Current Science Reports

Riverbed Sand

Replacing silica sand?

Silica sand has high thermal stability and maintains its shape even at high temperatures. So, it is used as a mould for casting iron, nickel, aluminium and copper. There is an increasing demand for silica sand by glass, ceramic, and other industries. In the last five years, the cost of silica sand rose by nearly 80%. For foundries in Odisha, the cost of transporting silica sand from Allahabad adds to the total expenditure. Why can't we use sand from riverbeds for sand mould casting?

Ramesh Kumar Nayak and Jatin Sadarang, Maulana Azad National Institute of Technology, Bhopal decided to investigate. They collected sand from the Mahanadi River near Cuttack and commercially available silica sand to compare.

Sand particle size determines the smoothness of the metals moulded. So the researchers checked grain sizes.

Riverbed sand particles were coarser – more than double the size of silica sand particles.

'But the size was within the acceptable range for foundry standards,' says Jatin Sadarang.

So the duo examined the sand's chemical composition.

Riverbed sand had lower silica content, about 80%, compared to 98.5% in silica sand. Aluminium, iron and tin contents were higher. But these, too, were within the range of acceptance.

The researchers then checked if the sand could withstand high temperatures. X-ray diffraction at different temperatures showed a change in silica peak at 1200 Celsius. Silica sand showed no significant change.

The researchers were undeterred. They decided to determine the fusion point of riverbed sand to understand its suitability.

For casting ferrous alloys, the melted metal at a high temperature of about 1350–1500 Celsius is poured into the mould.

The researchers heated both types of sand to 1350 Celsius. Riverbed sand fused. But there was no fusion in silica sand. This was disappointing.

Perhaps riverbed sand could be used for casting nonferrous alloys such as those of aluminium. The researchers checked.

For mould preparation, bentonite clay and coal dust is mixed with sand. Moisture is also an important factor.

The researchers optimised the mould ingredients using riverbed sand. For casting, 5% moisture, 11.5% bentonite clay and 3.5% coal dust gave the best results.

The duo prepared moulds from both types of sand to cast a cube-shaped aluminium alloy. Melted aluminium alloy was poured into the mould at around 700 Celsius. After the metal solidified, the researchers broke the moulds and evaluated the roughness, hardness and microstructures of the alloy.

Surface roughness and hardness were slightly higher in the alloy made in moulds from riverbed sand. But the microstructures were fine and uniform in the cast alloy.

'Riverbed sand can be an alternative to silica sand for non-ferrous alloy casting,' says Ramesh Kumar.

This solution to the problem faced by foundries opens up another problem. It signals another reason for regulating sand mining from riverbeds.

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Jhum for Sustainability

Agrobiodiversity in Garo Hills

Jhum, slash-and-burn rotational cultivation, is practiced in Meghalaya's West Garo Hills district, home of the matrilineal *Garo* tribe. In the wake of monoculture plantations spreading across the region, is it good to continue indigenous methods like *Jhum*? How does it impact biodiversity and the food diversity of the *Garo* tribe?

Researchers from the Central Agricultural University, Manipur and two ICAR institutes recently investigated the issue.

The team surveyed nearly a hundred households from four villages in the district to understand the dietary diversity among the *Garo* people,

The researchers obtained information on the diversity of food crops, livestock, and food sourced from the wild through gathering or hunting, along with data on land use, farming practices, etc.

The land is community-owned, where the village chief oversees agricultural activities. There was a diversity of crops cultivated including pulses, vegetables and spices. The most consumed food was maize, rice, banana and jackfruit. Chicken was the most consumed meat, followed by cattle, pigs and goats. The team found that food sourced from the wild constitutes a major portion of the diet.

'Fresh bamboo shoots were the most common. The underground rhizome is abundant, easily accessible and survives fires during *jhum*,' says Shantanu Kumar Dubey, ICAR-Agricultural Technology Application Research Institute.

'The diversity of the *Garo* people's ethnic cuisine is dependent on *jhum* cultivation. So, retaining areas under the traditional land use may play a big role in preserving the diversity in diet,' says Dileep Kumar Pandey, Central Agriculture University, Manipur.

'A major threat to this system is the rapid shift to monoculture plantation crops such as rubber, oil palm, and cashew,' says Kalkame Ch Momin, his colleague.

From 2000 to 2015, the area under *jhum* cultivation reduced to about 10% due to state policies.

'We already see a shift in food preferences. White rice and flour are gaining popularity over traditional coarse grains like millet and buckwheat. Potato chips, noodles and soft drinks are replacing traditional snacks,' says Poovaragavalu Adhiguru, ICAR, New Delhi.

In the attempt to balance ecology and economy, should we not factor in the sustainability of food diversity and culture?

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Silvi-medicinal Agriculture

Poplar and mint

Since the 1980s, poplars became a popular choice for agroforestry in the Indo-Gangetic region. Poplars are fast growing exotic trees and provide the maximum income in a short period. However, the price volatility of poplar wood is discouraging farmers from investing in new plantations. Can we make poplar plantations more profitable?

Manendra Singh and team at the G. B. Pant University of Agriculture and Technology, Uttarakhand knew that mint is extensively cultivated in the region for highly valued menthol. And, from February to July, mint and poplar can be intercropped with two harvests.

Image: Kham Tran via Wikimedia Commons

To investigate the interaction of mint with poplar when intercropped, the scientists decided to study the growth, yield and economics of silvi-medicinal forestry.

They selected a five-year-old block plantation of poplars with a 7 by 3 metre spacing. And planted root suckers of four different mint varieties in a line spacing of 50 centimetres, within the interspaces of the poplar plantation. For comparison, similar mint cropping was done in an open field.

After planting the mint, on days 60, 100 and 150, the team recorded plant height and number of branches.

Both were lower in the poplar-based plantation than in the open field. This could be due to the competition between the two species and the shade of the poplar canopy.

The researchers calculated the biomass, oil yield and content of all the mint varieties. The CIM Kranti variety of mint had higher biomass, oil yield and oil content per hectare.

But what is the effect of intercropping on poplar?

The researchers recorded the height, diameter at breast height and volume of forty poplars at the site, during sowing and after the second harvest of mint. There was a considerable increase in all the parameters.

After considering expenditure on land preparation, planting material, fertilisers, weed and pest management, and irrigation and harvesting, the researchers calculated the benefit from the total gross return from mint and poplar intercropping. The benefit–cost ratio for the model was 1.21.

Intercropping poplar with mint can generate more than one lakh rupees per hectare per year, claim the researchers.

So far, agroforestry has focused on selecting the right trees to grow among crops. This study signals a paradigm shift by selecting the right crop to grow in tree plantations.

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Improving Apple Wine

Enriching with phenolics

Himachal Pradesh is the main apple producing state in India. When there is a glut, farmers suffer losses as prices drop. Though producing apple juice improved the situation somewhat, it was apple wine that opened a new horizon.

The Dr Y. S. Parmar University of Horticulture and Forestry, Solan had taken a lead in standardising apple wine production. Researchers from the university continue to work on improving the quality.

Unlike grape wine, apple wine does not have high amounts of phenolics. It does not have the same nutraceutical quality to reduce free radicals. Why not add phenolics from tea to improve apple wine?

The quality of wine depends on the amount of sugar, nitrogen, sulphur, tea, the yeast strain used and the inoculum concentration. The researchers decided to optimise the parameters and standardise the quality.

They extracted juice from apples and added different amounts of apple juice concentrate to vary the sugar content. They also varied the amount of potassium metabisulphite, the source of sulphur, and diammonium hydrogen phosphate, the source of nitrogen. The amount of CTC tea, known for high phenolics content, was also varied. The yeast strain used was the *ellipsoideus* variety of *Saccharomyces cerevisiae.*

The process was simple: Boil tea leaves in water for three to four minutes, add apple juice, followed by apple juice concentrate, diammonium hydrogen phosphate, potassium metabisulphite to kill any microorganisms, pectinesterase for clarification, and, finally, the yeast inoculum. Incubate at 24 degrees Centigrade to allow fermentation.

The researchers monitored the rate of fermentation and other variables in the samples.

The initial concentrations of tea, sugar and inoculum affected ethanol concentration. But increasing sugar and tea concentrations beyond critical levels increased the production of higher alcohols, which can trigger hangovers. Sulphur concentration impacted volatile acid content. So did nitrogen.

Ten trained volunteers judged the wine on a 9 point hedonic scale to identify the best sensory perception.

Using all the data gathered, the researchers modelled the optimised ingredients: 4 grams of tea for 100 millilitres of apple juice, 20 degrees Brix of total soluble solids, 2% diammonium hydrogen phosphate, 100 parts per million potassium metabisulphite and 5% inoculum.

The researchers hope that the industry will pick up the recipe.

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Targeting Mitochondria

Future of cancer treatment?

Scientists have recently established a link between cancer and mutations in mitochondrial DNA. So, targeting mitochondria in cancer cells is a potential therapeutic strategy.

Recently, scientists from IIT Gandhinagar engineered a nanoparticle for the purpose. They chose cholesterol, the main constituent of cell membranes, and conjugated it with succinic acid. Such conjugates have been used

earlier for nanodelivery as they can cross cell membranes.

To localise the nanoparticles in subcellular mitochondria, the researchers attached triphenylphosphine.

This made the particle positively charged, a property that is useful to target mitochondria.

To this conjugate, the researchers attached cisplatin, an anticancer drug that stops tumour growth by cross-linking guanine bases in DNA double-helix strands.

To this complex conjugate, they attached another anticancer drug, camptothecin, which binds with DNA topoisomerase to stop transcription. They also attached tigecycline, an antibiotic that interferes with bacterial ribosomes. Since mitochondrial ribosomes are very similar to bacterial ribosomes, tigecycline interferes with the translation machinery in mitochondria.

The drug loading in the nanoparticles was quantified using UV-Vis spectroscopy, and characterised using dynamic light scattering. The nanoparticle size was below 200 nanometres and was positively charged. Tests showed that the nanoparticles were stable under physiological conditions for a week.

Would the nanoparticle home in on mitochondria? The researchers used a red stain to mark out mitochondria in lung cancer cells and loaded a green fluorescent dye in the nanoparticles before using them on cancer cells.

Within three hours, they could see green fluorescence merging with red, making the mitochondria look yellow. After six hours, when the mitochondria started to get damaged, they could see the fluorescence in other parts. Within twelve hours, the mitochondria were partially damaged.

Then, the researchers treated lung cancer cells with the nanoparticles without conjugating the drugs. The nanoparticles entered the mitochondria. But, even after 24 hours, the mitochondria were not damaged.

Further tests showed that the nanoparticles with conjugated drugs not only damaged mitochondria, but generated reactive oxygen species, ultimately leading to the programmed cell death of cancer cells. Tests on cancer cells with the drugs directly showed that lung cancer and HeLa cells require three to four times higher quantities to kill cancer cells. So, using nanoparticles could reduce the dosage burden and hence, the side effects of cancer treatment.

'These nanoparticles can be used against other types of cancer cells and we could also attach other types of anticancer agents,' says Aman Bajpai, IIT Gandhinagar.

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Bacterial Resistance

Use of human microbiome

The antibiotic resistance in bacteria is primarily mediated by the efflux pump present in the outer membrane.

The efflux pump transports proteins and eliminates toxic substrates, including all clinically relevant antibiotics, to the external environment.

This results in a poor response of antibiotics to microbial infections which, in turn, leads to enhanced morbidity and mortality.

Besides antibiotics produced by fungi, there are small peptides produced by bacteria to suppress or even to kill other bacteria. The human microbiome provides a rich source of antimicrobial peptides.

Can we use antimicrobial peptides from human microbiota against antibiotic resistance?

Viswajit Mulpuru and Nidhi Mishra, from IIIT Allahabad started to explore. They retrieved the protein structure of the multidrug efflux pump of *Pseudomonas aeruginosa* from the protein data bank, PDB.

The team screened around 150 peptides from human microbiome from the hepcidin antimicrobial peptide database and compared different parameters responsible for inhibiting the action of the efflux pump.

Molecular docking indicated that the majority of antimicrobial peptides could efficiently bind the bacterial efflux pump, especially peptides of 834 and 862 in the HAMP database, says Viswajit Milpuru.

The team used molecular dynamics simulation analysis to understand the stability and conformational flexibility of the top three peptide structures that docked well with efflux pump binding sites.

They found that peptides that are less than 30 amino acids can penetrate the cell wall of the microbe more effectively and inhibit the action of efflux pumps.

'These peptides can help constrain the multidrug resistance of the bacteria by inhibiting the action of multidrug efflux pumps,' says Nidhi Mishra.

In vitro and *in vivo* studies using the peptides identified need to be taken up.

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Detecting Diabetic Retinopathy

Efficient deep learning method

Diabetic retinopathy can be detected from fundus images of the eye. Clicking a picture of the fundus is easy if you have the equipment. But since the cases of diabetes are rising, it is becoming a tedious task for ophthalmologists to examine images that pile up every day.

So, several artificial-intelligence-based models have been developed to recognise diabetic retinopathy automatically from the fundus images.

But the training required for such models to achieve high accuracy is huge. If the learning from earlier algorithms and datasets are transferred by creating an ensemble of machine learning, perhaps this limitation can be overcome.

Researchers from NIT Warangal, SRM University, Amaravathi and BVRIT Hyderabad College of Engineering for Women decided to check.

They tested the performance of datasets from available pre-trained models. To check the model's performance, they used a dataset of about 4000 retina images from the Aravind eye hospitals. Accuracies ranged from 70% to 90%.

Then they created ensembles out of the four best performing ones, facilitating the transfer of learning from one model to the next. They trained the ensemble and examined the results.

The ensemble model which combined InceptionV3 and DenseNet169 had higher accuracy than available models for not only detecting diabetic retinopathy but also classifying the severity of retinopathy.

Hospital networks specialising in ophthalmology can now use the ensemble model to speed up the process of diagnosis.

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Breathing Sounds Diagnosis

Better machine learning method

Physicians use stethoscopes to hear breathing sounds and they identify respiratory diseases based on their clinical experience. Can machine learning methods improve the accuracy and speed of diagnosis?

Recently, scientists from the SASTRA Deemed University, Thanjavur and the Madurai Medical College sought to use breathing and wheezing sounds for classifying respiratory diseases using machine learning methods.

From respiratory sound datasets at kaggle.com, they took samples of sounds from patients and healthy subjects recorded using a stethoscope and microphone.

The team extracted features of sounds that are specific to diseases and trained various models to distinguish them from healthy sounds.

They found that vector quantisation modelling, a technique that uses inexact approximations and partial data discarding to represent the content, has better accuracy for respiratory disease classification.

The diseases that can be accurately diagnosed by the system are upper respiratory tract infections, pneumonia, bronchitis, bronchiectasis and chronic obstructive pulmonary disease.

'Computer-aided diagnosis can provide better accuracy in respiratory disease classification,' says Revathi, SASTRA, Thanjavur.

Medical instrument manufacturers and start-ups can use this information to make a diagnostic device for respiratory diseases.

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Metamaterial Microstrips

For compact bio-implants

Implants that can be remotely controlled, using electromagnetic signals, might help us handle several disorders. But there are hurdles.

The antenna has to be small enough to be implanted. The antenna should respond to signals and not be misled by random environmental signals. The material should not be rejected by the body.

Kasturi Sudam Patil and Elizabeth Rufus from the Vellore Institute of Technology recently reported a breakthrough in this direction. They considered micro-strips, low-cost compact antenna which can be installed in bio implantable devices for wireless communication.

Conventional micro-strips are fabricated by printing a metallic patch on a conducting plane, sandwiching a dielectric material that responds to electric fields.

Such antennas are small. But a large amount of electrical energy is trapped in the dielectric, resulting in radiation loss. Moreover, the bandwidth is narrow.

The material of the antenna substrate should be able to store an electric field and should allow magnetic field lines to pass through. As permittivity increases, the capacity to store charge increases, and, thus, the size of the antenna can be reduced. Elizabeth and Kasturi designed a material with both dielectric and magnetic properties.

The antenna is made by assembling specially designed basic building blocks, or unit cells. Out of the different unit cell configurations, the duo selected square-shaped split ring resonator unit cells as this configuration reduces radiation loss.

Suitably selecting the unit cell parameters, they achieved high permittivity and permeability values. This reduced the size of the antenna by one-fourth.

The antenna responds to two internationally used resonant frequencies – 2.4 GHz and 5.8 GHz. If we ensure that only signals that come to both bands activate the system, random noise will not impact the implant's functioning.

The researchers fabricated the structure using a composite material of woven fibreglass cloth with an epoxy resin binder. They tested the antenna's biocompatibility and radiation absorption in a liquid that mimics the properties of skin tissues.

The team now looks forward to collaborating with biomedical researchers to test the implant for various purposes.

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