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Climate Change

Making a difference through nuclear technologies

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You can't change what you can't measure: understanding greenhouse gas emissions in Costa Rica

By Michael Amdi Madsen

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>
> *— Ana Gabriela Pérez, researcher, University of Costa Rica*

In Costa Rica climate change is a real concern. Sea level rise, climatic variability, and climate-induced disease outbreaks are likely to affect the availability of drinking water and threaten local amphibians and marine life. The country is committed to reducing its greenhouse gas emissions, and is now taking steps to learn how much greenhouse gases the dairy and agricultural sectors emit in order to determine what actions it can take to reduce the impact of climate change.

"A lack of training, equipment and national laboratory mean that Cost Rica relies on international emission factors to estimate the emissions of greenhouse gases from agriculture," said Ana Gabriela Pérez, a researcher at the University of Costa Rica, who is working to develop a national reference laboratory for the measurement of greenhouse gases in the country.

"Costa Rica aims to become carbon neutral by 2021, but the international greenhouse gas emission factors aren't very accurate for us. The country needs more reliable data about its own emissions, and it needs to be able to gather those data itself," Pérez said. One way of obtaining greenhouse gas data from different land uses is to team up with the IAEA to develop Costa Rica's analytical and instrumental capabilities in regard to nuclear techniques.

Atomic answers

Nuclear techniques offer substantial advantages over conventional techniques for measuring climate change impact (see box). "Stable isotope analysers let us monitor agricultural processes as they happen. They allow us to quantify carbon capture and emission patterns of farming practices, enabling us to find ways to improve them," Pérez explained.

Key to counterbalancing the increase of CO_2 in agriculture is carbon sequestration. Carbon sequestration is a process of changing agricultural practices to minimize emissions and to help remove CO_2 from the atmosphere by replenishing the depleting CO_2 stores in degraded soil — boosting soil productivity and resilience to harsh climate conditions.

Quantifying CO_2 emissions from soil provides a unique insight into changes in carbon decomposition rates and the balance of microbial respiration — which in turn can be used to drive changes in agricultural practices influencing soil processes and the release of CO_2. The accuracy and robustness of near-infrared laser beam technology allows the technique to create precise quantification of soil and carbon processes in croplands.

Nitrous oxide (N_2O) is a greenhouse gas that has 298 times more global-warming potential per unit mass than CO_2, and is naturally produced in soils during the microbial

How do greenhouse gases cause global warming?

Greenhouse gases are gases that trap heat in the Earth's atmosphere. They absorb and emit infrared radiation, causing what is known as the greenhouse effect — a process in which thermal radiation from the Earth is absorbed and re-radiated back to the surface, increasing the Earth's temperature by about 33 degrees Celsius in comparison with a situation in which there were no such gases at all. While this process is necessary for the maintenance of a temperate climate on the planet, the growing accumulation of greenhouse gases is now leading to global warming.

The primary greenhouse gases found in our atmosphere are water vapour, CO_2, methane, N_2O and ozone.

Analysis of field samples with Gas chromatograph with headspace autosampler.
(Photo: Ana Gabriela Pérez, researcher, University of Costa Rica)

processes of nitrification, co-denitrification and denitrification. "We can use nuclear techniques to determine whether N_2O is produced from the nitrogen in fertilizers or from nitrogen in the soil," Pérez explained. It is known from ^{15}N measurements that of total N_2O emissions, 10 to 40 per cent can be attributed to fertilizers and 60 to 90 per cent originate from the soil, Pérez added.

Real change for climate change

These new data, specific to Costa Rica, will help to design policy change in the country. Greenhouse gas emissions, and in particular the effects of fertilizers, form the basis of cost–benefit calculations that can be used to determine the right amount and kind of fertilizer to be applied in order to move towards carbon neutrality in the dairy sector.

The project is helping to bring about change with the involvement of the private sector through lectures and field studies at the University of Costa Rica and through the joint Livestock Commission of the Programme of Research and Transference of Technology.

The project in Costa Rica is one of many ongoing coordinated research projects run by the IAEA in cooperation with the Food and Agriculture Organization of the United Nations (FAO) that focus on reaching a more accurate and complete understanding of greenhouse gas emissions around the world, said Mohammad Zaman, a soil scientist at the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture. Besides Costa Rica, the project also helps scientists from Brazil, Chile, China, Estonia, Ethiopia, Germany, Iran, Pakistan and Spain to enhance their ability to measure greenhouse gas emissions with greater precision as well as identify their exact source of production in soils, in order to apply mitigation measures, Zaman said.

THE SCIENCE

Using isotopes to study greenhouse gas production

Isotopes are chemical elements (like carbon or nitrogen) that have the same number of protons but a different number of neutrons. Though isotopes chemically react in the same way, their differing atomic weights make it possible to distinguish between them. By using isotopes as tracers, scientists can track how elements move through complex cycles and see how they're involved in the production of specific molecules like those in greenhouse gases.

In the case of N_2O, scientists can analyse isotopomers (molecules with the same number of isotopes of each element but in chemically different positions) in nitrification, denitrification and co-denitrification processes within soil to study how nitrogen-based molecules change in these processes and what individual factors influence the production of this potent greenhouse gas.