

## Current Science Reports

### Extreme Climatic Events

#### *Speleothem records*

Speleothems, literally meaning cave deposits in Greek, form when minerals, dissolved in water that leaches into caves, precipitate. They not only coat cave walls but also form pointed pendants from the roof and conical projections from the cave floor.



Image: Ponor via Wikimedia Commons

The chemical and physical compositions of the speleothems reflect environmental conditions during the depositional history. The ratio of the two isotopes of oxygen in various layers provides clues about precipitation, temperature and humidity. So speleothems are often used as palaeoclimatic proxies.

Ashok Priyadarshan Dimri and Pramod Kumar from JNU, New Delhi and Sampat Kumar Tandon from IISER, Bhopal collected the oxygen isotope records of speleothems in the Wah Shikar caves, Meghalaya, and compared them with those from the Jhumar and Dandak caves of Chhattisgarh.

Two deviations from the mean climate from 1850 to 2000 AD are well recognised in speleothems from different parts of the world: one is the Medieval Climatic Anomaly from about 900 to 1300 AD, and the other, the Little Ice Age from about 1500 to 1850 AD.

The team found two more notable deviations in their records: a Dry Century from about 850 to 950 AD and an Extremely Dry Century from 1280 to 1470.

Interestingly, the team found that, during the Little Ice Age, precipitation decreased a little over Meghalaya and showed levels similar to now. But it increased over the caves in Chhattisgarh.

What could be the physical mechanisms and long range couplings that are responsible for these deviations?

To understand physical and dynamical processes, the team used the CSIRO-Mk3L climate system model. The model is stable when dealing with millennial scales.

The Arabian Sea and the Bay of Bengal showed weaker latent heat flux during the monsoons in the Dry Century. And, except in the case of the Indo-Gangetic plains, the latent heat flux from the subcontinent increased, causing dryness.

Then the fluxes over Central India increased and those from the Western Ghats decreased. This led to stronger monsoons during the Medieval Climatic Anomaly.

Later, the sensible heat fluxes over the Western Ghats increased, but the surface was anomalously cold. This led to weaker monsoons and the Extreme Dry Century.

During the Little Ice Age, energy was transferred from the atmosphere to the surface to balance the energetics. Precipitation decreased over the North Eastern regions, and increased over the central parts.

Thus, the understanding from the analysis of the data from the speleothems was broadly corroborated by the CSIRO-Mk3L climate system model's simulation. There were minor discrepancies between reconstructions based on observed data and modelling. Tweaking the model to enable predicting the past better will make it a stronger tool to predict the future.

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### Sonakhan Gold Mining

#### *Exploration by prospectivity analysis*

Mining for gold is a risky business. Excavation costs rise if the exact location of the ore is not known beforehand. So, all that glitters is not gold even for mining companies.

Geologists Mruganka K. Panigrahi and Satyabrata Behera from IIT, Kharagpur have been seeking ways to get a grip on the problem.

Take, for instance, Sonakhan, inside the Bastar craton, identified as a prospective gold mining location by the Geological Survey of India.

There are quite a few methods to locate likely areas where gold can be found. For example, the binary index overlay segments the whole area as either 0 or 1 depending on the absence or presence of gold ore. Add a weight score to this binary classification and it becomes a multiclass index overlay. Fuzzy logic has been used to assign scores, based on assessed favourability for mining locations.

An updated form of classification dissects the problem into a hierarchical structure and applies fuzzy logic – the fuzzy analytic hierarchy process. To enable this, the existing knowledge of mineralization and geological features are used as their evidential signature.

'For example, areas adjacent to metavolcanics and granitoid are highly prospective for gold mining,' says Satyabrata Behera.

Gratinoid type rocks remobilize and concentrate lode type gold mineralization. Metals dissolved in hydrothermal solutions deposit gold inside fissures in the rocks. The duo also identified pathfinder elements. Elements like silver have close chemical affinity and are indicators of gold mineralisation.

Using all these methods together, the researchers created a prospectivity map with seventeen different evidential layers overlaid.

Initially the maps they made were in a continuous colour scale. They simplified it further to a binary map where each pixel is identified as either high or low prospects for gold ore.

'Among the four different model approaches to identify potential gold mining sites, the fuzzy analytic hierarchy process is better in organizing the evidential maps,' says Mruganka Panigrahi, IIT Kharagpur.

The analysis creates gold availability locations with an accuracy of 50 metres.

'We are not trying to create a treasure map,' stresses Satyabrata Behera.

'We are trying to define the methodology and approaches to explore gold anywhere,' clarifies Mruganka Panigrahi, IIT Kharagpur.

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### Fallow Land Management

#### *Residue from lentils*

Can the duration between cropping cycles be used to cultivate quick growing crops? Can crop residues like stubble be left behind to mulch in the fields? How will residue retention and no-tillage affect soil quality? Is it wise and economically viable? These are some questions facing agricultural scientists.

To answer these queries, Anup Das and a team of researchers from five ICAR organisations/research centres carried out experiments to cultivate short duration rice and lentils at an experimental site in Meghalaya.

The researchers cultivated mendri, a local rice variety, for the long duration cycle and Shahsarang, a medium duration high yielding variety developed by the ICAR Research Complex, Umiam, Meghalaya. To facilitate drainage of excess water, peripheral drainage was provided in the paddy field. Rice cultivation was followed by no-till lentils. The team monitored the impact on soil when crop residue is left behind and the land is not tilled.

During the three year-long experiments, the researchers observed that stubble retention improved soil quality significantly. And, under no-till conditions, the soil nutrients in the hilly terrain increased significantly.

The soil's water filtration rate and moisture holding capacity improved. Soil compaction reduced which enabled better penetration of roots, reducing dependency on irrigation. Along with the soil microbial ecosystem, lentil crop yield also improved.

To enhance soil productivity and crop yield in the eastern Himalayan region, the team suggests growing the medium duration rice, Shahsarang, followed by fast growing lentils and leaving crop residues to mulch.

'Small farmers in the region can adopt the retention of standing rice stubbles and save on labour costs. And even simple mulching can build up soil fertility and produce higher yield and income,' says Anup Das, ICAR Research Complex for North Eastern Hill Region.

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### Dried Fish for Livelihood

#### *Solar-thermal approach*

Fish drying is a natural preservation method and a source of livelihood for fishermen in India. However, unhygienic drying in open spaces and the low quality of the outcome diminish the market value and reduce the profits.

To meet this challenge, Subarna Maiti and team from the CSIR-Central Salt and Marine Chemicals Research Institute, Gujarat designed and implemented a direct-type solar thermal dryer.

In Sagar Island, about 100 kilometres from Kolkata, the team installed a hemi cylindrical walk-in dryer chamber. The chamber is covered with sheets which cut off UV radiations from the sun. Most of the solar energy that passes through is absorbed by the floor which is cemented black. Inside the chamber, there are racks of meshed metal sheets to keep the fish. Four draft fans are provided in the chimney to remove moisture.

Fresh air, entering through openings in the bottom, is heated by the trapped solar radiation. It rises and passes through the fish and goes out through openings at the top. This allows sufficient air flow and moisture removal. Solar voltaic driven dehumidifiers are installed to take care of night time drying.

The researchers tried the dryer on a few hundred kilos of fish and compared it with a natural open drying method. In less than 24 hours, the fish were dried to 10% moisture content inside the chamber, while it took 38 hours in the traditional drying process in open air. The team calculated the drying efficiency to be about 30% which is higher than that of earlier designs. A quality assessment based on sensory evaluation, showed that the fish dried in the solar thermal drier scored over fish dried in the open.

A local NGO, working to create awareness, projected an increase in income by 50% from the dried fish using the system. The calculations were done considering an average of 170 days of operation in a year.

'The system offers a hygienic method for fish drying and improves

economic sustainability for the fishing community,' says Subarna Maiti, CSIR-Central Salt and Marine Chemicals Research Institute.

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### Managing Malaria

#### *A scourge on the south east coast*

Chennai and Ramanathapuram districts are hotspots for malaria cases in the south east coast. The districts report a huge number of malaria cases throughout the year.

To investigate malaria prevalence in the coastal regions and to understand the environmental variables involved, Appadurai Daniel Reegan from the National Centre for Disease Control, Bengaluru branch collaborated with other entomology researchers in India.

They selected Besant Nagar in Chennai and Pamban in the Ramanathapuram district as case studies and took data of malaria prevalence screening at health centres from 2004 to 2019.

The researchers collected smears from people coming to clinics with fever and also during their field surveys, to analyse the samples microscopically for malarial parasites.



Image: Appadurai Daniel Reegan

'The adult population, 15 years and above, were the most affected. At Besant Nagar and Pamban, more than 70% of adults had malaria,' says Appadurai Daniel Reegan, NCDC, Bengaluru Branch.

'Malaria cases were high during summer,' says Pandia Nadar Udhayakumar, DDHS Office Ramanathapuram.

Mosquitoes are cold blooded. So, their activity increases with temperature. Thus, the frequency of mosquito feeding may raise the probability of transmission and infection.

The team collected temperature data from the meteorological department,

Chennai and correlated the annual malaria incidence. The highest malaria cases were recorded in 2005, when the maximum temperature was 41°C.

Malaria cases started to decline in 2006 and there were fewer cases in 2007. In 2011, cases increased significantly when the temperature was 42°C. There was a sudden reduction in malaria cases in 2012 and a declining trend in the subsequent years along with reduced temperature.

Meteorological factors are not under our control. But it is indeed possible to limit mosquito populations by reducing sites for mosquito breeding. Using insecticide-impregnated bed nets at night and immediate treatment of infected people are other steps to reduce transmission.

WHO has recently announced the first vaccine against *Plasmodium falciparum*. But the south east coast of India has infections by both *Plasmodium falciparum* and *Plasmodium vivax*. So preventing transmission remains the key to reducing morbidity and mortality due to malaria.

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### Adverse Pregnancy Outcomes

#### *Preceding risk factors*

The time before pregnancy has a significant impact on offspring health. But there is no clear definition of risk factors during preconception and their relationships with adverse pregnancy outcomes.

Dr Prakash Prabhakar Rao Doke and others from the Bharati Vidyapeeth Medical College, Pune recently inquired into the risk factors and various adverse pregnancy outcomes.

They randomly selected one tribal block and one non-tribal block in Nashik district, Maharashtra, and contacted all women aged between 15 and 49 years. There were more than 9000 women who had delivered a baby in the preceding year.

The adverse pregnancy outcomes were primarily low birth weight babies. Abortion, preterm birth and stillbirth were the other adverse outcomes. Congenital physical defects were also significant.

The team examined the risk factors and the relationships between adverse

outcomes. Risk factors for low birth weight were heavy work in the last six months and pre-existing illness. Risk factors associated with abortion included pre-existing illness with heavy work in the last six months of pregnancy. Blood related parents, tobacco consumption during pregnancy and pre-existing illness were identified as risk factors for stillbirth.

As most of these risk factors are behavioural in nature, better pregnancy outcomes can be achieved by providing counselling to women, their husbands and family members.

Teenage pregnancy, the team found, was slightly more in the tribal block than in the non-tribal block. In fact, all risk factors, except pre-existing illness, occurred more frequently among women from the tribal block.

Pregnancy outcomes in tribal areas can be improved by providing better access to health services, and counselling on the importance of preconceptional and antenatal care.

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### 3D Bioprinted Skin

#### *The future of wound dressing?*

According to the WHO, every year, more than a million burn injuries require medical attention. Intensive burn injuries are treated by surgically removing old skin from the wound and reconstructing it with skin substitutes. Conventional skin substitutes do not contain all skin cell types and skin grafted from others is often rejected by the immune system.

Recently, researchers from the Sree Chitra Tirunal Institute for Medical Sciences and Technology, Thiruvananthapuram found a solution: reconstructing skin tissue using 3D bioprinting.

They fabricated tissue constructs with skin cells within a non-toxic polymer scaffold.

3D bioprinting involved designing cell layer architecture in the scaffold using a suitable polymer-based bioink, a key ingredient that controls the porosity and adhesiveness of the bioprinted tissue.

To prepare the bioink, the researchers dispersed a cell adhesive resin, diethylaminoethyl cellulose, in powder

form, in a solution of alginate, an inert natural polymer. This solution was mixed with a cell adhesive gelatin solution.

The bioink was used to encapsulate the patient's fibroblast and epidermal keratinocytes, cells found in skin tissue.

The researchers bioprinted skin tissue layer by layer. At the base, bioink-encapsulated fibroblasts were printed into six layers and arranged as three stacks. On top, they bioprinted a single stack of two layers of bioink-encapsulated keratinocytes. These constructs were then cultured in a suitable medium.

'The bioprinted skin had precisely controlled pore architecture with micro- and macro-sized pores, which is not possible with conventional methods,' says Lakshmi T. Somasekharan.

These micro- and macro-sized pores help in effective cell infiltration and migration throughout the construct and promote the transport of oxygen and nutrients.

'When exposed to aqueous medium, the bioprinted construct did not swell much and retained physical shape and size – a good property for bioink,' says Naresh Kasoju.

Cells in the bioink-fabricated skin were viable even after 21 days. They maintained histologically necessary characteristics and showed the expression of epidermal/dermal markers. What is more, the hydrogel used for the biofabrication of skin tissue did not show any adverse reaction upon contact with blood.

The raw materials for the 3D printed skin are readily available at low cost. And 3D printed skin mimicking native tissue architecture and functionality makes this method useful in developing skin tissue equivalents.

'This can be integrated with the native tissue when implanted,' says Anugya Bhatt, Sree Chitra Tirunal Institute for Medical Sciences and Technology.

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### Bagasse Ash in Concrete

#### *For strength and durability*

Sugarcane bagasse is a by-product of the sugar and ethanol industry. Generally, these residues are dumped in

landfills. Discarding this biomass creates severe environmental problems. Combustion is another practice which produces sugarcane bagasse ash. Bagasse ash contains amorphous silica, a material with excellent cementitious properties.

Why can not we use this property for the partial replacement of cement, wondered researchers at the Motilal Nehru National Institute of Technology, Allahabad. They made ash from sugarcane bagasse collected from a sugar mill in Uttar Pradesh. And tried replacing ordinary Portland cement while making concrete.

They also experimented with replacing sand with stone dust, an alternative to natural river sand. A third set of experiments compared the effect of replacing potable water with sodium sulphate in the curing of the concrete.

The team analysed various properties of hardened concrete samples with standard concrete. Curing in sodium sulphate solution caused sulphate attack on concrete which reduced its strength and durability.

Scanning electron microscope images showed calcium-silicate-hydrate gel and calcium hydroxide in concrete cured in water. In sodium sulphate-cured concrete, the calcium sulphoaluminate formed was responsible for sulphate attack and loss of strength.

The researchers analysed the chemical properties of the cement and ash using X-ray fluorescence. Cement had a high percentage of lime and bagasse ash high silica.

The compressive strength of concrete increases when silica is hydrated in an alkaline environment.

A 10% replacement of cement with bagasse ash and sand with 40% stone dust provided maximum compressive and tensile strength and minimum sulphate attack, say the researchers.

However, the fineness of the bagasse ash and the higher water absorption of stone dust reduced the workability of the concrete mix. This may limit the applications to cases where the gain in compressive and tensile strength is more important than workability.

'Even a partial replacement of cement can considerably reduce dependence on Portland cement,' says Pooja Jha, Motilal Nehru National Institute of Technology, Allahabad.

'This will serve as resource recovery from agricultural residues and provide additional income to farmers,' adds her colleague, A. K. Sachan.

According to the International Energy Agency, cement production, which contributes significantly to global greenhouse gas emissions, will increase by more than 20% by 2050. Similarly, sand mining is causing environmental hazards in riverine systems.

'We cannot stop the rising demand for concrete structures. But we can do our best to reduce the harm,' says R. P. Singh.

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### Curbing Fake News

#### *An Indian data set*

Fake news detection in social media content manually is a tedious task given the large amount of output. Recently, many algorithms and deep learning methods have been proposed, to identify fake news in social media. However, the identification of fake news still faces a major challenge: lack of benchmark data sets for fake news for India.

That is what Dilip Kumar and Sonal Garg from GLA University, Mathura set out to do. They used Parsehub – a web scraping tool – to collect original news from the most trusted news portals. And fake news was collected from

those identified by reliable fact checking websites.

The data set consisted of both text and images from 2013 to 2021 - about 60 thousand news items under five categories such as election, politics, violence, COVID-19 and miscellaneous.

The researchers employed sentiment words as text features, the method usually used in sentiment analysis using social media. They found that more sentiment words in tweets generally indicate fake information.

The team created a word cloud of the most frequently used words for generating fake news. The word cloud of most fake news contained words such as fact, viral, check, etc.

Word embedding is another useful clue for fake news detection. So the researchers explored essential terms in each news item and the word embeddings. They used support-vector machine, a popular machine learning algorithm, to analyse data for classification.

They used machine learning and deep-learning classifiers for image analysis. For fake image detection, a convolutional neural network could achieve about 90% accuracy on a known dataset.

'While researchers can use the dataset and the models for further explorations, government, media and public can use it for detecting fake news,' says Dilip Kumar, GLA University.

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