

Current Science Reports

Western Ghats Climate Borehole records

The Western Ghats play a crucial role in meteorological processes over the Indian subcontinent. Understanding past climate change in such ecological hotspots can help forecast change and estimate impact. However, historical meteorological data of this area is limited.

Heat from the earth's surface is conducted to deeper layers and stored, whereas heat from the earth's core travels to the surface in a steady manner. So, deviations at any point underground are due to an inverse transfer of heat from the surface. Researchers identify the magnitude and timing of changes in surface temperature and climate warming in the past using differences between ideal and actual temperature–depth profiles.

Srinidhi Jha and D. V. Reddy, IIT Indore collaborated with researchers in other institutes around India to investigate climate records, archived underground. The team chose five deep boreholes, 140 to 198 metres deep, in the Koyna region of Satara district, Maharashtra. Drilled more than two decades ago by the National Geophysical Research Institute, for geophysical studies of this earthquake prone region, the boreholes do not have significant groundwater flow.



Image: Srinidhi Jha

The researchers analysed the temperature profiles of the boreholes. They observed a departure from line-

arity between 66 and 124 metres, indicating warming in the last one or two centuries.

Extending the linear profiles, they found the ideal surface temperature and calculated a warming of 0.49°C to 1.75°C between 1890 and 1948.

Variations in linear surface temperature, depth of linear deviation and temperature record periods vary, depending on local geophysical characteristics. But the boreholes' geothermal records agree, showing an average warming of about 0.77°C in the past 100 years. This is comparable with the warming of 0.56°C from meteorological data in the last century.

Confidence in the reliability of the estimates depends on the convergence and concurrence of results from different methods. Isotopic records and geothermal records, calibrated against meteorological records, will help us validate the climate models.

The upper 500 metres of the earth contain the thermal history of the past 1000 years. Boreholes specifically drilled for exploring paleoclimates will strengthen our understanding of climatic conditions, prior to instrumental meteorological records.

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Conserving the Reef Shark

Reef sharks are major marine predators. They play a vital role in the coral reef ecosystem and its food chain. So their population status serves as an indicator of ocean health.

There are indirect indicators of depletion of shark count in coral reefs which adversely affect coral ecosystems. For example, it may result in algae dominance. Direct observations needed for reliable estimates are far too few for evidence-based conservation efforts. So recently, researchers from 89 institutions across the world collaborated to get observational data of reef sharks around the globe.

Reef sharks spend most of their life on or around reefs. And some are quite shy. It is not easy to deploy divers to observe and record the pres-

ence of sharks. So the researchers deployed 15,000 video cameras underwater with baits to attract the sharks into the field of view. This was done at 371 reef sites across 58 nations for approximately 10 days.

To assess the impact of fishing on reef shark populations, the team selected sites which were both open and closed for fishing. They find that fishing strongly impacts reef shark populations. There were more sharks at shark sanctuaries, closed areas and outside catch limits.

The researchers also collected social and ecological data around the sites. They found that shark depletion was strongly related to socio-economic conditions such as the size and proximity of the nearest market, the density of the human population and poor governance.

To restore and manage reef shark populations, we need centralized fishing management and the establishment of shark sanctuaries, says Venkatesh Charloo, Coastal Impact, Goa.

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Protecting Pepper Bacteria manage nematodes

The root-knot nematode, *Meloidogyne incognita*, creates nodules in plant roots and sucks out nourishment. The worm reproduces fast and colonises roots. In annual crops such as potato and tomato, it causes severe loss of yield. And, in a perennial plant like black pepper, it is a disaster.

Chemicals that can manage the problem harm the environment. But there is a species of bacteria, a parasite of nematodes, which is mooted as a safer alternative. The *Pasteuria* species of bacteria infect the ovaries and completely suppress the reproduction of the nematodes.

Recently, researchers from five different ICAR institutions collaborated to investigate the possibility of the biocontrol of nematodes in pepper, using *Pasteuria*.

The *Pasteuria* genus has many species and is specialised in infecting specific nematodes. The strain of the species that is well adapted to the environment of pepper plantations works better at managing *Meloidogyne incognita*.

The researchers collected the nematode and the bacteria from the pepper rhizosphere from different parts of Kerala and Karnataka.

Eight samples from the Indian Institute of Spice Research, Kerala had *Pasteuria*-infected worms. The researchers extracted the nematodes from root nodules and cultured them on tomato plants, the preferred host for multiplication.



Image: Scott Nelson via Flickr

The roots were cleaned and kept for nearly 2 days for hatching. The freshly hatched juveniles, from infected tomato roots, were identified as *M. incognita* by morphology and DNA sequence matching.

The researchers inoculated the worms with *Pasteuria* spores from the pepper plantation soil samples. After 30 days, they found that infected female worms had no eggs but were filled with *Pasteuria* spores.

The team tested the *Pasteuria* strain against other nematodes and found no effect. The strain was specific to *M. incognita*.

While examining the attachment of the bacterial spore on the worms, the researchers noticed something strange: the spores were attached in different orientations. Besides the normal attachment of the concave part of the spore to the worm, there were inverted and sideways endospore attachments.

The strain now needs to be produced in larger quantities for field testing in pepper plantations. Since *Pasteuria* species are obligate parasites, the challenge now is to produce adequate amounts of spores. But it seems obvious that pepper farmers in the region will gladly cooperate for field trials.

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Watermelon Juice Concentrate Using membrane technology

Watermelon is a delicious and refreshing summer fruit. However, seasonal overproduction creates a glut. And much of it goes waste, including many useful minerals, vitamins and secondary metabolites.

Fresh juice, extracted and preserved, can be consumed even when the fruit is out of season. But a big part of the juice is just water. Heating to remove water leads to degradation of nutrients. If we can remove water and retain nutrients through ultrafiltration, the concentrate is easier to package and transport.

Chiranjit Bhattacharjee, Vinod K. Saxena and Suman Dutta from IIT Dhanbad chose flat sheet polyethersulphone membranes for ultrafiltration. These membranes have good thermal and mechanical strength.

But what are the ideal conditions to concentrate watermelon juice while retaining nutritional value?

They did ultrafiltration experiments at different temperatures, pressures and volumetric concentration factors to find more suitable processing conditions to retain nutritional compounds. The optimal level was at a volumetric concentration factor of 1.5 at 23°C and 3 bars pressure.

A low temperature of 23°C increases the rate of formation of insoluble aggregates that cannot pass through the membrane thus increasing the concentration of polyphenols and flavonoids in the concentrate. A lower pressure will require more time for concentrating and will increase the loss of bioactive compounds due to continuous recycling of the juice inside the membrane module.

However, what is the concentrate's shelf life? The researchers stored the

concentrate at minus 18°C for one month. There was no significant change in pH, total soluble solids and acidity. However, due to chemical and enzymatic oxidation, vitamin C concentration was reduced by 40%, phenolic content by 21% and lycopene by 7%.

Thus, using membrane technology and storage under appropriate conditions can increase the shelf life of watermelon juice along with nutritional value.

'Due to shorter operating time and greater efficiency, the membrane technology will reduce the manpower needed for processing', says Chiranjit Bhattacharjee. A sweet bit of science for watermelon growers.

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Roads on Soft Soil With coir waste and lime

Vytilla in Ernakulum district has marine clay soils. To construct anything on such soil is problematic since it has low load bearing strength and tends to swell and shrink with moisture. Researchers suggest stone dust, fly ash waste, plastic etc. as stabilising agents.

Leema Peter and P. K. Jayasree from the College of Engineering, Thiruvananthapuram thought of coir waste as yet another solution. Coir waste, available in large quantities, is posing a disposal problem in the region.

But then, though swelling and shrinking with moisture reduced considerably with the addition of coir waste, soil strength did not improve. So with their mentor, K. Balan from the Rajadhani Institute of Engineering and Technology, Thiruvananthapuram, Leema and Jayasree tried lime, another material that is easily made from abundantly available seashells.

The researchers air-dried and sieved the locally available coir waste to separate short fibres from coir pith consisting of baby fibres from the outer husk of coconuts.

To the clay, they added coir waste consisting of short coir fibre and coir pith by dry weight of the clay. Then they added different percentages of lime with the clayey soil-coir mix and

kept aside the mixtures separately for setting and hardening.

The service life of soil treated with only coir waste was eight times that of untreated soil. When soil was treated with coir waste and 10% lime, the service life of pavements increased 425 times!

They report an overall improvement in strength of the marine clay with increase in the value of the parameter – Strength Improvement Ratio – from 2 in soil treated only with coir waste to 26 in soil–coir waste treated with 10% lime.

‘The stability of the pavement improved when its deformation with untreated soil reduced to half with soil–coir waste and 10% lime treatment’, says K. Balan.

‘For durable road pavements on the clayey soils of Vytilla in Ernakulum district, there’s a local solution’, beams Leema Peter, College of Engineering, Thiruvananthapuram.

‘And it’s low-cost: lime and waste from the coir industry’, adds Jayasree, her colleague.

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Fixing Carbon Dioxide

Via nano-particles

Atmospheric carbon dioxide cannot be used directly for reactions and needs to be coupled with epoxides. There are catalysts which initiate this reaction but with low yield.

Venkatramanan Mahalingam and team at IISER, Kolkata now report a nanocatalyst which gives the best conversion of carbon dioxide and epichlorohydrin into cyclic carbonates.

Hematite, an abundant form of iron oxide, adsorbs carbon dioxide. At higher temperatures, it reacts with epoxides to produce traces of cyclic carbonates.

Tetrabutylammonium iodide is a commonly used catalyst for epoxide conversion. The team found that adding this salt as a co-catalyst along with hematite increases the yield to more than 70%. To drive up the yield, the team then tried adding traces of metals such as copper, silver or gold.

After different combinations, they achieved the best yield of cyclic compounds using a hematite–gold nano-

composite and tetrabutylammonium iodide.

Their lab decided to bring these together. To hold the structure of the hematite–gold nanoparticles together, they decided to use polyvinylpyrrolidone, a water-soluble polymer. They then used sodium acetate to keep the reaction in basic medium. Sodium acetate also helped hydrolyse the dimethylformamide that they used as a templating agent for the nanocomposite. They put all these together and autoclaved them at 180 degrees for a day.

They examined the resulting material for its physical properties and carried out chemical reactions with a variety of epoxides and co-catalysts.

Hematite, besides adsorbing carbon dioxide, activates the molecule by interacting with the oxygen in the epoxides. The co-catalyst, tetrabutylammonium iodide, opens up the epoxide ring. The gold nanoparticles in the hematite act as electron donors to carbon dioxide and activate it to enter into a closed cycling ring. This nanocatalyst can be used for five conversion cycles with its structure intact.

The team is now looking to scale this process for industrial applications.

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Vitamin D Deficiency

Urban South India

Vitamin D not only influences bone health and immunity but also insulin production. Lower levels are correlated with the prevalence of diabetes. What is the relationship between vitamin D deficiency in people with different levels of glucose tolerance, inquired researchers from the Madras Diabetes Research Foundation and Dr Mohan’s Diabetes Specialities Centre, Chennai.

They tested 1500 people enrolled in the Chennai Urban Rural Epidemiology Study. After excluding people with type 1 diabetes, chronic pancreatitis, and those on vitamin D supplements, they selected 900 with normal blood sugar levels, 300 with prediabetes and 300 with type 2 diabetes.

The team found that individuals with diabetes had higher blood pressure than the other two groups. There was no correlation between vitamin D

levels and increased blood pressure. However, there is an inverse correlation between glucose tolerance and vitamin D.

Vitamin D levels were lower in people with obesity, metabolic syndrome and insulin resistance. However, there was no significant correlation between lipid levels and vitamin D levels.

Nearly 85% of the study population had vitamin D deficiency or insufficiency measuring less than 30 nanograms per millilitre of serum. Most of those with the deficiency were individuals with diabetes or prediabetes. Women were more likely to be deficient than men.

Darker skin has high concentrations of melanin, the skin pigment that inhibits vitamin D production in our skin. So the low vitamin D levels may be due to higher melanin levels, low exposure to sunlight, and low intake of vitamin fortified foods, say the researchers.

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Going Smoke-Free

Associating work-place with home

The Cigarettes and Other Tobacco Products Act was enacted in India in 2003. The legislation bans smoking in all public areas and workplaces. But does it make people smoke more in the privacy of their homes?

Jaya Prasad Tripathy, from the All India Institute of Medical Sciences, Nagpur tried to find out. He took secondary data from the Global Adult Tobacco Survey India, 2016–2017. The survey contained information on the self-reported prevalence of second-hand smoke exposure in homes and workplaces more than a decade after the promulgation of the Act.

The researcher included data of all aged above 15, who reported working indoors, or both indoors and outdoors but outside their homes. There were more than 15,000 such respondents.

The data showed a strong association between being employed in a smoke-free workplace and living in a smoke-free home.

‘Since home remains a major source of second-hand smoke exposure for children and women, implementing smoke-free workplaces has had

unforeseen but useful consequences', says Jaya Prasad.

Based on the statistical correlations, he found urban residents significantly more likely to stay in smoke-free homes. People with education above secondary school level are also more likely to reside in smoke-free homes. So awareness campaigns on the Act targeting people who are uneducated, especially in rural areas, may improve the situation further.

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Vaccines for COVID-19

Manufacture, distribution, supply

Many companies and countries are racing to develop a vaccine against COVID-19. There are 125 candidate vaccines currently in the race.

Once an effective and safe vaccine is developed, the processes of manufacture, distribution and supply have the potential to delay attempts at immunising the population against the virus. However, while the competition is fierce, so is the collaboration.

Recently, the Developing Countries Vaccine Manufacturers Network, an international organization dedicated to increasing the quality and availability of affordable vaccines, reported on the capacity of its members to manufacture and supply a COVID-19 vaccine.

The researchers compiled the vaccine development activity of network members through an online search. They took data from the WHO's blueprint updated list, reports of scientific meetings, information identified from the internet and publicly available resources. Then, they initiated a survey among members to report their capacity to supply vaccines.

A total of 22 vaccines are being developed by 19 network members. Eight members have WHO prequalified vaccines. As of May 2020, vaccines of four members are in phase 1 or 2 and others are in the preclinical stage. Following up on the suggestion that immune modulation on the BCG vaccine may be effective on COVID-19, a network member company is testing the efficacy of a recombinant BCG vaccine, which is in the phase 3 study.

The network members have the capacity to supply 3.5 billion vaccine doses in a year. The existing manufacturing capacity can help accelerate the manufacturing of the vaccine. If member manufacturers dedicate 50% of their existing vaccine manufacturing capacity to the COVID-19 vaccine, billions of doses can be supplied in the short term, they say.

At present, network members represent 41 manufacturing member companies across Latin America, Africa, the Middle East, and Asia and their supply and distribution cover 170 countries. However, individual data regarding the number of doses supplied by members of the network was kept confidential to make the report free from conflict of interest.

The members of the network have not yet concluded the mode of vaccine delivery and other aspects such as dose requirement, universal applicability, etc.

Moreover, there are many companies that are not members of this network and there are prequalified WHO manufacturers, with vaccines for COVID-19 under clinical trial. Therefore, mass immunization for COVID-19 may be possible in the short-term if the vaccines clear efficacy and safety trials.

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Covid-19 Pandemic

Youthful perspectives

COVID-19 has impacted health, education and employment. The youth of India will face long-term economic and social consequences. But for now, their attitudes and opinions will determine how they cope with the pandemic.

Researchers from Visva-Bharati and the Presidency University, West Bengal assessed and analysed young perspectives on the pandemic. They used a combined qualitative-quantitative approach to assess different perspectives: a questionnaire during the national-level lockdown 1.0.

The researchers differentiated the perceptions into seven factors. The first three factors were about the Government's responsibility and proactive-

ness in pandemic management. The next three were about the origin of the virus and its impact on health and economy. The seventh was about control methods and misinformation.

Interestingly, the respondents advocated the use of centralized control of law and order along with the use of modern science and technology to combat the pandemic. Some respondents believe that the Government is doing its best while others feel that the situation was mismanaged. They believe that action by the government for combating the crisis of the economy will lead to severe losses in the future and that there are chances of revolt.

A significant number believed that the pandemic was intentionally created by China. Globalization was seen as a reason for the spread of the virus.

Most respondents were not sure about the scientific background of the pandemic and the methods that might help control it. They also believe that vaccination alone will not be a solution and that consuming indigenous natural materials can be solutions.

The researchers say that the young in India are subjected to misinformation, misinterpret science, and have low faith in governance and policy.

The questionnaire had more than fifty statements designed to elicit primarily negative reactions. It was circulated via WhatsApp and e-mail and the results are from the responses of only 90 people from 18 states. Statistically credible inferences on Indian youth cannot be made from such sparse data.

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Reports by: **Sushmitha Baskar, Sanghamitra Deobhanj, Ravi Mishra, Shwetakshi Mishra, Aradhana L. Hans, Ravindra Jadav, Sanghamitra Deobhanj, Manish Kumar Tekam, Sileesh Mullasserri and D. C. Jhariya**

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scienceandmediaworkshops@gmail.com