Difference Between Nitrifying and Denitrifying Bacteria

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Key Difference – Nitrifying vs Denitrifying Bacteria

Nitrogen is an essential nutrient for living organisms, and it is of great importance that the available nitrogen is well balanced and recycled in order to be used by living organisms. Nitrogen exists in its natural diatomic form (N_2), which cannot be absorbed by plants for their biological functions. The process of oxidizing fixed diatomic nitrogen into nitrates and nitrites is called nitrification; this is most often done by bacterial species which can utilize nitrogen in its fixed form. In order to maintain the nitrogen balance in the atmosphere, diatomic nitrogen should be produced through a recycling mechanism, where the nitrates and nitrites are reduced back to diatomic nitrogen by bacterial species. This process is termed as denitrification. Thus, bacteria involved in these two processes are characterized as nitrifying bacteria and denitrifying bacteria. The key difference between nitrifying and denitrifying bacteria is that **nitrifying bacteria are capable of oxidizing available ammonia to nitrate and nitrite** whereas **denitrifying bacteria are capable of reducing nitrates and nitrites to its naturally occurring diatomic form nitrogen gas.**

What are Nitrifying Bacteria?

Nitrifying bacteria are chemolithotrophic aerobic bacteria that are capable of oxidizing NH_3 in the soil to nitrate or nitrite. NH_3 in soil exists in its ionic form of NH_4^+. Complete nitrification takes place in two processes, where NH_3 is first oxidized to Nitrite (NO_2^-) followed by Nitrate (NO_3^-), which is utilized by plants.

1. $NH_4^+ + O_2 \, NO_2^- + H^+ + H_2O$
2. $NO_2^- + O_2 \, NO_3^-$

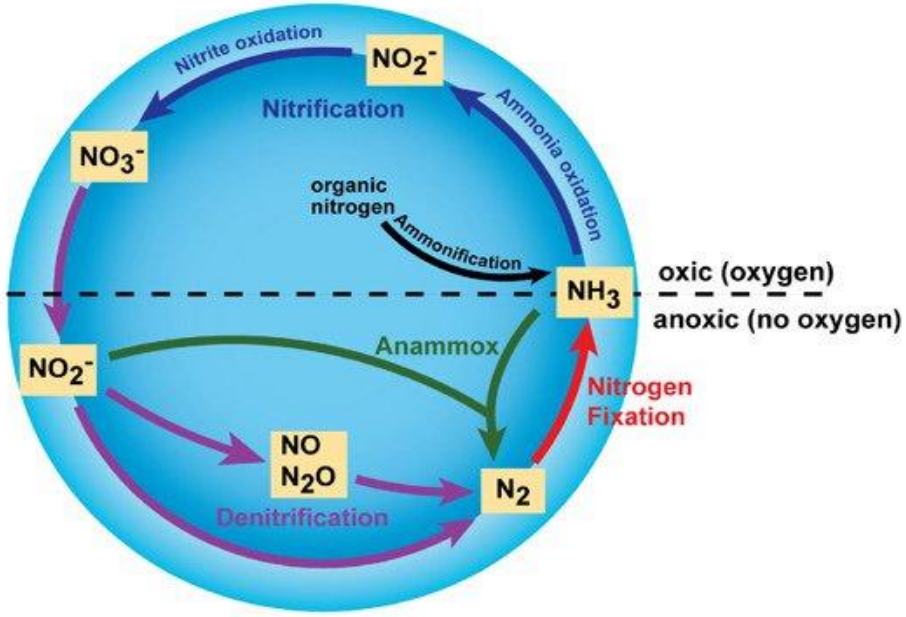

Figure 01: Nitrogen Cycle

Examples of Nitrifying bacteria which carry out the first reaction of nitrification include *Nitrosomonas* and *Nitrospira* which belong to the β subclass of *Proteobacteria*. Bacteria that are capable of carrying out the second reaction of the nitrification process and produce nitrate include *Nitrobacter*, which belong to α subclass of *Proteobacteria*.

What are Denitrifying Bacteria?

Denitrifying bacteria are a type of chemolithotrophic anaerobic or aerobic bacteria that are capable of reducing nitrates and nitrites to gaseous nitrogen forms. The two main forms are diatomic Nitrogen (N_2) and Nitrous oxide (N_2O). Through this process, atmospheric Nitrogen levels are regenerated to the normal concentration. The denitrification reaction is illustrated below.

$NO_3^- \rightarrow NO_2^- \rightarrow NO + N_2O \rightarrow N_{2\,(g)}$

Facultative anaerobes involved in denitrification are *Thiobacillus denitrificans*, and *Micrococcus denitrificans*. *Pseudomonas denitificans* is an aerobic denitrifying bacterium.

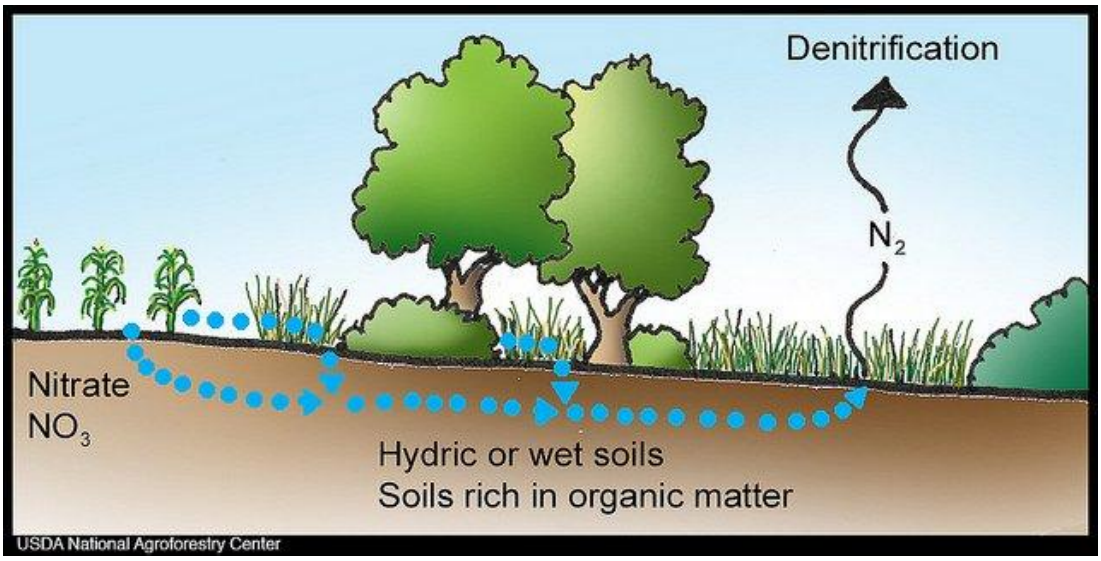

Figure 02: Denitrification

What are the similarities between Nitrifying and Denitrifying Bacteria?

- Nitrifying and denitrifying bacteria are chemolithoautotrophic.
- Most of them are soil borne bacteria.
- Both groups participate in maintaining the balance of nitrogen in the biosphere
- Both nitrifying and denitrifying bacteria contain enzymes which catalyze the reactions of nitrification and denitrification
- Both nitrifying and denitrifying bacteria are used industries.

What is the difference between Nitrifying and Denitrifying Bacteria?

Nitrifying vs Denitrifying Bacteria	
Nitrifying bacteria are bacterial species which are capable of oxidizing ammonium in the soil to nitrates, which could be utilized by plants.	Denitrifying bacteria are bacterial species which are capable of reducing nitrates or nitrites to gaseous forms such as nitrous oxide or diatomic nitrogen.
Type of Reaction	
Nitrification is an oxidation reaction.	Denitrification is a reduction reaction.

Products Formed	
Nitrifying bacteria produce nitrate or nitrite.	Denitrifying bacteria produce nitrous oxide or diatomic nitrogen.
Precursors for the Reaction	
Nitrifying bacteria use ammonia or ammonium ions.	Denitrifying bacteria use nitrate or nitrite as their precursors.
Oxygen Requirement	
Most of the nitrifying bacteria are aerobic.	Denitrifying bacteria can be aerobic or facultative anaerobic.
Industrial Use	
Nitrifying bacteria are used as nitrogen fertilizers.	Denitrifying bacteria are used in waste water management systems to degrade nitrogenous waste.

Summary – Nitrifying vs Denitrifying Bacteria

The nitrogen cycle is one of the most important biogeochemical cycles in nature where atmospheric Nitrogen is converted to various chemical forms, making it available for living organisms to utilize. The process of nitrification is an oxidative process where nitrogen present as ammonium in soil is converted to nitrates and nitrites, increasing the bio-availability of nitrogen for organisms. During denitrification, nitrites and nitrates are reduced to gaseous forms (diatomic nitrogen and nitrous oxide). This is the difference between nitrifying and denitrifying bacteria. Both these processes are biologically made favorable by the involvement of microbes, especially chemolithotrophic bacteria. At present, these bacteria are considered as industrially important in the fields of agricultural and environmental biotechnology. Therefore, they have become a potential research topic in the field of Biotechnology.

References:

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Image Courtesy:

1. “Nitrogen cycle” by KoiQuestion (CC BY-SA 2.0) via Flickr
2. “1.12 Buffers for nitrogen” by National Agroforestry Center (CC BY 2.0) via Flickr

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