

Quadrant II – Transcript and Related Materials

Programme: Bachelor of Science (First Year)

Subject: Generic Elective (Chemistry)

Paper Code: CHG-103

Paper Title: Basic Chemistry and Indian Scientists

Unit: Carbon and Nitrogen

Module Name: Nitrogen 1- nitrogen cycle, properties of nitrogen

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Notes

Nitrogen



- The element nitrogen was discovered as a separable component of air by Scottish physician Daniel Rutherford in 1772.
- Nitrogen is a chemical element with symbol N and atomic number 7.
- Elemental nitrogen is a colorless, odorless, tasteless, and mostly inert diatomic gas at standard conditions, constituting 78.09% of Earth's atmosphere by volume.

Chemical Properties of Nitrogen

- Nitrogen is a nonmetal with an electronegativity of 3.04.
- It has five electrons in its outer shell and is, therefore, trivalent in most compounds.
- The triple bond in molecular nitrogen (N_2) is one of the strongest known.
- The resulting difficulty of converting N_2 into other compounds, and the ease (and associated high energy release) of converting nitrogen compounds into elemental N_2 , have dominated the role of nitrogen in both nature and human economic activities.

Nitrogen

- Nitrogen gas exists in both organic and inorganic forms.
- Organic nitrogen exists in living organisms, and they get passed through the food chain by the consumption of other living organisms.
- Inorganic forms of nitrogen are found in abundance in the atmosphere. This nitrogen is made available to plants by symbiotic bacteria which can convert the inert nitrogen into a usable form – such as nitrites and nitrates.
- Nitrogen undergoes various types of transformation to maintain a balance in the ecosystem.

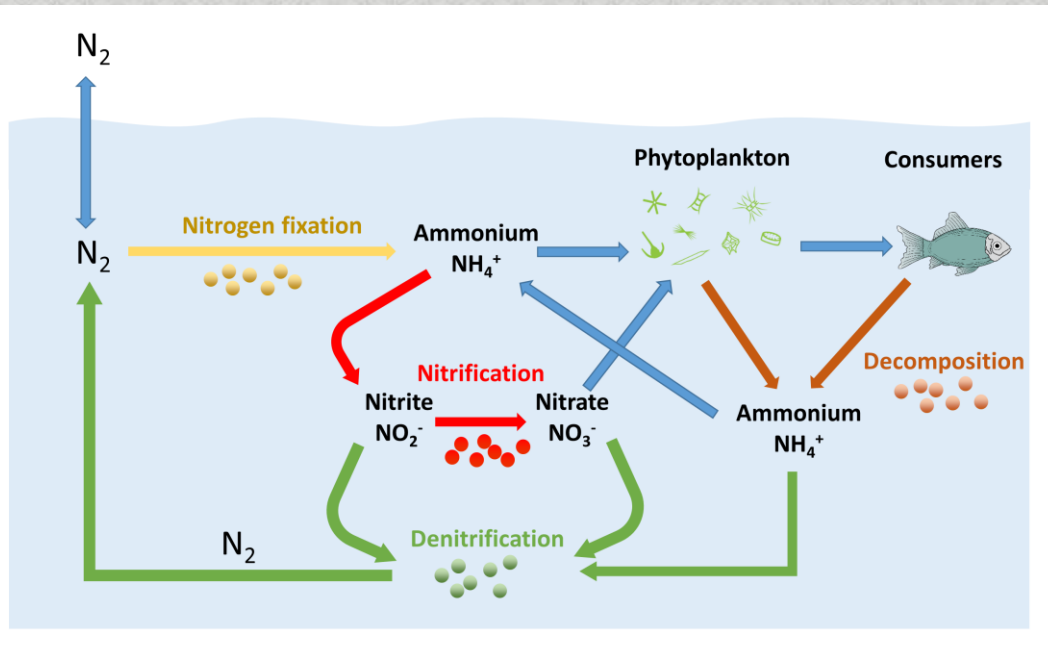
Nitrogen fixation

- Atmospheric nitrogen must be processed, or "**fixed**", into a usable form to be taken up by plants usually occurring by lightning strikes, but most is done by symbiotic bacteria known as diazotrophs.
- These bacteria have the *nitrogenase enzyme* that combines gaseous nitrogen with hydrogen to produce ammonia, which is converted by the bacteria into other organic compounds.
- The conversion of nitrogen gas (N_2) into nitrates and nitrites through atmospheric, industrial and biological processes is called **nitrogen fixation**.

Types of Nitrogen fixation

- **Atmospheric fixation:** A natural phenomenon where the energy of lightning breaks the nitrogen into nitrogen oxides and is then used by plants.
- **Industrial nitrogen fixation:** Is a man-made alternative that aids in nitrogen fixation using ammonia. Ammonia produced by the direct combination of nitrogen and hydrogen, is converted into various fertilizers such as urea.
- **Biological nitrogen fixation:** Nitrogen is not usable directly from the air for plants and animals. Bacteria like Rhizobium and blue-green algae transform the unusable form of nitrogen into other compounds that are more readily usable. These nitrogen compounds get fixed in the soil by these microbes.

The Nitrogen Cycle



Nitrogen Cycle is a biogeochemical process which transforms the inert nitrogen present in the atmosphere to a more usable form for living organisms.

Present in the environment in a wide variety of chemical forms including organic nitrogen, ammonium (NH_4^+), nitrite (NO_2^-), nitrate (NO_3^-), nitrous oxide (N_2O), nitric oxide (NO) or inorganic nitrogen gas (N_2).

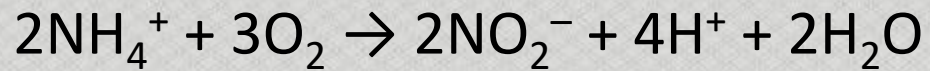
The processes in the nitrogen cycle is to transform nitrogen from one form to another.

Many of those processes are carried out by microbes, either in their effort to harvest energy or to accumulate nitrogen in a form needed for their growth.

Stages of Nitrogen Cycle

- 1. Nitrification:** In this process, the ammonia is converted into nitrate by the presence of bacteria in the soil. Nitrites are formed by the oxidation of Ammonia with the help of Nitrosomonas bacterium species. Later, the produced nitrites are converted into nitrates by Nitrobacter. This conversion is very important as ammonia gas is toxic for plants.

The reaction involved in the process of Nitrification is as follows:

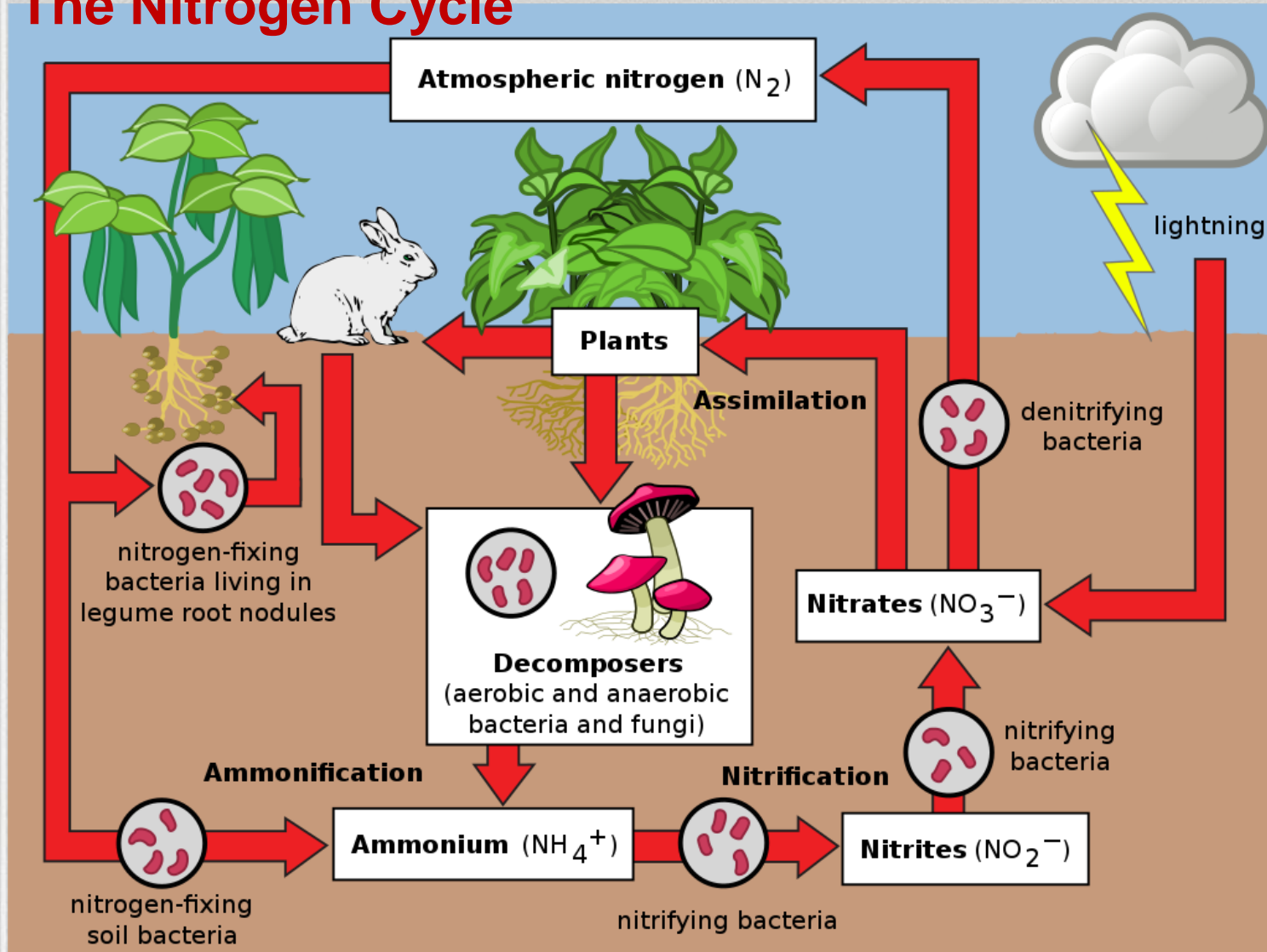


- 2. Assimilation:** Primary producers – plants take in the nitrogen compounds from the soil with the help of their roots, which are available in the form of ammonia, nitrite ions, nitrate ions or ammonium ions and are used in the formation of the plant and animal proteins. This way, it enters the food web when the primary consumers eat the plants.

Stages of Nitrogen Cycle

- 3. Ammonification:** When plants or animals die, the nitrogen present in the organic matter is released back into the soil. The decomposers, namely bacteria or fungi present in the soil, convert the organic matter back into ammonium. This process of decomposition produces ammonia, which is further used for other biological processes.
- 4. Denitrification:** Denitrification is the process in which the nitrogen compounds makes their way back into the atmosphere by converting nitrate (NO_3^-) into gaseous nitrogen (N_2). This process of the nitrogen cycle is the final stage and occurs in the absence of oxygen. Denitrification is carried out by the denitrifying bacterial species- Clostridium and Pseudomonas, which will process nitrate to gain oxygen and gives out free nitrogen gas as a byproduct.

The Nitrogen Cycle



Flow of nitrogen through the ecosystem. Bacteria are a key element in the cycle, providing different forms of nitrogen compounds able to be assimilated by higher organisms

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Importance of Nitrogen Cycle

The importance of the nitrogen cycle are as follows:

1. Helps plants to synthesize chlorophyll from the nitrogen compounds.
2. Helps in converting inert nitrogen gas into a usable form for the plants through the biochemical process.
3. In the process of ammonification, the bacteria help in decomposing the animal and plant matter, which indirectly helps to clean up the environment.
4. Nitrates and nitrites are released into the soil, which helps in enriching the soil with the necessary nutrients required for cultivation.
5. Nitrogen is an integral component of the cell and it forms many crucial compounds and important biomolecules.

Summary

- Nitrogen is abundant in the atmosphere, but it is unusable to plants or animals unless it is converted into nitrogen compounds.
- Nitrogen-fixing bacteria play a crucial role in fixing the atmospheric nitrogen into nitrogen compounds that can be used by plants.
- The plants absorb the usable nitrogen compounds from the soil through their roots, these are then used for production of proteins and other things in the cell.
- Animals assimilate nitrogen by consuming these plants or other animals that contain nitrogen. Humans consume proteins from these plants and animals and then, the nitrogen assimilates into our system.
- In the final stage of nitrogen cycle, bacteria and fungi help decompose organic matter to nitrogenous compounds, which get dissolved into the soil which is in turn used by the plants.
- Some bacteria then convert these nitrogenous compounds in the soil and turn it into nitrogen gas. Eventually, it goes back to the atmosphere.
- These sets of processes repeat continuously and thus maintain the percentage of nitrogen in the atmosphere.