Executive summary

Nitrogen is often the limiting nutrient for the growth of plants and crops on which animals and humans feed. The rapid growth in the use of fertilisers has been one factor contributing to increased crop yields. Around half the world's population depends on nitrogen fertilisers for their food consumption, making nitrogen essential to global food security, and it will be increasingly so as population grows to an estimated 9.7 billion by 2050.

Humans have doubled the annual flow of nitrogen following the discovery of the Haber-Bosch process a century ago, which allowed us to convert molecular nitrogen from the air into usable nitrogen for fertiliser (80%) and industrial uses (20%). The expansion of cropland devoted to nitrogen-fixing legumes and the large-scale burning of fossil fuels have also increased nitrogen fixation. The relative size of the modification of the nitrogen cycle by human activity is far greater in magnitude than the parallel modification of the carbon cycle.

Nitrogen moves among environmental media and takes on multiple forms, creating multiple risks to the environment. Atmospheric emissions of nitrogen oxides reduce air quality via the creation of ground-level ozone and, when combined with ammonia, via particulate matter, increasing human health risks such as respiratory illnesses and cancer. Nitrates in water bodies contribute to eutrophication in lakes and coastal areas, impacting on fisheries, and affecting drinking water quality. Nitrogen can also damage ecosystems through acidification of soils and seas.

Nitrogen is also intimately linked to climate change through its influence on rates of biological activity and the uptake of carbon dioxide by ecosystems, influencing the so-called carbon fertilisation effect. Additionally, nitrous oxide is an important greenhouse gas in its own right. In the stratosphere, nitrous oxide is also a powerful ozone depleting substance.

Each of these nitrogen forms contributes to a sequence of environmental and human health impacts. This has been referred to as the nitrogen 'cascade'. Uncertainties abound concerning such cascading effects. We do not fully understand the resilience of ecosystems to increased nitrogen loading. We are often unaware of the ecosystem services we may be losing by an insufficient focus on the wider consequences of the human acceleration of the nitrogen cycle.

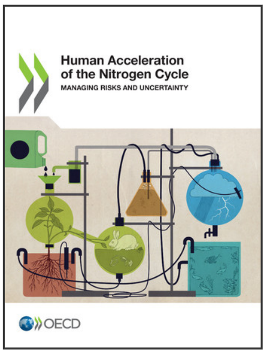
Such uncertainties, coupled with the need to manage the risks of nitrogen pollution and to monitor and control the steady increase in atmospheric nitrous oxide concentrations, calls for a three-pronged approach:

- First, there is a need to manage local pollution risks by better understanding the pathways of nitrogen between sources and impacts (the "spatially targeted risk approach")

- Second, account must be taken of the observed increase in global atmospheric concentrations of nitrous oxide that have consequences for both climate change and stratospheric ozone (the “global risk approach”)
- Third, there is a need to prevent “excessive” nitrogen entering the environment by developing strategies addressed to the different sources (on the basis of the most cost effective means) to reduce them (the “precautionary approach”).

Regardless of the approach (risk or precautionary), evaluation criteria are needed to select the right nitrogen policy instruments. First, it is necessary to assess and manage the unintended effects on nitrogen emissions of policies primarily aimed at economic objectives (agricultural production, energy supply) or environmental objectives other than nitrogen pollution (e.g. climate change). Secondly, nitrogen policy instruments can then be selected on the basis of their cost-effectiveness and provided that the "feasibility" of their implementation is not a problem.

To be effective, nitrogen policy measures should also consider possible unintended effects due to the nitrogen cascade. In particular, efforts to lessen the impacts caused by nitrogen in one area of the environment should not result in unintended nitrogen impacts in other areas (“pollution swapping” effects), and should maximise opportunities to reduce other nitrogen impacts (“synergy” effects).



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