

Nitrous Oxide (N₂O) Emission

Why in news?

Recently, scientists have noted that N₂O has higher potential to trap heat compared with CO₂.

What do you understand by Nitrous oxide (N₂O)?

*Nitrous oxide is also called as **laughing gas** due to the euphoric effects upon inhaling it, a property that has led to its recreational use as a dissociative anaesthetic.*

- **Properties** - At room temperature, it is a colorless non-flammable gas, and has a slightly sweet scent and taste.
- **Applications** - It has significant medical uses, in surgery and dentistry, for its anesthetic and pain-reducing effects.
- It is used as a propellant, and has a variety of applications from rocketry to making whipped cream.
- **Emissions** - Agriculture is one of the main sources of N₂O emissions.
- It is produced in the process of nitrification, consisting of the microbial conversion of ammonia to nitrate.
- The amount of N₂O produced from the soil through the combined processes of nitrification and denitrification is profoundly influenced by temperature, moisture, carbon, nitrogen and oxygen contents.

***Nitrification** is a microbial process by which reduced nitrogen compounds (primarily ammonia) are sequentially oxidized to nitrite and nitrate.*

***Denitrification** is the process that converts nitrate to nitrogen gas, thus removing bioavailable nitrogen and returning it to the atmosphere.*

What is the current trend of N₂O emissions?

- **Higher concentration** - It's concentration in the atmosphere reached 336 parts per billion in 2022 (25% above pre-industrial levels).
- **Accelerated emission** - Accumulation in the atmosphere has accelerated in the last four decades, with growth rates over the past three years (2020-2022) higher than any previous observed year since 1980.
- A total 10 million tonnes of N₂O were released into the atmosphere between 1980 and 2020.

- **Rise in anthropogenic emission** - Global anthropogenic emissions increased by 40% from 1980 to 2020.
- **Major sources** - Agricultural production contributed 74% of the total anthropogenic N₂O emissions in the last decade.
- Soil N₂O emissions are increasing due to interactions between nitrogen inputs and global warming, constituting an emerging positive N₂O-climate feedback.
- **Region-wise assessment** - In the 1980s, Europe made the largest contribution to global anthropogenic N₂O emissions followed by China and South Asia and the USA.
- From the 1980s to the 2010s, Europe and Russia had the largest decline in the share of anthropogenic N₂O emissions, while China and South Asia had the largest increase.

What are the major factors contributing to N₂O emissions?

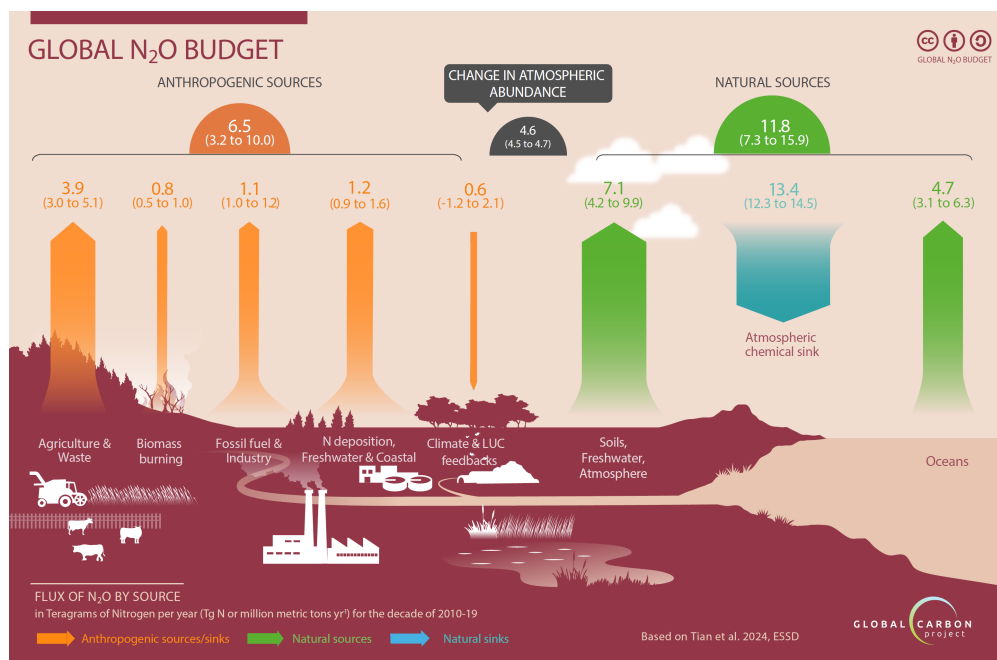
Natural Sources	Anthropogenic Sources
<ul style="list-style-type: none"> • Soils • Freshwater • Atmosphere • Oceans 	<ul style="list-style-type: none"> • Agriculture and waste • Nitrogen deposition in freshwater and coastal areas. • Fossil fuels and industry • Biomass burning

- **Soil pH** - Alkaline pH enhances the rates of both Nitrification and De-nitrification processes.
- In general, soil pH influences the microbial population and activity, which directly impact N₂O emission.

pH is a measure of how acidic/basic water is. The range goes from 0 - 14, with 7 being neutral. pHs of less than 7 indicate acidity, whereas a pH of greater than 7 indicates a base.

- **Soil moisture** - Moist soils enhance N₂O emission over long periods.
- **Temperature** - Bacterial populations increase with increasing temperature up to a certain range.
- **Soil Micro-Organisms** - The amount of soil organic carbon positively influences N₂O production and emission.
- Even microbes in the oceans releases N₂O.
- **Other sources** - They are also naturally released from tropical rainforests and permafrost melting in the Arctic
- **Farming** - Increase in farming practices like fertilizer usages increase N₂O emissions.
- Tillage disturbs the soil and increases CO₂ emission which release the organic carbon that favors microbial activities responsible for GHG emission.
- **Application of crop residues** - It provides a source of easily available Carbon and Nitrogen, henceforth, a potential source of N₂O emission.
- **Nitrogen fertilizers** - After their application, they enter the soil, undergo diverse reactions resulting in leaching, immobilization and volatilization.
- **Non-agricultural human sources** - It includes industry processes, biomass and

fossil fuel burning, and sewage (waste management).



What are the major challenges associated with N₂O?

- **Higher lifespan** - Its lifetime is over 120 years, much longer than 12 year lifetime of methane, another gas 80 times more harmful than CO₂.
- **Global warming potential** - N₂O is the *third most important GHG* contributing to human-induced global warming, after carbon dioxide (CO₂) and methane (CH₄).
- It has *higher potential to trap heat* compared with CO₂ and its global warming potential is 300 times more than CO₂.

Greenhouse gases (also known as GHGs) are gases in the earth's atmosphere that trap heat.

- **Human health** - Excess nitrogen leads to *soil, water and air pollution*, in turn affecting human health and wellbeing.
- **Ozone layer depletion** - Nitrous oxide has also been implicated in thinning the ozone layer.

What lies ahead?

- **Crop Residue Management** - The return of Crop Residue can serve as a source of carbon for microbial growth, stimulating the Nitrogen assimilation by microorganisms.
- **Fertilizer management** - The containment of Nitrogen doses at the lowest non-limiting levels decreases the soil N availability and, consequently, the N₂O emission.
- **Biochar Application** - It increases soil pH and drives N₂O complete reduction to N₂, thus curbing N₂O emission.

Biochar is a charcoal-like substance that's made by burning organic material from agricultural and forestry wastes.

- **Applications of Lime** - It modifies soil pH to reduce the alkalinity of the soil.
- N₂O emission decreases linearly with increased pH in a pH range of 4-7, irrespective of soil type.
- **Enable Nitrogen sink** - An improved inventory of sources and sinks will be required if progress is going to be made toward the objectives of the Paris Agreement.

References

1. [Deccan Herald| Rise in N₂O emission due to Fertilizers](#)
2. [Global Carbon Project| Global Nitrous Oxide Budget 2024](#)
3. [NIH| Management Strategies to Mitigate N₂O Emissions](#)

