

Science Last Fortnight

Groundwater in the Deccan Traps *Protective capacity of aquifers*

Satara, Solapur and Sangli in Maharashtra lie in the Deccan volcanic province, in the rain shadow region of the Western-Ghats. And the hard rock terrain also restricts water availability.

To locate and assess groundwater in the area, G. Gupta and team from the Indian Institute of Geomagnetism studied aquifers in the Mann River basin. There were many volcanic events in the region 65 million years ago. The resultant layers of porous rock can harbour water.

Rock, clay and subterranean water bodies have different electrical resistances. So the team used electrical resistivity to identify and assess subsurface water-bearing zones. They did 118 vertical electrical soundings to investigate subsurface geology and soil characteristics. They found water-bearing zones at 20 and 40 m. Deep confined aquifers below 40 m. Some aquifers were up to 75 m thick.

The central and western areas of the river basin had good groundwater potential. But the area has porous rocks and may allow fertilisers and chemicals to contaminate groundwater.

They prepared thematic maps to evaluate the protective capacity and hydrologic properties of the aquifers. Though most of the area had freshwater, lack of clayey materials allows fertilisers, pesticides and other chemicals to percolate into groundwater. Only about 20% area had adequate clayey overburden to protect aquifers from contamination.

The report offers insights into groundwater exploration and identification of areas that need protection.

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Oxygen-poor Oceanic Regions *A source of microbe diversity*

Intense oxygen depletion is found at different depths in some parts of the oceans. These zones are inhospitable to oxygen-breathing organisms. However, such zones support micro-

organisms that recycle nutrients and gases. In the Bay of Bengal, too, we see such anoxic regions.



Source: en.wikipedia.org

Samir Damare and associates from the CSIR-National Institute of Oceanography and the Goa University made two expeditions to the Bay of Bengal to study the phenomenon and the ecological roles that the microorganisms play.

They collected water from different depths using a water sampler with an attached oxygen sensor to record depth-wise oxygen concentration. Water till 43 m was oxygen-rich. But, at 200 and 1000 m, water became oxygen-poor.

The team could cultivate 156 bacteria isolates from the samples. Eleven bacterial genera showed nitrate-reducing ability.

To identify uncultivable microbes, the researchers extracted DNA from the water samples and did DNA-sequencing. Based on specific gene sequences, they segregated different microbial taxa. Altogether, the samples yielded 5778 taxa! Actinobacteria, Cyanobacteria, Proteobacteria and Marinimicrobium were most abundant.

Marine microbial diversity was highest at 1000 m, followed by 200 and 43 m. The photosynthesising group, Synechococcophycideae, however, was present only at 43 m and in high numbers. And Marinimicrobium was present only at 200 m where oxygen concentration was lowest. Gamma-Proteobacteria were distribu-

ted over all depths sampled. Sphingomonadales, bacteria from the oxygen-poor waters of the Bay of Bengal, were reported for the first time.

'We could not classify more than 63% of the gene sequences to any taxonomic level. There are more to be discovered in this region', says Samir Damare, CSIR-NIO.

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Sediments in Estuaries *Mercury distribution*

Every time it rains, water washes land. Running into streams and rivers, the water meets the sea in estuaries. The water often carries mercury, a poisonous heavy metal. Though elemental mercury atoms escape into the atmosphere, mercury, bound to natural ligands or with biomolecules, often congregates in estuaries.

With natural ligands, mercury undergoes complexation and reduction. Reduction of mercury produces elemental mercury which is transferred to the atmosphere. This can decrease mercury concentration, and the possibility of methylmercury formation. Methylmercury is one of the most toxic forms of mercury.

To check the molecular characteristics of natural ligands, such as sediment organic matter, and their impact on mercury and elemental mercury distribution in tropical estuarine systems, P. Chakraborty from the IIT Kharagpur and Prasad Padalkar and team from the CSIR-National Institute of Oceanography, Goa collected sediment samples during the wet and dry seasons from the Zuari and Mandovi estuaries of Goa.

They found that sediments collected from the downstream regions of both estuaries were dominated by coarser particles with sizes greater than 63 micrometres. Mid-stream, the Zuari Estuary was dominated by finer particles smaller than 63 micrometres.

The total organic carbon in the sediments was higher in the Zuari than in the Mandovi estuary. While

total organic carbon was low in downstream regions, it increased midway in both.

The researchers observed high carbon to nitrogen molar ratio in sedimentary organic matter during the monsoon, indicating the presence of terrestrial organic matter. The salinity of the overlying water column controls the physical and chemical characteristics of sedimentary organic matter, say the researchers. In downstream saline water, bacterial activity degrades sedimentary organic matter to polarized aromatic organic matter of smaller size.

The team qualitatively analysed the different functional groups present in the sedimentary organic matter using a Fourier Transform Infrared Spectrometer and a UV-Vis spectrophotometer. They observed more aromatic sedimentary organic matter upstream of the estuaries.

The team observed high total mercury concentrations in the midstream region. In the Zuari estuary, higher concentration of sedimentary mercury was found in the middle region. The lowest total mercury was in the downstream region of the Zuari estuary.

The competition between mercury complexation and mercury reduction by sedimentary organic matter controls mercury distribution in tropical estuaries. Sedimentary organic matter plays an important role in hosting and reducing mercury in marine/estuarine sediment, says P. Chakraborty, IIT Kharagpur.

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Subterranean Snakehead Fish Floods reveal hidden ecosystem

In September 2018, Mohammad Ajeer, a young industrial worker and fishing hobbyist from Malappuram, Kerala scooped two nine-centimetre long fish from his flooded paddy field. He found the fish strange and shared photos of the fish on social media.

Rajeev Raghavan, a fish taxonomist from the KUFOS, Kochi saw Ajeer's WhatsApp post. His interest was piqued. His colleagues, V. K. Anoop, KUFOS and Neelesh Dahanukar, IISER Pune collected speci-

mens for analysis. The fish looked like a snakehead. But they had never seen such fish before.



Image: V. K. Anoop

Ralf Britz, a scientist from the Natural History Museum, London, an expert on snakeheads, joined the team for the investigation.

The team did a detailed morphometric study and genetic analyses. They found the fish to be genetically different from known Asian and African snakeheads. So the species was placed in a new genus, *Aenigmachanna*. *Channa* comes from the generic term for snakeheads and, indeed, it is an enigma. The new species is named *gollum*, after the character in J. R. R. Tolkien's famous novel, *The Hobbit*. Gollum too lived a subterranean life like *Aenigmachanna gollum*, the recently found fish species.

The researchers say that this snakehead fish has adapted to underground life over millions of years. It has evolved a long cylindrical eel-like body with long fins and large scales in the head region, to crawl through crevices in subterranean water bodies. It has no use for eyes. While snakeheads are generally bright coloured, this one is mostly brown.

In August 2018, Kerala faced unusual floods. High rainfall during the monsoon might have brought out the species from their subterranean habitat. This could be how Mohammad Ajeer found the species.

The fish diversity of the Western Ghats is not appreciated, says Neelesh Dahanukar, IISER Pune, who has discovered 12 new species in recent years. He estimates that we have described only about 10% of the fish species in the region.

Involving citizen scientists, like Mohammad Ajeer, to document their findings and provoke scientists to follow through can help map as yet unknown biodiversity.

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Cotton Yield in Peninsular India Soil quality index for site evaluation

Cotton is a major cash crop, the main raw-material for the textile industry. But, in the last decade, there has been a decrease in cotton yield from the semi-arid tropical clay-rich black cotton soils of Peninsular India.

Scientists from the ICAR-National Bureau of Soil Survey and Land Use Planning, Nagpur in collaboration with researchers in Dehradun and the UK, compared soil sites for sustainable and profitable cotton cultivation, using two methods: the Soil Quality Index and modified Sys-FAO.



Image: Wikimedia Commons

Soil-site suitability for cotton depends on a combination of soil and landscape properties. The scientists selected a sub-humid moist site in Dhar, Maharashtra, and a semi-arid dry site in Thimmajipet, Telangana, where *Bt* cotton has been cultivated for more than 15 years.

They chose these two contrasting agro-ecological regions with varying physical and chemical properties. Clay-rich soil or vertisols in these regions were considered for land suitability.

The team collected twelve soil samples – seven from Dhar and five from the Thimmajipet sites. In the modified Sys-FAO method, biophysical and soil characteristics were considered. In the Soil Quality Index method, the team first selected indicators for a minimum dataset using principal component analysis. Then they scored the indicators, and calculated the Soil Quality Index.

The Soil Quality Index showed that the Thimmajipet site was better suited for cotton than Dhar. But the modified Sys-FAO method classified Dhar soils as more suitable. So the

team correlated values from both methods with actual crop yield for the sites. Soil Quality Index showed better agreement with actual cotton yield.

When the Soil Quality Index takes mean annual rainfall, slope, soil depth, and growing period into consideration, it is an even stronger predictor of cotton yield for the Dhar than for the Thimmajipet region.

The researchers report that the soils of the sub-humid moist region are moderately suitable for cotton cultivation with soil moisture as the major limiting factor, whereas the soils of the semi-arid dry region are marginally suitable due to high exchangeable sodium percentage and poor hydraulic conductivity.

The Soil Quality Index, though a strong predictor of cotton yield within regions, is a weak predictor across regions, say the scientists. These results can help create a strategy to locate soils suitable for cotton cultivation in different agro-ecological regions to improve cotton production in India.

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Identifying Tomato Varieties Resistance to *Tuta absoluta*

The South American tomato moth, *Tuta absoluta*, is an invasive pest. But, in natural conditions, why are some tomato plants not attacked?

To find out, researchers from the ICAR-Indian Institute of Horticultural Research, Bengaluru compared the ability of cultivated and wild tomato genotypes to resist *Tuta* attacks in both field and laboratory.

They cultivated wild genotypes of tomato in the nursery and allowed the pest to attack the plants. This helped identify plants resistant to the pest.

They then released first instar larvae on plant varieties less damaged by the pest. This no-choice bioassay confirmed that the pest does not favour that particular variety.

The team then analysed the biochemical composition of the leaves. The more the phenolic content in the leaf, they report, the less the pest attacks.

When the researchers examined trichomes in the leaves, they found more non-glandular trichomes on one of the wild varieties that was resistant to the pest attack.

Larval mortality was more significant in the wild genotypes. The duration of larval and pupal stages was higher. Least adult emergence was observed in one of the wild varieties.

The trait of resistance to *T. absoluta* can be used in tomato breeding programmes. 'But we need to know more about the genetic basis of the resistance. And how compatible wild tomato genotypes are with cultivated lines', says Hanamant, ICAR-IIHR.

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Tiny Friends of Lac

Lac, the only animal-derived resinous compound, is produced by the Indian lac insect, *Kerria lacca*. Lac is used for bangle making, sealing, wood finishing, in printing ink and leather tanning. However, the lac insect is vulnerable to *Wolbachia*, a ubiquitous bacterium that causes reproductive problems in hosts.



Image: Katja Schultz via Wikimedia Commons

There are 17 subgroups of *Wolbachia*. WO-phage is reported to infect some of these subgroups. It is the life-cycle stage of the WO-phage that determines *Wolbachia* concentration in lac insects, affecting reproduction.

Suman Lakhnpaul, Delhi University and her Ph D student, S. Kaushik were curious. Which subgroups of *Wolbachia* infect lac insects? Would any WO-phages show tripartite association with lac insects?

Lac insects are of two kinds: reengeeni and kusumi. Kusum and Ber are the host trees of Kusumi. Palas and Ber trees for reengeeni. Besides host preference, the life cycle

and lac quality of the two types also differ.

The team extracted total genomic DNA from kusumi and reengeeni female lac insects. They screened for *Wolbachia* and WO-phage DNA using PCR. The researchers detected *Wolbachia* B in both lac insect subgroups. They also found two types of WO-phage from the samples. The WO-phage infecting the *Wolbachia* in *Reengeeni* and *Kusumi* are phylogenetically distinct.

A better understanding of this association between lac insect, *Wolbachia* and WO-phages might help reduce *Wolbachia* infection and thus increase lac production.

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Water Hyacinth Treating kitchen wastewater

Managing domestic wastewater is a matter of increasing concern. Forty-four per cent of grey wastewater is from kitchens. Kitchen wastewater has a high concentration of detergents, oil and organic matter. Untreated kitchen wastewater is a source of pollution and breeding ground for pests.

Researchers from the NIT Rourkela decided to evaluate the efficiency of water hyacinth for remediate kitchen wastewater. They collected the wastewater from a hostel and analysed physicochemical parameters such as oil, nutrients and metals. The team treated the wastewater samples with water hyacinth and evaluated the parameters every week for four weeks.

After four weeks, they observed a decrease in turbidity, electrical conductivity, total dissolved solids, nitrates, ammonium, phosphates, sulphate, potassium, dissolved oxygen, total organic carbon, oil and grease, bicarbonate, total hardness and metals.

They measured the mass of water hyacinth and found an increase in the biomass. The researchers found that the bioconcentration factor was greater than 1000 and the translocation factor was greater than one for many metals. This, they say, shows that water hyacinth is an excellent bioremediator.

Using water hyacinth to clean wastewater from kitchens is an effective, inexpensive eco-friendly strategy, says Rijwana Parwin, NIT Rourkela.

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Treating Rheumatoid Arthritis *Eugenol and cinnamaldehyde*

In rheumatoid arthritis, an autoimmune disorder, the immune system fails to differentiate between self and non-self molecules. Joints become inflamed and painful, reducing the quality of life. Patients use nonsteroidal anti-inflammatory drugs and disease modifying anti-rheumatic drugs to manage this condition.

Recently, a team of scientists showed that the disorder can be better managed using two natural compounds – eugenol and cinnamaldehyde.



Image: Honmingjun via Wikimedia Commons

Researchers from the Aligarh Muslim University and the King Saud University, Riyadh used blood from 20 patients with rheumatoid arthritis and 10 healthy volunteers. As peripheral blood mononuclear cells give specific immune responses, they isolated and maintained the cells *in vitro*. The team found a characteristic increase in tumour necrosis factor- α and interleukin-6.

The team led by Shagufta Moin also found decreased levels of natu-

ral antioxidant enzymes like superoxide dismutase and glutathione peroxidase in peripheral blood mononuclear cells obtained from patients' blood. The reactive oxygen species and reactive nitrogen species in peripheral blood mononuclear cells from patients were also high.

The scientists used cinnamaldehyde from cinnamon or *Cinnamomum cassia* and eugenol – an active ingredient of many essential oils. They treated the *in vitro* cultured peripheral blood mononuclear cells with 10, 20 and 40 micro moles of both compounds individually. The results showed a dose-dependent decrease in the production of pro-inflammatory cytokines. The team also observed a significant elevation in natural antioxidant enzyme levels and a decline in reactive oxygen and reactive nitrogen species in the treated cells of patients.

The team confirmed results *in silico*. Molecular docking studies revealed that cinnamaldehyde and eugenol interact with key amino acid residues of the tumour necrosis factor- α and interleukin-6, thereby inhibiting the downstream pro-inflammatory cascade.

The study presents the potential of two well-known molecules of natural origin for managing rheumatoid arthritis. These molecules can be used as adjunct therapy to reduce the dose of synthetic medicines.

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Drug Resistance in Malaria *Genetic analysis*

Studies report that malarial parasites are becoming resistant to drugs. The failure of chloroquine, first line treatment for malaria, has been reported from around India.

Last year, a study from Mangaluru suggested that mutations in the chloroquine resistance transporter gene, *pvcr-t-o*, and the multidrug resistance 1 gene, *pvmdr-1*, confer resistance to *Plasmodium vivax*, one

of the five *Plasmodium* species. However, there is limited data on the relationship between chloroquine resistance and these genes from other parts of India.

Now, researchers from various hospitals and medical research institutions report confirming the role of the genes that lead to drug-resistant *P. vivax*. They checked the results from different regions of India with distinct endemicity of *P. vivax*: Puducherry, Mangaluru, Jodhpur and Cuttack.

They found that a change in a single nucleotide in both genes can confer chloroquine resistance to the parasite. These changes were identified as an insertion at the 36th codon in the *pvcr-t-o* and a mutation at codon 1076 in the *pvmdr-1* gene in *P. vivax*. The results are consistent enough: single nucleotide changes in these genes can indeed indicate chloroquine resistance.

The researchers found that the mutation in *pvcr-t-o* was less frequent in all four regions than the one in the *pvmdr-1* gene, which showed high frequency gene variants.

The report provides insights about the evolution and emergence of drug-resistant *P. vivax* parasites. The single nucleotide polymorphism in these genes can help monitor emergence of chloroquine resistance in *P. vivax*. Since *P. vivax* is responsible for more than 50% of malaria cases in India, there is an urgent need to contain its spread.

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