Current Science Reports

Himalayan Snow Cover Dynamic

In three river basins

Snow cover in the Himalayas is crucial for nations in South-Central Asia. As a provider of water resources, snow cover influences various natural processes and thus impacts the economies of the countries in the region. So, an understanding of snow cover trends is important for water resource management.

What is the extent of snow cover in the Indus, Ganga and Brahmaputra river basins and how does it vary in time?

To find out, Abhilasha Dixit, Indian Institute of Technology Roorkee collaborated with a researcher at the National Institute of Hydrology Roorkee, and a colleague in the US. They used remote sensing techniques to monitor snow cover dynamics in the three river basins from 2003 to 2021.

Images from the Terra and Aqua satellites of the Moderate Resolution Imaging Spectrometer, MODIS, had high average cloud cover. So the researchers applied a cloud removal algorithm to the images.

The long-term mean annual snow cover area was 42% for the Upper Indus, 27% for the Ganga and 22% for the Brahmaputra basins.

The highest average annual snow cover area had occurred in 2019. The lowest averages were recorded in 2016.

To analyse annual and seasonal variations in the snow cover area from 2003 to 2021, the researchers used data from the fifth-generation European Centre for Medium-Range Weather Forecasts Atmospheric Reanalysis of the global climate.

They checked for any correlation between annual and seasonal variations in snow cover area and critical climatic variables. They found a strong positive correlation of snow cover area variability with temperature, indicating a high sensitivity of the snow cover to temperature changes. Increasing temperatures significantly impacted the snow cover area in the Ganga and Brahmaputra basins.

Temperature increases during the accumulation season were most pronounced in the Ganga and Brahmaputra basins.

Annual precipitation trends indicated an increase of more than one millimetre per year in the Ganga basin, suggesting a shift towards intensified rainfall over snowfall. The Indus basin showed a minor declining trend.

Topographic attributes and climatic variables that influence snow cover are significant for disaster management. So the team examined topographical attributes such as elevation, slope, and aspect to understand the impact of these factors on the distribution of snow cover across the basins.

'Elevation, slope and aspect seemed to play a crucial role in shaping snow cover distribution,' says Abhilasha Dixit.

The trends observed underscore the urgency to adopt adaptive strategies for communities and ecosystems to address the impacts of climate change and for sustainable water resource management in these crucial river basins.

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Health Hazards and Biokinetics

Uranium in groundwater

Uranium, a heavy metal, can be present in rocks as trace amounts or as huge deposits. Depending on the chemical nature of the rocks and factors such as pH and the oxidation–reduction potential of the environment, uranium may dissolve and leach from the rocks, and enter groundwater aquifers.

What is the concentration of uranium in groundwater in the Fatehabad district of Haryana? What are the health hazards of uranium to the people who use the groundwater there for drinking?

Rohit Mehra and Abhishek from the Dr B. R. Ambedkar National Institute of Technology, Jalandhar recently investigated the problem.

They collected drinking water samples from 49 different locations in the Fatehabad district. They also assessed uranium levels in the groundwater near the power plant site at Fatehabad. To analyse the uranium in the samples, they used a LED fluorimeter. The gadget measured the intensity of fluorescent light emitted by the samples after excitation by light-emitting diodes as a proxy measure of the presence of uranium.

Their analysis indicated that the average uranium contamination in the water samples was below the recommended limit of the WHO and the Atomic Energy Regulatory Board. But some samples exceeded the WHO recommended threshold limit.

The researchers also calculated the physicochemical parameters of the groundwater, such as dissolved solids, salinity, electrical conductivity and dissolved oxygen. They found that the parameters were within acceptable ranges. Salinity was highly correlated with uranium concentrations.

The researchers then estimated the annual ingestion doses of uranium for different age groups, based on their water intake patterns. Infants were identified as more vulnerable to health risks from uranium ingestion.

The team used the latest biokinetic model for uranium computation to understand the kinetics and the organ-specific doses of uranium due to drinking the groundwater there. Bones were identified as the most affected.

'Though the average uranium contamination levels in the study area are below recommended limits, there is a need to monitor radioactive contamination in the area around nuclear power plants in the district for public health and safety,' says Rohit Mehra.

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Precision Crop Forecasting

Using LiDAR and AI

Accurately predicting crop growth parameters like plant height and crown area can help us forecast agricultural output. Traditional methods to do this are not viable and lack precision. To address this issue, researchers at the Indian Institute of Space Science and Technology, Thiruvananthapuram developed an approach that combines LiDAR and deep learning.

Light detection and ranging, LiDAR, is a remote sensing technology that uses a laser to calculate the distance from the time it takes for reflected light to return to a receiver. Computing the data helps create a three-dimensional (3D) view of the ground below. The technology has also been used for creating 3D images of far away mountain ranges.

Recently, Rama Rao Nidamanuri, IISST, Thiruvananthapuram asked his Ph.D. scholar, J. Reji, to try using the technology for the 3D mapping of crops. They started an experiment on tomato, eggplant and cabbage crops at the University of Agricultural Sciences, Bengaluru.

Using advanced LiDAR technology, they collected detailed 3D images of the crops at various growth stages. They then processed these point clouds to separate ground and crop data, creating a detailed crop height model.

To predict crop height, they used the hybrid deep learning model, TemporalCropNet. This deep learning model combines Long Short-Term Memory and Gated Recurrent Unit layers. Both these excel at analysing sequential data, such as time-series information, including crop growth.

TemporalCropNet accurately predicted plant height and crown area from the processed LiDAR data. The model's architecture handled the non-linear and temporal aspects of crop growth effectively. It provided predictions that closely matched the measured values across different growth stages of the crops and outperformed other models in prediction accuracy.

'The prediction errors reduced significantly, with margins between five and twelve per cent,' says Rama Rao Nidamanuri.

Future research will focus on integrating multi-sensor data to further enhance predictive accuracy, say the researchers.

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Treating Intractable Wounds

Using adipose stem cells

Yaseen Mohammad and team, Department of Plastic Surgery, Aligarh Muslim University, have been using stem cells in the fat tissue of patients for plastic surgery. Since the cells come from the patient, the graft is not rejected. And the results are better than when the patient's skin is used. Can such autologous fat cells be used to heal chronic wounds?

Normally, wounds heal in time. Pus, if any, is absorbed and new skin covers the wound. However, some wounds continue to fester. If the wound does not show signs of healing after six weeks of standard wound care, it is considered chronic.

To explore the use of autologous fat cells for healing chronic wounds, the team selected two females and sixteen males aged between 10 and 65 years. Two-thirds of the patients had wound ulcers for more than 6 months and the rest had them for more than 3 months.

The wounds were caused by various reasons: trauma, postoperative infection, veno-lymphatic ulcers, burns, insect bites and trophic ulcers. Though measures such as vacuum dressing and skin grafts were tried on some of the patients, they did not yield any results.

Sixteen patients had wounds on the leg while two had wounds near the elbow. One patient had three chronic wounds. The size of the wounds ranged from one to twenty square centimetres.

Pus cultures from the wounds showed a predominance of bacteria such as *Pseudomonas aeruginosa*, followed by *Klebsiella pneumoniae* and *Proteus mirabilis.*

For two weeks before treatment with autologous adipose stem cells, the doctors managed the wounds with conventional dressing to assess innate wound healing. None of the wounds showed any progressive signs of healing during this phase. This, to some extent, helped overcome having no control group for the experiments.

The researchers then harvested fat from the lower abdomen of each patient, using specially designed fat grafting cannulas, and applying negative pressure to extract fat.

The researchers centrifuged the extracted material. There were three separate layers after centrifugation. The topmost layer of oil was absorbed by tissue strips. The lowermost layer was removed by the controlled removal of the cap of the syringe. After emulsifying the fat, the researchers transferred it into smaller syringes for precise control of the amount of fat to be injected.

After injecting the patient with a single shot of cefuroxime, an antibiotic, as a preoperative prophylactic measure, the doctors injected the fat graft at the junction of dermis and hypodermis around the wound edges and then into the wound bed using approximately one millilitre of fat for an area of two and a half square centimetres. Occlusive dressings were then placed on top.

All these procedures were done under local anaesthesia, except in the case of the youngest patient, who was anaesthetised during the procedure.

After prescribing a short course of oral cefuroxime, the doctors followed up the patients every week and evaluated the progress by assessing the surface area of the wound, granulation tissue coverage and the formation of epithelial tissue.

As a quantitative measure of wound healing, they used the wound bed score, a simple visual tool designed to measure the healing of ulcers. The wound bed score was documented before and after the procedure to compare the progression of wound healing. The time taken to heal was correlated with the size of wounds.

One patient, with a wound on the arm due to an insect bite, did not show the same progress as the others. So a second sitting of grafting was done six weeks after the first procedure.

Within three to ten weeks, there was complete healing of the wounds.

Even patients with diabetes with non-healing wounds benefited from the procedure.

'We strongly suggest using autologous fat grafting for non-healing wounds. The procedure is simple and easy. Only basic training is required,' says Yaseen Mohammad.

'The procedure does not need any sophisticated infrastructure and it can be repeated, if needed,' adds Om Prakash, his mentee.

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Designing Peptide Drugs

For treating cancer

A few years ago, Krishnananda Chattopadhyay, a structural biologist at the

CSIR-Indian Institute of Chemical Biology, found a peptide that is secreted by *Mycobacterium tuberculosis*.

The peptide changed its conformation depending on the pH: the beta-sheet structure in normal physiological pH changed to an alpha-helical structure at lower pH.

Moreover, the peptide in the alpha-helical structure tended to aggregate into oligomers with the ability to punch holes in the membranes of lysosomes. The peptide seemed to be useful to the bacteria for survival in the intracellular environment.

But Krishnananda was struck by another thought: what if we can modify this peptide and use it to puncture cancer cells which are also reported to have a lower pH environment?

To explore this exciting possibility, he collaborated with his colleague, Krishna Das Saha, a cancer biologist, Asim Bhaumik, a materials chemist of the Indian Association for the Cultivation of Science as well as with researchers at the Jadavpur University and some Indian researchers working in the US.

The team located the sequences that are responsible for the conformational changes. They found eight strings of identical amino acid sequences which respond to changes in pH. Two of these sequences had overlaps, similar stretches of amino acids. Refolding simulation showed that they had a tendency to form alpha helices. So the team selected these two for further testing.

To improve the formation of oligomers, they tweaked the amino acid sequences, adding cysteine that can form disulphide bonds. When tested on liposomes, especially those with negatively charged lipids as seen in cancer cell membranes, one of these sequences formed oligomers and punctured the liposomes liberating the dye inside.

Encouraged by the results, the researchers started looking for ways to encapsulate the peptide sequence. Delivering these sequences to cancer cells is not easy since peptides are broken down by enzymes. The researchers chose phluroglucinol and diformyl cresol as precursors for designing a porous organic material bearing many phenolic-hydroxyl sites, useful for targeting cancer cells. They loaded the nanopores with the amino acid sequences that they had synthesised.

The alpha-helical conformation of the peptide led to the formation of proteolysis-resistant oligomers with efficient membrane pore-forming activity in liposomes. This was higher, especially for liposomes made with negatively charged phospholipids as is found in cancer cell membranes.

To test the packaged material on cancer, the team selected a colorectal cancer line. Colorectal cancer is quite common and mortality is very high. They found that the peptide undergoes a conformational transition to disordered alpha-helices triggered by a low pH environment within cancer cells. The team could establish that the death of cancer cells is due to ferroptosis.

Mice treated with the peptide-loaded porous polymer did not show any toxicity. The team induced tumours in five-month old mice and treated them with the peptide-loaded polymer. Tumour-bearing mice that were treated thus survived better than those which were not treated.

Pharmaceutical companies can use this information to develop peptide-based drugs to treat cancer.

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Microgreens in Soldier's Diet

As fresh food supplement

Soldiers at high altitudes often suffer from micronutrient deficiency due to lack of green vegetables in their diets. Green vegetables, however, are hard to grow at high altitudes.

A group of researchers at DRDO's Defense Institute of High Altitude Research (DIHAR), Leh-Ladakh has been assessing different microgreens as superfoods at high locations. Based on their previous research on the nutritional values of 15 microgreens, which had high yields at the Agriculture Research Unit, DIHAR, Leh, they selected six to study further.

They grew the microgreens in soilless medium, a cocopeat-based blend of cocopeat, perlite and vermiculite. The microgreens were kept at controlled conditions of light, temperatures and humidity levels for 10–12 days. To maintain moisture, the researchers sprayed drinking water when the growth medium surface showed dryness.

Based on a palatability survey done on 31 respondents, they prepared a box containing a blend of the six microgreens – radish, broccoli, cabbage, sunflower, mung bean and peas. The box contained a total dose of 100 grams of microgreens. This box was given to 65 soldiers in an army unit in Leh.

The soldiers consumed this dose of 100 grams of the microgreen mixture for 8 days. No side effects were reported by 98.46% of the soldiers. The researchers then asked the soldiers to rate the microgreens on a hedonic scale of one to nine. The blend of the six microgreens received good ratings for green colour, appearance, taste and crispiness. More than 90% of the soldiers liked the taste and were ready to accept the microgreen mixture in their daily diet. Nearly 85% of the soldiers enjoyed the microgreens as a fresh meal at high altitudes.

The soldiers reported that the microgreens improved bowel movement, relieved heartburn and the digestion of their regular diet.

The microgreens blend could serve as a fresh food supplement for soldiers at high altitudes, providing a beneficial addition to the packed foods otherwise available to them.

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Talcher Thermal Power Plant

Phytodiversity for phytoremediation

The Talcher thermal power station, Angul district, Odisha, is among the ten biggest thermal power plants of India with a power generation capacity of 3000 megawatts. The plant supplies power not only to Odisha, but also to Andhra Pradesh, Telangana, Karnataka, Bihar and West Bengal. However, the fly ash released from the plant is a major cause for concern. Fly ash is a ferro-aluminosilicate mineral containing toxic metals. It harms the flora and fauna in the region, and poses health risks.

Researchers from CSIR-NBRI, Lucknow started investigating the extent of the problem and possible solutions.

The thermal power plant releases millions of tonnes of fly ash annually. A part escapes into the air, while some parts settle down in the soil or enter the gushing waters of the Brahmani river that flows nearby. When the researchers examined the air quality, using a dust sampler, they found that the area had a slightly higher amount of particulate matter than the threshold set for industrial areas.

Using the standard protocols of the American Public Health Association, they analysed the soil and water samples there. The soil had high amounts of aluminium and iron, and groundwater in the vicinity of the plant was acidic in nature, while the river water nearby was slightly alkaline. Toxic metal pollution was a major issue in fly ash-filled places.

How can we address this to restore the pristine environment near the power plant?

The researchers decided to examine the potential of bioremediation with the help of local plants in the region. Some plants have a natural potential to accumulate such harmful metals. So, using an inductively coupled plasma spectrometer, they investigated the metal accumulation in the plants of the area.

Among terrestrial plants, herbs and shrubs turned out to be better metal accumulators than trees, showing their potential in remediating metal-contaminated soils.

The team also investigated the phytodiversity of the plants using random sampling techniques. *Senna siamea*, locally called the kassod tree, was the dominant plant species there.

The kassod tree tolerated and accumulated the metals. So, the researchers suggest that this tree could be used for restoring and revegetating fly ash landfills.

The aquatic plants in the Brahmani river showed a higher degree of metal accumulation than terrestrial plants. The researchers, therefore, recommend using aquatic plants like water thyme, lotus and fennel pondweed for remediating heavy metal contaminated water.

Thus the research team identified local plants that could help remediate metal pollution and restore fly ash-filled sites. Now it is up to the administration, decision makers at the power plant and local people to take action so that a better balance is achieved between economy and ecology.

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Smart Solar Cooker

Self-powered tracking

In mountainous regions and in the balconies of high rise buildings in cities, sunlight is available only during some part of the day. Conventional solar cookers are bulky and not designed to track the sun. The heating is imperfect and cooking takes a lot of time. So, though solar cookers can save energy, the uptake of the technology is low.

To address these problems, Dipankar Deb and Abhijeet Redekar, Institute of Infrastructure Technology Research and Management, Ahmedabad recently designed a self-powered, actively tracking and dual-heating solar cooker.

They combined solar heating with battery-powered heating by integrating a thermoelectric generator to derive the necessary power for heating and for the tracking mechanism.

For a precise tracking of the sun's azimuth and elevation, they used two actuators. By adjusting the base and reflector angles, the cooker consistently captured the maximum amount of sunlight throughout the day.

The team made sure that, in spite of the additional components, the design was well within the dimensions and weight of solar cookers recommended by ISO standards. The total weight of the cooker assembly is 18.45 kilograms, rising to 32.50 kilograms with the supporting structure. This is still comparable to traditional cookers, despite the added features.

'The design significantly reduces cooking time. The cooker operates effectively even in cloudy conditions,' says Abhijeet Redekar.

'The efficiency increases with the material used for reflectors and the tracking of the sun,' adds Dipankar Deb, his colleague.

The design of the solar cooker combines durability and efficiency. The prototype cost was about 7500 rupees. Mass production can bring down the costs. This may help the uptake of solar cooker technology in urban and hilly terrains.

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