Current Science Reports

Air Quality in Uttarakhand

Source of sulphur dioxide

Uttarakhand, a popular tourist destination, often experiences high levels of sulphur dioxide pollution. Sulphur dioxide is usually emitted by power plants, transportation, forest fires and agricultural biomass burning.

What exactly is the source of the sulphur dioxide in Uttarakhand?

Sanjeev Kumar, Hemvati Nandan Bahuguna Garhwal University, joined hands with other researchers to investigate. They conducted wide-ranging and continuous ground-based observation of sulphur dioxide levels and monitored seasonal variations in the Srinagar (Garhwal) valley.

For continuous ground-based sulphur dioxide monitoring, the researchers chose four sites in the area.

To track the level of sulphur dioxide, they used a sulphur dioxide analyser that measures the fluorescence emitted by sulphur dioxide gas when exposed to ultraviolet radiation. Using an automatic weather station, they also kept track of meteorological data, such as temperature, humidity and wind speed. There was a diurnal variation in sulphur dioxide, usually peaking towards noon, which could be attributed to human activities. A week-end effect was also detected in the variations which could be due to tourism and transportation.

The researchers found that sulphur dioxide is higher before and after the monsoon.

To track seven-day air mass back trajectories, they extracted data from the Global Data Assimilation System and used the Hybrid Single-Particle Lagrangian Integrated Trajectory model. The analysis suggested the movement of air masses from the Gulf region, western Pakistan, Afghanistan, eastern Rajasthan, Punjab and Haryana during the post-monsoon season. Before the monsoon, the valley received air masses from Iran, Iraq, western Pakistan, Rajasthan and Punjab via Haryana as well from western Uttar Pradesh. Agricultural biomass burning even in faraway regions influenced pollutant concentrations over the monitoring sites.

To assess the impact of forest fires on sulphur dioxide emissions and air quality, the researchers used satellite-based sulphur dioxide surface mass concentration data. And, to track the number and size of forest fires in the region, MODIS-derived fire spot activities. The researchers found that air quality deteriorated during forest fire incidents, as evidenced by increased sulphur dioxide levels.

Agricultural biomass burning and other human activities in the region as well as forest fires increase the concentrations of sulphur dioxide and degrade the air quality in the Srinagar (Garhwal) valley.

However, the air quality was generally good and sulphur dioxide concentrations stayed within the limits prescribed by the WHO.

The researchers stress the importance of robust monitoring of air quality as it can help identify sources to take remedial action when needed.

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A Trap for Females

To control melon flies

The melon fly, *Bactrocera cucurbitae*, poses a significant threat to global food security, infesting various crops in Africa, the Asia Pacific sub-continent and Southeast Asia. These flies can damage from 30 to 100 per cent of the crops.

Image: Polychronis Rempoulakis

The infestation of the flies begins when female flies penetrate the flesh of the fruit or vegetable and lay eggs 2–5 millimetres deep inside it. Larvae hatch inside the fruit and start feeding on the flesh. Controlling the infestation using pesticides is, therefore, not feasible.

Fruit fly traps are the most economical and a feasible option to control the outbreak of this pest. The traps use pheromones, chemicals used by the female insect to lure the males. This reduces the scope for the fertilisation of females and, hence, controls the pest population.

So Vijeth Arya and Vivek Kempraj set up the Bioorgo Innovation Centre in Bengaluru to produce Cuelure, a pheromone-based trap. Then they came up with the idea of trapping females using a protein-based trap. To become fecund, females need a lot of protein. And controlling the number of females also is even better than reducing only the male population.

But could the protein-based trap really attract females?

The researcher-turned entrepreneurs started conducting field experiments at 16 locations across Karnataka. Their protein-based lure contained the smell of fruits, a kairamone instead of a pheromone, to attract the female insects. The protein bait was placed in a transparent upper hemisphere with a yellow-coloured lower hemisphere to resemble the shape of a fruit.

The researchers placed both types of traps – ten protein-bait traps and one Cuelure trap per acre – around the borders of cucumber fields, by fixing them on wooden poles at a height of about 1.5 metres. The traps remained in the field from December to January and the researchers recorded observations every 15 days. They repeated the field experiments for three years from 2018 to 2020.

They compared data from the protein-based traps with those from Cuelure traps. Cuelure traps attracted male flies only, and, as expected, the number of males captured by Cuelure was more than those captured by the protein-based trap.

The protein-based kairomone formulation attracted adult flies of *Bactrocera cucurbitae* of both sexes. The protein-based traps were able to capture an average of 34 female flies per trap. The researchers also found that the number of melon flies captured became

significantly lower after each year, indicating a reduction in the population of melon flies.

They then tried to simulate the impact of trapping and removing female flies on reducing the number of viable eggs and individuals in the next generation. They needed help and so they collaborated with researchers from the UK for the mathematical and ecological perspectives on their data.

Despite lower capture rates than Cuelure traps, the protein-based traps had faster and more robust impact on the population size of melon flies due to the direct removal of egg-laying individuals from the population. This reduced the population size of the next generation.

Will farmers adopt the technique? The researcher-turned entrepreneurs await the results.

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Parkinson's Disease

Suggested pharmacotherapeutics

Many studies report the excess production of nitric oxide during the development of Parkinson's disease. The studies provide evidence that nitric oxide prevents autophagy, a cellular process that degrades and recycles damaged cellular components in our body.

Recently, researchers from the King George's Medical University and Government Medical College, Lucknow, decided to test the therapeutic efficacy of interventions in these two processes.

They chose 7-nitroindazole, a nitric oxide inhibitor, to reduce nitric oxide production, and glycyrrhizic acid, a compound in liquorice root reported to protect against neuronal damage.

Could the synergic action of glycyrrhizic acid and 7-nitroindazole help treat Parkinson's disease?

The researchers induced Parkinson's disease in mice using 1-methyl-4-phenyl-1,2,3,6-tetrahydropyridine hydrochloride, a chemical that leads to symptoms similar to Parkinson's disease when metabolised in the brain.

They treated one group of such mice with glycyrrhizic acid, another with 7-nitroindazole, and yet another with 7-nitroindazole and glycyrrhizic acid.

As control, the researchers used groups of normal mice without any treatment, with 7-nitroindazole, glycyrrhizic acid and combination treatments.

After fourteen days, using an activity meter, they examined the ambulatory, rearing, and speed parameters of all groups of mice.

They found that mice with induced Parkinson's disease had reduced ambulatory, rearing, and speed responses, as expected. But mice treated with glycyrrhizic acid and 7-nitroindazole showed great improvement.

The researchers analysed the brains of four animals from each group.

Since the neurotoxin used to induce Parkinson's disease symptoms elevates the degree of lipid peroxidation and impairs the antioxidant system, the researchers estimated the lipid peroxidation of the mice's brains. Mice treated with glycyrrhizic acid and 7-nitroindazole had lipid peroxidation that was close to normal levels.

The enzyme-linked immunosorbent assay revealed that the inflammatory markers and dopamine levels had increased in the Parkinson's disease model mice. But mice treated with glycyrrhizic acid and 7-nitroindazole showed results almost consistent with those of untreated mice.

The researchers used immunofluorescence to detect autophagy dysfunction and nitric oxide signalling in mouse brain tissue sections. These were also close to normal levels in the brains of mice treated with 7-nitroindazole and glycyrrhizic acid.

These results from mice models now need to be replicated in human clinical trials.

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COVID-19-induced Inflammation

Identifying therapeutic targets

The envelope protein of the SARS-CoV-2 virus induces an inflammation of the lungs and gastrointestinal tract. In fact, transfecting the cells with phages carrying the code for the envelope protein and the expression of the envelope protein are adequate for eliciting inflammation and necroptosis, a type of programmed cell death. Understanding how the envelope protein induces inflammation and cell death can help develop targeted therapies.

Researchers from IIT Indore, the Central Ayurveda Research Institute, Kolkata, the Regional Ayurveda Research Institute, Gwalior and the Devi Ahilya Vishwavidyalaya, Indore investigated the matter.

They procured lung and colon epithelial cells from the National Centre for Cell Science, Pune and cultured them in suitable media. They transfected the cells with the SARS-CoV-2 virus envelope protein code.

They analysed the RNA profiles in both cells using a quantitative real-time polymerase chain reaction and the Western blot technique. The levels of RNA for cytokines and chemokines that mediate inflammation as well as the levels of necroptotic markers were higher.

The researchers used immunofluorescence assays and Image J software to visualise envelope protein-transfected cells under a confocal microscope. To visualise the live apoptotic and necrotic cells separately, they used Hoechst/propidium iodide dual staining and confirmed necrotic cell death in addition to apoptosis in both lung and colon cells.

Necroptosis involves the receptor-interacting protein kinase 1 enzyme. To check whether the envelope protein acts through this enzyme, the researchers introduced a specific inhibitor, Necrostatin 2, into the cell culture, and analysed the RNA profile. There was a significant decrease in the inflammatory markers.

The researchers suggest that receptor-interacting protein kinase 1 could be a potential therapeutic target to treat inflammation induced by COVID-19 infection.

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Inhibiting Structural Mutation

Flavonoids can fight cancer

The tumour suppressor p53 protein is frequently mutated in many types of cancers. Mutation in the p53 gene causes a cavity in the DNA-binding region, making the p53 protein functionally inactive. Studies suggest that curcumin can reverse this mutation. But curcumin is a large molecule that is not easily absorbed. Could structurally similar, small natural flavonoids do the job?

Recently, researchers from AIIMS and the Sri Venkateshwara College, Delhi searched for flavonoids inhibiting structural mutation.

They downloaded the three-dimensional structure of the mutated p53 from the Protein Data Bank, a repository of protein structures. They also retrieved the structures of six curcumin-like flavonoids from PubChem, a chemical database.

They performed molecular docking using AutoDock 4.2.6 and simulated the molecular dynamics using the GROMACS-5.0.7 software. All the flavonoids were intact inside the structural cavity of the mutant.

To assess the physicochemical and drug-like properties as well as the pharmacokinetic parameters of the flavonoids, they analysed the absorption, distribution, metabolism, excretion and toxicity of the flavonoids using the SwissADME free online server. They found that the properties of these flavonoids were satisfactory.

They also predicted the toxicological characteristics of the flavonoids using Osiris Data Warrior software.

The researchers used cell-based cytotoxicity studies on BxPC-3 cell lines with mutants to assess the cytotoxic effects of the flavonoids, considering curcumin as a reference. They found that only two flavonoids, methylphiopogonanone A, and ethylophiopogonanone B showed about 75% cell death. These flavonoids are known to be abundant in mondograss, *Ophiopogon japonicus,* a Chinese herbal medicine.

The two flavonoids now need to be tested *in vitro* and *in vivo* for their potential for treating cancer.

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Diet and Chronic Disease

Children in low income groups

Nearly one in five children in India are born with low birth weight. Nearly half under the age of five are malnourished or stunted. On the other end of the spectrum, approximately 5 per cent of school-aged children and one fifth of adults are overweight.

As the country becomes more prosperous, obesity, and, consequently, the prevalence of non-communicable diseases will increase even among low income groups. What are the dietary patterns among low income groups in urban settings that increase the risk of non-communicable chronic diseases?

Researchers from the Institute of Home Economics, University of Delhi, in collaboration with a research centre in London, assessed the dietary patterns of children living in Delhi slums.

They collected data from a trial conducted a decade ago on low birth weight babies. From that cohort, they recruited 665 children and, as control, 77 children with normal birth weight.

The researchers measured the bodily parameters of the children and assessed markers for chronic diseases. Data on foods consumed in the past week were also collected using a food frequency questionnaire.

To analyse dietary patterns, the researchers divided the food items into 14 groups, excluding grains and fats since the two food groups were part of daily intake.

More than 85 per cent of the children had sweets daily. The consumption of fried foods and dairy products was also high. But meat, poultry, fish, nuts and vegetables and fruits, required for balanced nutrition, were low in most children.

Children with educated mothers and from higher socioeconomic backgrounds followed the sugar and fat pattern. They also showed increased height.

The fruit and vegetable pattern was associated with lower levels of haemoglobin A1C, indicating reduced risk of diabetes. On the other hand, children with the sugar and fat pattern in their diet had a distorted fat-mass index, indicating a potential risk for non-communicable diseases later in life.

Older children tended to have more fruits and vegetables. Interestingly, children who adhered to the fruit and vegetable pattern had lower adherence to the sugar and fat pattern, and vice versa.

The team recommends that parents include fruits and vegetables in the diet to mitigate the risk of chronic diseases.

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Co-worker Behaviour

Impacts collective progress

In workplaces, people from diverse backgrounds collaborate, plan, discuss, review and act together. Unjust, disrespectful, rude or inconsiderate behaviour during such processes may psychologically impact co-workers, leading to disengagement from work and even the hiding of knowledge. Even though a large body of literature on knowledge hiding exists, the process by which co-worker incivility leads to it is not fully understood.

Upasna Agarwal, Indian Institute of Management, Mumbai collaborated with researchers from Australia and the UK to explore the factors behind the phenomenon.

An employee can take different paths to conserve his or her resources in order to avoid the drain of mental energy. So the researchers applied the principle of conservation of resources in the workplace to analyse the phenomenon.

They hypothesised that uncivil behaviour can lead to an employee hiding their knowledge via work disengagement and thoughts of quitting the job. Cynicism about the intentions of colleagues may also impact the phenomenon.

To test their hypothesis, the researchers sought data from pairs of employees in three corporate companies.

During the first survey, questions related to co-worker incivility, work engagement and knowledge hiding were asked.

After three months, intentions of job-quitting and levels of cynicism were also surveyed.

Though 750 pairs of employees who work closely together and interact closely during work volunteered to take part in the survey, only a little more than 600 responses could be collected. After removing ineligible responses as detected by trap questions, the researchers analysed more than 580 responses.

Data from both surveys were used to derive relationships among the variables using structural equation modelling, a statistical method which can measure both the direct and indirect effects of the variables.

Then, via mediation models, the researchers found that knowledge hiding is mediated by work disengagement and quitting intentions.

Moreover, via the regression model, the researchers found evidence that

the more the person believes that colleagues are self-interested, and are cynical about their intentions, the more such a person hides their knowledge.

Overall, knowledge hiding is high when employees withdraw due to the incivility they face and feel disengaged from work. Their cynicism about the intentions of co-workers also plays a part in this.

Organisations can take steps to improve co-worker congeniality by setting behavioural standards to reduce incivility.

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Waste Lubricant Oil

Bacteria helps biodegrade

Biosurfactants, surface-active molecules produced by oil-degrading bacteria have a water-resistant tail and a water loving head; they can enhance the solubility and biodegradation of hydrocarbons by emulsifying them and increasing their accessibility to microorganisms.

Achromobacter xylosoxidans is a biosurfactant-producing bacteria found in the environment. Such bacteria in oil-contaminated soil may have a higher capacity to produce biosurfactants.

To investigate the possibility, researchers from the Gandhi Institute of Technology and Management, Visakhapatnam collected soil samples from the naval dockyard and railway diesel loco-yard.

Isolating biosurfactant-producing bacteria using the enrichment culture method, they mixed the surfactants produced by the bacteria with kerosene and measured the height of the emulsifying layer to calculate the emulsification index. The index was quite high.

To identify the bacterial strains, the researchers analysed the 16S ribosomal RNA gene sequences of the bacteria. By comparing them with sequences of known bacterial species, they found that the isolate was similar to the *Achromobacter xylosoxidans* strain ES-6.

They incubated bacterial cultures with hydrochloric acid for seven days. After centrifuging at ten thousand rotations per minute to remove the bacterial debris, they extracted the biosurfactant using chloroform and ethanol.

The researchers analysed the quality of the biosurfactant using various tests. The strain had extensive biodegradative potential. It could degrade components, including hydrocarbons and diethyl phthalate, with a relative degradation of about 40 per cent within seven days of incubation.

Oil industries can use the biosurfactant-producing bacteria to reduce soil and water pollution by degrading oil spills.

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Meandered Tungsten Nanowires

High performance photodetection

Superconductors are materials that exhibit negligible resistivity below a critical temperature. Most superconductors exhibit photoconductivity and generate an electric signal due to reduced resistance when light falls on them. Even a single photon can be thus detected with fast response, low noise and minimum energy.

Though superconductors can be used to detect and measure very low amounts of light and radiated heat, they require cryogenic cooling, which is expensive and complicated.

But now Abhishek Umar and colleagues at the CSIR-National Physical Laboratory, New Delhi have come up with a method for photoconductivity at room temperature using tungsten nanowires.

They fabricated meandering tungsten nanowires from hexamethyl carbonyl tungsten precursors, bombarding them with gallium ions using a focused a ion beam – a method used for the perfect shaping of specific patterns in a structure. Thus they created tungsten nanowires dotted with carbon and gallium atoms as well as some occasional oxygen atoms.

The researchers then illuminated the wires with halogen light and laser lights of wavelengths at 532, 1064 and 1550 nanometres at room temperature. In response, the illuminated wires produced electric signals.

The researchers measured the photoresponse of the meandering nanowires and found significantly high photocurrents and, hence, high detection abilities as well as efficiency. The responses were dependent on the width of the nanowire and the area covered by the meandering structure.

Encouraged by the results, they checked the stability of the wires. Even after keeping the meandering nanostructures at room temperature for six months, the measurements did not vary significantly, confirming that the wires were stable for photodetection applications.

The researchers attribute the enhanced photocurrent to the composition and structural properties of the meandered wires. They believe that a plasmonic effect is responsible for the phenomenon.

Based on this research, optoelectronic manufacturers can now start developing high performance devices with low energy consumption using superconductor photoconductivity.

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