

## Nitrous Oxide (N<sub>2</sub>O) Emission

### Why in news?

Recently, scientists have noted that N<sub>2</sub>O has higher potential to trap heat compared with CO<sub>2</sub>.

### What do you understand by Nitrous oxide (N<sub>2</sub>O)?

*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 N<sub>2</sub>O emissions.
- It is produced in the process of nitrification, consisting of the microbial conversion of ammonia to nitrate.
- The amount of N<sub>2</sub>O 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 N<sub>2</sub>O 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 N<sub>2</sub>O 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 N<sub>2</sub>O emissions in the last decade.
- Soil N<sub>2</sub>O emissions are increasing due to interactions between nitrogen inputs and global warming, constituting an emerging positive N<sub>2</sub>O-climate feedback.
- **Region-wise assessment** - In the 1980s, Europe made the largest contribution to global anthropogenic N<sub>2</sub>O 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 N<sub>2</sub>O emissions, while China and South Asia had the largest increase.

### What are the major factors contributing to N<sub>2</sub>O emissions?

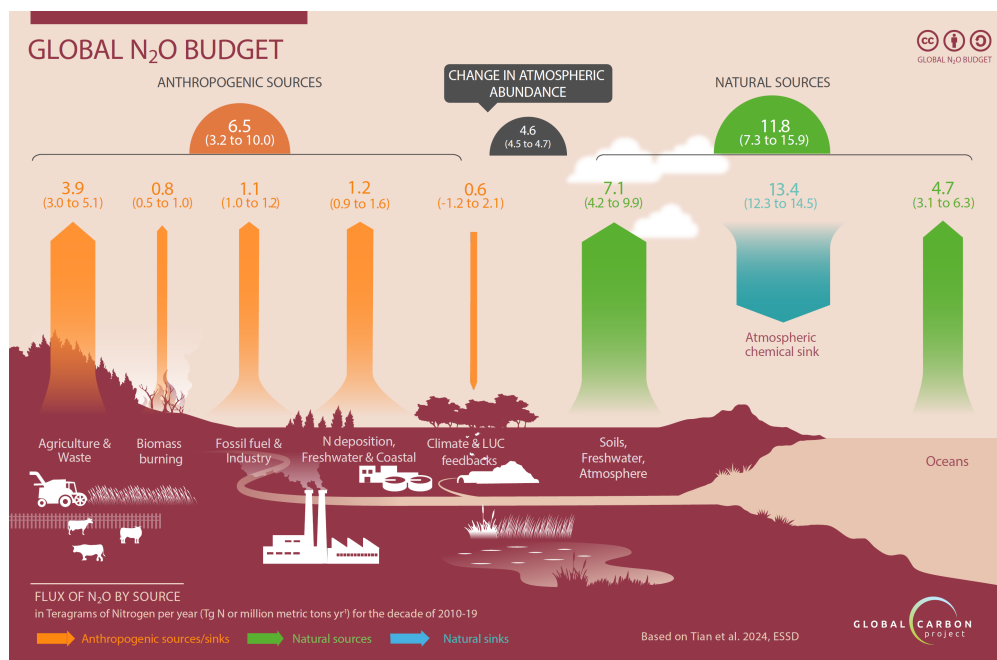
Natural Sources	Anthropogenic Sources
<ul style="list-style-type: none"> <li>• Soils</li> <li>• Freshwater</li> <li>• Atmosphere</li> <li>• Oceans</li> </ul>	<ul style="list-style-type: none"> <li>• Agriculture and waste</li> <li>• Nitrogen deposition in freshwater and coastal areas.</li> <li>• Fossil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

- **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 N<sub>2</sub>O 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 N<sub>2</sub>O 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 N<sub>2</sub>O production and emission.
- Even microbes in the oceans releases N<sub>2</sub>O.
- **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 N<sub>2</sub>O emissions.
- Tillage disturbs the soil and increases CO<sub>2</sub> 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 N<sub>2</sub>O 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 N<sub>2</sub>O?

- **Higher lifespan** - Its lifetime is over 120 years, much longer than 12 year lifetime of methane, another gas 80 times more harmful than CO<sub>2</sub>.
- **Global warming potential** - N<sub>2</sub>O is the *third most important GHG* contributing to human-induced global warming, after carbon dioxide (CO<sub>2</sub>) and methane (CH<sub>4</sub>).
- It has *higher potential to trap heat* compared with CO<sub>2</sub> and its global warming potential is 300 times more than CO<sub>2</sub>.

**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 N<sub>2</sub>O emission.
- **Biochar Application** - It increases soil pH and drives N<sub>2</sub>O complete reduction to N<sub>2</sub>, thus curbing N<sub>2</sub>O 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.
- N<sub>2</sub>O 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 N<sub>2</sub>O emission due to Fertilizers](#)
2. [Global Carbon Project| Global Nitrous Oxide Budget 2024](#)
3. [NIH| Management Strategies to Mitigate N<sub>2</sub>O Emissions](#)

