

Science Last Fortnight

Impact of Aerosols

It's big and getting bigger

The climate models of the past disregarded a few important factors in their analysis. As we now know, human emissions of aerosols too, affect the climate on a global scale. The previous models took only greenhouse gases besides natural factors, such as solar activity and volcanic eruptions, into account. To draw a more accurate picture, Tiwari and his team at the Indian Institute of Meteorology, Pune, examined the influence of aerosols over the regional climate of the Brahmaputra Valley.

Aerosols are fine particles spread in the atmosphere, emitted as dust, soot and ashes. They scatter sunlight; reflect the energy back and thus induce a global cooling effect on the climate. While some may argue that it is a good effect, it turns out they also add up to the warming effect since they indirectly affect the clouds also. They modify the size of the cloud thereby reducing the reflectivity (albedo) which changes the Earth's energy budget.

To understand the impact of aerosols such as black carbon, Tiwari and his team looked at Guwahati. They measured the aerosol concentration and temperature of the city for a span of one year. And they found that there is a significant cooling due to these soot particles. They also point out that the concentration of black carbon and carbon monoxide varies from season to season due to the burning of fuel. Biomass burning increases it and rainfall clears the air.

So much for regional climate. However, more is at stake. The team points out that their study can also be linked with other major global climate drivers. Aerosols perturb the hydrological cycle significantly. Black carbon can potentially alter the Indian summer monsoon. It triggers a chain of responses over the regional climate. The absorption and reflection of solar radiation by the aerosols induce cooling of sea-surface temperatures over the

Bay of Bengal, and the Arabian Sea because of the decreased solar radiation at the sea surface.

Aerosols bring changes in varied ways. They heat some places, cool others, altering precipitation patterns in unpredictable and sometimes dangerous ways. Developing nations in the tropics and Asia are the major source regions for black carbon aerosols. The governments are keen to have a check on the situation because they are deeply rooted in our global industrial infrastructure.

Sci. Total Environ., **562**, 504–516

Urban Pollution

Threat of polychlorinated biphenyls

Polychlorinated biphenyls – chlorinated hydrocarbons with two or more phenyl groups – are used in numerous industrial applications. They are quite stable and do not break down easily. Once they are released into the environment, they persist as pollutants in air, water and soil. And they slowly accumulate in the food chain. This has been a matter of environmental and health concern, especially in urban areas. Regions along the coast, particularly, the metropolitan cities, have higher atmospheric levels of these biphenyls.

A team comprising researchers from the SRM University, India, the Chinese Academy of Sciences, the Norwegian Institute for Air Research, the University of Oslo and the Lancaster University, UK, investigated the occurrence of biphenyls in surface soil and the diffusive exchange of these chemicals between air and soil. They quantified about thirty combinations of the biphenyls in surface soil in seven metropolitan cities of India, on a regional as well as local scale.

They find that polychlorinated biphenyls with high molecular weight are abundant in the urban cities. Soil seems to act as a sink for the heavier molecules. However, low molecular weight compounds get volatilized easily and act as a source of air pollution. These atmospheric phenyls eventually

make their way into less polluted areas.

The Government of India plans to prohibit these compounds by 2025. However, the present findings call for innovative research on containing the levels of these biphenyls in urban environments on a more urgent basis.

Sci. Total Environ., **562**, 928–934

Recharging Groundwater

Exploitation of the groundwater resources increased in the late 20th century, bringing the attention of scientists to the need for recharging of groundwater in depleted aquifers. But implementation and the effects of the present mitigation efforts take time.

S. Roy and A. S. Sahu at the University of Kalyani, West Bengal, studied a small watershed, Kunur River Basin, to understand the potential for recharge, using a multi-disciplinary approach: identification and assessment of hydrogeological factors, their influence on controlling groundwater occurrence and movement. Geomorphology, basin morphometry, remote sensing studies along with geological, geophysical and field data were also used to understand the basin hydrogeological framework. Based on these data, they propose a model to derive the groundwater recharge potential index of the basin.

They attempted a sub-basin wise and a grid wise approach to explore the recharge potential of the Kunur River Basin and found that a grid wise approach is more suitable: the results are correlated with the land-use pattern.

This multidisciplinary approach will help demarcate prospective recharge areas in a basin. Similar studies on other watersheds would help to adopt faster recharge methods to replenish groundwater resources in India.

Frontiers Earth Sci., **10**(2), 274–291

Removing Nitrate

Organic resin to purify water

There has been an increase in the use of chemical fertilizers to ensure food

security. But this has led to a problem: nitrate pollution. Most fertilizers contain nitrates which are converted to nitrites within the body. These nitrites can oxidize the ferrous iron in haemoglobin to its ferric form which diminishes its oxygen binding capacity. The health hazards of nitrate consumption are so drastic that nitrate pollution of drinking water has been recognized as a global issue by the World Health Organization.

Prabhakar and his colleagues from the Department of Chemical Engineering, SRM University, Tamil Nadu took inspiration from the commercial polymeric ion exchange resins which contain quaternary ammonium chloride functional groups, to solve the problem. They have synthesized an organic anion exchange resin to remove nitrate ions from brackish water. For the resin, the team selected chitosan – a biodegradable biopolymer bearing a primary amine in its structure. They first cross linked chitosan with glutaraldehyde up to a certain limit and then ethylated all the free amines to produce *N,N,N*-triethyl ammonium functionalized chitosan beads. These were then evaluated for nitrate removal from brackish water.

They tried different concentrations of ethyl bromide for synthesizing quaternized chitosan beads. The use of 5% ethyl bromide yielded the most capable variant. These beads swell up in 90 minutes and could remove about 60% of nitrate in the first 15 minutes. The presence of chloride and sulphate ions reduced nitrate ion removal only marginally. The resin could be regenerated by treatment with dilute HCl without affecting its ion exchange capacity, for up to 10 cycles. Given the promising results and minimum costs involved, the scientists are now optimizing this technique for field applications.

Carbohydrate Polymers, **147**, 525–532

Virus in Drinking Water

Fluorescent film for testing

Virus-contaminated drinking water is a major route for the transmission of epidemics. Nearly 25% of world population is exposed to sewage contaminated water and, thus, to water borne infections. Routine filtration and ster-

ilization methods may not remove the viral load completely from water.

Krupadam and his team of researchers from NEERI, Nagpur, have now designed an artificial molecular recognition sensor for the detection of virus. The first of its kind, the viral biosensor is rapid and cost-effective.

The researchers coated a gold electrochemical electrode with polythiophene, a film which, when activated via imprinting, binds the tobacco necrosis virus. The binding of the virus to the film generates signals capable of being detected by a voltameter. They tested the specificity of the sensor using the Tobacco Mosaic Virus and the Tobacco Necrosis Virus. Specific affinity of the sensor for the necrosis virus was confirmed using kinetic studies.

When a virus binds to the film, it gives off a fluorescent emission. The lowest detection limit is about 2 ng l^{-1} and the response time is about 12 seconds. Thus, the sensor has high sensitivity and stability in solutions.

The nanofilm fluorescence virus sensor may serve as an epic step towards translational research aiding in the prevention of epidemics.

Biosensors Bioelectronic, **82**, 20–25

Makings of a Mosquito Model

Aiding the fight against Aedes

The *Aedes aegypti* mosquito is the vector of the virus that causes dengue fever. The dissemination of *A. aegypti* is limited by spatial and climatic constraints. Mosquito survival is dependent on vegetation, human hosts, and breeding sites. These factors that allow for the breeding of *A. aegypti* are found to correlate with the outbreaks in Delhi. Overhead and ground level tanks, evaporation coolers and tires or pots have been reported as key containers harbouring *Aedes*. This allows for the description of the conducive environment for *A. aegypti*, using geographical information systems and remote sensing.

Somsakun Maneerat, New Delhi and Eric Daude from CNRS, France developed a predictive model for controlling dengue transmission, using GIS. They used this 'Model of Mosquito *Aedes*' or MOMA, to simulate the mosquito

populations in Delhi. In the model, the mosquito 'agent' interacts with artificial environments representing different localities stored in a Geographical Information System. The model was verified by entomologists to check whether activity planning is in line with available knowledge. MOMA simulation shows that *Aedes* are sedentary. Maximum dispersal observed is 21.35 m in all scenarios studied. The mosquito 'agent' adapts its behaviours to its needs and to the availability of its targets. The mosquito's longevity obtained from the MOMA model provided a daily survival rate very close to the survival rate found in literature.

The geospatial constraints captured in the MOMA model represent the distribution of *A. aegypti* in Delhi. There is a significant correlation between urban topology, human densities, and adult mosquito flight. The model can thus be used as a decision support tool for local health providers in Delhi. The same technique can also be applied to other geographical locations.

Ecol. Modeling, **333**, 66–78

Predicting Poverty

Overcoming lack of dependable data

The goal of eliminating poverty cannot be reached without dependable data on poverty. But in many cases – war torn countries, for example – such data is not easily available. So scientists found a way to get around the problem: measure wealth and consumption.

High resolution night time satellite data gives an indication of the use of electric lights. And day time data gives an indication of habitations. So it is not difficult to get an idea about the consumption of power, an indication of wealth. This data in conjunction with machine learning – training a convolutional neural network using the limited data available – can help in getting a fairly accurate measure of the level of poverty in countries where the data on poverty is either missing or unreliable, claim scientists. Based on these parameters, scientists have been able to predict poverty levels in five African countries.

Limited data can be overcome using machine learning techniques in other areas as well, where similar situations exist, say scientists.

Science, **353**(6301), 790–794

Alleviating Alzheimer's *Rational drug design*

Alzheimer's disease is a multifactorial neurodegenerative disorder, which usually develops in old age. The cause for Alzheimer's disease is still elusive. We know that the accumulation of amyloid plaques and neurofibrillary tangles in the brain leads to the death of neurons. Current therapy involves the inhibition of acetylcholinesterase, the enzyme that breaks down acetylcholine. This slows down the progression of memory loss and enhances cognition.

A team of researchers from three universities in Delhi have now synthesized new molecules to inhibit acetylcholinesterase, based on rational drug design approach. It is known that triazolopyrimidine interacts with the peripheral anionic site while quinoline interacts with the catalytic site of acetylcholinesterase. They connected triazolopyrimidine and quinoline with piperazine. Computational studies reveal that these molecules interact with acetylcholinesterase and have drug-like properties. The molecules selectively inhibit acetylcholinesterase over another similar enzyme, butyrylcholinesterase. Moreover, the molecule inhibits self-induced and acetylcholinesterase-induced amyloid aggregation. It provides a neuroprotective effect, relieves oxidative stress and disintegrates amyloid plaques. Thus, the molecule shows promise as a multi-functional acetylcholinesterase inhibitor for the treatment of Alzheimer's disease. Further testing and trials are, of course, needed before using the molecules in clinical practice.

Eur. J. Med. Chem., **119**, 260–277

Morphing Morphine Activity *Discovery by docking studies*

Morphine, derived from opium has been used for pain relief for many decades now. But it has a severe limita-

tion: it suppresses respiration and can even cause death in some cases. Aashish Manglik and others have come up with candidate molecules for effective analgesia without the concomitant side effects.

Scientists used computational docking studies to home in on the candidate molecules. The μ -opioid receptor G-protein signalling is responsible for the analgesia caused by morphine whereas the β -arrestin pathway is possibly responsible for the fatal respiratory arrest. Scientists tried out about three million molecules to find molecules that can selectively cause only analgesia – a feat that would have been impossible if not for computational studies. The study has been published in last week's *Nature*.

DOI: 10.1038/nature19112

Aging, Mutations and Cancer *Correlations become stronger*

As we age, somatic mutations continue to accumulate. There is enough evidence now that shows that these mutations – especially in the mitochondria – and aging are correlated. The mutation load tends to double every 8 years or so.

The accumulation of mutations increases with the cell proliferation rates of tissues. Cells of some tissues are more prone to mutations than others. Thus, for example, the reproductive system tends to have more mutations.

Scientists examined the mutation accumulation in cancer and find that, though the age related increase in mutations leads to the development of cancer by about a decade, which implies that the precancerous stage may perhaps be detected earlier than previously thought.

Interestingly there is a close parallel between the development of cancer and aging. Males tend to accumulate mutations earlier than females. This is reflected in cancer development. Moreover, in both sexes, the mutations tend to taper off at late life, which again, is seen to be the case with cancer.

Nature Commun., **7**, 12157

Baby, It's Hot Outside *Songbirds tell their eggs*

Just before going out into the cold outside, we may ask our children to put on a jacket. But that would be too much to ask of songbirds. But they too are concerned about the young ones. Happily, there are some developmental modifications that help the new hatchlings withstand the weather outside. And it appears that the Zebra finches acoustically signal high ambient temperature before the eggs hatch.

In a recent report in *Science*, scientists provide evidence to show that these cues alone can change the way the nestlings beg for food and thus impact their growth pattern.

Science, **353**(63010), 812–814

New Source of Chitosan *Muga silkworms are cost effective*

Muga silk is famous being a stain resistant and fast-coloured fabric. The silkmoth, *Antheraea assamensis*, is commonly found in Assam, India. In the process of sericulture, the cocoons are reeled off for silk thread and the dead pupae inside are treated as waste. A. K. Pal and his team from IIT, Guwahati, now suggest that dead Muga silkworms are a new source of raw material for the synthesis of chitosan. Chitosan is formed by direct deacetylation reaction in chitin, the exoskeleton of the pupae.

The scientists used various methods to calculate the degree of deacetylation for the formation of chitosan. They recommend proton nuclear magnetic resonance as the most reliable method while potentiometric titration is the easiest and most cost effective technique.

The chitosan, obtained through these methods, had high crystallinity index. Since chitosan has higher thermal stability, scientists prepared poly lactic acid-chitosan biocomposite films. This revealed that the composite has higher thermal stability.

The scientists could obtain about seven per cent chitosan from silkworms on dry weight basis. Thus, this waste material can be used for the extraction

of chitosan which has diverse applications in the field of pharmaceuticals, cosmetics and food. An important value addition to the silk industry in Assam.

J. Appl. Polym. Sci., **133**(31), 9–14

Meat Meets Ultrasound *Sound ways for juicier food*

Ultrasound treatment can change the colour, texture and even the gelation properties of chicken meat. Thus it has emerged as a novel approach to alter the biophysical properties of meat, which can find use in the food industry. Even though the macroscopic effects of low frequency ultrasonication have been explored on chicken meat, there seems to be a lacuna in our understanding of how ultrasonication affects the major myofibrillar proteins: actin and myosin.

Ahmad and his student from the Department of Zoology, Aligarh Muslim University, isolated and purified the actomyosin complex for chicken breasts and sonicated it at 20 kHz. When treated for 5 minutes, no discernible changes were detected in the protein structure. However, upon increasing the duration of treatment there was significant loss in the UV absorption spectra and alpha helical content of the protein.

Parallel changes were also expressed in the enzyme activity and chemical nature of the protein. ATPase activities

that correspond to structural integrity were reduced and there was a concomitant increase in the amount of reactive sulfhydryls. When the scientists looked at actomyosin gels under an electron microscope, they found that the ultrasound treatment before gelation can improve the 3-dimensional network of these gels. This increases its water holding capacity.

The scientists are of the opinion that treatment may expose charged residues to the surface which, along with increased availability of sulfhydryl groups, may contribute to a more ordered arrangement. The scientists are confident that the insights gained from this study can be utilized for modifying the properties of muscle protein to improve the attributes of food products.

Food Chem., **205**, 43–51

Imaging Fluorescent Zinc *Sensors for zinc detection*

Zinc is one of the most abundant micronutrients and is intricately involved in cellular functions. Therefore, it requires regular monitoring. However, zinc is spectroscopically silent. This has prompted several scientists to construct selective zinc sensors. Recently, Roy and his research team from the Jadavpur University, collaborated with researchers in Italy to develop one such turn on fluorescence sensor.

The scientists synthesized a small Schiff base molecule, through a con-

densation reaction between 4-(2-aminoethyl) morpholine and vanillin in methanol. They found that there is considerable difference in both the UV absorption spectra and fluorescence emission spectra of the Schiff base in the presence and absence of zinc.

The scientists tested the zinc selectivity of the compound in the presence of about 15 other commonly found metals like sodium, potassium, magnesium, copper, cadmium and nickel. They found that, although a few metals can quench the fluorescence emission intensity, zinc and cadmium give a characteristic green fluorescent colour when irradiated with UV light. This can be used as a distinguishing feature for zinc detection using the test Schiff base molecule.

Given its non-toxic nature and excellent results at physiological pH, the compound can be used for bio-imaging. Currently, scientists are further studying the molecule to understand how various functional groups can affect its spectral properties. It can then be employed for routine biological imaging.

J. Mol. Struct., **1118**, 325–334

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