

## Current Science Reports

### Climate Change on Mars

#### *Volcanic dome records*

Once upon a Noachian time, about 4100 to 3700 million years ago, Mars was bubbling with volcanic, fluvial and other geological activity. Now, it is a dry, cold and dusty planet.



Image: Pixabay

Vijayan and Harish from the Physical Research Laboratory, Ahmedabad, collaborated with a French researcher to study the geological processes and past climates that created Martian landforms.

The team chose a volcanic dome area, with volcanic, impact, glacial, and fluvial landforms. Using images and digital elevation models from the Mars Reconnaissance Orbiter and Mars Global Surveyor, they examined interrelationships between the landforms.

Degana, the largest crater there, is about 50 kilometres in diameter and 2 kilometres deep. Within this crater, the researchers found another crater, Degana A, about 20 kilometres in diameter and 0.7 kilometres deep.

The continuous exposed layer along Degana A's rim is pristine Noachian crust, uplifted by dome formation. The team analysed the exposed bedrock. There were igneous materials, indicating volcanic origins.

The team mapped sedimentary deposits and landforms within the craters. Nine fan-like deposits were predominant – four in Degana A and five in Degana. There were several chan-

nels and distributaries, a few kilometres long and a couple of metres wide. These were obviously made by water. And wind had removed finer materials.

Over the fan-like sediments, the team found thick, long and wide U-shaped debris ridges. These moraines are equatorward glacial deposits, formed later, about 3000 million years ago. Here, the researchers found polygonal features, formed by water evaporating from clay-like minerals, indicating that there were once glacial margins there.

'These landforms were formed by snow or ice that was deposited about 3700 million years ago onwards, suggesting local climate change on Mars,' says Vijayan. Understanding climate change on Mars will help throw light on climate change on our own planet.

DOI: 10.1016/j.icarus.2021.114397

### Exploring the Martian Ionosphere

#### *To save future probes*

High ion concentration in the Martian ionosphere damages probes. Only eight space probes actively orbit Mars now. So researchers from Udaipur and Ahmedabad collaborated with researchers from Spain and Brazil to probe the Martian ionosphere.

Molecules in the ionosphere's E region, at an altitude of 90–120 kilometres, absorb low energy X-rays and are ionised. But what about the D region below?

To find out, the team combined data from the Geostationary Operational Environmental Satellite and the Flare Irradiance Spectral Model to study X-ray spectra at a broader wavelength range.

'High energy X-rays greatly influence the D region,' says Siddhi Y. Shah, Pacific Academy of Higher Education of Research University, Udaipur.

From the Mars Global Surveyor, the researchers gathered data about two solar X-ray flares – 6 April 2001 and 17 March 2003. A model they developed, to analyse the impact of solar X-ray flares and galactic cosmic

rays, calculated D and E region electron densities simultaneously.

Electron density in the ionosphere constantly changes due to solar X-rays and galactic cosmic rays. But, in flare conditions, there is a drastic increase in electron content, say the researchers.

'Understanding and predicting the dynamics of the ionosphere will help avoid damage to future probes,' says Syed Aftab Haider, Physical Research Laboratory, Ahmedabad.

DOI: 10.1016/j.icarus.2021.114403

### Marine Transgression

#### *A trans-India seaway*

About a hundred million years ago, before the Himalayas and Deccan traps were formed, the earth once faced a severe lack of oxygen in the atmosphere. And the seas rose and came inland.

Researchers from the Mohanlal Sukhadia University, Rajasthan, along with researchers from the US and Switzerland have now found fossils of sea creatures more than a 100 kilometres from the present seashore.

Ostracod and foraminifera fossils, usually found at the bottom of the sea, were recovered from the Bhundmariya and Bilthana localities, in the Narmada basin, Gujarat. The foraminifera species identified generally lived in oxygen minimum zones of deeper oceans.

'They were perhaps washed into this estuarine environment,' says Maya Chaudhary, Mohanlal Sukhadia University.

The researchers analysed carbon and oxygen isotopes to evaluate nutrient and salinity trends. And they compared the results with previous reports from different parts of the world where similar evidence for large marine transgression have been reported.

'The fossils' characteristics show a faunal progression with global sea level transgressions, similar to those found elsewhere – from Egypt to Morocco and the USA,' says Nallapa Reddy, Chennai.

The largest sea level transgression was initiated in the western Narmada seaway.

'Later it may have connected to the Godavari seaway via the Narmada-Tapti rift, forming a trans-Indian seaway,' says M. L. Nagori, Mohanlal Sukhadia University.

Imagine! Once upon a time a sea ran through India!

DOI: 10.1016/j.gr.2021.02.013

### Uranium in Groundwater Gunnaur region, Uttar Pradesh

Uranium, a naturally occurring radioactive element, is toxic. To mitigate health-related issues, we have to identify the sources and concentrations.

So, Shwetank Shashi Pandey from the Delhi University teamed up with researchers from Delhi and Uttar Pradesh to investigate groundwater uranium in the Gunnaur region, Uttar Pradesh. The region is covered with thick alluvial soil. And the Narora nuclear power plant looms to the west.

From hand pumps and bore wells there, the team collected water samples. The samples had uranium concentrations varying from 0.1 to 51.5 parts per billion, revealed a LED fluorimeter. Two of the samples had uranium concentrations far above the WHO permissible limit of 30 parts per billion.

The team correlated the uranium concentrations with other physico-chemical parameters. There were positive correlations with calcium and magnesium, implying their influence on uranium in groundwater.

There was a predominance of uranium calcium carbonate minerals in the samples. These are more soluble.

Now that we know that there is uranium contamination at two places in Gunnaur, a highly populated region, the UP Water Board must monitor groundwater quality there and provide fresh water supply.

DOI: 10.1007/s10967-021-07756-2

### Drought Tolerance in Wheat Nanosilicon priming

Water scarcity at early stages causes severe reduction in wheat yield. There have been many attempts to tackle the problem. Anjana Jajoo, Devi Ahilya University, Indore approached the problem from a different angle employing nano priming of wheat seeds.

Anjana and her team primed wheat seeds by soaking the seeds in a silicon oxide solution. Owing to their small size, the silicon nanoparticles penetrated the seed coat more efficiently. There was increased water uptake by the primed seeds resulting in improved germination percentage.

'Water and nutrients are transported via aquaporins, membrane-bound proteins. Silicon upregulates the expression of aquaporins, resulting in increased water transportation. This activates enzymes like  $\alpha$ -Amylase, the major enzyme for starch metabolism in the seed, leading to faster germination,' explains Prabha Rai-Kalal, Devi Ahilya University.

'In contrast, the large silicon dioxide particles do not penetrate the seed. They accumulate on the seed surface and block seed coat pores. So water and oxygen do not enter the seed easily. This reduces seed germination and increases reactive oxygen species,' adds Rupal S. Thomar, her colleague.

In nano primed wheat seeds, the team observed increased activity of antioxidant enzymes which, in turn, alleviated oxidative stress. There was increased production of carotenoids in nano primed wheat plants resulting in more photo-protection. At the same time, enhanced chlorophyll pigments led to increase in total biomass.

'Cost-effective and ecofriendly, nano silicon seed priming can be used to improve drought tolerance in wheat,' says Anjana Jajoo.

DOI: 10.1071/FP21079

### Strawberry Cultivation in Plains Effect of seasons

Strawberry is mostly cultivated in hilly areas. But new varieties, such as Camarosa and Winter Dawn, can be grown in the plains. When is it best to harvest such strawberries?

Ram Asrey, Indian Agricultural Research Institute, New Delhi, and Pankaj Kumar Kannaujia, ICAR-Central Institute of Post-Harvest Engineering and Technology, Punjab teamed up to explore. They harvested Camarosa and Winter Dawn strawberries from a farm in Delhi from February, March and April. For 12 days, at 4-day intervals, the duo tested the

physiological and biochemical properties of the stored strawberries.

February-harvested fruits were firmer with a low decay rate and had high amounts of phenolics, vitamin C and low amounts of sugars.

March-harvested fruits had high sugar, organic acids, soluble solids, anthocyanin and antioxidant content.

April-harvested fruits were high in antioxidants and total soluble solids. But they were not so firm and decayed faster, making storage difficult. In summer, cell wall-degrading enzymes are more active, causing fruit to soften faster.

'With rising temperature, vitamin C and phenolic content decreases due to high oxidation,' says Pankaj Kumar Kannaujia.

The final test, of course, is taste. Sensory evaluation tests for appearance, taste and aroma showed that March strawberries were better.

The researchers found that the Camarosa cultivar performed better than Winter Dawn in Delhi.

'Farmers can now get strawberries with high nutritional quality by selecting growing conditions and harvesting time to gain higher profits,' says Ram Asrey.

DOI: 10.1007/s11738-021-03262-w

### Ensuring Energy Efficiency Assessing sugarcane life cycles

Sugarcane is used to produce sugar, ethanol and electricity. Sugar mill owners decide whether to produce ethanol or electricity or a combination, based on the profits. But what are the implications for environmental and agricultural sustainability?

Moonmoon Hiloidhari and team at IIT, Mumbai analysed input energy requirements in cultivation, transportation and processing. And the output energy in terms of sugar, ethanol and electricity. The researchers also estimated the footprints of carbon emitted and water consumed from farm to factory.

Cultivation consumes most of the resources. The Adsali season from June to July appeared most productive with lowest carbon and water footprints. But, in the preseasonal, Suru

and Ratoon cultivation of sugarcane, input energy costs were greater.

'The energy and carbon footprints are six times less when trucks transport bagasse, rather than tractors,' says S. Haran, IIT, Mumbai.

The energy return on investment is much higher when electricity is generated from sugarcane bagasse than in producing ethanol.

Recently, the Indian government has started encouraging increased ethanol production from molasses, to promote biofuel use. The research results question the wisdom of this initiative which affects five crore farmers involved in sugarcane cultivation.

Agriculture consumes 18% of total energy in India. Two per cent of GDP is given as subsidy for electricity used in agriculture. So it is more prudent to upgrade sugar mills to enable electricity production from bagasse than to divert it for ethanol production, say the researchers.

DOI: 10.1016/j.biortech.2021.125012

### Repurposing Aged Supercapacitors

#### *Low power-demand applications*

Supercapacitors age after repeated cycles of charging and discharging. Aging reduces the energy storing capacity and aged supercapacitors are slow to charge and discharge. Such supercapacitors cannot supply high power instantly. This makes them unsuitable for use in electric vehicles and elevators which require rapid charging and discharging.

However, aged supercapacitors can still store energy. Instead of recycling, why not reuse them in applications that demand low power supply, thought researchers from NIT Silchar, Assam.

In collaboration with researchers from the US, they selected three aged supercapacitors and used them in wireless sensor network nodes which operate with low power.

'Aged supercapacitors can still supply sufficient energy to operate a wireless sensor network,' says Pankaj Saha, NIT Silchar.

But when the supercapacitors were continuously charged and discharged, they underwent further aging.

'Up to 4% of energy-storing capacity was lost after 1000 cycles. However, the supercapacitors can run up to 13,000 cycles before they are recycled,' says Munmun Khanra, NIT Silchar.

Aged supercapacitors have a much higher number of charge and discharge cycles than standard Li-ion batteries.

The researchers suggest electronic companies can repurpose aged supercapacitors for use in low power-demanding applications like computers and automatic meter reading devices. Such repurposing can reduce electronic waste and its impact on the environment.

DOI: 10.1016/j.jpowsour.2021.229824

### Degrading Dye by Photocatalysis

#### *Using tungsten oxide*

Photocatalysis by semiconductors is an eco-friendly method to degrade dyes. But semiconductors like titanium oxide require UV rays for photolysis. This makes the process costly.

Tungsten oxide, however, is cheaper. And it functions in the visible spectra. But it is less efficient.

Increasing surface area for catalysis by dispersing tungsten oxide in a mesoporous structure might improve efficiency, thought researchers from Chennai. To investigate, they collaborated with universities in Taiwan and the Republic of Korea.

After analysing various mesoporous materials, they found that SBA-15, a mesoporous form of silica, with highly ordered honeycomb-like hexagonal pores, can serve the purpose.

The team synthesised tungsten oxide SBA-15 catalysts, with varying ratios of tungsten oxide. To test, they chose three harmful, widely used dyes: rhodamine B, methylene blue and crystal violet.

'The catalyst with 5.5% tungsten oxide in SBA-15 was most active,' says Sivakumar Thiripuranthagan, Alagappa College of Technology, Chennai.

The researchers checked for decolourisation at varying dye concentrations. The catalyst decolourised dyes of up to 30 parts per million concentrations within 5 hours.

'At higher concentrations, the catalyst's active sites became saturated, leading to lower decolourisation,' explains Thamaraiselvi Sureshkumar, University of Madras.

'The dye molecules were broken into simpler non-toxic formate and acetate ions with water, carbon dioxide and mineral salts,' elaborates Sakthivel Kumaravel, Alagappa College of Technology.

On exposing the catalyst to sunlight, high degradation was observed in the 30 parts per million dye solution. In 4 hours, 93% rhodamine B, 85% methylene blue and 91% crystal violet dye degraded.

The team checked for reusability. The catalyst remained effective even after four cycles, when washed with water and dried.

'The tungsten oxide SBA-15 catalyst can be cost-effective for textile and other industries to degrade dyes in effluents,' says Elangovan Erusappan, Alagappa College of Technology.

DOI: 10.1016/j.ijleo.2021.166599

### Ecosystem in Metropolises

#### *Impact of urbanisation*

Population explosion and rapid urbanisation have put the natural ecosystem under tremendous pressure in the Kolkata Metropolitan Area.

Recently, researchers from the University of Gour Banga, West Bengal, and the Mykolas Romeris University, Lithuania collaborated to assess how the rapidly growing city impacts the ecosystem.

Using satellite images from the USGS Earth Explorer, and parameters such as ecosystem productivity, landscape heterogeneity, and the ability to bounce back from interference and disturbance, they constructed a model of land use in the area from 2000 to 2019, to evaluate impact on ecosystem health.

The researchers found a drastic change in land use over the period. Vegetation cover had decreased by around 55% while built-up area had increased by almost 90%.

The team's findings show that, over the past two decades, the area's ecosystem health reduced by more than

half. Ecosystem was most affected in urban areas.

'Some rural areas are doing fine. But urban centres have seen uncontrolled development at the cost of the ecosystem,' says Arjit Das, University of Gour Banga.

'More and more agricultural and open land is being converted into built-up areas. This reduces the ecosystem's overall productivity,' says Manob Das, University of Gour Banga.

To achieve sustainable growth, it is time to start considering the ecosystem as an important element in planning and urbanisation.

DOI: 10.1016/j.ecolind.2021.107584

### Noise-induced Hearing Loss

#### *Proteins diagnose early*

Noise-induced hearing loss is irreversible when hair cells in the ear are damaged. The damage can reach up to 50% before getting detected by audiometry. Can we detect noise-induced hearing loss earlier?

Shubhangi K. Pingle, Rajani G. Tumane and team, National Institute of Miners' Health, Maharashtra, reasoned that damage to cochlear proteins should leave traces in blood serum. To check, they selected participants, based on exposure to high decibel noises and extent of hearing loss. Audiometry showed a dip at 4000 hertz for participants with hearing loss.

The team extracted proteins from the serum samples and fractionated the peptides using electrophoresis. Then, they characterised the peptides with mass spectrometry. Using sequence databases, the researchers identified the proteins.

Forty-six were exclusively upregulated in participants with hearing loss. But only 25 were overexpressed in groups exposed to high decibel noises.

The changes were apparent even in the group yet to develop measurable hearing loss, providing the opportunity for an early diagnosis. Most expressed were myosins, proteins crucial for the development and functioning of stereocilia, hair bundles on cochlear hair cells.

In serum, these proteins indicate noise-induced damage well before audiometry can detect hearing loss.

'Early diagnosis can be a boon for miners and industrial workers, who work in loud environments,' says Shubhangi K. Pingle, National Institute of Miners' Health.

Government and stakeholders need to invest in putting such research to good use.

DOI: 10.1016/j.jprot.2021.104185

### Terminal Cancer

#### *Hospice care*

Hospice care centres for terminal cancer patients were started in India in the 1980s. The centres use non-pharmacological approaches such as psychotherapy and music intervention to provide mental, emotional and spiritual relief.

Recently, researchers from the Central University of Karnataka, teamed up with Srinagesh Simha, Karunashraya Hospice, Bengaluru to evaluate hospice care. The team conducted interviews with cancer patients. An analysis of the interviews revealed four common themes.

The first was intolerable pain leading to anxiety, self-isolation and suicide attempt. However, pain control and emotional support by hospice care led to better quality of life.

The second theme was altruism. Patients wished to be sources of happiness to others. Most patients even displayed gratitude to society by donating their organs.

Overall satisfaction due to the fulfilment of their needs by doctors, nurses and counsellors was the third theme. Most participants compared the hospice to their own home and even to heaven.

The last and most important theme was the desire for a good death. The hospice care centres fulfilled the needs of cancer patients in terminal stages, the researchers found.

However, some states and union territories of India do not have any hospice care centres. More than 90% of hospice care centres in India are located in Kerala and Karnataka. Other state governments must follow suit to provide relief to millions of cancer patients registered every year.

DOI: 10.1186/s12904-021-00757-8

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ACKNOWLEDGEMENT: NCPOR, Goa, for access to scientific databases.

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