Reactive nitrogen compounds and their influence on human health

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Abstract

Reactive nitrogen (Nr) has a wide range of beneficial and detrimental effects on ecosystems and human health. Of all essential nutrients nitrogen (N) is required in the largest amount and is often the limiting nutrient. Humans need to take up N with protein that is basic for the development, upkeep and repair of all body's cells.
Human production of Nr via Haber-Bosch process and cultivation-induced biological N_2 fixation has doubled global N cycling over the last century, with negative effects on the environment. Increased circulation of Nr in the environment is responsible for serious human health effects via different pathways.

Keywords: Reactive nitrogen (Nr), nitrate, methemoglobinemia, nitrogen dioxide, ammonia, particulate matter, pulmonary disease, nitrous oxide, climate change, ground-level and stratospheric ozone, UVB, skin cancer

1. Background

Nitrogen is crucial for crop productivity. In pre-industrial agricultures N was the most yield-limiting nutrient. Only production of Nr by human activities broke this barrier. However, while in affluent nations average protein intakes are adequate or excessive, they are inadequate for hundreds of millions of people in Africa, Asia and Latin America (Smil, 2002).

Currently more than half of the N added to cropland is lost to the environment. This produces threats to water, air, soil and biodiversity, climate and human health.

2. Methods

A literature search identified a number of articles relating to N compounds and their influence on human health (for details see Nieder et al., 2018).

3. Results and Discussion

3.1 Human health effects of inadequate dietary N

In the human body, N is essential for amino acid and protein synthesis, creation of compounds that influence growth hormones, brain functions and immune system (Smil, 2002). Protein deficiency may cause various health problems such as kwashiorkor, impaired mental health, edema, organ failure, wasting and shrinkage of muscle tissue, and weakness of immune system.

3.2 Health effects of water pollution with NO_3^-

Nr can lead to harmful health effects via water pollution with nitrate (NO_3^-), including methemoglobinemia ("blue baby syndrome") which is potentially fatal, usually in infants under 6 months. Nitrite ions can inactivate hemoglobin in the blood by oxidizing iron from Fe^{2+} to Fe^{3+}, thereby lowering the oxygen (O_2) carrying capacity.

3.3 Health impacts of exposure to NO_2 and NH_3

Human health can also be affected by exposures to airborne nitrogen dioxide (NO_2), mainly resulting from combustion of fossil fuels, and ground-level ozone (O_3), the latter being formed from reaction of NO_2 with O_2 (Wolfe and Patz, 2002). Increased O_3 levels are known to cause serious respiratory diseases. Ammonia (NH_3) is also responsible for inflammatory responses of human airways. Moreover, exposure to NH_3 leads to irritation of the eyes, sinuses and skin. NH_3 is also involved in particulate matter formation which plays an important role in human health.

3.4 Health consequences resulting from N_2O emissions

Nr can also affect human health via global warming. Nitrous oxide (N_2O) accounts for 6% of the greenhouse effect and its concentration has increased from about 270 ppb in pre-industrial times to 320 ppb in 2011 (IPCC, 2014). The only significant process that removes N_2O is its reaction in the stratosphere with excited oxygen atoms formed by photolysis of O_3 (Crutzen, 1981). Stratospheric ozone layer depletion increases the amount of ultraviolet B-rays (UVB) that reach the Earth's surface (Hegglin et al., 2015). UVB causes skin cancer and has been linked to the development of cataracts, a clouding of the eye's lens. The impacts of climate change include extreme weather events, land degradation, spread of vector-borne pathogens, and impacts mediated through societal systems.

4. Conclusions

Optimized ways of N use and minimizing stress to natural resources and humans presents a major challenge across the fields of agriculture, ecology and public health. To cope these cross-border challenges, interdisciplinary dialog and collaboration are the key prerequisite.

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