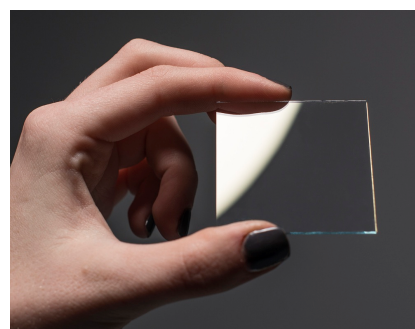


Image: Adafruit Industries/Flickr, CC

Last fortnight, scientists from the Alagappa University, Tamil Nadu in collaboration with a scientist from the Shizuoka University, Japan made a detailed analysis of transparent conducting oxide materials and came up with a new class of material, cadmium stannate, for this purpose.



They prepared cadmium stannate thin films using magnetron sputtering – a plasma vapour deposition technique. And reported that the surface of the deposited thin films show smooth surfaces with nano grains.

The recorded optical transmittance and absorbance spectra of cadmium stannate films show high transmittance of the order of 80% in the visible region, they report. But more importantly, the optical band gap decreased to around 2.5 eV from 3.0 eV. The electrical analysis revealed that the film has low resistivity and higher carrier concentration.

Thus, the scientists claim that the thin film prepared using cadmium stannate – a ternary combination of a transparent conducting oxide material – has good electrical conductivity, wide band gap, and is highly transparent to visible light. Therefore, it is a reliable candidate for solar cell devices. However, the efficiency of these materials for solar cells in field applications has yet to be tested.

The researchers also claim that the application of this material is not limited to solar cells. It is suitable for optical-to-electrical transducers in optoelectronic devices and so they hope that this material has scope for future developments.

*Ceram. Int.*, **44**(2): 2529–2538

### Arresting Hydrazine An environmental pollutant

Hydrazine, a compound with two nitrogen and four hydrogen atoms, is a seemingly harmless, colourless liquid. It is used extensively in pharmaceutical, chemical and agricultural industries. But it poses an environmental threat. It damages the nervous system, liver and brain upon exposure. Hence, we must detect and capture the carcinogenic compound.

Last fortnight, researchers from the Madurai Kamaraj University in collaboration with the Utah State University reported identifying aluminium-doped boron nitride nanotubes as a material to arrest hydrazine.

Several studies on the decomposition of hydrazine into hydrogen and

ammonia reveal that hydrazine adsorption depends on hosts and active sites on the surface of the compounds. The scientists used the density functional theory to describe the adsorption of hydrazine in interactions between hosts and guests in the compounds.

Boron nitride is one of the best adsorbents. It contains both Lewis acid and base centres, alternate to each other at the surface, giving more scope to interact with hydrazine derivatives. However, smaller diameter tubes form weaker interactions due to their high structural strain. This limits the use of boron nitride nanotubes as hydrazine adsorbents.

Previous studies show that aluminium-doping enhances the adsorption energy of boron nitride nanotubes. The aluminium atom, being larger than boron, is well above the surface of the tube and makes the tube more absorbent: adsorption energy increases from 10–70 kcal/mol to 32–35 kcal/mol.

The scientists say that the aluminium doped boron nanotubes could be an alternative to metal-based materials for hydrazine adsorption.

*Struct. Chem.*, **29**: 375

### Recommending Books Challenge for universities

The Indian tertiary education sector has seen a quantum leap in this decade. The number of universities has doubled. So has the number of new books published. Which books should be recommended to the students?



Image: S. Suresh Ramanan

Universities recommend books based on experts' personalized rec-

ommendations while framing syllabus. However, this leads to large variations in the list of books recommended by different universities, raising the question: which list is better? How do we reduce the personal and subjective biases of the experts that recommend books for university curriculum?

Last fortnight, a team of researchers from the Aligarh Muslim University reported a solution: Ordered Weighted Aggregation of a ranked recommendation. First, the team selected the leading Indian universities in the field of computer science and information systems, based on the QS World University ranking. These top universities had recommended a total of 158 books for ten courses.

The team allotted ranking to the books based on the syllabus of the leading university in the list. They gave weightage to the university rank, as well as to the book ranking. Thus they came up with a final list of books that can be recommended for each course separately.

The team then compared the results of the study with un-weighted aggregation based scoring where university ranking is not taken into account. Experts from different parts of the world compared the two lists and agreed that the list created using ordered weighted aggregation is better.

Ordered Weighted Aggregation does better because it normalises the differences in the personal knowledge and preferences of the experts as well as the differences between universities. Now it is up to academicians, students and librarians to use this tool effectively.

*Int. J. Intel. Syst.*, **33**(2): 396–416

**Reports by:** J. Srinath, K. V. Srividhya, Sileesh Mullasserri, P. Gowdhaman, Khushbu K. Birawat, Sanghamitra Deobhanj, G. Sharath Chandra, Mridula Vellore, Pudi Venkatesu and S. Suresh Ramanan

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scienceandmediaworkshops@gmail.com

## Science Last Fortnight

### Areca Nut Husk in Drug Delivery *Formation of giant vesicles*

Betel-nut, the *Areca catechu* nut, is a prominent crop of India. Its production in the country is the highest in the world. Areca nut husk, a waste product, has hard fibres and has been exploited as an industrial raw material for manufacturing hard-board, paper board, insulation wool and wrapping paper. The cellulose nanofibres of this husk have recently gained attention due to their potential in the preparation of polymer composites with improved properties.



Image: palmpedia.net

Scientists from the CSIR-National Institute for Interdisciplinary Science and Technology, Thiruvananthapuram now report synthesising nano-fibrillated cellulose from the husk fibres. They used oleylamine, an unsaturated fatty amine, for this. The oleylamine molecules self-assemble to form giant vesicles in this modified nano-fibrillated cellulose, which, the researchers claim, have immense potential in drug storage and delivery.

To synthesise these vesicles, they extracted cellulose from the husk fibre. They bleached it to remove lignin and washed it with a dilute alkali solution to purify the cellulose. They neutralised the product by washing with distilled water and modified this product by carboxylation. After adjusting the acidity, they added an oleylamine solution for further modification and finally purified it by centrifugation.

The team studied these nanoparticles using conductometric titration, X-ray photoelectron spectroscopy, energy dispersive spectroscopy,

transmission electron microscopy, Fourier-transform infrared spectroscopy and dynamic light scattering. These tests confirmed the self-assembly of the modified system into spherical particles, the size of the fibrils and the amidation of the carboxyl groups functionalised with oleylamine.

The researchers prepared solutions of the nano-fibrillated cellulose with tetrahydrofuran for a self-assembly study. And they observed the formation of large vesicles with a diameter thickness of 300–600 nm.

The scientists suggest that the non-polar interactions of the unsaturated long aliphatic chains, stabilised by the intermolecular hydrogen bonding interactions within these modified fibrils, lead to the formation of such giant vesicles.

The scientists claim that these giant vesicles of biocompatible nanomaterials have great potential for applications in the storage and delivery of drugs and cosmetic materials as well as in biosensors.

*Carbohydr. Polym.*, **182**: 62–74

### Drug Repurposing for Cancer *Quinoline acetohydrazide derivatives*

Developing new drugs is challenging for the pharmaceutical industry – most drugs fail during development and do not reach the market. This means huge expenses without any returns. Drug repurposing – using known drugs and compounds to treat new indications – has a significant advantage over drug development: the drug has already passed through a stringent clinical trial protocol and toxicity tests. This significantly reduces expenses.

Scientists from the Sri Sathya Sai Institute of Higher Learning, Andhra Pradesh and the VIT University, Tamil Nadu now report repurposing quinoline acetohydrazide derivatives. Quinoline derivatives are wide-spectrum antibacterial agents. With azomethine, they become anti-inflammatory and anti-convulsive.

The researchers used computer simulation to study the possibility of repurposing. They used *in silico* molecular docking techniques to predict the preferred orientation of one molecule to another when bound to form a stable complex.

The scientists used a membrane stabilisation study and an enzyme assay to measure enzymatic activity for evaluating the mode of action of the drug.

The entire data set demonstrated the significant anti-cancer and anti-inflammatory activity of quinoline acetohydrazide derivatives. The *in silico* binding affinities are comparable to those of the prescribed standard reference drugs. This suggests their potential role in inflammation and cancer therapeutics.

The scientists consequently confirmed these effects *in vitro*. For clinical applications, however, even the repurposed drug has to pass through further experimental procedures and clinical trials.

*J. Mol. Struct.*, **114**: 437–444

### Nanohybrid Doxorubicin Delivery *Heating up cells for cancer therapy*

Graphene is biocompatible, cost-effective and has extensive applications in biomedicine. It is non-toxic and an efficient drug nanocarrier. Iron oxide, yet another nanomaterial with paramagnetic properties, is an important marker in cancer research and therapy.

Last fortnight, scientists from the IIT Mumbai, reported using a nanohybrid of graphene and iron oxide to deliver doxorubicin, a widely used anti-cancer drug. The combination, they say, can synergise drug therapy with hyperthermia therapy to manage cancer. A magnetic field, produced by an AC electric current, can create heat in the delivery platform due to the action of iron oxide.

The researchers dispersed graphene oxide by ultrasonication. Then they combined iron oxide salts with the graphene oxide suspension. A series

of chemical treatments produced a crystalline precipitate of the nanohybrid. X-ray diffraction patterns of the nanohybrid showed an arrangement of iron oxide over graphene-stacked sheets.

From transmission electron microscope images, the team observed that the nanohybrids were segregated, and had particle sizes of 8–10 nm. With the help of the Raman spectrum, the team confirmed the functional groups of the nanohybrid. Magnetisation plots confirmed its superparamagnetic property.

For drug loading studies, they screened three varying concentrations of doxorubicin and the nanohybrids and arrived at an optimal ratio. They conducted a drug release assay by scoring HeLa cell viability. Inhibition of cell proliferation *in vitro* indicated sustained release of doxorubicin from the nanohybrid.

On exposure of HeLa cells to the magnetic field of an AC current, the nanohybrid led to maximal cell death, clearly suggesting the synergetic action of the drug delivery system and the higher temperature.

The complex, diverse and heterogeneous nature of tumours has imposed challenges in choosing any single-therapy strategy. Synergistic cancer therapies seem to be more efficient in suppressing tumour progression.

The nanohybrid is versatile in terms of functional group, drug binding-release kinetics and cytotoxicity. The next important step is to target the delivery of the nanohybrids specifically to cancer tissues for effective chemo-thermo cancer therapy.

*J. Magn. Magn. Mater.*, **448**: 332–338

### No More Contaminated Water Antibacterial filter

Polyvinylidene fluoride is an extensively used membrane material for water purification applications. Tethering biocides on the membrane helps increase antimicrobial properties. However, the leaching of such chemicals leads to loss of antibacterial activity and pollution of the environment.

Scientists from the Indian Institute of Science, Bengaluru used a con-

tact-killing approach to create an antimicrobial membrane. Graphene oxide and phosphonium salts are reported extensively for their antimicrobial and antifouling activities. The team facilitated ester bond formation between the membrane surface and graphene oxide. Then they grafted phosphonium salt molecules onto it.

The researchers used Fourier transform infrared spectroscopy to confirm the presence of the characteristic epoxy bond of graphene oxide. They observed a chemical shift in  $^{31}\text{P}$  nuclear magnetic resonance spectroscopy which established the presence of phosphorus on the composite. X-ray photoelectron spectroscopy confirmed these findings.

The synergistic effect of graphene oxide and phosphonium salts made the hydrophobic polyvinylidene fluoride membrane hydrophilic. The membrane does not clog easily and allows a stable flux of water due to the pore structure.

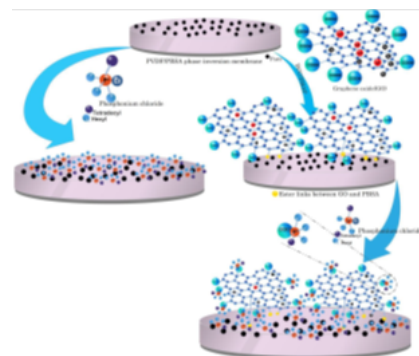
The scientists documented reduced contact angle and increased uptake per cent of water flux. They also noted decreased membrane hydraulic resistance and increased trans-membrane flux. This suggests increased affinity of the membrane to water.

High water flux recovery ratio and low irreversible flux decline ratio indicated lower susceptibility of the membrane to bio-fouling. So the team used model coliform strains, *Escherichia coli* (Gram-negative) and *Staphylococcus aureus* (Gram-positive) bacteria, to study the antimicrobial action of the modified membrane. A two-hour treatment, with the modified membrane, showed a seven-fold reduction in bacterial count indicating highly antimicrobial activity.

The team studied the mechanism of the antimicrobial action systematically. They used a hydrophobic fluorescent probe, *n*-phenyl-1-naphthylamine, for bacterial membrane permeabilisation studies. They noted high probe uptake and maximum leakage of intracellular  $\text{K}^+$  ion and nucleic acids in bacterial cells which were in contact with the graphene-modified membrane. They

also recorded high fluorescence intensity of dichlorofluorescein in the bacterial cells. Scanning electron microscope images showed punctured holes in bacterial cells attached to the modified membrane. This indicated the presence of a high concentration of reactive oxygen species due to metabolic stress in the bacterial cells. Thus, the membrane modified with graphene and phosphonium derivatives seems to work like a beta lactam antibiotic, making the bacterial cells leaky.

The scientists then performed a long run-time anti-fouling flux experiment. The membrane showed efficient microbial purification even after continuous feed of contaminated water.



The modifications suggested for the membrane surface are simple and effective with excellent fouling resistance, showed impressive reduction of bacterial count and had stable flux performance. Now it will take a synergy between the Water Mission and the Make in India programme to mass produce such membranes.

*J. Membr. Sci.*, **548**: 203–214

### Monitoring Mercury Smart sensor

Mercury is a toxic heavy metal, even at low concentrations. It spreads to unexposed regions, in atmosphere, water and soil through a biogeochemical cycle. Thus, it enters the food chain and poses health problems. Hence, continuous monitoring of the pollutant in the environment is indispensable.

Recently, a team from the JNCASR, Bengaluru and the RMIT



University, Australia designed an ultrasensitive sensor to detect mercury in water. The crucial element of this sensor is a quenching probe for mercury – histidine conjugated perylene diimide. The molecule contains perylene diimide, a fluorescent compound with high quantum yield, with histidine, attached at both ends. This creates a bolaamphiphile structure making this macromolecule more water soluble – a necessary condition for practical applications.

The team prepared a monolayer of polystyrene nanospheres, using electron beam evaporation, on a silica platform as base template for the sensor. Then they deposited gold particles onto the template monolayer. This acted as signal transducer.

The scientists attached histidine conjugated perylene diimide to the surface of the gold particles using one of the histidines. This leaves the other histidine free to take part in the quenching reaction with mercury. Histidine has an imidazole group that chelates with metals. When a green laser was applied, the sensor produced visible fluorescence, if bound with mercury. This can be measured accurately with Raman spectroscopy.

The team tested this sensor with different concentrations of mercury. And found that it can accurately measure mercury concentrations of up to 5 nM – two folds lower than the allowed standard limit of mercury in drinking water. The scientists tested this sensor with other metal ions such as manganese, copper and cadmium also. They found the response of the sensor non-significant. Thus the sensor is specific to mercury.

The mercury bound to the sensor can easily be removed by using cysteine, which sequesters mercury from the histidine. Thus the sensor is reusable.

The scientists claim that this technology is robust and handy. And it enables rapid field detection of mercury at parts per quadrillion concentrations. Now, entrepreneurs can commercialise this technique to mitigate mercury contamination.

*Biosens. Bioelectron.*, **100**: 556–564

### Nanocomposite Adsorbents *An effective way to purify water*

Rapid industrialisation has contributed to the release of toxic heavy metals into water bodies in India. Heavy metals tend to accumulate in living tissues, causing various diseases and disorders. A report<sup>1</sup> from 2010 indicates that one third of samples collected from selected cities failed to meet WHO standards of safe potable water.

LEAD CONTENT IN WATER:: CITIES AT RISK			
ALARMING	HIGH	MEDIUM	LOW
Kolkata	Delhi	Chennai	Bangalore
Kochi	Coimbatore	Ludhiana	Ahmedabad
Mumbai	Madurai	Surat	Hyderabad
Pune	Bhubaneswar	Ghaziabad	Indore
Nagpur		Jamshedpur	Bhopal
Nashik			Chandigarh
Guwahati			Lucknow
			Mangalore
			Mysore

Among the techniques developed to remove toxic metals such as lead, cadmium, chromium and nickel, adsorption is efficient and fast. Moreover, diverse adsorbents are easily available. Among them, chitosan has emerged as the most promising. Though chitosan has small surface area, low porosity and poor selectivity, studies show that the chemical modification of chitosan with an acidic polymer, such as polymethacrylic acid, improves its adsorbency. Chitosan can also be modified with an inorganic filler to make it a more efficient adsorbent. One such filler is the halloysite nanotube, a naturally occurring clay mineral with nanotubular structure.

Last fortnight, scientists from the University of Calcutta, West Bengal, reported a nanocomposite by integrating chitosan with cross-linked polymethacrylic acid and a nano-sized halloysite nanotube to create an adsorbent that can remove lead and cadmium ions from water<sup>2</sup>.

They tested the material for the removal of lead and cadmium ions and report that the composite shows high adsorption. It removes a high percentage of these metals from water as single and as binary mixtures.

Developing the technology will give water authorities more room to be

stringent with industries that release heavy metals. Heavily polluted rivers, such as the Yamuna and the Kaveri may, in the near future, get a respite and chances of the availability of safe potable water become brighter.

<sup>1</sup>*LEAD Action News*, **10**(1), June 2010

<sup>2</sup>*Carbohydr. Polym.*, **182**: 159–171

### Improving Algal Biodiesel Stability *Binary combination of antioxidants*

Biodiesel is a renewable alternative to petroleum diesel. It is easily manufactured by the trans-esterification of edible and non-edible vegetable oils. However, biodiesel has poor storage stability. Oxidising biodiesel leads to the formation of oxidised by-products and reduces engine performance.

To overcome this problem, a team from the University of Petroleum and Energy Studies, Dehradun collaborated with scientists from the Government Post Graduate College Gopeshwar, Uttarakhand, to report a solution: adding binary combinations of antioxidants to algal biodiesel.

‘From available literature, we came to know that pyrogallol was the best antioxidant. But to align our research with current trends of biofuel production and processing, we focused on evaluating lower concentrations of binary antioxidants to achieve the best antioxidant synergy for the maximum stabilisation of algal biodiesel’ says Girdhar Joshi.

The scientists obtained a culture of micro alga, *Chlorella vulgaris*, from the Vivekananda Institute of Algal Technology, Chennai. They extracted lipids from the micro algae and trans-esterified the lipids using a base catalyst. After purification, they obtained biodiesel and glycerol, as by-products. The team washed the biodiesel with lukewarm distilled water to remove residual glycerol and purified it by vacuum distillation to get rid of impurities and moisture.

Besides pyrogallol, the scientists used propyl-gallate and tert-Butyl hydroxyquinone as antioxidants. They prepared blends of algal biodiesel with two antioxidants at a time, in different ratios. Then, they stored the samples indoors and periodically

took them out to study the effects of the antioxidants added.

'We observed improvement in the induction period of algal biodiesel with a binary mixture of antioxidants compared to what we found with individual doses of similar concentrations' says Devendra Rawat.

'The binary combinations of 1 : 3 and 3 : 1 by weight of pyrogallol : propyl-gallate showed maximum effectiveness in induction period, stabilisation factor and antioxidant synergy' says Pankaj Kumar.

The team feels that the stabilisation is probably because of the optimum molecular interaction achieved with the 1 : 3 ratios of antioxidants. Further research is required to understand the reason behind the increased effectiveness of the synergy between the antioxidants at the 1 : 3 ratios, says Girdhar Joshi.

However, it is clear that 500 ppm of 1 : 3 binary formulations of antioxidants can be mixed with algal biodiesel for increasing long-term storage. The Ministry of Petroleum and Natural Gas and the Ministry of Agriculture can use this research to popularise biodiesel and to replace petroleum diesel with algal biodiesel in the near future.

*Fuel*, **214**: 471–479

### Degrading Diclofenac *TiO<sub>2</sub> nanocomposite*

Environmentally hazardous diclofenac is used as topical pain reliever in small doses. However, due to improper use and disposal, it ends up in aquatic ecosystems. Photocatalysts can be used to enhance the natural photodegradation of diclofenac. To speed up the reaction further, photocatalysts are doped.

Last fortnight, Thiruppathi and team from the Kalasalingam University and the VIT University, Tamil Nadu attempted to use nanocomposites to degrade diclofenac. They synthesised a cerium ion doped titanium nanocomposite by exposing a cerium nitrate and titanium isopropoxide-mixture to high temperature along with sodium borohydride. Then, they characterised the nanocompo-

site, using X-ray diffraction, and scanning and transmission electron microscope techniques. They found that it had a pristine, closely compacted crystalline nature.

They added the nanocomposite to a diclofenac solution and monitored photodegradation using a UV visible spectrometer. By the end of 80 minutes, the absorbance value reached zero showing that there was complete degradation.

The team went on to test the nanocomposite for stability and reusability. They separated the composite by centrifugation and tested the photodegradation ability again. They report that the nanocomposite is re-usable for five cycles.

They used the nanocomposite in sewage water samples with concentrations from 5 to 25  $\mu\text{M}$ . They observed a reduction in degradation when diclofenac concentration increased beyond 20  $\mu\text{M}$ . The cerium ion-doped titanium nanocomposite performed better than widely used photocatalysts. It is now up to policy makers, corporations and municipalities to effectively use this technology to reduce water contamination by diclofenac.

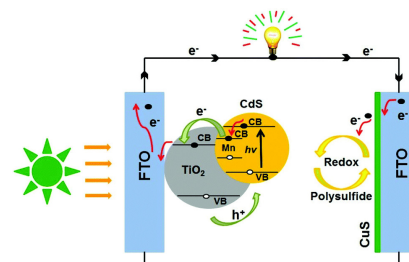
*J. Alloys Compd.*, **735**: 728–734

### Quantum Dots in Solar Cells *Photovoltaic performance analysis*

Researchers are fascinated by the photovoltaic performances of quantum dots – very small semiconductor nanoparticles. The lower costs of producing quantum dot nanomaterials make them an attractive alternative to silicon for producing solar cells. Among the many semiconductor quantum dot nanomaterials reported so far, cadmium sulphide is well suited to solar cell applications due to its lower band gap value – around 2.4 eV. However, the performance varies widely depending on the size of the nano-semiconductor.

Recently, scientists from the SSN College of Engineering, Chennai came up with a technique to identify the optimum size of cadmium sulphide nanoparticles for solar cell applications.

To prepare the samples, they adopted the SILAR method – adding successive ionic layers by means of adsorption in a chemical reaction. By increasing the number of cycles of deposition, from 9 to 12, 15 and 18 cycles, they could get increasing sizes of cadmium sulphide quantum dots. Using X-ray diffraction, they determined that the size of the cadmium sulphide increased from 3 to 9 nm with increase in deposition cycles. The optical properties showed a decrease in band gap with increase in deposition cycle, they report.



*Courtesy Dalton Trans.*, 2015, **44**, 630–638.

By carefully evaluating photovoltaic parameters, including current density and voltage, the team reported an efficiency of 1.8% for the 6.8 nm sized cadmium sulphide quantum dots, prepared using 15 deposition cycles. Beyond this deposition cycle, the particle size and series resistance increases abruptly. Therefore, efficiency decreases.

This research is an innovative step towards developing solar cells with the right sized quantum dots. However, though the efficiency of the cadmium sulphide nanomaterial reported is relatively low, its photostability, ease of fabrication and low cost make it attractive for solar cell applications.

*J. Alloys Compd.*, **735**: 202–208

**Reports by: Sanghamitra Deobhanj, Sileesh Mullasser, S. Suresh Ramanan, K. S. Nitin, S. Balaji, K. V. Srividhya, Mridula Vellore, Nivedita Mishra and P. Gowdhaman**

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scienceandmediaworkshops@gmail.com

## Science Last Fortnight

### Declining Peanut Production *Effects of salinity*

Gujarat is the major producer of peanut in the country. However, it is claimed that peanut production is decreasing due to climate change. Since freshwater for irrigation is a challenge in the coastal belt, farmers use saline water to irrigate crops. Salinity affects soil health and results in yield loss. Another factor is the insufficient supply of quality seeds. Farmers sow seeds from previously harvested crops.

This further impacts yield and quality. Soil type and health as well as seed type and water quality determine yield. Though there are many studies on the relationship between these parameters and yield, there is insufficient information on the effect of the reuse of salinity grown peanut seeds on yield and quality traits such as oil content, protein and seed mass.

Recently, Meena and Yadav from the ICAR-Directorate of Groundnut Research, Gujarat reported a solution for the decrease in peanut production in the coastal belt. They chose two Spanish peanut cultivators, TG 37A and GG 2. The team cultivated both cultivars and irrigated the sample plots with normal and saline water from germination to harvest. They found salinity delayed the germination process – germination percentage and velocity as well as the real value of the seeds. Salinity resulted in an accumulation of soluble salts around peanut seeds.

Peanut seed setting and flowering were also affected. Salinity also reduced pollen viability, and photosynthesis at grain filling and seed setting stages. High salinity reduced the number of nodules, mature pods and kernels. And it decreased pod and seed mass. Using these seeds will lead to a crop with even lower productivity.

The researchers also noted that the survival rate of the GG 2 cultivar is higher than that of the TG 37A in saline conditions. Though salinity levels influenced the oil, protein and sugar content of the peanut seeds,

the GG 2 cultivar seems to be more tolerant of salinity. Therefore, they suggest that farmers use quality seeds of the GG 2 cultivar from areas not affected by salt for improving peanut production. Agriculture extension agencies and the Krishi Vigyan Kendras must ensure sufficient supply of quality seeds in salt-affected areas.

*J. Irrig. Drain. Eng.*, **144**(3): 04018002

### Tale of Transmission *Plasmid adds genes in Vibrio*

*Vibrio* species are the causative agents of the life-threatening diarrhoeal disease, cholera. To manage outbreaks effectively there has been extensive research on the *vibrio* family of bacteria, to understand the epidemiology. *Vibrio fluvialis* BD146 is a clinical isolate from Kolkata collected during the 2002 cholera-like gastroenteritis outbreak. It emerged resistant to many antibiotics and is, thus, a threat to human health.

Last fortnight, scientists from the Indian Institute of Advanced Research and the University of Baroda, Gujarat reported the role of plasmids in conferring multidrug resistance to *Vibrio fluvialis* BD146. They found two plasmids in the *Vibrio* strain – one a high copy number, and the other, a low copy number plasmid.

They carried out a detailed gene analysis of the two plasmids. The team found the presence of a class 1 integron in the low copy number plasmid, by polymerase chain reaction amplification and sequence verification in databases. Using BLAST search and DNA analysis, they annotated the genes in the high copy number plasmid and found the presence of integrase, efflux pumps and toxin–antitoxin genes – genes potentially involved in antibiotic resistance.

Then they checked antibiotic susceptibility to establish minimal inhibitory concentration. By doing a synergy test of antibiotics in the presence of an efflux pump inhibitor, they observed a decrease in the minimal inhibitory concentration of

antibiotics, confirming their role of imparting antibiotic resistance.

To check whether the high copy number plasmid could transfer genes horizontally from one bacterium to another, they performed conjugation experiments with a *Vibrio fluvialis* BD146 donor and a standard strain of *E. coli* XL1-blue as recipient. In the first step, they scored for transconjugants by antibiotic screening specific to the plasmid.

They further confirmed the presence of the class 1 integron region in the transconjugants after primer specific polymerase chain reaction amplification.

The team reports that the plasmid may be conserved across *Vibrio* species: *Vibrio cholerae* O1 El Tor from Vietnam and *Vibrio parahaemolyticus* v110 from Hong Kong, suggesting a horizontal gene transfer event across South Asian countries.

*Vibrio* species are ubiquitous, and resistant to many antibiotics. This poses a challenge to manage outbreaks globally. It is critical to understand the mechanism and its mediators to arrive at better disease treatment strategies. The scientists from Gujarat have now adequately addressed the genetic basis of antibiotic resistance and the role of mobile genetic elements in the *V. fluvialis* involved in the Kolkata outbreak.

*Indian J. Microbiol.*, **58**: 60–67

### Gamma Irradiated Oat Glucan *Enhancing bioactivity*

Oats are a good source of dietary fibres, proteins, anti-oxidants and unsaturated fats. Their beneficial properties – reducing cholesterol and blood glucose levels, stimulating the immune response and protection from cancer – are mostly due to oat soluble fibres, especially beta-glucan. Recent reports show that when these high molecular weight polysaccharides are broken down into smaller ones, their bioactivity increases. However, we lack methods to produce the desirable compounds without affecting structure and function.



Last fortnight, a team led by R. Hussain, at the Bhabha Atomic Research Centre, Srinagar, reported an undisruptive solution for degrading oat beta-glucan using gamma irradiation. They were inspired by earlier studies using this method for degrading complex polysaccharides.

The team extracted oat beta-glucan by solvent precipitation. They found that the purity of the beta-glucan in such extracts was 91.2%. The scientists irradiated dried beta-glucan at different gamma radiation doses such as 3, 6, 9, 12 and 15 kGy. The resultant molecular weight of the beta-glucan reduced from 200 to 45 kDa – a unit of molecular weight – at a dose of 15 kGy.

The scientists analysed the structure of the irradiated samples with Fourier Transform Infrared Spectroscopy and X-ray diffraction and found that, compared to the control, it was unchanged. They also found enhanced solubility and water absorption capacity as the dose increased.

The researchers then studied the toxicity of the degraded beta-glucan in colon and breast cancer cells. They found arrested growth of cancer cells and no such effect on normal cells. The team also proved the increased antioxidant activity of the degraded beta-glucan.

Interestingly, the irradiated samples enhanced hypoglycaemic activity, a condition of lower blood glucose level. They confirmed this by studying the inhibition of the activities of alpha-glucosidase and alpha-amylase – enzymes responsible for carbohydrate digestion.

The scientists say that consuming this irradiated beta-glucan is safe and provides improved biological properties. Further studies in animals and humans are needed to authenticate edibility and acceptability.

*Radiat. Phys. Chem.*, **144**: 218–230

### **A Cocktail for Health** *Bacteria produce antioxidants*

Carotenoids are fat soluble pigments associated with the 'redness' of fruits and vegetables such as carrots, cantaloupe and orange. Humans cannot synthesise them. Dietary carotenoids have been proved to alleviate risks of cataract, cancer, cardiovascular dis-

ease and osteoporosis. Biofortification of edibles and dietary supplements have enabled the prevention of vitamin malnutrition in poorer countries. Additionally, they are used as alternatives for toxic colorants. The increasing demand for producing carotenoids calls for novel strategies.

Carotenoids are also found in the cell membrane of non-photosynthetic bacteria. Saroj Mishra and her team from the IIT Delhi tested a salt loving bacterium, *Microbacterium paraoxydans* for the production of carotenoids. The scientists found that a methanolic extract of 100 ml culture gave a yield of 7.5 mg per g of wet weight biomass.

The team established the presence of carotenoids with silica based chromatographic analysis. They did spectroscopic studies to identify the carotenoids. And identified three peaks, characteristic of the carotenoid profile, in Raman spectroscopic analysis for the whole cell. Using an absorption analysis in the range of 400–460 nm, they additionally confirmed the presence of pigments.

C<sub>40</sub>H<sub>56</sub> neurospene family members were identified on the basis of their mass/charge ratio by mass spectroscopy. Antioxidant efficacy of the neurospene 'cocktail' was assessed by TLC autobiography using 1,1-diphenyl 2-picrylhydrazyl.

Neurospene exposed to breast cancer cell line was evaluated in both time and concentration dependent manner for the anticancer effect. The researchers modulated bacterial growth parameters in solid and liquid media to assess changes in production levels. They observed that adding sucrose enhanced production 3.1 fold. And NaCl increased carotenoid yield to 0.051 g (g wet wt cells)<sup>-1</sup>.

With changing growth parameters, the neurospene production pathway in *Microbacteria* was charted based on the accumulation of different intermediates. They found that Crt-I type phytoene desaturase catalysed the conversion of geranylgeranyl pyrophosphate to 'phytoenes' like lycopene.

The method presents a clean, non-toxic sustainable mechanism for producing carotenoids. Using non-photosynthetic bacteria enables the

manufacture of neurospene at submerged conditions and, hence, may be scaled up, without much variation, to industrial levels.

*Indian J. Microbiol.*, **58**(1): 118–122

### **Reversing Cervical Cancer** *MicroRNA epigenetic regulation*

Cervical cancer ranks second as most commonly diagnosed cancer in women. The American Cancer Society's Global Cancer Statistics state that nearly 67,500 women died in India due to this cancer. Cervical cancer is caused by multiple factors, including infection with human papillomavirus, multiple sexual partners, use of tobacco and oral contraceptives. These factors alter the genome expression epigenetically by methylating the promoters of some important genes and this leads to the conversion of healthy cells to cancerous cells.

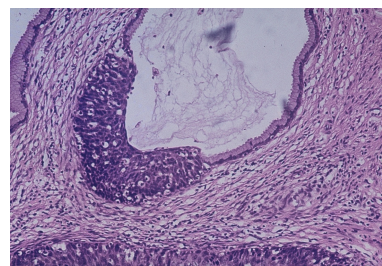


Image: John Hayman via Wikimedia Commons

Last fortnight, researchers from the Manipal University, Karnataka, found a way to turn cancerous cells back into healthy cells. They identified key master regulators such as microRNAs that play a key role in the development of cervical cancer. MicroRNAs are small non-coding RNAs that regulate the expression of a set of genes necessary for maintaining a healthy state in cells. The researchers collected tissue biopsy samples from 30 participants aged 25 to 75. They studied the methylation of microRNA promoters in these samples using microarray and sequencing technologies.

The researchers found changes in the methylation pattern of microRNA-200b and microRNA-424 leading to the development of cervical cancer. The increase of microRNA-200b expression and decreasing of microRNA-424 expression due to methylation leads to cancer development.

Moreover, the researchers over-expressed microRNA-424 and suppressed microRNA-200b in the cervical cancer cell lines and that resulted in the conversion of cancerous cells to healthy cells.

Cervical cancer is one of the most widespread gynaecological malignancies in women. It remains a national and global health challenge. Death from cervical cancer is preventable with early identification and treatment. In this regard, early identification of changes in DNA methylation is useful for reversing the cancer state. The authors' demonstrated findings can be helpful for early cancer diagnosis and for the development of better therapies.

*Mol. Carcinog.*, **57**(3): 370–382

### Leishmania Therapeutics New drug for old disease

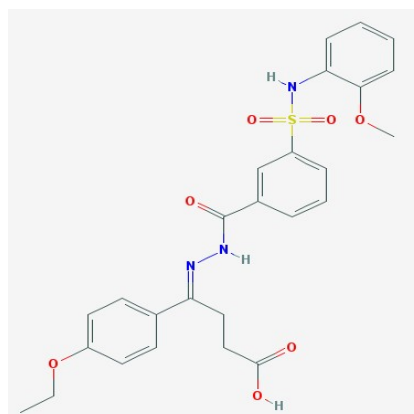
Leishmaniasis, a vector-borne disease, transmitted by female blood-sucking sand flies, is spreading worldwide. Caused by the *Leishmania* parasite, this neglected tropical disease leads to skin lesions, *kala-azar*, which attract social stigma and visceral symptoms, fatal if untreated. Though WHO efforts have reduced fatality, around one billion people are still at risk.

The existing Amphotericin B and Miltefosine therapies have low efficacy, adverse side-effects and are costly. Moreover, they tend to generate drug resistance. Thus, there is urgent need for new, effective medicines for leishmaniasis.

Abdur Rub from Jamia Millia Islamia, Yusuf Akhtar from the Central University of Himachal Pradesh with collaborators from BHU, JNU and the Majmaah University, Saudi Arabia focused on an enzyme, UDP-galactopyranose mutase, absent in humans. But, in the *Leishmania* pathogen, it is responsible for a very important sugar,  $\beta$ -galactofuranose, a precursor for the synthesis of the complex lipids on the cell surface. These lipids play an essential role in the survival and virulence of the pathogen. So the researchers decided to search for small molecules to stop the synthesis of  $\beta$ -galactofuranose by inhibiting the enzyme, UDP-galactopyranose mutase,

involved in the synthesis of this sugar.

As the structure of the enzyme is not yet known, they predicted its structure to facilitate computer-aided drug discovery. They carried out molecular docking and discovered molecules that could inhibit the enzyme. Then, they validated their prediction via wet-lab experiments.



The molecule showed lesser toxicity on the same concentrations than the existing drug, miltefosine hydrate, when tested on human macrophage cells. The researchers claim that the molecule could be further optimised. This report brings hope in the fight against leishmaniasis.

*J. Cell. Biochem.*, **119**: 2653–2665

### Tuberculosis in Wild Animals Rapid, sensitive diagnosis

Tuberculosis in wild animals is of global concern. They form a reservoir for tuberculosis bacteria that can be transferred to humans. This impacts public health. Diagnostic kits for testing wild animals are based on antibodies of mycobacteria. Since wild animals are exposed to both pathogenic and non-pathogenic mycobacterium species, the antibodies tend to cross-react. Hence, it is a challenge to detect pathogenic species in infected animals. Moreover, in the case of wild animals, there are practical difficulties in implementing existing diagnostic methods, such as the culture method, Interferon Gamma Release Assays, and skin testing.

Recently, B. Mohana Subramanian from the Veterinary and Animal Sciences University, Chennai and researchers from Wildlife SOS, an

NGO based in New Delhi, developed a cheap, rapid point-of-care serological kit that can be used on a variety of wild animals. This kit uses special conjugate proteins unlike the species-specific antibodies used in diagnosis. The diagnostic kit can differentiate pathogenic from non-pathogenic bacteria.

To create the kit, they used a recombinant fusion protein of *Mycobacterium tuberculosis* with purified protein derivatives of *Mycobacterium bovis* and *Mycobacterium avium*.

The team validated the specificity of the kit on a wide range of wild animals – elephants, cape buffaloes, wild bear and wild dogs as well as animals of the cat and deer family. Alarming, the tests revealed that most wild animals in India are seropositive for tuberculosis!

Given this high prevalence of tuberculosis in Indian wildlife, the serological kit will surely help zoo caretakers and wildlife authorities in systematic tuberculosis surveillance and for control programmes to prevent TB in wild animals.

*Indian J. Microbiol.*, **58**(1): 81–92

### Artificial Neural Network For cancer diagnosis

Thyroid swelling is a commonly occurring symptom in clinical practice. Most benign and malignant thyroid lesions are successfully diagnosed by fine needle aspiration cytology. It is a rapid, easy, reliable and well-recognised technique to diagnose various thyroid enlargement symptoms. However, the efficacy of the method is limited because it fails to differentiate between follicular adenoma and follicular carcinoma of the thyroid.

Immunohistochemical and molecular markers, miRNA analysis and specific mRNA have also been used to distinguish malignant follicular lesions from those which are benign. These methods have a specificity of nearly 90% and show overlapping features but are not successful in all cases.

Recently, scientists from the Postgraduate Institute of Medical Education and Research, Chandigarh, examined the cytological features and morphometric data of follicular

cells. Based on the data, they developed an Artificial Neural Network model to differentiate between follicular adenoma and follicular carcinoma using fine needle aspiration cytology.

The model was made with the help of neuro-intelligence software, Alyuda Neurointelligence 2.2, and trained by online back propagation. The efficiency of the model was verified in a test set. The model successfully distinguished all cases of follicular adenoma and follicular carcinoma with 100% accuracy. This is an open-ended Artificial Neural Network model and more parameters and cases can be included to make the model more reliable. The study provides a promising technique that may be extended to include other types of cancers.

Presently, the Artificial Neural Network model is efficient enough to diagnose follicular adenoma and carcinoma cases in cytology smears without error and can be used in clinical practice.

*Diag. Cyt.*, 2017: 1–6

#### **Coconut Shell Oil** *Eco-friendly wood protectant*

Throw coconut shells, along with your kitchen waste, into the garden. The kitchen waste disappears in a few weeks. The coconut shell will remain for years. It seems to be impervious to the attacks of fungi and termites that feed on dead plant materials.

When coconut shells are burnt under anaerobic conditions, pyrolytic oil is produced. This oil contains active principles with antifungal and termiticidal properties. So, pyrolytic oil is

used as an eco-friendly wood protectant. However, the dark colour of the oil restricts its use to outdoor purposes.



Image: Uzhavan, via Wikimedia Commons

Last fortnight, K. S. Shiny and team from the Institute of Wood Science and Technology, Bengaluru reported the development of an ecofriendly wood protectant from coconut shell pyrolytic oil. They distilled dark coloured coconut shell pyrolytic oil into one that was colourless and analysed the composition of this colourless distillate using gas chromatography–mass spectroscopy. The team found that it essentially comprises phenol and phenolic compounds.

To test the efficiency of the coconut shell pyrolytic oil distillate, they performed a decay test as per BIS 4873: Part I: 2008 using rubber wood blocks. They adopted two methods of treatment: surface application and dipping. They inoculated the treated wooden blocks with a pure culture of

white rot and brown rot fungus. After 16 weeks of inoculation, the scientists estimated weight loss in the blocks and compared it with that of the control blocks to assess the improvement in durability.

As the weight loss in the wooden block treated by the dipping method was significantly less than that of the brush coated and control blocks, the team concluded that the dipping treatment was effective against both white rot and brown rot fungus. Coconut shell pyrolytic oil distillate increased the resistance of rubberwood to wood decay fungi and consequently improved its durability. They also confirmed the decay resistant property of coconut shell pyrolytic oil distillate using FTIR spectroscopy.

The results indicate the potential of coconut shell pyrolytic oil distillate, a colourless liquid, as an effective wood protectant. Coconut shell is an abundant raw material. It is now up to entrepreneurs and industries to produce and market this technology for use.

*Eur. J. Wood Wood Prod.*, 76(2): 767–773

**Reports by: K. Siranjothi, S. Balaji, K. V. Srividhya, S. Suresh Ramanan, Manali Datta, Jinsu Varghese, Sileesh Mullaseri, G. Sharath Chandra and Saravanan Parameswaran.**

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scienceandmediaworkshops@gmail.com



## Science Last Fortnight

### Himalayan Weathering More silicate flow to the Ganga

Ever since the Himalayas emerged, some 70 to 40 million years ago, the chemical weathering of silicates has acted as a carbon sink. At higher temperatures, the weathering of silicates increases. This leads to increased removal of carbon dioxide from the atmosphere. This, in turn, leads to cooling. The magnitude of this negative feedback on the earth's temperature depends on the ratio of calcium and sodium in the water that carries carbonates to the sea. Moreover, if the weathering is too fast for the chemical reactions, only a fraction of the carbon dioxide is thus trapped. These introduce uncertainties into our understanding of the geological processes.

Recently, a team of scientists from the Jamia Millia Islamia, the University of Cambridge, the Université de Lorraine, France and the Fargau-Pratjau, Germany examined the output of chemical weathering from the Ganga flood plains. The Ganga begins its journey from Gangotri in Uttarakhand, 10,200 feet above sea level. The active flood plain of the Ganga – the area on either or both sides of the river, which is periodically flooded – begins from Haridwar and continues till Farakka.



Image: Wikimedia Commons

The researchers collected water from rivers in the Ganga flood plain and from some major rivers rising in the Himalayas as well as from the southern tributaries of the Ganga.

The samples were collected from river banks, or under bridges or from boats.

The team focussed on regional variations in flood plain river chemistries – the extent of precipitation of secondary carbonates in the flood plain and the quantification of chemical inputs from rain and erosion, and weathering of carbonate and silicate minerals.

The researchers report that chemical weathering in the floodplain is more than double that of the rapid erosion and chemical weathering in the Himalayas. They found that flood plain weathering supplied up to 63 per cent of the flux of positively charged ions of sodium, potassium, calcium, magnesium and strontium. At Farakka, the alkaline flux was 58 per cent.

In comparison, the weathering by Himalayan rivers was only 24 per cent and that by the southern tributaries was 18 per cent. The scientists used sequential leaching of floodplain bedloads to determine the compositions of the carbonate and silicate components of the sediments. They found that the bicarbonate flux, resulting from the weathering of silicate minerals, causes long-term removal of carbon dioxide from oceans and the atmosphere, by precipitating the carbonate minerals in the oceans.

Thus, the researchers conclude that the weathering of the Ganga flood plain also makes a dominant contribution to the material eroded. As the weathering of the flood plain also supplies chemical fluxes to the oceans, these results have significant implications for our understanding of the contributions of the continent to climate stabilisation.

*J. Geochim. Cosmochim. Acta*, **225**: 146–175

### Cleaning Textile Effluent Electro-catalytic oxidation

Wastewater from the textile industry is complex. It contains metals, salts, fabric softeners, pesticides, surfactants, polishing, bleaching, fixing, anti-

wrinkle, coupling and coating agents. Releasing the effluents is, therefore, detrimental to aquatic ecosystems. The Central Pollution Control Board has made it mandatory for textile industries to set up in-house effluent treatment technologies to attain zero liquid discharge.

Existing effluent treatment approaches are time consuming, energy intensive and are not effective in removing non-biodegradable synthetic dyes. Researchers from the Thapar Institute of Engineering and Technology, Punjab, now suggest a solution: an electro-catalytic oxidative reactor to treat the non-biodegradable part of textile effluents. They prepared a model reactor, using titanium coated with ruthenium oxide, as anode and aluminium as cathode.

The researchers first determined the pH, biological and chemical oxygen demand, total dissolved salts and the colour of a sample of textile wastewater. Then, they continuously pumped the effluent into their model reactor. The team found that the effluents could be treated in about 2 hours.

They simulated the process and, using model fitting and statistical analysis by regression, they found that the actual and simulated responses were highly correlated. This simplifies the setting up of systems to monitor the electro-catalytic oxidation process in water-treatment plants.

Next, using GC–MS and UV spectrophotometric analysis, the team confirmed that fabric softeners, dyes, and polymers degrade into chlorinated and other transformed compounds. The researchers propose a detailed mechanism to deal with oxidation events and the degradation mechanism.

Performing a bioassay against a common freshwater fish, *Aplocheilichthys panchax*, the team found that the treated effluent had reduced toxicity.

What is more, using scanning electron microscopy and XRD analysis, the researchers confirmed that the anodes are reusable as the morphology of the Ti/RuO<sub>2</sub> anodes was intact after the effluent oxidation process.

Such a cost-effective and efficient electro-catalytic process could be used by textile factories to meet the stringent conditions set up by pollution control authorities.

*J. Hazard. Mater.*, **346**: 242–252

### Enhanced Chromium Recovery From tannery effluent

Chromium, as pure metal, has no adverse effects. However, its toxic trivalent form causes dermatitis and bronchial carcinomas. This form of chromium is a major constituent in tannery effluent.

Recently, a team from the CECRI, Karaikudi and the CLRI, Chennai developed a simple membrane electro-chemical reactor to recover chromium from tannery effluent. Where earlier techniques used surfactants and coagulating agents to recover chromium, the team claims that their method employs organic compounds already present in tannery effluents.

The electrochemical cell was fabricated using solid polypropylene. The cell had two chambers separated by a cation exchange membrane, to allow proton flow. One chamber has Ti/TiO<sub>2</sub>–RuO<sub>2</sub> as anode and the other, Ti as a cathode. The team took H<sub>2</sub>SO<sub>4</sub> as anolyte and tannery effluent as catholyte.

During electrolysis, the protons flowed from anolyte to catholyte, reducing the pH of the effluent. The hydroxyl ions, produced by the cathode, were absorbed by protein–lipid complexes, in the catholyte. The protein–lipid complexes act as coagulating agents. These negatively charged alkaline complexes absorb the positively charged trivalent chromium and form insoluble complexes, say the scientists.

The team observed that the hydrogen and oxygen evolving from the cathode lift this insoluble chromium complex to the top as foam, which can be collected easily. Thus, there was no need for any external addition of surfactants.

The initial concentration of trivalent chromium, in the tannery effluent, was 2000 to 5000 mg l<sup>−1</sup>. After three hours of the process, the scientists recovered about 98% chromium.

They claim that this simple and effective technique for chromium removal from tannery waste could help tanning industries comply with Pollution Control Board directives. Moreover, the chromium thus recovered can also be reused in tanning, making investments cost-effective for leather industries.

*J. Hazard. Mater.*, **346**: 133–139

### Low Energy RO Membrane For low cost desalination

Reverse osmosis uses membranes for desalination. The properties of these membranes greatly impact productivity and costs. So, scientists have been working to develop high-performance RO membranes.

Recently, scientists from the CSIR-Central Salt and Marine Chemicals Research Institute, Gujarat, reported developing a reverse osmosis membrane that requires very low energy inputs, to reduce the cost of desalination. To make the membrane, they experimented with different concentrations and combinations of polyamide and chitosan. They used glutaraldehyde to modify the surface of the membranes. They found that glutaraldehyde effectively cross linked the supramolecular assembly formed by chitosan. This increased salt rejection.

The researchers observed that the contact angle of the modified membrane declined significantly, increasing hydrophilicity. They also noted that the membrane had increased surface roughness and area ratio. They say that these properties are responsible for increased water-flux.

By optimising and fine-tuning this method, an ultra-low energy RO technology based on a polyamide–chitosan–glutaraldehyde membrane can be further developed for commercial application of this invention for desalination.

*J. Appl. Poly. Sci.*, **135**(10): 2017

### Eco-Friendly Nanoparticles Guava leaves degrade synthetic dye

Synthetic dyes, from the textile industry, are discharged as wastewater. They contain harmful chemicals. Existing electrochemical and electrolytic methods require electrical energy in-

puts, increasing costs. So, researchers are actively investigating photocatalysis using nanoparticles to reduce operational expenses.

Last fortnight, scientists from the Sri Guru Granth Sahib World University and the Thapar University reported efficiently using eco-friendly SnO<sub>2</sub> nanoparticles as photocatalysts. SnO<sub>2</sub> has high electron mobility, ensuring faster photocatalysis.

Preparing nanoparticles by conventional methods such as the sol–gel technique, electrodeposition, chemical vapour synthesis, and mechanical attrition is complicated and not too eco-friendly. The team worked around the issue by using guava leaf extract to make SnO<sub>2</sub> nanoparticles.

To obtain the extract, the scientists ground sun-dried guava leaves. They heated the ground leaves at 60°C and filtered the mixture, to which they added tin chloride. They converted the mixture into jelly by stirring it at 60°C and then at room temperature. The researchers calcined the jelly at high temperature to obtain SnO<sub>2</sub> nanoparticles.

They added these nanoparticles to a solution of vinyl disulphone, a yellow synthetic dye, and stirred the mixture for 30 minutes, in the dark, to establish an adsorption–desorption equilibrium in the reaction mixture. The team then exposed the mixture to sunlight for different time intervals and monitored the remaining concentration of dye using UV-Vis spectrophotometry. They found that the SnO<sub>2</sub> nanoparticles could degrade 90% of the dye in 3 hours in the presence of sunlight.

What is more, the photocatalytic activity remained constant even after using the same nanoparticles for up to five times, establishing reusability of the material. The report, thus, offers a simple method to prepare reusable and eco-friendly nanoparticles.

*J. Mater. Lett.*, **215**: 121–124

### Nanoparticles in Ecosystems Understanding the interaction

Nanoparticles have a wide array of applications. However, there is a hue and cry about tapping their full potential, due to their size. It is hypothesised that these small particles can enter

living systems and significantly alter biological mechanisms. So there is a need to understand the mechanism of nanoparticles in living beings.

Last fortnight, a team of scientists from the Tezpur University, Assam and the Visva Bharati Santiniketan, Kolkata conducted a study to understand the dynamics and impacts of silver nanoparticles at different concentrations in earthworm, microbe, plant and soil.

They mixed a plant extract of *Thuja occidentalis* with a mixture of silver nitrate and polyethylene glycol to synthesise the nanoparticle. They confirmed the size, silver content and the nature of the nanoparticle using TEM, atomic absorption spectrometry and BET analysis.

The nanoparticle was then fed at different concentrations to earthworms, maintained in a cow dung based substrate. The team measured fecundity, body weight and silver accumulation through histological analysis in both treated and untreated earthworms. There was a significant reduction in all the parameters but there was no apparent lethal effect in treated earthworms.

They also monitored soil properties and enzyme activities in response to the addition of silver nanoparticles at different concentrations. The pH level dropped and there was a decline in the bioavailability of nitrogen, phosphorus and potassium levels in the soil. There was a decrease in enzyme activity at week 72 where the concentration of silver nanoparticles was  $50 \text{ mg kg}^{-1}$ . This contributed to a decline in soil microbes.

Finally, the team used the treated soil to grow tomatoes. There was a drastic reduction in tomato yield at  $10 \text{ mg kg}^{-1}$  level. The result of this study can be the foundation for researchers to carry out future studies to figure out the long-term effects of manmade nanoparticles in soils.

*Geoderma*, **314**: 73–84

### **Turmeric as Photosensitiser** *Performance and stability analysis*

Better photovoltaic performance makes dye-sensitised solar cells increasingly attractive to researchers.

This performance depends not only on the photo anode, electrolyte, cathode, and solar radiation intensity, but also on the nature of the dye. Though there are many natural dyes, we are yet to explore the effectiveness of their molecules as photosensitiser to improve solar cell efficiency.

Recently, scientists from the Dr B. C. Roy Engineering College, Durgapur and the Shree Ramkrishna Shilpa Vid-yapith, Birbhum, reported investigating the use of turmeric as photosensitiser. They prepared dye-sensitised solar cells using zinc oxide as photo anode and turmeric stem extract as dye sensitiser.



Image: Wikimedia Commons

The team observed that the dye-loaded zinc oxide film showed a broad absorption band in the ultraviolet region. This extended up to the visible region due to the bonding of the dye with the zinc oxide surface. The researchers measured the voltage-to-current response using cyclic voltammetry to study stability and photoconversion efficiency. They noted that the dye has a wide band gap with high electron affinity. This confers long-term stability to the dye molecule due to a combined oxidation and reduction process in the presence of sunlight.

Though the power conversion efficiency of the cells sensitised with the dye was only 1%, compared to 15% per cent with other dyes, the turmeric stem dye is stable and has enhanced visible light to electrical conversion efficiency. So, the scientists claim that it is suitable for photovoltaic applications.

The efficiency of dye-sensitised solar cells with the natural dye is low because of the weak interaction between the semiconducting zinc oxide layer and the dye. Moreover, the dye molecules tend to aggregate on the photoanode film – another important factor which strongly affects efficiency.

If these limitations can be overcome, the long-term stability of the turmeric dye molecule could be leveraged for solar cell applications.

*Spectrochim. Acta A*, **193**: 467–474

### **Barrier for Betterment** *High efficiency solar device*

Perovskite-based solar devices have better efficiency than semiconductor dependent devices and they are cheaper to make. Scientists at the Marathwada University, Nanded in collaboration with Korean scientists now report improving the efficiency of such solar devices further.

Their perovskite-based solar device is made up of layers: a transparent, glassy conducting substrate made of fluorine doped tin oxide, a methylammonium lead iodide perovskite-based absorber layer, and a metallic back contact layer. Since the extraction and transport of electrons depends closely upon interface and energy levels, the researchers modified the interfacial layers. They deposited a few layers of zinc sulphite, using successive ionic layer adsorption and reaction between the mesoporous tin oxide conduction band layer and perovskite absorber layer. This, they hypothesised would block the backflow of electrons, and thus improve the power conservation efficiency.

The researchers used X-ray photoelectron spectroscopy and found intimate interfacial contact between layers, affecting microstructure of perovskite material. Instead of irregular projections there was a more crystalline appearance.

After adding a barrier between conduction and absorber layers, the scientists studied the process of electron transfer, using dark current and Mott-Schottky analyses. They recorded enhanced external quantum efficiency and current density value of the device along with improvement of open power circuit voltage and fill factor. These findings show that modified perovskite solar devices have a reduced energy barrier facilitating better electron transfer.

Photoluminescence and time-resolved photoluminescence spectroscopic



measurements showed that there is no hindrance in electron flow between the layers. The researchers found similar energy level alignment of conduction and absorber layers using ultraviolet photoelectron spectroscopy analysis.

Thus photo-generated electrons in the perovskite layer are captured efficiently by the mesoporous tin oxide layer. The zinc sulphite layer added in between by the scientists, resulted in higher bandgap energy, as shown by electrochemical impedance spectroscopy. It acted as a physical barrier to retard backflow of electrons and charge recombination. This improved the efficiency of the device.

The scientists made twenty devices with different composition and thickness of deposited layers and compared the devices using UV-visible absorption spectroscopic measurements. The best results were found when four cycles of deposition of ZnS was applied.

They found the process highly reproducible for making solar devices having similar specifications and performance. The modifications done by the scientists promise perovskite solar cells with a consistent high-performance compared to other interface modifications reported.

*J. Alloy Compound*, **738**: 405–414

### Waste to Curb Waste

#### Plastic from nut shell and fruit peel

Plastics derived from petroleum have versatile applications due to their high stability. However, this also causes them to persist in the environment. Managing plastic waste thus becomes a challenge. Plastic packages are either burned or dumped, causing further detriment to the environment. Researchers are now exploring bio-based polymers as alternatives to petro plastic.

A team of scientists led by M. Sukumar from the Anna University, Tamil Nadu has now come up with a method to make bio-plastic from agriculture waste. In the past bio-based polymers have been prepared from tamarind seeds, mango kernel, pineapple leaves, rice bran and sugar-cane bagasse. However, the supply

of raw materials did not match the demand and the method of extraction was tedious. Also, the polymers lacked adequate plasticity.

Sukumar and team selected the inedible shell of cashew nut and walnut to produce bio-plastic. They used cashew nut shell, a rich and easily extractable source of starch as a film forming matrix. The cellulose from walnut shell acted as reinforcing material. The scientists added citric acid to cross-link the starch and cellulose.

They, then, performed tests on the bio-plastic to assess its commercial viability. And found that it has high tensile strength, low oxygen permeability and moisture content. This makes it suitable for superior quality packaging film.

The bio-plastic was stable up to 220°C – perfect for the range of temperatures used in food processing and packaging. The addition of cellulose increased the thermostability of the matrix many fold. The solubility of the film in water was high, making it easily biodegradable.



Image: Jiumoni

To ensure its applicability for packaging fruits and vegetables, the team experimented further. Since cashew nut starch and walnut cellulose have limited antibacterial properties, the bioplastic would be susceptible to contamination. So the scientists added an extract of pomegranate peel – another agro waste product – to the bio-plastic, to enhance the antimicrobial property. Since the extract possesses antioxidant properties, storage and shelf life would also improve.

The team then tested the bio-plastic against six food pathogens. They report that the extract improved antibacterial property against all six.

The bio-based plastic is a cost effective and safe packaging material with superior plasticising properties. This alternative to petro plastic will reduce the threat to the environment.

*Carb. Pol.*, **184**: 231–242

### The Mystery of the Missing FRS Story and History of Sir P. C. Ray

Sir Prafulla Chandra Ray worked at the Presidency College in Calcutta and then at Calcutta University, to build a successful school of chemical research in India and even received Knighthood for his contributions to chemistry. He attracted bright and dedicated students, published more than 150 papers (in those days), mostly in English and some in German. He was the first Indian of that era to be nominated as Fellow of the Royal Society – in 1913. He was nominated again and then again and again. But he did not get to be a FRS.

Meanwhile, many other scientific giants in the country – H. J. Bhabha, J. C. Bose, S. N. Bose, C. V. Raman, M. N. Saha, ... – were nominated. And they became Fellows. Why? What were the personal, academic, political, procedural, social, cultural or historical reasons that could have prevented P. C. Ray from reaching the coveted honour?

Arnab Rai Choudhuri from the Indian Institute of Science collaborated with Rajinder Singh from the University of Oldenburg, Germany to examine the problem. Their findings were published last fortnight.

To paraphrase Santayana, those who do not study history are condemned to repeat it.

*Notes Rec.*, **72**(1): 57–73

*Reports by:* Khushbu K. Birawat, Sileesh Mullasserri, K. V. Srividhya, S. Balaji, S. Suresh Ramanan, Sanghamitra Deobhanj, Nivedita Mishra, P. Gowdhaman, Jiumoni Lahkar and P. K. Udham

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scienceandmediaworkshops@gmail.com

## Science Last Fortnight

### Geotextiles to Stabilise Slopes *Nettle and poly(lactic acid) fibres*

Geotextiles maintain soil stability and control erosion. They are usually made of synthetic polymers, such as polypropylene, polyester, polyethylene and polyamides. Unfortunately, these polymers are non-biodegradable and survive in the soil long after the soil is stabilised.

Recently, a team, led by Dipayan Das from the Indian Institute of Technology, Delhi, reported an environment friendly alternative for stabilising slopes: nonwoven geotextiles made from nettle and poly(lactic acid) fibres.

Nettle is a cellulosic plant fibre – very strong, but rigid and inextensible. Called *Bichhu Ghass* by locals, it grows abundantly on the hills of Uttarakhand where it is widely used as medicine, food and fibre. And poly(lactic acid) is biodegradable.



Source: wikivisually.com

The researchers cut nettle filaments into fibres and cleaned them with a sodium hydroxide solution to improve flexibility and extensibility. Then, the team used a carding machine to produce parallel-laid fibre webs of nettle and poly(lactic acid) fibres in different proportions.

They processed these fibre webs, using a needle punching machine to bond and entangle the fibres mechanically. Thus, unlike other geotextiles, this one was nonwoven – useful in areas that also require filtration.

From various tests, the researchers found that the nonwoven geotextile was not as strong as the constituent fibres. The scientists say that this is

because of increased fibre-to-fibre slippage in the nettle fibres. But this was not a concern as the geotextiles are meant to cover the soil till vegetation is established.

The researchers tested the geotextile for slope stabilisation. The bioengineering process consists in installing a geotextile, followed by the seeding and planting of saplings. As the vegetation grows, the roots stabilise the soil, ultimately protecting the slope from erosion, even after the biodegradation of the geotextile.

The researchers found that the nettle fibres had higher biodegradability than the poly(lactic acid) fibres. The biodegradation of poly(lactic acid) fibres resulted in more phosphorus in the soil, leading to enhanced soil fertility. The team reports that, after degradation of the geotextile made with a 1 : 3 proportion of nettle and poly(lactic acid) fibres, the soil was almost 3.7 times more fertile than soil without degradation of the geotextile.

These findings are, therefore, useful for stabilising road and flood embankments, as well as hilly slopes and mine dumps.

*Geotext. Geomembr.*, 46(2): 206–213

### Estimating Soil Carbon *Under long-term fertiliser use*

The soil carbon pool is the most stable carbon stock. Agricultural practices significantly alter it. Fertilisation, especially, influences the formation of soil aggregates – clumps of soil particles held together by clay, organic matter, fungal hyphae and gummy substances from bacteria and fungi. The dynamics of the soil carbon pool on long-term fertilisation is necessary to estimate its role in carbon capture and storage.

Last fortnight, researchers from the Indian Agricultural Research Institute, the National Physical Laboratory, New Delhi and the Birbal Sahni Institute of Palaeosciences, Lucknow reported a long-term fertilisation experiment. They chose a field where pearl millet was being cultivated in 1971 but which, by 2015, had been gradually used for wheat cultivation.

The team experimented with six fertiliser treatments in three replications. Besides the recommended dosage of 120 : 60 : 40 NPK, the scientists used 150% NPK, 100% NP, 100% N as well as NPK plus farmyard manure. There was also a control.

The researchers collected soil samples from six distinct depths and performed wet sieve analysis to understand the aggregate composition. The soil was grouped into large and small macroaggregates, microaggregates and clay-silt fractions, on the basis of size.

The team estimated labile and recalcitrant carbon pools within bulk soils and the soil aggregates. They found that 44 years of fertiliser use increased the proportion of macroaggregates with higher carbon concentration. However, in the surface layer of up to 15 cm depth, both labile and recalcitrant carbon pool were equal in all aggregates.

They computed carbon accumulation at different depths. Different dosages of fertilisers did not create significant changes in soil carbon sequestration. However, applying NPK plus farmyard manure significantly increased carbon sequestration and accumulation compared to the control as well as to the case with the recommended dosage.

The findings underline the role of fertilisation in agriculture in impacting soil carbon and in mitigating climate warming.

*Soil Tillage Res.*, 177: 134–144

### Insect Resistant Indian Plum

*Ber*, the Indian plum, cultivated in hot arid regions, is used to treat diabetes, ulcers and inflammation. However, there is 80% yield loss due to the fruit fly, *Carpomyia vesuviana*. The insect shows increasing resistance to existing insecticides.

Recently, a team from the ICAR-Central Institute for Arid Horticulture, Rajasthan, conducted a study to identify fruit fly resistant cultivars of the Indian plum tree – *Ziziphus mauritiana*. The team selected 54 Indian

plum cultivars, based on tree spread, height, leaf, fruit and incidence of fruit fly from various northern Indian states. The scientists maintained tree cuttings with bud from each location under ambient environment.

They noted a variation in fruit infestation in different cultivars – from about 10% to more than 80%. Based on this, they classified the cultivars as resistant, moderately resistant, susceptible and highly susceptible.

The resistant cultivars, *Tikadi*, *Katha* and *Illaichi*, they observed, had harder pulp texture and rougher fruit surface. They found higher amounts of flavonoids, tannins and phenols – secondary metabolites of plants, involved in stress tolerance – in the resistant cultivars.

The scientists suggest that these resistant cultivars can be used for breeding programmes. The biophysical characteristics associated with resistance phenotypes can help farmers identify resistant cultivars. Scientists can now inquire into relevant secondary metabolites in other fruit cultivars such as lasora, jamun, bael, date palm and mosambi.

*Crop Protect.*, **106**: 117–127

### Cashew Classification

#### Machine vision approach

Cashew classification is generally carried out through visual inspection by skilled labourers based on size, colour and shape. Commonly whole, split, bits and pieces are the gradings that determine the price.



Midori, via Wikimedia Commons

Some level of automation is followed to grade cashew based on size but it is difficult to distinguish between whole cashews and pieces. Hence, a labour intensive manual process is followed, even now.

Recently, researchers from the Sethu Institute of Technology, Tamil Nadu, in collaboration with scientists from the US, developed a machine vision algorithm which accurately classifies whole and split cashews. They used ImageJ – an open source Java platform – to develop the application.

The scientists placed cashew nuts on pink letter paper to provide good colour contrast between background and subject. Using a DSLR camera, they captured images representing three samples – whole, split-down and split-up. The split-up cashew's surface exhibits smooth texture, while whole and split-down cashew surface have rough texture. This textural difference can be used to first classify the split-up cashew. Then, whole and split-down cashews are classified by comparing their shadow dimensions.

The team tested this algorithm on a lab scale model, which could cover three cashews per image in a single column. They found that, if the cashews touch each other, it may lead to inaccurate output. In spite of this limitation, with suitable modifications, this algorithm can be easily extended to peanuts and peas which have a similar classification. Exporters of cashew nuts may now partner with the scientists to reduce processing costs.

*Postharvest Biol. Technol.*, **138**: 19–30

### Pectin from Mango Peel

#### Waste to wealth

The peel of mango accounts for 20–25% of the waste discarded during processing. But the peel is a good source of pectin. Pectin, a complex polysaccharide, is a good thickener, gelling and stabilising agent for processed foods. Since India is a major producer and consumer of mangoes, peel waste can easily provide cheap raw material for pectin extraction.

So a team, led by Amit Arora from the IIT Bombay, developed a patented hydrothermal process for extracting pectin from mango peel. They selected ripe Totapuri and Calypso mangoes. The hydrothermal method they used is an eco-friendly and economically viable process to produce quality pectin. The method consists of a pressurised heating of water

which changes the physicochemical properties of the peel. The elevated temperature changes the dielectric constant of water and it behaves like an acidic solvent. Thus, pectin can be easily extracted from the biomass without using harsh chemicals or costly equipment.

The team reports that the yield of pectin with the hydrothermal process is comparable to that from the conventional process. Gelling tests revealed that mango peel pectin matched commercial pectin in quality.

Besides pectin, mango peel contains important bioactives. Detailed characterisation of liquid co-products showed a significant quantity of gallic acid, mangiferin, ellagic acid and quercetin. These compounds have high nutraceutical and pharmaceutical properties.

The solid co-product of the extract contained cellulose, hemicellulose and lignin. These molecules can be directly used as chemicals, ruminant feed or feedstock for biofuels.

After extraction of these compounds, the peel still leaves some residual solid. The analysis of the solid revealed a high percentage of nitrogen, which could be utilised as fertiliser for crops.

Pectin extraction from mango peel using the hydrothermal method is economical. There is zero wastage, minimising waste management costs. The by-products are high value compounds – an additional source of revenue. So, valorisation of mango peel may find takers from fruit processing industries, hope the scientists.

*Food Hyd.*, **77**: 142–151

### Intestinal Model

#### Predicting dosage

The absorption of medicines depends on the permeability of the gastrointestinal wall. Existing models, such as Caco-2 and the Ussing chamber, have limitations. They do not take the mucosal wall into account.

Now, Anandharamakrishnan and team from the CSIR-Central Food Technological Research Institute, Mysuru and collaborators from the Indian Institute of Food Processing Technology, Thanjavur, report designing



a more true-to-life model to overcome the challenges of predicting the permeability of a given medicine. They used a perfusion chamber and a small intestinal segment of a male Wistar rat to simulate *in vivo* intestinal conditions. The perfusion chamber was under a constant supply of Krebs–Henseleit buffer – a physiological solution which maintained the viability of the intestinal segment. A constant supply of carbogen in the perfusion chamber, maintained the physiological pH – 7.4 – of the buffer. The team used two peristaltic pumps: one to maintain a constant flow rate of the Krebs–Henseleit buffer and the other to maintain a constant flow of feed liquids in the intestinal segment.

To test the accuracy of the system, the researchers used two model drugs: vitamin E, a hydrophobic drug, and gallic acid, a hydrophilic drug. The scientists reported that both drug molecules were transported passively across the intestinal wall. They were not carrier mediated. Resultant values were close to *in vivo* transport values. Thus, the system is useful to test and predict gastrointestinal permeability of both hydrophilic and lipophilic drugs in the body.

The scientists say that the intestinal model is the best suited for passive transport across the gastrointestinal barrier. They claim that the model will help develop better formulations for bioactive foods and oral medicines.

*J. Food Engg.*, **222**: 110–114

### **Machines Learn to Diagnose** *Iris images for diagnosing diabetes*

Recently, scientists from the Thapar University, Patiala reported developing a method for the non-invasive diagnosis of diabetes – from the image of the iris of the eye. They taught a machine to recognise diabetes from the irises of patients.

The team captured infrared images of both eyes in 180 diabetes type II patients and 158 non-diabetic persons, used as sample for the research. Since diabetes affects the eyes in specific areas, they cropped the region of interest from the image of the eye, to process and extract suitable features for diagnosis.

Thus, the researchers extracted 180 features that quantify broken tissue in the iris. Further analysis showed that the statistical, textural and discrete wavelet transforms features have potential to classify diabetic and non-diabetic people from iris images.

The team employed six different data classifiers – the Binary Tree Model, the Support Vector Machine, the Adaptive Boosting Model, the Generalized Linear Models, the Neural Network Model and the Random Forest. They trained the application repeatedly using cross validation. And found that the use of *t*-test feature selection and Random Forest classification led to the best results, to reach an accuracy of nearly 90% using only 50 out of the 180 features. The scientists claim that using combinations of different classifiers might improve sensitivity and accuracy even further.

To check the performance of the algorithm for subjects with different durations of diabetes, they performed further analyses on iris images of non-diabetic and diabetic subjects from different groups. The automatic detection could easily diagnose people living with diabetes for more than 2 years.

Since diabetes is a silent killer that goes unnoticed by many till complications such as stroke, kidney problems or blindness crop up, this automated detection of diabetes may be a powerful tool for public health. Presently, the government has Aadhar data bases of irises. These can, perhaps, be used for a mass screening of the Indian population for diabetics. The method is not costly and can, therefore, modernise the traditional diagnosis of diabetes.

*Meth. Progr. Biomed.*, **157**: 121–128

### **Trombay Air Quality** *A case study*

Trombay is a rapidly growing urban industrial area. Industrial activities and urbanisation in this densely populated area lead to an increase in particulate matter in the ambient air. These tiny solid and liquid droplets, floating in the air, especially those less than 10 micrometres, enter lungs and

bloodstream and cause health problems.

Last fortnight, scientists from the Bhabha Atomic Research Centre and the Homi Bhabha National Institute, Mumbai reported investigating the magnitude of this problem in Trombay. The team studied particulate matter, in the range of 2.5 to 10 micrometres, in air samples, from the vicinity of industries and the port. Major sources of particulate pollution, they found, were soil dust, metal industry, road traffic, as well as coal and biomass combustion.

They also found that Trombay was most polluted with particulate matter in winter, less so in summer and least during the monsoon.

They used X-ray diffraction to analyse the elemental composition of the samples and found that the concentrations of metals, such as aluminium, silicon, carbon and iron, were higher than limits set by the Pollution Control Board.

The scientists claim that their study is a baseline reference for future studies. And a wake-up call to monitor activities that deteriorate air quality.

*Particulology*, **37**: 143–153

### **Inhaling Pollution** *The highway story*

Traveling on highways exposes people to dust and smoke. Long-term exposure can cause cardiopulmonary diseases, neurobehavioural problems, and even cancer. Though pollution in cities has been investigated extensively, data from highways are insufficient to deploy pollution control measures.

Recently, a team from the IIT Kharagpur conducted a study on the effect of pollution exposure on travelers on national highways. They attempted to determine the effect of different travel modes – AC car, car without AC and bus – on NH 30 and NH 65. From Bhadrachalam, they set out for Vijayawada in the morning and returned in the evening.

On the way, the scientists measured PM<sub>2.5</sub> – particulate matter of aerodynamic diameter  $\leq 2.5 \mu\text{m}$  – inside the vehicles using an Environment Particulate Air Monitor. They found that

exposure to PM<sub>2.5</sub> was highest in the car without AC, average in the bus and lowest in the car with AC. This, the scientists say, is because of closed windows.

The scientists also measured carbon monoxide, carbon dioxide, temperature and relative humidity using a portable multi-parameter environmental monitor. They observed that carbon monoxide was highest in the car with AC – due to emissions from the engine – and lowest in the bus. Carbon dioxide concentration was highest in the car with AC and lowest in the car without AC.

The scientists observed differences in measurements at different times of the day. The maximum exposure was at noon. There was no significant difference in pollution exposure in the morning and evening.

The team also noted that exposure to the pollutants increased during road repair. Road repairs performed in minimum time can reduce exposure to pollutants for highway travellers. The researchers suggest avoiding national highways for short journeys to reduce mass exposure to carbon monoxide by 50%. Improving public transport will also help.

Levels in cities were higher due to traffic density and emissions. New highway layout plans must bypass towns and cities to reduce congestion in crowded areas and the pollution exposure faced by highway travellers.

*Sci. Tot. Environ.*, **619**: 155–164

### Improving Horsepower

#### *Nano-lubricants for diesel engines*

Nowadays, most transport vehicles such as buses, ships, heavy-duty trucks, trains and agricultural machines run on diesel. The efficiency of diesel engines is constrained by a loss of energy due to mechanical friction between piston and cylinder wall. Currently, high viscosity oil lubricants are used to reduce the friction. However, these tend to increase fuel consumption.

Last fortnight, researchers from the DIT University, Dehradun in collabo-

ration with the Indian Institute of Technology, Dhanbad suggested a nano-lubricant to reduce friction and increase the performance of diesel engines, without increasing fuel consumption.

The researchers used 40–60 nm spherical aluminium oxide and silicon oxide nanoparticles, mixed with commercially available engine oil, to reduce friction and to improve the efficiency of a 4-stroke diesel engine. The addition of nanoparticles enhanced the viscosity of the engine oil and that resulted in the formation of a tribofilm. This film prevented direct contact between rubbing surfaces and also aided in converting sliding friction to rolling friction. Rolling friction consumes less energy and generates less heat. Thus, the nano-lubricants reduced the fuel consumption of the 4-stroke engine.

The frictional force decreased with increased volumes of nanoparticles. The scientists determined that the best results are achieved with a 0.3% volume of the nano-lubricant. They observed a decrease in wear and tear of the engine due to the ball bearing effect contributed by the nano-lubricant.

As the difference between petrol and diesel fuel costs is narrowing down, many people now prefer to opt for petrol engines. However, diesel engines are more efficient than petrol engines. Using nanoparticle mixed engine oil further improves the efficiency of diesel engine performance. So the development of large-scale nano-lubricant formulations suitable for different types of diesel engines may benefit the public and private sectors as well as consumers.

*Particuology*, **37**: 54–63

### Evaluating Solar Cells

#### *Electro-analytical method*

Numerical simulation and modelling is a time and cost effective tool to measure solar cell performance. Silicon-based solar cells record an efficiency of 25% in the laboratory, but only up to 19% on the commercial

scale. Researchers are trying to increase the efficiency of commercial silicon solar cells to laboratory levels. Accurate measurement of solar cell efficiency before deployment is, therefore, critical.

Now, scientists from the Pandit Deendayal Petroleum University, Gandhinagar in collaboration with scientists from Saudi Arabia and the Republic of Korea report developing an electro-analytical method for identifying and understanding solar cell parameters. They framed a set of analytical equations based on current–voltage response and impedance spectroscopy measurements.

The scientists compared individually extracted parameters, from the electro-analytical method, with experimentally obtained current–voltage characteristics of silicon solar cells under illumination. And found that there was a good agreement between the two. So, the electro-analytical method is a good proxy for predicting efficiency.

Other analytical models to check solar cell efficiency are complex, tedious, or lead to wrong estimations. The electro-analytical method is simple. The limitations and advantages of current–voltage response and impedance spectroscopy measurements were taken into account, say the scientists.

They claim that the electro-analytical method is the best for evaluating silicon solar cell parameters. It provides a simple tool for analysing commercial silicon-based solar cells. The technique is applicable to other solar cells also, say the scientists.

*Mater. Res. Bull.*, **100**: 440–445

ACKNOWLEDGEMENT. IISER Pune, for access to scientific databases.

**Reports by: Sanghamitra Deobhanj, G. Sharath Chandra, R. Srinivasan, Jiumoni Lahkar, Neeta Shrivastava, Ashwathy Nair, V. Anoop Kumar, Sileesh Mullasserri, P. Gowdhaman, S. Balaji and S. Suresh Ramanan**

scienceandmediaworkshops@gmail.com

## Science Last Fortnight

### Carbon Budget in the Sundarbans *Reducing uncertainty*

The concentration of carbon dioxide in the atmosphere has increased from 277 ppm in the pre-industrial era to about 400 ppm in recent years. Accurate estimates of natural carbon sequestration will lead to a better understanding of the carbon cycle and help us formulate appropriate policies.

Mangroves are carbon-rich ecosystems with high carbon burial rates within soils. However, there are very few detailed carbon budgets available for the Sundarbans mangrove forests. Yet mangroves which are not studied are also included in global budgets. This data upscaling creates uncertainties in the estimates produced.

Raghab Ray from the University of Calcutta and collaborators from Germany tackled the problem of improving the accuracy of the global carbon data inventory. They collected water and sediment samples to analyse dissolved organic and inorganic carbon, as well as particulate organic carbon. And estimated carbon export from the Sundarbans into the Bay of Bengal.



Image: via Wikimedia Commons

The team puts the export rate of dissolved organic carbon at approximately 20% of the mangrove carbon export worldwide. However, particulate organic carbon is only 2%, and dissolved inorganic carbon 4%, of the total mangrove export of carbon.

According to the researchers, the mangroves are a major source of carbon transported from the Sundarbans into the Bay of Bengal, amounting to 7.3 teragrams of carbon per year. These estimates from the Sundar-

bans exceed the 'missing carbon' of previous budget estimates.

The report presents empirical data on carbon export from the Indian Sundarbans mangrove to the Bay of Bengal. The approach used was rigorous and the results obtained improve the global carbon data inventory and reduce uncertainties in global carbon budget estimations, say the researchers.

*Sci. Total Environ.*, **621**: 535–547

### Side-effects of Pharmaceutical Use *Contamination of the Yamuna*

India is the third largest producer of pharmaceuticals and exports 56% of total drugs produced. The remaining 44% are consumed by Indians. Though important for health and disease control, pharmaceuticals pose serious environmental side-effects when released into water.

Last fortnight, researchers from the Indian Institute of Technology, Delhi in collaboration with the National Mission for Clean Ganga assessed the ecotoxicological risk of various active pharmaceutical compounds in the Yamuna. They collected water from the river at six different locations where sewage and industrial discharge enter the Yamuna and assessed the levels of nine commonly used drugs – aspirin, paracetamol, ranitidine, ibuprofen, diclofenac, caffeine, carbamazepine, codeine and diazepam. These represent widely used analgesic, anti-inflammatory, antipyretic, antiepileptic, anticonvulsants and muscle relaxant drugs as well as stimulating agents.

The researchers found substantial amounts of these drugs in their samples. The study revealed that these compounds are released into the Yamuna from sewage treatment plants.

During the monsoon, the levels of these compounds were lower in river water due to dilution by rain water. But there were substantial amounts of the compounds in summer. Although the researchers did not find signs of acute toxicity on aquatic life,

these compounds may have long-term effects. Not only on aquatic life, but animals, and humans as well, since the Yamuna is the major source of drinking water and irrigation in the region.

Risk assessment of toxicity is largely measured by mortality. So the current tests may not be adequate to assess the side effects of these compounds on growth and fertility. Moreover, the interaction of multiple drugs may pose a greater risk. The current single-compound assessment methods fail to address this issue.

Earlier studies had pointed out the emergence of antibiotic-resistant bacteria due to exposure to antibiotics in river water. The present study extends the problem to the issue of emerging toxicity due to an array of other commonly used pharmaceuticals.

Rivers are lifelines for any civilisation. There is a need to prevent overloading them with drugs. Sewage must be efficiently treated to remove pharmaceutical contaminants before discharge into rivers.

*Ecotoxicol. Environ. Saf.*, **150**: 297–304

### Toxic Chemicals in E-waste *Dangerous to the environment*

E-waste recycling poses risks for the environment and for health. Environmental pollutants, such as polychlorinated biphenyls, polychlorinated dibenzo-p-dioxins and dibenzofurans, are released during the recycling process. Toxic chemicals which impact humans accumulate as elements in the environment.

Most e-waste recycling processes in India are carried out by the informal sector which does not follow the necessary safety measures. And there are not enough studies in India to evaluate the environmental and health impacts of the recycling of electronic waste by the informal sector.

Recently, Paromita Chakraborty and team from the SRM Institute of Science and Technology, Tamil Nadu, in collaboration with scientists



from the US, France and Japan investigated the problem<sup>1</sup>. They chose Chennai, Mumbai, New Delhi and Kolkata for the study. The sites were classified into three categories: dismantling, shredding or grinding and metal recovery.

The team collected soil samples from these sites and determined the amounts of polychlorinated biphenyl, polychlorinated dibenzo-p-dioxin and dibenzofuran using gas chromatography and high-resolution gas chromatography. Their results show that these toxic chemicals are substantially higher in the soils at metal recovery sites in Indian cities.

The scientists used the positive matrix factorisation model developed by the Environment Protection Agency of the US to derive information about pollution sources. And they found that burning of electrical wires for copper extraction increased polychlorinated biphenyls, polychlorinated dibenzo-p-dioxins and dibenzofurans levels in the soils.

The researchers suggest periodic monitoring and evaluation of persistent pollutants at e-waste recycling sites after the implementation of the new law which was recently introduced by the Government of India to regulate e-waste recycling industries<sup>2</sup>.

<sup>1</sup>Sci. Total Environ., 621: 930–938

<sup>2</sup><http://meity.gov.in/esdm/e-waste>

### Edible Coating on Guava For better shelf life

Raw or processed guava, *Psidium guajava*, is popular worldwide. India is top producer, exporting the fruit and its products to several countries. However, guavas continue to ripen after harvest, shortening shelf life to a few days at ambient temperatures. Under cold storage, guava shows signs of chilling injuries. This poses a major challenge for traders and exporters.

Edible coatings are known to reduce transpiration and weight loss in fruits. And essential oils have been shown to enhance this property. Besides, essential oils also act as antimicrobials. S. B. Murmu and H. N. Mishra from the Indian Institute of

Technology, Kharagpur, decided to follow this thread. Last fortnight, they reported the results of using a coating of Arabic gum and sodium caseinate along with essential oils.



Image: Wikimedia Commons

Both gum arabic and sodium caseinate form edible films. Combining them leads to intermolecular interactions that will lead to stronger films, reasoned the scientists. They used two different essential oils: cinnamon and lemon grass.

They analysed the effects of different proportions of Arabic gum and sodium caseinate with lemon grass oil and cinnamon oil as base. The team applied five different coating formulations using uncoated fruits as control. They thus identified two formulations that prolonged shelf life – one combining cinnamon essential oil with gum arabic and sodium caseinate, and the other, using cheaper lemongrass oil instead. The scientists say that the guava treated with these preparations extended shelf life up to 40 days versus the 7 days of uncoated samples.

The coating resulted in lower activity of polyphenol oxidase and peroxidase – enzymes responsible for browning and flavour loss. The antioxidant effect of the essential oils increased the radical scavenging activity in the coated samples. What is more, the coating seemed to retain comparatively high levels of ascorbic acid, phenols and flavonoids, leading to slower ripening of guava.

With this simple procedure that uses inexpensive substrates to delay the rapid postharvest ripening, the scientists are confident that their formulations will benefit guava traders and exporters. The method might

also work on other similar fruits, they say.

Food Chem., 245: 820–828

### Oligosaccharides Inhibit Tumours Promoting apoptosis in cancer cells

Polysaccharides – polymers made of sugars – are now attracting attention for their biological significance. Plant-based dietary pectins, especially, have been shown to impede cancer growth and progression. One of the plants where polysaccharide content has been well researched is *Dioscorea hamiltonii* or swallow root. The plant is endemic to South India, where it is used to make pickles and confectionary. Traditionally, it is known for its gastroprotective and bactericidal properties.



Image: Vinayaraj via Wikimedia Commons

Scientists from the CSIR-CFTRI, Mysuru now report that a smaller oligosaccharide of the swallow root has anticancer effects. Having established galectin-3 inhibition activity for the whole polysaccharide in their previous work, they now address the bioavailability and accessibility of the oligosaccharide.

After multiple extraction steps, the team isolated the swallow root oligosaccharide fraction. From mass spectroscopy results, they estimated that the oligosaccharide had a molecular size of 831 Da, close to the cell division inhibitors, used in chemotherapy.

Using gas liquid chromatography, they identified arabinose as a major component along with rhamnose and galactose. They deduced the structure to have core type I rhamnogalacturonan units by nuclear magnetic resonance and Fourier transform infrared spectra.

Next they evaluated the antiproliferative and apoptotic activity of the

whole polysaccharide and oligosaccharide using mouse melanoma cells. They found that the swallow root oligosaccharide modulates the well-studied cancer promoting proteins, galectin-3 and survivin, under *in vitro* conditions.

By varying the concentration of the swallow root oligosaccharide, they found a dose dependent inhibition of cell proliferation comparable with a known anticancer drug. The cells incubated with swallow root oligosaccharide and polysaccharide displayed a condensed nuclei characteristic of an apoptotic body substantiating their role in mediating apoptosis.

Using RT-PCR experiments, they found a reduction in the mRNA levels of galectin-3 and survivin. They confirmed down regulation in protein levels also. These proteins inhibit programmed cell death or apoptosis and their silencing is perhaps responsible for halting tumour progression, say the scientists.

The team proposes the use of oligosaccharide rather than the whole polysaccharide to enhance bioavailability. Further studies will help make the most out of this dietary polysaccharide based nutraceutical for cancer therapy.

*Carbohydr. Polym.*, **186**: 402–410

#### **Determining Neurotransmitters** *An efficient analytical method*

Neurotransmitters, chemical messengers between neurons, modulate various biological and immunological processes, as well as behaviour. Neurotransmitters are involved in conditions as simple as stress and as complex as schizophrenia, Parkinson's and Alzheimer's diseases. The levels of these chemical messengers can be used as indicators of disease onset in the central nervous system. However, there is no efficient diagnostic method available for the simultaneous determination of these messengers in a biological matrix.

Devendra Patel and collaborators from the CSIR-Indian Institute of Toxicological Research, Lucknow and the Academy of Scientific and Innovative Research, Lucknow, now report devising an efficient method

for the extraction and measurement of neurotransmitters. The team developed a modified dispersive liquid–liquid extraction method using a nontoxic eco-friendly ionic liquid, 1-butyl-3-methylimidazolium hexafluorophosphate, as extraction solvent in place of a toxic chlorinated solvent. To improve the extraction efficiency they used ultrasonic waves. Then they quantified the neurotransmitters in the extracted samples using liquid chromatography–mass spectrometry.

The method is sensitive enough to detect the presence of neurotransmitters as low as  $0.021 \mu\text{g l}^{-1}$ ,  $0.028 \mu\text{g l}^{-1}$  and  $0.025 \mu\text{g l}^{-1}$  in extracted samples of brain, plasma and cell respectively.

The method can extract and detect 15 neurotransmitters simultaneously in one go even if they are present only in traces in the biological matrix. It needs less than 3 ml of plasma, or brain or cell homogenate for analysis.

The technique developed by the team from Lucknow is environment friendly. It can be developed as a diagnostic kit for the quantitative determination of neurotransmitters in complex biological matrices.

*Anal. Chim. Acta*, **1005**: 43–53

#### **Mild Steel becomes Strong** *Resists corrosion and UV rays*

Low-carbon steel, or mild steel, has many applications in engineering projects, as it is malleable and ductile. Since it is cheap and easily available, industries use it as construction material. Besides buildings and bridges, it is used in marine applications such as rigs and pipelines. Mining, automobiles and power plants also use mild steel. Thus, protecting these mild steel applications against corrosion has enormous importance to global economy.

Organic coatings used to prevent corrosion of mild steel are usually adhering films or membranes made from either natural or synthetic organic compounds such as polymers, oligomers, monomers, or a mixture of these. But long exposure to UV radiation causes significant degradation to the coated surface by discolouration of dyes and pigments, weathering,

loss of gloss and change in mechanical properties.



Image: Wikimedia Commons

Recently, a team of researchers led by K. Anver Basha from the C. Abdul Hakeem College, Tamil Nadu reported developing a polymer hybrid coating on mild steel to overcome the problem. They incorporated zinc oxide nanoparticles into a selected polymer matrix to prepare the preventive coating against both ultraviolet radiation and corrosion. Zinc oxide is a wide-band gap semiconductor. The electronic properties of the metal oxide are precisely controllable. And its nanoparticles are used to prevent corrosion reactions at the metal-coating interface.

The researchers first synthesised the rod-shaped zinc oxide nanoparticles from zinc acetate and sodium hydroxide and modified those with oleic acid as a preparation for creating the hybrid coating.

Poly (pyridine-4-yl) methyl methacrylate was chosen as it is an electroactive polymer, capable of storing a large quantity of charge at the interface, forming a passive layer on a metal. It was copolymerised with *n*-butyl methacrylate, which exhibits better adhesive property and enhances solubility. The coating was then prepared from this polymer hybrid and zinc oxide nanoparticles in a tetrahydrofuran solvent.

The scientists coated the polymer hybrid on mild steel surface using the spin coating technique. The X-ray diffraction and Fourier-transform infrared spectra of the coated substrate showed good compatibility between the polymer hybrid and the nanocomposites. The team also report that the addition of zinc oxide nanocomposites enhanced the thermal stability of the polymer hybrid.

From the study of electrochemical parameters, they report that the coating decreased the pores of the polymer and provided a better barrier, blocking the access of charged particles to the steel surface. The surface analysis proved that the coating was uniform and has good adherent property.

UV absorption and transmission studies revealed that the coating on the steel substrate was homogeneous and the UV absorption was below 350 nm wavelengths, which was good for the UV screening effect.

The researchers tested the corrosion resistance of the coating in a sodium chloride solution, which demonstrated that the nanocomposite is effective as an anticorrosive coating with UV blocking property in aggressive conditions.

The polymer-hybrid coating has excellent potential in paint technology, as UV blocking and anticorrosive material for mild steel, say the researchers.

*J. Appl. Polym. Sci.*, **135**(16): 46175

### Electrode for Supercapacitor

A supercapacitor is a high capacitance storage device used to store huge amounts of electrical charge. Traditionally batteries are used for the purpose. The quick charging/discharging efficiency makes supercapacitors a strong competitor to batteries for application in future technologies. Additionally, supercapacitors are less toxic and have a long life time. The major challenge, however, is their high cost of production and low specific energy.

Priyanka Londhe from the Savitribai Phule Pune University, in collaboration with scientists from the Korea University and the University of Buffalo has now developed an electrode material for supercapacitors which is simple, electrochemically stable and superior in performance. 'I was working on nanoparticles for solar cells and this is my first foray into supercapacitors', says Priyanka. 'But my experience with nanoparticles came in handy'.

They fabricated nanoparticles of inorganic metal oxide of zinc on graphene and used the ZnO/graphene composite as the electrode. Compared to other methods for preparing such composites, this one is simple, low-cost and showed improved performance.

ZnO shows remarkable reversible redox reaction but long-term use leads to fast decay and agglomeration, resulting in poor conductivity. Graphene, just one atom thick, is extremely porous and acts as an ion sponge. However, graphene fails to exhibit high capacitance due to restacking of graphene sheets. The scientists combined the synergistic properties of both and produced a composite with reduced particle agglomeration, less restacking and improved capacitance. The nanostructure of the material further enhanced the surface to volume ratio and, thus, increased electrochemically active sites for charge transfer.

Conventionally, the synthesis of electrodes is a multistep process, relatively expensive and uses binders

which become residual impurities and reduce the desirable properties of active materials. The team used electrospray deposition under ambient temperature to create a uniform coating with low material consumption. They used nickel foil as base to create a binder-free electrode.

The team prepared a coin cell using two electrodes and used a sodium sulphate solution as electrolyte to test the properties of the supercapacitor. The long term cycling performance test showed that even after 1000 cycles, 90% capacitance was retained by the electrodes. The tests also confirmed that the diffusion of ions from electrolyte to electrode occurred readily, indicating efficient charge transfer with low resistance.

The electrospray deposition-based binder-free ZnO/graphene composite electrodes are easy to make, cost effective and show high capacitive performance compared to existing composite electrodes. ZnO nanoparticle-graphene electrodes will prove to be promising candidates for future supercapacitor technology, hopes the team.

*J. Alloys Comp.*, **741**: 781–791

**Reports by: Neeta Shrivastava, G. Sharath Chandra, R. Srinivasan, K. V. Srividhya, Sanghamitra Deobhanj, P. Vijisha, Biraja Kumar Sahu and Jiumoni Lahkar**

ACKNOWLEDGEMENT: IISER Pune, for access to scientific databases.

scienceandmediaworkshops@gmail.com



## Science Last Fortnight

### Fungi Play a Supporting Role Partnership for phytoremediation

Plants, such as the sunflower, that can absorb heavy metals, are grown in contaminated areas to improve soil quality. However, when the concentration of metal is high, plant growth is compromised. There is stunting and loss in biomass. Recently, Muthusamy Govarthanan from the Mahendra Arts and Science College, Tamil Nadu in collaboration with South Korea isolated a fungus that, when added to soil, could prevent many of these adverse effects.

The fungus, *Trichoderma*, produces substances such as indoleacetic acid, siderophores and ACC deaminase that promote plant growth. The scientists searched wood from a heavy metal contaminated area in Namakkal, Tamil Nadu, to isolate a metal-resistant variant of this fungus. Three species of *Trichoderma*, isolated from the trunks, were cultured in the presence of heavy metals. Thus, they found a variant, *Trichoderma* MG, which was resistant to both arsenic and lead.

To test its usefulness in phytoremediation, the researchers grew sunflower saplings in arsenic and lead rich soil that either contained or lacked these fungal spores. They found that the fungus enhanced plant growth. The plants had longer roots, shoots and more biomass. The soil itself exhibited improved enzymatic activity.

This fungus could both remove arsenic and lead and produce growth inducing substances that could limit the effects of heavy metal toxicity on crops. The scientists believe that this strategy can be used to improve phytoremediation naturally.

*Ecotoxicol. Environ. Saf.*, **151**: 279–284

### PAHs Attack DNA Integrity SOS from Goa beaches

Polycyclic aromatic hydrocarbons (PAH) are toxic substances produced when coal, oil, and biomass are burned. Industrial discharge, oil spills and transport vessels pour PAHs into marine ecosystems. There have been reports about the damaging effects on

sea urchins and marine gastropods. Now, scientists from Goa, Kolkata and Sydney reveal their DNA damaging effects on marine rock oysters.

The team collected oysters from 10 different locations in Goa, with different human and/or commercial activities. They extracted DNA and studied their integrity using a combination of partial alkaline unwinding and comet assay. They also looked for correlation between PAH and toxicity in local oysters. As control, they used oysters collected from Betul beach, the most undisturbed site.

The scientists also looked for other pollutants – heavy metals and pesticides – which could have contributed to the observed DNA damage. However, they did not find any meaningful associations. Instead, anomalies in DNA structure were strongly correlated with total PAH concentrations. The highest damage was observed in oysters from Hollant, Bogmalo and Velsao beaches – all popular tourist destinations. Sailing and water sports could, perhaps, be a source of PAH contamination. The vessel, MV River Princess, grounded in the Arabian Sea, near Goa, could be another source.

Chemical pollutants accumulate quickly within oysters and could mediate toxic effects in their bodies. The scientists suggest that DNA integrity can be used as proxy for measuring the intensity of PAH contamination in marine environments. The study raises an early alarm for taking action.

*Ecotoxicol. Environ. Saf.*, **151**: 132–143

### Jute–Rice–Mustard–Mung Bean Agriculture for carbon capture

Soil microorganisms use organic carbon to grow and to convert organic nitrogen into mineral nitrogen that can be readily taken up by plants. There is more carbon in the soil than in the atmosphere or in plants. Soil organic carbon improves soil stability and is a key indicator of soil health. Properly managed, it can improve food production, and regulate water and climate. Crop rotation, conservation tillage, quality crop residue, water manage-

ment and soil erosion control can maintain the balance between carbon in soil and carbon in atmosphere.

The carbon–nitrogen ratio of soils in the eastern Indo-Gangetic Plain is of great concern. Stretching from east Bihar to Bangladesh, this is a globally important agricultural eco-region with intensive rice based cropping systems. Soil fertility in the region has reduced because of indiscriminate use of inorganic fertilisers. This has led to a continuous decline in organic content.

Recently, Mukesh Kumar and team from the ICAR-Central Research Institute for Jute and Allied Fibre Crops, Kolkata examined carbon and nitrogen mineralisation of a jute–rice cropping system under different nutrients. The field experiment was conducted on institute land in Barrackpore.



Source: Wikimedia Commons

The scientists studied five cropping systems: Fallow–rice–rice, jute–rice–wheat, jute–rice–baby corn, jute–rice–garden pea and jute–rice–mustard–mung bean. For their experiments, they adopted four levels of nutrients and crop-residue management techniques with recommended doses of fertilisers. They collected soil samples before the experiments and after four years of crop rotation. Then, they investigated the release of carbon dioxide and the amount of mineralised nitrogen in the soil samples.

The researchers observed that potentially mineralisable carbon was higher in jute–rice–mustard–mung bean followed by fallow–rice–rice. Potential and active nitrogen fractions were also higher in jute–rice–mustard–mung bean. The next best combination was jute–rice–garden pea.

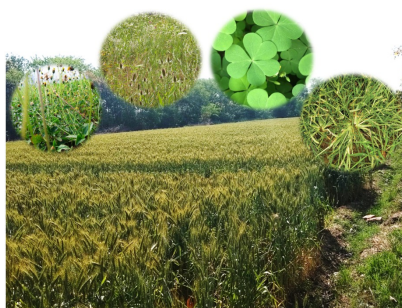
They conclude that, in the jute–rice ecosystem, a legume crop should be included in the crop rotation. The crop residue should be blended into the soil with a proper dose of nutrients. This helps sustain the carbon–nitrogen dynamics in the soil.

These findings are useful to improve soil fertility in the Indo-Gangetic plains and increase agricultural production. The crop rotation system and management practices can also help mitigate climate change, say the scientists.

*Soil Till. Res.*, **178**: 108–117

### **Economic Loss Due to Weeds** *A pan India investigation*

Weeds are a threat to agricultural productivity. Though there are studies that estimate yield and economic loss due to weeds in particular localities or crops, they tend to focus on short-term effects. Such studies may not reveal the magnitude of the problem.



Source: S. Suresh Ramanan

Now, scientists from the ICAR-Directorate of Weed Research and the Krishi Vigyan Kendra, in Jabalpur, compiled data from 1581 field trials to provide a more holistic picture. The data were collected from the trials conducted by centres of the All India Coordinated Research Project on Weed Management 2003 to 2014. The study covered 18 Indian states. The scientists focused on ten major field crops: transplanted rice, direct-seeded rice, soybean, groundnut, sorghum, pearl millet, green gram, sesame, wheat, maize and mustard.

Two types of treatments were applied in all the field trials. One was a completely weed-free condition achieved by combining mechanical weeding and herbicide application. The other adopted either mechanical

weeding or herbicide application or no weeding at all, as per the practice of local farmers. The scientists also maintained control plots where no mechanical or chemical weeding was done. Thus, they could collect data related to potential loss (weed free plots vs control plots) as well as actual loss (weed free vs farmers' practice of weed removal). 'Among the ten crops evaluated, we found that both potential as well as actual yield loss are more in groundnut and soybean', says Yogita Gharde, ICAR Directorate of Weed Research.

The team collected field data to determine the most critical factors contributing to yield loss. They found that crop, soil type and location significantly influenced yield loss due to weeds.

They used the minimum support price from 2014–2015 to compute economic loss based on yield at the different treatment trials. And they found that economic losses at an all India level can go as high as Rs 29,446 crores for rice and Rs 22,490 crores for wheat.

The magnitude of loss in agricultural productivity due to weeds is a wake-up call to policy makers. Now, it is up to agricultural scientists to devise methods to control weeds using ecologically sustainable approaches.

*Crop Protect.*, **107**: 12–18

### **Easier Diagnosis from EEG** *New hardware removes noise*

The electroencephalogram is a cost-effective and non-invasive tool to explore brain regions and to identify cognitive and other event-related activities. However, relevant EEG signals are mixed with other biological signals, including that from a blink and other muscle artefacts. This makes it difficult to extract diagnostic features. During offline visual observation, medical practitioners, thus, have to learn to discard EEG channels containing these artefacts.

Recently, scientists from the IIT Hyderabad collaborated with researchers from the UK and Australia to develop a simple hardware for the reliable and automated removal of ocular and muscular artefacts from EEGs. They based the method on wavelet decomposition,

using the Haar function – a simple threshold-based wavelet domain denoising and artefact removal scheme.

They used practical experiments, with their hardware system, to demonstrate that the system can, indeed, remove low-frequency blink artefacts as well as high-frequency muscle artefacts.

The hardware complexity and computational delay of the system are less than in conventional methods. This makes it favourable for real-time hardware design to diagnose neurodevelopmental disorders and to enhance brain-computer interface.

The hardware gives satisfactory results when prototyped on a field-programmable gate array prototyping platform – a method for hardware verification and early software development. This shows that the methodology can be easily translated into a chip in the near future.

*Comput. Meth. Prog. Biomed.*, **158**: 123–133

### **A Marker for Brucellosis** *Advantages of T4SS antigen*

Brucellosis is caused by a Gram-negative bacterial species of the genus *Brucella*. The infection is zoonotic and spreads from animals, mainly cattle, to humans. The symptoms, fever and malaise, are often clubbed as fevers of unknown origin and symptomatic treatment is prescribed. However, the disease can lead to abortion, infertility and neurological disorders. Since there are no easy methods for accurate diagnosis, timely therapeutic intervention for the disease is, often, not received.

Last fortnight, Thavaselvam from the Defence Research and Development Establishment, Gwalior, scientists from the Defence Institute of High Altitude Research, Leh and the Jiwaji University, Gwalior reported overcoming this challenge in diagnostic ease and accuracy.

The scientists focused on Type IV Secretion Systems – T4SSs – strong virulent factors required by the pathogen to create infection in the host system. They are coded by a set of 11 genes. The researchers cloned and expressed one of the genes and purified the denatured form of the

recombinant T4SS protein. Then, they assessed the potential of this recombinant protein, as diagnostic marker, in sera samples of field cattle and experimental rodents, infected by two different isolates of *Brucella melitensis*.

The team found a time-dependent response of infection towards the diagnostic marker. The sera samples showed highest response towards T4SS after 60 days of infection starting with minimum response after two weeks of infection.

The scientists say that the marker is very specific to *Brucella* infection as it did not receive any response when checked with sera samples of experimental animals infected with another closely related bacterial pathogen – *Yersinia enterocolitica*. The conventional serological marker shows response with *Y. enterocolitica* also, leading to misdiagnosis.

The team hopes that this marker may translate into a diagnostic system, for brucellosis. It will help early detection and treatment of the disease. This will also be a good tool for epidemiologists and move towards eradication.

*Prot. Exp. Purif.*, **145**: 53–58

### Water Hyacinth Biogas Improving production

Water hyacinth is a common weed in fresh and wastewater resources worldwide. Its high growth rate clogs water bodies resulting in oxygen and nutrient depletion, and, thus, affects aquatic ecosystems. Yet, water hyacinth biomasses are looked at as resources for producing biogas, biofertilisers and animal feed. They can also be used to treat effluents.

Recently, researchers from the CSIR-National Institute for Interdisciplinary Science and Technology, Thiruvananthapuram, reported improving biomethane production from water hyacinth. To understand the impact on total biogas yield, they co-digested the biomass with food waste and primary sludge.

The team harvested water hyacinth from the Aakkulam Veli backwaters, Thiruvananthapuram and characterised total solids, volatile solids, nitrogen, phosphorus and cellulose content. They used a two-step reactor

for biomethanation. A Leach Bed Reactor first digests the water hyacinth biomass into soluble organics. Then, a Sludge Blanket Reactor generates methane biogas.



Image: Ted Center, via Wikimedia Commons

The researchers got 36 L of biogas from 4 kg of crushed water hyacinth biomass in 12 days. They performed continuous mode experiments, for one year, regularly replenishing the bioreactor with fresh biomass. They estimated the biogas yield at 8.85 L/kg wet weight of water hyacinth.

The scientists experimented with different factors involved, such as the use of sun-dried plants and fermented biomass.

Using gas chromatography and high performance liquid chromatography, the team characterised the produce, and analysed the volatile fatty acids of the ensiled and wilted biomass samples.

They observed that co-digesting with food waste and activated sludge improves biogas yield from water hyacinth.

A cost-effective production of renewable fuels from water hyacinth is a paradigm shift, converting a weed to wealth. The report provides an initiative for efficiently using non-conventional water hyacinth biomass which, otherwise, is an impenetrable foliage in water bodies. The improved biogas yield has increased the feasibility of cost-effective scaling-up of the technology.

*Bioresour. Technol.*, **255**: 288–292

### Textile Meets Nanoparticle Antimicrobial clothing is born

Scientists have reported developing antimicrobial textiles, using nanoparticles. However, the question is: how long can such fabric retain the property?

Recently, Kamlesh Panwar, Manjeet Jassal and Ashwini Agarwal from the IIT, Delhi developed a process to incorporate silver nanoparticles into cotton fabric. Silver nanoparticles are highly antimicrobial. They are non-toxic and, unlike the case with antibiotics, the probability of microbes becoming resistant to silver is negligible.

When nanoparticles are applied on textile, they agglomerate and show weak attachment. The distribution of the particles on fabric is non-uniform and durability is poor. The particles have to be maintained in a low concentrate liquid dispersion. These dispersions are unstable and have low shelf-life which makes them inconvenient to store or transport.

To overcome these problems, the team incorporated the silver nanoparticles into the fabric as Janus particles. They have two faces with distinct functionalities. One side attaches tightly to the fabric and the other holds the nanosilver. The scientists prepared the Janus particle with amine, thiol and epoxy groups.

They produced the Janus particles in powder form, which is stable for long durations without deteriorating. They then tested the antimicrobial efficacy of the fabric against *Staphylococcus aureus*. The nanoparticle incorporated cotton fabric showed no bacterial growth.

The fabric was washed and tested to check durability. The bacteria could not colonise the fabrics, indicating high antibacterial activity and good wash durability of the particle on the textile.

The team tested the physical attributes of the treated cloth such as whitening index, stiffness and tensile strength. The treated cloth showed a marginal decrease in whiteness while the tensile strength of the yarn increased slightly, compared to the case with the untreated cloth.

The team suggests that these Janus particles, with different functional groups, can have multifaceted applications. The antimicrobial silver nanoparticles could be attached to various substrates and the efficacy modulated as required.

Such nanosilver Janus particle incorporated fabric could find versatile use in the clothing, medical dressing,



cosmetic and food industries, hopes the team.

*Carb. Pol.*, **187**: 43–50

### Neutron Radiography

#### *An efficient non-destructive technique*

Neutron radiography is an imaging technique for the non-destructive testing of materials. It can efficiently characterise nuclear fuels and engine turbine blades. Researchers commonly use the technique to deal with fuel cells, archaeological artefacts and geological formations. Neutron tomography and phase contrast imaging are used to produce and distinguish between similar 3D images. However, these imaging techniques fail with objects that have poor neutron absorption.

Last fortnight, scientists from the Bhabha Atomic Research Centre, Mumbai addressed the problem by tweaking different components of the beam line at the Dhruva reactor.

In general, any neutron imaging beam line consists of a collimator, a shielding material, a sample manipulator and a digital imaging system. The collimator is designed with reactor-grade aluminium cone shaped housing. Then, it is filled with a mixture of sand, boron carbide powder, lead rings, and boral rings for absorbing scattered neutron and gamma radiation. A combination of sapphire and bismuth single crystals, with a thickness of 90 mm each, is used to achieve high neutron/gamma ratio.

Radiography/tomography studies using neutrons can be performed using this fixed collimator. For phase contrast imaging studies, the team fabricated a thin-walled cadmium-lined, cone-shaped structure with a pin hole. They inserted this component in the

conical space within the main collimator.

Using this advanced collimator with both neutron and gamma filtering, they achieved a high cadmium ratio of ~250 and a collimation ratio of ~160.

They also tested the instrument to find hydrogen concentration in Zr-alloy, aluminium foam and ceramic metal seals and found it fit for quality assurance checks. The researchers say that this imaging system, in combination with data acquisition and image processing software, can be used for neutron radiography, neutron 3D tomography and neutron phase contrast imaging.

*Nuclear Inst. Methods Phys. Res.*, **889**: 63–68

### Automatic Speech Recognition

#### *Mapping the child's pitch*

Research on speech recognition is a thriving field. Automatic speech recognition is necessary for developing digital assistants and robots that respond to human speech. The present systems are trained using adult voices. And they fail to recognise the speech of children. In children, the variability in acoustics, such as pitch and tone, and linguistic aspects, such as accent and choice of words, make automatic recognition a daunting task. 'The main problem in automatic recognition of children's speech is pitch', says Hemant Kumar Kathania, from the National Institute of Technology, Sikkim.

While adult speech predominantly uses a small bandwidth between 100 to 200 Hz, children use higher frequencies and bandwidth – between 200 to 350 Hz. Automatic speech recognition systems have been trained using adult speech and, therefore,

there are errors when the system is confronted with the pitch variations in the speech of children.

For a decade now, scientists from the National Institute of Technology, Sikkim and the National Institute of Technology, Patna have been working on speech recognition. They felt that it is not easy to train the system separately for children, considering the difficulties in getting child volunteers. So they decided to tackle the problem by an easier route: pitch mapping the speech of children onto an adult speech recognition platform.

'Mapping pitch can be done in two ways and we decided to try both', says Shahnawazuddin, NIT Patna.

The team realised that, in scaling pitch, extra compensations must be done for the higher frequencies in the speech of children. 'After making these tweaks, when we tested the speech of children using the voice recognition system trained on adult voices, we found that the word error rate came down by half!', beams Samaddar, NIT Sikkim.

This, we hope will prove to be a step forwards to making the digital world more accessible for children, an inclusive world where children are also heard and understood, says Waquar Ahmad, NIT Sikkim.

*Circuits Syst. Signal Process.*, **37**: 2021–2044

**Reports by: Sarah Iqbal, Sileesh Mullasser, K. V. Srividhya, Jiumoni Lahkar, Sudarshana Dhar, Neeta Shrivastava, S. Suresh Ramanan, Sanghamitra Deobhanj and Pudi Venkatesu**

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scienceandmediaworkshops@gmail.com

## Science Last Fortnight

### Electro-Bio-Stimulation

#### *Restoring soils with textile dyes*

Tirupur, in South India, an export hub for textiles, has many textile units that use chemical dyes. The dyes pollute soils in the area. The soils, thus, become unfit for agriculture.

Scientists from the Central Electrochemical Research Institute, Karaikudi, the Dryland Agricultural Research Station, Chettinad, and the University of Vigo, Spain recently proposed an integrated approach to address the problem: electro-bio-stimulation.

Bioremediation is a cost effective method for treating polluted soil environments. However, it may not be useful for soils heavily contaminated with dyes, heavy metals and chlorinated compounds. Moreover, it is slow, compared to chemical and physical methods of remediation.

The team combined electrical and biological principles for quicker and more efficient clean-up of farming soils.

They first isolated four bacterial strains: *Brevibacterium halotolerans*, *Bacillus subtilis*, *Achromobacter* sp. and *Pseudomonas aeruginosa* from textile effluent contaminated soils and petroleum pipelines at Tirupur.

The scientists used three compartments separated by perforated acrylic sheets for their experiments. The soil to be treated was placed in the central one. For the electrical components, they used 0.5% starch as anolyte and 0.1 M acetic acid as catholyte. Starch enhances electrokinetics – applying an electric field dissociates fluid from particles and propels it.

In the electro-bio-stimulation experiments, they added the culture of isolated microbes to starch. The starch now doubles up as food for the microbes and as anolyte. The bacteria bio-stimulate the existing electric phenomena.

The team conducted these experiments on lab scale, using a voltage gradient of 2 V/cm for five days. They found that, for removing pollutants such as chlorides and sulphates, electro-bio-stimulation was more effective

than electrokinetics. This, the scientists say, is due to the bacteria that produce B-cyclodextrin, known to improve the solubility of many compounds.

Once they realised the superior performance of electro-bio-stimulation, they conducted pilot scale experiments for fifteen days using 0.5 V/cm. The scientists then evaluated soil quality using the germination of black gram as indicator. They found germination rates significantly higher in electro-bio-stimulation treated soils.

These experiments show that soils contaminated with textile dyes can indeed be reclaimed for agriculture. The zero effluent policy that has recently come into effect will reduce contamination of soils near textile industries. However, to clean up already polluted soils, we need more policy initiatives.

*Sci. Tot. Environ.*, **624**: 1649–1657

### Flower Power to Clean Water

#### *Nanosolutions bloom with microwaves*

The textile industry has become the epicentre of large scale water pollution. Scientists have attempted to degrade pollutants using semiconductor photocatalysts. However, the efficiency of these techniques is, so far, not adequate for large scale applications.

Researchers from the National Institute of Technology, Assam recently reported a solution for the problem.

Using a microwave assisted technique they engineered a low-cost, non-toxic semiconductor photocatalyst of zinc oxide. Field Emission Scanning Electron Microscopy and Transmission Electron Microscopy images reveal that variation of microwave irradiation power resulted in nanorods. When reaction temperature was increased from 28°C to 180°C, the nanorods exhibited a more orderly arrangement resulting in flower-like morphology.

Each rod-shaped petal was about 150–200 nm in length. This could be attributed to the nucleation and differences in rates of growth at elevated temperatures. Further increase of microwave power transformed the

nanostructures into dense, uniform nanoflowers with greater petal diameter.

The researchers evaluated the photocatalytic performance using an organic dye – methylene blue – as model pollutant. The dye was successfully decolourised by the photocatalytic action when exposed to solar irradiation. The nanoflower form of zinc oxide showed better photocatalytic performance.

The flower-like structures of the photocatalyst have larger surface area and are porous. These help increase photon absorption and improve the performance, say the researchers.

Using the right temperature and microwave power, the scientists could control the morphology of the nanoparticles. The strategy may be useful in producing nanoparticles of other metal oxides possessing the required morphology.

*J. Matlet*, **219**: 76–80

### Magic Membrane

#### *Drinking water from wastewater*

Drinking water scarcity drives research to develop technologies to make dirty water potable. Sophisticated equipment and costly materials make present technologies unaffordable for the majority. Membranes made with polymers hybridised with nanocomposites are easy to produce. However, most have shortcomings when tested on wastewater.

Recently, K. Buruga and J. T. Kalathi of the NIT, Karnataka and collaborators from the Hanyang and Korea Universities, reported fabricating a polymer–clay nanocomposite membrane to purify wastewater. Halloysite is an aluminosilicate clay mineral. The halloysite nanotubes have a hollow, tubular structure with high biocompatibility and good mechanical strength. Besides serving as sieve, they possess inherent antibacterial abilities and display high antifouling properties. The nanotubes also exhibit a unique geometry and surface chemistry, with positively charged lumen and negatively charged surface

to capture contaminants with opposite charge.

The team suspended the halloysite nanotubes in a solvent and sonicated the solution to a homogenous mixture. Polystyrene, which acts as matrix, was added to the mixture. The team uniformly spread the mixture over glass plates. When the solvent evaporates, it leaves a thin membrane with uniform tiny pores.

The team tested the chemical, physical, morphological and performance-related aspects of the membrane. Using different solvents, they found that they could get membranes with different properties.

To ensure high purity of water, they designed a two-staged filtration unit with micropore and nanopore membranes. Both membranes were fabricated using the same protocol but with different solvents. The micropores of  $1000\text{--}10^4\text{ \AA}$  facilitated microfiltration whereas  $10\text{--}1000\text{ \AA}$  nanopores enabled ultrafiltration.

For real-world application, the team assembled the membranes in an apparatus, with a vacuum pump between the compartments. The wastewater sample was first passed through the microporous membrane. The vacuum pressure created by the pump on the lower compartment forced the micro-filtrate to enter the nanoporous membrane.

The filtered water met the WHO standards for drinking water. The scientists say that the membrane is reusable and provide a simple base-acid cleaning method to retain high performance after multiple uses.

Halloysite is an easily available and naturally occurring mineral, making fabrication low cost. The membranes made by hybridising polymer and halloysite have high mechanical and tensile strength, and are, thus, resistant to harsh environments. The membranes will attract entrepreneurs from the water purification sector, hopes the team.

*J. Ind. Eng. Chem.*, **61**: 169–180

### Levodopa from Itchy Beans

#### Supplement for breast cancer therapy

*Mucuna pruriens* – velvet or itchy or devil beans – is a traditional herbal

medicine. This nutritive herb is used for treating scorpion bites, infertility, diabetes, Parkinson's and depression. Though the hairy pod causes severe itching, the seeds are relatively rich in the neurotransmitter levodopa, a dopamine precursor. Levodopa is also a natural inhibitor of the prolactin hormone, which plays a critical role in breast cancer progression.

Recently, a team led by Neeta Shrivastava from PERD, Ahmedabad, and scientists at the NIPER, Gandhinagar, reported the molecular mechanism underlying dopamine-mediated prolactin inhibition in breast tumour progression, using *M. pruriens*. 'Re-purposing existing drugs using *in vitro* and *in silico* techniques will reduce the cost and time of drug discovery and development – much required in the Indian scenario', says Neeta Shrivastava.



By Ton Rulkens, Wikimedia Commons

The team first prepared a methanolic extract of *M. pruriens* seeds. After dehydrating the extract into powder using a lyophilizer, they estimated the levodopa content using high performance liquid chromatography. Next, they established the anti-proliferative property of this extract under *in vitro* conditions using different breast cancer cell lines. They also analysed the effect of *M. pruriens* seed extract and standard levodopa over colony forming ability, cell cycle progression, DNA damage and apoptosis in the cell lines. And found inhibition in cell proliferation and cell cycle arrest, followed by apoptosis in the cells treated with seed extract.

Using real time PCR, they quantified the expression of the prolactin gene and followed protein expression using western blot experiments. The

researchers observed that the presence of *M. pruriens* inhibits prolactin protein expression, thus halting cancer progression. This blockade also increased the efficacy of the chemotherapeutic drug, cisplatin, when co-supplemented with the *M. pruriens* extract.

The study successfully tested a well-known antiparkinson drug on breast cancer suppression. The crude form, in particular, gave better results as it works in synergy, remarks Neeta Shrivastava.

The team suggests using levodopa from *M. pruriens* seeds as dietary supplement along with chemotherapeutic drugs for effective breast cancer therapy.

*J. Ethnopharmacol.*, **217**: 23–35

### Fighting Neurodegeneration

#### Is quercetin the answer?

Estimates report that, in India, two in hundred suffer neurodegenerative disorders – progressive cognitive, behavioural and motor dysfunction. These diseases cause serious disabilities in many old people. This may increase with the demographic shift, when the majority of the population becomes older.

Interestingly, there is a common factor in neurological disorders: deficiency of cathepsin D, a protein essential for the health of neurons.

Recently, Phaniendra Alugoju and team, from the Pondicherry University, reported a solution. They chose *Saccharomyces cerevisiae* with *PEP4* proteinase A gene mutation, as their experimental model. This mutation is equivalent to the cathepsin D gene mutation in humans. Both proteinase A and cathepsin D help increase protein turnover after oxidative damage. As a result, the cells are protected from hydrogen peroxide and acetic acid induced apoptosis.

The oxidative and apoptotic stresses progressively increase during aging. If that is the case, antioxidants should reduce the problem, reasoned the researchers.

So they set out to explore the neuro-protective property of quercetin, by using the yeast model. Quercetin is a well-known antioxidant found in fruits,



vegetables, tea and red wine. They cultured wild type yeast and mutant yeast under the stressful conditions by adding acetic acid and hydrogen peroxide to the culture medium and observed the effects.

The results showed the mutant cells to be highly sensitive to induced oxidative and apoptotic stress.

Then the scientists added quercetin to the medium. However, quercetin pre-treatment protected the experimental group from oxidative and apoptotic stress-induced sensitivity. Further, pretreatment also increased viability as well as stress tolerance against oxidant, apoptotic and heat stress.

The scientists say that quercetin could be a potential therapeutic molecule for reducing aging of the central nervous system at the cellular level.

Though these experiments were done on a mutant yeast strain, the results raise hope in the fight against neurodegenerative complications as the *PEP4*/yeast models are a widely accepted model for the purpose.

So the researchers hope that in the future, quercetin could be used in the treatment of neurodegenerative diseases associated with cathepsin D gene mutation.

*Curr. Microbiol.*, **75**(5): 519–530

### Monitoring Kidney Function Electrochemical biosensor

To prevent chronic kidney disease progressing to renal failure it has to be detected early. However, detecting progression, with available techniques, is tedious, time-consuming and expensive. There is a biomarker for kidney function, cystatin C, a small protein. The protein is broken down by the kidney but a small amount is excreted through urine. As kidney function deteriorates, cystatin C levels in urine increase. However, so far, there is no sensor to detect this.

Recently, Manali Datta and team from the Amity Institute of Biotechnology, Rajasthan collaborated with the CSIR-IGIB, Delhi and an Indian scientist in Nigeria, to propose a new sensor – a screen printed multiwall carbon nanotube electrode with immobilized papain for the rapid and accurate detection of cystatin C.

When cystatin C binds with the immobilized papain, it induces an electric signal which can be measured using cyclic voltammetry and differential pulse voltammetry – good methods to get qualitative results of electrochemical processes in various conditions.

The team used different concentrations of cystatin C to calibrate fluctuations in electronic transitions. The sensor detected chronic kidney disease stages accurately with a small volume of sample in 10 minutes. The scientists tested other biomarkers such as creatinine, albumin and gliadin, to confirm the specificity of the sensor.

‘Diabetic, hypertensive and heart patients are prone to kidney malfunction at later stages’, says Manali. The team hopes this economical, fast and reliable technique, for the early detection and monitoring of progression of chronic kidney disease, will soon find use in clinical practice. ‘Such a point-of-care device to monitor kidney disorder can help stall progression if followed up with simple diet modifications’, suggests Manali.

*J. Biosens. Bioelectron.*, **105**: 90–94

### Detecting Chlorpyrifos Pesticide Using ultrasensitive nanoparticles

Chlorpyrifos, a pesticide, is liberally used, worldwide, on crops such as fruits, vegetables, cotton and tea. This highly toxic chemical enters the food chain. Long-term exposure can lead to cancer, reproductive and neurological disorders, allergic reactions as well as neurodevelopmental impairment in children.

There are many qualitative and quantitative techniques to detect the pesticide. Instrument based techniques provide high sensitivity but are time consuming and costly. They call for trained personnel and are not suitable for on-site application.

Now, Sonul Gandhi and team from the Amity University and the CSIR-IGIB in collaboration with researchers from Russia have worked together to develop a sensitive, specific and economic electrochemical nanosensor. The sensor is made of a fluorine-doped tin-oxide electrode fabricated with gold nanoparticles and immobilised anti-chlorpyrifos antibodies. Fluorine-doped tin oxide coated glass is electrically conductive and ideal for use in a wide range of devices. Gold nanoparticles enhance its sensitivity.

The team found that the nanosensor exhibited high sensitivity and a stable response for the detection of chlorpyrifos, ranging from 1 femtomole to 1 micromole. They successfully tested the sensor for the rapid detection of chlorpyrifos in apple, cabbage and pomegranate. A 5 g sample is crushed, mixed in buffer solution and centrifuged. Only one millilitre of the sample is needed to check for the presence of the pesticide.

This nanosensor can be miniaturized and used as quantitative tool for rapid, on-site detection of chlorpyrifos traces in real samples.

*J. Biosens. Bioelectron.*, **105**: 14–21

### Nitrous Oxide Emissions Reducing through muffler design

There are extensive global efforts to replace fossil fuel with blended fuel. Blending alcohols, such as methanol, with petrol, can reduce carbon emissions. But that leads to higher temperature which, in turn, leads to increase in nitrogen oxide emission. Researchers are looking for ways to dissipate the temperature of exhaust gases.

Modifying muffler design can reduce exhaust temperature, thought researchers at the KIIT University, Bhubaneswar. In collaboration with the Veer Surendra Sai University of Technology Odisha, they undertook a study to understand the pattern of temperature under perforated and non-perforated muffler design.

First, the team blended methanol with petrol in different proportions to investigate the fuel characteristics. They confirmed that fuel blending does not create any major variation in fuel properties. Then, using solid modelling software, the scientists created a three dimensional solid model of the muffler. They converted the design layouts to a CAD model for computational fluid dynamics analysis, using back pressure, exhaust temperature, gas density and velocity streamline as primary parameters. They carried out this analysis on both perforated and non-perforated

mufflers. And found that an increase in back pressure increases exhaust temperature. The perforated muffler had less back pressure than the non-perforated design. This is because of the availability of the multiple passages in the design which helps the gases expand, say the researchers. The expansion of the gases reduces the temperature – which, in turn, reduces nitrogen oxide formation.

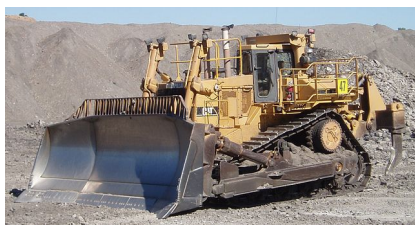
The team recommends that the design be adopted in all ranges of petrol engines. They also have suggestions for further research to reduce emission even more by regulating perforation hole size.

*J. Clean Prod.*, **183**: 869–879

### **Abrasion-resistant Steel Buckets** *Carbide-free bainite*

Mining, agriculture, transport and construction industries use huge steel buckets in excavators and shovels. They are essential components for soil penetration and for handling bulk material. Since they are in direct contact with different types of sands and rocks and, that too, in harsh field environments, such buckets need to be hard, and strong, as well as abrasion and corrosion resistant.

Abrasion-resistant equipment is mostly made with tempered martensitic steel. The tetragonal crystalline microstructure makes martensitic steel hard. But it is less ductile and sensitive to heat-treating variables. The heat and strain generated during abrasion reduces hardness of surface significantly. Moreover, martensite steel suffers fragmentation of the wear track because of low plastic deformation at the wear surface, resulting in less adhesion of the damaged area.



Source: Wikimedia Commons

Last fortnight, Minal Shah and Subhankar Das Bakshi, from the National

Metallurgical Laboratory, Jharkhand reported overcoming the problem. They developed a bainitic steel – steel with plate-like microstructure – with superior abrasive wear resistance, high strength, good ductility and low cost.

They experimented with three ferrous alloys of similar hardness but with different microstructures – carbide-free bainite, austenite, martensite – and a mixture of martensite and bainite. The scientists prepared sample bars with these three types of ferrous alloys by melting, forging and heat treatment. They conducted microstructural analyses for confirming the fine structural details of the sample bars.

For abrasion test, they used a standard dry-sand rubber wheel, repeating the test on five samples of each type, to confirm and validate the results. The team made abrasions on the sample bars by manual grinding and shear punching.

They conducted X-ray diffraction analysis before abrasion to find the phases present in the steel. Then, after abrasion, they conducted a three-body abrasion test to calculate the specific wear rates.

The scientists found the specific wear rate of martensite to be approximately two times higher than that of the other two. They report that steel with a mixture of bainite and martensite shows better wear resistance than martensite. Carbide-free bainite has significant plastic deformation at the active surface, and is, thus, most wear resistant, say the scientists.

The plate-like structure of bainite steel undergoes plastic deformation when stressed. But the plates had good adhesion. So, unlike with martensite steel, the harder layer on the active surface improved the abrasion resistance of bainite steel.

Earth moving equipment undergo abrasive wear. This not only reduces the service life but also affects the safety and reliability of the equipment. The costs incurred due to such abrasive wear are high. This research collaboration between CSIR and Tata Steel may soon lead to the replacement of the existing martensitic steel

buckets, with more abrasion-resistant carbide-free bainitic steel buckets.

*Wear*, **402**: 207–215

### **Simulating Functional Molecules** *Improving solar cells*

Metal-free organic dyes are efficient solar cell sensitisers. They improve sunlight absorption, making solar cells perform better. Prior knowledge of the properties of such sensitisers facilitates pragmatic design strategies for sensitisers. Now, the accumulated structure–property correlations of many sensitisers can be used to drive ‘theory precedes practice’.

In a recent conceptual paper, Mohankumar, Senthil Pandian and P. Ramasamy from the SSN College of Engineering, Chennai derive the light harvesting efficiencies of newly designed sensitisers using computations.

The researchers investigated the donor configuration and computed the properties relevant to sensitisers. The simulation brought out an interesting result: doubling the donors helps decrease the energy gap.

The predicted efficiencies are high. ‘Our results are useful to tailor new sensitisers’, says P. Ramaswamy who led the research team.

‘It is now possible to design dye molecules to improve the performance of solar cells.’

About a century ago, Paul Dirac had observed that it is not our knowledge that limits us, but the complexity of the equations. But, now, armed with computing power, researchers are overcoming the limitation. India needs to invest more on high performance computing and take advantage of emerging scientific tools.

*Mater. Lett.*, **219**: 216–219

**Reports by: Sushmitha Baskar, Jenice Goveas, R. Srinivasan, Sanghamitra Deobhanj, Biraja Kumar Sahu, Jiumoni Lahkar, K. V. Srividhya, K. Siranjothi and N. Sekar**

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scienceandmediaworkshops@gmail.com

## Science Last Fortnight

### Mystery of Mud Banks

During the southwest monsoon, the coastal waters of Alappuzha, in Kerala, draw attention because of the occurrence of fluid mud: mud banks. A large number of fish and prawns throng the shore along with the mud bank formations. 'Chakara', as the local people call it, is a seasonal gift of abundance from the sea. Though the phenomenon proves a boon to local fisher folk, the factors behind mud bank formation continue to be a mystery.



Image: Liju Coolbean

Recently, scientists in Goa and Kochi, from the National Institute of Oceanography and the Naval Physical Oceanographic Laboratory, conducted a detailed study on mud bank formation. They selected mud bank reported regions for their field experiments and conducted weekly profiling of physico-chemical and meteorological parameters for over seven months. From the time-series data on meteorological and oceanographic parameters at three locations, the team drew insights into the mud bank triggering mechanism.

During the southwest monsoon, ambient wind and wave strengths are generally high. These initiate strong bed-sediment movement through frictional coupling. Occasional atmospheric low-pressure events enhance this process by supporting the suspen-

sion of bottom sediments, creating fluid mud.

Once the fluid mud is formed, the prevailing onshore upwelling current disperses it through a depression channel network towards the coast. The accumulation of a sufficient quantity and thickness of fluid mud near the coast creates the mud bank condition. Nutrients from the mud bank attract micro- and macro-organisms including fish, creating a rich ecosystem, resulting in huge fish catch with low effort.

The scientists say that extensive data is required to confirm whether the process is the same in other regions, where the occurrence of mud banks is reported. Besides Kerala, this rare phenomenon is observed only along the coastal waters of South America. Collecting data from turbid fluid mud regions in such hostile wind and wave conditions is a major challenge, say the scientists.

*Estu. Coast.*, **41**(4): 1021–1035

### Encroachment in Banni Grasslands Behaviour change in rodents

The Banni grasslands of Gujarat are important tropical grasslands in Asia. The grassland has a long tradition of supporting livestock and wildlife. Of late, woody vegetation and manmade intervention in the name of afforestation, have encroached on the Banni grasslands.

Last fortnight, scientists from the National Centre for Biological Sciences, the Wildlife Conservation Society, and the Ashoka Trust for Research in Ecology and the Environment, Bengaluru, reported their study on the effect of bush encroachment in the Banni grasslands. The team found that this affected the foraging behaviour and community composition of rodents. Rodents play a significant role in maintaining biodiversity and are 'keystone' species of the grassland.

In Banni about 45% of the grassland is encroached upon by *Prosopis juliflora*. The team sought to understand the effect of woody cover on nocturnal rodents adapted to open grasslands.

The team selected two areas having dense and sparse cover of woody vegetation. They used Sherman traps baited with wheat plus peanut butter to trap rodents to understand the abundance and species richness in the two sites. They found that in the site with dense cover, there was higher abundance of generalist species, associated with disturbed habitats.

To study the change in foraging behaviour of rodents, the team examined the foraging cost between the sites using the giving-up density theory. The theory says that species tend to quit a food patch with diminishing returns, if the energy spent for searching for food is more than that obtained from the patch.

Using this concept, the team placed 32 food patches consisting of pearl millet mixed with sand, separated by a distance greater than the foraging radius of the largest rodent species, *Tatera indica*. They levelled the soil around the food patch so that they could see the tracks made by the rodents when they visit the patch. Pearl millet seeds remaining in the food patch were sieved and weighed.

From the test results, the team concluded that the rodents had higher foraging costs in the site with high bush encroachment in early summer. This is likely due to higher perceived predation risk and food availability in the dense site.

The team says that higher foraging costs and a shift in the community composition of native prey species could have negative impacts on grassland restoration. Therefore, policymakers and conservationists need to think twice before implementing grassland afforestation programmes in grasslands.

*J. Arid Environ.*, **153**: 32–38

### Oil Spill in Chennai Coast A curse on the marine ecosystem

On 28th January 2017, about three kilometres from the Chennai shoreline, two cargo ships collided. The accident released about 75 metric tonnes of heavy fuel oil into the



coastal waters of Chennai. Oil spills are a major cause of concern as they contain polycyclic aromatic hydrocarbons – carcinogenic, mutagenic and potent immune-suppressants.

This unfortunate incident provided Indumathi Nambi from IIT Chennai and collaborators Yuling Han and Prabhakar Clement in the USA with an opportunity to study the time evolution of oil spills. They characterised the oil spill using gas chromatography. The collected samples had a relatively large percentage of heavy polycyclic aromatic hydrocarbons.

The scientists used petroleum biomarkers, hopane and sterane, complex organic compounds derived from former living organisms, for the chemical fingerprinting of the water samples. The biomarkers helped pinpoint the source of the spilled oil.

Based on ambient temperature and wind conditions, the scientists inferred that volatilisation processes played a significant role in degrading and reducing the amount of oil spill. Volatilisation and evaporation were, perhaps, the major weathering processes immediately after the spill, say the researchers.

To understand the time evolution of the spill in a marine environment, the scientists measured the density of the oil and monitored the viscosity for several days. The viscosity values increased with time as the emulsification process transformed spilled oil into heavy, semi-solid emulsions.

The scientists observed that the seawalls and groins installed along the Chennai shoreline to manage coastal erosion problems controlled the oil transportation and deposition patterns. A large amount of oil was trapped within the relatively stagnant zone near the seawall–groin intersection region.

It is important to monitor and track the long-term environmental impacts of the Chennai oil spill residues on the Bay of Bengal coastal ecosystem, as the effects continue for a long time after the accident. The study provides clues for focused action for the remediation of the spill and to reduce long-term effects.

*Sci. Total Environ.*, **626**: 795–806

### Biodegradation of Azo Dyes *K. pneumoniae* for biotreatment

Kanpur, the former 'Manchester of the East', was the first textile industrial town of India. The textile mills established during the British rule flourished in the city after independence and generated employment. They also generated large quantities of effluents with toxic dyes, polluting the environment.

Conventional physico-chemical treatments are expensive, have high sludge production rates, and produce toxic by-products. On the other hand, biotreatments are inexpensive and eco-friendly.

Researchers from IIT Kanpur have isolated a bacterium that degrades azo dyes and aromatic amines in textile effluents. The scientists used nutrient broth for isolating the bacterial strains, to which sludge from a local dyeing industry was added. Methyl orange was used as model dye for screening the decolourising microbes. Then the team cultured them for a fortnight and inoculated them onto nutrient agar plates.

They then grew the isolated strains in an enrichment medium, consisting of methyl orange, cosubstrates such as glucose and yeast to increase microbial degradation abilities. The researchers could thus select a strain which had the maximum decolourising potential. Using DNA sequencing they identified the strain: *Klebsiella pneumoniae*.

The scientists used sulphonated azo dyes to test the efficiency of the bacterium. They observed that 95% of the azo dyes were decolourised in less than a day and that the bacteria decolourised only in the presence of cosubstrates.

They also observed aromatic amines. This, they hypothesised, may be due to limited oxygenation. So they used an aquarium pump to aerate the decolourised cultures. The aromatic amines were mineralised within a day.

The decolourised cultures and degradation products were analysed using UV visible spectroscopy and high-performance liquid chromatography.

Finally the team evaluated the toxicity of the treated water on *Cicer arietinum*. They concluded that the biodegraded products were not toxic to the plant.

The researchers proposed a mechanism for the process: an electron transport-linked reduction of dyes in the outer membrane of the bacterial cell where it makes contact with the dye. The reducing equivalent possibly shuttles between the dye and an NADH-dependent azoreductase, present in the cell.

The research shows that *Klebsiella pneumoniae* has the potential for degrading toxic dyes. But it is pathogenic to humans. Further studies are needed to identify the metabolic pathways and the microbial components responsible. These can perhaps be isolated for use in dye degradation.

*J. Environ. Eng.*, **144**(6): 04018035

### Detecting Pathogens in Water With nanogold and colistin

A large number of water-borne diseases are caused by bacteria that upset the gastrointestinal system, leading to diarrhoea, nausea, vomiting, dehydration and, often, death. According to a WHO report, nearly 38 million Indians are affected by water-borne diseases and, every day, 4000 children die.

To test whether water is safe, there are many methods. But the current methods of detecting bacteria in water are cumbersome and technically challenging, and often fail to detect low levels of pathogenic organisms in water.

Last fortnight, researchers from the Institute of Microbial Technology and the Panjab University, Chandigarh, reported developing a simple, cost-effective and rapid assay to detect bacterial contamination in water samples.

The assay depends on the interaction of gold nanoparticles and colistin – a peptide antibiotic used to detect pathogenic organisms. The method consists of just adding colistin and gold nanoparticles to water samples. The results are visualised based on colour change.

In bacteria-free potable water, the positively charged colistin binds and neutralises gold nanoparticles leading to aggregation of the gold nanoparticles. The colour of the sample changes from red to blue. In the presence of bacteria, however, colistin binds to lipopolysaccharides present in the bacterial cell wall. This renders the gold nanoparticles free in solution without aggregation. And the solution remains red.

This method can be used for onsite detection of bacteria in just 5 minutes without any instrumentation. Of course, to do this, the water to be tested has to be filtered to remove impurities.

The researchers successfully applied the method to detect *E. coli*, *Salmonella typhimurium* and *Klebsiella pneumoniae* and a combination of these bacteria in water. Even 10 bacterial cells per ml of tap water and 100 bacterial cells per ml of lake water are detectable with the naked eye, say the researchers.

Safe drinking water is a major concern. Rapid and sensitive detection methods are needed to control water-borne diseases, especially in rural areas. The report offers the possibility of a technology to test water at home.

*Sens. Actuator B-Chem.*, **262**: 603–610

### Which Leukaemia Subtype?

*Microarray and AI to diagnose*

The subtypes of leukaemia, the most fatal of all cancers, are acute lymphoblastic leukaemia and acute myeloid leukaemia. Though similar in morphology, these cancer subtypes respond differently to medicine. If diagnosed wrongly, the patient can die.

Last fortnight Ashok Kumar Dwivedi from the Maulana Azad National Institute of Technology, Bhopal, reported a method to discriminate between the two subtypes of leukaemia. He explored the use of artificial intelligence methodologies to discriminate between the gene expressions in the two subtypes.

He took data from the microarray based gene expression of 46 leukaemia patients. 32 had acute lym-

phoblastic leukaemia and 14 had acute myeloid leukaemia. The microarray data contained the expression profiles of 7129 genes of each patient.

The researcher tested six available algorithms for automatic classification – artificial neural network, support vector machine, logistic regression, naïve Bayes, classification tree, and *k*-nearest neighbour – to classify the data into leukaemia subtypes.

Ashok found that, among all six algorithms, the artificial neural network could efficiently classify the samples correctly – with only one error of classifying acute myeloid leukaemia as acute lymphoblastic leukaemia. In other algorithms, the errors ranged from 9% to 50%.

The findings indicate that the artificial neural network can efficiently discriminate between the cancer subtypes based on the differential gene expression profile generated by microarray and convert it into useful information for diagnostic purposes. The scientist says that this lays the foundation for a differential gene expression based classification of cancer subtypes to get better medical outcomes.

*Neural Computing Network*, **26**(12): 1545–1554

### Drug-resistance in Leprosy

*New drugs in pipeline*

Leprosy, an infectious communicable disease caused by *Mycobacterium leprae*, primarily affects skin and nerves, though some forms destroy other organs too. The social stigma associated with the disease worsens the issue.

Leprosy was believed to have been eliminated from India in 2005. But it still exists in some areas and new cases of leprosy continue to surface. In 2015, more than 120,000 new cases were reported from India, accounting for 60% of new leprosy cases the world over. On the verge of its eradication, the world witnessed drug-resistance, notably in India. Before drug-resistance makes leprosy as life threatening as tuberculosis, new drugs have to be discovered.

Mohanty and team from the National JALMA Institute for Leprosy and Other Mycobacterial Diseases, Agra, made an effort to address the issue. They focused on ribonucleotide reductase, an enzyme involved in DNA synthesis, essential for the survival of the pathogen. The enzyme in humans has a different structure and that makes it a good target for treatment. However, the 3D structure of the enzyme is not yet elucidated and this hampered the rational discovery of drugs against the disease.

The enzyme is made up of two subunits. One of the subunits is believed to be directly important for DNA synthesis. Since the protein is absolutely necessary for the survival of the *Mycobacterium*, it would have conserved sequences. So the scientists used homology modelling to predict the structure of the subunit.

Once they confirmed that the structure was reliable, they looked for potential inhibitors via molecular docking – a simulation technique that predicts effective binding between molecules of interest. They took more than 1800 FDA-approved small molecules with desirable molecular properties. The team identified three molecules – lincomycin, novobiocin and telithromycin – as potential inhibitors of ribonucleotide reductase.

As the three molecules are already approved for use on humans, clinical trials using the three drugs for the treatment of leprosy need to be undertaken to validate the *in silico* studies.

*Infect. Genet. Evol.*, **60**: 58–65

### Regenerating Knee Meniscus

*Silk-fibroin and egg shell scaffold*

The human knee meniscus is cartilage. Though not as hard as the femur bone or the tibia and fibula, it has to bear loads. As a result, the chance of injury to the meniscus is very high. Conventional treatment strategies like compression wrap or meniscectomy cannot heal the injuries completely. Patients risk developing osteoarthritis later in life.

An alternative strategy is tissue engineering: creating a suitable supporting structure and microenvironment

for human meniscal tissue to regenerate. Naturally occurring and synthetic polymers are used to create three dimensional support structures – scaffolds on which cells can attach themselves, grow and proliferate, to repair the damaged tissue.

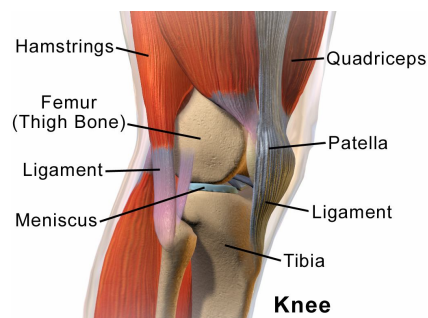


Image: Bruce Blause

Last fortnight, scientists from four institutions in Coimbatore reported developing a 3D scaffold for human meniscus regeneration by combining two polymers – silk fibroin and poly vinyl alcohol – which are often used in scaffold generation. These polymers are non-toxic, biodegradable and durable. And what is more, they could be moulded into different shapes.

Previously, the scientists had tried to prepare scaffolds by combining these two polymers in different ratios. They found that a 3 : 1 blend of silk fibroin and polyvinyl alcohol was the best suited scaffold for growing primary human meniscal cells. They added powdered egg shell membrane which mimics the function of the extracellular matrix present in the intercellular space to the mix. The blend was supplemented with a combination of biomolecules which would help the meniscus cells multiply.

To find out whether these scaffolds were suitable, the researchers collected primary human meniscal cells from patients undergoing meniscectomy and seeded them on the scaffolds. After a few days, they observed meniscal cells on the scaffold.

The scientists then checked whether these scaffolds are toxic to animals. They implanted the scaffold subcutaneously in New Zealand rabbits. 28 days later, they removed the implants surgically.

They observed that cells had multiplied, attached themselves to and infiltrated the scaffolds. Blood vessels and connective tissue had also started to develop on the scaffold. The implants had elicited an immune response in the animals, albeit mild.

So if your meniscus is damaged, here is hope.

*J. Biomed. Mater. Res. A.*, **106**(6): 1722–1731

### Formaldehyde Synthesis Utilising the full solar spectrum

Formaldehyde serves as base material for products such as decorative laminates, wrinkle-proof fabrics and chrome printing. So tonnes of formaldehyde are synthesised worldwide every year. Large-scale synthesis of formaldehyde involves oxidation of methanol using catalytic agents – potassium permanganate and potassium dichromate. While the produce is sufficient, the process is toxic, unstable and generates unwanted by-products such as carbon monoxide, methyl formate and formic acid. An efficient and benign synthesis of formaldehyde is essential considering the scale of its production for industrial and laboratory uses.

A team from the IIT Mandi has now come up with a solution that is not just safe but energy efficient too: a photocatalyst that can turn methanol to formaldehyde under sunlight.

To be deemed proficient, a photocatalyst has to show appreciable absorption over a range of irradiation wavelengths and prevent recombination of charge carriers. The team used titania as base owing to its abundance, low cost and excellent photo-physical properties. But, titania has poor absorption at the visible and near infrared regions of the solar spectrum due to its large band gap.

To overcome this limitation, the scientists embedded gold nanoparticles on a titania matrix. Gold nanospheres offer tunable surface plasmon resonance, a collective oscillation of conduction electrons resulting in absorption of light over a range of visible wavelengths. Such an interface between metal and metal oxide pre-

vents recombination of charge carriers. They confirmed the homogeneity of gold nanosphere dispersion on the titania matrix using transmission electron microscope and spectroscopic studies.

The researchers demonstrated the photocatalytic activity of the titania-gold nanocomposite through the conversion of methanol into formaldehyde. Under ultraviolet radiation, electrons in the valence band jump into the conduction band by absorbing the incident light energy, thereby influencing the catalytic process. This is complemented with gold nanospheres enhancing the charge carrier separation, say the scientists.

On irradiating with visible light, surface plasmon resonances of the gold nanospheres help photo-generated electrons migrate from gold to titania and interact with dissolved oxygen in the reaction mixture, resulting in formaldehyde.

With near-infrared radiation, electrons collide with the ionic lattices of gold nanospheres. Such collisions lead to heating of the matrix environment, resulting in increased photocatalytic activity. The electrons move from metal to matrix, thereby influencing the conversion process.

The scientists say that the efficiency of the titania-gold nanocomposite is enhanced by its synergistic response to sunlight, which comprises of ultraviolet, visible and infrared radiations.

What could be better than simple, non-toxic formaldehyde synthesis assisted by sunlight! Now, it is up to industrialists to capitalise on the method for safe large-scale formaldehyde production.

*Surf. Interface*, **11**: 98–106

**Reports by: Neeta Shrivastava, G. Sharath Chandra, A. Siva Shakthi, R. Baskar, Sushmitha Baskar, S. Saravanan Parameswaran, Suresh Ramanan, Sileesh Mullaseri and Roopkatha Bhattacharya**

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scienceandmediaworkshops@gmail.com



## Science Last Fortnight

### Rice Straw Revolution

#### *Bio-nano-silica for CO<sub>2</sub> separation*

Each kilogram of milled rice produces a corresponding kilogram of straw. Rice straw, considered waste, is either dumped into rivers or burned. This results in greenhouse gas emissions, contamination and pollution. But the same straw can be used to separate carbon dioxide from atmospheric gases, say scientists from the NIT Durgapur.

The conventional process for CO<sub>2</sub> separation involves reversible absorption. This consumes high amounts of energy and is costly. The need for a more efficient and eco-friendly CO<sub>2</sub> separation process led scientists to membrane technology which offers greater energy efficiency, processability and lower maintenance costs.

The scientists from the NIT Durgapur synthesised a nano-composite polymeric membrane comprising a polyether-polyamide block copolymer and nanosilica from rice straw for CO<sub>2</sub> separation.

The researchers used a gravimetric method to isolate bio-nano-silica from rice straw. They analysed the morphological features of the bio-nano-silica using scanning electron microscopy, transmission electron microscopy and dynamic light scattering. The nano-silica had an average diameter of about 15 nm, a surface area of more than 400 square metres per gram and more than two-and-half times the porosity of commercial silica – almost half a cubic metre per gram!

Using field emission scanning electron microscopy, the team found that silica particles from rice straw tend to agglomerate and form clusters. They say that this may be due to the high specific surface area to volume ratio.

The amorphous silica particles reduced the composite membrane's crystallinity. When hydrated, the nano-silica formed a gel-like structure, which helps increase contact with the solvent. And the strong

hydrogen bonds enhanced the stability of the silica in the matrix.

The scientists conducted gas permeation experiments under a steady-state condition at different pressures, temperatures and nano-silica particle concentrations. The blended membranes selectively separated CO<sub>2</sub> gas. Under all parametric conditions, the permeability of CO<sub>2</sub> was more than that of air.

As no chemicals or energy are needed for the separation of CO<sub>2</sub>, the scientists hope that this will become a candidate for carbon sequestration technology for climate mitigation.

*J. Cleaner Prod.*, **186**: 241–252

### Carcinogens in the Ganga

#### *Unholy cocktail*

The Ganga is holy to many Indians. Yet polycyclic aromatic hydrocarbons have been detected in the air, water, and bulk depositions along the river. This is a serious environmental concern as polycyclic aromatic hydrocarbons are carcinogenic, mutagenic, and teratogenic.

Recently, Girija Bharat from TERI, along with collaborators from the Czech Republic and Norway, measured the concentrations and distributions of polycyclic aromatic hydrocarbons in air, atmospheric depositions and surface waters at various locations along the Himalayan, middle and lower reaches of the river. This is the first basin-scale report of the occurrence of polycyclic aromatic hydrocarbons in the region.

The scientists used air samplers and deposimeters to collect air samples and a high volume flow sampler to collect water samples. They recorded the results during two seasons: pre-monsoon and monsoon. And analysed the chemistry of the samples using chromatographic techniques.

In the Himalayan reaches, the effects of forest fires or biomass combustion were evident during the dry pre-monsoon season. The researchers surmised that the seasonality of

the concentrations of these pollutants was also influenced by glacier melting.

The team did not find seasonal effects in the middle and lower reaches of the river. They attributed the presence of atmospheric poly-aromatic hydrocarbons in the middle and lower reaches of the river to fossil fuel combustion.

'Polycyclic aromatic hydrocarbon concentrations in air are strongly correlated with population density', says Brij Mohan Sharma from the Masaryk University, Czech Republic.

'We found that ambient air concentrations correlate with cancer risk. As expected, the risk was higher in the middle and lower reaches than in the Himalayan reach', adds Girija Bharat, TERI.

Policy makers should leverage on such reports to tackle the issue in the clean Ganga programme.

*Sci. Total Environ.*, **627**: 1495–1504

### Particulate Matter Pollution

#### *Source profiles*

Raipur-Bhilai, in Central India, has a number of industries. These industries release particulate matter making the air polluted. So do burning of domestic and agricultural wastes. Particles with aerodynamic diameter smaller than 10 or 2.5 microns have distinct properties meteorologically, and on the health of the population. PM10 and PM2.5 thus serve as indicators of air quality. While PM10 can be deposited in the lungs, fine particles of PM2.5 can penetrate the alveoli of lungs and affect the cardiovascular system and other major organs. The problem in Raipur-Bhilai was to identify the exact sources and nature of these particles.

Researchers from Raipur, Jagdalpur, Chhattisgarh, Nagpur and New Delhi, collaborated with scientists in the US and China to understand this problem. With the help of Minivol air samplers, they collected PM10 and PM2.5 on quartz fibre filters from various locations. They used atomic

absorption spectrophotometry, ion chromatography and thermal/optical transmittance to analyse the samples and evaluate similarities and differences between the profiles of 32 chemical species from various sources. The team profiled PM10–2.5 from both domestic and industrial facilities.

In both domestic and industrial locations, there was more PM2.5 than the PM10–2.5 fraction. The researchers observed more carbon in domestic and municipal solid waste burning. There were more toxic elements in industrial emissions. They also noted high amounts of calcium from steel rolling mills and cement industries, and iron from ferro-manganese, steel and electric-arc welding industries. There were more emissions from brick kilns, followed by steel rolling mills and nickel steel industries. This, they suggest, may be due to the incomplete combustion of fuels.

This study will help policy makers take steps to reduce pollution from industries and formulate strategies to protect people from toxic emissions.

*Sci. Total Environ.*, **627**: 1137–1145

### **Nanoparticles for Soil Health** *Promoting antifungal compounds*

Though nanoparticles are good antimicrobial agents, their presence in soil affects beneficial microbes. These microbes produce antimicrobials and protect plants from various fungal diseases. Nanoparticles also reduce the production of secondary metabolites by the microbes and this impacts soil health. However, now, Shams Tabrez Khan from the Aligarh Muslim University, Uttar Pradesh in collaboration with scientists in Saudi Arabia and the Netherlands, suggests nanoparticles to promote soil antimicrobials.

The team synthesised nanoparticles of silver, silicon dioxide, titanium dioxide and zinc oxide and characterised them. They used *Pseudomonas protegens* CHA0 – a beneficial bacterium – which produces *pyrrolnitrin*, an antifungal compound that protects plant roots from fungal pathogens.

The team tested different concentrations of the nanoparticles – 500 micrograms and 500 nanograms – on the growth of *P. protegens* CHA0. Then they assessed the growth of the bacterium and its ability to suppress *Candida albicans*, a fungal pathogen, using a green fluorescent protein as reporter to measure the expression of the fungal genes.

The researchers noted that, while the higher concentration of nanoparticles inhibited the growth of *P. protegens*, the sub-lethal dose stimulated the production of *pyrrolnitrin*. The team found that the sub-lethal dose of nanoparticles induces the expression of *prnA* operon – a functional unit of DNA which accounts for *pyrrolnitrin* production.

The team suggests that nanoparticles, in low doses, can be used to stimulate the activity of beneficial microbes. Agriculture extension agencies and the Krishi Vigyan Kendras can do a pilot study in the field to corroborate the usefulness of the technique for sustainable agriculture.

*Sci. Total Environ.*, **627**: 658–662

### **Managing Pests in Stored Grains** *Plant based pesticide*

Storage pests ruin grains, postharvest. Managing grain pests with chemicals leads to environmental retention of pesticides in the food chain. The use of plant-based pesticides, however, can circumvent the problem.

Now scientists from the ICAR-National Rice Research Institute, Cuttack report the insecticidal and insect repellent activities of *Cleistanthus collinus* against the rice weevil and the red flour beetle.



By J. M. Garg, Wikimedia Commons

*Cleistanthus collinus* is toxic and is often used to commit suicide. The researchers prepared a *Cleistanthus collinus* leaf concentrate by solvent extraction followed by rotary evaporation. They reared the storage pests in a closed jar with rice grains and flour.

The team performed toxicity assays, spraying adult rice weevils and red flour beetles with varying concentrations of the extract. The researchers monitored the insects for one, three and seven days. The rice weevil showed more mortality than the red flour beetle. The toxicity of the extract was comparable with that of a common insecticide, deltamethrin.

To test for repellent activity, the researchers exposed the insects, for just 30 minutes, to a filter paper infused with the leaf extract. The extract showed repellent activity against both insect species.

The extract also impacted the reproduction of the insects. Upon evaluating the survival capacity among the insects after exposure, the scientists found a decrease in the population build up for the succeeding two generations.

The team proposes to substitute synthetic pesticides with such eco-friendly botanicals especially in storage warehouses. However, it is essential to customise formulation to avoid toxicity, before extending plant-based insecticides to field trials.

*Ecotoxicol. Environ. Saf.*, **154**: 92–99

### **Medicinal Properties of Black Clam**

Black clams are exclusive to limited geographic regions. They are endemic in the brackish waters of the southwestern coast of India. Coastal populations in Kerala depend on this species for their livelihood. This traditional seafood is extensively harvested from the wild for its commercial and export value.

Studies on the nutritional values and bio-potentials of the black clam – *Villorita cyprinoides* – have been reported. Now, scientists from the Central Marine Fisheries Research Institute, Cochin, report finding anti-inflammatory and antioxidant compounds in bivalve black clams.

To identify the bioactive compounds, they used nuclear magnetic resonance spectroscopy, nuclear Overhauser effect spectroscopy, ultraviolet spectrophotometry, gas-chromatography mass-spectroscopy and high-pressure liquid chromatography. The scientists thus discovered furano-meroterpenoid analogues in the black clam.

Furano-meroterpenoids are antioxidants and have anti-lipoxygenase activity. This signifies the utility as functional food ingredient, says Minju Joy. The greater antioxidative and anti-inflammatory properties of the furano-meroterpenoid in the black clam may be because of the optimum hydrophobic-hydrophilic balance along with lesser steric bulk in the compound, proposes Kajal Chakraborty.



Image: indiabiobiodiversity.org

The scientists also discovered specialised naturally occurring chromenyl or pyranoid metabolites in the black clam. These could be used as potent anti-inflammatory and antioxidant agents in functional food preparations and nutraceutical formulations, say the scientists.

*Food Chem.*, **251**: 125–134

### Targeting Colon Disorders

#### *Drugs in nano-micelles*

Many diseases, including colon disorders, cannot be cured by oral drugs due to the acidic environment of the stomach. Even if the drug crosses the acidic region it may get absorbed in the small intestine. This leads to the colon not receiving the therapeutic dosage. Hence, such diseases require special treatment.

Recently, researchers from the CSIR-IGIB, Delhi developed a new targeted drug delivery system for colon disorders using nano-carriers.

They selected polyethylene glycol as nano-carrier for sulfasalazine and ornidazole. Sulfasalazine is prescribed for colon diseases such as Crohn's disease and ornidazole for amoebiasis.

The carriers self-assemble as micelles in a dimethylformamide solution. Dicyclohexylcarbodiimide forms reversible chemical bonds with both drug and carrier. Thus, the drugs are encapsulated in the nano-micelles.

These nano-carriers release the drug based on the pH of the surroundings. The drug is not released in the acidic pH of the stomach. The nanocarrier releases the drugs only near neutral pH, similar to that of the colon.

Both drugs have an azo moiety in their structure. This bond is easily broken down by the azoreductase enzyme secreted by the colon's microflora. This was demonstrated by the scientists using a mimic of the enzyme. Based on these studies, they say that the activity of the drug ceases within five hours for sulfasalazine. And around three hours for ornidazole.

Colon related diseases are distressing and hard to tackle. Also, bacteria are getting resistant to most antibiotics. Sulfasalazine is usually prescribed only when no other drug works and, hence, this report is significant for pharmaceutical companies and the health care sector. It has the potential to improve targeted delivery of drugs for diseases of the colon.

*Colloids Surf. A*, **547**: 157–167

### Lab-on-body: Wearable Sensors

#### *Flexible electronics step forward*

In the past two decades, the electronics industry has witnessed some paradigm shifts – device miniaturisation, organic base materials and flexible components. Thanks to these advancements, we now have wearable health monitors, human-robot interfaces, and soft-actuators. But there remains an underlying challenge: developing components that are pliable and which adapt to human skin.

Though there exist magneto-electric systems based on ultra-thin glass,

metal foil and polymer substrates, these fall short of expectations due to their fragility, opacity and thermal instability. Last fortnight, scientists from the Indian Institute of Science, Bengaluru and the National Chiao University, Taiwan presented an approach to overcome these limitations. They developed a pliable magneto-electric nano-composite that responds to changes in the magnetic field by changing its electrical properties.

To build the nano-composite, the researchers used muscovite, a transparent, poly-silicate mineral containing potassium and aluminium, as substrate. Muscovite is elastic and has high thermal stability, properties that make it a good choice as substrate. Moreover, the two-dimensional nature of muscovite facilitates van der Waals epitaxy, alleviating stringent lattice matching conditions. The result is a sensing structure with almost free-standing layers, an essential property of pliable devices.

The researchers fabricated a heterostructure comprising bismuth ferrite rods embedded in a cobalt ferrite matrix. Cobalt ferrite has large magnetostriction and bismuth ferrite has ferroelectric properties. Together, they offer high magneto-electric coupling. This, in turn, influences the sensitivity of the device.

Thus, with a sound combination of materials and fabrication techniques, the researchers created the largest lab-on-body to perform non-invasive sensing. They are sure that this would accelerate progress in the area of flexible electronics. For capitalists aiming to find a niche, here is something to invest in.

*J. Phys. D: Appl. Phys.*, **51**(23): 234006

### High Energy Bio-Oil

#### *From agri-plastic waste*

Renewable liquid biofuel is a hot topic for research, as an alternative for fossil fuels. Last fortnight, a team of scientists led by R. Vinu, IIT Madras, reported a technique for producing high quality, high energy bio-oil via microwave-assisted co-pyrolysis of waste biomasses and plastics.

The researchers collected five different types of lignocellulosic



biomasses: groundnut shell, bagasse, rice husk, *Prosopis juliflora*, and sawdust. The plastics for the study – polypropylene beads and polystyrene pellets – were procured from local markets.

The team pyrolysed the mixtures of the biomasses and the polymers in batch mode, in a microwave oven. To increase the heating rate and reduce the processing time of the feedstock, they used industrial grade graphite powder, as susceptor to convert electromagnetic energy into heat.

First, the susceptor and the feedstock were mixed in 1 : 5 ratios. Then, the team co-pyrolysed each biomass and polymer in 1 : 1 mass ratios.

They found that when the biomasses are mixed with polymers, the heating value of the mixture is more than that of the biomass alone. The pyrolysis temperature of 600°C is reached in about 10 minutes in all the combinations at a moderate 450 W microwave power.

The scientists also report that the energy yields of the bio-oils from the co-pyrolysis of all five polystyrene-biomass mixtures were consistently higher than yields of bio-oils from individual biomass pyrolysis. They found that polystyrene mixed with sawdust gave maximum bio-oil yield. Rice husk-polystyrene and rice husk-polypropylene mixtures were better biomass-plastic combinations than others for recovering high quality, high energy density bio-oil.

Moisture content and total acidity counts of these co-pyrolysis bio-oils were lower than those from individual biomass pyrolysis. Generally, bio-oil obtained from biomass pyrolysis is acidic, contains high moisture and oxygen, and has low calorific value. Co-pyrolysis of different combinations can overcome these limitations, say the scientists.

'Microwave-assisted heating is a promising technique for pyrolysing different biomasses and common plastics in combination', says R. Vinu, IIT Madras. These findings can be useful for solid waste management and for producing much needed high-energy bio-oils.

*Fuel Processing Tech.*, **175**: 64–75

### Signature Based Authentication 3D Convex Hull Approach

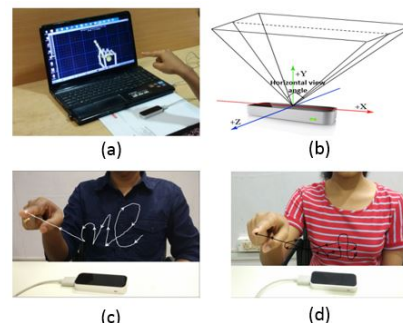
Signature-based authentication is considered reliable in biometric systems. Signatures are collected either online or offline. Online, signatures are collected with pen-sensitive devices and a pointer or finger. While online verification is carried out with the help of writer dependent features like velocity and pressure, offline verification is carried out by validating only the writing pressure, extracted from the handwritten stroke. Hence, the online mode is more secure than the offline mode.

Earlier research suggests that storing signatures in 3D format will increase the robustness of the biometric systems. But comparison and verification take a lot of processing time, if the user database is large. Scientists from the IIT Bhubaneswar proposed a new method, recently, to reduce processing time without compromising accuracy.

The team used a leap motion sensor to capture the signatures and stored them in 3D format. Then they extracted features or attributes from that data and represented them in the form of a convex hull structure.

To establish the authenticity of the signature, the team first classified the signatures with the help of classifiers such as the *k*-nearest neighbours algorithm and the hidden Markov model. The first looks at the patterns of relationships in the strokes of the signature while the other looks for

patterns hidden in the process of signing. Both algorithms find use in learning machines. To compare features against values stored in the database, the team used different classifiers.



To test the effectiveness of this method, they recorded the signatures of eighty volunteers using a leap motion sensor. Then they used another set of volunteers to forge the signatures. They found that their algorithm accurately and rapidly predicted forgery.

They found the hidden Markov model classifier computationally more efficient than the *k*-nearest neighbour algorithm. The team says that the method significantly reduces average time for signature recognition and verification.

The team proposes that this method can be used to develop robust biometric techniques and for designing computer interface systems.

*Expert Syst. Appl.*, **100**: 106–119

**Reports by: Sileesh Mullasserri, R. Srinivasan, K. Siranjothi, R. Baskar, K. V. Srividhya, Sushmitha Baskar, Mahadeva Swamy, S. Aishwarya, A. Siva Shakthi and Sanghamitra Deobhanj**

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scienceandmediaworkshops@gmail.com