Science Last Fortnight

Glacier Melt or Snow Melt?
Isotopes in water discriminate

Water feeding the Bhagirathi River originates due to the melting snow from its catchments as well as from the melting of the Gangotri Glacier. Estimating their relative contribution is important as it decides the amount of water available downstream. Knowledge of the ratios of snow, glacier and stream water thus helps formulate water management strategies.

Image: Arpit Rawat, via Wikimedia Commons

The proportion of heavier isotopes of hydrogen and oxygen in water molecules from fresh snow is different than that in melt water from glacier ice. Thus, measuring the isotopic composition of rivers can help distinguish between the contributions from various water sources. So, Shive Prakash Rai from the Banaras Hindu University and collaborators from various Indian and Austrian institutions set about determining the isotopic composition of the Bhagirathi River. They used an isotope ratio mass spectrometer to periodically monitor the ratios of normal and heavier isotopes of hydrogen and oxygen in the river water.

In May, when the flow increases, isotopic ratios of the river water were close to that of snow. This implies that the major contribution to the river, at this time, was from melting snow – about 92%.

The water from snowmelt decreased slightly in June, and then, abruptly, from July to September. This indicates that the glacier meltwater contributed more during this period. Overall, only about 37% of the flow, from May to September, was due to glacier meltwater.

The scientists also measured the level of tritium, a radioactive isotope of hydrogen, using an ultra-low-level liquid scintillation counter. They found lower values of tritium in glacier meltwater than in the river and snowmelt. In glacier meltwater, the team found an average of one tritium unit. But in the river, it was more than eight and, in snowmelt, more than twelve. The low concentrations of tritium in glacial ice indicate that the glacier is old – more than 60 years.

During May–June, demand for water in the Ganga basin is high. In this period, snowmelt is crucial to sustain the flow of the Bhagirathi River. But the trend of decreasing snowfall around the Gangotri Glacier poses a concern. The research provides data for planners and scientists to rework strategies for climate change adaptation.

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Natural Hazards
Economic impacts

Economic growth and development are important for disaster preparedness, management and mitigation. But the relationship between natural disasters and economic growth is still not well understood.

So, researchers from the IIT Roorkee examined the links between natural hazards and economic growth to formulate efficient disaster management policies. They collected five years of data on hazards from 29 developed and 73 developing countries from the EM-DAT database maintained by the Centre for Research on the Epidemiology of Disasters. The data contains variables such as mortality, total economic damage and number of people affected due to hazards. Using this data, the team classified the hazards as moderate or severe. The severe ones included the 2015 Nepal earthquake and the 2015 Chennai floods.

The researchers used sectoral growth rates along with the overall GDP growth rate to quantify the average growth effects of the hazards in terms of economic impacts. They report that more economic damage is observed in developed countries and that the hazards had varied effects on the macroeconomy.

The team observed that flood and drought impact agricultural growth more in developing countries. The observed positive impact of floods on agricultural growth may be related to the timing of the cropping season, which, the team says, can trigger higher economic growth in agrarian economies. However, severe floods and droughts caused destruction, impacted economy and reduced the GDP. Storms, too, had negative effects on economic growth in developing countries.

Floods and earthquakes have positive effects too. The researchers explain that increased investment in reconstructing houses and public property enhance a nation's economy. Earthquakes led to a decline in non-agricultural growth in developing countries. But, for the other countries, the results were positive. The scientists conclude that, though direct damage was greater in developed nations, macroeconomic impacts were higher in developing nations.

The report provides new empirical evidence of the probable short-to-medium-term growth effects of natural disasters in countries with different levels of economic development.

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Sorting Smoke
Seasonal shifts in pollution

Last Diwali, the Supreme Court banned crackers in Delhi-NCR to control air pollution. However, smoke from automobiles and stubble burning is the main culprit, argue citizens. But is there a difference between pollution from crackers and that from vehicles? Is there any pattern? It is as unclear as the smoke itself.

In a recent publication, Umesh C. Dumka from the Aryabhatta Research Institute of Observational Sciences, Nainital and collaborators measured and segregated air pollutants for a

year in Panchgaon in rural Delhi-NCR. Soon patterns emerged from the smoke.

The team recorded a sharp rise in black carbon levels during early morning and late evening – periods when traffic and wood burning for cooking peak.

A seasonal shift is also prominent. The researchers recorded the highest black carbon concentration in winter. They observed that wood and stubble burning during winter are additional sources of black carbon. Without wind and rain, the dispersion of pollutants is slow. Nevertheless, fossil fuel burning contributes to more than 80% of the black carbon content throughout the year.

Seeing these trends, Dimitris Kaskaoutis from National Observatory of Athens asked: 'Can we estimate black carbon levels appropriately through computational modelling?' To answer this, the scientists tested a Weather Research and Forecasting model coupled with chemistry. The prediction is reasonably accurate for summer but not for winter. But why does it underestimate pollution for winter? Is it because of Diwali?

Only further studies can help us answer this question. Meanwhile, reducing the burning of agricultural waste and limiting fossil fuel use seem to be only way to make Delhi soot-free.

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Rice Field Methane Emission

Variation in varieties

Image: Vespertunes, via Wikimedia Commons

Rice, a major food crop, plays an important role in the food security of South Asian countries. But growing rice produces methane contributing to 10% of the total global methane flux to the atmosphere. How can we reduce methane emission from rice fields?

Recently, Bhattacharya and team from the ICAR-National Rice Research Institute, Cuttack collaborated with four other institutes to understand the mechanism of methane emission. They examined seven contrasting rice varieties based on crop duration and ecological preference in tropical eastern India.

Using gas chromatography, they observed that methane emission varied at different growth stages across the varieties. It was highest at the initial stages of flowering. At this time, exudates from roots also increase. This helps methanogenic bacteria and consequently methane emission from rice fields increases.

The short duration cultivar, Kalinga-1, had minimum methane emission rates compared to the long duration cultivar, Varshadhan. However, Varshadhan has higher grain yield per hectare than Kalinga-1.

The scientists suggest that, besides using cultivars with less methane emission potential, we should also consider ecology and crop management to reduce methane emission.

The team also observed that the pore to space ratio of shoot aerenchyma was positively correlated with methane emission. Aerenchyma, tissues with airspaces, that evolved to deliver oxygen from leaves to roots immersed in water, may be transporting methane from soil to atmosphere, say the scientists.

These findings give us clues to use genetic engineering or physiological manipulation to reduce methane emission from rice.

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Agricultural sustainability

Mathematical model

Inefficient irrigation and drainage salinise agricultural land, reducing crop productivity. In many places around the world, mathematical models have been used to address the problems. However, these models have not been compared for their accuracy and applicability.

Recently, Ajay Singh from the IIT Kharagpur undertook to analyse existing mathematical models. He compared recent models, using climatological data, soil and crop properties, for predicting salinisation. He found DRAINMOD most suitable. The other models could either not predict salinisation in agricultural lands, or were time consuming.

To overcome the salinisation of agricultural land, DRAINMOD suggests draining out water without affecting nitrogen in soil. The model simulates drainage systems over a long period. It can predict surface runoff on a day-to-day as well as hour-by-hour basis.

Irrigation is an artificial supplement to increase productivity. The study revealed a better model for sustainable agricultural performance. It is estimated that about 70% of water resources are used for irrigation when water demand already surpasses the supply. The researcher claims that DRAINMOD can be used to mitigate salinisation and improve irrigation efficiency.

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Probiotics in *Takrarishta*

Probing the ancient brew

Fast food fuels the fast pace of life today. But at what cost? The nutritional inadequacy of fast foods often leads to gastrointestinal diseases such as irritable bowel syndrome and necrotising enterocolitis. Probiotics, as dietary supplements, might provide a solution for such ailments. Traditional fermented preparations are known to have probiotic properties. But Ayurvedic fermented medicines have not been examined for the purpose.

Now, Bhushan L. Chaudhari and team from the Kavayitri Bahinabai Chaudhari Maharashtra University, Jalgoan explore the past to remedy the present. They reproduced a fermented concoction, *Takrarishta*, mentioned in the Charaka Samhita. They prepared the slightly alcoholic remedy as prescribed by the ancient text.

Takrarishta has buttermilk as base along with a plethora of spices typically

available in Indian households. Components like harda, amla and ajwain are known to inhibit bacterial pathogenesis.

From *Takrarishta*, the scientists isolated probiotic microorganisms, such as *Kluyveromyces* yeast and *Lactobacillus*. They found that these microorganisms can survive the stressful conditions of gastric acid and bile salt. The scientists say that these microbes can even tolerate the presence of antibiotics. *Takrarishta* also contains postbiotics that can support the immune system locally.

This palatable brew may help prevent, or even alleviate acute symptoms of gastrointestinal diseases. Its organoleptic properties indicate it to be an appetiser. *Takrarishta* might be gentle enough for infants and the elderly.

Further studies are required to evaluate the safety of all the bacterial isolates in *Takrarishta.*

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Dragon Slays Cancer

Capped nanoparticles

Gold nanoparticles penetrate cells efficiently. This can be useful in treating cancer. Gold nanoparticles are usually prepared using reducing agents to convert salts to metals. However, the chemicals are toxic to cells.

Image: SMasters, via Wikimedia Commons

Recently, Rohit Srivastava and team from the IIT Bombay came up with an alternative. They used dragon fruit extract to develop a simple, efficient and nontoxic capping for gold nanoparticles. Dragon fruit is a proven antioxidant and cancer therapeutic.

They prepared the nanoparticles by vigorously mixing chloroauric acid tetrahydrate salt and dragon fruit extract in an aqueous solution. The team used both dragon fruit extract and dragon fruit-capped gold nanoparticles to check toxicity on two types of breast cancer cell lines: one with hormone receptors and one without. The researchers found that dragon fruit-capped gold nanoparticles are more effective in the cell line with hormone receptors.

In the cancer cell line with hormone receptors, the extract killed around 60% of the cells. With dragonfruit capped gold nanoparticles, cell death increased to around 80%. However, more than 20% of normal cells also died.

Further research on the compound profile of dragon fruit extract will reveal the active molecule responsible for the anticancer property.

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Preventing Tumour Relapse

Sugar coated nanomedicine

The drugs used in conventional chemotherapy to treat cancer patients often cause collateral damage to healthy cells surrounding cancer cells. Moreover, some cancer cells are resistant to the action of chemotherapeutic drugs. These cancer stem cells can regenerate, multiply and form tumours again, leading to a relapse. Therefore, to prevent tumour recurrence, we need to combine drugs that target cancer cells with those that go for cancer-initiating stem cells.

Recently, scientists from the National institute of Pharmaceutical Education & Research and the Central Research Institute of Unani Medicine, Hyderabad collaborated to create a nanoparticle loaded with two different anti-cancer drugs that could be targeted specifically to destroy cancer-initiating stem cells.

They prepared liposomes, less than a hundred nanometres in size. The tiny spherical vesicles, bound by lipid membranes, can carry water soluble molecules. And the small size helps in transportation to cancer cells.

The liposomes were made of positively charged lipid molecules. Electrostatic attraction made it possible for the cationic liposome to be coated with hyaluronic acid, a negatively charged carbohydrate or sugar polymer. Hyaluronic acid receptors are present mainly on cancer stem cells. This helps target cancer cells, thus reducing damage to surrounding healthy cells.

The researchers loaded the nano-sized liposomes with Cabazitaxel and Silibinin. Cabazitaxel is a drug that stops cancer cells from dividing uncontrollably and has been used for treating prostate cancer. Silibinin is derived from plants that prevent the self-renewal of cancer stem cells thus reducing the chances of tumour recurrence.

The team tested the anti-cancer effects of the nanoparticle on two different immortalised cell lines derived from prostate cancer. The results were promising. Standard assays to check for anti-cancer effects showed that the drugs carried by the nanoparticle were successful in preventing cancer cells from multiplying, migrating and forming bigger colonies.

Further studies with animal models of cancer need to be done before the sugarcoated nanomedicine is used for clinical trials.

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Safer Food Packaging

Zinc oxide nanoparticles

Proper packaging of food can prevent food-borne diseases. Zinc oxide nanoparticles can be used in food packaging, due to their antimicrobial and antioxidant activities. There are many ways to synthesise the nanoparticles, but slow growth, cost of production and negative environmental impact limit their use. Researchers have been looking for faster ways to synthesise stable zinc oxide nanoparticles.

Recently, K. Byrappa and team from the University of Mysore, used thyme leaf extract to synthesise zinc oxide nanoparticles using a hydrothermal process. Thyme, a medicinal herb, has reducing and stabilising properties.

To synthesise the nanoparticles, the team added sodium hydroxide to

an aqueous zinc nitrate solution and introduced the thyme leaf extract in different concentrations. They found that as the amount of thyme leaf extract increased, the size of the zinc oxide nanoparticles decreased and reached a threshold at 1.5 ml of the leaf extract.

The researchers say that the smaller zinc oxide nanoparticles can easily kill bacteria by penetrating the cell membrane. The nanoparticles also show higher antioxidant activity than those produced by other techniques.

The researchers now plan to examine the effect on packaged food to convince industries to adopt the technique.

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Oil Waste-water at Barekuri

Electrocoagulation and microfiltration

Drilling at oil well sites produces toxic drilling mud and oily wastewater. Several other industries also discharge oil-water emulsions. Adsorption, coagulation, reverse osmosis, flocculation and ultrafiltration are used to separate oil from oily wastewater. But these methods are slow or require additional chemicals. Though some of these methods are combined with electrocoagulation to treat polluted drinking water, textile industry wastewater and brackish water, they have not been tested on oil drilling wastewater.

Image: John Hill, via Wikimedia Commons

So, recently, scientists from the IIT Guwahati decided to try electrocoagulation followed by microfiltration in batch mode to treat oily wastewater.

The team collected effluent from the Oil India Limited drilling site at the Barekuri oil field, Assam. The samples had oil, and grease along with several metals. The team tested different operating parameters such as current density, electrode distance and acidity to find the optimum results in electrocoagulation.

They used aluminium instead of iron electrodes during electrocoagulation, to avoid the reddish tinge iron gives to the treated water.

During electrocoagulation, the team observed that the potential difference across the electrodes produced large amounts of loosely aggregated masses or flocs. Floc formation helped remove oil and grease as well as unwanted metals from the effluent.

The scientists prepared a ceramic membrane from thermal power plant waste slag with high concentrations of alumina and silica. They mixed the slag with sodium carbonate, boric acid and sodium metasilicate. For successful microfiltration, they ensured that pore channels in the membrane were continuous from top to bottom.

With the method, the concentration of oil and grease in the effluent reduced from 35 g/l to nearly 10 g/l in just 20 min.

'The advantages are lower investment and operating costs', says M. Paswan, IIT Guwahati. 'No additional chemicals are required for destabilising the emulsion', adds M. K. Purkait, his colleague. 'Most importantly, very little sludge waste was produced', says M. Changmai, IIT Guwahati.

From exploration, through transportation to consumption, the stages of oil production damage the environment. The study may help us address the troublesome issue of oily wastewater.

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No Stain Cotton

Self-cleaning cloth

Cotton is major raw material for the textile industry. Cotton clothing is referred to as the clothing of the poor, because of its low cost. But, with its water absorbing property, it easily gets stained and regular washing brings down the cloth's durability.

Researchers at the IIT Dhanbad with collaborators at The Ohio State University recently tackled this problem, by making liquid repellent cotton. They achieved this using a simple technique – dipping the cloth in a hexadecyltrimethoxysilane solution, which forms a liquid repellent layer on the surface. This layer on cotton cloth forms a barrier between the liquid and the material, reducing the surface energy of the cloth.

'As a result, the liquid doesn't stick to the cloth, and drains off, without leaving a stain', says Bharat Bhushan, The Ohio State University.

This has been tested with water, and other common household liquids, such as coffee, tea and honey, which otherwise leave stains. The modified cloth has antibacterial properties as well. Bacterial growth is slow on the surface.

'The cloth can now withstand harsh heat and washing better than normal cotton, making it more durable', adds Aditya Kumar, IIT Dhanbad.

The liquid repellent cotton cloth holds promise for the textile industry. So do not be surprised, if, in the near future, cotton clothes come with antibacterial and self-cleaning properties. However, any reaction to the skin and side effect of long-term contact of hexadecyltrimethoxysilane with the human body are yet to be tested.

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