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 N20 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?

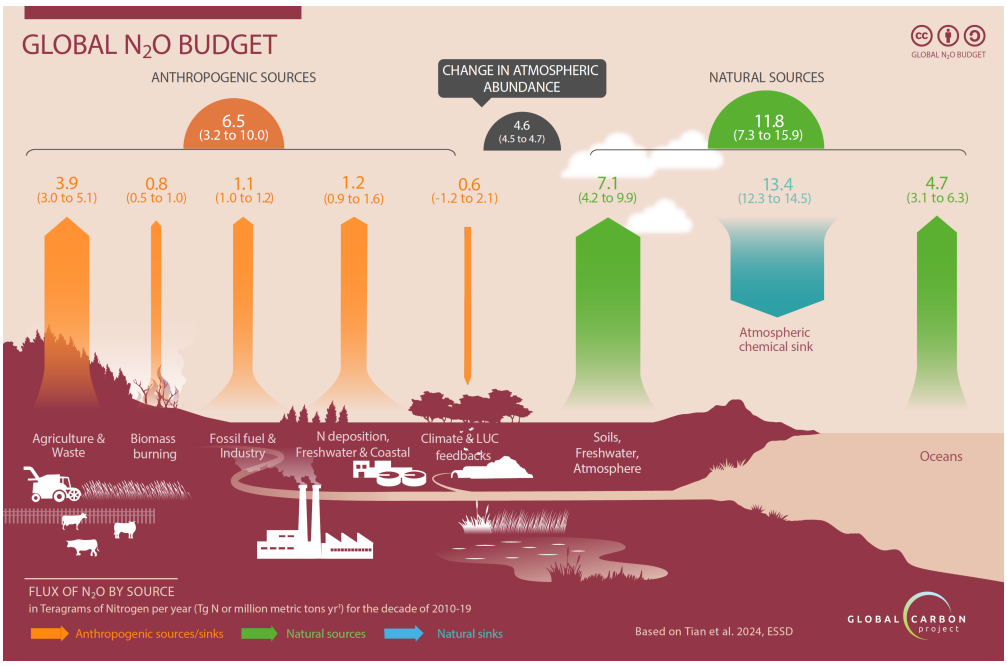
Natural Sources	Anthropogenic Sources
• Soils • Freshwater • Atmosphere • Oceans	• Agriculture and waste • Nitrogen deposition in freshwater and coastal areas. • Fossil fuels and industry • Biomass burning

- **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 micro-organisms.
- **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