

Current Science Reports

Blue Ice in Antarctica

Preserving extra-terrestrial dust

The amount of extra-terrestrial materials entering the earth was estimated at 40,000 tonnes per year, based on impacts on a satellite orbiting the thermosphere. Later, from osmium isotope ratios in deep sea sediments, extra-terrestrial input was calculated as 30,000 tonnes. Measurements from water below ice in the South Pole and those from a mountain glacier at Antarctica have much lower figures. This was bewildering.

So when N. G. Rudraswami and team from CSIR-NIO went to the Maitri station in Antarctica, they decided to delve into the problem. About 8 kilometres from the station, there was blue ice in what is now called the Schirmacher Oasis. Extra-terrestrial material, trapped in the ice there, is relatively undisturbed by anthropogenic influences.

Rudraswami and team dug one metre from the surface and extracted 50 tonnes of ice. They processed 9 tonnes – melting, and sieving with a mesh of 50 micrometres.

Three tonnes, they found, was contaminated by dust particles from the surroundings.

They used an optical binocular microscope to measure the diameter of the particles. Most of the extra-terrestrial material was in the range of 80 to 140 micrometres.

This was surprising. Earlier collections have shown an abundance of particles of about 200 micrometres. The dominance of the smaller size particles may be because of a recent influx of smaller particles or it could be due to the movement of heavier particles into the ice, say the scientists.

Using a scanning electron microscope, the scientists examined the petrographic textures and identified different mineral phases. An electron probe microanalyser pinpointed their chemistry. The porphyritic content, the researchers found, was much more than usually found in deep sea sediments and the shape and size of

the micrometeorites seemed to be different too.

Chondrules and refractory inclusions were rare in the extra-terrestrial dust. Calcium–aluminium-rich inclusions were also rare. From the composition, the researchers identified that the source of the dust could be carbonaceous chondrites of meteorites. These are composed of porous materials that break up into dust on entering the earth's atmosphere.

'There is wide variation in extra-terrestrial fluxes received by the earth's surface depending on the frequency of passing through the asteroid belt and incursions of cometary bodies toward the inner solar system. The heterogeneity in dust reaching the earth's surface reflects this variation,' says Rudraswami, CSIR-NIO, Panaji.

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Laxmi and Laccadive Ridges *Integrating with geophysics*

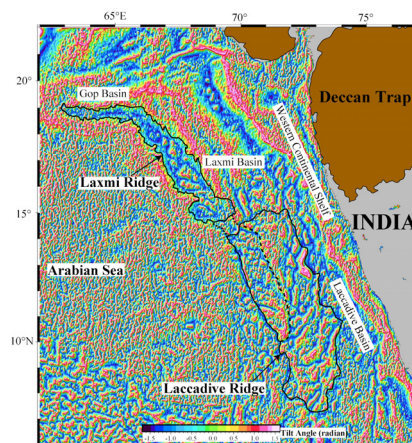


Image: Anil Kumar Chaubey

The Laxmi and Chagos-Laccadive ridges are dominant physiographic features in the Arabian Sea. These ridges are associated with the separation of Madagascar and Seychelles from the Indian continent. The Chagos-Laccadive ridge was formed about 85 million years ago during the separation of Madagascar, whereas the Laxmi ridge was formed about 65 million years ago during the separation of Seychelles from India.

The Laxmi and Laccadive ridges are quite different from typical ocean ridges. The crusts of both ridges are thicker than oceanic crust and thinner than continental crust. The Chagos-Laccadive ridge is a volcanic ridge. The Laccadive ridge, a part of this ridge, is made of continental crust. The Laxmi ridge, on the other hand, is associated with low gravity. So they were considered separate from each other. But now scientists from the CSIR-National Institute of Oceanography, Goa show that they are related.

Anil Kumar Chaubey and team applied an integrated geophysical approach with new as well as previously acquired geophysical data over the Laxmi and Laccadive ridges to address the gaps in the paleogeographic reconstruction of the Indian subcontinent.

They combined gravity and magnetic data to derive the crustal model. The model indicated that both ridges have almost similar crustal structure. Both ridges are carpeted with flood basalt and heavily intruded.

The team delineated ridge boundaries, using the tilt angle of gravity anomaly, and applying the limits from the seismic data. The elastic plate thickness of both ridges is low and in the same range of 3 to 4 kilometres. The subsurface to surface load ratio for both is also in the same range. Results indicate that the lithosphere is weak and the ridges are locally compensated.

The north-western part of the Laccadive ridge has NW–SE structural lineaments similar to those of the NW–SE segment of the Laxmi ridge. The Laxmi Ridge is continued towards the southeast and joins the north-western part of the Laccadive Ridge.

Both ridges are broken pieces of continental plates, and had experienced stretching and rifting at the eastern and western ends in the geological past.

This paleogeographic reconstruction of the western continental margin

of India delineates the continent-ocean transition along the margin.

'Our results support the need to extend the subcontinent's maritime boundaries. This will allow Indian oil industries to conceptually evaluate hydrocarbon prospects over the ridges,' says Anil Kumar Chaubey, CSIR-NIO.

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Fluoride Contamination

In Khurda and Nayagarh, Odisha

In parts of the Khurda and Nayagarh districts of Odisha, fluoride concentration in groundwater is high and this is leading to severe health issues. The region is a part of the Eastern Ghats, comprising deformed metamorphic and igneous rocks, which contain fluoride-bearing minerals. Is the fluoride in the groundwater due to this or due to agricultural activity there?

There are two hot springs in the region – Atri and Tarbalo. Could they be the reason?

Researchers from IIT Kharagpur, the Bhabha Atomic Research Center, Mumbai, and the Homi Bhabha National Institute, Mumbai jointly decided to resolve the issue.

They collected and analysed twenty-two water samples from tube wells and dug wells in the area. The team also analysed one rainwater sample, water from each hot spring and a sample from the local river.

While rainwater was acidic with low electrical conductivity, groundwater was slightly acidic to neutral with low to high electrical conductivity. High electrical conductivity indicates salinity in groundwater. Given the composition of the rocks in the area, the researchers suggest that this could be due to the leaching of sodium and chloride ions from host rocks.

Besides chloride, there was a high concentration of sulphide, calcium and bicarbonate ions in the groundwater. And high concentrations of fluoride in nearly 40% of the groundwater samples! Some samples had more than 3.5 milligrams per litre, much above the Bureau of Indian Standard permissible limit of one milligram per litre.

Samples with low fluoride concentration show comparatively higher bicarbonate values. This suggests that the accumulation of fluoride in water is not due to evapotranspiration or due to calcite precipitation, say the researchers.

Fertilizers are sources for fluoride contamination. But along with fluoride, there should be higher potassium and nitrate concentrations. This correlation was not seen in all the samples collected. So the primary source of high fluoride could not be fertiliser use.

There is an occurrence of very high fluoride concentration – up to 12 milligrams per litre – around the hot spring area, perhaps due to increased dissolution. The mixing of hot and cold reservoirs could also increase fluoride content.

The researchers observed that villagers in the Atri and Tarbalo areas are affected by skeletal and dental fluorosis. They estimated the fluoride exposure dose for infants, children and adults. Exposure risk is double for children, making them vulnerable to severe fluorosis.

'Similar high fluoride concentrations have been recorded in groundwater near geothermal regions in Telangana, Rajasthan and Gujarat,' says Asmita Maitra, IIT Kharagpur.

'In such cases, we recommend using alternative sources such as surface water bodies and dug wells for drinking water to reduce chances of fluorosis,' says Saibal Gupta, her colleague.

'Defluoridation using coagulation-precipitation or membrane-based techniques are choices where safer water is not accessible,' says Tirumalesh Keesari, BARC, Trombay.

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Beneficial Soil Bacteria

Promoting plant growth

Ranjana Bhatia, Panjab University, has been investigating biofertilisers – bacteria that can help increase crop productivity by increasing the availability of nutrients to plants and warding off infections by pathogenic bacteria and fungi.

She was confronted with this problem: can we have a soil bacterium

that can be beneficial to different crops cultivated on a rotational basis? She set the problem to Priyanka Pathania, her student.

Crop rotation of maize and tomato is a common agricultural practice in the area. It is easy to inoculate maize seeds with growth promoting bacteria. But this is difficult in tomato since tomato saplings are transplanted. So Priyanka went ahead and isolated a growth promoting bacteria from a local maize field. And the team identified the strain as belonging to the *Bacillus* species, by comparing the sequence of its 16s ribosomal RNA with the sequences in the EzBioCloud database.

The rhizospheric microflora of one crop may influence the next crop either positively or negatively. And this depends on the interactions between the plant and the microbe. Do tomato root exudates attract the *Bacillus* strain, MT7? Does the bacterial strain form a biofilm around roots to colonise? Does it solubilise phosphorus in the surrounding soil so that it becomes easy for tomato to take it up? And how about nitrogen availability to the plant? Does MT7 contribute?

Ranjana Bhatia and her colleague, Madhu Khatri pestered Priyanka till she came up with experimental data, which showed that MT7 works for both crops.

The *Bacillus* strain was contributing indole acetic acid, a plant hormone involved in growth and development; it had antifungal activity.



Image: N. G. Ramesh

And what is more, they tested the response of bacillus strain MT7 to various abiotic stresses such as heat, salinity, drought and heavy metals. And found that the species survived well in all stress conditions.

The team then conducted pot experiments with tomato plants treated with bacterial inoculums and

confirmed that the treated plants performed better than the untreated ones.

The *Bacillus* species was compatible with both maize and tomato rhizospheres and has the potential to increase the productivity of both crops.

'Both maize and tomato roots exude lactic acid, which may be acting as a chemoattractant for our strain,' says Priyanka Pathania.

'We now have to do field trials. And we need support from farmers and authorities for that,' says Ranjana Bhatia, Panjab University.

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Nano-cellulose from Rice Husk *Best out of waste*

India produces nearly 24 million tonnes of rice husk each year. Most of it is wasted. Some use it as fuel or to produce biochar. There have also been attempts to extract nano-silica from rice husk for various applications. But silica content in rice husk is less than 15% while about 50% is cellulose. And more recently, there have been attempts to extract nano-cellulose from rice husk for various applications.



Image: T. Bhagat

Sumira Rashid from Amity University, Uttar Pradesh, and Himjyoti Dutta from Mizoram University had recently tried using nanocellulose from the husk to stabilise yogurt. And they found wide variations in the properties of nanocellulose from rice with long, medium and short grains. Depending on grain size, the cellulose properties seemed to change.

So they decided to investigate further. The researchers collected mature paddy samples of short, medium, and long grains. After dehull-

ing, the team dried and powdered the husk. Then, they treated it with an alkali and bleached the sample to eliminate all non-cellulosic components. The amount of cellulose extracted from the three varieties of husk was directly dependent on grain size.

The researchers then did a series of experiments to characterise the nanocellulose from different grain sizes. The nano-cellulose particles from rice husk are spindle-shaped nanowhiskers. The size of the nanocellulose was directly proportional to grain size.

The husk from long grain rice has more regular alignment of nanocellulose molecules than those from shorter grains. This suggested a higher order of crystallinity, leading to higher strength and stiffness.

To evaluate the stability of the nanocellulose, the researchers determined the surface charge on the cellulose particles. They found a negative charge over these particles, suggesting good colloidal stability of the nanocellulose.

Using thermogravimetric analysis, the researchers found that the nanocellulose was thermally stable. Nanocellulose from the husk of long grain rice had the highest heat resistance – about 490°C.

Materials of nanoscale dimensions pose the risk of interacting with human blood cells and lysing them. So, the researchers used fresh goat blood erythrocytes to test and found a negligible effect.

'Rice husk nano-cellulose is safe for making consumer products – including processed foods,' says Sumira Rashid, Amity University, Noida.

'Such applications will help manage tonnes of waste from paddy processing,' adds Himjyoti Dutta, Mizoram University.

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Water Purification in a Jiffy *Chlorinated stirrer, pen and stick*

Many fall ill due to water contamination. The WHO puts related deaths at 15 lakhs annually. There are many water purification technologies. But

even chlorination, the most common, low-cost method to control microbial contamination, is not as widely used as it should be.

Researchers in the innovation lab at Tata Consultancy Services reasoned that lack of ease of use limits the application of chlorine. And they started designing simple water purification devices.

They decided to use trichloroisocyanuric acid as the chlorine releasing compound. Unlike other chlorine releasing chemicals, trichloroisocyanuric acid does not release chlorine in excess. Excess chlorine can leave a bad taste and smell. This chemical releases chlorine in smaller quantities and is more stable than other chlorinating agents.

The team designed a simple disposable stirrer, around 15 centimetres long with a flat end, having a small absorbent pad containing the chlorant.

'Stirring for 30 seconds is enough to decontaminate a glass of water,' says Rajshree Patil, Tata Consultancy Services, Pune.

But what if one wants to disinfect about 1000 glasses?

The researchers devised a pen whose cap had the disinfectant tablet. A spring in the cap ejects the chlorant into water through an absorbent pad.

But what if we need to disinfect 10,000 litres?

The team designed a stick which held more disinfectant tablets. Stirring with the stick could disinfect about 10,000 litres of water.

The team measured the chlorine content of the water after using the three prototypes. They found that all three released about 0.2 to 0.6 milligrams per litre of chlorine after each round of stirring.

To check whether the chlorine content was enough to inhibit microbes, they spiked some groundwater with bacterial and viral contaminants. They found that all three prototypes effectively inactivated bacterial and viral contaminants.

Given the ease of use, flexibility and effectiveness, the only other factor that comes in the way is the cost.

'The cost is around Rs 30–100 per piece for 1000 uses, depending on whether it is the stirrer, pen or stick,' says Dilshad Ahmad.

'These devices can be used when travelling or during situations like floods and tsunami when safe drinking water is scarce,' says Chetan Malhotra.

Will the devices appear on the market? Only time will tell.

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Indian Diets

Healthy and sustainable?

The green and white revolutions in India reduced hunger. But, while under nutrition reduced to less than 15%, obesity has increased to nearly 20%. Changing diets along with rising prosperity are leading to unsustainable consumption patterns. Crops that have negative environmental impact, such as sugar, are consumed in higher amounts.

Tushar Ramchandra Athare from the ICAR-Agricultural Technology Applications Research Institute, Jabalpur collaborated with researchers from Germany, to examine the impact of Indian diets on health as well as the socioeconomic contexts and the sustainability of the diets.



Image: Mirza Asif Beg

They used food intake data from the household consumer expenditure survey 2011–12 of India. Using

k-means clustering, they classified Indian diets into 11 mutually exclusive groups.

A low calorie diet consisting primarily of rice, fish and pulses, they found, is common in Kerala, Karnataka and coastal Maharashtra. Some districts of Tamil Nadu, Jharkhand and West Bengal also have a similar diet pattern.

A moderate calorie diet consisting primarily of wheat, sugar and dairy products is common in Maharashtra, Gujarat and Madhya Pradesh. Another moderate calorie diet consisting primarily of rice is common in the southern and eastern states of India. In parts of the western states where rice is replaced with other cereals, along with higher consumption of sugar and dairy products, the researchers noted a slightly higher amount of calories.

Bihar, UP, Himachal, Uttarakhand and J&K had very high calorie diets based on rice.

Madhya Pradesh, Rajasthan and western UP had high calorie diets based on wheat.

Odisha, West Bengal, Arunachal Pradesh and Manipur had even higher calorie diets based on rice.

The highest calorie diet was seen in Punjab, Haryana, western Uttar Pradesh, and a few districts of Rajasthan and Gujarat, where dairy products and sugar consumption was high.

Consumption of commercially sold ready-to-eat foods was uniformly spread in all states, with higher consumption in urban areas. Rural areas preferred cereal-dominated, moderate to high calorie diets.

Interestingly, low-, middle- and high-income households seemed to have calorie-rich diets. This, the re-

searchers say, shows over-nourishment as an issue in all income groups. For low-income groups, over nourishment comes from government-subsidised high calorie items – rice, wheat and sugar, point out the researchers.

They also found over-nourishment in Sikh and Jain households, where preferences are for dairy products and sugar.

The researchers then examined the environmental impact of the diets. Dairy and sugar-based high calorie diets contribute the maximum in terms of greenhouse gases. Even the low-calorie diet based on rice has high emissions. Rice and sugar also require high, unsustainable amounts of water. Freshwater usage was highest for wheat-dominated diets. However, it was lowest for a diet with cereals other than wheat and rice.

Indian dietary habits are currently unhealthy with over-nourishment in all income groups. They also carry a high environmental footprint due to the higher consumption of rice, dairy products and sugar.

The researchers suggest that including pulses, fruits, vegetables and nuts in food subsidy programmes can make the diets healthier.

Reducing rice, sugar and dairy product consumption can also lower the environmental footprint of our diets.

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