Current Science Reports

Identifying Palaeochannels

Remote sensing and field data

When rivers reach the plains, they tend to meander and often change their course. Changes in land morphology due to sedimentation and tectonics play a role in shifts in the course of the rivers. There are many such palaeochannels created due to diversions of the Damodar fan delta. Older, abandoned channels usually have high groundwater potential and are easily recognised by younger sediments. But field work to identify palaeochannels is cumbersome and time consuming.

Aznarul Islam and Sadik Mahammad from the Aliah University, Kolkata came up with an easier method. They collected satellite data of the Damodar river delta and incorporated the data into Google Earth images. Then, with image processing software, they processed the satellite images in the geographical information system. Removing various atmospheric and topographic effects and artefacts, they identified six major palaeochannels.

'All the major palaeochannels originated from the lower Damodar due to morpho-tectonic changes. And flow in radiating patterns towards the northeast, east, southeast, and south,' says Aznarul Islam, Aliah University, Kolkata.

'The elongated channel depressions can be easily identified in the field and in Google Earth images,' adds Sadik Mahammad, Aliah University, Kolkata.

To confirm the identified palaeochannels, they analysed subsurface geology data, and carried out a field survey. Subsurface and horizontal rock variations helped confirm the palaeochannels.

The palaeochannels are mainly composed of clay, sand, pebbles and gravel of different grain sizes. They are filled with newer sediments and, in some cases, have been transformed into agricultural fields.

Some parts of the palaeochannels are also seen as local water bodies. Near Boinchi and Simlagarh in the Hooghly district, many kilometres east of the present river, the palaeochannels appear as continuous ponds and water bodies in a linear pattern.

The local administration can use such shallow channels to exploit groundwater and meet the increasing demand for water. It is also important to protect the palaeochannels to save groundwater from contamination.

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Ozone in Lower Atmosphere

Impact of lockdown

Ozone in the upper atmosphere shields us from ultraviolet rays. But, at ground level, it is harmful to us.

Ozone is formed in the lower atmosphere during the day due to chemical reactions between nitrogen dioxide and volatile organic compounds such as those from vehicular and industrial emissions. In the absence of sunlight, ozone reacts with nitrogen monoxide which normally reduces ozone concentrations at night.

Emissions of organic compounds reduced drastically due to the COVID-19 lockdown last year. How did that affect ozone chemistry?

Metros like Delhi and Ahmedabad recorded an initial decrease in ozone due to a reduction in nitrogen dioxide levels and then there was a return to the normally observed levels. This was attributed to a lowering of nitrogen monoxide levels. But does this pattern hold good for a coastal region that is subject to sea breeze and land breeze?

To investigate, Girach Imran and Suresh Babu from the Space Physics Laboratory, Thiruvananthapuram and Narendra Ojha from the Physical Research Laboratory, Ahmedabad analysed changes in ozone and nitrogen oxide levels at Thumba, about half a kilometre from the Arabian Sea. They conducted *in situ* measurements of these gases and photochemical box model simulations to understand the impact of lockdown.

Nitrogen dioxide had reduced by about 40 per cent from March 25. This led to a reduced rate of ozone production by a factor of three and hence daytime ozone was lower by 36 per cent during the lockdown.

Interestingly, the researchers observed an increase in surface ozone around the onset of land breeze. This ozone-hump, consistently observed during 1997–1998, reappeared during the lockdown.

The team used a photochemical box model to simulate ozone enhancement during the onset of land breeze. They found that, during lockdown, significant ozone remained over the land till the onset of land breeze due to weaker titration with nitric oxide. Under normal conditions, higher nitrous oxide in the evening hours titrates ozone effectively and ozone levels during the land breeze onset are much lower.

It appears that the chemistry and dynamics of ozone is complex in the lower atmosphere and requires more comprehensive localized studies.

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Methane in Water Column

Cold seepage in Mannar basin

The Mannar basin is located between India and Sri Lanka in the northern Indian Ocean. The basin sediments are very thick, about six kilometres. And bear the potential for hydrocarbon resources in the form of gas hydrates – crystalline solids of water and methane.

Seismic studies in the Cauvery–Mannar basin show the signature of gas hydrates. To investigate further, Aninda Mazumdar and team from the CSIR-NIO Goa carried out a marine survey on board the RV *Sindhu Sadhana*.

Methane seepage can confirm the presence of gas hydrates. So, they collected water samples from different depths and simultaneously measured seawater temperature and salinity – factors that could influence their findings.

They continuously acquired sub-bottom profiler data using a ship hull-mounted system for the entire 150 minutes of operations. The data showed an intensification of gas plumes at a water depth of about a kilometre.

The team continued exploring to a water depth of more than one and a half kilometres, where gas flares

are observed in sub-bottom profiler data.

'A high amplitude zone is also detected at 0–350 metres. But this could be due to scattering by biological and physical ocean processes. Not the gas plume,' says Aditya Peketi.

Methane concentration in the deep water column was very high – almost 50 nanomoles per litre, more than ten times that from shallow water. The enhanced methane concentration in deeper water indicates a methane flux seeping from sea beds, claim the researchers.

The study opens possibilities of gas hydrate exploration in the Indian exclusive economic zone between India and Sri Lanka.

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New Varieties of Cereals

Deficient in zinc and iron?

Now that India is more or less self-sufficient in cereal production, it is time to improve the nutrient values. But we are still focusing on increasing yield, forgetting the need for micronutrients. Some new varieties of rice and wheat are in fact deficient in essential nutrients such as zinc and iron, report researchers from the Bidhan Chandra Krishi Viswavidyalaya.

Sovan Debnath and others from the Bidhan Chandra Krishi Viswavidyalaya, West Bengal grew 16 rice and 18 wheat cultivars released during the Green Revolution in the 1960s to the present.

When they analysed the zinc and iron content, they found lower concentrations in the grains of modern rice and wheat cultivars than in the grains of older cultivars.

'There could be two reasons for this. A dilution of their concentrations caused by yield enhancement or an inadequate supply of the nutrients in growing soils,' says Biswapati Mandal.

To check, they externally supplied nutrients as fertilisers. And, surprisingly, they found that the newer cultivars were more stubborn to external application of zinc and iron than the older ones.

'This can be due to lack of favourable Zn–Fe transporter alleles in newer cultivars,' explains Susmit Saha.

Interestingly, the application of one nutrient element had depleted the grain loading of the other. This seemed to increase in intensity through decades of release of both the cereals.

'This depletion in grain zinc or iron concentration could be also due to down-regulated translocation from root to shoot or shoot to grain,' adds Sovan Debnatha.

'Growing these cultivars of rice and wheat cannot be a sustainable option to alleviate zinc and iron malnutrition,' says Biswapati Mandal.

Besides the focus on increasing yield, breeders and seed industries need to ascertain whether grain nutrient densities have improved before releasing cultivars in future breeding programmes, say the researchers.

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Fish Farming

In arsenic-contaminated water

Aquaculture in arsenic-contaminated water can lead to fish containing arsenic – a toxic element. But not all species of fish accumulate arsenic to the same extent.

To identify the species that accumulate less arsenic and are thus safer to cultivate and consume in arsenic contaminated regions of the country, ICAR scientists recently conducted a series of experiments.

In the arsenic-contaminated areas of the North 23-Parganas district of West Bengal, they selected nine ponds with high arsenic-contamination and one with low-arsenic contamination from Hooghly district for comparison.

The team evaluated arsenic concentration in twelve cultured species including tilapia, catla, rohu, giant freshwater prawn and grass carp. They found high arsenic accumulation in tilapia. Then came catla and rohu.

'High arsenic accumulation is seen in gastropods dwelling at the pond bottom and feeding on detritus materials,' says Santhana Kumar, ICAR-CIFRI, Barrackpore.

'Indian major carp, mrigal, grass carp, java barb and tank goby, and giant freshwater prawn accumulate the least arsenic. So these species should be given preference in aquaculture practiced in arsenic-endemic regions,' says B. P. Mohanty.

The scientists assessed the health risk of consuming fish contaminated with arsenic based on estimated daily intake and found that grass carp is safer for those who eat fish daily.

They also calculated target hazard quotient and target cancer risk. Giant freshwater prawn was found to be safer to eat. Consuming gastropods grown in arsenic contaminated water poses high risk for cancer, they warn.

The scientists point out that, if the water is slightly alkaline, arsenic becomes less soluble in water.

There is a need to convince the authorities and fish farmers in arsenic-contaminated areas to grow more Indian major carp, mrigal and giant freshwater prawn instead of fish such as tilapia and catla, say the scientists.

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Mosquito Gut Microbiota

Wolbachia in Aedes aegypti

Image: Apurv013 via Wikimedia Commons

Wolbachia, a genus of bacteria, infects most insects. It is a common reproductive parasite. The bacteria decrease the lifespan of *Aedes aegypti*, a vector for four major diseases. So *Wolbachia* has the potential to be exploited for vector control.

During earlier research on the issue, S. Balaji, Bharathiar University, Coimbatore noticed a change in the bacterial community in the mid gut of *Aedes* mosquitoes infected by *Wolbachia*. Now, Balaji along with Geetha Deepthi and S. Prabagaran followed up the lead to explore how *Wolbachia* influences the bacterial composition of gut biota in *Aedes aegypti*.

They collected *Aedes aegypti* mosquitoes from four different locations in Coimbatore and maintained the

mosquito colonies under controlled environmental conditions in the lab.

The researchers treated one group of mosquitoes with antibiotics to eliminate *Wolbachia* from the mosquito gut. Another group was reared without antibiotic treatment.

Wolbachia survives through the life cycle of the mosquito. So the researchers observed the infection status of the two groups through two generations.

To analyse the differences in bacterial composition, the team took mosquito larvae as well as adult female mosquitoes of the same age from both groups. They extracted the mid gut from the two mosquito groups, and homogenised and enumerated bacterial load. By extracting and analysing genomic DNA, they constructed a phylogenetic tree of the bacteria.

There were 65 distinct species of bacteria in the minuscule mid guts of the tiny mosquitoes. The mosquitoes that were not carrying *Wolbachia* had an abundance of *Pseudomonas*, and *Acinetobacter*. *Serratia* species were more abundant in *Wolbachia*-carrying mosquitoes.

Balaji and team now plan to explore how these subtle shifts in the gut bacteria lead to reproductive failure in insect vectors infected by *Wolbachia*.

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Repurposing Cancer Drugs
For COVID-19 lung infections

Hyper-inflammation in lungs due to COVID-19 has a close similarity with lung cancer-associated pathology. So is it possible to repurpose anticancer drugs for treating COVID-19?

Scientists from the National Brain Research Centre, Haryana, recently investigated the possibility.

They downloaded gene expression data from a lung adenocarcinoma dataset using the cBioPortal platform, to study the genes co-expressed with the angiotensin-converting enzyme-2, popularly known as ACE2.

ACE2, attached to cell membranes of the respiratory system, is the first target of the spike protein on the SARS-CoV-2 virus. This binding of these two facilitates the entry of the virus into cells. So ACE2 is implicated in the severity of lung infections.

They also studied the correlation between ACE2 and interleukin-6 in lung cancer cells. Interleukin-6 acts as a proinflammatory mediator in the pathology associated with COVID-19.

The team found a negative correlation between pro-inflammatory interleukin-6 and ACE2.

They then introduced the genetic material of the COVID-19 virus into lung cancer cell lines in culture media. There was a decrease in ACE2 expression and a simultaneous increase in interleukin-6 signalling.

The researchers thought of methotrexate, an anti-cancer drug that inhibits several enzymes responsible for inflammation and cell division. They treated the transfected cells with methotrexate. Western blot analysis and qRT-PCR showed that methotrexate can decrease interleukin-6 signalling and increase ACE2 expression, thus decreasing inflammation.

'Methotrexate could be a potential therapy for COVID-19. However, more detailed investigation and clinical trials are needed to confirm the use of methotrexate in COVID-19 treatment,' says Ellora Sen, National Brain Research Centre, Haryana.

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Removing Phenols from Effluent
Achromobacter denitrifacians

Phenols in wastewater effluent are toxic to all life forms and can cause serious environmental pollution. P-nitrophenol in effluents from pharma, insecticide and leather industries, especially, causes slow poisoning and is a serious public health concern. Industrialists, however, find the physical and chemical treatments to remove phenols expensive and, so, are reluctant to adopt them.

A cheaper option could be remediation by microbes. But which microbes should we use and how can we go about it?

Sreeja Mole from the Christu Jyothi Institute of Technology and Science, Telangana collaborated with researchers from Tamil Nadu to explore the problem.

They collected industrial effluents from pharmaceutical industries in 10 different areas in Ranipet, Tamil Nadu. The team cultured all bacteria in the effluents and carried out their 16S rRNA sequencing to identify them.

Using molecular characterization of phenol degrading pathways, they identified the bacteria with the highest potential.

'*Achromobacter denitrifacians* was the most efficient,' says D. S. Vijayan, Aarupadai Veedu Institute of Technology, Chennai.

To investigate the optimum nutrients to mass produce *Achromobacter denitrifacians*, the team cultured the bacteria in different media with varying carbon and nitrogen sources.

'Glucose as carbon source and peptone as nitrogen source worked best,' exclaims T. Jarin, Jyothi Engineering College, Thrissur.

The researchers grew the bacteria in nutrient media containing phenols at varying pH and temperatures to check for conditions to maximise phenol degradation. The bacteria could degrade 90 per cent of phenols in about a day at 35 degrees centigrade at 7.5 pH.

The researchers then checked the effect of metal ions on bacterial growth and phenol degradation. Adding zinc at minor concentrations of 0.01 grams per litre of nutrient solution increased degradation to 92 per cent of phenols.

The researchers hope that their cost-effective method of degrading phenols using the protocols for mass producing the native species of *Achromobacter denitrifacians* will be acceptable for industrialists.

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Amylase from Starch Effluent
Cost cutting in textile industry

Starch is used as an adhesive to reduce the breakage of yarn during weaving, in a process known as sizing. This starch has to be removed from the fabric before dyeing, to allow the absorption of dyes.

Desizing is mostly done using enzymes and the process releases starch-rich effluent. Why can't we use this carbon-rich effluent to produce the enzymes needed?

Shweta Kalia and her team from IIT Delhi and Roorkee, decided to explore different fungal strains for the purpose.

They used starch effluent generated from a textile industry desizing process as an additional carbon source to enhance the production of α-amylase enzymes using solid-state fermentation.

For solid substrate, they used agro-industrial waste. Given the low cost of the substrate, solid state fermentation was preferred over submerged fermentation.

The researchers experimented using different fungal strains and media supplements on various solid substrates and compared the yield of α-amylase.

Production of α-amylase was highest with *Trichoderma reesei* when wheat bran was used as a solid substrate and starch effluent was used as an additional carbon source.

'The amylase produced using effluent can be used for desizing the fabric – an example of resource recovery,' says Anushree Malik, IIT Delhi.

Enzymatic desizing using amylase has many advantages over chemical desizing such as non-toxic by-products, reduced water consumption, and energy efficiency. If textile industries use the starch effluents to produce the enzymes needed, it will help reduce the costs and also reduce investments for wastewater treatment in the textile industry.

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Improving Health Infrastructure

Identifying the factors

The United Nations has envisioned 17 Sustainable Development Goals to be attained by all countries by 2030. India has been lagging in the march towards the third goal: good health and well-ness of its people. And we have only eight more years to go.

Image: Kalyan Neelamraju

Our existing public healthcare systems are ill-equipped to meet requirements. Healthcare is often hard to access because of the distances involved, understaffing of centres and long waiting times in queues.

Given these challenges, how can we inch closer to the goal of better health for citizens?

To understand the drivers of better healthcare, Prabir Kumar Ghosh from the National Council of Applied Economic Research, New Delhi collaborated with researchers from Australia and the UK. They hypothesised that there is a connection between public spending and choice of healthcare provider – either public or private hospitals.

The team conducted a behavioural study of different socioeconomic groups. They considered people with only one ailment as patients. They divided the patients into inpatient and outpatient in government and private clinics and hospitals.

They also sifted through health expenditure data from the national sample survey 2016 and scanned government data on per capita health spending published by the Central Bureau of Health Intelligence.

They analysed the data to find how healthcare for different socioeconomic strata is impacted by government spending. Using regression analysis to identify the strength and character of the relationship between dependent and independent variables and a multilevel logistic model to ensure that variables of interest are dependent on each other, they sought out correlations between the variables.

The most striking outcome was that the per capita government spending on health influences which medical provider people choose. This implies that a government policy of increased spending on public health leads to people opting for public health facilities. This would place pressure on private healthcare to provide better services at cheaper rates – a win–win situation for government and public!

While countries like the US spend 17 per cent of their GDP on healthcare, India spends less than 1 per cent. The COVID-19 pandemic has amply demonstrated that a nation's economy depends on the health of its citizens. Should the country hesitate to invest in healthcare anymore?

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