Water Is Life

Wetlands: A multifunctional solution

The saviours of coastal waters

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2.1 Abstract

The pollution of the water environment by nitrogen and phosphor is one of the largest environmental issues in our lakes, fiords and open sea areas. This problem appears in Denmark and in the most European countries as well. Large emissions of nitrogen cause an increased growth of planktonic algae, which affect the ecosystem negatively. The Danish lakes, fiords and sea areas are very important habitats for many plants and animals, and the nitrogen pollution limits the biodiversity. A wetland works as a filter, which cleanses the flow of water for nitrogen. The wetlands can thereby contribute to reduce the supply of nitrogen to the inner Danish coastal waters, so the water environment improves. To investigate how nitrate is converted in an ecosystem, we are going to make an experiment with denitrification. In the experiment, we are using water samples and sediment from the wetlands on Nyord as a starting point, to show that the nitrate content in the water samples and sediment by denitrification is converted to gaseous nitrogen.

2.2 Keywords

- Wetlands
- Nitrogen
- Denitrification
- Eutrophication
- Ecosystems

2.3 Purpose of our research

The purpose of this experiment is to investigate how nitrogen is processed in a wetland ecosystem by denitrification Eq.(1). Additionally, we want to investigate the significance wetlands have on animal and plant life near the wetlands and the water quality in the Danish coastal waters and groundwater. We will investigate the wetlands on the island Nyord.

1.6 $2NO_3 \rightarrow N_2 + 3O_2$ (1)

A wetland is a habitat that covers all types of wet and moist areas, where the water level is just below the surface, or above, where the maximum water depth can be six meters. The water can be both salt water, fresh water and brackish water. What separates wetlands from other landscapes is the characteristic vegetation of water plants, which have adjusted to the unique soil. There exists both naturally and constructed/man-made wetlands. The wetland on Nyord is a natural occurring coastal wetland (see figure 1). Wetlands creates a possibility for growth of a large biodiversity, and the wetlands are thereby home to many different kinds of flora and fauna.

Nyord's varied nature is home for many different species. Flocks of birds gathers around the wetlands, where they eat worms and other small animals in the ground. The wetland is an important breeding ground for many wading birds and ducks, and beside you will find smaller birds in the area as golden plovers and sandpipers. These smaller birds attract many predatorial birds as the peregrine falcon. The wetland on Nyord is thereby essential for the survival of these species. Nyord and its surroundings are appointed as the first biosphere area in Denmark by UNESCO because of the unique nature, fauna and flora (ref.).

1.5 Figure 1: The coast wetland on Nyord

Function and purpose of wetlands

The function of wetlands is to reduce the transport of nitrogen and other substances to lakes and the coast water. It is possible to reduce the transport of nitrogen by denitrification where the nitrogen is transformed to gaseous nitrogen. The nitrogen derives almost exclusively from animal manure, which through farming is distributed across fields. The fertilizer's purpose is to enhance the growth of the crops, but not all of the nitrogen is consumed by the plants. Approximately 60% of the farming industry's nitrogen is emitted into the environment, where a large part is emitted into streams, lakes and fjords by the rain or it seeps into the groundwater. It is the fertilizer that stores the large amounts of nitrogen and large amounts of farm animals thereby also emit a problematic amount of nitrogen. The wetland on Nyord has a huge number of cows. By letting the cows graze on the wetland the wetland can reduce the emission of nitrogen from their faeces into coastal waters and the groundwater. The nitrogen supply and the growth of water plants are relatively poor in naturally circumstances and it creates a stable plant and animal environment. The nitrogen supply is increased by a human affection and it can make the environment unstable. With an increasing nitrogen supply into lakes or fjords, the amount of algae are massively increased and the water becomes less transparent. The sunlight cannot reach the bottom of the lake or fjord due to the cloudy water, which results in death of the water plants. When the large amount of algae dies, they sink to the bottom, where they rot and thereby they consume the water's oxygen. This can result in fish and plant death. The

process where a wetland is fertilized so much that it causes deoxygenation is called eutrophication.
The amount of nitrogen which is leached into lakes, fjords and the groundwater depends on the type of soil. In areas with sanded farm lands approximately 10% of the nitrogen is emitted into the coastal waters, while the main part of the nitrogen seeps into the groundwater. In an area with sanded soil the ground water is therefore more sensitive to nitrogen pollution. Compared to the areas with sanded soil, the areas with clay-rich farmlands were approximately 40% of the leached nitrogen emitted into the coastal water. The duration the nitrogen is in the subsurface is short. While a small part of the substance seeps into the groundwater, the main part will flush through the ground via drain lines to streams. During the short journey the nitrogen is not transited into gaseous nitrogen.
To analyse the nitrogen consumption in the wetland areas two experiments were conducted following a protocol published by EMU (ref). Initially freshwater and lake sediment including bacteria was obtained in a small, low eutrophicated pond. For comparison water and lake sediment was collected in the Nyord wetlands where cattle graze.

Hypothesis:

1. We expect that the amount of nitrogen in our water samples will be transited into gaseous nitrogen by the bacteria from the soil.
2. Besides we expect that there will be a larger transition of glucose in the water samples with the largest amount of nitrogen.

2.4 Lake experiment

Materials:

- 500 ml Volumetric flask (7)
- Rubber plug (7)
- Rubber tube (7)
- Bent glass tube (7)
- 100 ml beaker (7)
- 1 ml pipettes
- 700 ml sediment from a lake
- 3 L water from the same location
- Glucose
- Calcium nitrate
- Semi quantitative nitrate strips
- 15 ml commercial plat fertilizer
- 3 L plastic container
- Funnel
- Ladle

Procedure:

We collected the sediment and water samples from a local lake behind the school area. We produced two solutions from the water sample:

- Nitrogen solution
- Glucose solution

The nitrogen solution was produced by adding 2.97 g calcium nitrate to 1500 ml water sample. The glucose solution was produced by resolving 1.64 glucoses in 150 ml water sample. Additionally, we added 15 ml commercial plat fertilizer in 1500 ml water sample, as there was no nitrogen in the water sample from the lake. Thereafter we filled seven flasks according to the given procedure below:

1. 100 ml sediment + 325 ml water sample
2. 100 ml sediment + 300 ml water sample + 25 ml glucose solution
3. 100 ml sediment + 25 ml water sample + 300 ml nitrogen solution
4. 100 ml sediment + 25 ml glucose solution + 300 ml nitrogen solution
5. 100 ml sediment + 25 ml glucose solution + 300 ml nitrogen solution + 0.27 g glucose
6. 100 ml sediment + 25 ml glucose solution + 300 ml nitrogen solution + 0.59 g calcium nitrate

The nitrogen levels for each flask was then measured, using nitrogen strips. After a minute, we could read the content of nitrogen on the strips. The content of nitrogen could be read as a change in colour. We placed a rubber plug with a bent glass tube on each of the seven flasks and lead the rubber tubes into a bowl of water. Thereafter, we left the experiment for seven days. After seven days, we noted if the flasks contained bubbles indicating production of CO_2. Thereafter, we left the experiment for another seven days. After these seven days, we investigated once again how much gas had developed in the flasks and noted the new results. Besides we determined the content of nitrogen in all of the flasks with the nitrate strips and notated the results in a table.

2.4 Wetland experiment

Materials:

- 500 ml Volumetric flask (6)
- Rubber plug (6)
- Rubber tube (6)
- Bent glass tube (6)
- 100 ml beaker (6)
- 1 ml pipettes
- 700 ml sediment from a lake
- 3 L water from the wetland on Nyord
- Glucose

- Calcium nitrate
- Test tubes
- Fehling’s reagent
- Thermometer
- Hotplate + pot
- Nitrate strips
- Plastic bottles
- Funnel
- Ladle

Procedure:

We collected the sediment and water samples from the wetland on Nyord. We produced two solutions from the water sample:

- Nitrogen solution
- Glucose solution

The nitrogen solution was produced by resolving 2.97 g calcium nitrate in 1500 ml water sample. The glucose solution was produced by resolving 1.64 glucoses in 150 ml water sample. Subsequently we filled six flasks according to the given procedure below:

1. 100 ml sediment + 325 ml water sample

2. 100 ml sediment + 300 ml water sample + 25 ml glucose solution

3. 100 ml sediment + 25 ml water sample + 300 ml nitrogen solution

4. 100 ml sediment + 25 ml glucose solution + 300 ml nitrogen solution

5. 100 ml sediment + 25 ml glucose solution + 300 ml nitrogen solution + 0.27 g glucose

6. 100 ml sediment + 25 ml glucose solution + 300 ml nitrogen solution + 0.59 g calcium nitrate

When the mixtures were made we performed a nitrogen decision for every flask with nitrogen strips. We notated the result in a table. After a minute, the content of nitrogen could be read on strips, as a change of colour.

We made the Fehling’s reagent by mixing equal parts Fehling I with equal parts Fehling II.

Thereafter, we made a dilution series by mixing 100 ml sediment, 300 ml water sample and 25 ml glucose solution. This was equivalent to 0.64 g glucose/liter. We tested then the mixture with Fehling and notated the colour reaction in a table. We then mixed 25 ml of the mixture with 25 ml of the water sample from Nyord. We tested again the mixture with Fehling’s reagent and notated the colour reaction in the table. We continued with 50% dilution until a negative reaction with Fehling appeared.

We then measured the glucose content in the six flasks with Fehling’s reagent. We filled a pipette with Fehling’s reagent and a pipette filled with sample from one of the six flasks and mixed it in a test tube. We did this for each of the six flasks. The test tubes with the mixtures were then heated in a 90 ° C water bath. We noted the colour reactions of each flask in a table.

We placed a rubber plug with a bent glass tube on each of the six flasks and lead the rubber tubes into a bowl of water. This way, we could see if gas would develop and show in the form of bobbles in the water.

Thereafter, we left the experiment for seven days. After the seven days, we investigated how much gas were developed in the flasks and notated in the table. Thereafter, we left the experiment for another seven days. After these seven days, we investigated once again how much gas were developed in the flasks and notated the new results. Besides we decided the content of nitrogen in all of the flasks with the nitrate strips and notated the results in a table as the first decision of nitrogen. With Fehling, we then decided the content of glucose in the flasks. We used the same procedure as earlier described and noted the colour reaction in the table.

2.5 Results – Lake experiment

1.4 Content of nitrogen

Flask No.	Start	End
1	500 mg/L	500 mg/L
2	500 mg/L	0 mg/L
3	500 mg/L	500 mg/L
4	500 mg/L	50 mg/L
5	500 mg/L	0 mg/L
6	500 mg/L	500 mg/L

1.41 Production of gas

Flask No.	Production of gas
1	No production of gas
2	No production of gas
3	No production of gas
4	Huge production of gas
5	Huge production of gas
6	No production of gas

1.51 Figure 2: Flasks containing sediment and water sample from the local lake

As the tables: 1.4 and 1.41 show there was no nitrogen processed in flask No. 1 and flask 3. Also nothing of the nitrogen was processed in flask No. 6, because there was added extra calcium nitrate. In the maintaining flasks big parts of the nitrogen were processed. All the nitrogen was processed into gaseous nitrogen in flask No 4 and 5, while there was no production of gas in the other flasks.

2.5 Results – Wetland experiment

1.42 Production of gas after one week:

Flask No.	Production of gas
1	No production of gas
2	No production of gas
3	Little production of gas
4	Huge production of gas
5	Little production of gas
6	Huge production of gas

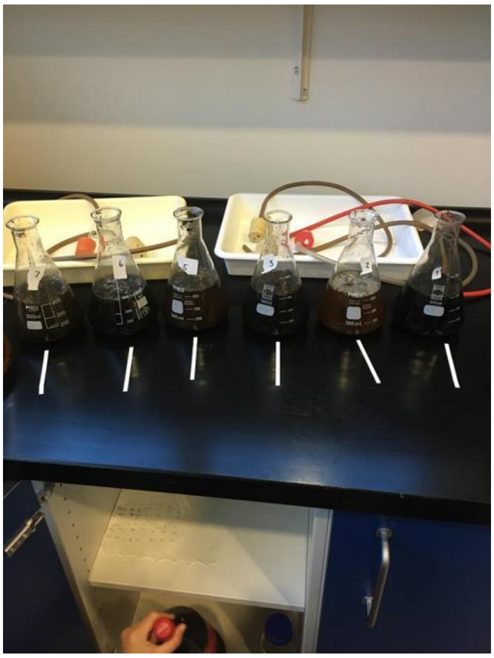
1.43 Content of nitrogen:

Flask No.	Start	End
1	0 mg/L nitrogen	0 mg/L nitrogen
2	0 mg/L nitrogen	0 mg/L nitrogen
3	250 mg/L nitrogen	0 mg/L nitrogen
4	250 mg/L nitrogen	0 mg/L nitrogen
5	250 mg/L nitrogen	0 mg/L nitrogen
6	500 mg/L nitrogen	0 mg/L nitrogen

As it is shown in table; 1.43 all the nitrogen was processed in all flasks. It appears from the table; 1.42 that there was a large production of gas in flask No. 4 and 6 after a week, which indicates that there has been the most effective process of nitrogen in these flasks. After 2 weeks it was not possible to observe the gas - perhaps because all of the nitrogen was processed.

1.44 Content of glucose:

Flask No.	Start	End
1	No colour reaction	No colour reaction
2	Rust red sediment	No colour reaction
3	No colour reaction	No colour reaction
4	Rust red sediment	No colour reaction
5	Bright red sediment	No colour reaction
6	Rust red sediment	No colour reaction

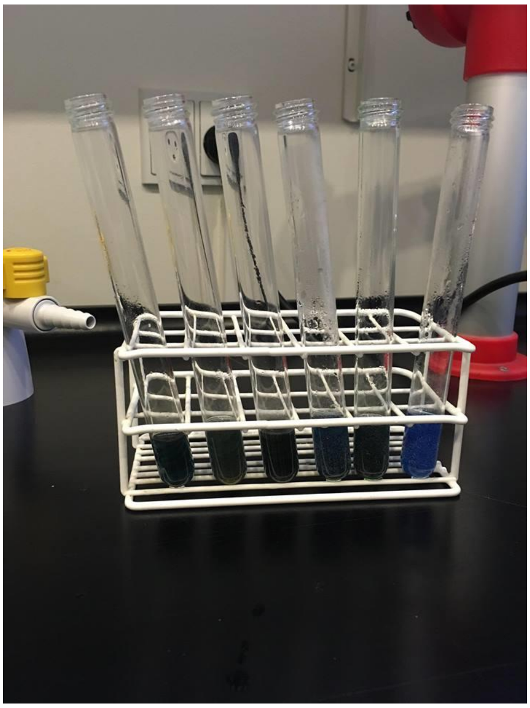


1.52 Figure 3: Flasks containing sediment and water sample from the wetland on Nyord

1.4 Dilution of glucose

G glucose/liter	0.64	0.32	0.16	0.08	0.04	0.02
Colour reaction with Fehling	Brownish red	Rust red	Faint rust red almost brown	Little sediment faint rust red	Little sediment brownish red	Almost no sediment very faint brownish red

1.53 Figure 4: During test of water sample from Nyord with Fehling reactor



1.54 Figure 5: Results of test with Fehling reactor after two weeks

There was no reaction with Fehling reactor after two weeks, which is shown in table; 1.44, but it is proved from the results of both experiments that the nitrogen was processed faster in the flasks where there were added glucose. The dilutions of the glucose is shown in table; 1.45.

2.6 Conclusion

Lake experiment:
There was no nitrogen processed in flask No. 1. This is because no kind of glucose was added to this flask and the bacteria in the soil which were supposed to process the nitrogen had therefore no “fuel”. This is also the cause for flask No. 3 where the bacteria had no nutrition. In the maintaining flasks were big parts of the nitrogen processed. All the nitrogen was processed into gaseous nitrogen in flask No. 2 and 5. Nothing of the nitrogen was processed in flask No. 6, because there was added extra calcium nitrate. This large amount of calcium nitrate made it impossible for the bacteria to process all of the nitrogen, even though we also added glucose to the flask.
There was a huge production of gas in flask No. 4 and 5, while there was no production of gas in the other flasks. There was no production of gas in flask No. 2 and the reason for that could be that the nitrogen was already processed when we checked the flask and because of that could there not be produced more gas.
There is a connection between the production of gas and the process of nitrogen and in the flasks where the nitrogen is processed are also the flasks where there is a production of gas. cf. Eq. (1).

Wetland experiment:
The amount of nitrogen was processed in all flasks. It appears from the tables of the production of gas that there was a large production of gas in flask No. 3 and 4, which indicates that there has been the most effective process of nitrogen in these flasks.
The nitrogen was surprisingly processed in flask No. 3 in spite of that there was not added glucose to this flask. The bacteria could still process the nitrogen. This was impossible in the Lake experiment perhaps because there was a larger amount of nitrogen in the flask. There was 500 mg/L in the flask in the pilot experiment while there was only 250 mg/L in the flask in the final experiment. The reason why the content of nitrogen was higher in the lake experiment was that we added commercial fertilizer, which contained extra nitrogen.
The bacteria can therefore still process the nitrogen without glucose, but with glucose they are more effective. It appears from the table of the content of glucose that there was no glucose left in the end of the experiment. There was no reaction with Fehling reactor.

It is shown from the results of both experiments that the nitrogen was processed faster in the flasks where there were added glucose.
We can finally conclude that the bacteria in the soil from the wetlands on Nyord processes nitrogen into gaseous nitrogen and that the process is furthermore efficient when glucose is added.
It is thereby more advisable to let cattle populations live on wetlands rather than dry areas as the nitrogen emitted from their faeces is processed by the bacteria from the wetlands’ soil. It is therefore favorable to let cattle graze there, as it prevents nitrogen pollution of coastal waters and ground water. Additionally, it is advisable that wetlands are located near farming lands. The nitrogen from the fertilizer can then be absorbed and processed in the wetland.

Further investigations:
To further research wetlands and nitrogen pollution, one could investigate whether it is affordable to let more cattle populations graze on wetlands in order to decrease nitrogen pollution. Additionally the sustainability of establishing more wetlands to decrease nitrogen pollution of Danish coastal waters and groundwater could be researched.

2.8 References

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