

Current Science Reports

Predicting Landslides *Kullu–Rohtang Pass*

The Kullu–Rohtang Pass lies in the heart of Himachal Pradesh, in the rugged terrain near the Pir Panjal Mountain range. In the region, high tectonic activity and steep slopes of easily crumbled rocks cause landslides, obstructing the transport corridor.



Image: B. Balaji via Flickr

Existing methods of predicting such events take time and specialized knowledge. Could we use machine learning to offer timely landslide warnings?

Researchers at the Delhi University in collaboration with colleagues from Australia and Vietnam decided to test five machine learning models for the purpose.

To train the models, the team took images of the Kullu–Rohtang region with details about its landforms and features. Using the Global Positioning System, the researchers inserted data about the exact locations of more than 50 previous landslides into the area's topographic map. They also input location features that could have triggered the landslides. Due to the sheer number of triggers, input variables that were similar in function were correlated to reduce complexity. In this way, the team created a database of landslides in the region with necessary details.

They used two different types of machine learning: generation-based algorithms that segregate data such as the decision tree, K-nearest neighbour, and the support vector machine and generation-type algorithms, such as Gaussian Naive Bayes and multilayer perceptrons, that predict outcomes by extrapolating input data.

To train the models, the researchers divided the landslides into training and validation datasets. When tested, all five models showed a high capacity to predict landslides in the Kullu–Rohtang Pass transport corridor. The decision tree, the support vector machine, Gaussian Naive Bayes, and the multilayer perceptron showed 100% accuracy.

Now that we have reasonably good models to predict locations prone to landslides, early warning and mitigation measures for landslides can be more easily put in place – at least in the Kullu–Rohtang Pass.

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Marine Bioluminescent Bloom *Estimating by remote sensing*

Noctiluca scintillans is a marine alga that causes bioluminescent blooms in oceans. Though the bloom looks spectacular, it is harmful to other marine species as it accumulates excess carbon and ammonium, on the one hand and reduces dissolved oxygen, on the other. To counter the environmental harm, it is crucial to monitor and, if possible, forecast the blooms.



Image: Bruce Anderson via Wikimedia commons

Researchers from Andhra University, Indian National Centre for Ocean Information Services, National Centre for Polar and Ocean Research, and Berhampur University, came together to investigate the dense *Noctiluca* blooms in the northeastern Arabian Sea during the winter–spring transition.

There are two types of *Noctiluca scintillans*: red, which prey on other phytoplankton, and green, which can prey on other phytoplankton and also produce their own food through photosynthesis, facilitated by friendly algae living within them.

To understand the role of the availability of other phytoplanktons and the environmental factors that lead to the bloom, the research team set off on the *Sagar Sampada*, a research ship, on March 2016 and February 2017 to collect samples from 15 different locations. They measured sea surface radiance and other environmental factors.

Publicly available daily satellite-derived sea-surface temperature data was also downloaded by the team.

They then used regression methods to derive various models. The best-performing model suggests that the presence of other phytoplankton during the early phase and sea-surface temperature in the later phase are the most important factors for the blooms. The first phase in the development of the bloom is when it feeds on other phytoplankton and grows in number. During winter, convection brings nutrients to the surface and increases the availability of other phytoplanktons.

This makes it difficult for the red variety of *Noctiluca* to survive. The green variety then expands using the food produced by the algae within.

'This second phase of the bloom was correlated with the degree of sea surface warming,' says Sanjiba Kumar Baliarsingh, INCOIS, Hyderabad.

'We developed a metric to estimate the bloom from the data of the reflectance at different wavelengths and sea-surface temperatures,' says Sudarsana Rao Pandi, NCPOR, Goa.

'The metric will be used for monitoring harmful *Noctiluca* bloom on the west coast,' adds Nittala S. Sarma, Andhra University, Visakhapatnam.

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Food Grade Xylitol *Fermented from corncob biomass*

Xylitol is an artificial sweetener, a safe alternative to sugar for people living with diabetes. Though India ranks 3rd in the Asia-Pacific for xylitol demand, it does not produce enough and relies on imports.

The conventional chemical synthesis of xylitol causes considerable greenhouse emissions. Can we develop a

cheaper, more eco-friendly way to produce xylitol?

Recently, scientists from three CSIR institutes, IIP, NCL and CFTRI, collaborated to check the feasibility of using corncobs for xylitol production. Xylitol can easily be produced by fermenting xylose sugar. And xylose is available in large quantities in corncobs, agricultural waste.

The team washed corncobs with water, and crushed and digested them using dilute sulphuric acid and steam. To remove toxic components from the solution, they used activated charcoal as an adsorbent.

The resultant liquid was filtered to remove multivalent ions. Using a rotary evaporator, the remaining solvent was evaporated to get a high concentration of D-xylose sugar.

For producing xylitol, some *Candida* species and genetically engineered microbes have been used. However, the species can be pathogenic and using genetically modified organisms leads to an extensive regulatory review period and additional costs. So, the scientists used a strain of *Pichia caribbica*, a yeast known for its ability to ferment xylose.

They first acclimatised the cells with D-xylose solution, to activate the enzymes that use xylose as a carbon source instead of glucose.

Then, the researchers inoculated the cells into a medium containing a very high concentration of D-xylose sugar. The low oxygen conditions in the reactor triggered the fermentation of xylose into xylitol.

The researchers removed the yeast cells by centrifugation after 95% of the xylose was consumed in the reaction vessel.

The supernatant, rich in xylitol, was treated with activated charcoal to remove phenolics and other fermentation impurities. The solvent from the resulting solution was evaporated to prepare a 90% weight-by-volume concentration of xylitol.

The final task was to produce crystals of xylitol. The researchers seeded one gram of commercial xylitol crystals into the supersaturated xylitol solution. Crystallisation led to 85% product recovery.

The researchers double checked the safety of the product. Rats injected

with as much as 10,000 milligrams of xylitol per kilogram of body weight did not show any abnormal activity or gross pathological lesions.

The next step, the commercial production of xylitol by scaling up the process, will not only make India self sufficient in xylitol, but can also prove an extra source of income for corn farmers.

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High-salt and Antibiotics Drug–diet interaction

Long-term high salt in the diet disrupts the gut microbial ecosystem. This can lead to gut inflammation and metabolic abnormalities such as hypertension, cardiovascular complications and renal injury.

As with high salt intake, the consumption of antibiotics has increased. Antibiotics also cause changes in gut microbiota.

What happens to people who have a high salt diet and take antibiotics?

To investigate, V. Samuel Raj and team at the SRM University, Sonepat collaborated with scientists from NII, AIIMS, New Delhi, the National Institute of Biologicals, Noida, and a researcher from Taiwan.

They fed mice a high salt diet for three weeks. The mice were administered amoxicillin in the third week, mimicking a short course of the antibiotic.

The high salt diet decreased the number of white blood cells and increased total blood glucose and cholesterol – signs associated with metabolic syndrome. There was also increased creatinine, suggesting impaired renal function. Low blood urea levels in the mice indicated liver dysfunction.

The amoxicillin treatment on the high salt diet mice restored all the biochemical parameters involved in the metabolic disorders to a normal range.

To identify and compare the composition of gut microbiota under normal conditions, with that during a high salt diet as well as with the amoxicillin treatment, the researchers did 16s rRNA high-throughput sequencing.

The number of bacterial species was higher in mice on the high salt diet. The total number of unique microbial

species also increased in the high salt diet group. In mice on the high salt diet, the normal gut-associated bacteria such as *Firmicutes* and *Bacteroidetes* decreased. Proteobacteria, a family of pathogenic microbes, as well as a number of opportunistic gut pathogens, increased. There was also a significant increase in the ratio between *Firmicutes* and *Bacteroidetes*, a hallmark of obesity.

The amoxicillin treatment restored this ratio, and reduced the abundance of gut microbes linked with metabolic disorders. There was also an increase in *Bacteroides acidifaciens*, *Bacteroides uniformis* and *Akkermansia muciniphila*, gut microbes associated with improved insulin signalling and gut integrity.

‘Overall, amoxicillin treatment for a short duration showed beneficial effects on metabolic health by partially restoring gut bacteria composition,’ says Samuel Raj.

Reducing salt intake, however, is better than taking amoxicillin to overcome the intestinal dysbiosis and consequent pathologies.

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Cysteine-rich Protective Antigen Antimalarial vaccine candidate

The first ever antimalarial vaccine, Mosquirix, recently approved for use by the WHO, has poor efficacy. All past endeavours also failed to develop a successful vaccine probably because of variations in the antigen or polymorphism across different malarial parasite strains. Will we ever be able to overcome this challenge?

Anjali Somanathan from JNU collaborated with researchers from other institutes from the National Capital Region to take up the challenge. The group decided to focus on an antigen that is essential for the survival of the malarial parasite. Such antigens have limited polymorphism.

In the course of their literature survey, the team came across a cysteine-rich protective antigen of the parasite. The residues of the amino acid, cysteine, interlinked with each other to create a protein structure, used by the parasite to enter red cells. The protein exhibits high immunogenicity and induces neutralising antibodies. A perfect candidate.

But the large-scale production of these antigens remained a challenge. To resolve the problem, the group cloned the gene sequence coding the antigen and inserted it into *E. coli*.

The *E. coli* were cultured. After breaking the *E. coli* cells, the researchers extracted the protein from the insoluble fraction.

To purify the protein, the researchers first unfolded the protein and then refolded it to its native conformation. They confirmed the quality of the refolded purified protein using reverse phase high performance liquid chromatography.

Satisfied with their method for producing the antigen, they scaled up the production using fermenters.

Now the issue was the adjuvant for the vaccine formulation. The group tested formulations with three different human compatible adjuvants: Adda-Vax, Monatide ISA 720 and alhydrogel. They immunised mice with the purified protein and found a strong antibody response with all three formulations.

The efficacy of the antibody in the alhydrogel formulation was greater than that found in the other two.

But why is there this variation in the effects? The team checked.

The antigen in the alhydrogel formulation induced secretions of different cytokines such as the tumour necrosis factor alpha, interleukin 4 and interleukin 6. This was not the case with the other formulations.

But is the formulation effective enough to neutralise different strains of Plasmodium?

The group evaluated its efficacy against the strains 7G8, Dd2, FVO and HB3. They observed 80–96% inhibition of erythrocyte invasion by these strains.

The cysteine-rich protective antigen monomer forms complex oligomers. Which one induces the better immune response – the monomer or the oligomer?

The team found that antibodies induced by the monomers inhibited erythrocyte invasion better than those induced by oligomers.

The cysteine-rich protective antigen seems to be more effective than the one that is currently in use.

However, further *in vivo* studies followed by clinical trials are needed for

the vaccine candidate to be used in clinical settings.

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Cisplatin Toxicity Probiotics mitigate?

Cisplatin, a widely used cancer chemotherapy drug, arrests DNA replication, ultimately resulting in cancer cell death. Although this platinum-based drug effectively treats advanced cancer, it also causes severe side effects on the kidneys, ears and brain, affecting the quality of life of cancer patients undergoing treatment.

To reduce these side effects, can we use probiotics that promote gut health, boost the immune system and reduce inflammation?

Buddolla Viswanath and team from Dr Buddolla's Institute of Life Sciences, Tirupati recently investigated the possibility. To test their hypothesis, the research team conducted experiments using zebrafish, a popular animal model in biomedical research.

They exposed the zebrafish to cisplatin and found that the drug caused various side effects, including histopathological abnormalities. Cisplatin-treated tissues lost intact basement membranes surrounding the intestines. It also caused ovarian damage and a decrease in follicle number.

The zebrafish exposed to cisplatin, were administered *Bacillus megaterium*, a large bacillus known for its ability to produce compounds with antimicrobial, anti-inflammatory and antioxidant properties. The probiotic reduced side effects. The follicles and epithelial barriers in the intestines remained normal and intact.

What is the underlying mechanism of the reduced toxicity?

The team measured the reactive oxygen species scavenging activity in the intestines and ovaries of the zebrafish treated with cisplatin along with the probiotic. They found that the probiotic increased scavenging activity in both organs.

They measured the levels of enzymes involved in the scavenging reactive oxygen species – glutathione reductase, glutathione peroxidase, catalase and superoxide dismutase. *Bacillus megaterium* reduced lipid peroxidation

and increased the levels of all the enzymes involved in scavenging reactive oxygen species. This suggests that the probiotic works by reducing the oxidative stress caused by cisplatin.

The research provides evidence for the potential use of *Bacillus megaterium* to reduce the toxic effects of cisplatin-induced toxicity. However, further studies are needed to determine its efficacy and safety in other animal models and human subjects.

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Spontaneous Cancer Regression Target genes identified

Almost all cancers seem capable of regressing spontaneously. This regression is thought to be caused by the activity of certain biomolecules in the immune system. However, the genes involved in spontaneous regression are poorly understood.

Recently, scientists from IIT Varanasi, the Indian Institute of Information Technology, Nagpur, Jawaharlal Nehru University, New Delhi and Shiv Nadar University, Delhi collaborated to gain insights into the biomolecules involved in tumour regression.

They injected rats with a malignant cell culture. About 35% of the rats developed malignant tumours and died. But 65% showed a decline in tumour cells and their tumours completely disappeared.

Investigating the activity of the immune system of this group, the researchers found that the infiltrating leukocyte cells – T cells and natural killer cells – were highly activated.

Were the leukocytes from cancer-resistant rats responsible for the remission?

To find out, the researchers injected wild-type rats with a malignant cell culture. After one week, the rats developed cancer. The researchers extracted leucocytes from rats that had survived the previous experiment and transferred them to the wild-type rats. There was a gradual decrease in the tumour lesion and, ultimately, complete remission.

The team continuously monitored the rats for about one year. There was no sign of recurrence.

For gene expression profiling, the researchers conducted the same

experiment with pigs. As expected, some showed spontaneous tumour regression.

The team profiled the gene expression of the pigs and identified four differentially regulated genes. A decrease in the expression of the Type IIA topoisomerase gene was found to be the most important factor in regression.

Can we induce tumour regression by blocking the activity of this gene?

To find out, the researchers conducted molecular docking using available drugs from databases. They identified some 35 drugs that could be used to target the Type IIA topoisomerase gene.

In vitro and *in vivo* studies as well as clinical trials to induce tumour regression using the drugs identified for blocking Type IIA topoisomerase, such as podophyllin and anthracycline derivatives, need to be undertaken now.

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Indian Stingless Bees

Nest-building materials

The Indian stingless bees, *Tetragonula iridipennis*, collect plant latex and resin to build nests in cavities in walls, tree trunks and even in termite mounds and ridges in agricultural fields. They make the colony's opening small, using a mixture of cerumen, a waxy substance, made by mixing secretions and resinous substances that they collect from plants. But which plant materials do these bees use to make their nests?

To find out, researchers from the Vidyasagar University, Midnapore collaborated with Ujjwal Layek from Rampurhat College, Birbhum. They collected resin and latex samples from the hives of stingless bees.

Using slides and literature as references, they identified plant sources from the pollen.

'We recorded 25 plant species as sources of latex and resin for the Indian stingless bee,' says Nandita Das, Vidyasagar University, Midnapore.

'The most frequent latex and resin sources for the bees are jackfruit, banyan, peepul, gum arabic and mango trees,' says Suman Kumar De, Vidyasagar University, Midnapore.

'Among shrubs, giant calotropis and pinwheel flower plants are favourites of the species,' adds Prakash Karmakar, the leader of the research team.

The nest building material of the stingless bee has antimicrobial, antioxidant, antihypertensive and anticancer properties. Are these medicinal properties due to the plant materials or bees secretions?

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Nicobarese Fishers

Impact of COVID-19 lockdown

The COVID-19 pandemic and the lockdown affected people worldwide. It degraded livelihoods and food security, especially in urban areas.

But how did it impact tribal fishers on the isolated island of Car Nicobar?

Researchers at the ICAR-Central Island Agricultural Research Institute, Port Blair, and the ICAR-Krishi Vigyan Kendra, Car Nicobar Island decided to investigate.

In January 2021, after the first wave of COVID-19, the researchers interviewed 95 Nicobarese tribal fishermen.

They found that, post COVID-19, the average monthly fish catch and income had dropped to nearly one-third!

The biggest reason for this decline was the fear of getting infected by SARS-CoV-2. The fishers also faced shortages of fuel and other fishing-related inputs.

COVID-19 also exacerbated existing problems such as lack of infrastructure, logistics and skilled people.

To re-establish their livelihoods and to survive the pandemic, most respondents suggested subsidies and compensation packages as an immediate solution.

The researchers suggest a COVID-19 framework to strengthen the marine fisheries sector of the Car Nicobar Island, and to make it robust to deal with future pandemics.

'To improve the livelihood of fishers on these islands, we need to set up knowledge hubs to disseminate new technologies, to promote awareness on responsible fishing practices, and to build resilience to deal with future pandemic-like situations,' says R. Kiruba-Sankar, ICAR-Central Island Agricultural Research Institute, Port Blair.

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