

Current Science Reports

Gauging the Sun's Mood

A new barometer

The sun's behaviour has stumped scientists as both sunspot numbers and solar magnetic fields have shown a steady decline since the mid 1990's. On average, every 11 years or so, we expect a few spots to appear about 35 degrees north and south of the sun's equator. Gradually, more spots surface closer to the solar equator and then, slowly, their number reduces to a minimum. And the cycle starts again.

Predicting solar cycle amplitude is important as it may also influence the earth's climate. However, there have been times when sunspots were almost entirely absent for many decades. The sun's magnetic field also flips polarity with every cycle, due to a meridional flow that transports surface magnetic flux towards both equator and poles. Magnetic fields drive all solar activity – the eruption of sunspots, coronal mass ejections, solar flares and the solar wind.

Janardhan Padmanabhan from the Physical Research Laboratory, Ahmedabad and Susanta Kumar Bisoi from the National Astronomical Observatories, Beijing now propose a new tool to predict the amplitude of solar activity. Rather than observing visible proxies such as sunspots, they measured the magnetic flux that gets transferred between the sun's equator and poles.

Janardhan and Susanta Kumar investigated a correlation between the flux cancelled at the equator and the net flux carried to the poles, using charts of magnetic fields over the sun's surface. This magnetic field evolution model can be used to predict the amplitude of the next solar cycle.

Their model forecasts that the upcoming solar cycle 25 is likely to be as weak as the on-going cycle. The minimal solar activity opens a larger window of opportunity for upcoming space missions.

DOI: 10.1007/s11207-020-01645-9

Groundwater Quality

Shanmuganadhi river basin

The Shanmuganadhi river basin, Tamil Nadu, has fluoride-bearing minerals – apatite, hornblende, mica and amphiboles. For groundwater, these minerals are sources of fluoride contamination – a public health problem.

So, recently, D. Karunanidhi and P. Aravinthasamy from the Sri Shakthi Institute of Engineering and Technology collaborated with researchers from the Anna University, Chennai and the French Institute of Pondicherry to assess fluoride contamination in the river basin and the associated health risk.

They collected groundwater samples from dug and tube wells and measured pH, electrical conductivity and total dissolved solids. They checked calcium, magnesium, chloride, carbonate and bicarbonate levels. Sodium, potassium, phosphate, sulphate and fluoride concentrations were also evaluated.

About 26 per cent of the samples had higher than admissible fluoride concentration. From the computed water quality index, the researchers found that more than half the samples were in the poor to very poor category – unsafe for drinking.

To evaluate the non-carcinogenic health risk in children, teens and adults, they examined daily intake of fluoride-contaminated drinking water. The risk was much higher in children than in teens or adults.

Spatial variation maps for the distribution of groundwater quality showed that the higher southern part had low fluoride and good drinking water quality, whereas northern low lands had poor groundwater quality and, therefore, high health risk.

While people in the area need to be alerted to the health risk, the district administration must consider the feasibility of fluoride removal kits to provide potable water and to reduce risks to public health.

DOI: 10.1007/s10653-020-00613-3

Water Security in Bhopal

Nature-based solutions

Bhojtal Lake, to the west of Bhopal, is the primary source of drinking water. However, rapid urban expansion is eroding the ecosystem.

Concerned about the drying up of the Bhojtal Lake, Pankaj Kumar from IISER Bhopal, Sunita Sarkar from the Centre for Ecology and Hydrology and researchers from the UK collaborated to assess the potential contributions of nature-based solutions to Bhopal's water security.

Literature search to understand the history, condition, uses and current trends in Bhojtal showed no evidence of declining water level or other hydrological change. However, vegetative cover has declined, increasing erosion and siltation in the lake.

The team surveyed a sub-catchment of the upper Kolans River, a major water input to Bhojtal and the downstream end of Bhojtal, including the lake margin of Bhopal city as well as the wastewater treatment lagoons to the south of the lake. And they assessed ecosystem services at Bhojtal.

Bhojtal is fed by a predominantly rural catchment of more than 300 square kilometres – about 10 per cent is urban, more than 80 per cent agricultural and only 5 per cent is forest land. The urban area has been steadily increasing. The team found that urban encroachment, siltation and other forms of pollution are degrading the quality and quantity of lake water. In the catchment area, groundwater depletion, due to increased extraction, reduces base flow contributions to streams and, directly, to Bhojtal. This has already led to the drying up of many wells.

The researchers suggest wastewater treatment, afforestation, soil and water conservation structures and changes in cropping patterns to solve reported issues of water quantity and quality for the Bhojtal Lake.

DOI: 10.1016/j.scitotenv.2020.138061

Watershed Development *Evaluation in Panchkula*

Morni Hills, Panchkula, is part of the Siwalik Himalayan ecosystem. Though mean annual rainfall here is more than 1100 millimetres, water for irrigation is scarce due to swift runoff. Erosion leaves the soil degraded, impacting food security. So, watershed development programmes were implemented.

To evaluate these programmes in the Morni Hills, researchers from Kurukshetra, Karnal and Jajjar, Haryana administered a questionnaire to 120 randomly selected people from eight villages in the Panchkula District. And, to investigate their impact on agriculture and livestock, socio-economic development and environment, the team conducted focused group discussions.

Respondents reported reduction in soil erosion and improved agricultural yield. Most agreed that there was an increase in individual income and living standards. They attributed this to employment opportunities in the agriculture and construction sectors, as well as to an increase in wages. About 80% believed that watershed development programmes are useful for socio-economic uplift. But only a third felt that these activities benefited environmental conservation. All factors considered, satisfaction levels were low.

The data show a shift in cropping pattern from traditional to commercial crops, such as vegetables, spices, pulses, mustard, paddy and high-yielding wheat. The shift to crops that need more water may become an unsustainable practice.

The respondent sample did not have adequate gender balance, a problem that is common when a male-only team tries to collect data.

DOI: 10.1007/s10668-020-00812-z

Solar-driven Seawater Desalination *Using plant-derived nanoparticles*

Converting seawater to potable water is energy-expensive. Solar energy might prove more economical for the purpose. However, converting solar energy into heat for distilling sea-water needs to be made more efficient.

Presently, a black coating is given to solar water heaters to absorb light. Carbon nanospheres are better at capturing light energy even at low solar intensities. So, researchers at the Institute of Chemical Technology, Mumbai made carbon nanospheres from camphor pellets, using a well-known method: burn camphor pellets with a copper plate above to collect the soot.

Now, the problem was to more efficiently transfer the energy captured to water. The researchers thought of polyvinyl alcohol sponges. They are hydrophilic with porous structure. Capillary action may provide a constant supply of water. The material, moreover, has low thermal conductivity for heat localization.

The team coated carbon nanospheres on a polyvinyl alcohol sponge and designed a capillary system using polystyrene foam and a cotton cloth setup.

To evaluate evaporation, they used distilled water and measured the change in water quantity using a weighing balance. A thermal camera monitored evaporation. The results were very encouraging.

For the desalination study, they made a prototype to condense and collect water vapour. Using water from the Arabian Sea and a solar simulator, they tested the system. Encouraged by the results, they tested the system under natural sunlight. The device could remove 99.9% of salt even at very low solar intensities!

The scientists say that the system suits long-term applications. They advocate this low-cost and toxicity-free method for large-scale desalination systems.

DOI: 10.1016/j.solmat.2020.110489

Vision in Flying Insects *Evolutionary constraints*

Flying insects, Lepidoptera, are amongst the most diverse organisms and have adapted to a wide variety of niches. Moths, for instance, are mostly nocturnal, and have high sensitivity to light, achieved by combining optical and neural superposition as well as temporal integration. Butterflies are believed to have evolved from moths, but are mostly diurnal. How did the

adaptation to day time activities change the structure and function of the compound eyes of butterflies?

Sanjay P. Sane from NCBS, Bangalore posed the problem to his colleagues. Payel Chatterjee and Umesh Mohan, his PhD scholars along with Anand Krishnan from IISER Pune, collaborated to crack a part of the problem.

If there is a flickering light, two consecutive flashes will fuse into one signal due to temporal integration. Flicker fusion will occur at higher frequencies in butterflies than in moths, they reasoned.

To check, they collected insects – two moth families and four butterfly families – to represent the entire range of flying insects that are active in dark, dim and light conditions. They kept the insects at -20°C for approximately 10 minutes to immobilize them. Then they placed one electrode at the head of each insect for electrical contact and another in contact with the right eye to record responses. And they exposed the insects to a flickering light stimulus for two seconds, at flicker frequencies ranging from 10 Hertz to 250 Hertz. The response to these frequencies was recorded as electroretinograms, measuring the information captured by photoreceptors in the eyes.

After making sure that there was no variation in data from the same insect due to changes in the time of day when the electroretinograms were recorded, they went on to complete their experiments on 37 butterflies and 18 moths.

The researchers found that, for moths, the fusion of these flickers in response to light was at a lower range of frequencies. For butterflies it was higher and for skippers, intermediate.

However, the response of the nocturnal moths did not differ much from moths that were diurnal, suggesting that there is a phylogenetic control on the responses. This was confirmed while comparing the responses of other diurnal, crepuscular and nocturnal insects.

The evolution of diurnal butterfly families from nocturnal moth-like ancestors led to a transition towards sensitivity to higher temporal frequencies. But, perhaps the anatomical and

physiological changes in the eyes came after the change in niche.

The team now plans to explore the physical mechanisms that increased temporal sensitivity in butterflies.

DOI: 10.1007/s00359-020-01429-3

Agricultural Pests and Pesticides *Between devil and deep sea*

Pesticides are used by farmers to protect crops. Besides impacting the environment, pesticides cause health problems for farmers who are exposed. Including higher risk for cancer. Karashdeep Kaur and Rupinder Kaur, from the Sri Guru Granth Sahib World University and the Gulzar Group of Institutes, Punjab, recently investigated factors behind this risk.

Over three years, they collected blood samples from 225 farmers, exposed to pesticides, from Punjab and north-west India. Blood samples were also taken from an equal number of individuals with no history of pesticide exposure, as control.

They extracted DNA from the blood samples and, using an alkaline comet assay, they quantified the extent of DNA damage in the cells. In this assay, under the microscope, undamaged cells appear normal, while cells with DNA damage appear to form a comet with a tail. The length of the tail is a measure of the extent of the damage.

After accounting for lifestyle and demographic differences, the researchers found that the extent of DNA damage in the group of farmers exposed to pesticides was much higher than in the control group.

'Farmers exposed to pesticides run a greater risk of DNA damage which, in turn, increases the risk of diseases including cancer,' says Rupinder Kaur.

To recover from the damage, our body has repair mechanisms. So the researchers examined the DNA repair genes in the samples. 'These genes have different variants, and the functioning of the genes depends on the variant present. We checked the different variants of the genes involved in the DNA repair mechanism,' says Karashdeep Kaur.

They found a correlation between the extent of DNA damage and the

genotypes of two such genes belonging to the xeroderma pigmentosum group. These two genes modulate the results of the harm done by pesticides. Some variants are able to protect the people having them from cancer and other diseases caused by pesticides. Whereas other variants increase the risk to people having them.

Exposure to pesticides is an occupational hazard to farmers. In the near future, when DNA testing becomes a part of the clinical routine, perhaps, the farmers having the gene variants that increase risk will be identified and advised not to undertake spraying of pesticides.

DOI: 10.1007/s11033-020-05600-6

Arsenic in your Mushrooms? *Invisible risk of bioaccumulation*



Image: T. Roychowdhury

Oyster mushrooms are globally cultivated for their nutritional and medicinal values. But cultivating them using rice straw from high arsenic zones, like the Indo-Gangetic plains, may lead to arsenic bioaccumulation. Consuming such mushrooms may adversely affect health.

Researchers from the Jadavpur University, Kolkata and the Vidyasagar University, Midnapore were concerned. So they tested the possibility with two oyster mushroom species: the blackish *Nagaland florida*, *Pleurotus ostreatus*, and the normal whitish *Pleurotus* species.

They cultivated both species on rice straw from arsenic-free and arsenic-contaminated locations. In the rice straw from arsenic contaminated areas, the team also used arsenic-

contaminated water. A control set each from both species was also cultured in arsenic-free rice straw with distilled water.

The team evaluated arsenic concentration in the first three harvests using an atomic absorption spectrophotometer and found that, in both species, arsenic concentration increases three-fold from the first to the third flush, especially in the stem portion of the fruiting body. Arsenic content in the cap portion, however, increases gradually from first to second flushing followed by a decrease in the third flushing.

To examine the impact of arsenic on nutritional values, the researchers estimated moisture, total protein, total lipid, crude fibre, ash, and carbohydrate content. The results suggest that arsenic bioaccumulation in the fruiting bodies leads to a significant decline in nutritional properties.

Now, what about the risk to health? Using estimated daily intake and reference dose of oral exposure, the researchers computed the health risk index. The health risk index was moderately high for both species.

So, to make oyster mushrooms nutritionally rich and safe for consumption, it is better to cultivate them in arsenic-free substrates – a useful tip for mushroom growers.

DOI: 10.1007/s12011-020-02224-6

Occupational Hazards *Heat stress and kidney stones*

Heat can induce changes in sugar metabolism and blood pressure. Industrial workers exposed to high levels of heat are reported to have higher risk of heart disease, kidney stones, myalgia and stroke. Most of these studies were done in temperate zones. How about workers in hot tropical areas such as Tamil Nadu? Can diet and physical activity or lifestyle play roles in tackling heat stress in occupational settings?

To find out, researchers from the Sri Ramachandra Institute of Higher Education and Research, Chennai recently examined the relationship between heat stress and kidney stones among workers in a steel industry in Tamil Nadu. They selected people working in high heat areas such as coke ovens,

blast furnaces, and power plants. Those with pre-existing health conditions were excluded.

More than one-fourth complained of back pain, swollen and numb legs, and painful urination with changes in urine colour. The team subjected them to renal ultrasounds and found that they had renal anomalies. Twenty-five had kidney stones.

These workers had to endure temperatures of over 50 degrees. The researchers noted that the workers sweated profusely, causing dehydration and change in urine colour. The team noted that 65 per cent had higher body temperatures. They complained of nausea, headache and fatigue.



Image: via needpix

Most of those with renal calculi were above forty. Heat and dehydration lead to concentrated urine and prolonged exposure makes urine too acidic and renal stones are formed from calcium oxalate or calcium phosphate.

Such industries need to provide better ventilation and working environments, to ensure health and productivity. Workers in high temperature environments need to drink more water, and replenish water soluble vitamins and minerals.

DOI: 10.1016/j.scitotenv.2020.137619

Diagnosis from Distance Smartphone helps pathology

Diagnosing a disease from a pathology image requires a certain amount of expertise and experience. And sometimes, even experts may differ in their judgments. So doctors need to consult their colleagues to make sure that the diagnosis is accurate. Can mobiles help to come to a concurrence?

Recently, Nadeem Tanvaer and his team from the University College of Medical Sciences and AIIMS, Delhi

evaluated the intra-observer concordance between diagnosis of gynaecological specimens using smartphone based telepathology and conventional microscopy.

They retrieved more than 180 cases of gynaecologic pathology in a tertiary care hospital of North India. The cases consisted of gynaecological pathology of different organs such as cervix, ovary, fallopian tube etc. A trained pathologist photographed the representative areas using a 20 megapixel smartphone camera and binocular microscope. They sent these images by Whatsapp messenger to the same pathologist who had made the diagnosis on conventional microscopy six months ago. Other relevant clinical details were also sent to the reporting pathologist who viewed the images on a smartphone screen only.

The smartphone-based diagnosis was concordant in 96% cases though it varied with the organ involved. The concordance was highest for endometrial and myometrial pathology and lowest for ovarian lesions. The discordance was primarily due to pixelation of images on digital zoom and orientation, say the researchers.

Though it is a pilot study with a limited number of cases, the results are encouraging for doctors who want to use mobiles for a second opinion on pathology images. Meanwhile, the methods of artificial intelligence and machine learning are also being developed for automatic identification of pathology from images, with similar accuracy.

DOI: 10.1111/jog.14347

Poor Job Performance Perfectionists lose sleep

Perfectionism can be adaptive and improve performance or maladaptive, leading to obsessiveness, anxiety, sleep disorders and depression. This can impact work. Excessive daytime sleepiness can also affect job performance. Which of the two is better at predicting poor job performance?

Sasmita Palo and Moitrayee Das from the Tata Institute of Social Sciences, Mumbai recently reported finding a connection between perfec-

tionism, hypersomnia and job performance.

They analyzed more than 400 people: consultants, academicians, marketing managers and technical professionals – groups with varying amounts of rigid work schedules and stress – to remove the effects of confounding variables.

To measure perfectionism, they used questions on self-oriented perfectionism, other-oriented perfectionism and socially prescribed perfectionism. They also elicited information on daytime sleepiness using a questionnaire and rated job performance.

The duo found a positive correlation between self-oriented and other-directed perfectionism with daytime sleepiness. The results also showed an inverse correlation between daytime sleepiness and task performance. However, task performance had an inverse correlation with only self-oriented perfectionism.

But which is the more powerful and proximate contributor to task performance? Perfectionism or daytime sleepiness? The researchers checked using mediation model analysis and found that both self-oriented perfectionism and sleepiness directly affect performance.

When perfectionism scores lower than the mean, sleepiness mediates task outcome, they found. Higher scores of perfectionism predicted a direct correlation with reduced task performance and the mediating impact of sleepiness became insignificant

'Daytime sleepiness predicts lower task performance. The level of perfectionism is a moderating variable and governs the outcome in the workplace', clarifies Sasmita Palo.

DOI: 10.1007/s10942-020-00362-3

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ACKNOWLEDGEMENT: IISER Pune.

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