Science Last Fortnight

Defluoridating Water

An easy way

Availability of clean and hygienic drinking water is one of the biggest challenges of the 21st century. Fluoride is a non-biodegradable pollutant that contaminates water. While it is a minor but essential mineral for the generation and maintenance of healthy bones and teeth, excessive fluoride consumption can lead to dental fluorosis. Clinical studies show that excessive intake of fluoride may also cause osteoporosis, arthritis, brittle bones, cancer, infertility, brain damage, Alzheimer's disease and thyroid disorders.

Although many techniques are used for wastewater treatment, researchers are focusing on the use of cellulosic low-cost adsorbents because of their abundance and renewability.

Last fortnight, scientists from the Madurai Kamaraj University, Tamil Nadu, in collaboration with the Qatar University, developed an effective and relatively inexpensive adsorbent for the removal of fluoride. They successfully extracted cellulose from waste sugar cane, and impregnated metal lanthanum into the cellulose. This lanthanum impregnated cellulose was used for fluoride adsorption studies.

The team confirmed the effectiveness of fluoride adsorption using different methods and found that lanthanum impregnated cellulose is a better adsorbent for fluoride than plain cellulose.

The scientists claim that the lanthanum impregnated cellulose adsorbent can now be used to design effective and economical household defluoridation units.

Carbohydr. Polym., **176**: 402–410

Hot Days affect Potato Yield

Time for heat tolerant varieties

Potato, the fourth major food crop, prefers cooler temperatures. Increase in temperature reduces productivity. Which variety of potato can withstand higher temperatures better? The answer would help us identify heat stress tolerant cultivars. And, thus, widen the cultivation prospects of potato.

Recently, Sreyashi Paul and team from the Tezpur University, Assam joined an international team from various institutions around the globe to study the impact of temperature on five major potato cultivars. They collected seeds of local cultivars – Rangpuria and Badami from Assam, and Kufri jyoti, Kufri megha and Kufri pokraj from CPRS, Shillong. Then they designed three different experimental conditions: early hot season from August to November, normal growing season from October to January and normal season but inside the polyhouse, where the temperature is two to four degrees higher.

The team studied the carbon dioxide assimilation rate and sucrose–starch ratio, a measure of the synthesis of sucrose and its availability for translocation. Though sucrose is produced in leaves, transport to tuber is imperative. Xylem and phloem are the water and sucrose transporting systems in plants. When the temperature rises, xylem has abnormal enlargement and this affects adjacent phloem development. Improper phloem structure affects sucrose transport from leaves to the tuber, which, in turn, leads to smaller tuber size. So the scientists examined tuber-bulking rate by observing the development of xylem and phloem in all cultivars.

Data, from two years of observation, show that tuber size is reduced in cultivars grown under early hot season and polyhouse conditions, except in the case of Kufri megha and Rangpuria. Tuber growth under normal growing season was normal.

The scientists conclude that cultivars maintaining the typical xylem and phloem structure, even under unusual temperature, might yield better. It remains the task of future research to investigate the factors influencing such significant productivity in Kufri megha and Rangpuria varieties under higher temperature. Such studies will help develop heat stress tolerant potato crops.

Sci. Hort., **225**: 134–140

Shelf-life of Green Chilli

Post-harvest treatment

Green chillies are perishable. High moisture content makes them prone to infections and spoilage, thus reducing their shelf-life. It is a challenge to preserve them, without compromising colour and quality. Many studies show that a coating helps extend the shelf-life. However, so far, we lack adequate research on green chillies.

Recently, Jitendriya Panigrahi and team from the A.N. Patel PG Institute of Science and Research, Gujarat collaborated with an agricultural researcher in West Bengal to come up with a solution. The team applied a coating agent, gibberellic acid, on green chilli to extend shelf-life. Gibberellic acid – gibberellin – is a plant hormone which stimulates plant growth and development. The team coated chilli samples with 1, 2 and 3 ppm of gibberellic acid for 30 sec. They stored the samples in cold storage and observed them for 45 days. Every nine days, the researchers assessed their multi-enzyme and antioxidant content.

The team noted a decline in the metabolic activities of organic acids like citric acid and a reduction in total phenolic content as well. They found that, in coated samples, many enzymes and antioxidants showed increased activity during cold storage. The scientists report that better results could be achieved with 2 ppm gibberellic acid coated samples than with 3 ppm or 1 ppm. Just 2 ppm concentration of gibberellic acid gave a maximum shelf-life of up to 45 days with good colour and quality. In uncoated chillies, skin colour changed and they spoiled easily.

The researchers conclude that gibberellic acid is a successful coating agent for perishable foods. It delays ripening and extends shelf-life. Since it is a plant hormone, the quantity used is not harmful for human consumption. For food and nutrition security, farmers, traders and the government can adopt this strategy for the post-harvest treatment of green chillies.

Sci. Hort., **225**: 581–588

Pomegranate Peel for Pest Control

Alternative to chemical termiticides

Termites consume cellulose. In central India, they cause major damage to wheat crops. Termiticides, pesticides specific to termite management, impact the ecosystem as residue enters the food chain.

Recently, scientists from the CSIR-National Botanical Research Institute and the KVK-Indian Institute of Sugarcane Research reported a termiticide prepared from the peel of *Punica granatum* – pomegranate.

The team first performed solvent extraction and fractionation of pomegranate fruit peel powder and isolated the active polyphenol compounds. They characterized and annotated them using thin layer chromatography, using standard polyphenols for comparison.

With the help of liquid chromatography, the researchers quantified five phenolic compounds – Gallic, Caffeic, Ferulic, and Vanillic acid as well as Quercetin – from solvent extracts of pomegranate peel. By incubating *Microcerotermes beesoni* termite species with filter paper, pre-blotted with the phenol compounds, they arrived at percentage mortality with continuous monitoring over three days. They discovered that, among the phenolics, Quercetin was the most effective termiticide with significant mortality rate.

Besides promising an alternative to hazardous chemical pesticides, this report also throws light on the use of waste material such as fruit rind. Commercializing such naturally available cost-effective polyphenols as eco-friendly pest management will help farmers protect valuable crops.

Ind. Crops Prod., **107**: 320–325

Soil Condition in Tree Plantations

After successive planting

Successive cropping in the same land degrades soil quality. With felling bans in forests, tree plantations are the only viable source of wood. Farmers now find tree cultivation more profitable. Some are even doing successive plantations on the same land. However, due to the lack of continuous and long term studies, there is a lacuna in our understanding of the impact of tree plantations on soil.

A collaborative effort of Vasu Duraisamy from the National Bureau of Soil Survey and Land Use Planning, India, with Selvalakshmi Selvaraj and Xiangqing Ma of the Fujian Agriculture and Forestry University, China, reports that more than two successive plantations on the same site can have negative implications.

They collected soil samples from two different sets of Chinese fir plantation. A total of 275 soil samples were thus randomly collected at different levels of 1 m soil profile. The first set was from 12, 21, 40 and 97-year-old plantations of first rotation and the second set from plantations of second, third and fourth rotations. The team compared the soil properties.

The researchers used metal soil cores to estimate bulk density by driving them into the soil. Then, they dried samples at 105°C and estimated the soil dry weight to volume ratio – bulk density. Samples were used for estimating the soil organic carbon concentration using a Shimadzu total organic C analyzer and C : N ratio using a C/N analyzer.

The soil organic carbon concentration and C : N ratio were maximum at the 97-year-old plantation. However, the soil organic carbon concentration decreased by 3%, 3.6% and 14.3% between the first and second, second and third, and third and fourth rotations. Similarly, the C : N ratio also decreased in subsequent successive rotations.

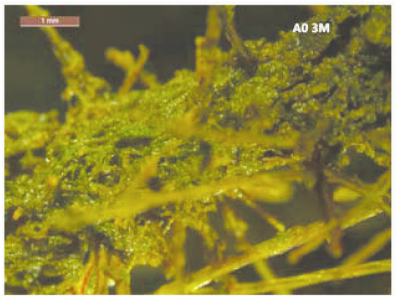
This study reveals that the successive growing of a single tree species on the same site causes a reduction in soil nutrient status. So it is up to forestry scientists, tree growers and industrial plantation managers to reframe their stand management practices for sustainable productivity.

Geoderma, **306**: 127–134

Aquaculture Cage Nets

Preventing fouling

Aquaculture using submerged nets is popular in many coastal areas as a means of livelihood. But the nets soon get a deposit of microorganism. Filamentous fouling organisms increase the weight, deform the cages and reduce mesh openings. This, in turn, reduces the diffusion of water, food and waste, adversely impacting fish health.



Removing the fouling is costly. The nets are made of high density polyethylene, a nonpolar material, not conducive to incorporating biocides to ward off the fouling agents. So Muhamed Ashraf and team from the ICAR Central Institute of Fisheries Technology thought of a coating of polar or conducting molecules over polyethylene to overcome the problem. They experimented with PANI – polyaniline – a conducting polymer. PANI is easy to synthesise, cheap and highly stable. It offers good adhesion with organic films.

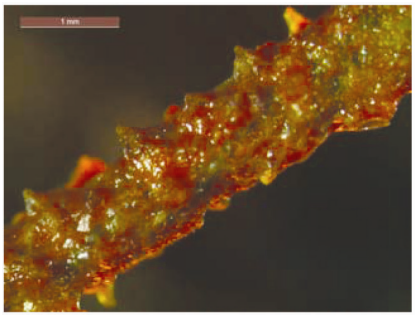
The researchers tried applying PANI over polyethylene nets. But PANI did not stick to the nets. So the scientists soaked the polyethylene nets in aniline. And then, on the next day, they added ammonium persulphate to polymerize aniline *in situ*. The aniline molecules polymerized and precipitated over polyethylene. The coating was stable, as demonstrated by continuous stirring of the nets in water. Hypochlorous acid produced by PANI over the surface reduced fouling. But not significantly.

So the scientists immersed the nets coated with PANI in a solution containing varying concentrations of aqueous nano copper oxide solution. Copper oxide nanoparticles are known to prevent attachment of microorganisms.

Using atomic force microscopy, the scientists confirmed that nano copper oxide nanoparticles are indeed adsorbed over the polyethylene–PANI matrix in a uniform manner as projections which increased the roughness of the net.

Then the scientists left the treated nets in the waters of the Cochin estuary

for three months. Though the treated nets showed attachment of calcareous crystals, they were completely free from filamentous foulers. The nets coated with 0.02% nanocopper oxide showed good fouling resistance.



All this now brings hope to the people who depend on aquaculture using submerged nets. However, to realize that hope, entrepreneurs may need to step in, to make the treated nets available in the market.

Arabian J. Chem.,
10.1016/j.arabjc.2017.08.006

Biodiesel Synthesis

Reengineering Proteus vulgaris lipase

Biodiesel is a mixture of fatty acid methyl esters produced by the transesterification of triacylglycerol with methanol. This was traditionally achieved using catalysis by bases. Now, lipases, a family of enzymes, emerged as an alternative catalyst for biodiesel production. But lipases are notorious for their low stability. And that increases the costs of using the enzyme on an industrial scale.

Researchers from the Maharaja Sayajirao University of Baroda in collaboration with the University of Melbourne, Australia have now come up with a simple solution to overcome this problem: they engineered *Proteus vulgaris* lipase for thermal stability.

The thermal stability of an enzyme depends on internal linkages. Introducing disulphide bonds is a common strategy to improve enzyme thermal stability. The team engineered lipase from *Proteus vulgaris* to add cysteine amino acid residues into lipase to introduce disulphide bridges.

The scientists then immobilized the newly engineered lipase by trapping it on hydrophobic polysulphone beads. These lipase loaded beads could now act as an easily retrievable catalyst for a transesterification reaction. The researchers synthesized biodiesel using neem oil and methanol with the help of these beads. They improved the efficiency of lipase catalysed transesterification further, using ultrasonication. Ultrasonication helps the formation of a fine emulsion between immiscible fluids, leading to increased rate of the transesterification reaction. Sonication decreased the reaction time from 22 to 24 h to 30 min. The team achieved 98% yield with the method.

Thanks to a little tweaking of the enzyme and the use of ultrasonication, biodiesel production from non-edible oils, can be made more efficient. This changes the cost effectiveness of biodiesel production. Such approaches may pave the way for the industrial production of biofuel, reducing dependence on fossil fuels.

Fuel, **208**: 430–438

Improved Power Conversion

Dye sensitized solar cells

Over the past few years, dye-sensitized solar cells are emerging as alternatives to conventional silicon solar cells. Though they have lower power conversion efficiency than the latter, their low cost, flexibility and good performance under ambient temperature attract the attention of scientists around the globe.

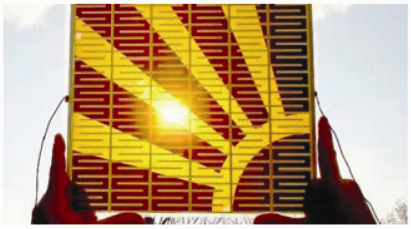


Image: Fraunhofer ISE

Recently, a group of scientists from the Savitribai Phule University, Pune, in association with scientists from the Hanyang and the Dongguk Universities, Korea attempted to improve the efficiency of dye-sensitized solar cells. They report that plasma technology – treating thin film surfaces with ionized gas molecules – helps improve the efficiency of solar cells.

The scientists used oxygen plasma treatment on zinc oxide thin film dye-sensitized solar cells and examined ZnO thin films before and after oxygen plasma treatment. The team observed no significant change on the structure and surface of the ZnO thin films, confirming their stability. However, they noted a considerable shift in the photoluminescence spectra of plasma treated thin films.

They suggest that oxygen plasma treatment is useful to increase intermediate energy levels and they claim that it is this which is responsible for the improved efficiency. The current density – voltage characteristics – showed that the power conversion efficiency of plasma treated thin film solar cells increases to 0.76% from 0.36%.

Research on dye-sensitized solar cells is still in the initial stages. However, this use of a simple plasma treatment to double power conversion efficiency might improve the efficiency and long-term stability of dye sensitized solar cells.

J. Alloys Compound., **724**: 348–352

Anode for Lithium Ion Battery

Higher performance

Lithium-ion batteries are popular energy storage devices. However, those with graphite-based anodes have low lithium storage capacity and poor rate performance due to slow lithium-ion intercalation kinetics.

Scientists are trying to overcome these limitations by introducing alternative anode materials with higher lithium storage capacities and better rate performance. Different metal oxides and sulphides have been proposed as alternatives to graphite-based anodes. Recently, researchers shifted their focus to mixed, rather than simple metal oxides, because they have better electrochemical performance and electrical conductivity due to the synergistic effect of multiple metal species. Thus, many metal oxides became candidates for anodes in lithium-ion batteries.

Inspired by this concept, Indian scientists from the Norwegian University of Science and Technology and the K. S. Rangasamy College, Tamil Nadu recently collaborated with the National University of Science and Technology, Russia to come up with experimental evidence for the improved

electrochemical performance of the $Mg_{0.25}Cu_{0.25}Zn_{0.5}Fe_2O_4/NiFe_2O_4$ nanocomposites.

The scientists used ultrasonic spray pyrolysis. Ultrasonic waves mix the reactants well. The mixed fluids are broken into very small droplets by the spray and pyrolysis completes the reaction. The process involves simultaneous change of chemical composition and physical phase. The resulting nanocomposites were hollow structures with high surface area – an advantage when used as anode material.

Using galvanostatic charge–discharge, cyclic voltammetry and electrochemical impedance spectroscopy on the electrochemical lithium storage behaviour of this anode material, the team demonstrated its efficacy. They found that the nanocomposites exhibited excellent cycling stability at a very high rate – 1000 mAg^{-1} even after 500 cycles – making them highly promising anode material for future lithium-ion batteries.

Since the resultant products are fine spherical particles with uniform chemical composition and narrow particle size distribution, they have appropriate properties for large-scale applications in industry.

J. Alloys Compound., **725**: 665–672

Capturing Carbon

Environmental culprit

World climate is changing. Ice at the poles is melting and this is mostly attributed to an increase in carbon dioxide concentration in the atmosphere. According to the National Oceanic and Atmospheric Administration, the atmospheric carbon dioxide concentration has risen by 40% between 1750 and 2016. Though renewable energy technologies, such as solar energy, wind power and biofuels, emit low carbon, they are still in their infancy. Mitigating atmospheric carbon dioxide has become one of the greatest challenges of current times.

Last fortnight, researchers from IIT Bombay in collaboration with the RMIT University, Melbourne, developed computational tools designed to capture carbon with porous materials using simulation.

The scientists conducted a detailed computational study on porous materials like zeolites, porous carbon, covalent organic frameworks and recently emerging metal organic frameworks. They found that creating open metal sites, adding functional groups, forming constricted pore size, performing postsynthetic metal exchange and adding extra framework ions enhance carbon dioxide uptake, particularly at industrial point sources. They also suggested modifications for better carbon capture.

The researchers say that assessing millions of possible nano-porous materials for carbon capture using experiments is time consuming and expensive. Computational methods help us understand the molecular mechanism of the formation of nano-porous materials and, thus, help design and optimize the protocol for the low-cost production of efficient nano-porous materials targeting carbon.

J. Phys. D: Appl. Phys., **50**(46): 463002

Reinforced Concrete

Blending improves strength

Reinforced cement concrete of high strength is preferred for mass construction. Yet stories of untimely damaged bridges and buildings are not uncommon. Long-term studies on structural properties are needed to understand the resilience of such constructions, especially in marine environments.

Scientists from the CSIR-Central Electrochemical Research Institute, in collaboration with scientists from the Republic of Korea experimented with reinforced concrete blocks made up of ordinary Portland cement and different types of blended cements. The long-term performance-related study was done at Tuticorin, Tamil Nadu.

The concrete cubes were exposed to three conditions: atmospheric zone or dry condition, immersion zone at a depth of 5 m in the sea and splash zone or natural wave alternate wetting and drying conditions. Corrosion measurements were carried out periodically, over 10 years. The scientists used AC impedance, potentiodynamic polarization, and gravimetric weight loss to measure the corrosion rate. To understand the structural changes, they used X-ray diffraction and scanning electron microscopy analysis.

The chloride and sulphate ions present in salt water cause damage due to corrosion of the reinforcement. Irrespective of exposure conditions, steel embedded in the blended concrete showed improved corrosion resistance. Higher amounts of silicon dioxide in blended cements accelerate the formation of calcium-silicate-hydrate gel. The presence of high amounts of alumina accelerates the formation of Friedel's salt in marine environments. It reduces porosity and permeability and gives considerable resistance against chloride and sulphate induced corrosion.

After 10 years of exposure, blended cements show superior compressive strength in atmospheric zones, compared to ordinary cement. A minor strength decrease occurs in immersion and splash zones due to the formation of calcareous deposits as a result of pozzolanic reactions.

The blended cement concretes showed high bio-fouling attachment indicating suitability for the growth of marine organisms. Thus, blended cement concretes are more durable than ordinary cement in marine environments. So, now, we can look forward to safer bridges.

Construct. Build. Mater., **154**: 349–360

Reports by: **Mridula Vellore, K. V. Srividhya, S. Balaji, K. Siranjothi, S. Suresh Ramanan, P. K. Udham, H. M. Mahadeva Swamy, P. Gowdhaman, Sileesh Mullasseri, Nivedita Mishra** and **Pudi Venkatesu**

ACKNOWLEDGEMENT. IISER Pune, for access to scientific databases.

scienceandmediaworkshops@gmail.com