Ozone and food security

Carbon emission hurts the whole world but high ozone at ground level hurts us directly

S ANANTHANARAYANAN

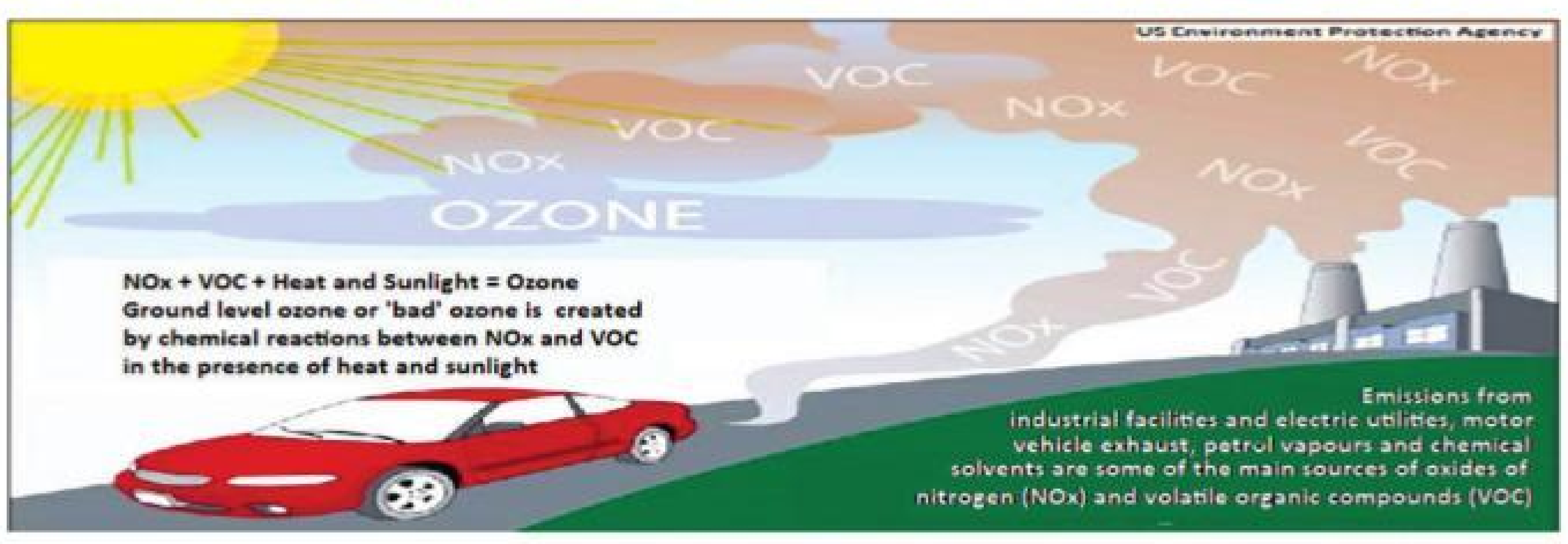
India has the distinction of being the third largest emitter of carbon dioxide in the world. That India has the second largest population may mitigate the shame, but not the price India would pay for carbon dioxide-linked global warming. And still, some may find consolation because the evils would be shared by all countries of the world.

There is, however, another distinction where India pays a heavy price, and the cost is borne by India alone. This is in the emissions that result in high ozone levels, which cause respiratory disease and serious diminution of forest and agricultural produce. And global warming is expected to worsen the effect.

On the harm that ozone does, the journal, *Nature Food* carries a report by Zhaozhong Feng, Yansen Xu, Kazuhiko Kobayashi, Lulu Dai, Tianyi Zhang, Evgenios Agathokleous, Vicent Calatayud, Elena Paoletti, Arideep Mukherjee, Madhoolika Agrawal, Rokjin J Park, Yujin J Oak?and Xu Yue, from Nanjing University of Information Science & Technology, Nanjing, China, Ministry of Agriculture and Rural Affairs, and the Chinese Academy of Sciences, Beijing, the University of Tokyo, Seoul National University, National Research Council, Sesto Fiorentino, Italy, and Banaras Hindu University. The report collects data in a manner that has not been done so far and finds the reduction of yields of wheat, rice and maize crops due to high ozone levels can be as high as 33 per cent, 23 per cent and nine per cent.

Ozone is a form of oxygen, but a more reactive form. While oxygen consists of molecules that contain two atoms, the ozone molecule has three atoms of oxygen. And ozone is formed when oxygen molecules split into a pair of independent oxygen atoms. The oxygen atoms thus set free can now combine with oxygen molecules to form ozone, like this -- $O_2 + O = O_3$.

Ozone, however, is unstable and readily gives up its extra oxygen atom, which makes it more reactive. While being reactive has its uses, the downside is that even traces of ozone cause damage to plant tissue, or mucous or respiratory tissues of animals and humans.



The bulk, 90 per cent of the ozone, fortunately, is found very high up in the atmosphere. As air is rarefied at high altitudes, the concentration of ozone is higher, at two to eight parts per million. And high-altitude ozone performs a useful function of blocking harmful ultraviolet rays. Only the remaining, 10 per cent of ozone, is there in the lower, or ground level atmosphere, and, till recent times, this presence was just 10-15 parts per billion.

But, with the start of the industrial period, the paper says, the levels have been increasing worldwide, with those in East Asia rising as high as 60 parts per billion. There has been slowing, even a decrease in the United States and Europe in the last two decades, but the increase in Asia "has outweighed trends in other regions," the paper says.

While rising ozone levels is a health hazard, another consequence is that it can bring down crop production, thus becoming a threat to food security. The paper cites a published study which says that a level of 30-50 parts per billion (which was the average during 2010-12) leads to a fall in yield of 12.4 per cent, 7.1 per cent, 4.4 per cent and 6.1 per cent for soybean, wheat, rice and maize, respectively. And this adds up to 227 million tonnes in a year.

High losses in the Asia region are disconcerting, as the paper notes that "Asia produces large portions of the world's cereals -- on average, 90 per cent of rice, 32 per cent of maize and 44 per cent of wheat came from the region between 2014 and 2018." Methods to estimate ozone-related crop losses in Asia, however, have not been suited to the crops and conditions, the paper says. The authors have hence carried out specifically designed studies, covering Japan, South Korea and China, along with some parts of India.

The source of ground level ozone is not direct emission of ozone into the atmosphere. Ozone arises by reaction of other emissions, oxides of nitrogen, and different volatile organic compounds, or VOCs. The main sources of the former, known as NOx, are burning of nitrogen compounds in motor fuel and the combination of oxygen and nitrogen in the air, at high temperature, as in internal combustion engines and coal-based power plants. The use of fertilisers in agriculture is another major source. The main sources of the second factor, the human-made VOCs, are industrial chemicals, paints and solvents, even handling petroleum-based fuels, and combustion of fossil fuel, biofuel and biomass.

We can see that the rise in population and industrial activity, increased travel and means of transport are causes of rise in ground level ozone levels. The authors of the paper used ground-based ozone measurements at over 3,000 monitoring sites, in conjunction with existing and current experimental data of crop yields, to assess the crop losses that can be pinned on ozone levels. And there was another assessment that could be regarded as a "control" with the application of a compound called ethylenediurea, or EDU, which is an "anti-ozonant". It counteracts the effect of ozone and enhances the yield of plants and crops that are limited by ozone.

The results of the trials were a measure called "relative yield", or the ratio of the yield of farming under a level of ozone exposure to the yield at a base level of exposure. And from this result, we can work out the "relative yield loss". At a base level of 40 parts per billion, it was found that wheat is the most sensitive, with a loss of 38 per cent; with rice the loss was 19 per cent, maize lost 10 per cent, and hybrid, high-yielding rice was hit by 42 per cent. These rates of loss were confirmed by corresponding rise of production when the ozone-suppressing EDU was applied. And these yield losses of rice and wheat, as found in experiments in Asia, are significantly greater than those derived from experiments in North America and Europe, the paper says.

While Japan, South Korea and China are large producers of food grain, India is a large producer too. Although the paper does not examine the case of India, there are Indian studies which document high ground level ozone presence. It means Indian crops are also suffering yield losses at the scale as reported in the paper.

A factor that makes things worse is that ozone production rises with temperature. The reaction of NOX with VOCs, which give rise to ozone, is faster in the daytime and during the summer months. The rise of temperature in a warming world would hence heavily dent the crop yield in regions with high ground level ozone. As India is one such, she urgently needs to contain the ozone levels that she faces.

One urgent measure would be to promote the use of public transport. The wisdom of moving to the electric vehicle is still not clear, as our electricity generation depends heavily on coal, and our coal is low-grade. With the danger presented by ozone, and rising demand for food, India needs to rethink priorities.

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STRIVING FOR A BALANCE

Scientists must make sure that their work is translated into good policy to serve public

BIJU DHARMAPALAN

In every field of life, one comes across different missions and policies implemented by governments of the time. All such policy decisions are put in place after extensive discussions with various stakeholders, including scientists, bureaucrats, academicians and political leaders.

Science generates knowledge and understanding by attempting to eliminate potential sources of bias, often through controlled experiments. This pursuit of objectivity increases the credibility of scientific advances and expands society's willingness to take up the new knowledge and understanding that science provides.

Societal choices, however, necessarily involve two facets. First is objective information. For example, one needs to consider what the potential response options are; what benefits and risks may be associated with those options, and how the same may be distributed among different groups or individuals. The second is subjective value judgments. They entail considering the most desirable outcomes, how one balances competing interests, or what one "should" do.

This means that people can agree on a common set of facts related to a societal challenge but disagree on the appropriate policy responses. Scientists produce evidence, which policymakers use for their decisions. In return, policymakers provide scientists with evidence requirements and resources for research.

The discoveries and innovations that our researchers come out with would remain within the four walls of a laboratory until and unless they are translated to societal application. In this regard, researchers could take proactive measures to increase the policy impact of their work. They should establish strong relationships with elected officials or government staff members and learn to provide clear and concise summaries of existing scientific evidence to help policymakers understand the options. Scientists and policymakers can also collaborate on projects aimed at real-world questions.

Science policy refers to the act of applying scientific knowledge and consensus to the development of public policies. It is about the impact that science has on society and those that work in science policy are liaisons between policymakers and scientists. The science policy establishment is dominated by bureaucrats and politicians who, for the most part, have never done science and consequently, have little idea what day-to-day science is like. As a result, they have a limited ability to understand the science behind their policy decisions.

Therefore, science policy experts must have an understanding of science, politics and economics, and larger work involving a combination of science writing, communication and advocacy. They should be able to communicate clearly through accessible language and, if possible, tell a compelling story about science. Most of all, scientists should understand that policymakers rarely want to hear about the results of a researcher's latest peer-reviewed study. The former should start discussing and collaborating with policymakers during the research design stage itself.

On the other hand, policy actions should inspire trust across the science community, policymakers and the public. Although trust in politics and trust in science are often aligned, there are also a significant number of citizens who have much more confidence in scientists than in politicians. Promoting trust among different advisors and users of scientific data is also a longer-term challenge. Politicians, for example, rely on policy experts to analyse and produce scientific reports, and interpret laws and bills.

Science policymakers, therefore, should bridge the gap between scientists and the public. They must use their knowledge and skills to find a way to translate highly technical scientific issues into something that can be easily understood as good policy. As experts in their respective fields, scientists have an obligation and an opportunity to help to inform science policy and shape what the future landscape of research looks like.

The success of science policy has been clear during our fight against the Covid-19 pandemic. This is particularly challenging in a situation where much of the evidence is uncertain and is evolving rapidly. Though science advisory processes are organised differently in different countries, they invariably engage a variety of institutions, committees, and individuals to assess and provide evidence to policymakers.

Science policy is also concerned with the allocation of resources for the conduct of science towards the goal of serving public interest. Topics include the funding of science, careers of scientists, and the translation of scientific discoveries into technological innovation to promote commercial product development, competitiveness, economic growth and economic development.

Science policy focuses on knowledge production and the role of knowledge networks, collaborations, and the complex distributions of expertise, equipment, and knowhow. Understanding the processes and organisational context of generating novel and innovative science and engineering ideas is a core concern of this field.

Science policy thus deals with the entire domain of issues that involve science. A large and complex web of factors influences the development of science and engineering that include government science policymakers, private firms (including both national and multinational firms), social movements, media, non-governmental organisations, universities, and other research institutions. In addition, science policy is increasingly becoming international as defined by the global operations of firms and research institutions as well as the collaborative networks of non-governmental organisations and the nature of scientific inquiry itself.

Perhaps the greatest challenge in science policy is creating a framework that strikes the balance between preserving public trust in research and promoting rapid and exciting scientific advances. Science policy is therefore rooted in several sources and ideally, is as dynamic as the science it underpins.

Scientists who contribute to policy are most effective when they have clear goals and a strategy for achieving them. Developing those goals and strategies starts with thinking carefully about the role of science in policy making. Every piece of research we do in our scientific institutions, whether one calls it basic or applied, has some use. A good policy researcher could identify the utility of their research and help its translation for the benefit of society.

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New institute

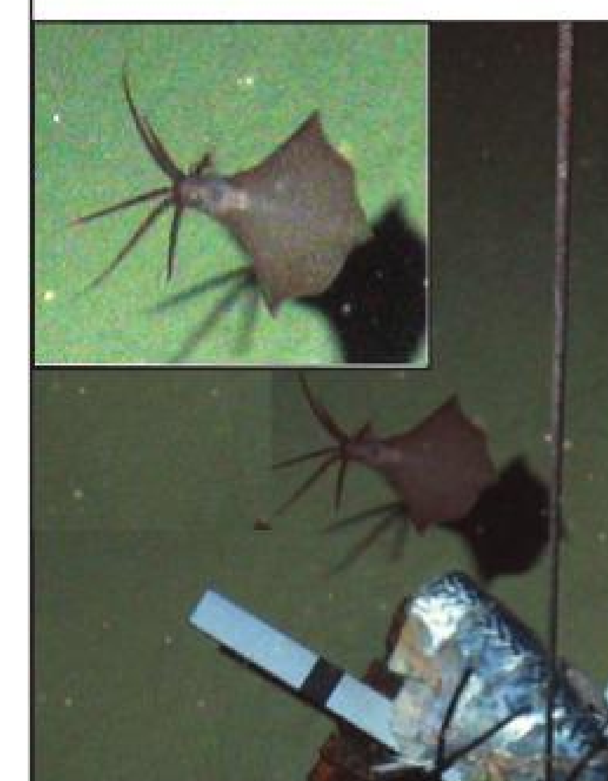
New institute

With the objective of developing a globally respected thinktank in science policy research, the Government of India started a new institute last year called the Council of Scientific and Industrial Research-National Institute of Science Communication and Policy Research, or CSIR-NIScPR, by merging two premier research organisations, the National Institute of Science Communication and Information Resources and National Institute of Science, Technology and Development Studies.

CSIR-NIScPR, headed by Ranjana Aggarwal, has made commendable contributions within a short span of time. It has brought out a compendium of CSIR technologies and shortlisted 313 of them as promising and market ready. It has prepared socio-economic impact assessments of various technologies developed by CSIR labs and mobilised those labs to deploy their technologies in rural areas by using the Unnat Bharat Abhiyan network.

PLUS POINTS

Deep dwellers



Researchers looking for the wrecked remains of a World War II destroyer ship have instead found the deepest-dwelling squid ever recorded swimming about six kilometres below sea level.

The bigfin squid, spotted swimming about 20,380 feet under the Philippine Sea just above the ocean floor, has become the deepest-swimming squid known to humans, beating the record of another squid discovered about 4.7 km below the Pacific Ocean.

Researchers also found four cirrate octopuses during the dive. This was the second time the octopuses, which have fins, were observed at such a deep level. The scientists, however, said the octopuses did not appear to be the same species as those found earlier in the Java Trench near Indonesia.

Their findings, described in the journal *Marine Biology* last month, suggested that some cephalopods -- a group that includes squids, octopuses and cuttlefish -- may live in the deep and dark ocean trenches. This new discovery has increased the depth range known for squids by over 1,400 metres -- an increase of about 30 per cent compared to previous findings.

In the study, researchers also raised questions about how the cirrates have physiologically adapted to living at depths ranging from one to six km, where the atmospheric pressure can be up to 600 times more than at sea surface level.

"These observations extend the known hadal occurrence of cirrates, and cephalopods in general, from the Indian Ocean to the equatorial North Pacific Ocean," the researchers wrote in the study. The hadal zone is the deepest region of the ocean, lying in oceanic trenches from a depth of about 6,000 to 11,000m.

The independent

Predicting disease

Scientists have developed a new Machine Learning model for the discovery of genetic risk factors for diseases such as motor neurone disease, or MND.

Designed by researchers from the University of Sheffield in the United Kingdom and the Stanford University School of Medicine in the United States, the Machine Learning tool, named RefMap, has already been utilised by the team to discover 690 risk genes for MND, many of which are new discoveries.

One of the genes highlighted as a new MND gene, called KANK1, has been shown by the team to produce neurotoxicity in human neurons very similar to that observed in the brains of patients. Although at an early stage, this is potentially a new target for the design of new drugs.

Johnathan Cooper-Knock, from the University of Sheffield's Neuroscience Institute, said, "This new tool will help us to understand and profile the genetic basis of MND. Using this model, we have already seen a dramatic increase in the number of risk genes for MND, from approximately 15 to 690.

"Each new risk gene discovered is a potential target for the development of new treatments for MND and could also pave the way for genetic testing for families to work out their risk of disease."

The 690 new genes identified by RefMap lead to a five-fold increase in discovered heritability, a measure which describes how much of the disease is due to a variation in genetic factors. "RefMap identifies risk genes by integrating genetic and epigenetic data. It is a generic tool and we are applying it to more diseases in the lab," Sai Zhang, PhD, instructor of genetics at the Stanford University School of Medicine said.

Michael Snyder, PhD, professor and chair of the department of genetics at the Stanford School of Medicine and also the corresponding author of this work said, "By doing Machine Learning for genome analysis, we are discovering more hidden genes for human complex diseases such as MND, which will eventually power personalised treatment and intervention."