Current Science Reports

Ozone Hole Monitoring

From Maitri, Antarctica

The Antarctic polar vortex, a large area of low pressure, strengthens in winter. At 10–40 kilometres above the pole, huge tunnels of wind, at 300 kilometres per hour, travel anticlockwise, creating the vortex.

Polar stratospheric clouds, formed during this period, act as a surface for chemical reactions, releasing halogens, which react with ozone, deplete the ozone layer, creating the Antarctic ozone hole there.

Monitoring ozone loss can provide information on climate change. So Jayanarayanan Kuttippurath and colleagues from IIT Kharagpur recently investigated ozone loss around Maitri. Previous studies had shown that Maitri is well inside the polar vortex zone.

Braving the cold harsh winters there, from 1999 to 2003 and in 2006, the researchers used ozone observations made by a Brewer spectrometer, which employs the differences in absorption of various UV bands to measure ozone. From this data, they calculated the ozone loss using dynamical tracer simulations in conjunction with measurements.

Ozone loss was highest in 2006, which was one of the coldest winters. In 2002, when the winter was warmest, there was a split of the polar vortex, and the loss was the least, owing to the weaker chlorine activation in that winter.

The team compared their estimates with those of other ground-based and satellite data, and found that it was in good agreement with data from other stations.

'Maitri measurements represent the entire Antarctic region – valuable for monitoring temporal changes in the Antarctic ozone hole,' says Jayanarayanan, IIT Kharagpur.

Ozone loss estimates from Maitri can reliably be used as inputs into chemistry-climate models.

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Paleoriver in the Ganga basin

Airborne electromagnetic survey

The Ganga and the Yamuna meet, at Allahabad, now known as Prayagraj. The rivers recharge the aquifer system and the region holds a huge amount of groundwater. However, the region is under heavy stress of groundwater withdrawal and quality deterioration.

To address the potential groundwater crisis in the land lying between the Ganga and the Yamuna, scientists from the CSIR-National Geophysical Research Institute, Hyderabad carried out a helicopter-borne transient electromagnetic survey.

Electromagnetic surveys are done by inducing electric and magnetic fields using transient pulses of electric current. The subsequent decay responses are measured to understand the resistivity. Resistivity provides clues about properties such as grain, porosity and compactness. Hard and very compact rocks have high resistivity, whereas porous and water bearing formations have very low resistivity.

Earlier this was done at the ground level. In the past few decades, airborne transient electromagnetics surveys have become globally popular for hydrogeological studies, to find the spatial distribution of aquifer structures and to locate buried valleys or paleochannels.

'Airborne surveys are low cost, convenient and save time, compared to ground-based surveys', explains Subash Chandra, CSIR-NGRI.

The team covered about 12,000 square kilometres, going back and forth in the confluence region aboard a helicopter. The distance between two consecutive flights varied from 100 metres to 2 kilometres.

Using the SkyTEM312, a high resolution, surface-to-depth exploration tool, the team collected dual mode data – shorter pulses to investigate the shallow depths and longer pulses for deeper depths. These two data sets provide continuous subsurface information to a depth of more than 250 metres.

Using the data, the team prepared a high-resolution three-dimensional resistivity distribution map.

Resistivity in the area varied from 1 to 1,000 ohm-metres. Low resistivity of 1–12 ohm-metre suggested clayey sediments whereas Vindhyan formations in the southern parts showed high resistivity of up to 1,000 ohm-metres.

To validate the results, the team measured the electrical resistivity of actual downhole soil/rocks from the nine boreholes drilled in the region.

After this confirmation, the team prepared a depth-wise map of mean resistivity of every 5 metres up to 50 metres depth and thereafter every 10 metres up to 250 metres depth.

At 5–10 metres depth, they discovered a 45 kilometre long, approximately 6 kilometre wide, low resistivity feature, which became more prominent at 10–15 metres depth, indicating a buried channel, running almost parallel to the Ganga and joining the Yamuna before the confluence.

The profiles and downhole geological information show a downward displacement of about 30 metres of the clay layer below the Ganga.

'This suggests that the area has had tectonic disturbances. The buried channel is perhaps not a paleo course of the Ganga. Both had the same base level,' says Virendra M. Tiwari.

The researchers found that the buried channel is connected with the aquifer of the region. It starts losing lateral connectivity at 30–35 metres depth, where it becomes patchy. They estimate that the storage capacity of the palaeo channel has significant potential for aquifer recharge.

Since the palaeo channel is interconnected with the Ganga and the Yamuna at a few locations, it can play a major role in groundwater replenishment.

The channel as an interconnection between the rivers and groundwater is also a critical factor for consideration in groundwater quality management, say the researchers.

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Malaria Eradication Programme

Species-specific, region-specific

India achieved more than 80% reduction in morbidity and mortality due to malaria in the last two decades. We

are now very near the goals of a malaria-free nation by 2027 and of elimination by 2030.

The last leg of total eradication requires more focus on hard-to-reach areas, especially in malaria-endemic states like Odisha. Moreover, there are five malarial parasites with varying degrees of virulence. This necessitates differential diagnosis and species-appropriate treatments. Some parasites remain untreated which can cause their further spread. So we need to identify and use region-wise and parasite-specific strategies.

Since more diverse parasites are found in Odisha, Madhusmita Bal and team from ICMR, Bhubaneswar recently conducted a blood sample survey in over 2000 households in 23 districts there.

They used a rapid diagnostic test to find plasmodium-infected individuals. From the samples that were identified with the parasites, the team extracted DNA sequences of parasites using a two-step PCR test. This gave a distribution of varieties of parasites among positive samples.

Only 5% of samples had single malaria parasites. Forty per cent among these were *Plasmodium vivax*. Most samples had mixed infections and one third of these had *P. ovale* spp.

P. falciparum and *P. vivax* are generally considered the dominant parasites in India and so the eradication programme focuses on these. However, how do we deal with the other parasites, such as *P. ovale* spp.?

'The WHO recommends treating malaria due to *P. ovale* spp. with primaquine. Other parasites are treated with a chloroquine and artemisinin combination. So the National malaria programme should be redesigned with diagnostic tools to identify the specific parasites and adjust treatment protocols accordingly,' says Madhusmita Bal, ICMR-MRC.

Fever due to *P. vivax* malaria recurs every two days whereas *P. ovale* spp. infection is symptomised by recurring fever with chills. Such symptomatic identification is useful at PHC level where the diagnostic tools may not be available. But differential diagnosis becomes difficult in mixed infections.

The researchers suggest using the molecular diagnostic facilities for COVID-19 already established at all district headquarters for identifying the malarial parasite species as well.

'District headquarter hospitals should be prepared to identify and provide species-specific treatments for malaria,' says Manoranjan Ranjit.

This is an essential step towards achieving the goal of the total eradication of malaria from our country.

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Chandipura Virus

For cancer treatment?

In 1965, a new virus was isolated from two patients in Chandipura village, Maharashtra. The virus, now named the Chandipura virus, is an RNA virus, which causes childhood encephalitis in humans.

The Chandipura virus is a member of the Rhabdoviridae family. Many viruses in this family are used as a vector for targeting cancer cells, because their life cycle is simple and restricted to the cytoplasm. Cell lysis is often the result.

So can the Chandipura virus be used to target cancer? Recently, researchers from the RGCB, Thiruvananthapuram investigated.

They collected Chandipura virus samples from the National Institute of Virology, Pune and human cell lines from the University of Central Florida. They infected both cancer cells and normal cells grown with the Chandipura virus and monitored the results using phase-contrast microscopy.

After 48 hours, they observed remarkable rounding and loss of adherence in cancer cells. But virus-infected normal cells had only minor changes. The cancer cell lines were seen to support Chandipura virus growth to a greater extent than normal cells. Biological assays showed that growth of cancer cells is restricted by the virus.

The researchers tested the feasibility of exploiting the oncolytic property using the Xenograft tumour model – a preclinical model for cancer research – in laboratory mice. And they found that tumours were restricted in mice infected with the Chandipura virus.

'The virus is reported to be non-pathogenic to adults and cancers are more common among adults. So the Chandipura virus has potential for use in cancer therapy,' says John Bernet Johnson, RGCB, Thiruvananthapuram. 'But of course, there should be extensive studies before using it as an oncolytic vector,' he adds.

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Improving sleep quality

Using white noise app

Sleep is vital for our physical and mental well-being. Sleeplessness can cause anxiety and behavioural changes. Sleep helps in healing and energy conservation especially in critically ill patients in the intensive care units of hospitals. However, the noises from medical equipment, exposure to artificial light and ventilator mode cause sleeplessness among patients in intensive care units. Can mobile applications be used to counter the noise and to improve sleep quality?

Fatima D'Silva and her team from NITTE, Karnataka used a white noise mobile app, to check.

The android application has frequencies between 20 and 20,000 hertz with white, pink and brown noises. White noise, resembling the humming of air conditioners, contains a broad range of frequencies with similar intensities. Pink noise has lower intensities at higher frequencies, like ocean waves. In brown noise, intensity reduces even more steeply with higher frequencies. Like the sound of steady rainfall. These sounds have a soothing effect on the brain and can be used to mask the other sounds in ICUs.

The researchers collected sleep quality data at regular intervals from critically ill patients in a tertiary care hospital in Mangalore. They divided fifty-four patients into two equal groups. Only one group received white noise.

The team assessed sleep quality before the test using the Likert scale, a system for scaling responses in questionnaires. They also identified physiological, environmental and psychological factors affecting sleep patterns in the patients.

Then, on day one, the app was set to white noise and was used twice a

day. Pink noise was used on the second day and brown noise on the third day.

After three days, the team measured sleep quality again. Fatigue, use of urinary catheters, cannula or NG tube and worry about health were sleep-disturbing factors in those who used the app.

Patients who did not use the app also experienced similar factors but, instead of fatigue, they had pain and breathing difficulty.

The investigators found a significant improvement in sleep quality among those who used the app during the three days.

Perhaps a white noise app can be useful to improve sleep quality when you have to spend the night in strange places.

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Embryonic Development

Self-eating stem cells

Your life began from a single-celled zygote after the union of egg and sperm. The zygote quickly divided to form a sphere of cells, a blastocyst.

The blastocyst contains stem cells that are pluripotent, capable of developing into any type of tissue cell. These stem cells divide and organise themselves into gastrula, a ball of three germ layers of cells: an outer ectoderm, inner endoderm and a mesoderm in the middle.

Later, the ectoderm will become skin and nervous system, mesoderm becomes bone, muscle and connective tissue and endodermal cells become liver, pancreas, etc.

During the development of the three-layered structure, along with rapid cell division, many cells are eliminated. In some cells, lysosomes, the organelle containing digestive enzymes, consume the cytoplasm, eating the cells from within. This self-eating or autophagy is required for reprogramming and maintaining stem cells.

Is the role of autophagy limited to the elimination of cells or is it also deciding the fate of cells in the germ layers?

To investigate, Kulbhushan Sharma of INMAS, Delhi and a team of researchers from Norway induced differentiation in human pluripotent stem cell lines.

By assessing the levels of autophagy and the related gene products, the proteins that induce and regulate autophagy, as well as the consequent changes in the morphology of the cells, they could unravel how autophagy influences the formation of the three germ layers.

When they inhibited autophagy briefly, the stem cells started exiting the pluripotent state.

Further prolonged inhibition of autophagy led to the formation of the neuroectoderm from which the nervous system will develop. In contrast, when the researchers stimulated autophagy, the stem cells transitioned into mesoderm and endoderm.

But which are the genes involved in these processes?

The researchers quantified the proteins involved and identified the sex-determining region Y-box transcription factor 2, or SOX-2 protein, as the main factor.

Reduced SOX-2 led to increased autophagy resulting in the formation of endoderm. When the levels of the SOX-2 protein were maintained, stem cells developed into neuroectoderm.

Thus it appears that the SOX-2 protein regulates the self-digestion of stem cells and decides the germ layer fate.

If this protein were not there, you would not have been born!

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Malabar Tamarind

A source of edible oil

India is a major producer and importer of edible oils. The growing population increases the demand. Thankfully, India has numerous plant resources that are yet to be explored for edible oils and fats.

Malabar tamarind, *Garcinia gummi-gutta*, for example, is widely cultivated as a crop plant in Kerala. The dried fruit rind of the plant is used as a flavouring agent in fish curries, similar to kokum from *Garcinia indica*. The fruit rind is also used to isolate an anti-obesity agent, hydroxyl citric acid. But the seeds are considered waste.

Kokum butter has now found use in food and cosmetic industries. Can Malabar tamarind seed oil be used as edible oil too?

Image: K. B. Rameshkumar

K. B. Rameshkumar and team from the KSCSTE-Jawaharlal Nehru Tropical Botanic Garden and Research Institute, Thiruvananthapuram explored the possibility.

They took mature Malabar tamarind seeds and extracted oil using different techniques: Soxhlet, reflux and cold extraction techniques with hexane as solvent, along with conventional rotary press and screw press methods. Soxhlet extraction gave better yield – 35%.

The team used nuclear magnetic resonance spectroscopy to evaluate the quality of fatty acid constituents and also for determining various physico-chemical parameters. The extracted oil was a mixture of stearic and oleic acids.

Quality index, measured by saponification, iodine and free fatty acid values also support the use of Malabar tamarind seed oil for cooking.

'And we observed no mortality or any clinical signs of toxicity in laboratory rats,' says M. Priya Rani, JNTBGRI.

Exploring such edible oil sources from our indigenous plants may help curb edible oil shortage in India and provide opportunities for agricultural start-ups.

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Pesticides Impact Birds

Modelling toxicity

Globally, over 2 billion kilograms of pesticides are used annually to control agricultural pests and vectors that transmit human diseases. These pesticides are known to pose threats to fish, bees and birds.

Estimating the real-world impact of pesticides on birds is especially tricky. Many factors including weather, time and season of application as well as the composition of the pesticide alter toxicity effects on birds.

So, researchers from the Jadavpur University, Kolkata decided to develop models to identify the structural features of pesticides responsible for toxicity in birds.

They drew the structure of 128 commonly used pesticides using the MarvinSketch software. Using the pesticide structures, the researchers developed quantitative structure toxicity relationship regression models.

To extrapolate toxicity data across bird species, they also developed 11 interspecies models. The researchers then compared the prediction from the models with the pesticide's acute toxicity data from published literature and the Pesticide Ecotoxicity database. The predictions were comparable to the already reported data.

'In general, pesticides containing electronegative atoms and lipophilic compounds can easily penetrate cells through the plasma membrane. So such pesticides have higher toxicity on birds,' says Rajendra Kumar Mukherjee, Jadavpur University, Kolkata.

But pesticides with hydrophilic atoms and polar nature-disulphide bonds have reduced penetration through the lipid layer of the plasma membrane and hence reduce pesticide toxicity.

To further confirm their results on interspecies variations, they also tested the acute toxicity of pesticides by feeding them to five bird species: wild duck, house sparrow, ring-necked pheasant, Japanese quail, and bobwhite quail. And they monitored the birds for mortality or any phenotypic signs of toxicity for fourteen days.

'Sixty-two pesticides were toxic to wild ducks, 29 to ring-necked pheasants, 15 to Japanese quails, and 10 to house sparrows,' says Vinay Kumar, Jadavpur University, Kolkata.

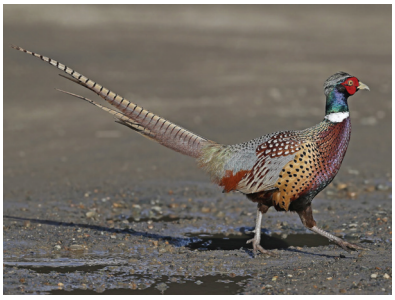

Image: Wikimedia Commons

'The models are extremely useful for predicting the toxicity of new pesticides on various bird species,' says Kunal Roy, Jadavpur University, Kolkata.

He advises reducing the use of pesticides with electronegative atoms and lipophilic features to reduce the impact of pesticides on birds.

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Convert Biomedical Waste

To vermicompost

Biomedical waste is incinerated to kill pathogens. The resulting ash is used by construction industries or dumped in landfill.

But the ash is rich in toxic heavy metals and polyhydroxy aromatic hydrocarbons. So, the leaching of these toxic materials remains a concern.

Adding the ash to composting may help reduce the toxicity, but natural composting is slow.

Can we expedite the process using earthworms?

Researchers from the Guru Nanak Dev University, Amritsar collaborated with a researcher at the Government Degree College Anantnag, Jammu and Kashmir, and a Japanese university to investigate composting biomedical ash with the earthworm, *Eisenia fetida*, which is good at bioaccumulating heavy metals.

They found that high concentrations of the ash were toxic to the earthworms. So, they added cow dung.

Before adding the earthworms, the researchers degassed the mixture by turning it over from time to time.

This helped in removing harmful gases and excess heat, which otherwise would have killed the earthworms.

The team designed a 105-day experiment using different ratios of biomedical ash and cow dung.

The researchers monitored the growth of the worms along with the medium's pH, conductivity and organic carbon.

They found a decrease in the growth with ash concentration. Ten to twenty-five per cent ash in cow dung was suitable for the worms in a decreasing order.

The mixture containing the earthworms reduced in pH, conductivity and organic carbon. Along with this, there was an increase in plant nutrients – nitrogen, phosphorus, potassium and sodium. Thus, the final product came out to be suitable compost.

But what happened to the toxic heavy metals?

The researchers say that zinc, cadmium, cobalt, nickel and lead were reduced to permissible limits after composting. Copper and chromium were also reduced significantly.

Municipal bodies now have a win-win solution for biomedical waste disposal.

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