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 mauritiania*. 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.

Particuology, **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 travellers 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 $PM_{2.5}$ – particulate matter of aerodynamic diameter ≤ 2.5 μm – inside the vehicles using an Environment Particulate Air Monitor. They found that

exposure to $PM_{2.5}$ 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 collaboration 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

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