

Science Last Fortnight

Making Artificial Rain

Artificial rain is a solution for drought. Such rain can be initiated by seeding clouds with external agents. Cloud seeding was done in Tamil Nadu, Karnataka and Maharashtra during droughts in the past.

Clouds consist of very small water droplets. For precipitation, these droplets need to grow through condensation and coalescence. About one million cloud droplets, usually 0.001 mm or less, stick together to form a single raindrop. Generally, the process is slow and takes about one day to reach full development. Cloud seeding alters microphysical processes within clouds and serves as nuclei for condensation to elicit precipitation from clouds.

Recently, scientists from the Banaras Hindu University proposed a nonlinear deterministic mathematical model, for artificial rain using aerosols. In the modelling process, they considered three dynamic variables: density of cloud droplets, density of raindrop and concentration of conductive aerosols.

Cloud droplets are continuously formed at a constant rate but conversion into raindrops does not take place in the same proportion. Artificially introduced aerosols increase the rate of formation of raindrops from cloud droplets. These aerosols are introduced in the regional atmosphere at a rate proportional to the density of cloud droplets. Any excess would be harmful to the environment.

The researchers analysed the model using the stability theory of differential equations in deterministic as well as stochastic environments. They did numerical simulations to see the effect of important parameters on the process leading to rainfall.

The team found that if the natural rate of raindrop formation is low, seeding is effective. However, without cloud growth, rain soon stops.

The scientists say that precipitation is not a closed chamber experiment and the movement of gases is unpredictable. So, it is necessary to involve

environmental noise in the study, to deal with the real situation. This tends to make artificial rain as unpredictable as natural rain.

Phys. A, **505**: 1113–1126

Bacteria for Bioethanol

Isolate from a Himalayan hot-spring

In the Leh district, in the North West Himalayas, there is a hot spring at Chumathang, at an altitude of nearly 4000 m. From this hot spring, Indian researchers recently isolated a bacterial strain that promises to be a game changer in bioethanol production.

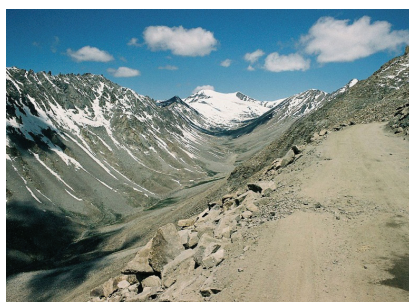


Image: Wikimedia Commons

Ethanol is easily produced from six carbon sugars – hexoses – such as glucose and more complex sugars such as sucrose or even starch. But, when it comes to ethanol production from agricultural waste, such as rice straw, pentoses – five carbon sugars – pose a problem. Researchers from the Centre for Advanced Bioenergy Research, Faridabad recently isolated a bacterial strain from the hot spring that can break down pentoses to produce ethanol. In collaboration with Australian scientists, the team demonstrated the ability of the strain to ferment both hexoses and pentoses.

The researchers collected samples of multi-layered sheets of bacteria from the submerged surface of the hot spring. From these samples, they isolated a subtype of bacteria that proliferate in the absence of oxygen. This bacteria was then tested for its ability to ferment rice straw.

The team collected rice straw and treated it with dilute sulphuric acid in a continuous pilot-scale biomass

plant to disintegrate the lignocellulosic matrix. Then they centrifuged this biomass slurry to separate the residual mass of cellulose and pentose-rich liquid fractions. After determining the composition of the liquid using high performance liquid chromatography, the researchers introduced the bacteria.

Experiments indicated high ethanol production by the bacterium from the pentose liquid.

This isolate can directly and simultaneously pick up and ferment pentose and hexose sugars in waste streams to produce ethanol. So the process is cost-effective, say the scientists. This research finding can be used to produce bioethanol industrially and thus reduce fossil fuel consumption.

Biomass Bioenergy, **116**: 122–130

Microbial Fuel Cells

Bacteria at work

Microbes are wizards. Experts in evolving from drugs, they are also tireless hard-workers. Give bacteria waste matter and they decompose it using their metabolism. The chemical energy released is a potential source of electrical energy.

This caught the attention of Sunil Patil, a microbiologist from the IISER Mohali. Along with collaborators from China, he designed a miniaturised microbial fuel cell. The fuel cell uses cultures of bacteria to generate electrons by oxidising organic matter. These electrons then migrate towards the anode chamber, made of carbon black. Parallel to this, hydrogen ions from water pass through a membrane to reach a separate cathode chamber. The electrons, flowing to the cathode, mix with hydrogen ions to produce an electric current.

The production of electricity in microbial fuel cells is self-sustaining. As long as you feed the substrate, the microbes will keep breaking down organic matter. But a crucial part of making this work is the cells' cathode design. Conventional microbial cells use an air-cathode, where oxygen is

supplied by self-diffusion. This limits the oxygen supply which lowers the current produced.

Patil and team used a hydrogel electrolyte made of sodium polyacrylate, a super-absorbent polymer. This electrolyte initiates capillary action, similar to transpiration in plants. The setup ensures a regular supply of oxygen. And the substrate solution could be continuously fed to the cell without applying extra power.

The microbial cell clocks a stable voltage generation of 0.55 V. The team is hopeful that the auto-feeding mechanism will further the power density produced from the fuel cell. Soon, the microbial fuel cells will be ready for commercial use.

Appl. Energy, **225**: 934–939

Fighting DNA damage

Tulsi seed extract

Tulsi, *Ocimum tenuiflorum*, is known to have medicinal properties. However, the bioactive phytochemicals of the seeds have not been investigated. Now, Sukhvinder Singh Purewal and team from the Chaudhary Devi Lal University, Sirsa in collaboration with Kawaljit Singh Sandhu, from the Maharaja Ranjit Singh Punjab Technical University, Bhatinda report evaluating bioactive compounds from *O. tenuiflorum* seeds.

They used ethanol, methanol, acetone and chloroform to extract phytochemicals from tulsi seeds and investigated the antioxidant potential, and DNA damage protection activity of the extracts.

The team reports that the antioxidant potential of the methanol extract is the highest. The least activity was found in the acetone extract.

Qualitative tests using High Performance Liquid Chromatography showed the methanol extract contained pharmacological compounds such as gallic acid, cinnamic acid, catechol and ascorbic acid.

The team investigated DNA damage protection activity with a plasmid pBR322 model, as well as with the standard quercetin, and found that the methanol and acetone extracts provide protection against DNA damage.

'Tulsi seeds are a good source of antioxidants', says Sukhvinder Singh Purewal.

Pharmacologically bioactive compounds could be used to prepare various pharmaceuticals and food products. 'Tulsi seed flour, for example, can be used to make pharmaceuticals and food products', says Kawaljit Singh Sandhu.

J. Food Meas. Charact., **12**(3): 1530–1538

Camptothecin Production *in vitro*

Hope for cancer patients

Camptothecin is a plant derived drug, approved for treating cancer. However, this natural alkaloid is not abundant enough to meet increasing demand. So, such cancer treatment can come at great cost and even threaten family sustainability. Researchers are, therefore, searching for new sources for the compound and ways to increase productivity.



Image: Vinayaraj via Wikimedia

Ophiorrhiza mungos var. *angustifolia*, an herb of the coffee family, found in the Western Ghats, was recently reported to produce camptothecin, especially in the roots. Exploitation of the plant for treating cancer can lead to extinction of the threatened species. To conserve natural resources, a team from the University of Kerala and the Jawaharlal Nehru Tropical Botanic Garden and Research Institute, Palode attempted to produce camptothecin under *in vitro* conditions.

First, the group cultured nodes and shoot apices of the *Ophiorrhiza mungos* var. *angustifolia* in a tissue culture medium. They supplemented the medium with different concentrations of growth regulators to increase shoot formation. Thus, they could produce about 20 shoots in three

weeks from a single node. The team needed only minimal concentrations of growth regulators. These shoots developed into whole plants in 45 days. The level of camptothecin recorded in the roots of these plants was higher than that in the naturally grown plant.

The team then treated the shoots with methyl jasmonate, salicylic acid and chitosan, to trigger camptothecin production. And found that methyl jasmonate induced a five-fold increase in camptothecin in the shoots!

The team has, thus, demonstrated the potential of *in vitro* culture in scaling up camptothecin production. The next step is to understand the genes responsible for enhanced production, say the scientists.

The research opens up new opportunities for pharma companies involved in producing camptothecin. The technology ensures a continuous supply of the compound and a substantial reduction in costs, making it more affordable for patients.

Industrial Crops Products, **119**: 64–72; 93–101

Contact Lenses Deliver Drugs

Treating conjunctivitis

Conjunctivitis is treated with a high dose of antibiotics through eye drops. However, this mode is ineffective due to poor drug availability and required frequent dosing. Thus, better ways to treat microbial conjunctivitis are being researched.

Contact lenses are being explored for delivering drugs for conjunctivitis. However, the method of incorporating formulations affects the optical qualities of the lenses.

Recently, scientists from the Uka Tarsadia University, Surat collaborated with researchers in the US to design contact lenses for sustained drug delivery. The team developed drug coated lenses using two different approaches to select a more effective way to deliver drugs.

They fabricated two semi-circular acrylate rings, one with hyaluronic acid, a common ophthalmic agent used for water retention, and another with varying concentrations of moxifloxacin HCl – a broad spectrum

antibiotic. Then, they implanted these two rings in the periphery of the contact lens.

'This helped enhance optical transparency with clear vision for patients' says Furqan Maulvi, Maliba Pharmacy College, Surat.

The team also tested contact lenses soaked in hyaluronic acid and moxifloxacin HCl.

'There was not much difference in the swelling behaviour – a critical parameter determining the shape of the lenses after wearing – of the drug loaded lenses compared to control. However, the optical transparency of drug loaded lenses was higher in implanted lenses than in soaked lenses' says Dinesh Shah, Dharrnsinh Desai University.

The team compared drug levels in the contact lenses and found that implanted lenses contained an optimum level of drugs, compared to soaked lenses. They say it was due to the uneven absorption of drugs into the lenses while soaking.

As wet sterilisation – an essential process to prevent eye irritation and infection – of drug loaded lenses resulted in leaching of drugs, they sterilised the lenses using UV-B radiation.

The scientists analysed the surface smoothness of the lenses using an atomic force microscope and found that the implanted lenses were much smoother than commercially available contact lenses.

The team detected an increased drug release of up to 96 h from implanted lenses, much more than in the soaked lenses *in vitro*. The *in vivo* experiments on rabbit showed sustained release of moxifloxacin HCl in tear fluid from the implanted lens group.

Finally, the scientists studied the effect of these lenses on conjunctivitis induced by *Staphylococcus aureus*. A single implant contact lens was adequate to cure the disease compared to the eye drop therapy which requires frequent dosing. It thus appears that this semi-circular ring implanted contact lens could be an effective platform for sustained ophthalmic drug release.

Int. J. Pharma., **584**: 139–150

Burma Neem

A native fast growing tree

Burma Neem, *Melia composita* Willd., thrives under a range of climates. It is a good alternative for making plywood and furniture. However, the drying and seasoning properties of *Melia composita* wood have not been adequately investigated.



Image: S. Suresh Ramanan

Recently, a team from the Forest Research Institute, Dehradun developed a kiln-drying schedule. They estimated density and shrinkage properties following the Bureau of Indian Standards for testing small specimens. They used a 2 × 2 × 6 cm wood sample from a 7-year-old *M. composita* tree. After drying the samples in an oven, the researchers computed the weight to volume ratio to estimate wood density. They calculated shrinkage percentage in the radial and tangential planes by changes in the dimensions of the wood samples after drying.

To determine the drying schedule, the team converted the round wood logs into 50 × 10 × 2.5 cm flat wooden planks. They oven dried the samples till constant moisture content was attained. After about two hours, they examined the samples for end crack defects due to drying. Once the drying was complete, they examined inside planks for deformation and splits or cracks formed inside the wood, by cross-cutting the samples. The team scored the planks based on the occurrence and degree of such defects.

On the basis of the established relationship between the time needed to reduce moisture content to 1%, and the actual kiln drying period, as well as the relationship between actual kiln-drying time and the differ-

ence in wet and dry bulb temperature, the researchers framed a tentative drying schedule.

The low density of the wood, the scientists found, correlates with reduction in drying defects. Overall, the team concluded that Burma Neem wood is suitable for fast drying.

Burma Neem is a fast-growing indigenous tree, and from the results it appears that it may be useful for furniture industries.

J. Forest Res., **29**(5): 1435–1442

Managing Municipal Solid Waste *Sustainable solutions?*

Municipal solid waste is disposed off in open dumps and landfills, endangering health and environment. Researchers suggest using anaerobic digestion, composting, incineration and gasification – processes that produce electricity and fertilisers while reducing the threat. But which process should the municipality adopt?

Recently, Prasenjit Basak and Arashdeep Singh from the Thapar University, Patiala used an industrial ecology approach to analyse the problem. In this approach, industries are organised in a network of input–output relationships, as naturally happens with species in an ecosystem.

The team ecologically and economically evaluated different strategies from different countries.

Gases from landfills decrease over time. For a capital cost of about 120 million rupees and a maintenance cost of 0.7%/year, the system only absorbs 500 tonnes/day.

Anaerobic digestion produces biogas for electricity and reduces waste by 70%. And the remaining digestate is fertiliser. But capital and maintenance costs are high.

Composting reduces waste by 50%. The end product is biofertiliser. And capital and maintenance costs are low.

Gasification of refuse-derived fuel from waste produces electricity. And reduces waste by 90%. Capital and maintenance costs are slightly more than for landfills but less than for all the other processes.

In incineration, up to 80% can be recovered as heat energy.

The researchers note that landfills and gasification are cheaper but gasification and incineration rapidly reduce waste by 90%.

The team then analysed the pros and cons in various plants in Punjab. They report that organic waste is suitable for anaerobic digestion and compost. What remains can be fed into incineration and gasification.

For dry waste, gasification is most appropriate: it reduced acidification, photochemical oxidation and eutrophication. It also reduced sulphur and carbon emissions and was more effective than incineration.

For processing wet waste, anaerobic digestion is the best method. The team observed that anaerobic digestion and composting released less greenhouse gases.

The researchers observed that the product of each process depends upon the amount of waste processed and the efficiency of a particular technology.

'For sustainable development, combine waste processing technologies, based on the amounts of dry and wet wastes', says Prasenjit Basak.

J. Clean. Prod., **195**: 10–20

Circular Economy

A sustainable business model?

As population grows, so does dependence on natural resources. Resources are dwindling. The planet can no longer support 'take-make-dispose' industrial models.

To restore balance, researchers propose a circular economy. Here, resource input, waste production and energy leakage are minimised. A circular economy suggests slowing, closing and narrowing energy and material loops to allow the system to regenerate.

Researchers from the Institute for Competitiveness, India and the Grenoble Ecole de Management, France examined how feasible circular economy would be in India. With 17% of global population, India has a

well-balanced population pyramid. The researchers evaluated the business models of three companies, Goonj, Attero and HaathiChaap, as case studies.

HaathiChaap, based in Rajasthan, makes paper products out of elephant dung. The manure is disinfected, dried, beaten to pulp, and drawn to sheets of paper. Water from the treatment is used as fertiliser. Elephant dung has, thus, created employment opportunities for tribal communities in the region. The researchers laud HaathiChaap for removing taboos associated with using animal waste.

Goonj, a Delhi-based NGO, collects unused clothes, sorts and distributes them to weaker sections. Goonj also trains women from rural communities to make sanitary pads and mattresses with unused clothes – a parallel economy for weaker sections, drawing resources from urban communities. The researchers found Goonj successful in creating a trash to cash system.

Noida-based Attero is an electronic waste management enterprise. Tonnes of electronic waste go untreated in India. Attero extracts metals of value from waste. The metals are then used as raw material in the electronic industry. Attero has also launched an online platform to directly sell refurbished products. With Attero, the researchers identify efficient management of waste.

The researchers highlight the importance of entrepreneurs in value creation and value delivery. For a more sustainable future, industries would do well to adopt circular economy models.

Thunderbird Int. Bus. Rev., **60**(5): 729–740

Active Learning Classrooms

Multi-station exercises

Problem-based learning has long been used for medical education. But when student count increases, active learning becomes a challenge.

Last fortnight, scientists from the Mahatma Gandhi Medical College and Research Institute, Puducherry

reported a strategy that effectively combines problem-based learning with team-based learning, to allow learners to develop problem-solving and critical thinking skills within a team environment.

They planned structured exercises for a module on 'Blood and body fluids', a topic already covered by lectures.

Two hundred and fifty students were divided into six groups. Each group was then sent to six different stations to solve problems related to anaemia. At every station, the group was further divided into teams of seven. The teams were supervised by an expert faculty member. After a 15-min task, students moved to another station. A session was also planned to obtain reflections and feedback from the students and teachers.

The students were then assessed, and the results were compared with those of the previous year's batch, with the same number of students. These students were also given the same duration for writing the test and were taught by the same faculty members. Comparisons showed that the batch which attempted the exercises had fewer unanswered questions and scored significantly higher than their seniors.

The researchers attribute this to active learning exercises that combine the strengths of team-based and problem-based learning. They say that the method could help institutes with large class size and offer an alternative to traditional lectures.

Adv. Physiol. Edu., **42**(3): 424–428

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