

Science Last Fortnight

Carbon Sequestration

Role of agroforestry

India released its National Policy on Agroforestry in 2014, the first of its kind in the world. The policy recognizes that incorporating trees in farmlands, along with crops, will increase productivity as well as aid in mitigating environmental issues.

That trees sequester carbon dioxide is well established. But how much carbon is sequestered by trees, especially in complex systems like agroforestry?

Twenty one scientists, from different institutions in India, came together to tackle this problem. They conducted a detailed survey in 26 districts of 10 different states in India, using two-stage random sampling. The average number of trees on farmers' fields was around 19 trees per ha. The team enumerated the available trees per hectare through complete survey and found that 32 tree species were predominant. The researchers grouped them into three categories: fast, medium and slow growing.

The scientists collected primary as well as secondary data on tree and crop components. They used some data like rotation length, wood density, carbon contents, incremental data, etc. from already published works. These data were used for the quantification of the carbon sequestered using a process based carbon estimation model. The net carbon sequestered, including the soil carbon sequestration, ranged from 4.28 to 24.13 Mg ha⁻¹.



Image: S. Suresh Ramanan

The team reports that the total biomass per unit of land was higher in the case of agroforestry systems than in monocropped farmlands. This is due to higher carbon sequestration. The re-

searchers also quantified the sequestration potential of existing agroforestry systems: 0.21 Mg C ha⁻¹ yr⁻¹.

The scientists claim that the agroforestry systems in the country can offset one-third of total greenhouse gas emissions from the agriculture sector and more than 6% of total greenhouse gas emissions at the country level.

This information is useful not only for farmers but also for planners and policy makers in negotiations related to climate change.

Agrofor. Syst., **91**(6): 1101–1118

Cheaper Source of Eugenol

Selection of a superior tulsi

Tulsi – *Ocimum sanctum* – is a sacred plant with several medicinal and therapeutic properties. The presence of eugenol in its essential oils contributes to its therapeutic potential. Eugenol is also used in perfumes, aromatherapy and as flavouring agent in the food industry. But how do we select the best accession for industrial application?

Last fortnight, Parmeshwar Lal Saran and a team of scientists from the ICAR-Directorate of Medicinal and Aromatic Plants Research, Boriavi studied the morphological and chemical characters of different accessions of tulsi.

The researchers selected 10 accessions from different regions of Gujarat, sowed the seeds, raised the plants and harvested the leaves. They extracted essential oils and examined their chemical composition using gas chromatograph–mass spectrometry, to separate liquid mixtures and identify the components. The team observed maximum eugenol content in DOS-1 – accession, collected from Mogar, Anand. Eugenol content increased with harvesting stages. However, younger leaves had lesser β -caryophyllene, a constituent of essential oils that reduces inflammation and neuropathic pain response.

The scientists studied the relationship between peltate gland and age of leaf at three stages of growth. They found that DOS-1 leaves contained maximum number of peltate glands in

all stages along with maximum dry leaf recovery.

Ocimum species grow in varied soil and climatic conditions. The crop can be harvested 90–95 days after planting and produces subsequent harvests at 60–65 day intervals. Examining the economics of cultivation, the scientists also found that it is cheaper to cultivate tulsi than clove, a major source of eugenol. Farmers can now start cultivating tulsi instead as it is more economical and herbal industries can use this cheaper source of eugenol.

J. Ind. Crop. Prod., **108**: 700–707

Pineapple for Health

Avoid insulin side effects

Insulin, a peptide hormone produced by the pancreas, regulates the metabolism of carbohydrates, which in turn helps maintain the sugar level in the body. When the pancreas fail to produce adequate insulin, as in Type-I diabetes, body sugar level can be maintained by supplying the hormone from outside. Due to the periodic surges in insulin level, such patients are prone to insulin deposition in the body. The deposition of insulin aggregates on the liver surface pose threats of improper liver functioning. Neuropathological symptoms may also develop.



Image: Wikimedia Commons

Sromona Das and Debasish Bhattacharyya from the CSIR-Indian Institute of Chemical Biology now suggest bromelain, an enzyme from pineapple, to tackle this problem. Bromelain is

extensively used for therapeutic purposes and has the ability to hydrolyse collagen, elastin, casein, fibrin and haemoglobin.

The researchers dialysed insulin exhaustively against water, added acetic acid and filtered the solution to obtain its monomer form. The monomeric insulin was diluted with hydrochloric acid and heated for three hours to initiate fibril formation.

In the meantime, they took the edible portion of ripe pineapple, ground and centrifuged it, to separate the juice. They mixed this juice with sodium phosphate to reduce its sticky nature and centrifuged it again. They ran the supernatant through a gel filtration column and assayed the fraction that contained bromelain for proteolytic activity. Then they digested the bromelain, separated the peptides and checked the molecular weight, to make sure that the fraction was indeed bromelain.

To study the effect of bromelain peptides on the formation and destabilization of insulin fibrils, the scientists added bromelain peptides to insulin fibrils after six hours. They withdrew small samples from the mixture at 12 hour intervals for observation under high resolution microscopes. And found that the fibrillar structures were being converted to oligomers of low molecular weight due to the activity of bromelain.

They re-confirmed this through many other tests and imaging procedures.

This finding can be used to develop a preventive treatment against insulin fibril formation in the body and commercialized at an affordable cost.

J. Cell. Biochem., **118**(12): 4881–4896

Pregnancy Disorder

Early screening technique

Preeclampsia, hypertensive disorders of pregnancy, is an obstetrics problem commonly encountered during the second trimester of pregnancy. If untreated, it leads to severe eclampsia – convulsions, coma and death. It is the major cause of maternal and foetal morbidity and mortality. The aetiology of the disease remains unknown and there is no good biomarker for early

diagnosis of the problem. Available biomarkers – single or combination – exhibit only 73% sensitivity.

A team of researchers from the Lady Hardinge Med College and Hospital in collaboration with the Indian Council of Medical Research, New Delhi, recently reported a placental growth factor as biomarker in the Asian population for the early detection of hypertensive disorder of pregnancy. The team found that the placental growth factor is a better marker than pregnancy associated plasma protein A and biophysical parameters.

The researchers considered a combined model of maternal factors, plasma protein A and a uterine artery pulsatility index, and found 73% sensitivity towards detection. When the placental growth factor biomarker was considered with the combined model, they recorded 91% increased sensitivity for detection and 35% false positive results.

Reflecting on these facts, the researchers stated that placental growth factor is a better marker than plasma protein A and biophysical parameters.

Further studies are required to investigate the specific role of biophysical parameters when placental growth factor is used as biomarker.

Int. J. Gynecol. Obstet., **139**(3): 301–306

Sewage Treatment

Increases antibiotic resistance?

Antibiotic resistance is a global health concern. Indiscriminate use of antibiotics is the primary cause. Antibiotics are not always metabolized completely and are excreted with faeces. This creates a selection pressure for the proliferation of resistant bacteria. Existing sewage treatment plants cannot eliminate residual antibiotics. In fact, it is reported that there is a higher abundance of *Escherichia coli* resistant to ciprofloxacin and cephalothin in treated effluent than in raw sewage.

Recently, scientists from IIT Delhi studied antibiotic resistance in microorganisms from Delhi's sewage treatment plant effluents. They collected samples from 12 sewage treatment plants, two of which have chlorination units and anaerobic digesters.

The scientists found *E. coli* and *Pseudomonas aeruginosa* in abundance. These bacteria are commonly associated with diarrhoea and pneumonia, and are among the top ten causes of death in India. They examined the presence of extended-spectrum β -lactamase, an enzyme that confers resistance on most β -lactam antibiotics and carbapenem-resistant bacteria. Both species showed resistance to extended-spectrum β -lactamases and carbapenem. The scientists found that sewage treatment plants with chlorination units and anaerobic digesters performed better and had significantly less antibiotic-resistant bacteria.

These findings go against the belief that treated water is safer: in fact, it becomes more dangerous. Continuous monitoring of sewage plant effluents and improvement of treatment technologies are solutions to prevent the increase of bacterial resistance. Use of antibiotics needs to be regulated to reduce the disease burden in the country.

J. Chemosphere, **188**: 249–256

Bamboo Charcoal Nanocomposites

Removing dyes from wastewater

Dye molecules in wastewater from industries pose environmental issues. Photodegradation of organic dyes using nanomaterials in the presence of sunlight is emerging as an innovative solution to the problem.

Last fortnight, Nithiyadevi and Ravichandran, from the AVVM Sri Pushpam College, Thanjavur, reported enhancing the photocatalytic activity of ZnO : Ag nanoparticles using bamboo charcoal.

The team prepared ZnO : Ag/bamboo charcoal nanocomposites using a soft chemical method and studied their photodegradation performance in comparison with pure ZnO : Ag nanoparticles.

The scientists used photoluminescence spectroscopy – an effective tool to evaluate surface defects of the synthesized samples – and found uniform dispersion of ZnO : Ag nanoparticles on the bamboo charcoal. Moreover, there are no traces of nanocomposite agglomeration on the sample surface.

They also measured the photodegradation of methylene blue and malachite

green dyes by the ZnO : Ag/bamboo charcoal nanocomposite. The scientists recorded a photodegradation efficiency of around 95% for both dye samples after 45 min of solar irradiation.

They also tested the antibacterial activities of the samples against *Staphylococcus aureus* and *Escherichia coli* bacteria. They observed improved antibacterial activity of the nanocomposite.

The scientists claim that the ZnO : Ag/bamboo charcoal nanocomposite is a promising photocatalyst to deal with harmful organic dyes and, since the material doubles up as an antibacterial agent against microorganisms, it can be used in wastewater treatment. They suggest that the properties are mainly due to the presence of a natural adsorbent, bamboo charcoal.

Bamboo charcoal is an easily available raw material that helps hold the nanoparticles. Thus, it improves photodegradation efficiency. This report can be used to develop a cost effective material for the degradation of water contaminants.

Acta Metal. Sin-Engl., **30**: 1249–1256

Bifunctional Peptide Gels

Oil spill and wastewater management

Effluents, especially oil and textile dyes, are major pollutants affecting water ecosystems. Though the water is treated partially, toxic sludge remains a challenge. Recently, gel-based systems for wastewater treatment have emerged as material for water treatment. They are gaining attention due to their efficiency, high sensitivity, water permeability and reusability. Such gelators are gel-based assemblies of polysaccharides or peptides.

Scientists from the Indian Association for the Cultivation of Science, Kolkata in collaboration with the University of Reading, United Kingdom now report a peptide gelator with bifunctional property to bind to organic dyes and oil spills. The researchers synthesized an amphiphilic peptide gelator P, comprising 9-fluorenylmethoxycarbonyl coupled to 12-aminododecanoic acid and alanine. With the help of Fourier transform infrared spectroscopy, small angle X-ray scattering and field emission scanning

electron microscopy, they interpreted the structural arrangement and molecular packing of gelator P in assembled state.

Using UV-Vis spectroscopy, they characterized the dye absorption ability of P against Acid black 1, Congo red, Direct red 80, Malachite green and Rhodamine B. Gelator P had good removal efficiency towards all dyes tested, irrespective of cationic or anionic nature.

By phase-selective gelation, P is also effective to gel out diesel, petrol and pump oil from a water–oil mixture. Recovery of dye bound P was possible after three cycles of dye removal.

Peptides gelators are biocompatible and environmentally safer remediation systems. This study recommends the biomaterial gelator P as a cost-effective starting material for wastewater treatment. The textile industry and oil spill recovery organizations will benefit from such ambidextrous, biocompatible and bifunctional gelator reclamation systems.

Interface Focus, **7**: e20160128

Analysing Rainstorm Events

Predict rainfall, prevent floods

Extreme rainfall can cause severe floods and destroy lives. Increased human activities, leading to rise in global temperatures, have impacted rainfall events. In the last century the frequency of occurrence of rainstorms over India shows an increasing trend. Predicting rains to prevent flood risks has become crucial.

Last fortnight, scientists from the Sri Venkateswara University, Tirupati, the Ministry of Earth Sciences and the National Centre for Weather Forecasting, New Delhi collaborated to evaluate various models for weather prediction in India. The team performed a global ensemble data analysis using THORPEX, a system research and predictability experiment for three weather forecasting models: the European Centre for Medium-Range Weather Forecasts, the National Centre for Environmental Prediction and the UK Met Office.

The researchers took data sets from 15 rainstorm events for the period 2007–2015. They analysed the data for

the spatial distribution and intensity of the rainstorm events. The team also studied various statistical parameters such as mean error, root mean square and correlation coefficients to compare these models.

They found that the spread is large in the European Centre for Medium-Range Weather Forecasts and UK Met Office models, followed by the National Centre for Environmental Prediction model. The comparison also revealed that rainstorm events are predictable up to five days in advance.

The scientists claim that this is a new milestone in atmospheric research. Such comparisons of existing systems can also form the basis for designing new and more efficient models.

Atmos. Res., **198**: 194–204

Biodegradable Food Packaging

Food packaging enhances and protects food all the way from the processing stage, through storage, to the final consumer. Without packaging, materials handling would be messy and inefficient. In the last decade, new forms of food packaging have not only increased the shelf life of foods, but also their safety and quality. Antimicrobial packaging is one such innovation.

Recently, a research team from the CLRI, Chennai; AC&RI, Madurai and RVS Agriculture College, Thanjavur developed a new material for food packaging using the combinatorial effect of sustainable and biodegradable natural antimicrobial compounds.

The scientists created the new environment friendly food packaging by fortifying natural chitosan-based composite film with basil oil that has antimicrobial and antioxidant properties. The team evaluated the antifungal effect of the composite film with a poison plate technique using four important food pathogenic fungi – *Aspergillus niger*, *Aspergillus flavus*, *Fusarium* sp. and *Penicillium* sp. They found that the film inhibited pathogenic fungal growth at 0.1% concentration. The researchers also studied its thermal stability using thermogravimetric analysis and the smooth morphology of the composite films with scanning electron microscopy.

The chitosan used in the study came from *Loligo duvauceli* pens. Since the squid pen obtained from *Loligo duvauceli* were wastes from the food processing industry, the films also proved economical.

The researchers claim that this new eco-friendly packaging could provide food safety and minimize the need for chemical preservatives. The reduced risk of spoiling makes it amenable for various food packaging applications.

Food Measure, **11**: 2160–2170

Muting Mycobacteria

Epigenetic regulation

Epigenetics is a modification of genome, without changing DNA sequence, to switch off or switch on genes that are necessary to deal with environmental changes. Epigenetic changes are important for survival. However, little is known about such modification of genetic expression in bacteria.

Take tuberculosis, for example. This devastating disease is caused by *Mycobacterium tuberculosis*. To deal with the pathogen, we need to understand how epigenetic modifications help

overcome stresses within the human body. We know that a part of the genome of the bacteria is packed together with histones, a class of proteins, and are not expressed while a part of the genome is more open to translation to RNA. What are the molecular processes that lead to binding of histones?

Nagaraja and others from the Indian Institute of Science suspected that a histone-like protein, HU, plays a major role in the gene regulation of mycobacteria. From their experiments, they observed that HU is essential for bacterial growth. They also noticed that HU is acetylated at specific sites by enhanced intracellular survival protein, Eis. Acetylation of HU decreased its binding to DNA and relaxed the chromatin structure, making the genes at that site accessible for translation.

They discovered that another protein, Rv1151c, removes the acetyl group from HU. They also confirmed that the deacetylation of HU changes its DNA binding and leads to the formation of bridged compact structures of the bacterial chromatin, making that part of the genome inaccessible for translation.

Rv1151c is the only Sirtuin information regulator 2 like protein in mycobacteria. Sirtuins have been seen to have antiaging action in higher animals. The researchers claim that this is the first report showing that Sirtuin deacetylates a histone-like protein from mycobacteria.

They say that epigenetic regulation of HU might equip the pathogen for survival. Understanding epigenetic regulation of mycobacteria will help develop drugs to control the pathogen in this era of antibiotic resistance.

Biochem. Biophys. Res. Commun., **493**: 1204–1209

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