Current Science Reports

Foraminiferal Oxygen Isotopes

Reliable palaeosalinity records?

When foraminifera calcify, they incorporate oxygen isotopes from sea water. After they die, the shells are preserved in ocean sediments. These microfossils are useful for estimating the past environment using isotope ratios.

Sea water oxygen isotopes from foraminifera are used to infer the salinity of the sea in the past, assuming a constant relationship between isotope ratios and seawater salinity. But, if this assumption is not correct, it can introduce large uncertainties in palaeosalinity estimation.

So, Arvind Singh at the Physical Research Laboratory, Ahmedabad and researchers from Chandigarh and the US took up the challenge of estimating the relation between salinity and oxygen isotopes and the extent of uncertainty in palaeosalinity records.

They used archival data sets of sea water salinity and oxygen isotopes from 1116 locations in the Bay of Bengal and the Arabian Sea. To analyse the correlation, they categorized the data spatially and temporally.

The researchers observed regional and seasonal variations in the relationship between salinity and sea water isotopic oxygen. The relationship varied from point zero seven to point five. Coastal areas had higher variations than other areas. The Bay of Bengal showed higher variations than the Arabian Sea.

'This relationship is not always constant. There are seasonal and regional variations. This could perhaps be due to high freshwater inputs,' explains Arvind Singh.

The team calculated the total uncertainty in palaeosalinity estimation due to the variation in the relationship between salinity and sea water isotopic oxygen. It varied from 3% to about 50%!

'This very high uncertainty in estimating palaeosalinity can significantly alter our understanding of past monsoon variability and oceanic circulation,' says Kaustubh Thirumalai, University of Arizona.

They also observed the seasonal abundance of species. Some are more abundant during the summer monsoon and others, during the winter monsoon.

'We plan to use season-specific foraminiferal species to reconstruct seasonal changes. That will give us more accurate and temporally resolved data,' says Arvind Singh.

'We also need to look into regional relationships between oxygen isotopes and salinity, for greater spatial resolution,' says Shreya Mehta, Panjab University.

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Subcontinental River Basins

Runoff sensitivity

A part of rain that falls on the ground runs off and joins streams and rivers which empty into oceans. Other parts of rain evaporate or infiltrate soil. Part of the water infiltrating the soil is taken up by plants and transpired. It is only the remaining water that percolates into groundwater aquifers.

Understanding the relationships between precipitation, runoff and evapotranspiration can inform decisions about constructing water conservation structures. So, Shalinee Bharat and Vimal Mishra from IIT Gandhinagar examined runoff sensitivity at a subcontinental scale.

They collected daily precipitation, wind speed, and maximum and minimum temperature data from the India Meteorological Department and other sources. They examined how precipitation, evaporation from soil and transpiration by plants changed from 1980 to 2014.

To analyse runoff, the researchers selected more than 200 major stream gauge stations within 18 river basins in India, Pakistan, Bangladesh, Nepal and Bhutan. Hydrologic modelling and statistical methods helped them estimate the runoff sensitivity.

To examine runoff with respect to other factors at the scale of river basins with widely varying geographies, elevations, soil and climatic conditions, the researchers had two choices: Budyko's framework, a non-parametric equation to estimate evapotranspiration and runoff, and the Variable Infiltration Capacity model, a semi-distributed large scale hydrologic model.

They used both and found the Variable Infiltration Capacity model better than Budyko's framework to estimate evapotranspiration and runoff.

Thus, triangulating the results from multiple models and different observational datasets, they estimated runoff in all major river basins to get more reliable evidence for better water conservation decisions. The results show that northern India witnessed decreasing trends in mean annual precipitation whereas southern regions experienced increasing trends

Northern river basins had higher evapotranspiration. But it was lower in the south. So the Krishna and South Coast basins witness higher annual runoff. And northern river basins have reduced mean annual runoff.

'Reduction of mean annual runoff in the Brahmaputra, Ganga and Indus river basins is due to decreasing trends of precipitation over the northern parts of the subcontinent,' says Shalinee Bharat.

'This, in turn, could be due to the warming of the Indian Ocean, as reported by other researchers,' adds Vimal Mishra, IIT Gandhinagar,

Understanding the causes is only one part. Preparing for consequences by constructing water harvesting structures to reduce runoff and to sustainably store the precious resource for drinking, agriculture and industry is the other.

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Green Spaces of Bengaluru

Local cooling effects

The rapid urbanization in Bengaluru has been at the expense of green cover. Replacing green cover with tall structures of concrete, stones and glass leads to the trapping of heat, and

creates urban heat islands. Green spaces within urban areas are cooler because they reflect near infrared light and because of the transpiration and evaporation of water from the soil. Heat exchange from the greenery also cools nearby areas. But, by how much and how far?

Researchers from IIT Gandhinagar and IIM Ahmedabad investigated cooling effects in the garden city of India, Bengaluru. Using geographic information systems, based on Google Earth imagery and Landsat data from April 2017, the researchers identified the green spaces. They drew concentric circles at different distances around the green spaces and examined the temperature difference.

Green spaces were about two degrees cooler and the temperature increased as the radius of the circles increased.

The average cooling effect extends to about 350 metres. The median of cooling distance is only a little more than a quarter of a kilometre.

The cooling effect is dependent on factors such as the greenness, size and shape of the green spaces. The team analysed the influences of the factors statistically.

'An increase in vegetation in green spaces would enhance the cooling distance,' says Vimal Mishra, IIT Gandhinagar.

'Increase in the area covered by gardens decreased its temperature more. But it did not increase the cooling effect on the nearby surroundings substantially,' adds Amit Garg, IIM Ahmedabad.

Making large green spaces in a land-starved city is difficult. 'Planting trees or shrubs in barren lands, herbs and vegetables on rooftops and ornamental plants on balconies are easy steps to keep the surroundings cooler,' says Arpit Shah, his colleague.

Besides Bengaluru, which grew around green spaces, Delhi and Chandigarh have much higher summer temperatures despite a lot of planned green spaces. Most green spaces in these cities are circles, squares and rectangles. Cooling improves if green spaces are irregular and asymmetric through greater heat exchange with the surroundings, suggests the research team.

Do planners need to switch to fractal shaping of landscapes for better cooling, we wonder.

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Plasma Treatment for COVID-19

Effectiveness in Indian patients

When we get infected by viruses, our body generates antibodies that recognise the shapes of antigens on the virus. These antibodies start attaching themselves to the virus. This neutralises the viruses. So we could, theoretically, use the antibodies in the plasma of patients convalescing after COVID-19 to treat the infected. But does it really work, in practice?

The method is simple enough. Patients who have recovered from COVID-19 are requested to donate blood. The donated blood is processed to remove all blood cells, leaving plasma with antibodies. This plasma is injected into infected patients.

Researchers from the Max Healthcare, New Delhi recently took nearly 700 patients admitted to the ICU with moderate and severe COVID-19 infection and requiring oxygen.

They treated more than 330 with plasma. Others were not given plasma. Both groups received equal palliative and supportive care.

The team monitored the patients for 28 days. The plasma infusion given had no adverse effects. But there was no significant difference in mortality rates.

However, the researchers found that female patients above 60 with comorbidities show some positive response to the plasma treatment.

But these results are not adequate evidence for recommending using plasma for COVID-19. The patients in the sample also received other medicines such as remdesevir, ivermectin, azithromycin, steroids...

'We also don't have data whether some patients had already developed adequate antibodies before the treatment,' says Sandeep Budhiraja, Max Healthcare.

According to WHO and ICMR guidelines, convalescent plasma therapy has limited scope in treating COVID-19 patients.

Extracting blood from a person who has recently suffered oxygen deficiency is meaningful only when we have more precise data on the types and amount of antibodies in the plasma and the stage of infection or viral load in new patients as well as the health status of patients receiving the therapy. Unfortunately, generating such data is difficult at this juncture, when people resort to whatever treatment is possible, without looking at evidence.

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Mutations in SARS-CoV-2

What lies ahead?

The second-wave of Covid-19 in India is more severe. The surge is attributed to mutated strains of SARS-CoV-2. Mutations that increase transmissibility, virulence or vaccine resistance are of concern.

The genome of SARS-CoV-2 has over 29,000 nucleotides that encode for 29 proteins. Four of these are structural proteins that protect the viral genome and aid attachment to the host. The rest are non-structural proteins involved in infection and accessory proteins responsible for virulence.

Rezwanuzzaman Laskar and Safdar Ali from the Aliah University, Kolkata recently did a mutational analysis of SARS-CoV-2 genomes prevalent in India by June 2020. The researchers downloaded genomic data available in GISAID EpiCoV, an open access repository of novel coronaviruses. There were a total of 641 sequences of the corona virus from India with varying clinical profiles.

The duo used various genomic tools on the data to find the mutations and the proteins encoded in the mutated sites. There were a total of 841 probable mutation sites. After removing gaps and ambiguous sequences, there were only 493.

The highest mutations occurred on non-structural protein 3, the largest protein of the virus. This protein performs many essential functions during infection.

Mutations were also present in sites coding the structural spike protein, involved in recognizing the human host cell, the non-structural protein 12, involved in the replication of the virus and open reading frame 3a that prevents the virus from lysis by the lysosomes in our cells.

The researchers then checked for the impact of the mutations on the encoded proteins. They found that only around half of the mutations could affect protein translation. And only 83 of the 493 mutations would have implications on the progression and pathology of the disease.

Symptomatic patients had more such mutations than those who were asymptomatic. Mutations were marginally higher in females. And the virus is mutating faster in some geographic regions than in others, say the researchers.

With each new infection, the virus gets a chance to evolve. Following the protocols to break the transmission chain of the virus seems to be the only way to stop it evolving further. Meanwhile, stay safe.

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COVID-19 Treatment

Repurposing ayurvedic medicines

The COVID-19 pandemic continues to affect huge populations. The evolution of SARS-CoV-2 mutants which are highly transmissible and limited supplies of vaccines and emergency-approved drugs drive the surge. India's Ministry of AYUSH recommends that scientists try Ayurveda.

So, researchers from India, Korea and Brazil recently assessed three ayurvedic plant compounds – gingerol, curcumin and quercetin – as potential drugs against SARS-CoV-2. The team took the structures of these compounds from the PubChem database and simulated their docking with two proteins of the virus – the spike protein which initiates infection and the RNA-dependent RNA polymerase, involved in viral replication.

Molecular dynamic simulations and binding energy calculations predicted that curcumin can prevent viral entry into host cells by binding with the virus spike protein, inhibiting entry into host cells.

Quercetin blocks the activation of the virus spike protein and prevents it from entering the host cell's cytosol. And gingerol inhibits viral genome replication by blocking the viral genome replication protein, RNA-dependent RNA polymerase. The researchers also found that gingerol and the currently prescribed drug, remdesivir, are similarly effective in blocking viral replication.

'Combining these compounds may help prevent COVID-19 infection and perhaps reduce the pathology,' says Akalesh Kumar Verma, Cotton University.

However, computer simulations cannot specify the dosage and concentration needed to elicit the desired action at the site of infection. So *in vitro* and animal studies and, finally, clinical trials are needed to test their effectiveness against COVID-19.

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Treating Obesity

Using Terminalia chebula

Terminalia chebula fruit, Harad, one of the three components in triphala, is highly valued in Ayurveda to treat diabetes and liver diseases. From recent discoveries, we now know that diabetes and liver diseases are associated with complications of obesity. Can this fruit help cure obesity, wondered Vasanth Krishnan and team from the Bharathiar University, Coimbatore.

Image: Yuvraj Shingate via Wikimedia Commons

The team first induced obesity in mice by giving them a high-fat diet. Then, they gave *T. chebula* ethanolic extracts to one set of obese mice, while another set remained untreated. Regularly checking the weight of the mice, they found that the oral administration of the fruit extracts significantly decreased weight.

After nine weeks, mice were subjected to a 12 hours fast. The researchers then analysed glucose and fat levels in mice serum. Untreated obese mice had elevated glucose and fat levels. But mice fed with the fruit extracts had controlled levels of blood glucose and lower levels of cholesterol and triglycerides. The extracts led to the upregulation of the expression of genes involved in fatty acid metabolism, say the researchers.

The team checked for inflammatory markers such as TNF-alpha and IL-6. The mRNAs of these markers were also downregulated in obese rats fed on the extract. The downregulation of these mRNAs could explain the reduced inflammation in obese mice, say the researchers.

They conducted a similar experiment on mice on a standard diet. Healthy mice already have proper metabolism and gene regulation. So, the effect of *T. chebula* extracts was not noticeable, say the researchers.

'Identifying and extracting anti-obesity compounds from *T. chebula* may help create alternatives for obesity treatment,' says Kalpana Tankay, Bharathiar University, Coimbatore.

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Pre-treating Pineapple Cubes

Ohmic heating – an alternative

Drying pineapples increases shelf life. Before drying, pineapple slices are blanched: dunk them into boiling water and then quickly transfer onto ice. Blanching kills microbes and denatures enzymes to preserve taste and quality. But, during blanching, some nutrition is lost due to the diffusion of nutrients in water.

Recently, researchers from the Tezpur University, Assam teamed up to compare blanching with ohmic heating, where electricity is passed through pineapple cubes to heat them up. The team made equal-sized pineapple cubes. One set of cubes were conventionally blanched, while other sets were treated at varying timings and electric field intensities in an ohmic chamber.

Using a texture analyser, the researchers found that ohmic heating at 25 volts per metre of a AC electric field for three minutes retained the best texture.

'Electricity heats the inside and outside of the cube uniformly. So texture is not degraded,' says Arjuara Begum, Tezpur University, Assam.

Ohmic heating retained more solutes than blanching. Nearly no solute diffusion occurs as no water is involved.

The researchers then investigated drying behaviour in the cubes using a tray drier. Ohmic-heated pineapple cubes reduced drying time by 3–4 hours compared to blanched cubes.

'Passing AC current produces pores in pineapple cubes. This allows water molecules to escape easily and reduces drying time,' says Amardeep Kumar, Tezpur University, Assam.

The actual flavour and texture of dried pineapple cubes depends on rehydration. So, the team rehydrated dried cubes using water and found that ohmic-heated cubes had a higher rehydration capacity than conventionally blanched cubes.

When we pass electric current, cells in pineapple cubes get ruptured. These ruptures help moisture to diffuse more easily. So there is better rehydration, say the researchers.

'The rehydrated samples had the same size as freshly cut cubes,' says Saddam Hussain, Tezpur University.

'Ohmic heating gives better control over temperature and time of heating,' says Monjurul Hoque, his colleague.

'Ohmic heating can become an alternative to conventional blanching to better retain pineapple nutrients,' says Brijesh Srivastava, Tezpur University.

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Trapping Dog Ticks

Using pheromones and solar devices

The brown tick, *Rhipicephalus sanguineus* sensu lato, infects dogs around the world. The ticks sometimes carry pathogens that can infect humans. There are chemicals that kill the ticks, but they are toxic. And, over time, the ticks develop resistance to the chemicals. Why not try pheromones, chemicals secreted by the ticks?

Researchers from the Tamil Nadu Veterinary and Animal Sciences University, Chennai devised a pheromone-based tick trap, with a small printed circuit board and a collecting tray attached at the bottom. They connected the trap electrically to a grid, using a solar panel to recharge the battery. Any tick coming into contact with the circuit board would thus get electrocuted.

To the board, they stuck a vapour patch consisting of synthetic tick pheromones. They used sex pheromones that attract ticks of the opposite gender, and assembly pheromones that cause ticks to cluster. The team tested the device at a local Blue Cross animal shelter that houses around 40–60 strays per kennel.

Four solar tick traps were set up per kennel for a month. The traps electrocuted a large number of ticks. The researchers found that assembly pheromones attracted more ticks than did sex pheromones.

'Managing ticks could now be easier for dog owners and dog shelters. They just have to periodically replace pheromone-filled vapour patches,' says Gowrishankar, Tamil Nadu Veterinary and Animal Sciences University.

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Making Porous Structures

3D printing

Porous structures can bear mechanical stresses. The load is uniformly distributed over the surface. Porosity reduces the amount of material needed to bear loads. And porous structures have low density and weigh less. However, porous structures that can bear mechanical stresses cannot be fabricated by traditional methods like smelting and casting.

Chandra S. Tiwary and team at IIT Kharagpur collaborated with researchers from the US to fabricate porous structures using 3D printers. The researchers first made a digital blueprint of the object with pores. This was then converted to a set of codes. Now, the programming instructions could control a laser beam moving up and down over layers of powdered plastic or metal to produce the desired shape.

The team tinkered with the density and distribution of the pores to understand consequent changes to elasticity, strength and energy absorption. They found that, under certain limits, increasing porosity improves a material's load distribution and stress-bearing capacity.

Manipulating the position and distribution of pores enhances compressive strength and energy absorption. The experimental results agreed with the group's modelling studies.

The team now studied surface area properties for the porous structure. They took high-speed imaging snaps of the porous structure at varying deformations. The voids in the porous shape allow higher resistance to deformation.

To study their bulk properties, the team stacked these structures.

Combining materials of different strengths gave rise to an anisotropic structure where the material is resistant to deformation in one direction. But shows different characteristics in other directions.

'By systematically controlling the pores, we control the density, thus tuning the mechanical properties of materials,' says S. Chandra, IIT Kharagpur.

After enhancing the strength of materials by changing the geometry, the team is also experimenting with blending metals to produce usable machine parts.

3D printing is now broadening in application from making trinkets to rockets.

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