Group discussion 1
Environmental chemistry and biology
HSLU, Semester 1

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October 9, 2024

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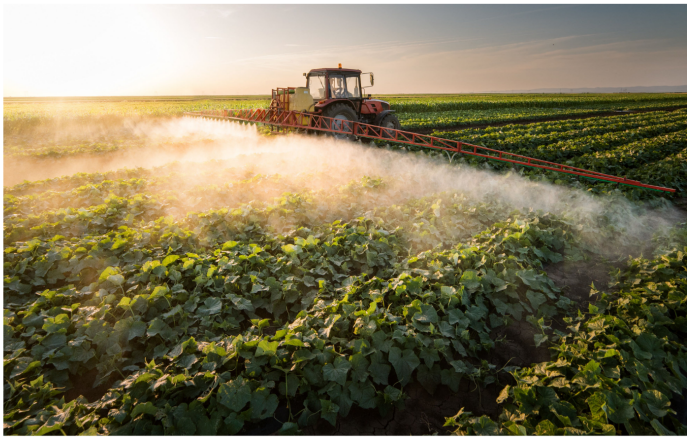
2 Case of study: The role of Nitrification and Denitrification in soil fertility and environmental impacts of fertilizer use

Consider a farming system where ammonium-based fertilizers are regularly applied to crops. The soil is a typical loamy soil, with pH initially around 6.5. Over time, the farmer notices variations in crop yield and occasional signs of nitrogen deficiency, despite regular fertilization. Additionally, groundwater tests show elevated nitrate levels, raising concerns about water quality.



1. How do nitrification and denitrification processes affect soil pH and redox potential?. Write the chemical equations.

2. What are the implications of these processes for fertilizer efficiency and environmental impact?

3. How do intermolecular forces play a role in the solubility and movement of nitrogen compounds in soil?.

4. Which Solutions and Best Practices would you recommend?

2.1 Nitrification and denitrification

2.1.1 Nitrification

The **nitrification process** converts ammonia (NH_4) into nitrite (NO_2^-) and finally into nitrate (NO_3^-). This mechanism causes many hydrogenions to be released into the soil, consequently increasing soil acidity and thus a decrease in pH.

The RedOx potential of soil decreases is inversely proportional to the increase in soil oxidation. In an extremely oxidized environment, aerobic activity of bacteria is favored.

Ammonium to Nitrite
$2NH_4^+ + 3O_2 \rightarrow 2NO_2^- + 4H_2^+ + 2H_2O$

Nitrite to Nitrate
$2NO_2^- + O_2 \rightarrow 2NO_3^-$

2.1.2 Denitrification

The **denitrification process** reduces nitrate NO_3^- first to nitrite NO_2^- and then converts it to nitrogen gas in the soil (N_2O) and then completes the cycle, releasing it into the air as N_2.
The pH of the soil increases as a result of the reduction of the molecules, causing it to return to more neutral conditions.

The RedOx potential is lowered during denitrification, because as the soil is reduced, the anaerobic activity of bacteria in the soil is favored

Denitrification
$2NO_3^- \rightarrow N_2 + 3O_2$

2.2 Fertilizer efficiency and environmental impact

Due to the increase of acidity in the soil caused by the nitrogen reactions, the fertilizer would then need to use a more basic solution to neutralize these effects and maintain a balanced pH level. For environmental impact, since the crops require specific pH levels, they may die or become tainted due to this change in acidity.

2.3 Role of intermolecular forces

Ammonium is a soluble compound meaning it can move easily in water whereas Nitrate is not easily soluble meaning it could become "stuck" in the soil.

2.4 Solutions and practices

Our solutions where to either create a mixture in the fertilizer that is more basic to neutralize the acidifying effects of nitrification/denitrification or to simply use less fertilizer.