Greenhouse Effect of Nitrogen

Mains Syllabus: GS III - Conservation, environmental pollution and degradation.

Why in News?

Global Nitrous Oxide Assessment by United Nations warns that nitrous oxide (N2O), emissions are rising faster than expected, and that immediate action is required to curb the environmental and health impacts of this super pollutant.

What is the significance of Nitrogen?

- **Nitrogen** – It is the non-metallic element and a colourless, odourless, tasteless, non-combustible and nontoxic gas.
- **Abundance in Universe** - It is the 5^{th} -most abundant gas in the universe.
- **Nitrogen in atmosphere** – About 78% of Earth's atmosphere is nitrogen and it is roughly three times more nitrogen in the air than oxygen.
- **Nitrogen in Bio life** - While it constitutes a mere 3% of our body weight, life, without it, life would be impossible i.e. it is a constituent of all living matter.
- **Nerve signalling** - NO, or nitric oxide, inside your body mediates the efficient transmission of messages among the nerves.
- It dilates arteries easing the flow of blood and improves immunity.
- **Cell energy** - Adenosine triphosphate (ATP), the fundamental currency of energy for cells, is part-constituted of nitrogen.
- **Building blocks of DNA (deoxyribonuclease)** - DNA are made up of four nitrogenous bases [adenine (A), guanine (G), cytosine (C), and thymine (T)].

Knuckle-cracking pop results from the synovial fluid between your joints releasing a small bubble of nitrogen when fingers or toes are twisted or compressed.

What are the components of nitrogen cycle?

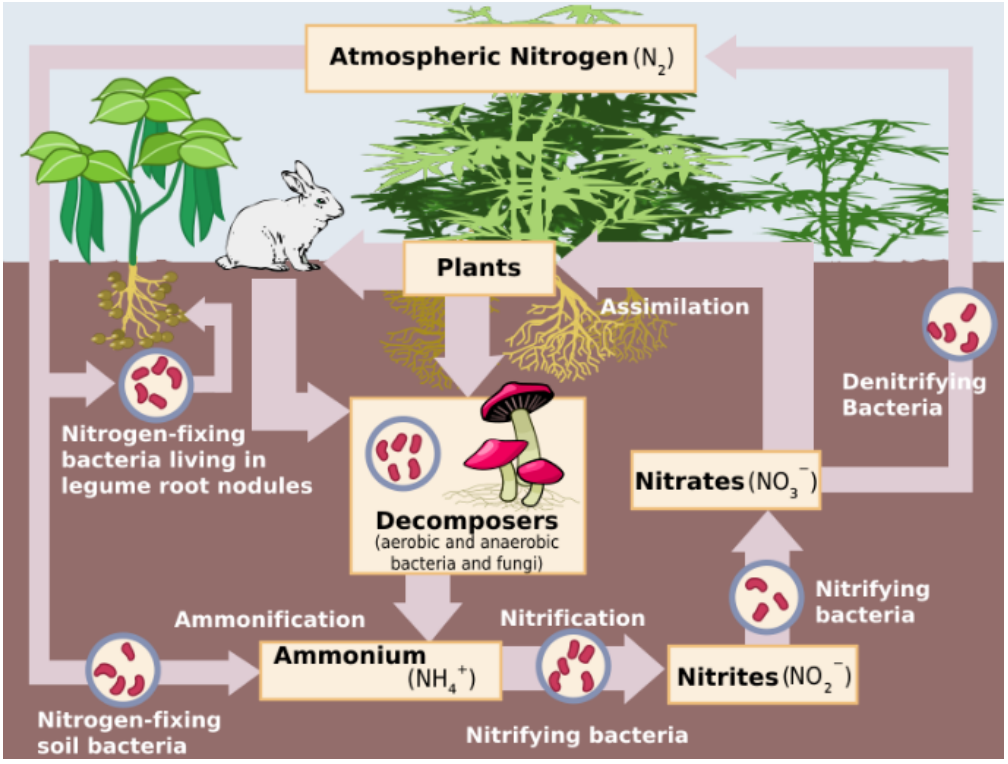
- **No direct intake** – Animal kingdom cannot directly consume or absorb nitrogen.
- The lungs, masters at extracting every molecule of oxygen from inhaled air to keep our cells alive , are flummoxed by nitrogen.
- **Symbiosis of plants** - Nearly 20,000 species of plants of the family Leguminosae, which include beans, chickpeas, lentils, soybeans, and peanuts ,form an alliance with

certain ancient bacteria and archaea called ‘diazotrophs’ to extracting nitrogen from the air.

Diazotrophs are bacteria and archaea capable of converting atmospheric nitrogen (N2) into usable forms like ammonia (NH3) through a process called nitrogen fixation.

Nitrification is the process by which bacteria – that usually attach themselves to the root or live in the soil – turn the ammonia and ammonium into nitrites and nitrate.

- Plants that are non-leguminous, rice, wheat, maize must depend on diazotrophs in the soil.
- **Transmission to animals** - Plants uses the suitable form of nitrogen to make proteins, chlorophyll, their own proteins, and these make their way into other animals and us.
- **Denitrification** - Not all of the available nitrogen and the manufactured nitrate can be used and a large ecosystem of microbes exists to convert these nitrates back to nitrogen, called denitrification, and the cycle continues.



- **Lightning strikes** - These are the other way that atmospheric nitrogen can be broken down to nitric acid – another natural source of nitrogen.

What is the Green House Gas (GHG) potential of Nitrogen?

- **Nitrous oxide (N2O) -** While atmospheric nitrogen (N2) is not a greenhouse gas

itself, Nitrogen in the form of nitrous oxide (N2O) is a potent greenhouse gas with a high Global Warming Potential (GWP).

- **Nitrogen GHG** – It is now the 3rd largest greenhouse gas and Nitrous oxide is believed to be responsible for approximately 10% of net global warming since the Industrial Revolution.
- **GHG effect** - Nitrogen accentuates the greenhouse effect in the same way as carbon dioxide does by capturing re-radiated infrared radiation from the Earth's surface and subsequently warming the troposphere (lower atmosphere).
- **Greenhouse potential of Nitrogen** - For every unit of nitrous oxide emitted there are 1,241 as many CO2 atoms in the atmosphere.
- Nitrous oxide is 300 times more potent than methane and carbon dioxide as a greenhouse gas.
- **Ozone destruction** - Nitrogen is chemically inert in the troposphere and stays in the troposphere for about 120 years before moving into the stratosphere where it ultimately leads to the destruction of stratospheric ozone.

How did Nitrogen become a Green House Gas (GHG) pollutant?

- Agricultural and industrial practices impact the natural nitrogen cycle, leading to increased N2O emissions.

A study in 2010 by in 2010 by the Indian Nitrogen Initiative reported that 70% of N2O emissions were from agricultural soils, 12% from wastewater, 6% from residential and commercial units, 3% from electricity generation and 2% from crop residue burning.

- **Fertilizers** - Composting, manuring, crop rotation were the strategies employed to keep nitrification and denitrification going on manually.
- United Nations Environmental Programme assessment suggest that about 200 million tonnes of reactive nitrogen applied as fertiliser, or about 80%, is lost to the environment leaching into soil, rivers and lakes and emitted into the air.

Chemical fertiliser (over 82% of it is urea) accounts for over 77% of agricultural N2O emissions in India.

- Animal and bird excrement, crushed animal bones were the main external sources of fertiliser, being rich sources of nitrate.
- **Saltpetre** – Also known as nitre or niter, this is a common name for the chemical compound potassium nitrate (KNO3).
- It's a white, salty-tasting solid that has various uses, including as a fertilizer, an ingredient in gunpowder and other explosives, and a food preservative.
- **Cereals dominated mono agri pattern** - The overwhelming quantity of fertilisers goes into cereals, such as rice and wheat, which account for most of the N2O emissions from India.
- Before the Green Revolution it was about 60: 40 (cereals: legumes) and now it is close

to 90:10 with most of our legumes being imported.

War History of Nitrogen
• King Charles I of medieval England ordered subjects to collect their urine for creating nitrate beds to aid small-scale saltpetre mining. • The mines in Chile, that manufactured saltpetre and deposits of guano – the nitrogen-rich excrement of birds and bats – in Peru became key sources of fertiliser and gunpowder for Europe. • The Guano War fought in the 1860s between Spain and its former colonies Peru and Chile revolved around control of nitrate reserves. • English raiders pillaged the tombs of pharaohs – not for their treasures – but for the nitrogen in the bones of thousands of slaves buried along with the mummified pharaohs. • More than three million human skeletons along with the bones of thousands of dead horses of soldiers in the battles of Austerlitz, Leipzig and Waterloo were sent to the port of Hull in north of England. • There they were ground in the bone-mills of Yorkshire to make nitrate and fertilise fields.

- **Synthesise of ammonia** - In 1907 , German chemist, Fritz Haber, figure out the degrees of heat and pressure needed to combine nitrogen from the air with hydrogen and synthesise ammonia.
- **Haber-Bosch process** - Engineer Carl Bosch figure out – most vitally the addition of an iron catalyst – a way to manufacture ammonia on an industrial scale.
- **Industrialization** - The industrial fixing of nitrogen to produce ammonia added excessive nitrogen in the soil.
- **Explosives** – Reactive nitrogen are widely used in modern-day explosives trinitrotoluene(TNT) and nitroglycerine.
- This adds excessive nitrogen in biosphere and atmosphere.

Reactive Nitrogen - An atom of nitrogen will prefer pairing up with another nitrogen via three strong bonds but once these bonds are broken by bacteria or industrial methods, it becomes extremely reactive.

- **Fossil fuel burning** – Nitrogen oxides (NO_x - NO and NO_2) results from burning fuel in engines.

What are the impacts of Nitrogen pollution?

- **Water pollution** - Being extremely soluble, ammonium nitrates are washed away during rains and enter into canals and streams, and stimulate algal blooms.

First noted in the Gulf of Mexico, there are large patches of ‘dead oceans’ where algal blooms resulting from a surfeit of nitrates rapidly multiply, decompose and use up vast quantities of ocean inside the lakes and seas.

- **Respiratory diseases** – Nitrogen oxides NOx forms smog and triggers a host of respiratory ailments.

- **Blue Baby Syndrome** - Water containing elevated levels of nitrate raises the risk of infants developing methemoglobinemia, commonly referred to as “blue baby syndrome”, which can be fatal.

  Nitrate is a form of nitrogen resulting from animal waste, plant decomposition and fertiliser run-off.

- **Acid rain** - Nox can also constitute acid rain if mixed with water vapour, turning into nitric acid.
- **Ground ozone formation** - Nitrogen dioxide will break apart in sunlight and the free oxygen atoms latch onto oxygen molecules forming dangerous ground-level ozone.
- **Economic impact** - According to UNEP’s 2018-2019 Frontiers Report, nitrogen costs the global economy between US$340 billion and US$3.4 trillion annually when taking into account its impact on human health and ecosystems.

What needs to be done?

- Urgent action on N2O is critical to achieving climate goals and to limiting warming to 1.5°C in the context of sustainable development as outlined in the Paris Agreement.
- Abating N2O emissions could avoid up to 235 billion tonnes of CO2-equivalent emissions by 2100.
- This is equivalent to six years’ worth of current global carbon dioxide emissions from fossil fuels.
- Practical, cross-sectoral abatement strategies that could cut N2O emissions by more than 40% from current levels.
- A sustainable nitrogen management approach not only reduces nitrous oxide emissions but also prevents the release of other harmful nitrogen compounds
- By transforming food production systems and rethinking societal approaches to nitrogen management, even deeper reductions could be achieved.
- Simultaneously reducing nitrogen oxide emissions and ammonia would also significantly improve air quality, the UNEP report notes, potentially avoiding up to 20 million premature deaths globally by 2050.
- India’s efforts at insisting on utilising neem-coated urea, the use of nano-urea fertiliser, and organic farming are viewed as important steps to improve such nitrogen use efficiency.

Reference

[The Hindu | Is nitrogen, the building block of life, a latent time-bomb?]