Science Last Fortnight

Soil Quality in the Deccan Plateau

The Deccan Plateau is large, forming most of the southern part of India. A diversity of dryland crops, including cereals, pulses, oilseeds, vegetables such as beans, gourds, onions and commercial crops such as ginger, turmeric and chillies, sustain the agriculture sector in the semi-arid regions of the plateau. However, the growing conditions on the Deccan plateau are poor. The soil is low in organic carbon. It has low nitrogen content and phosphorus fixation capacity. Hence it has poor response to fertilizer application and is, thus, low in productivity. So it requires the implementation of scientific farming strategies to produce enough food throughout the year.

Scientists from Maharashtra, Assam and Tamil Nadu have now come up with a tool – Soil Quality Index – to evaluate crop productivity in the semi-arid Deccan plateau. They collected soil and subsoil samples from various localities. They evaluated the soil quality using parameters such as hydraulic conductivity, degree of modifications of soil properties due to pedogenic processes and weathering, pH and $CaCO_3$ content. They then related the crop productivity of the study area to these parameters.

The study shows that the large variation in soil quality in this region is due to soil heterogeneity and soil degradation caused by subsoil sodicity. The soils of the Chegunta series are of better quality. The soil quality of the Gummagonda series is very poor and is not suitable for deep rooted crops like cotton and pigeon pea because these soils are very shallow, poor in organic matter content and water holding capacity.

The soils of Koduparthy are also low in productivity. But this is due to the leaching of nutrients in the sandy layers along with percolating water. Lack of root anchorage impairs the capacity to support optimum plant growth. Crop productivity in Nerelapally and Avancha is low because the soils here are sodic with a pH of 8.5.

Based on these results, scientists recommend adoption of suitable soil management practices for better agricultural productivity in this semi-arid region. They hope that the study will pave the way for reformulating agricultural strategies in the Deccan Plateau.

Geoderma, **282**, 70–79

3D-Imprinted Membranes

Removing arsenic from water

Parts of West Bengal, Jharkhand, Bihar, Uttar Pradesh, Chhattisgarh, Assam and Manipur are facing high arsenic levels in ground water[1]. This has led to adverse public health issues in these states. The permissible limit of arsenic in water should be below 10 ppb or 0.01 mg/litre. But, in these regions, the level, in water used for human consumption, exceeds the WHO and BIS guidelines.

Last fortnight, researchers from the Indian School of Mines, Jharkhand, reported a new filtration method. They used integrated molecular level arsenic adsorption: membrane technology molecularly imprinted for a specific target molecule[2].

They synthesised the membranes using cysteine@ZnS : TiO_2 nanoparticles and tested the efficiency of these membranes with water samples collected from arsenic-affected areas. They found that 96% of arsenic could be easily removed through this method.

This membrane exhibits high adsorption capacity and selectivity for arsenic removal in comparison to currently available conventional membranes. It is also stable, reusable and highly resistant to breakage. What is more, it is antibacterial.

Membrane-based methods have been used for water purification for decades. However, recently, a combination of membranes with metal nanoparticles has become popular due to better performance, improved permeability, fouling resistivity and selectivity. Moreover, these are commercially viable because of the low-cost involved in production.

This new filtration system has the potential to be the next-generation technique for removal of arsenic from water. It is an economical and effective alternative to the existing membranes for drinking water. Perhaps, the public health problem in the north, east and north-east of India, caused by arsenic toxicity, could be solved with this new method.

[1]*J. Trace Elem. Med. Biol.*, **38**, 33–45

[2]*Chem. Engineering J.*, **304**, 259–270

Nano Alarms for CO Sensing

Carbon monoxide (CO) is formed as a result of the incomplete burning of fuels such as gas, oil, coal or wood. The gas is commonly found in our houses in central heating systems, boilers, water heaters, and next to open fire chimneys. Breathing increased levels of CO can cause poisoning. CO binds to haemoglobin in the blood forming carboxyHb that restricts the supply of oxygen to the tissues of the body, leading to nausea, dizziness, stomach pain, shortness of breath and even death.

The human body cannot sense CO because it is odourless, tasteless and is non-irritating. Hence, we need CO sensors in our homes and industries to prevent CO poisoning.

Researchers at the Institute of Chemical Technology, North Maharashtra University, in collaboration with the University of Mumbai, Maharashtra, have developed a nanocomposite sensor for CO by grafting the nanoparticles of cobalt oxide (Co_3O_4) in a polyaniline matrix (PANI), an intrinsically conducting polymer known for its modifiable electrical conductivity, low cost and ease of synthesis.

The method of synthesizing cobalt oxide (Co_3O_4) nanoparticles is easy. NaOH is added to cobalt chloride ($CoCl_2$) drop by drop under ultrasound. The cobalt hydroxide thus formed is sonicated, centrifuged, washed with water and rinsed with acetone. And you get 23 nm wide Co_3O_4 nanoparticles. These are then grafted in PANI and doped with hydrochloric acid to form the resulting nanocomposite, PANI/HC/Co_3O_4.

The researchers found that the biosensor efficiently senses carbon monoxide with a short response time of 40–45 seconds. Scientists say that the

sensor's response reduces under high humidity and they are trying to improve its performance under different field conditions. Despite this shortcoming, the biosensor can be used for homes and factories to prevent accidents and death due to carbon monoxide leakage.

J. Applied Polymer Sci., **133**(42), 1–8

Biosensor Identifies Suspect:
Bacteria that poison food

Food poisoning due to *Salmonella typhimurium* infection accounts for the maximum number of deaths from contaminated water and food. *S. typhimurium* is a category-B bioterrorism agent because the infection is rapid and, if untreated, fatal.

Researchers at the CSIR Institute of Microbial Technology, Chandigarh, have identified and purified a surface antigen protein, OmpD, specific to the *S. typhimurium* species. They immunised rabbits with purified OmpD protein and extracted the antibodies specific and non cross-reactive to other species of *Salmonella*. They then developed a biosensor by conjugating the OmpD-specific antibodies to a matrix that was composed of reduced graphene oxide on a screen-printed carbon electrode.

They tested the biosensor on contaminated litchi and orange fruit juice and found that it could detect *S. typhimurium* as low as 10 CFU per ml of bacteria.

The biosensor can be used for making clinical kits to detect *Salmonella typhimurium* contamination in food and water. It can also detect infection in patient samples with high specificity and sensitivity.

Biosensors & Bioelectronics, **85**, 707–713

Spices to Combat Cancer

Two of the most popular ingredients of spicy Indian curries – nutmeg and mace – are members of the *Myristica* spp. family. The other members of this family are used in Unani and Ayurveda medicines. In addition to their peculiar flavours, members of the family have antimicrobial, aphrodisiac, memory enhancer, psychotropic, hepatoprotective, anticancer, anxiogenic, and antidepressant properties. Screening and isolating the bioactive components from these plants may therefore lead to the discovery of useful drugs.

Researchers at the Central Drug Research Institute, Lucknow, and the Academy of Scientific and Innovative Research, New Delhi, in collaboration with the Jawaharlal Nehru Tropical Botanic Garden and Research Institute, Kerala, screened 21 compounds from *Myristica beddomeii* and *M. fatua*. They were successful in identifying five bioactive components.

Using Sulphorhodamine B assay which detects cell density and toxicity based on the response of a fluorescent dye, they tested the active compounds in five human cancer cell lines from lung, colorectal, prostate, pharynx and breast tissues. The results show that these compounds have anti-proliferative activity. Hence, they can be used to treat cancer – unregulated cell growth and division.

These compounds are natural and nontoxic and, thus, better alternatives to conventional cancer treatments such as chemotherapy. A series of animal testing and clinical trials is, of course, needed. So for the moment, we might have to depend on the *jaiphal* and *jaivatri* plant family merely as neutraceuticals.

Food Chemistry, **211**, 483–493

Healing Human Tendons
Insect exo-skeleton to rescue

Injuries to tendons, tissues connecting muscles and bones, result in joint pain and, in severe cases, permanent loss of function. The present treatments do not restore the tissue completely. This results in complications: joint stiffness, reduced strength and risk of repair rupture.

Jayakumar and his team of scientists from the Amrita Centre for Nanosciences and Molecular Medicine, Amrita University, Kochi, have designed an innovative scaffold that may provide a solution. They used poly (lactic acid) fibres, collagen and chitosan, a derivative of insect exoskeleton, in a hydrogel form to design a substitute of tendon and coated it with calcium alginate to prevent peritendinous adhesion. Tissue thus engineered was biocompatible, cost-effective and suitable for cell immobilization and encapsulation.

Spectroscopic studies indicated that the scaffold so formed contained a blend of chitosan and collagen. Microscopic studies confirmed porosity of the construct required for cell and nutrient infiltration. The mechanical strength of the construct increases with the layers of poly (lactic acid) fibres. The adsorption pattern indicated alginate coating on the scaffold prevented protein adhesion on the surface. High DNA retention on the scaffold confirmed progressive increase in cell concentration. Confocal microscopy showed cell passage through the scaffold layers, enabling efficient regeneration. Alamar blue was used to test cyto-compatibility and no toxicity was found.

Biodegradability rate was 50% after 21 days – ample time for the natural regeneration process. Thus, this tissue therapeutic may play an important role in regenerative and rehabilitation medicine.

Carbohydrate Polymer, **153**, 492–500

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