UKRI GCRF South Asian Nitrogen Hub

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Rediscovering Nitrogen!

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It is nearly 250 years since Daniel Rutherford discovered nitrogen in 1772 at the University of Edinburgh in Scotland. With the world now assembling in Glasgow for COP26, it is time to find nitrogen again. It is a chance to embrace action on nitrogen as one of the world's great environmental challenges and a key solution to climate change. The "" event heralds a "new enlightenment" on the importance of nitrogen interactions with carbon. Action on carbon must be at the heart of our commitment to Net Zero, but to get to Net Zero we also need to take action on nitrogen. This is why the Scottish Government has committed to a Scottish National Nitrogen Balance Sheet as part of the Scottish Climate Act. This is an opportunity for us to show the multiple benefits of better nitrogen management for climate, air, water, biodiversity, health and the economy. The International Nitrogen Management System (INMS) is itself based in Edinburgh, and we look forward to working with countries in COP26 and beyond as we grasp the climate challenge – with nitrogen as an integral part.

What is nitrogen?

Nitrogen gas (N_2) is everywhere and invisible! It makes up 78% of the atmosphere, but its strong triple bond makes it unreactive so that it has little impact on living processes. Biological nitrogen fixation and industrial production of synthetic nitrogen fertilizer convert unreactive nitrogen gas into reactive forms (N_r). Reactive nitrogen is essential for life; nitrogen is a key element in the nucleic acids, which build DNA and RNA. But reactive nitrogen is also responsible for nitrogen pollution, which has many different forms, impacting the air, water, soil and ecosystems.

The language of nitrogen

N_2	Unreactive di-nitrogen. 78% of the air we breathe.
N_r	Reactive nitrogen – all other forms, with many impacts.
NH_3	Ammonia, the primary form of reduced nitrogen. Used for fertilizers & emitted to the air.
NH_4^+	Ammonium ion, contributes to air & water pollution.
NO	Nitric oxide, the primary form of oxidized nitrogen, emitted to the air from burning & soils.
NO_2	Nitrogen dioxide, rapidly formed in air from NO.
NO_x	Mixture of NO and NO_2, affecting human health and indirectly impacting climate.
NO_3^-	Nitrate ion, contributed to air and water pollution.
N_2O	Nitrous oxide, a greenhouse gas. It also depletes the stratospheric ozone layer.
OrgN	Organic nitrogen, a plethora of forms with many impacts
PM	Particulate Matter, especially as air pollutant, adversely

How does nitrogen impact the environment?

Ammonia (NH_3) is the primary form of reduced nitrogen which is used to produce fertilisers and is emitted to the atmosphere by soils, plants, fertilisers and animal manures. Ammonia in the atmosphere can reduce air quality by forming fine particles of ammonium (NH_4^+) salts. Nitrogen oxides (NO_x), mainly formed through fossil fuel burning, further affect air quality and can have a detrimental impact on the human respiratory system.

Ammonium is highly soluble and so can also add to excess nitrogen in river and lake water, contributing to water pollution together with organic nitrogen forms. In the soil, it can be quickly converted by micro-organisms to nitrate (NO_3^-). Nitrate is highly mobile in the soil, and so is easily leached with the soil water, further contributing to water pollution. Under wet conditions, nitrate is also used by micro-organisms as a source of oxygen, producing nitrous oxide (N_2O), a powerful greenhouse gas.

Why is nitrogen important for climate action?

The greenhouse gas, nitrous oxide, has a global warming potential over a 100-year period around 265 to 298 times that of carbon dioxide. Therefore, small changes in nitrous oxide emissions can have a large impact on the climate. Poor fertiliser and manure management can greatly increase the climate impact of food production through increased nitrous oxide emissions and interactions with soil organic matter to increase carbon dioxide flux. But if we really want to reduce nitrous oxide emissions, then we need to transform the way humans manage the nitrogen cycle. This points to multiple win-wins between climate, air, water biodiversity and health. The Colombo Declaration ambition to 'halve nitrogen waste' from all sources, offers the opportunity to save US$100 billion annually to stimulate green economic recovery.

Why is nitrogen important now?

Nitrogen is essential for food production. In 2019, 820 million people worldwide were undernourished, equivalent to 11% of the world's population. It is now essential that we find better ways of increasing food production without increasing nitrogen pollution, bringing benefits to the climate, as well as to air quality, water quality, biodiversity and ecosystems. We need nitrogen to feed the world but, depending on how we use it, nitrogen could be either the cause or the solution to climate change!

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