Current Science Reports

Ammonia in Atmosphere

Fertilizers and biomass burning

Biomass burning and the unscientific use of chemical fertilizers release ammonia. This ammonia is converted to ammonium sulphates and nitrates in the atmosphere. These suspended particles cause environmental and health problems. So there is a need to monitor ammonia in the atmosphere and to locate the sources for timely intervention. However, it is difficult to measure ammonia because of its high reactivity and solubility. Moreover, it sticks to measuring instruments.

But there is another method: remote sensing. Data from infrared interferometers onboard satellites can be processed to estimate ammonia in the atmosphere.

Recently, researchers from IIT Kharagpur and the Indian Institute of Tropical Meteorology, Pune collaborated with scientists in France and Belgium to use daily data from the Metop A meteorological satellite for the purpose.

In the data for 2008–2016, they found that crop lands and highly cultivated regions, such as the Indo Gangetic Plains, have much higher concentrations than the ice-clad and barren regions of Kashmir and Arunachal Pradesh.

Ammonia concentration has seasonal variations – high in the monsoon and lowest in winter. It also seems to be influenced by cultivation practices. The northwest region, for example, shows a low ammonia concentration. This could be due to the cultivation of groundnut in sandy soils during the monsoon, say the scientists.

Kharif crops, mostly cereals, require frequent application of nitrogen fertilisers such as urea, until the flowering stage. This leads to high ammonia concentration.

The researchers analysed particulate matter and climatic data such as temperature and gridded rainfall to assess the impact of ammonia emissions.

They observed high particulate matter of ten micrometres in the winter *rabi* crops season. This could be due to the conversion of ammonia to particles in low temperature and favourable soil moisture conditions during the winter from October to February, say the scientists.

The team analysed total fertiliser consumption data and found high consumption of nitrogen fertilisers during the monsoon period, June to September, for *kharif* crops. Fertiliser consumption correlated with ammonia concentration. The highest annual ammonia concentration was observed in 2010 – the year with the highest fertiliser consumption and higher mean temperature.

The researchers also collected fire count information from radiance measurements of the Terra and Aqua satellites to study the relationship between biomass burning and ammonia emissions. They found a double peak of fire counts – in May and in October. These fire events are associated with *kharif* and *rabi* harvesting and lead to higher ammonia concentration over the Indo Gangetic Plains.

In the intensely agricultural areas of Punjab and Haryana, fire events are very high in October.

'This could be due to the burning of the *kharif* crop stubble in the small time window available before sowing *rabi* crops,' says Jayanarayanan Kuttipurath, IIT Kharagpur.

The researchers suggest regulating fertiliser use and biomass burning to reduce ammonia concentration and to improve air quality. Soil testing, using biofertilisers instead of chemical fertilisers and crop rotation practices can improve soil fertility and crop yield, while reducing the release of ammonia from the cultivated lands of India.

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Papaya Drying Techniques

Enhancing shelf life

Papayas are loaded with many benefits. However, short shelf life makes preservation hard. Farmers suffer huge losses due to spoilage. To enhance papaya shelf life, conventional drying could be used to remove moisture, reducing the vulnerability of the papaya slices to microbes. This is cheap and easy. But it is also time consuming and energy inefficient.

Recently, researchers from the National Institute of Food Technology, Entrepreneurship and Management, Sonepath evaluated different drying techniques and pre-treatments on papayas to find out which most efficiently retained taste and nutrition.

To freshly peeled and sliced papaya, they applied different drying combinations, including two pre-treatments followed by two drying techniques and two direct drying methods.

Pre-treatment with traditional osmotic dehydration is simple: dip the samples in highly concentrated sucrose. This could be combined with ultrasound. Ultrasound breaks up the cellular structure and releases trapped water. Osmosis pulls water towards a higher concentration of solutes.

These pre-treatments could be followed by convective air drying or vacuum drying. Convective drying uses hot and dry air to remove moisture. Vacuum allows boiling to remove all moisture at lower temperatures, and thus, retains heat-sensitive nutrients.

Image: via Wikimedia Commons

Using convective air drying and vacuum drying without pre-treatment on some papaya samples helped the team evaluate the impact of pre-treatments.

Initially, the moisture content of the slices was 95%. It reduced to nearly 8% in vacuum drying. The moisture content did not vary significantly and the highest among all drying techniques was only 12%.

But which type of drying best retains the nutritional quality? The researchers estimated the phenolic content of the dried samples. They prepared methanolic extracts from the dried samples and found that the highest total phenolic content was in samples with ultrasound assisted pre-treatments. The team determined the radical scavenging activity of the extracts and found that ultrasound pre-treated samples showed the highest radical scavenging activity, followed by samples pre-treated with simple osmotic dehydration.

Estimating colour characteristics, they found that the dried papayas were darker than fresh ones. This may be due to the oxidative browning of the surface, say the scientists. Osmotic dehydration followed by convective air drying showed minimal colour change.

As hardness affects the consumption of dried papaya, the team applied a range of forces to samples and observed shape deformation. Samples without pre-treatment were harder than pre-treated samples. Convective air drying led to the hardest dry papaya. Interestingly, drying by air or vacuum, after any pre-treatment, helped the dried sample remain soft.

Thus, considering all methods of drying papaya for preservation, farmers can lower losses by using simple osmotic dehydration followed by air drying.

For industrial settings, using ultrasound-assisted osmotic dehydration pre-treatment followed by vacuum drying would be convenient to obtain acceptable papaya products.

Dried papaya can be consumed as crispy papaya chunks or used in salads. It can be ground and the powder can flavour dishes. Dried papaya has many applications in cosmetics as scrubs, face wash, face packs and more.

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Soil Texture Analysis

Using smartphone images

Soil texture determines practices adopted for sustainable soil management and aids precision agriculture. But lab-based analysis consumes time and is expensive. Most farmers cannot access labs. But most farmers have smartphones. Why not a mobile app for testing soil texture?

Somsubhra Chakraborty and team from IIT Kharagpur collaborated with researchers from Canada and the USA to face the challenge. They collected 90 soil samples from three ecologically different regions in West Bengal: coastal saline, alluvial and laterite zones. They dried and sieved the samples with a 2 millimetre sieve. Clay and sand in the samples showed high variability and clay showed low variability.

The researchers put the soil samples in a dark chamber made of cardboard. Using a smartphone, they took three photos of each sample in high, medium and low light, to account for diverse light conditions in the field. The 270 images were divided into a training set of 180 and the rest were retained for testing.

The team then extracted features and descriptors of the images. Besides texture, they considered colour. Clustering the descriptors, they generated a visual dictionary using the Bag of Visual Words algorithm.

To test the ability to predict soil texture based on the extracted image features, the researchers chose two artificial intelligence algorithms – the convolutional neural network and the random forest.

The random forest model was executed with 500 decision trees. Each tree was built from the calibration set. Each node of the tree gave a random predictor. By trimming the trees that were less precise, the model slowly became more accurate.

To predict soil texture using the convolutional neural network, a total of eight convolutional layers were applied to the images followed by a dropout layer to avoid overfitting. This was then connected to a fully connected network. The output was a three-dimensional vector representing the clay, silt and sand contents.

After training the two models, their relative merits were compared using the testing set of samples. Prediction accuracy for clay and sand was as high as 96–98% for both models. In fact, for clay, the error in the model prediction was less than that found in the results from traditional lab analysis. However, prediction accuracy was moderate for silt: 62–75%. The researchers found that the deep learning of the convolutional neural network model led to better predictions than random forest and it had fewer errors.

Among all extracted features, colour showed the maximum influence on model performance. This, they say, can be attributed to the high resolution of the smartphone camera.

Now the problem that remained was an android application. The researchers developed one, the Soil Analyser, using the pre-trained convolutional neural network model. They input soil images and the app returned clay, silt and sand values via SMS.

The setup and application are definitely cheap and consume less time and effort than conventional testing. However, the model can be improved by adding a wider range of soil samples. The impact of soil moisture and organic matter content on texture has also not been considered in the model. So, interested researchers can now take up the task of improving the system.

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Nanoparticle Health Risk

Method to measure

The unique properties of nanomaterials, while useful, can pose risks to the ecosystem and humans. Since the field of nanomaterials is relatively new, we do not know much about what happens when they enter nature.

So Tanushree Parsai and Arun Kumar from IIT Delhi decided to develop a framework to assess the potential health hazards of nanoparticles. Nanoparticles can interact with everything from bacteria to mammals. There are multiple routes via which they

reach humans. Tanushree chose to focus on the concentration of nanoparticles in water and fish consumed by humans.

The duo investigated zinc, copper and titanium oxides in water bodies and the exposure of fish to these metal oxide nanoparticles. They considered bioaccumulation and bioconcentration. These two parameters in aquatic toxicology estimate foreign particles ingested directly and through the food chain.

The researchers applied a four-step risk analysis: identify the hazard, assess exposure, examine dose response and estimate risks.

Nanoparticles are released into aquatic systems from electronics, medical, pharmaceutical and personal care products. The particles may be consumed directly by humans during recreational activities in water or when people eat fish that have consumed the nanoparticles. Nanoparticles accumulated by plankton or smaller fish can be ingested by fish that we eat, increasing the bioconcentration. To assess the exposure, the researchers developed equations for each of these routes.

The next step was to identify the allowable dose for the three metal oxide nanoparticles. The researchers took the reference dose values provided by the FAO and the US Environmental Protection Agency. They point out that the reference dose values are presently based on the ionic content of the metal oxides in water and not on their nanoparticle concentration.

To estimate risks due to a mixture of nanoparticles in water plus nanoparticles in the fish consumed, the researchers created a hazard index. An index is an appropriate choice where there are a large number of factors involved. For example, nanoparticles of different sizes have different rates of bioaccumulation.

Now the problem was to estimate the loading of nanoparticles in the human digestive system. When contaminated water is consumed, copper oxide nanoparticles smaller than 100 nanometres are deposited in the digestive system. But in the case of zinc and titanium oxides, nanoparticles greater than 100 nanometres are deposited.

Fish grown in contaminated water accumulate more nanoparticles in the liver and gills. Eating only fish muscle is less hazardous since muscle tissue does not accumulate zinc oxide nanoparticles.

Eating whole fish poses more risk from zinc oxide than from other nanoparticles. The risk increases if the fish consumed has eaten prey that has accumulated the nanoparticles.

From all these considerations, the team calculated the ingestion risk for combined exposure. Interestingly, titanium oxide posed the least threat.

'As per the experimental evidence available, there is no risk if fish from water containing less than one-tenth of a milligram of the nanoparticles per litre is consumed,' says Tanushree Parsai, IIT Delhi.

'What we have done is to create a theoretical framework to understand the risks due to nanoparticle-contaminated water and from fish growing in contaminated water. We hope that the framework leads to the generation of more reliable experimental data and estimates of nanoparticles in aquatic environments,' says Arun Kumar, her mentor.

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Antiviral Compounds for COVID

In silico exploration

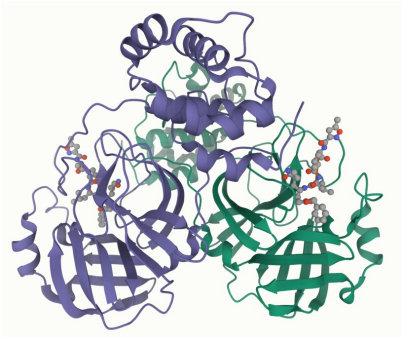

Image: Worldwide Protein Databank

The main protease of the coronavirus plays an important role in viral gene expression and replication. It is responsible for breaking the extremely long chain of amino acids into the functional and structural proteins of the virion. So, the SARS-CoV-2 main protease is considered as an important target for drug design.

Recently, scientists from the Jamia Millia Islamia University and King Saud University, Saudi Arabia mounted a search for high affinity inhibitors of the SARS-CoV-2 main protease.

Using computational tools such as MG tools, Auto Dock Vina and Discovery Studio Visualizer to guide rational drug design based on structure, they found 121 unique ligands that co-crystallise with the main protease of the virus.

Using the molecular docking approach the scientists then redocked the 121 functional groups to find high affinity binding partners of SARS-CoV-2's main protease. And they selected the top ten high-affinity binding partners.

The team then searched PubChem – a database of chemical molecules and their activities against biological assays – for compounds with above 90 per cent structural similarities with the selected top ten high affinity-binding partners. They found 10,433 such compounds.

Then they applied sorting criteria – the properties that are expected of pharmaceutical chemicals such as absorption, distribution, metabolism, excretion, toxicity and other drug-like properties. This reduced the number of compounds to 4802.

Applying a virtual screening approach based on their affinities with SARS-CoV-2 main protease, the scientists homed in on the top five high affinity compounds.

To identify specific interactions of the five molecules, the scientists used the PASS server prediction. The scientists say that the five compounds have similar classes of biological activities. However, based on protease inhibitory potential, they identified two compounds with antiviral activity: 6-Deaminosinefungin and UNII-O9H5KY11SV.

After simulation studies, the scientists confirmed that the two compounds are suitable for antiviral treatment for COVID-19.

However, the compounds were identified by *in silico* experiments. Now they need to be tested *in vitro* and *in vivo* before clinical trials.

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Corporate Social Reporting

Shareholder perception

India was the first country to legally mandate corporations making profits beyond a certain amount to spend a percentage of their profits on socially, environmentally or ecologically beneficial activities. The Corporate Social Report provides how fairly the surplus fund is used for the betterment of society. But what importance do the shareholders attribute to it?

Researchers from two colleges in Coimbatore collaborated with a researcher in Saudi Arabia to investigate. They created a structured questionnaire. With the help of stock broking firms, they administered it to 500 investors. Valid inputs were received from 300.

The questionnaire listed 26 activities usually carried out by companies under the Corporate Social Report. The activity items were grouped under four broad categories: environment, community involvement, products and employee details. The level of importance shareholders attribute to these 26 items was rated on a 3-point scale.

The researchers found that investors gave greater importance to environmental action support, education and arts, quality control in products, and employee health and safety than to the other items.

But there was quite a lot of variation between the perceptions of shareholders on the activities under the Corporate Social Report. So the researchers were confronted with the question: what variables influence the perception of shareholders on corporate social reporting?

The team developed a perception index to examine associated variables. The perception index included twenty-seven items, including gender, occupation, education, etc. of the respondents. The 26 activities in the first part of the questionnaire were regressed over the perception index to find the influence of characteristics of stakeholders on their perception about the different Corporate Social Report activities. The level of importance given to the Corporate Social Report as a whole, the motivation for capital gains from the investments and retired from occupation were the most prominent variables that influence the shareholders' perceptions on corporate social reporting. Educational level and opinion about NGOs were other important factors that influenced perceptions.

The research thus provides pointers to companies when they draft the social responsibility reports.

The Government of India presently only monitors whether companies abide by the law in executing the provisions of the Companies Act. It would do better to make companies document and report the activities and to create a system for auditing the reports, say the researchers.

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Improving Mathematical Ability

By learning Carnatic music

The impact of western music training on learning maths in children is well established. The same cannot be said about Carnatic music. Carnatic music is composed with mathematical principles. Hence, practicing Carnatic music should also subconsciously improve the understanding of mathematics.

Two experienced musicians, Vidya Raja from the Sangyan Music Academy, Bengaluru and Deepti Omcherry Bhalla from the Delhi University explored the possibility.

They chose children from 1st to 3rd standard, aged five and a half to eight and a half from a government-aided school in Delhi. Using a questionnaire to be completed by parents, they selected about 150 children who did not have any documented learning disabilities or training in music. The duo tested the mathematical abilities of the children first, using standard protocols.

They divided the children into two groups. The children in the experimental group were trained in Carnatic vocal beginner lessons: singing the scale or *swaras* of Mayamalavagowla raga and simple songs in the raga set to the eight beat *adi tala* to the accompaniment of the drone of a tanpura. The children were taught to keep rhythm using finger and hand gestures while singing. They were also encouraged to express the meanings of the songs.

After five months of music lessons, four times a week for 5 months, all the students underwent the test for early mathematics ability again. Children who underwent Carnatic music training scored better than those without training. Interestingly, the impact of learning classical music on mathematical ability was more pronounced in younger children.

Image: Pratham via Wikimedia Commons

'The earlier a child is trained in Carnatic music, the better the ability in mathematics,' says Vidya Raja, Sangyan Music Academy, Bengaluru.

'Parents and teachers should implement music training early to help improve academic performance in children,' says Deepti Omcherry Bhalla, Delhi University.

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