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Exploration of changes in nutrient availability in rewetted Dutch agricultural peat meadows by use of a mesocosm experiment

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Abstract

Following years of peat meadow drainage, the unforeseen consequences of land subsidence and increased carbon emissions has become evident. These consequences follow from increased decomposition of the organic compounds stored within the soil. A promising method to combat this is by rewetting formerly drained agricultural peat meadows with submerges, or pressurized, drainage. It is important to understand the hydrochemical responses of formerly drained peatlands on rewetting to foresee and prevent possible negative consequences. With a full-factorial mesocosm experiment, this research aims to unravel the influence of the water table, water quality and nutrient application on the hydrochemical processes of formerly drained agricultural peatland during rewetting. Rewetting treatments within the mesocosm are represented by a combination of the variable groups; 2 water quality groups (groundwater and surface water), two nutrient application groups (high and low) and 5 water table groups (-60. -40, -20, 0 cm below ground level and fluctuating water table from-20 to -70 cm). The variables determine the oxic state of the peat soils and the external nutrient input. For each treatment (5*2*2=20), phosphate, ammonium, nitrogen oxides, sulphate, iron, aluminium, and calcium are measured to represent the nutrient availability within the soil pore water. This indicates the plant available nutrients and minerals related to the nutrient processes within the soil. The hydrochemical processes studied in the peat soil indicate increased phosphate and ammonium availability in rewetted peat soil. The influx of new nutrients, from fertilization or the water source, did not have a substantial impact on the nutrient availability within the soil pore water.

Key words: Submerged drainage, Peat meadows, mesocosm, Hydrochemical processes, Nitrogen mineralization, Phosphate availability

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1. Introduction

In natural conditions the carbon sequencing rate of peatland is larger than the decomposition rate, making peatlands a carbon sink (Jabłońska et al., 2014). This natural ecosystem functioning is acquired by the characteristically anoxic (water-saturated) and nutrient-poor soil conditions of peat (Bérubé & Rochefort, 2018; Hoekstra et al., 2020; Kuikman & van den Akker, 2005). These hamper decomposition rates and consequently resulting in carbon storage within the soil region. Globally, peatlands are the largest terrestrial carbon sink (Foster et al., 2016; Verhoeven et al., 2006). With the release of an annual total of 36.43 billion tons of carbon into the atmosphere globally (Friedlingstein et al., 2019), the carbon-sink and storage capacity of peatlands is an important ecosystem service. However, the large carbon content in the soil could also be a cause for climate pressure itself when the organic matter is exposed to oxygen leading to enhanced decompositions rates and emissions of CO_2 and CH_4 (methane).

Human activity degraded more than 50% of the total peatland globally (Vasander et al., 2003). Within the Netherlands, more than 90% of the peatland is lost due to the repurposing of the land for economic activity (Zak et al., 2010). 82% of all peat soils in the Netherland is used for dairy farming (van den Born et al., 2016). Dairy farming requires pastures with a firm soil structure to endure the trampling of cattle, accessibility with heavy machinery and large biomass production for feed. This is in contrast with the natural soil properties of peat under wet circumstances (van den Born et al., 2016). In the sixties of the last century, it became the dominant Dutch land management approach to artificially maintain low water tables on peat meadows to increase the firmness and productivity of the land (Kwakernaak & Veenendaal, 2010; van Hardeveld et al., 2019).

The lowered water table has enabled the decomposition of organic material to exceed carbon sequencing (Klimkowska et al., 2019). This annuls the peatlands natural carbon-sink functioning. Organic matter accounts for a large portion of the soil body mass, and this increased decomposition leads to land subsidence in addition to the increased carbon emissions (Berezowski et al., 2018; Bérubé & Rochefort, 2018). It costs the Netherlands millions a year to restore roads and houses damaged by land subsidence (van Hardeveld et al., 2018). The yearly greenhouse gas emissions coming from Dairy peat meadows is approximately 4.7 Mt, which translates into 2-3% of the yearly total CO_2-eq emissions in the Netherlands (Kuikman & van den Akker, 2005). In 2019, the Dutch government stated that measures need to be implemented to reduce CO_2 emissions of agricultural peat meadows by 1 Mt by 2030 (van der Ree et al., 2019). As a result, efforts to restore the net carbon sequencing rate of peatlands are becoming a more dominant land management approach.

Peatlands in the western low-lying part of the Netherlands are predominantly classified as fens, peat meadows that are hydrologically connected to ground-, surface- and rainwater (Klimkowska et al., 2019). Naturally, fen development follows from two interplaying stressors, a shortage of oxygen in the root zone (i.e., anoxia stress), and low nutrient availability (i.e., nutrient stress) (Klimkowska et al., 2019). Efforts to restore the net carbon sequencing rate of peatlands relate to these objectives and it is important to assess the impact of land management approaches on nutrient availability and the oxygen penetrability within the soil region (Zak et al., 2017). Since the net carbon-storing balance was disrupted due to manually lowered water tables, the reinstatement of this balance is approached by increasing the water table in peat meadows. Increased water tables are implemented for a variety of envisioned land use purposes, from large scale dairy farming to nature restoration. The overarching aim is to increase carbon sequencing and lower carbon decomposition, i.e., restore the carbon sink and combat land subsidence.

Submerged drainage is a new and already widely used method to rewet formerly drained peatlands (Hoekstra et al., 2020). With submerged drainage, tubes are placed within the peat meadows at approximately -40 below the surface to increases the hydraulic connectivity between the trenches and the peat meadow (ibid.). This enables water to flow from the meadow towards the trenches during wet winters and from the trenches to the meadow during dry summers. Another form of drainage is pressurized drainage, this combines submerged drainage with a pump (Hoekstra et al., 2020). This increases the control over the water table and is often used to enables original practises of dairy farming on peat meadows with an increased water table. In recent years, the rewetting of peat meadows with drainage pipes has been implemented on a large scale, stimulated by governmental monetary support. However, literature on the effectiveness of drainage pipes remains inconclusive (Cusell, Kooijman, & Lamers, 2014; Güsewell, 2004; Zak et al., 2010). The effectiveness is often measured in terms of carbon emission and land subsidence ((Jansen et al., 2009; Tanneberger et al., 2020; Tiemeyer & Kahle, 2014). However, to make sure that the implementations are effective it is important to understand the nutrient responses as well. The desired nutrient availability might vary between the envisioned land use purpose of the rewetted peatland, but in all cases, it is important to understand and, with that, foresee nutrient responses after rewetting.

Many drained peat meadows were subjected to years of heavy fertilizer application. Consequently, these soils often store high nutrient concentrations and rewetting could lead to the release of these nutrients into the ecosystem (Cusell, Kooijman, & Lamers, 2014). This is internal eutrophication. Additionally, with submerged drainage, the land is hydrologically increasingly connected with surface water, where initially most peatlands are hydrologically connected to nutrient-poor and minerally-rich groundwater (Klimkowska et al., 2019). Surface water, mainly stemming from ditches are expected to be higher in nutrient richness (Lamers et al., 2015). This could stimulate eutrophication further. Literature is inconsistent concerning specific nutrient responses in formerly drained peat meadows (Cusell, Kooijman, & Lamers, 2014). Therefore, it remains unclear to what degree eutrophication occurs in the current rewetting restoration initiatives (Klimkowska et al., 2019).

This research aims to unravel the hydrochemical processes during the rewetting of formerly drained peat meadows with the use of a mesocosm approach to examine the nutrient dynamics in formerly drained peat meadows under various treatments. The nutrient dynamic is expected to depend heavily on the contextual factors of past and current land use, nutrient application, water quality and -table (van der Grift et al., 2018). The mesocosm experiment includes the combination of various water tables (5), water qualities (2) and nutrient concentration applications (2) in a full-factorial design of (5*2*2) 20 treatments. A full-factorial design generates insights into the individual effects of all variables, as well as insights into the interactions between the effects of the main variables.

2. Nutrient dynamics

Within natural ecosystems, nitrogen and phosphorous are often limiting factors for plant growth (Güsewell, 2004; Klimkowska et al., 2019). As a response, agricultural land has been heavily fertilized to alleviate this limit to crop production (van Hardeveld et al., 2019). This altered nutrient availability has the short-time effect of increased production but also causes side effects like eutrophication. When the nutrients leach out of the system an overload in nearby water bodies can arise, which leads to algae sprawls and could eventually cause substantial ecological degradation (Cusell et al., 2013; Siljanen et al., 2019). Within agricultural land, a portion of the nutrients, mainly phosphorous, is stored within the soil, bound to soil particles of other organic matter (Koerselman et al., 1990; Zak et al., 2010). When this agricultural land is rewetted these nutrients dissolve and the nutrient availability peaks. This could cause a delayed nutrient overload in rewetted (formerly) agricultural peat meadows, also referred to as internal eutrophication (Zak et al., 2017). Within this process, the former land use is very important to consider because natural areas have not been as heavily fertilized.

Literature concerning nutrient response within rewetted of agricultural peat meadows predominantly focuses on phosphorous and nitrogen availability (Hoekstra et al., 2020; Kwakernaak & Veenendaal, 2010; Lamers et al., 2015; van der Grift et al., 2018; Verplanck et al., 2000). This research builds on the existing knowledge and investigates the nutrient responses, with a focus on nitrogen and phosphorous, in a full factorial experimental design. This way the possible cumulative effects of variables can be studied. The next section discusses the biochemical processes of interest for the research, whereafter phosphorous and nitrogen dynamics are described in more detail.

2.1 Biochemical processes

The water table within an ecosystem determines the oxygen permeability of the soil and, with that, determines the oxic state (Smolders et al., 2013). This is an important driver in biochemical processes in peat soils. Additionally, the quality of the water that enters the system impacts the influx of nutrients and other elements (Smolders et al., 2013; Verplanck et al., 2000). The quality of the water is partially determined by the origin, sea-, rain-, ground-, or surface water. The Netherlands is a delta, and this means that in the coastal regions there is often slightly brackish water, however, saltwater is slightly heavier and is more abundant in the lower regions of groundwater (Jansen et al., 2009). Within the Netherlands, peat drainage also led to land subsidence and therefore, more land area is now exposed to more salty water influxes, this increases the electroconductivity of the porewater (Roelofs, 1991). Within drained peat meadows, groundwater is drained and the relative portion of rainwater that enters the system is higher, the ratio change of water source impacts the hydrochemical dynamics (Cusell et al., 2013). Rainwater has a lower electroconductivity and can be slightly acidic. Therefore, under periodic water table fluctuations in seepage areas, the general trend is that there is a gradual decrease in electroconductivity, pH, chloride and calcium content and an increase in ammonia and phosphate (Cusell, Kooijman, & Lamers, 2014; Kwakernaak & Veenendaal, 2010; Roelofs, 1991).

Rainwater can have an acidifying effect on the hydrochemical dynamic. The pH levels within an area are connected to the oxic state and decomposition rates, which are closely connected themselves (Bérubé & Rochefort, 2018). Carbon dioxide is a result of decomposition, and functions as a weak organic acid (Cusell et al., 2013). Decomposition rates increase when the oxygen availability increases. Microorganisms decompose soil organic matter (SOM) through a redox reaction in which electrons are exchanged, freeing up energy (Smolders et al., 2013; Zak et al., 2010). Additionally, H^+ ions are released, lowering the environmental pH of the soil even further. Within a redox reaction, a reductor donates electrons, and an oxidizer accepts the electrons. The decomposition rate of organic matter (reductor) is mainly dependent on the strength of oxidizers. Oxygen is a very strong oxidizer and will therefore increase the decomposition rate (Smolders et al., 2013). In the absence of oxygen, weaker oxidizers become the driving force of the decomposition, decreasing the decomposition rate. The driving oxidizers in anoxic soil conditions are, in consecutive order, nitrate (NO_3^-), iron (Fe^{3+}), sulphate (SO_4^{2-}) and carbon dioxide (CO_2). These oxidizers are reduced into ammonium (NH_4^+), iron (Fe^{2+}), sulphide (S^{2-}) and methane (CH_4). A higher water table lowers the oxygen availability and forces the redox reaction to be driven by weaker oxidizers. This also stops the acidification of peat meadows.

As described, rainwater and the water table impact the pH within the system, the pH is also determined by the abundance of buffering nutrients that can bind the H^+ ions and combat acidification (Cusell et al., 2013). The quality of the water that is hydraulically connected to the ecosystem influences the influx of new nutrients, which often have a buffering effect (Verplanck et al., 2000). Surface water is expected to have a higher nutrient concentration and could have a neutralizing effect on acidification when the water tables are increased with an increased inflow of surface water.

2.2 Phosphorous

Phosphorous is a natural element present in rocks, soils, and organic compounds and it is an essential nutrient for the basic functioning of plants. Organic phosphorous is either bound to soil components or dissolves in the soil pore water in a variety of dissolved organic matter (primarily P-esters), making it unavailable to plants (Illmer & Schinner, 1995; Zak et al., 2010). Soluble reactive phosphorous is the phosphorous form that is not bound and is available to plants. In ecosystems that are hydrologically connected to natural water, soluble reactive phosphorous is mainly present in the form of phosphate (PO_4^{3-}) (Cusell, Kooijman, Fernandez, et al., 2014; van der Grift et al., 2018). The concentration of phosphate is often very low in clean water because it is either used by plants or bound to soil particles.

Naturally, peat meadows are supplied with groundwater, however, with most rewetting strategies the peat meadows are hydraulically connected to surface water stemming from ditches (Hoekstra et al., 2020). This water source is considered higher in nutrients and minerals than groundwater. A field study, considering 25 locations in the Netherlands allocated surface water as the source of 49% of the total phosphorus content available within the soil (Koerselman et al., 1990). Groundwater only accounted for 39% of the total phosphorous. Rewetting formerly drained peat meadows with surface water may lead to high phosphorous and nitrogen inputs within the system (Illmer & Schinner, 1995; Roelofs, 1991; Wassen et al., 1996).

In the Netherlands, phosphorus has been heavily used in fertilizers to alleviate the phosphorus limitation and increase the land productivity of agricultural sites. The density of agricultural sites in the Netherlands is very high, leading to phosphorous overloads ((Cusell, Kooijman, Fernandez, et al., 2014; Koerselman et al., 1990)). While phosphorous is initially not very mobile in soil because it binds to soil particles, excessive phosphorous leaches out of the system and causes eutrophication in nearby waterbodies. Smolders et al (2013) ascribed 50% of the phosphorous concentration in peat soils to historical fertilization and only 7 % of the phosphorus in the soil comes from present fertilization on agricultural sites. This indicates that agricultural peat meadows have a high phosphate storing capacity.

Iron (Fe), aluminium (Al) and calcium (Ca) compounds in the sediment and pore water bind phosphorous to organic compounds (Kooijman et al., 2020). Phosphate binding by iron is heavily redox-dependent. In anoxic conditions, Fe^{3+} is reduced towards Fe^{2+}, which decreases the strengths of the bond and mobilizes the iron and phosphate within the soil pore water (Klimkowska et al., 2019; Smolders et al., 2013). When the increased water table is generated by an increased influx of surface water the redox reaction can be driven further leading to a higher release of phosphate (Dijk et al., 2019). Surface water often has a higher sulphate (SO_4^{3-}) concentration, and phosphate must compete with sulphate for Fe^{2+} to bind to. The bond between sulphate and Fe^{2+} is stronger. Therefore, iron to bind phosphate becomes scarcer in a sulphate rich ecosystem leading to increased phosphate availability.

2.3 Nitrogen

Ammonium (NH_4^+), nitrate (NO_2^-) and nitrite (NO_3^-) are generally the most important forms of nitrogen in the biochemical dynamics (Güsewell & Koerselman, 2002; Tiemeyer & Kahle, 2014). In saturated soils, nitrogen oxides are used as an oxygen source by microorganisms, this process is called denitrification (Siljanen et al., 2019). Oxygen is used by the microbes and the nitrogen is lost in the form of dinitrogen gas (N_2) is emitted into the atmosphere (Paulissen et al., 2016). In drained peatlands the opposite reaction, nitrification, transcends. Nitrification is the oxidation of ammonium into nitrogen oxides (Smolders et al., 2013). The produced nitrogen oxides leach out easily towards underlying anoxic regions or nearby water bodies. The balance between denitrification and nitrification determines which nitrogen form is more abundant in the pore water. Initially, ammonium enrichment stimulates nitrification in drained fens, however, this reaction releases H^+ ions that decrease the pH. The pH decrease strongly reduces the nitrification rate (Paulissen et al., 2016). Below a pH of 6 the nitrification rates can be reduced to only 10-20% of the nitrification rates around a pH of 7 ((Siljanen et al., 2019). In oxic environments with a low pH, the ammonium concentration is higher than expected from the oxic state because the ammonium cannot be oxidized. In addition to the limiting nitrogen oxide production due to low pH values, the concentration of nitrogen oxides is often low because it is lost within the system due to leaching. Overloads of nitrogen mainly enter the ecosystem through agricultural practices, like fertilization or cattle ((Koerselman et al., 1990; Tiemeyer & Kahle, 2014). The nitrogen use efficiency of crops is relatively low (25-30%). The largest part of nitrogen added to the system is not taken up by plants because most nitrogen forms are soluble and leach out of the system (Paulissen et al., 2016). This ends up in groundwater and surface water through the hydraulic connectivity between the soil pore water and water sources (Cusell et al., 2013).

2.4 Rewetting approaches

The availability of nutrients (PO_4^{3-}, NH_4^+, NO_x^-) essential to plants and minerals (SO_4^+, Fe^{total}, Al^{2+}, Ca^+) that influence the concentration of the plant-available nutrients under a variety of rewetting treatments is determined with soil pore water analysis. The rewetting treatments are a combination of 5 water table treatments, 2 water quality treatments and 2 nutrient treatments. By combining all in one full-factorial design the correlative effects can be untangled. The treatments are designed to represent actual rewetting approaches.

A set of five different water tables was used in the experiment to represent the most common representative ranges of water dynamics in the field, The first treatment was a constant low water table (-60 cm from ground level), representing the average water level in regular dairy agricultural peatlands (Lamers et al., 2015). The second was constant medium (-40 cm from ground level), this is the average water table that remains relatively constant throughout the year in fields with submerged or pressurized drainage (Hoekstra et al., 2020), Third, is a constant high water table (-20 cm from ground level), representing fields in which pressurized drainage maintains a high water table (Hoekstra et al., 2020). The fourth water table treatment used was permanently saturated (0), common in plaudicultures in which the natural, non-economic, functioning was restored (Verhoeven et al., 2006). The fifth, and last, was the seasonally varying treatment (-70 cm and -20 cm from ground level) that represents the water table flux throughout a year in conventional dairy farming that experiences heavy drying-rewetting cycles from summer to winter (Kooijman et al., 2020). The water qualities used are groundwater and surface water. Groundwater is the natural water source for most peat meadows, but drainage pipes connect the meadow to the ditches, therefore, surface water is often the artificial source for increased water tables. Biochemical processes and, with that, nutrient concentrations also dependent on nutrient application (Koerselman et al., 1990). Therefore, one set of samples was treated with a high nutrient application and the other set with a low nutrient application. The high nutrient application represents common dairy farming, and the low nutrient application represents more extensive farming. It is important to understand the hydrochemical changes under different rewetting approaches and land use activities.

This research follows the research question "*How does the combination of the water table, nutrient application and water quality impact the hydrochemical processes within rewetted agricultural peat meadows*". By experience (H1) a phosphate boost is observed after rewetting. Additionally, (H2) the increased sulphate in the surface water is expected to increase the phosphate boost. Looking at ammonium, (H4) the ammonium rate found in saturated and high-water table treatment groups is higher by experience, while nitrogen oxide is lower. Considering the nutrient treatment, (H3) the nutrient application is probably seen in the nutrient availability.

3. Material and methods

This research has been conducted with the use of a mesocosm approach that enables control over the variables of interest (water table, water quality and nutrient application). Within the mesocosm, various treatments have been conducted to represent various rewetting and land management approaches. With the use of soil pore water samples, plant-available nutrient (PO_4^{3-}, NH_4^+, NO_x^-) content and mineral (Fe^{total}, Al^{2+}, Ca^+) availability have been tested to obtain insight into the hydrochemical dynamics under various rewetting approaches.

3.1 Peat core sampling site

The fen samples were collected on the North Holland side of the border between the provinces North-Holland and Utrecht near Zegveld within a drained fen approximately 50 meters from the Bosweg (52°08'41.2"N 4°50'10.7"E) (figure 1). This location was selected based on the soil disposition and to decrease the ecological impact because a trench will be created on the sampling site in the near future. The properties of heavily disturbing peat soil alter permanently, and restoration takes a long time. The purpose of the collection site changes and the ground will be heavily disturbed, in collecting the cores from this site there was no additional peat soil degradation. Additionally, this location has no, or very low clay content. This was important for three reasons. First, clay heavily influences the oxygen permeability of the

Figure 1 Location of peat core sampling 52°08'41.2"N 4°50'10.7"E (yellow outline). Image from google earth.

soil, which determined the oxidation rates. Generally, clay reduces oxidation rates with a factor of 1.3 (Rienks & Gerritsen, 2004). Second, clay layers vary heavily between locations and the experiment would therefore be less representable for the biochemical functions within Dutch peat meadows. Third, most rewetting practices occur on the fens without clay content, because the soil subsidence has been most urgent in these locations due to the higher oxidation rates and this is, therefore, a more representable and relevant sample for experimentation.

Peat cores were collected in PVC pipes with a diameter of 20 cm and a height of 80 cm. These pipes were placed on the topsoil and the grass sods were cut around the edge. The first 30 cm of the PVC pipe was pressed and hammered into the soil manually, the bottom was sharpened to ease this. The final 50 cm was pressed into the soil with a crane. To collect the soil columns from the field a ditch was dug whereafter the columns could be pried loose. After collection, a plastic cap was placed on the bottom of the pipe to prevent leakage.

3.2 Experimental design

The research was performed in an experimental setup using a mesocosm approach. Within the mesocosm, three variables are under investigation, water quality, water table and nutrient application. There were two groups (groundwater and surface water) in the water quality variable, 5 groups (saturates, constantly high, medium, low, and seasonal fluctuation) in the water table variable and 2 groups (high and low) in the nutrient application variable (table 1). Each group is considered a specific treatment.

The mesocosm existed out of 20 tanks that contained five peat cores replicas. Each tank represented one of the 20 (2*5*2) treatment combinations. This is a full-factorial design in which all groups were both variables and constants because within the comparison of two tanks there was always one variable, while the other treatments were constant. The mesocosm setup is displayed in figure 2, a vertical comparison of 2 tanks enables the comparison between water quality (e.g., tanks 1 and 2), the horizontal comparison between two sets with the same water table enables comparison between nutrient input (e.g., tanks 2 and 4) and a horizontal comparison of the set-ups with either high or low nutrient input enables the comparison between water table levels (e.g., tanks 2, 6, 10, 14 and 18).

Groundwater was obtained from a well at -80 m near the sample collection site. The first month the used groundwater was high in salinity, therefore, this water supply was diluted with tap water until EVG values dropped under 1300. The ditch water was collected at the test farm Kennis Transfer Centrum (KTC) near the peat core sampling site. Both water supplies were refreshed once a month, briefly after pore water measurements were performed. With slow-releasing granules from Osmocote Flower (N 16-5-12 2/3), the nutrients were applied at the beginning of April. In the high nutrient applications treatment, the equivalent to 250kg N per year in granules was added and in the low nutrient application the equivalent of 50kg per year. The granules were applied once and gradually release the nutrients.

Beyond the variables, all test columns were subjected to the same environmental influences of sun exposure and rainwater entering the system. Weekly pH was measured using an ion-specific electrode (WTW pH meter 3110, Sentix 41 electrode) and electrical conductivity (EC) with a conductivity meter (WTW COND 3110). The tank water pH and EGV measurements were used to ensure consistency in the independent variables and to enable the interpretation of the results and explain possible deviations.

Table 1 Variables and groups used within the mesocosm experiment. Within the full-factorial design of 20 treatments, each combination of groups was present.

Water table	cm	Water supply	Nutrient application
Constant Low (CL)	-60	Groundwater (G)	Low (L)
Constant Medium (CM)	-40	Surface water (S)	High (H)
Constant High (CH)	-20		
Permanently saturated (PS)	0		
Seasonally varying (SV)	-70/-20		

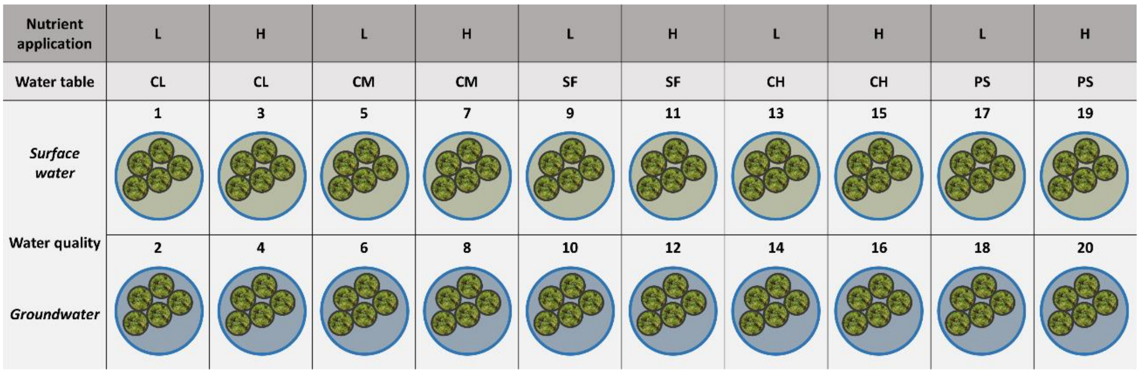

Figure 2 Full-factorial mesocosm set-up. Vertical comparison of 2 set-ups enables the comparison between water quality. horizontal comparison between two sets with the same water table enables comparison between nutrient input. horizontal comparison of the set-ups with either high or low nutrient input enables the comparison of water tables.

3.3 Data collection

3.3.1 Pore water sampling

Pore samples were taken every month from each column in the mesocosm experiment, a few days before the water in the tanks was refreshed. In each column, two Rhizon samplers were placed, one in the root area at -10 cm below ground level and one at -40 cm below ground level (figure 2). For the Rhizon sampler at -40 cm a small hole was drilled at the beginning of the experiment, thorough which the Rhizon was placed. Whereafter, the hole with the Rhizon was closed with kit. The Rhizon samplers stayed in place for the entire length of the experiment (12 months, only 3 months included in this paper). To prohibit water from entering the pore sample extraction point of the Rhizon sampler, Rhizon samplers with 50 cm long tubes were placed at -40 cm to ensure that the Rhizon samplers reach above the water table level.

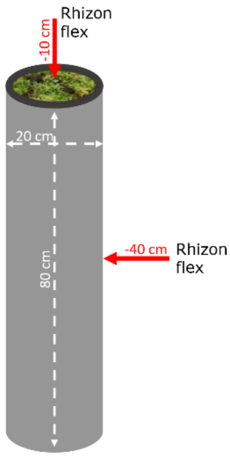

Figure 3 Set up individual peat column (20x80) with the placement of two Rhizon flexes at -10 and -40 cm below ground level.

Every month the syringes were places on the Rhizon flexes a day in advance, to make sure the syringes had enough time to fill. This was especially important in the topsoil region of the peat columns with low water tables because these soil regions were dryer. Except for the first month, the samples were collected in two batches. One of the batches was acidified with a 1mmol nitric/hydrochloric acid at the moment of collection to prevent iron(III)phosphate from forming and precipitating. The samples were stored as cool as possible throughout the collection process and before opening all samples were weltered to prevent ammonia to be lost from the solution. The acidified samples were used for the determination of phosphate and elements related to phosphate availability, Ca^{2+}, Fe^{total}, and Al^{2+}.

3.3.2 Nutrient detection

The soil pore water samples were analysed within the GeoLab of the UU. Alkalinity was measured using a Hach test. The ion chromatography (IC) was used to determine the Cl^{-} concentrations and the Inductively coupled plasma - optical emission spectrometry (ICP-OES) was used to measure Ca^{2+}, Fe^{total} and Al^{2+}. PO_4^{3-} and NH_4^{+} were measured with the colorimetric approach, in which the wavelength of colour reactions that indicate the nutrient concentration was measured with a photometer.

3.4 Data Analysis

Data collected from the experimental setup was analysed with RStudio, following the guidelines described by (Field et al., 2012). A full factorial ANOVA test was performed to investigate the nutrient/mineral availability variance between the treatments that can be explained by specific variables or the interaction between variables. Beforehand the assumptions of the ANOVA were tested with the Shapiro-Wilk test (normality) and Levene's test (variance). The ANOVA test assumes that the data was normally distributed group (Shapiro-Wilk test: p>0,05) and that the variation was larger between groups than within a group (Levene's test: p>0,05) (Foster et al., 2016). The data was transformed with a log-transformation to meet the assumptions of the test as good as possible. However, the data does not always meet the required variance and distribution. The full factorial design of the experiment requires many comparisons, when this was done with a non-parametric test the statistical power was very low, leading to possible type I errors ((Field et al., 2012; Hilbe, 2006)). This error was a false negative, meaning that no significance was found while there was a significant interaction between the variable and the availability of the nutrient/mineral. To maintain statistical power, this research chose to continue with the parametric tests (ANOVA and Tukey HSD) even when the assumptions were not completely met. The data was transformed to fit as good as possible, and the regression plots (Q-Q plots) were used as a guideline (**Appendix A**). When the data follows the regression lines (Q-Q plots), the parametric full-factorial ANOVA and the posthoc test were performed. The maximum model (full-factorial model) included all variables and all possible interactions:

Element of interest ~ (AB) + (Water) + (Table) + (Nut) + (Time) + (AB:Water) + (AB:Table) + (Water:Table) + (AB:Nut) + (Water:Nut) + (Table:Nut) + (AB:Time) + (Water:Time) + (Table:Time) + (Nut:Time) + (AB:Water:Table) + (AB:Water:Nut) + (AB:Table:Nut) + (Water:Table:Nut) + (AB:Water:Time) + (AB:Table:Time) + (Water:Table:Time) + (AB:Nut:Time) + (Water:Nut:Time) + (Table:Nut:Time) + (AB:Water:Table:Nut) + (AB:Water:Table:Time) + (AB:Water:Nut:Time) + (AB:Table:Nut:Time) + (Water:Table:Nut:Time) + (AB:Water:Table:Nut:Time)

In this model, the effects (~) of all variables and interactions on the individual nutrients/minerals were assessed. From this maximum model, the minimum adequate model can be defined by the step-by-step removal of factors with an insignificant (p>0,05) relation to the element of interest (Crawley & Wiley, 2005). In reducing the model, the variables can be identified that are necessary to predict the nutrient/mineral availability. The factor (variable or interaction) with the highest number of included variables and an insignificant p-value was removed. When there were multiple insignificant factors with the same number of variables the factor with the highest p-value was removed first. After each step, the new model (old model – a factor) was compared with the old model, to assess the validity of the fit. If this comparison was insignificant (p>0,05) the new model was not significantly worse in the description of the nutrient dynamic. Eventually, the minimal adequate model was obtained, which includes only the necessary variables and interactions for an accurate prediction of the availability of the nutrient/mineral. When a variable, or interaction, was necessary for prediction, there was a relation between the variable/interaction and the nutrient/mineral availability. When interactions were significant the main effects were of no value to discuss because a more detailed description of the effect of the main effect was given within the interaction.

The ANOVA test indicated that a factor has a significant influence on the availability of the nutrient/mineral, but it does not describe what that influence is. Therefore, the minimal adequate model was further analysed with Tukey's HSD posthoc test (Foster et al., 2016). This test gave the significance of the differences between the means of the nutrient/mineral availability for each combination of variables tested, while automatically correcting the p-value for the number of tests performed on the same data. This correction was required because multiple tests on the same dataset increase the possibility of a type II error. This error was a false positive, meaning that a significant interaction was found where there was none. The sequence of tests was performed for all nutrients, each nutrient was an individual dependent variable and needed to be analysed separately. The relation between variables/interactions and the nutrient availability was brought back to the groups to obtain as detailed an understanding of the impact of the water table, water quality and nutrient application on the hydrochemical dynamics in the mesocosm experiment.

4. Results

This section discussed the results acquired from the mesocosm experiment. First, the Minimal adequate models (MAM's) are addressed. These models follow from the data acquired and describe the necessary aspects required to accurately predict the availability for each element. The MAM's direct the focus of the further results section that discussed the availability of plant-available nutrients and the other minerals of interest to the treatments. The result section only includes relevant data. **Appendix B** includes an oversight of the mean values within all treatments separate per measuring moment. values are given in a log scale because this is also the scale in which the data was analysed within R and the scale in which the figures are presented. It is important to consider that there are no negative values in the data, therefore all negative log values indicate that the actual value lies between 0 and 1. The actual value is calculated by using the value as the power of 2 (2^x).

4.1 Minimal adequate model

The MAMs are a set of variables (and possibly the interaction between variables) necessary to explain the availability of a specific element, i.e., the formula that predicts the availability. Table 2 shows the MAMs for the plant-available nutrients. To describe the hydrochemical dynamics under seasonal fluctuating water tables, a separate MAM was composed for each element (Table 3). All MAMs, including all the minerals of interest, pH, electroconductivity and alkalinity are given in appendix C. Overall, the models following from the seasonal fluctuation are reduced further. When there is an interaction between the effects of two variables, this interaction has higher explanatory power than the individual variables, and therefore, these individual variables should not be further considered. All interactions with a lower order of variables, that are included in higher-order interactions remain part of the model, these interactions are not displayed in the table because they do not add to the explanatory power. the full model and the significant codes are displayed in appendix C.

All variables that are not classified as a required feature to predict availability are not considered in the MAM, so all groups from that variable are merged as one. This can be done because there is no significant difference between a model that separates and a model that merges the groups (ANOVA $model_n$~$model_{n+1}$ gives $p>0,05$). Likewise, in an interaction between the effects of two variables, the groups within all other variables are neglected even if this variable is of importance outside of the interaction. Because the MAM indicates that the other variables are not a necessary aspect to explain the observed data. The MAMs for the plant-available nutrients and important minerals are discussed in more detail in the following sections.

Table 2 The minimal adequate models (MAM) for the plant-available nutrient phosphate (PO4), ammonium (NH4) and nitrogen oxides (NO_x) with an externally varying water table (between treatments). This table only includes the variables and interactions necessary for an accurate prediction of nutrient availability. The formula indicated the full set of variables and interactions of the MAM, the variables and interactions relevant to discuss are given with their significance code (the full set included in appendix C).

PO4	PO4 ~ Depth + Water + Table + Nutrients + Time + Depth:Water + Depth:Table + Water:Table + Table:Nutrients + Depth:Water:Table					
		Df	Sum Sq	Mean Sq	F value	Pr(>F)	
	Time	1	1,33	1,3	4,274	0,0393	*
	Table:Nutrients	6	6,84	1,1	3,677	0,0014	**
	Depth:Water:Table	3	4,45	1,5	4,780	0,0027	**
NH4	**NH4 ~ Depth + Water + Table + Nutrients + Depth:Table + Water:Table + Depth:Nutrients + Table:Nutrients**						
		Df	Sum Sq	Mean Sq	F value	Pr(>F)	
	Depth:Table	3	87,50	29,2	37,162	< 2e-16	***
	Water:Table	3	8,00	2,7	3,382	0,0182	*
	Depth:Nutrients	2	12,40	6,2	7,902	0,0004	***
	Table:Nutrients	6	24,60	4,1	5,219	0,0000	***
NOx	**NOx ~ Depth + Water + Table + Nutrients + Depth:Table + Water:Nutrients**						
		Df	Sum Sq	Mean Sq	F value	Pr(>F)	
	Depth:Table	3	178,90	59,6	19,419	0,0000	***
	Water:Nutrients	1	14,20	14,2	4,623	0,0332	*

Table 3 Table 4 The minimal adequate models (MAM) for the plant-available nutrient phosphate (PO4), ammonium (NH4) and nitrogen oxides (NO_x) with an internally varying water table (within treatments). This table only includes the variables and interactions necessary for an accurate prediction of nutrient availability. The formula indicated the full set of variables and interactions of the MAM, the variables and interactions relevant to discuss are given with their significance code (the full set included in appendix C).

PO4	PO4 ~ Depth + Water + Table + Depth:Water						
		Df	Sum Sq	Mean Sq	F value	Pr(>F)	
	Table	1	2,42	2,4	32,205	0,0000	***
	Depth:Water	1	0,41	0,4	5,493	0,0217	*
NH4	**NH4 ~ Depth**						
		Df	Sum Sq	Mean Sq	F value	Pr(>F)	
	Depth	1	103.2	103.23	177,000	<2e-16	***

4.2 Phosphate

To predict phosphate availability the interaction between sampling depth, water source and water table, and the interaction between the water table and nutrients application, and the variable time are required. This follows from the MAM describes before. While a three-way interaction is more complex, this also captures a lot of information in one term and generates a detailed nutrient dynamic understanding. The details of interactions- p-values and differences between the various combination of treatments within the interaction- are given in **Appendix D**. For the three-way interaction, the table is also shown within the text to increase clarity. Phosphate was fitted with a log transformation therefore all values are given on a log scale; negative values indicate that the actual value lies between 0 and 1.

The interaction between the effects from de different water tables, water quality and sampling depth are important to consider in the prediction of phosphate. There is no significant difference between the water sources when the other variables are considered a constant (table 4). Meaning that the pore water samples collected at the same depth and from the same water table treatments do not differ significantly between the surface and groundwater treatment. The interaction mainly affects the significance between different water table treatments when the other variables are constant, e.g., within the same sampling depth and water table treatment groups. The saturated treatment has a significantly higher (p<0,002) phosphate availability in the topsoil compared to topsoil regions treated with the same water source but under different water table treatments (figure 4); Diff(Surface 0:-60)= 1,500, Diff(Surface 0:-40=2,4780), Diff(Surface 0:-20)= 0,620, Diff(Ground 0:-60)= 1,625, Diff(Ground 0:-40=2,104), Diff(Ground 0:-20)= 1,285.

Within the deep soil (figure 4), the same positive relation between phosphate availability and the increasing water table is seen, but more moderately. Within the deep soil, there is a significant difference (p<0,001) between the low and saturated treatments (Diff(Surface)=0,872, Diff(Ground)=0,918), but the saturated and the constantly high-water table treatments are not significantly different (surface p=0,999, Ground p=1,000).

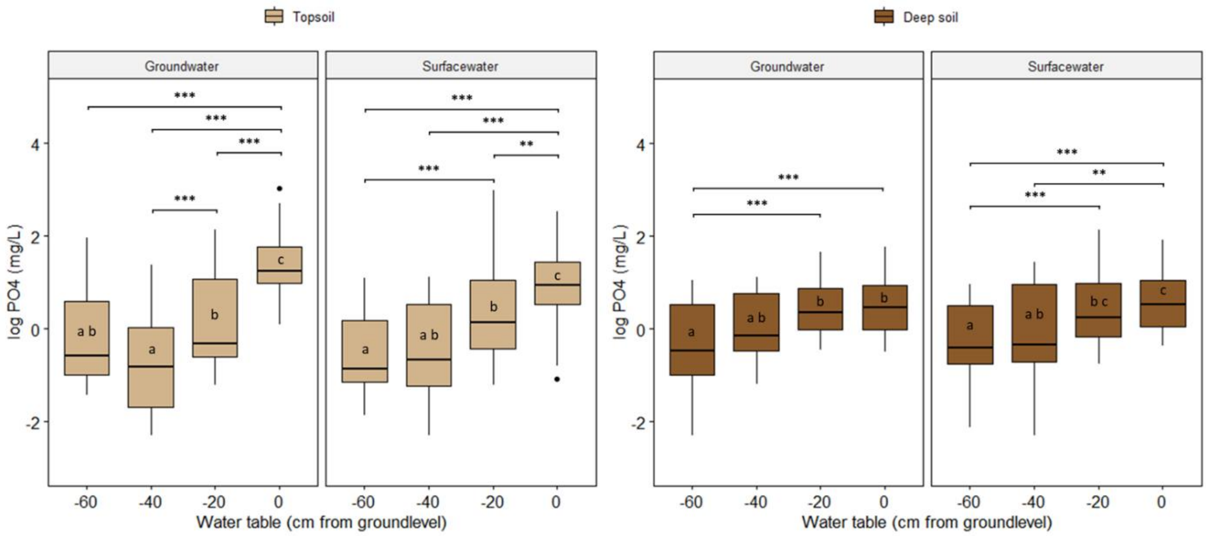

Figure 4 PO_4^{3-} availability in top- and deep soil pore water samples. The groups from the variables of the water table, sampling depth and water quality are included in the figure. All acquired data from the mesocosm with a constant water table is included and only grouped based on the variables considered within the figure. The remaining variables are neglected, groups from these variables are merged within this display of the data. Within the boxplot, vertical lines indicate the maximum and minimum, horizontal lines the mean, and dots the outliers. Matching letters within the same sampling depth groups indicate that the mean values are not significantly different. Significance codes: p<0.001 (***), p<0.01 (**), p<0.05 (*).

The interaction between the effects of nutrient application and water table predominantly describes that the treatment in which no nutrients were applied have a higher phosphate availability, the difference increases when the water table decreases (p<0,001 with the Diff varying between -0,96 and -1.68). Additionally, within the respected nutrient groups of no, low and high nutrient application, all water table levels differ significantly (p<0,001) except for the constant low and medium water table treatment (No p= 1,00, Low p= 0,981, and high p=1,00) and the saturated and constantly high water table treatment without nutrients application (p=0,673).

Time is the only variable whose effect does not interact with the others, but it is a necessary variable in the prediction of phosphate availability. Phosphate levels are significantly (p<0,05) higher in March (Mean= 1.0190430) compared to April (Mean= -0.2598079) and May (Mean= -0.3957602) (figure 5).

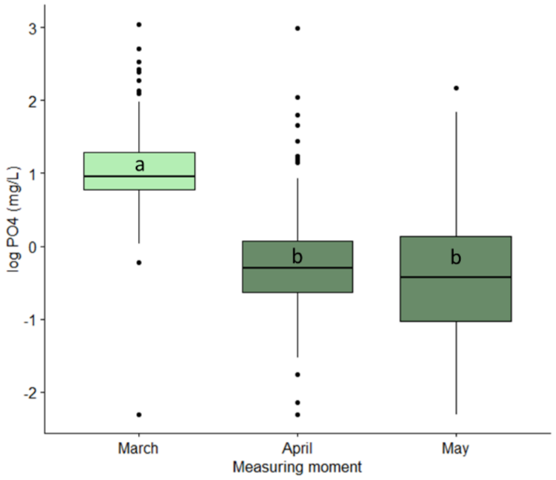

Figure 5 PO_4^{3-} availability over time in the pore water samples. The data is grouped in measuring moment (variable Time). All acquired data from the mesocosm treatment with a constant water table is included and only grouped based on the variables considered within the figure. The remaining variables are neglected, groups from these variables are merged within this display of the data. Within the boxplot, vertical lines indicate the maximum and minimum, horizontal lines the mean, and dots the outliers. Matching letters within the same sampling depth groups indicate that the mean values are not significantly different (p<0,05).

Table 5 Tukey HSD results specifying the significance of the differences between the mean phosphate availability in the treatments. All combinations of the groups within the interacting variables are compared to understand which treatments have a significant impact on the phosphate availability in the mesocosm experiment. The p-value is automatically corrected for the number of tests performed on the same data set. The difference is in mg/L and based on a log scale to maintain consistency throughout the research.

Sampling depth : Water source : Water table			95% confidance	
	diff	p	lwr	upr
Topsoil:Surfacewater:0-Topsoil:Groundwater:0	-0,411	0,242	-0,906	0,085
Topsoil:Surfacewater:-20-Topsoil:Groundwater:-20	0,254	0,927	-0,241	0,750
Topsoil:Surfacewater:-40-Topsoil:Groundwater:-40	0,285	0,844	-0,215	0,784
Topsoil:Surfacewater:-60-Topsoil:Groundwater:-60	-0,285	0,852	-0,789	0,219
Deepsoil:Surfacewater:0-Deepsoil:Groundwater:0	0,031	1,000	-0,464	0,527
Deepsoil:Surfacewater:-20-Deepsoil:Groundwater:-20	-0,086	1,000	-0,582	0,409
Deepsoil:Surfacewater:-40-Deepsoil:Groundwater:-40	-0,112	1,000	-0,611	0,388
Deepsoil:Surfacewater:-60-Deepsoil:Groundwater:-60	0,077	1,000	-0,418	0,573
Deepsoil:Groundwater:0-Topsoil:Groundwater:0	-0,822	0,000	-1,317	-0,326
Deepsoil:Groundwater:-20-Topsoil:Groundwater:-20	0,425	0,193	-0,071	0,920
Deepsoil:Groundwater:-40-Topsoil:Groundwater:-40	0,810	0,000	0,310	1,310
Deepsoil:Groundwater:-60-Topsoil:Groundwater:-60	-0,114	1,000	-0,619	0,390
Deepsoil:Surfacewater:0-Topsoil:Surfacewater:0	-0,380	0,373	-0,875	0,116
Deepsoil:Surfacewater:-20-Topsoil:Surfacewater:-20	0,084	1,000	-0,411	0,580
Deepsoil:Surfacewater:-40-Topsoil:Surfacewater:-40	0,414	0,244	-0,086	0,913
Deepsoil:Surfacewater:-60-Topsoil:Surfacewater:-60	0,248	0,940	-0,248	0,743
Topsoil:Groundwater:-40-Topsoil:Groundwater:-60	-0,478	0,092	-0,987	0,030
Topsoil:Groundwater:-20-Topsoil:Groundwater:-60	0,341	0,602	-0,163	0,845
Topsoil:Groundwater:0-Topsoil:Groundwater:-60	1,625	0,000	1,121	2,130
Topsoil:Groundwater:-20-Topsoil:Groundwater:-40	0,819	0,000	0,319	1,319
Topsoil:Groundwater:0-Topsoil:Groundwater:-40	2,104	0,000	1,604	2,603
Topsoil:Groundwater:0-Topsoil:Groundwater:-20	1,285	0,000	0,789	1,780
Topsoil:Surfacewater:-40-Topsoil:Surfacewater:-60	0,092	1,000	-0,404	0,587
Topsoil:Surfacewater:-20-Topsoil:Surfacewater:-60	0,880	0,000	0,385	1,376
Topsoil:Surfacewater:0-Topsoil:Surfacewater:-60	1,500	0,000	1,004	1,995
Topsoil:Surfacewater:-20-Topsoil:Surfacewater:-40	1,376	0,082	-0,070	2,821
Topsoil:Surfacewater:0-Topsoil:Surfacewater:-40	2,478	0,000	1,032	3,924
Topsoil:Surfacewater:0-Topsoil:Surfacewater:-20	0,620	0,002	0,124	1,115
Deepsoil:Groundwater:-40-Deepsoil:Groundwater:-60	0,446	0,134	-0,050	0,941
Deepsoil:Groundwater:-20-Deepsoil:Groundwater:-60	0,880	0,000	0,385	1,375
Deepsoil:Groundwater:0-Deepsoil:Groundwater:-60	0,918	0,000	0,423	1,414
Deepsoil:Groundwater:-20-Deepsoil:Groundwater:-40	0,434	0,166	-0,061	0,930
Deepsoil:Groundwater:0-Deepsoil:Groundwater:-40	0,472	0,081	-0,023	0,968
Deepsoil:Groundwater:0-Deepsoil:Groundwater:-20	0,038	1,000	-0,457	0,534
Deepsoil:Surfacewater:-40-Deepsoil:Surfacewater:-60	0,257	0,924	-0,242	0,757
Deepsoil:Surfacewater:-20-Deepsoil:Surfacewater:-60	0,717	0,000	0,221	1,212
Deepsoil:Surfacewater:0-Deepsoil:Surfacewater:-60	0,872	0,000	0,377	1,368
Deepsoil:Surfacewater:-20-Deepsoil:Surfacewater:-40	0,459	0,113	-0,040	0,959
Deepsoil:Surfacewater:0-Deepsoil:Surfacewater:-40	0,615	0,003	0,115	1,115
Deepsoil:Surfacewater:0-Deepsoil:Surfacewater:-20	0,156	0,999	-0,340	0,651

Between April and May, the water table level had been decreased to represent the shift from winter (-20 cm from ground level) to summer (-70 cm from ground level). To predict the phosphate availability in this scenario the MAM only includes the main variables sampling depth, water source and table and the interaction between sampling depth and water source. Due to the interacting effects, only the interaction and the table are important to discuss. From the interaction follows that only the deep and topsoil within the water quality groups differ significantly (groundwater with p<0,01 and surface water with p<0,001). Figure 6 shows that there is a significant decrease (p<0,001) in phosphate availability from winter (Mean= 0.833 mg/L) to summer (Mean=0.486 mg/L). Within the data analysation of the seasonal fluctuation no log transformation is performed, the values are the unaltered measurements.

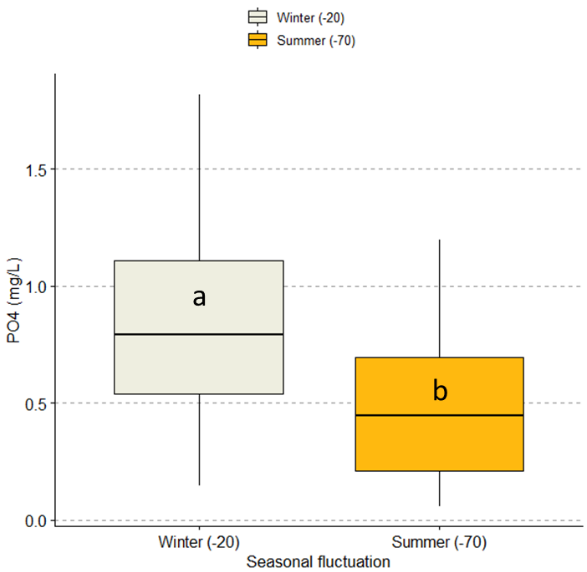

Figure 6 PO_4^{3-} availability throughout seasonal water table fluctuation. The data is grouped in measuring moment, which also specifies the water table level; time and water table group the data identically. All acquired data from the mesocosm treatment with a seasonally varying water table is included and only grouped based on the variables considered within the figure. The remaining variables are neglected, groups from these variables are merged within this display of the data. Within the boxplot, vertical lines indicate the maximum and minimum, horizontal lines the mean, and dots the outliers. Matching letters within the same sampling depth groups indicate that the mean values are not significantly different (p<0,001).

4.3 Ammonium

The model to predict ammonium availability has multiple overlapping two-way interactions (table 2); water table and sampling depth, water table and water source, water table and nutrient application, and sampling depth and nutrient application are also required within the model. The details of interactions, p-values and differences between the various combination of treatments within the interaction, are given in Appendix D. Ammonium values are given on a log scale; negative values indicate that the actual value lies between 0 and 1.

The interaction between the effects of the water table and sampling depth is shown in figure 7. The ammonium concentration in the constantly high, medium, and saturated water treatments is significantly higher (p<0,001) in the deep soil. In the constantly low water treatment, there is no significant difference (p= 0,795) between the top and deep soil (Diff= -0,246) because there is a lower ammonium availability in the deep region of this treatment. Within the topsoil, no significant difference between the water table treatments is identified. Contrary to the deep soil, where all have a significantly different ammonium availability (appendix D) except for the saturated and constantly high-water table treatments (p= 0,988, Diff=0,140). The ammonium availability decreases in the deep region when the water table decreases.

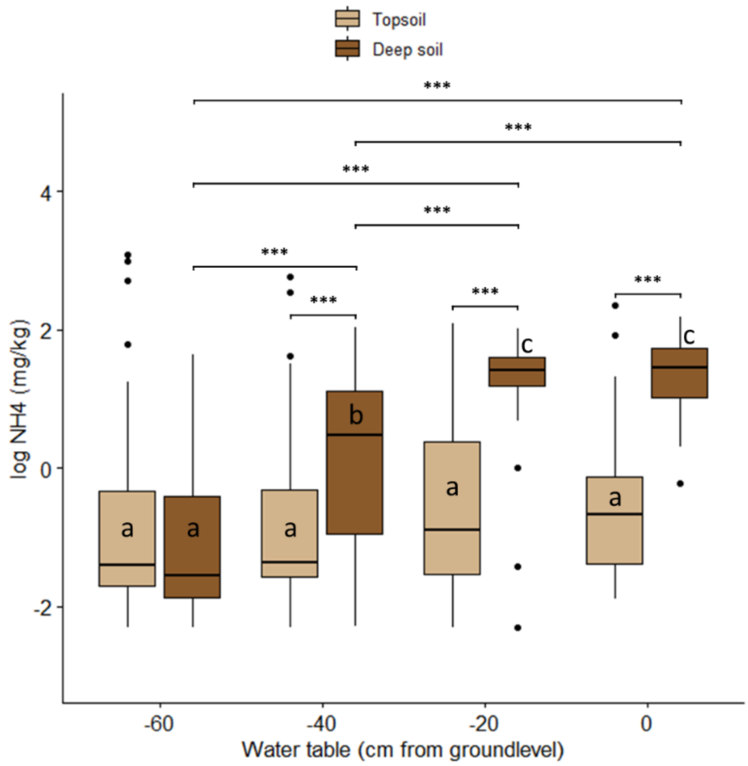

Figure 7 NH_4^+ availability in top- and deep soil pore water samples. The groups from the variables of the water table and sampling depth are included in the figure. All acquired data from the mesocosm with a constant water table is included and only grouped based on the variables considered within the figure. The remaining variables are neglected, groups from these variables are merged within this display of the data. Within the boxplot, vertical lines indicate the maximum and minimum, horizontal lines the mean, and dots the outliers. Matching letters within the same sampling depth groups indicate that the mean values are not significantly different. Significance codes: p<0.001 (***), p<0.01 (**), p<0.05 (*).

There is little difference between the ammonium availability under different water quality treatments when the water table is constant. The only difference between the surface water treatment and groundwater treatment is that there is a slightly lower (non-significant) ammonium availability in the saturated surface water treatment.

Within the interaction between the effects of nutrient application and water table, the saturated and constantly high-water table treatments do not differ much following different nutrient applications. The lower water tables have higher ammonium availabilities when there is no nutrient application, which is in March. The values lower in the low and high nutrient application treatment (data derived in March and April). The values in the high nutrient application are often lower, although the difference between the low and high nutrient application is not significant.

During the shift from the winter to the summer water table the only variable considered necessary following the MAM is the sampling depth. This shows that the change in the water table does not affect the ammonium availability and that the expected concentration can be predicted solely based on the sampling depth. Deep soil has a higher ammonium concentration (M=1.4256939) than the topsoil (M=-0.8461922). There is no significant difference between the total ammonium availability under the winter and summer water table.

4.4 Nitrogen oxides

For nitrogen oxide, the model is relatively simple, described with the interaction between sampling depth and water table and the interaction between nutrients application and water source, prescribed in the MAM. The other variables from the mesocosm experiment do not impact the model's capacity to predict nitrogen oxide availability. Considering the interaction between sampling depth and water table, the topsoil has a significantly lower nitrogen oxide availability in the permanently saturated treatment in comparison to the constant high (p<0,05, Diff=-1,829) and low water table treatments (p<0,05, Diff=-1,913) (figure 8). More significant differences are found in the deep soil, here only the permanently saturated and constant high water table treatments are not significantly different in nitrogen oxide availability (figure VVV). In the low nutrient application treatments, there is a significant difference between the groundwater and surface water treatments, with a lower nitrogen oxide availability in the surface water treatment (p<0,05, Diff=-1,039).

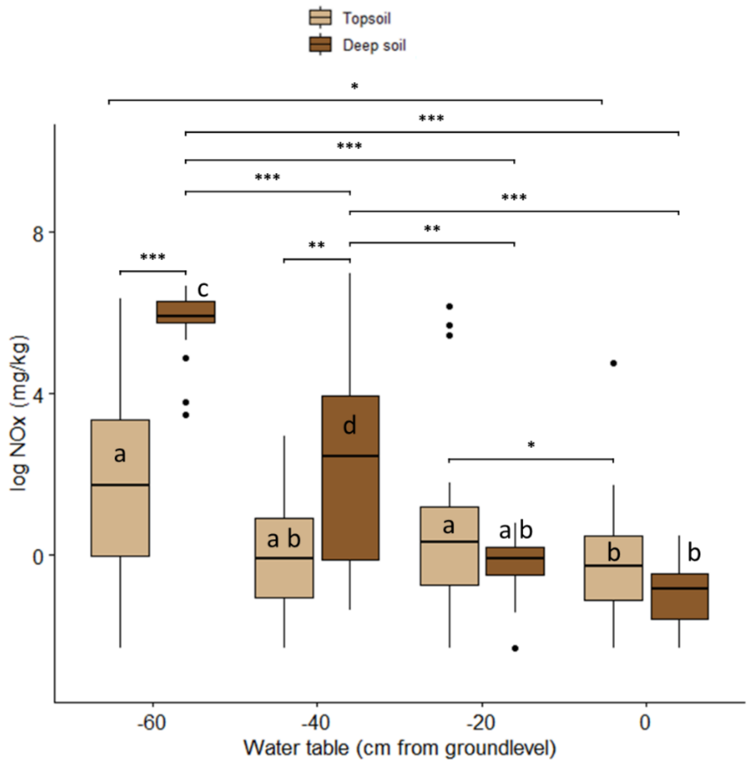

Figure 8 NO_x^- availability in top- and deep soil pore water samples. The groups from the variables of the water table and sampling depth are included in the figure. All acquired data from the mesocosm with a constant water table is included and only grouped based on the variables considered within the figure. The remaining variables are neglected, groups from these variables are merged within this display of the data. Within the boxplot, vertical lines indicate the maximum and minimum, horizontal lines the mean, and dots the outliers. Matching letters within the same sampling depth groups indicate that the mean values are not significantly different. Significance codes: p<0.001 (***), p<0.01 (**), p<0.05 (*).

4.5 Minerals and water properties

The changes in the plant-available nutrients depend on other soil properties, therefore, to understand changes in their availability the changes of these other properties need to be known as well. Additionally, the results from the thank water analyses are discussed, to gain a notion of the hydrological dynamics between the environmental water and the soil pore water.

All elements that impact the phosphate availability, sulphate, iron, calcium and aluminium, show significantly higher concentrations within the deep soil pore water samples (p<0,001). For Iron, the availability within the pore water also increases with increasing water tables, mainly in the deep soil (the difference between the low and saturated treatments as an indication; p<0,001, Diff0:-60 =3,982) but also in the topsoil (p<0,001, Diff0:-60 = 3,402). Further dynamics only prescribe small variabilities in the availability and are not important within this research.

To predict the pH of the pore water, the interaction between the water table and the sampling depth and the main variables water source, nutrient application, and time are required, following from the MAM. pH is fitted with a log transformation, so all results are on a log scale. The pH values are significantly (p<0,001) higher in the topsoil compared to the deep soil within the same water table treatment (Diff0 =-0,403, Diff-20=-0,430 Diff-40=-0,756, Diff-60=-0,421). Within the deep soil specifically, the saturated treatment has a significantly (p<0,001) higher pH (Diff 0:-20 =0,330 , Diff 0:-40= 0,509, Diff 0:-60=0,546). The pH decreased slightly over time, but only the decrease from April to May was significant (p<0,01, Diff=-0,171). The two water sources also influence the pH significantly (p<0,05), with a slightly higher pH in the surface water treatments (Diff= 0,092).

The nutrients, minerals, pH, electroconductivity and alkalinity within the tank water are given in table 6. **Appendix E** includes all weekly EC and pH tank water measurements to monitor changes and ensure consistency in the independent variables and enable the interpretation of the results and explain possible deviations. The iron and aluminium concentration in the surface water was higher in March. The Al and Fe concentration in April was approximately equal in surface water and groundwater, at a value that was approximately in between the values of March. Sulphate concentrations were higher in the tanks with surface water (Mean=4,65) than with groundwater (Mean=3,84). Likewise, nitrogen oxides concentrations in surface water (Mean=3,33) were higher than in groundwater (0,64) fed tanks. Ammonium in the tank water decreases with time, however, in May, the groundwater tanks displayed an increased ammonium concentration. Phosphate remained relatively stable, except for the surface water concentration in April, which was lower compared to groundwater tanks and compared to the other measuring moments.

Table 6 Plant-available nutrients, minerals, and other water properties in the tank water samples in March, April and May, data is given on a log scale to maintain consistency throughout the research. Negative values indicate an actual value between 0 and 1, the actual values follow from using the mean value as the power of 2 (2^x). Each tank represents one treatment in the full-factorial mesocosm design. The treatments are composed out of all group combinations between the three variables; nutrient application with high (H) and low (L) nutrient application groups, water quality with surface water (S) and groundwater (G) groups, and water table with constantly low (-60 cm from ground level), constantly medium (-40 cm from ground level), constantly high (-20 cm from ground level), permanently saturated (-0 cm from ground level), and a seasonal flux (-70: -20 cm from ground level).

	Tank	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
	Nutrient application	L	L	H	H	L	L	H	H	L	L	H	H	L	L	H	H	L	L	H	H
	Water quality	G	S	G	S	G	S	G	S	G	S	G	S	G	S	G	S	G	S	G	S
	Water table	-60	-60	-60	-60	-40	-40	-40	-40	Flux	Flux	Flux	Flux	-20	-20	-20	-20	0	0	0	0
PO4	March	0,70	0,34	0,43	0,29	0,56	0,34	0,53	0,18	0,50	0,43	0,46	0,29	0,50	0,34	0,46	0,39	0,53	0,34	0,53	0,50
	April	-0,24	0,35	-0,38	0,29	-0,33	0,39	-0,33	0,37	-0,39	0,42	-0,31	0,50	-0,39	0,46	-0,26	0,45	-0,39	0,65	-0,39	0,45
	May	0,59	0,71	1,23	0,58	0,35	0,44	0,52	0,52	0,76	0,79	0,80	0,65	0,42	0,38	0,47	0,42	0,18	0,08	1,94	0,28
Mean		0,35	0,47	0,43	0,39	0,19	0,39	0,24	0,36	0,29	0,54	0,32	0,48	0,18	0,40	0,22	0,42	0,10	0,36	0,69	0,41
NH4	March	0,44	0,39	0,47	0,25	0,39	0,06	0,38	0,10	0,24	0,01	0,24	-0,07	0,25	0,00	0,25	0,62	0,15	-0,05	0,13	-0,10
	April	0,16	0,11	0,09	-0,08	-0,59	-0,29	-0,04	-0,39	-0,39	-0,49	-0,46	-0,53	-0,49	-0,45	-0,33	-0,42	-0,62	-0,80	-0,63	-0,61
	May	-0,52	0,16	0,54	0,01	-0,62	0,25	-0,59	0,20	-0,22	0,19	-0,22	0,24	-0,70	0,24	-0,59	0,24	-0,77	0,09	-0,86	0,13
Mean		0,03	0,22	0,36	0,06	-0,28	0,01	-0,09	-0,03	-0,12	-0,09	-0,15	-0,12	-0,31	-0,07	-0,22	0,15	-0,41	-0,25	-0,45	-0,20
NOx	March	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
	April	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
	May	0,82	0,59	1,26	0,56	1,68	0,31	1,30	0,32	1,63	-0,35	1,56	0,04	1,50	0,24	1,55	0,03	1,60	0,24	1,56	0,85
Mean		0,82	0,59	1,26	0,56	1,68	0,31	1,30	0,32	1,63	-0,35	1,56	0,04	1,50	0,24	1,55	0,03	1,60	0,24	1,56	0,85
Fe	March	0,40	-0,85	0,29	-0,14	0,33	-0,88	0,45	-0,85	0,33	-0,53	0,29	-0,86	0,28	-0,36	0,51	-0,26	0,48	-0,67	0,48	-1,00
	April	0,21	0,16	-0,15	0,07	-0,20	0,39	0,06	0,16	-0,16	0,05	-0,04	-0,20	-0,02	0,10	0,44	-0,21	0,04	-0,03	0,12	-0,02
	May	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Mean		0,31	-0,35	0,07	-0,04	0,07	-0,24	0,25	-0,34	0,09	-0,24	0,12	-0,53	0,13	-0,13	0,47	-0,24	0,26	-0,35	0,30	-0,51
SO4	March	2,22	2,03	2,12	2,05	1,97	1,65	2,01	1,72	1,98	1,64	1,95	1,30	1,96	1,80	2,06	1,57	1,96	1,46	1,98	1,42
	April	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
	May	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Mean		2,22	2,03	2,12	2,05	1,97	1,65	2,01	1,72	1,98	1,64	1,95	1,30	1,96	1,80	2,06	1,57	1,96	1,46	1,98	1,42
Al	March	-0,44	-0,88	-0,51	-0,94	-0,41	-0,81	-0,29	-1,00	-0,36	-0,80	-0,37	-0,91	-0,41	-0,82	-0,34	-0,82	-0,36	-0,94	-0,37	-0,76
	April	-0,71	-0,81	-0,70	-0,76	-0,69	-0,84	-0,69	-0,70	-0,68	-0,84	-0,70	-0,77	-0,83	-0,69	-0,73	-0,74	-0,78	-0,69	-0,80	-0,69
	May	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Mean		-0,58	-0,85	-0,60	-0,85	-0,55	-0,83	-0,49	-0,85	-0,52	-0,82	-0,53	-0,84	-0,62	-0,76	-0,53	-0,78	-0,57	-0,82	-0,59	-0,72
Ca	March	2,15	2,09	2,09	2,17	1,97	1,97	1,99	1,99	1,94	2,03	1,90	1,95	1,91	2,01	2,10	2,00	2,05	1,99	2,05	1,96
	April	1,94	1,33	1,80	1,15	1,80	1,40	1,84	1,29	1,83	1,28	1,86	1,64	1,24	1,89	1,61	1,81	1,33	1,82	1,34	1,84
	May	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Mean		2,05	1,71	1,95	1,66	1,89	1,69	1,92	1,64	1,88	1,65	1,88	1,80	1,57	1,95	1,86	1,90	1,69	1,91	1,69	1,90
pH	March	0,85	0,86	0,86	0,86	0,87	0,87	0,88	0,88	0,88	0,88	0,88	0,88	0,88	0,88	0,88	0,87	0,88	0,88	0,88	0,88
	April	0,88	0,89	0,88	0,89	0,87	0,88	0,87	0,88	0,87	0,87	0,87	0,87	0,87	0,87	0,87	0,87	0,88	0,88	0,87	0,88
	May	0,87	0,87	0,87	0,88	0,88	0,89	0,87	0,89	0,85	0,86	0,85	0,88	0,87	0,89	0,87	0,91	0,89	0,92	0,89	0,93
Mean		0,86	0,87	0,87	0,88	0,87	0,88	0,87	0,88	0,87	0,87	0,87	0,88	0,88	0,88	0,87	0,88	0,88	0,89	0,88	0,89
EC	March	2,99	3,12	2,93	3,13	2,84	3,10	2,86	3,08	2,83	3,13	2,78	3,10	2,79	3,14	2,93	3,12	2,89	3,11	2,89	3,08
	April	2,79	3,12	2,78	3,12	2,78	3,11	2,78	3,11	2,78	3,11	2,78	3,11	2,78	3,11	2,78	3,11	2,78	3,11	2,78	3,11
	May	2,72	3,04	2,85	3,05	2,73	3,05	2,76	3,03	2,88	3,13	2,83	3,06	2,72	3,06	2,77	3,04	2,73	3,05	2,75	3,06
Mean		2,83	3,10	2,85	3,10	2,78	3,09	2,80	3,07	2,83	3,12	2,80	3,09	2,76	3,10	2,83	3,09	2,80	3,09	2,81	3,08
Alk	March	2,08	2,15	2,15	2,15	2,15	2,00	2,08	2,20	2,15	2,20	2,00	2,15	2,08	2,26	2,00	2,20	2,08	2,20	2,15	2,20
	April	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
	May	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Mean		2,08	2,15	2,15	2,15	2,15	2,00	2,08	2,20	2,15	2,20	2,00	2,15	2,08	2,26	2,00	2,20	2,08	2,20	2,15	2,20

5. Discussion

Within the Netherlands, the aim was to reduce decomposition rates within peat meadows, to decrease land subsidence and carbon emission (van der Ree et al., 2019). A promising method to achieve this is by rewetting formerly drained agricultural peat meadows (Hoekstra et al., 2020). In the past, the water tables have been artificially lowered to increase land productivity. Past changes in the water table led to the unforeseen consequences of increased decomposition rates. It is important to understand the hydrochemical responses of formerly drained peatlands on rewetting to foresee and manage possible negative effects. Rewetting approaches can be implemented for a variety of land use purposes, ranging from business-as-usual dairy farming to nature restoration. The full-factorial mesocosm experiment makes it possible to systematically unravel the impact of a broad range of variables, and their interactions, on the hydrochemical processes of formerly drained agricultural land (Lamers et al., 2015). The full-factorial design starts with a large array of variables and interactions included in the description of the hydrochemical responses. This maximum model was reduced step by step until only the necessary variables and interactions are identified to explain the hydrochemical observations. This is the minimal adequate model (MAM), from this model the relations between the variables and the hydrochemical processes can be understood in more detail. The processes seen within the mesocosm are now discussed in more detail following the hypotheses.

Within the mesocosm experiment, the expected (H1) phosphate boost stemming from internal eutrophication after the rewetting of formerly drained agricultural peat meadows cannot be conclusively confirmed but the data does suggest that the underlying dynamics that substantiate the phosphate boost occur. Time is not included as a necessary variable within the MAM that describes phosphate availability. This means that the model that does and does not include time as a variable did not significantly ($p<0,05$) differ in their accuracy to describe the observed phosphate availability within the mesocosm. However, the saturated water treatment has a higher phosphate availability in March (figure 9). This trend between the water table treatments is seen and even becomes more evident over time. The phosphate availability in the deep soil is higher in the treatments with the higher water table (0 and -20 cm below ground level). In the topsoil, the saturated treatment is significantly higher than all other water table treatments. This indicated that the anoxic state of the topsoil in the saturated treatment increases phosphate availability. However, over time, the decrease in phosphate availability in oxic regions seems to play a larger role considering phosphate availability (figure 9). This is in line with the theory that Iron is oxidized from Fe^{2+} to Fe^{3+} in unsaturated soils, this iron form binds stronger to phosphate (Smolders et al., 2013; Zak et al., 2010). This process is also seen within the iron availability, which increases in the pore water with increasing water tables, i.e., in anoxic soil regions. The iron-binding of the soluble phosphorous stores the phosphorous in the soil in organic compounds. This phosphorous is unavailable for plants and not included in the measurements. This process could explain the observed reduction of plant-available phosphate in oxic regions. The peat columns were collected in the winter, therefore, the conditions upon collection were relatively wet (i.e., anoxic). This means that phosphate was probably already largely present within the peat columns as soluble reactive phosphorous, and the mesocosm results mainly displayed the effect drainage on the phosphate content within the soil pore water.

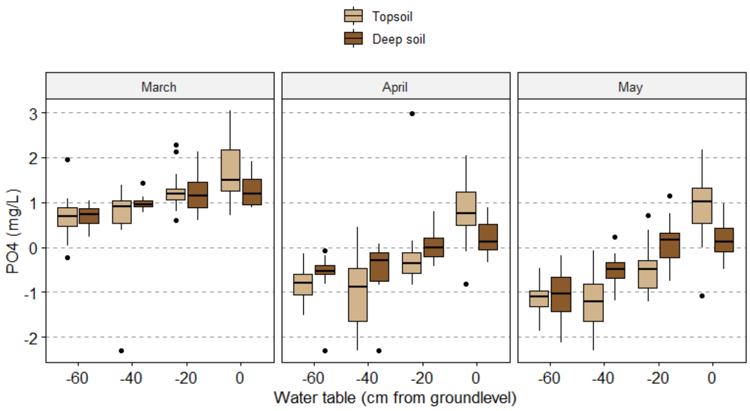

Figure 9 PO_4^{3-} availability in top- and deep soil pore water samples. The groups from the variables of the water table, sampling depth and sampling moment are included in the figure. All acquired data from the mesocosm with a constant water table is *included and only grouped based on the variables considered within the figure. The remaining variables are neglected, groups from these variables are merged within this display of the data. Within the boxplot, vertical lines indicate the maximum and minimum, horizontal lines the mean, and dots the outliers.*

The surface water used as a water source has a higher sulphate concentration than the groundwater (Table 6). This increased sulphate is not seen in the pore water region (appendix B). It is possible that the sulphate was bound to iron and was, therefore, undetected within the pore water. In theory, the increased sulphate would mean an increased competition over iron particles to bind to, which would lead to an iron shortage and a higher phosphate availability (Dijk et al., 2019; van der Grift et al., 2018). However, there was not a significantly higher phosphorous nor significantly lower iron availability observed within the surface water treatments. The expected (H2) increase of phosphate availability in surface water treatments stemming from the iron-sulphate-phosphate dynamic is not confirmed within the mesocosm experiment.

The hydrochemical dynamics that alter the ammonium concentration are related to the pH and the oxic state of the soil (Cusell, Kooijman, & Lamers, 2014; Paulissen et al., 2016). The availability of ammonium and nitrogen oxides roughly follows the line of expectation based on the oxic state, where (H3) the ammonium availability is higher in anoxic soil regions than in oxic conditions and the reversed trend is seen in the nitrogen oxide availability. The dynamic driven by the oxic state is also seen within the internal column dynamics between the soil layers. The deeper (anoxic) soil has a higher ammonium availability. Interestingly, this difference between the soil regions is also evident in the permanently saturated water treatment, while both the top and deep soils were in an anoxic state. The positive relation between the water table and ammonium availability can be seen in the deep soil, where there is a significant increase in ammonium from the constant low to constant medium to the constant high water table treatment. Between the high and permanent saturation water table treatments there is no change in ammonium availability. This is expected because these treatments have the same anoxic state in the deep soil region. The deep soil pore water is sampled at -40 cm and the water table is also -40 cm in the medium water table treatment, therefore this deep soil probably shifts between oxic and anoxic states, leading to ammonium availability higher than in permanently dry and lower than in permanently wet conditions. No significant change in ammonium availability is identified between the oxic (-20, -40 and -60 cm from ground level) and anoxic (0 cm from ground level) topsoil conditions. The ammonium levels in the topsoil of the saturated treatment did not have an increased ammonium availability, while this is expected following the theory. The ammonium possibly leached out of the topsoil to lower soil layers and was therefore undetected in the topsoil pore water.

Nitrogen oxide levels measured within the mesocosm are very low (Cusell et al., 2013; Paulissen et al., 2016). The nitrogen oxides are measured in micromole/L, when these values are converted into mg/L, the measurements need to be multiplied by the Molar mass*10^{-6} (NO_2^- = 46,006 g/mol and NO_3^- = 62,005g/mol). The low nitrogen oxide levels could be the result of leaching or from inhibited nitrification caused by the pH value in the pore water. The pore water samples all had a mean pH below 6, meaning that the nitrification rate was only 10-20% from the rate at a pH of 7 (Paulissen et al., 2016). Additionally, nitrogen oxides are soluble in water and therefore move easily through the soil, leading to the loss of nitrogen oxides to surrounding water bodies. This leaching could boost nitrogen availability in these water bodies and cause eutrophication. The surface water in the tanks had a higher nitrogen oxide concentration compared to groundwater, however, this difference was not seen in the soil pore water. Unfortunately, there was only one measuring moment of nitrogen oxide in the pore water and the tank water. This means that it is not possible to conclusively state something about the dynamics of eutrophication, because it remains unclear whether the increased nitrogen oxide in the surface water was a property of the surface water itself that does not impact the pore water composition, or whether the nitrification rates were higher in the surface water treatment leading to increased nitrogen oxide values in the tank water due to leaching. However, there is no difference in pH between the surface (Mean=2,01) and groundwater (Mean=2,03) in the tanks and only a slightly higher pH in the pore water on the surface water treatment ($p<0,05$, Diff=0,092), so there is probably no substantial difference between the nitrification rates in both water quality treatments.

Between the high and low nutrient applications, little difference in nutrient availability was identified. Within this research (H4) the nutrient quantities applied on the peat cores did not change the nutrient availability of the soil pore water. Smolders et al (2013), state that the larges phosphate content stems from previous fertilization, this is in line with the findings of this research, where internal processes outweigh the importance of external inputs. Nitrogen leaches out easily and is not stored within the soil, internal eutrophication is therefore not a factor. However, no increase in nitrogen content was identified following increased nutrient input of surface water use.

Concerning large scale implementation of submerges and pressurized drainage, this research confirms the increased availability of phosphorous and nitrogen expected within rewetted peat meadows (Cusell, Kooijman, & Lamers, 2014). The hydrochemical processes studies in the peat soil indicate the relation between the oxic state of the soil and dominant soil processes because a relationship is seen between increased water table levels and increase plant-available nutrient concentrations in the soil pore water. The influx of new nutrients, from fertilization or the water source, did not have a substantial impact on the nutrient availability within the mesocosm.

The experiment was explorative and should be interpreted as such. Multiple, slight, changes in the sampling method, set-up and data measuring techniques occurred throughout the project bases on insights gained through practice. An important change from the first measuring moment was the acidification of part of the samples during sampling, this was not done in the initial measurement series. In unacidified samples, the phosphorous and iron particle can bind and precipitate within the sample because the samples came in contact with oxygen. This means that the phosphorous and iron is not homogeneously diluted in the sampled and the concentration measured could deviate from the actual phosphate availability in the samples. This could explain why there was no higher phosphate boost observed in the anoxic regions, but that remains uncertain. Due to time restraints and multiple machines malfunctioning the sample analyses with the IC and discrete analyser were not performed, or delayed, and part of the envisioned results could not be included within this research. The samples were frozen to remain useable and will be analysed for further research.

This research is an element of a larger multi-year research project into the impact of various rewetting approaches on the biodiversity in peatlands within the Netherlands. This research generated a basic notion of hydrochemical processes, unravelled in an experimental setup. The insights of this investigation can be used to interpret the hydrochemical processes from nutrient availability in future field research. The nutrient availability impacts the biodiversity and productivity of the land (Güsewell & Koerselman, 2002). It would be interesting to gain a more detailed understanding of the influence of the hydrochemical processes on biodiversity. Additionally, the information gained is highly practise oriented. Therefore, it is important to assess the impact of the hydrochemical processes, and eventually biodiversity, considering a variety of land use purposes. To restore natural fens, natural boosts can lead to biodiversity losses because dominant species outcompete less dominant but naturally essential species (Klimkowska et al., 2019; Verhoeven et al., 2006; Wassen et al., 1996). However, in the business-as-usual dairy farming practice and nutrient overload might not pose a problem if leaching is prevented. Follow up research into the relation of water quality on the nutrient dynamic, surface water is highly heterogeneous (Cusell et al., 2013). This study only included surface water won from one location, it is important to gain a more detailed understanding of the impact of water quality with the use of a variety of surface water sources and their respective hydraulic characteristics. Like surface water, peat soils are also highly homogeneous (Lamers et al., 2015; Vasander et al., 2003). Additionally, the electroconductivity of the pore and tank water, in both water quality treatments, was high. This indicates that the peat cores had a relatively high salt content, which could be the result of long-term hydraulic connectivity with brackish groundwater (Verplanck et al., 2000). Reproduction of the experiment with peat cores samples from different sites must determine whether the data is representative of formerly drained agricultural peat meadows in the Netherlands.

Peat is highly diverse and ecologically essential in combatting land subsidence and consequently greenhouse gas emission. The long-lasting land management approach of artificially decreased water tables on agricultural sites has altered the peatland properties from a carbon sink to a carbon source (Tanneberger et al., 2020). These consequences were discovered well after implementation. In the rewetting of formerly drained agricultural sites, it is important to assess the consequences timely for successful implementation on a large scale. This research attempted to unravel the influence of the water table, water quality and nutrient application, that combined create a full-factorial set of 20 rewetting treatments, on the hydrochemical processes of formerly drawing agricultural peat. The nutrient availability measured in the mesocosm confirm the relation between increased water table levels and increase plant-available nutrient concentrations in the soil pore water. The oxic state of the soil influences the hydrochemical processes in the soil substantially, and influence the plant-available nutrient concentration in the pore water. The influx of new nutrients, from fertilization or the water source, did not have a substantial impact on the nutrient availability within the mesocosm.

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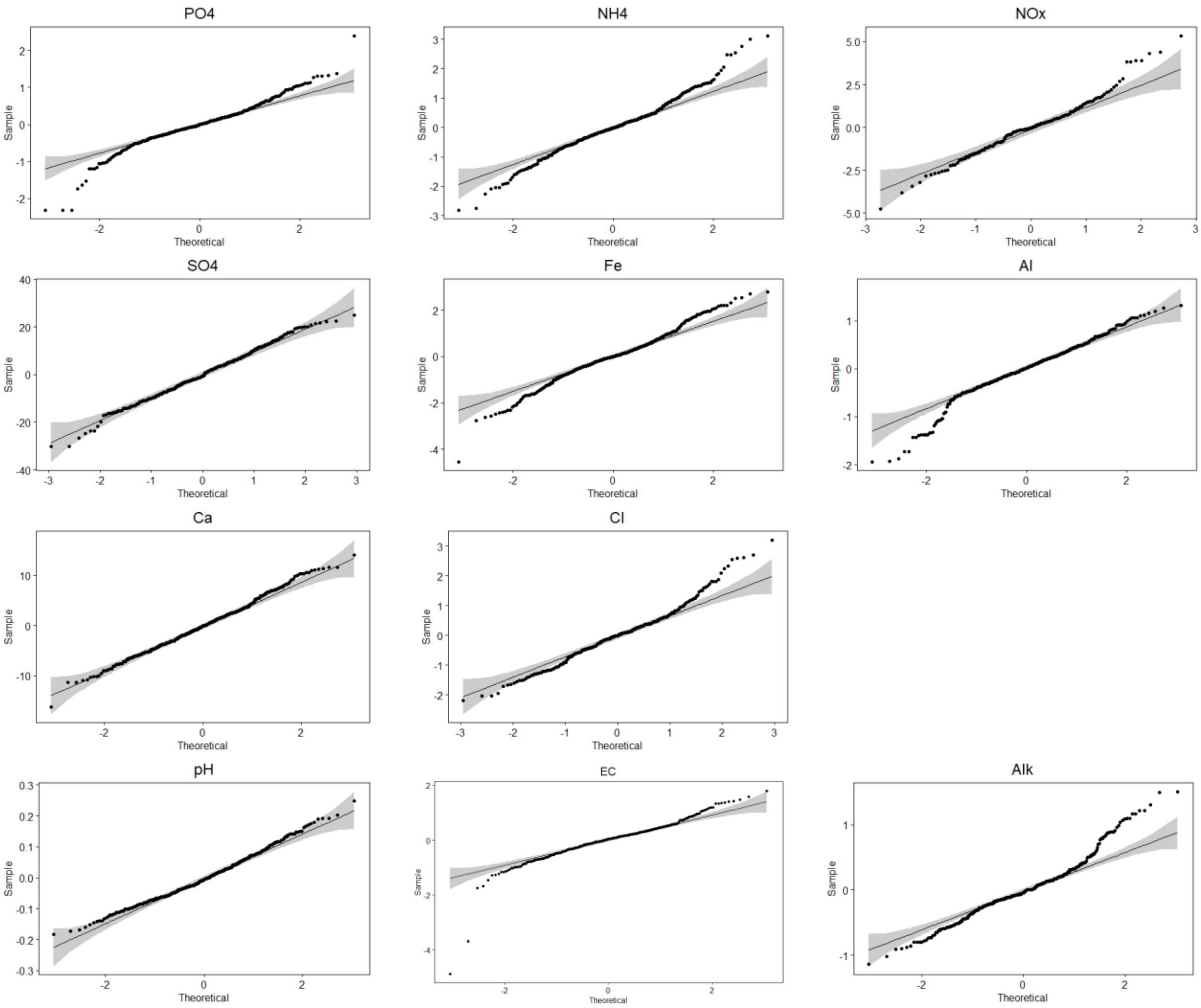
Appendix A

Q-Q plots used to assess the distribution of data.

The regression line indicates the expected values, and the dots represent the values measured within the mesocosm. When the data follows the regression lines approximately, the data is considered to meet the assumptions for further statistical analysis. The data on seasonal fluctuation meets the assumptions significantly as well (Shapiro.wilk >0,05, Levene.test >0,05), these Q-Q plots are therefore not included.



Appendix B

Mean availability in the full-factorial mesocosm experiment.

Mean availability of phosphate (PO4, mg/L), ammonium (NH4, mg/L), nitrogen oxides (NOx, uM), iron (Fe, mg/kg), aluminium (Al, mg/kg), calcium (Ca, mg/kg), chloride (Cl, mg/L), pH (pH), electroconductivity (EC, uS) and alkalinity (Alk) measured in the pore water samples for each treatment within the full-factorial mesocosm design for each month. The data is not log-transformed and before acquiring this information, so the actual data is shown.

		March															
		No															
		-60				-40				-20				0			
		G		S		G		S		G		S		G		S	
		Top	Deep	Top	Deep	Top	Deep	Top	Deep	Top	Deep	Top	Deep	Top	Deep	Top	Deep
PO43-	n	9	10	10	10	10	10	10	9	10	10	10	10	10	10	10	10
	Mean	2,5	1,9	1,7	1,9	1,9	2,4	2,3	2,8	3,7	3,4	3,7	3,5	7,5	3,4	5,7	3,8
	SE	1,7	0,5	0,7	0,4	1,4	0,3	0,6	0,5	1,9	1,1	2,2	1,9	6,2	1,2	3,6	1,4
NH4+	n	10	10	10	10	9	9	10	10	10	10	10	10	10	10	10	10
	Mean	3,2	0,6	4,2	1,9	0,9	3,0	4,4	3,4	2,6	4,3	3,0	4,1	2,5	4,3	1,1	3,9
	SE	6,6	0,6	7,1	1,8	0,8	1,3	5,5	2,0	2,4	0,7	2,6	0,9	3,3	2,2	1,3	1,6
Nox-	n	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
	Mean	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
	SE	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Fetot	n	10	10	10	10	9	10	10	9	10	10	10	9	10	10	10	10
	Mean	0,6	0,5	1,0	1,5	1,9	16,8	2,9	22,6	15,1	55,0	19,3	54,8	28,6	58,7	24,8	44,4
	SE	0,5	0,2	1,0	2,3	2,2	12,8	3,0	23,1	18,5	32,0	32,8	36,3	19,8	45,2	33,2	30,2
Al2+	n	10	10	10	10	9	10	10	9	10	10	10	10	10	10	10	10
	Mean	0,9	1,0	1,1	1,4	1,3	1,6	1,2	2,5	1,7	2,2	1,7	2,2	1,0	1,7	1,2	1,7
	SE	0,6	0,3	0,6	0,8	1,0	0,4	0,6	1,1	0,5	1,0	1,2	1,0	0,5	0,6	1,0	1,1
Ca+	n	10	10	10	10	9	10	10	9	10	10	10	10	10	10	10	10
	Mean	265,8	480,3	295,0	490,4	108,7	508,9	138,1	481,1	177,6	401,2	194,3	419,8	230,8	505,1	227,5	537,5
	SE	188,9	145,4	228,1	154,2	161,5	127,5	151,4	186,3	192,3	172,1	208,7	122,0	60,4	283,3	157,0	157,5
pH	n	8	10	8	10	6	10	10	10	10	10	10	10	10	10	10	10
	Mean	5,5	5,2	5,5	5,1	6,0	5,0	6,1	5,2	5,8	5,4	5,9	5,4	6,0	5,7	6,4	5,8
	SE	0,4	0,2	0,4	0,4	0,4	0,1	0,4	0,5	0,5	0,4	0,5	0,4	0,3	0,5	0,6	0,6
EC	n	8	10	8	10	6	10	10	10	10	10	10	10	10	10	10	10
	Mean	1635,8	2385,9	2107,7	2455,1	868,0	2549,4	901,9	1880,0	927,8	2423,5	1190,2	2193,7	1816,6	2491,1	1171,6	2477,7
	SE	984,6	666,9	834,9	727,9	836,8	551,2	781,2	1012,3	955,2	1006,9	1155,0	627,3	709,9	1070,8	837,8	740,0
ALK	n	6	6	6	10	2	8	5	8	10	10	10	10	10	9	10	10
	Mean	43,3	53,3	40,0	46,0	40,0	52,5	48,0	100,0	74,0	86,0	74,0	96,0	144,0	104,4	176,0	174,0
	SE	8,2	10,3	17,9	13,5	0,0	18,3	22,8	73,3	29,9	26,8	28,4	26,3	74,1	24,0	126,8	157,5

April

		Low -60				Low -40				Low -20				Low 0			
		G		S		G		S		G		S		G		S	
		Top	Deep	Top	Deep	Top	Deep	Top	Deep	Top	Deep	Top	Deep	Top	Deep	Top	Deep
PO43-	n	4	5	5	5	4	5	5	5	5	5	5	5	5	5	5	5
	Mean	0,4	0,3	0,3	0,5	0,3	0,7	0,3	0,6	0,7	1,1	0,5	1,0	3,4	0,9	2,9	1,2
	SE	0,1	0,3	0,1	0,1	0,3	0,3	0,2	0,4	0,1	0,4	0,1	0,7	1,4	0,2	2,8	0,5
NH4	n	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
	Mean	0,1	0,1	0,1	0,2	0,1	1,5	0,2	2,7	0,4	2,5	0,1	2,6	1,2	4,0	0,3	4,0
	SE	0,1	0,0	0,0	0,2	0,0	1,1	0,2	2,5	0,4	1,6	0,1	1,5	1,2	1,5	0,3	1,4
Nox	n	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
	Mean	59,8	380,1	2,0	299,5	4,4	22,6	0,4	43,7	47,7	0,8	60,5	0,7	24,6	0,7	0,8	0,4
	SE	86,3	64,1	2,4	225,4	8,1	35,8	0,5	85,2	103,8	0,7	134,0	0,2	51,1	0,6	0,9	0,3
Fe	n	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
	Mean	0,5	0,5	0,7	1,7	1,0	23,0	0,9	47,7	15,4	49,3	2,3	44,3	34,1	46,6	20,0	60,1
	SE	0,4	0,2	0,4	2,4	0,6	23,1	0,5	43,7	22,9	21,7	3,0	20,7	22,4	27,6	18,6	32,3
Al	n	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
	Mean	0,9	1,2	1,1	1,4	0,9	1,6	0,7	2,3	1,4	1,6	0,8	1,7	1,0	1,6	0,7	1,7
	SE	0,6	0,4	0,8	0,9	0,5	0,3	0,3	1,3	0,7	0,5	0,2	0,5	0,7	0,4	0,4	0,8
Ca	n	4	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
	Mean	344,2	415,2	240,8	432,8	69,7	467,8	136,4	417,7	126,1	423,2	135,9	357,2	233,9	425,0	256,3	513,8
	SE	251,2	189,6	196,0	181,1	24,4	96,7	129,4	206,3	105,3	103,7	166,1	85,7	127,9	222,6	115,7	129,1
pH	n	2	3	5	5	4	5	5	5	5	5	5	5	4	5	5	5
	Mean	5,1	5,2	5,6	5,1	5,9	5,0	5,9	5,5	5,7	5,1	5,7	5,3	6,0	5,4	5,9	5,4
	SE	0,3	0,2	0,7	0,5	0,3	0,1	0,6	0,7	0,5	0,2	0,4	0,3	0,4	0,4	0,5	0,5
EC	n	2	3	5	5	4	5	5	5	5	5	5	5	4	5	5	5
	Mean	2685,0	2406,7	1234,0	2220,4	544,5	2524,0	740,4	2178,6	816,4	2488,0	861,2	1922,6	1706,5	2349,6	1539,8	2686,2
	SE	813,2	932,9	935,6	868,8	181,0	479,3	629,6	1101,4	590,1	296,8	907,8	474,9	818,4	1171,2	587,4	820,2
ALK	n	2	3	3	5	2	5	5	5	5	5	5	5	4	5	5	5
	Mean	60,0	60,0	46,7	60,0	50,0	56,0	76,0	116,0	68,0	88,0	80,0	148,0	220,0	128,0	184,0	140,0
	SE	0,0	20,0	11,5	14,1	14,1	8,9	47,7	76,7	17,9	11,0	46,9	41,5	112,0	30,3	211,4	90,6

		High -60				High -40				High -20				High 0			
		G		S		G		S		G		S		G		S	
		Top	Deep	Top	Deep	Top	Deep	Top	Deep	Top	Deep	Top	Deep	Top	Deep	Top	Deep
PO43-	n	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
	Mean	0,5	0,6	0,4	0,5	0,4	0,6	0,5	0,5	0,5	1,0	4,7	0,9	3,1	1,5	1,3	1,2
	SE	0,2	0,2	0,3	0,1	0,4	0,1	0,6	0,2	0,2	0,2	8,4	0,2	1,8	0,6	0,4	0,4
NH4	n	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
	Mean	1,4	0,1	0,2	0,3	0,1	1,4	0,1	0,9	0,1	3,8	0,4	3,4	0,3	3,5	0,3	2,7
	SE	2,5	0,0	0,1	0,6	0,1	1,4	0,1	1,0	0,1	0,9	0,3	1,1	0,2	1,8	0,5	1,2
Nox	n	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
	Mean	134,7	493,0	22,8	433,0	4,0	26,1	4,7	237,1	1,7	1,3	96,8	0,9	1,1	0,2	0,5	0,3
	SE	251,4	256,0	31,8	217,9	4,7	27,5	5,8	465,8	2,4	0,8	210,3	0,6	0,6	0,2	0,7	0,2
Fe	n	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
	Mean	0,6	0,4	0,8	0,5	2,2	23,0	2,3	21,5	3,5	54,2	32,3	68,9	25,0	67,1	25,2	33,7
	SE	0,2	0,1	0,2	0,1	2,8	29,7	2,7	28,8	2,5	28,3	40,0	47,6	9,2	51,8	36,7	23,9
Al	n	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
	Mean	0,9	1,1	1,0	1,6	1,4	1,5	1,2	1,8	1,0	2,0	1,2	2,5	0,9	1,8	1,2	1,4
	SE	0,5	0,2	0,5	0,4	0,6	0,3	0,4	0,8	0,2	0,6	0,1	1,4	0,6	0,6	1,0	1,3
Ca	n	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
	Mean	296,5	494,7	242,6	473,8	131,5	411,2	119,9	403,1	152,3	399,7	204,8	396,0	214,7	414,6	210,8	412,4
	SE	221,3	76,1	235,8	120,6	168,3	118,4	98,4	108,0	175,3	168,7	143,2	145,8	67,4	279,2	155,4	111,1
pH	n	4	5	3	5	4	5	4	5	5	5	5	5	4	5	5	5
	Mean	5,5	5,1	5,5	4,9	5,7	5,0	5,7	5,1	5,6	5,2	5,8	5,1	5,8	5,4	6,0	5,8
	SE	0,5	0,1	0,4	0,2	0,5	0,2	0,3	0,2	0,3	0,3	0,3	0,3	0,4	0,5	0,7	0,9
EC	n	4	5	3	5	3	5	4	5	5	5	5	5	4	5	5	5
	Mean	1800,3	2299,2	1793,7	2409,6	1117,7	2301,2	903,5	2150,8	957,2	2261,6	1311,2	1701,6	1570,8	2685,4	1188,2	2032,2
	SE	953,0	575,7	1283,7	562,9	1159,5	590,7	626,1	491,9	999,7	894,1	781,3	1090,8	306,1	1368,4	690,1	408,3
ALK	n	3	4	3	5	2	5	2	4	5	5	5	5	4	5	5	5
	Mean	46,7	55,0	53,3	48,0	40,0	52,0	40,0	60,0	72,0	108,0	100,0	96,0	165,0	128,0	200,0	228,0
	SE	11,5	19,1	11,5	11,0	0,0	11,0	0,0	16,3	11,0	46,0	40,0	16,7	118,2	17,9	156,8	192,1

May

		Low -60				Low -40				Low -20				Low 0			
		G		S		G		S		G		S		G		S	
		Top	Deep	Top	Deep	Top	Deep	Top	Deep	Top	Deep	Top	Deep	Top	Deep	Top	Deep
PO43-	n	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
	Mean	0,3	0,2	0,2	0,4	0,2	0,5	0,4	0,5	0,5	1,1	0,8	1,2	4,3	0,9	2,8	1,2
	SE	0,1	0,1	0,1	0,3	0,2	0,2	0,4	0,2	0,1	0,4	0,7	1,1	3,1	0,4	2,2	0,5
NH4	n	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
	Mean	0,1	0,2	0,5	0,4	0,1	0,6	0,4	1,4	1,7	3,5	0,2	4,9	0,7	5,0	0,3	5,7
	SE	0,1	0,4	0,5	0,5	0,0	0,9	0,4	1,3	3,5	2,4	0,3	0,5	0,5	1,8	0,3	2,0
Nox	n	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
	Mean	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
	SE	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Fe	n	5	5	5	5	5	5	4	5	5	5	5	5	5	5	5	5
	Mean	0,7	0,6	0,6	1,8	0,6	20,8	0,6	38,6	4,1	42,5	10,5	53,4	43,5	65,0	26,6	77,0
	SE	0,2	0,2	0,3	2,6	0,2	26,6	0,3	32,4	4,8	38,4	19,6	15,2	13,4	30,2	19,4	40,1
Al	n	5	5	5	5	5	5	4	5	5	5	5	5	5	5	5	5
	Mean	0,9	1,2	1,1	1,3	0,6	1,5	0,6	1,8	0,9	1,6	1,0	1,8	1,5	1,7	0,8	1,9
	SE	0,3	0,4	0,8	0,9	0,3	0,4	0,3	1,0	0,2	0,6	0,5	0,7	0,8	0,4	0,5	0,9
Ca	n	5	5	5	5	5	5	4	5	5	5	5	5	5	5	5	5
	Mean	371,9	468,9	336,9	500,8	136,6	511,6	203,5	451,5	192,8	388,8	179,9	359,9	346,1	483,5	442,0	548,1
	SE	330,5	150,2	239,2	154,5	44,2	82,2	165,5	186,8	125,3	185,2	213,9	70,0	183,7	202,2	215,8	134,1
pH	n	5	2	4	4	2	5	3	5	4	5	5	5	4	5	5	5
	Mean	5,4	5,1	5,1	4,9	5,8	4,8	5,7	5,1	5,4	5,1	5,6	5,2	5,8	5,2	5,5	5,3
	SE	0,4	0,2	0,6	0,5	0,5	0,2	0,8	0,8	0,4	0,2	0,3	0,4	0,7	0,3	0,6	0,7
EC	n	5	2	4	4	2	5	3	5	4	5	5	5	4	5	5	5
	Mean	2192,2	2484,0	2037,5	2847,5	969,5	2623,2	718,3	2368,4	1190,0	2368,2	1097,8	1881,2	1987,8	2325,0	1935,2	2409,2
	SE	1311,6	1069,1	1051,0	571,6	181,7	429,4	249,7	1014,5	711,4	504,4	1253,7	462,1	795,7	1202,8	879,5	623,2
ALK	n	5	2	4	4	2	5	3	5	4	5	5	5	4	5	5	5
	Mean	68,0	80,0	60,0	65,0	70,0	68,0	86,7	160,0	80,0	88,0	76,0	136,0	240,0	132,0	200,0	172,0
	SE	11,0	0,0	0,0	10,0	14,1	11,0	64,3	147,0	16,3	17,9	32,9	43,4	187,6	46,0	227,2	140,4

		High -60				High -40				High -20				High 0			
		G		S		G		S		G		S		G		S	
		Top	Deep	Top	Deep	Top	Deep	Top	Deep	Top	Deep	Top	Deep	Top	Deep	Top	Deep
PO43-	n	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
	Mean	0,3	0,3	0,3	0,3	0,3	0,6	0,2	0,5	0,4	1,1	0,8	1,1	3,2	1,5	2,1	1,1
	SE	0,1	0,2	0,1	0,3	0,2	0,4	0,1	0,1	0,2	0,6	0,5	0,1	1,8	0,7	0,7	0,6
NH4	n	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
	Mean	0,1	0,1	0,3	0,0	0,3	0,7	0,3	0,4	1,8	4,1	0,4	4,6	0,4	5,2	0,3	3,7
	SE	0,1	0,1	0,4	0,0	0,4	0,9	0,4	0,4	3,4	1,9	0,5	2,0	0,2	2,7	0,4	1,5
Nox	n	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
	Mean	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
	SE	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Fe	n	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
	Mean	0,7	0,4	0,9	0,6	1,0	24,4	1,5	20,2	5,1	45,8	19,0	75,9	75,8	46,6	41,6	38,0
	SE	0,3	0,1	0,1	0,1	0,8	28,7	1,7	26,9	5,7	36,6	26,7	46,6	40,7	37,1	53,7	33,7
Al	n	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
	Mean	0,9	1,1	1,1	1,5	1,0	1,4	0,8	1,6	0,9	1,9	1,0	2,3	2,2	1,6	1,7	1,5
	SE	0,4	0,2	0,6	0,3	0,6	0,4	0,2	0,6	0,4	0,9	0,2	1,0	1,5	0,6	1,4	1,4
Ca	n	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
	Mean	297,1	534,7	355,2	517,3	212,1	395,7	190,3	397,8	195,1	395,6	267,9	388,0	421,8	326,7	267,9	336,4
	SE	138,2	53,8	383,4	111,2	222,8	158,7	159,6	115,9	136,4	157,7	149,2	164,2	197,8	249,8	149,2	217,3
pH	n	5	4	5	5	4	4	3	5	5	5	5	5	5	5	4	4
	Mean	5,4	4,8	5,4	4,6	5,4	4,9	5,4	4,9	5,4	5,0	5,3	5,1	5,7	5,3	6,2	5,9
	SE	0,4	0,1	0,6	0,3	0,4	0,1	0,3	0,3	0,2	0,4	0,4	0,4	0,5	0,4	0,9	0,9
EC	n	5	4	5	5	4	4	3	5	5	5	5	5	5	5	4	4
	Mean	1705,6	2767,5	1759,4	2616,6	1308,5	2031,5	1339,7	2099,6	1229,8	2209,8	1427,0	2117,4	1953,2	2335,2	1155,5	1775,3
	SE	717,8	217,8	1661,9	532,4	1134,6	450,1	1122,1	539,9	754,4	785,6	646,1	860,9	717,7	1245,7	86,4	316,9
ALK	n	5	4	5	5	4	4	3	5	5	5	5	5	5	5	5	5
	Mean	56,0	65,0	68,0	76,0	65,0	80,0	60,0	84,0	72,0	88,0	64,0	92,0	184,0	148,0	220,0	260,0
	SE	16,7	10,0	11,0	16,7	10,0	16,3	0,0	8,9	17,9	36,3	26,1	11,0	151,3	68,7	203,0	213,1

Appendix C

Minimal adequate models

The minimal adequate models (MAM) that describe the availability of phosphate (PO4), ammonium (NH4), nitrogen oxides (NOx), iron (Fe), aluminium (Al), calcium (Ca), chloride (Cl), pH (pH), electroconductivity (EC) and alkalinity (Alk) with an externally varying water table (between treatments).

PO4	PO4 ~ Depth + Water + Table + Nutrients + Time + Depth:Water + Depth:Table + Water:Table + Table:Nutrients + Depth:Water:Table						
		Df	Sum Sq	Mean Sq	F value	Pr(>F)	
	Depth	1	0,72	0,7	2,307	0,1295	
	Water	1	0,16	0,2	0,516	0,4728	
	Table	3	119,25	39,8	128,152	< 2e-16	***
	Nutrients	2	191,55	95,8	308,761	< 2e-16	***
	Time	1	1,33	1,3	4,274	0,0393	*
	Depth:Water	1	0,01	0,0	0,026	0,8723	
	Depth:Table	3	23,09	7,7	24,819	0,0000	***
	Water:Table	3	1,70	0,6	1,832	0,1405	
	Table:Nutrients	6	6,84	1,1	3,677	0,0014	**
	Depth:Water:Table	3	4,45	1,5	4,780	0,0027	**
NH4	NH4 ~ Depth + Water + Table + Nutrients + Depth:Table + Water:Table + Depth:Nutrients + Table:Nutrients						
		Df	Sum Sq	Mean Sq	F value	Pr(>F)	
	Depth	1	148,10	148,1	188,581	< 2e-16	***
	Water Source	1	0,40	0,4	0,500	0,4799	
	Water table	3	158,40	52,8	67,255	< 2e-16	***
	Nutrients	2	134,20	67,1	85,460	< 2e-16	***
	Depth:Table	3	87,50	29,2	37,162	< 2e-16	***
	Water:Table	3	8,00	2,7	3,382	0,0182	*
	Depth:Nutrients	2	12,40	6,2	7,902	0,0004	***
	Table:Nutrients	6	24,60	4,1	5,219	0,0000	***
NOx	NOx ~ Depth + Water + Table + Nutrients + Depth:Table + Water:Nutrients						
		Df	Sum Sq	Mean Sq	F value	Pr(>F)	
	Depth	1	47,40	47,4	15,445	0,0001	***
	Water	1	7,90	7,9	2,557	0,1119	
	Table	3	418,70	139,6	45,454	< 2e-16	***
	Nutrients	1	3,00	3,0	0,973	0,3256	
	Depth:Table	3	178,90	59,6	19,419	0,0000	***
	Water:Nutrients	1	14,20	14,2	4,623	0,0332	*
SO4	SO4 ~ Depth + Table + Depth:Table						
		Df	Sum Sq	Mean Sq	F value	Pr(>F)	
	Depth	1	43809343,00	43809343,0	159,782	0,0000	***
	Table	3	5926778,00	1975593,0	7,205	0,0001	***
	Depth:Table	3	2297569,00	765856,0	2,793	0,0406	*
Fe	Fe ~ Depth + Water + Table + Nutrients + Depth:Water + Depth:Table + Water:Table + Depth:Nutrients + Water:Nutrients + Depth:Water:Nutrients						
		Df	Sum Sq	Mean Sq	F value	Pr(>F)	
	Depth	1	158,00	158,0	144,867	< 2e-16	***
	Water	1	0,10	0,1	0,093	0,7600	
	Table	3	975,30	325,1	298,027	< 2e-16	***
	Nutrients	2	0,60	0,3	0,292	0,7468	
	Depth:Water	1	0,20	0,2	0,227	0,6340	
	Depth:Table	3	107,40	35,8	32,815	< 2e-16	***
	Water:Table	3	14,00	4,7	4,285	0,0054	**
	Depth:Nutrients	2	12,20	6,1	5,602	0,0040	**
	Water:Nutrients	2	0,20	0,1	0,077	0,9258	
	Depth:Water:Nutrients	2	8,30	4,1	3,784	0,0235	*
Al	Al ~ Depth + Water + Table + Nutrients + Water:Table						
		Df	Sum Sq	Mean Sq	F value	Pr(>F)	
	Depth	1	18,70	18702,0	63,997	0,0000	***
	Water	1	0,16	0,2	0,549	0,4593	
	Table	3	7,96	2654,0	9,082	0,0000	***
	Nutrients	2	2,04	1022,0	3,495	0,0311	*
	Water:Table	3	3,11	1035,0	3,542	0,0146	*
Ca	Ca ~ Depth + Table + Time + Depth:Table + Depth:Time						
		Df	Sum Sq	Mean Sq	F value	Pr(>F)	
	Depth	1	5745,00	5745,0	241,231	< 2e-16	***
	Table	3	862,00	287,0	12,065	0,0000	***
	Time	2	162,00	81,0	3,391	0,0345	*
	Depth:Table	3	500,00	167,0	7,000	0,0001	***
	Depth:Time	2	285,00	143,0	5,994	0,0027	**
CL	Cl ~ Depth + Water + Table + Nutrients + Time + Depth:Water + Depth:Table + Water:Table + Depth:Water:Table						
		Df	Sum Sq	Mean Sq	F value	Pr(>F)	
	Depth	1	288,51	288,5	326,735	< 2e-16	***
	Water	1	48,82	48,8	55,288	0,0000	***
	Table	3	178,22	59,4	67,280	< 2e-16	***
	Nutrients	2	7,25	3,6	4,108	0,0174	*
	Depth:Water	1	3,63	3,6	4,111	0,0435	*
	Depth:Table	3	73,38	24,5	27,701	0,0000	***
	Water:Table	3	46,63	15,5	17,602	0,0000	***
	Depth:Water:Table	3	20,31	6,8	7,668	0,0001	***
pH	pH ~ Depth + Water + Table + Nutrients + Time + Depth:Table						
		Df	Sum Sq	Mean Sq	F value	Pr(>F)	
	Depth	1	27.54	27,5	136,564	0,000	***
	Water	1	0.93	0,9	4,613	0,032	*
	Table	1	14.73	14,7	73,015	2.23e-16	***
	Nut	2	5.91	3,0	14,662	6.90e-07	***
	Time	1	2.13	2,1	10,565	0,001	**
	Depth:Table	1	0.22	0,2	1,071	0,301	
EC	EC ~ Depth + Water + Table + Depth:Table						
		Df	Sum Sq	Mean Sq	F value	Pr(>F)	
	Depth	1	100033014,00	100033014,0	154,703	< 2e-16	***
	Water	1	2740931,00	2740931,0	4,239	0,0401	*
	Table	3	22096361,00	7365454,0	11,391	0,0000	***
	Depth:Table	3	7637219,00	2545740,0	3,937	0,0086	**
Alk	Alk ~ Depth + Water + Table + Nutrients + Time + Depth:Water + Depth:Table						
		Df	Sum Sq	Mean Sq	F value	Pr(>F)	
	Depth	1	0,85	0,8	4,242	0,0401	*
	Water	1	0,62	0,6	3,120	0,0781	,
	Table	3	53,13	17711,0	88,484	< 2e-16	***
	Nutrients	2	2,92	1458,0	7,283	0,0008	***
	Depth:Water	1	1,18	1178,0	5,884	0,0157	*
	Depth:Table	3	2,90	1,0	4,826	0,0026	**

The minimal adequate models (MAM) that describe the availability of phosphate (PO4), ammonium (NH4), nitrogen oxides (NOx), iron (Fe), aluminium (Al), calcium (Ca), chloride (Cl), pH (pH), electroconductivity (EC) and alkalinity (Alk) with an internally varying water table (within treatments).

PO4	**PO4 ~ Depth + Water + Table + Depth:Water**						
		Df	Sum Sq	Mean Sq	F value	Pr(>F)	
	Depth	1	2,78	2,8	37,053	0,0000	***
	Water	1	0,07	0,1	0,924	0,3394	
	Table	1	2,42	2,4	32,205	0,0000	***
	Depth:Water	1	0,41	0,4	5,493	0,0217	*
NH4	**NH4 ~ Depth**						
		Df	Sum Sq	Mean Sq	F value	Pr(>F)	
	Depth	1	103.2	103.23	177,000	<2e-16	***
NOx	**NOx ~ Depth + Water + Table + Nutrientsrients + Depth:Table + Water:Nutrientsrients**						
		Df	Sum Sq	Mean Sq	F value	Pr(>F)	
	X	X	X	X	X	X	
Fe	**Fe ~ Depth + Water + Table + Nutrientsrients + Water:Nutrientsrients**						
		Df	Sum Sq	Mean Sq	F value	Pr(>F)	
	Depth	1	133,41	133,41	113,655	< 2e-16	***
	Water	1	0,36	0,36	0,305	0,582	
	Table	1	10,52	10,52	8,963	0,004	**
	Nutrientsrients	1	0,05	0,05	0,044	0,835	
	Water:Nutrientsrients	1	10,22	10,22	8,707	0,004	**
Al	**Al ~ Depth + Water + Table**						
		Df	Sum Sq	Mean Sq	F value	Pr(>F)	
	Depth	1	3,83	3,8	8,962	0,004	**
	Water	1	1,72	1,7	4,025	0,048	*
	Table	1	2,47	2,5	5,787	0,019	*
Ca	**Ca ~ Depth + Table + Time + Depth:Water + Depth:Table + Depth:Nutrients + Water:Nutrients + Depth:Water:Nutrients**						
		Df	Sum Sq	Mean Sq	F value	Pr(>F)	
	Depth	1	20,27	20,3	70,311	3,57E-12	***
	Water	1	0,15	0,2	0,519	0,473	
	Table	1	1,45	1,5	5,039	0,028	*
	Nutrients	1	0,16	0,2	0,56	0,457	
	Depth:Water	1	0,01	0,0	0,05	0,824	
	Depth:Table	1	1,62	1,6	5,629	0,020	*
	Depth:Nutrients	1	0,62	0,6	2,155	0,147	
	Water:Nutrients	1	4,30	4,3	14,911	0,000	***
	Depth:Water:Nutrients	1	1,49	1,5	5,152	0,026	*
pH	**pH ~ Depth**						
		Df	Sum Sq	Mean Sq	F value	Pr(>F)	
	Depth	1	0,1	0,06	12,360	0,001	***
EC	**EC ~ Depth + Water + Table + Depth:Table**						
		Df	Sum Sq	Mean Sq	F value	Pr(>F)	
	Depth	1	15,3	15,3	64,614	1,42E-11	***
	Water	1	0,1	0,1	0,502	0,481	
	Table	1	2,7	2,7	11,457	0,001	**
	Nutrients	1	0,1	0,1	0,344	0,559	
	Depth:Table	1	3,1	3,1	12,929	0,001	***
	Water:Nutrients	1	1,2	1,2	5,221	0,025	*
Alk	**Alk ~ Depth + Water + Table + Nutrientsrients + Time + Depth:Water + Depth:Table**						
		Df	Sum Sq	Mean Sq	F value	Pr(>F)	
	Depth	1	2,472	2,4719	18,815	4,43E-05	***
	Nutrients	1	0,628	0,6281	4,781	0,0319	*

Appendix D

Tukey HSD results of interactions for the constant water table treatments

Tukey HSD results specifying the significance of the differences specified by the interaction of variables between the mean availability in the treatments with a constant water table. All combinations of the groups within the interacting variables are compared to understand which treatments have a significant impact on the availability in the mesocosm experiment. The p-value is automatically corrected for the number of tests performed on the same data set. The difference is in the unit of the nutrient measurement specified in the data and based on a log scale to maintain consistency throughout the research.

Phosphate (mg/L)

Water Table : Nutrient application	diff	p	95% confidance lwr	upr
-40:NoNA:-60:NoNA	0,025	1,000	-0,389	0,439
-20:NoNA:-60:NoNA	0,539	0,001	0,127	0,951
0:NoNA:-60:NoNA	0,792	0,000	0,380	1,204
-20:NoNA:-40:NoNA	0,514	0,003	0,102	0,926
0:NoNA:-40:NoNA	0,767	0,000	0,355	1,179
0:NoNA:-20:NoNA	0,253	0,673	-0,156	0,662
-40:LowNA:-60:LowNA	0,161	0,981	-0,253	0,576
-20:LowNA:-60:LowNA	0,808	0,000	0,396	1,220
0:LowNA:-60:LowNA	1,509	0,000	1,097	1,921
-20:LowNA:-40:LowNA	0,647	0,000	0,235	1,058
0:LowNA:-40:LowNA	1,347	0,000	0,936	1,759
0:LowNA:-20:LowNA	0,701	0,000	0,292	1,110
-40:HighNA:-60:HighNA	0,063	1,000	-0,346	0,472
-20:HighNA:-60:HighNA	0,761	0,000	0,352	1,171
0:HighNA:-60:HighNA	1,381	0,000	0,972	1,790
-20:HighNA:-40:HighNA	0,698	0,000	0,289	1,107
0:HighNA:-40:HighNA	1,318	0,000	0,909	1,727
0:HighNA:-20:HighNA	0,620	0,000	0,211	1,029
0:LowNA-0:NoNA	-0,959	0,000	-1,369	-0,550
-20:LowNA:-20:NoNA	-1,407	0,000	-1,817	-0,998
-40:LowNA:-40:NoNA	-1,540	0,000	-1,954	-1,125
-60:LowNA:-60:NoNA	-1,676	0,000	-2,091	-1,262
0:HighNA-0:NoNA	-0,921	0,000	-1,330	-0,512
-20:HighNA:-20:NoNA	-1,288	0,000	-1,698	-0,879
-40:HighNA:-40:NoNA	-1,472	0,000	-1,884	-1,061
-60:HighNA:-60:NoNA	-1,511	0,000	-1,922	-1,099
0:HighNA-0:LowNA	0,038	1,000	-0,371	0,447
-20:HighNA:-20:LowNA	0,119	0,998	-0,290	0,528
-40:HighNA:-40:LowNA	0,067	1,000	-0,344	0,479
-60:HighNA:-60:LowNA	0,166	0,976	-0,246	0,577

Sampling depth : Water source : Water table	diff	p	95% confidance lwr	upr
Topsoil:Surfacewater:0-Topsoil:Groundwater:0	-0,411	0,242	-0,906	0,085
Topsoil:Surfacewater:-20-Topsoil:Groundwater:-20	0,254	0,927	-0,241	0,750
Topsoil:Surfacewater:-40-Topsoil:Groundwater:-40	0,285	0,844	-0,215	0,784
Topsoil:Surfacewater:-60-Topsoil:Groundwater:-60	-0,285	0,852	-0,789	0,219
Deepsoil:Surfacewater:0-Deepsoil:Groundwater:0	0,031	1,000	-0,464	0,527
Deepsoil:Surfacewater:-20-Deepsoil:Groundwater:-20	-0,086	1,000	-0,582	0,409
Deepsoil:Surfacewater:-40-Deepsoil:Groundwater:-40	-0,112	1,000	-0,611	0,388
Deepsoil:Surfacewater:-60-Deepsoil:Groundwater:-60	0,077	1,000	-0,418	0,573
Deepsoil:Groundwater:0-Topsoil:Groundwater:0	-0,822	0,000	-1,317	-0,326
Deepsoil:Groundwater:-20-Topsoil:Groundwater:-20	0,425	0,193	-0,071	0,920
Deepsoil:Groundwater:-40-Topsoil:Groundwater:-40	0,810	0,000	0,310	1,310
Deepsoil:Groundwater:-60-Topsoil:Groundwater:-60	-0,114	1,000	-0,619	0,390
Deepsoil:Surfacewater:0-Topsoil:Surfacewater:0	-0,380	0,373	-0,875	0,116
Deepsoil:Surfacewater:-20-Topsoil:Surfacewater:-20	0,084	1,000	-0,411	0,580
Deepsoil:Surfacewater:-40-Topsoil:Surfacewater:-40	0,414	0,244	-0,086	0,913
Deepsoil:Surfacewater:-60-Topsoil:Surfacewater:-60	0,248	0,940	-0,248	0,743
Topsoil:Groundwater:-40-Topsoil:Groundwater:-60	-0,478	0,092	-0,987	0,030
Topsoil:Groundwater:-20-Topsoil:Groundwater:-60	0,341	0,602	-0,163	0,845
Topsoil:Groundwater:0-Topsoil:Groundwater:-60	1,625	0,000	1,121	2,130
Topsoil:Groundwater:-20-Topsoil:Groundwater:-40	0,819	0,000	0,319	1,319
Topsoil:Groundwater:0-Topsoil:Groundwater:-40	2,104	0,000	1,604	2,603
Topsoil:Groundwater:0-Topsoil:Groundwater:-20	1,285	0,000	0,789	1,780
Topsoil:Surfacewater:-40-Topsoil:Surfacewater:-60	0,092	1,000	-0,404	0,587
Topsoil:Surfacewater:-20-Topsoil:Surfacewater:-60	0,880	0,000	0,385	1,376
Topsoil:Surfacewater:0-Topsoil:Surfacewater:-60	1,500	0,000	1,004	1,995
Topsoil:Surfacewater:-20-Topsoil:Surfacewater:-40	1,376	0,082	-0,070	2,821
Topsoil:Surfacewater:0-Topsoil:Surfacewater:-40	2,478	0,000	1,032	3,924
Topsoil:Surfacewater:0-Topsoil:Surfacewater:-20	0,620	0,002	0,124	1,115
Deepsoil:Groundwater:-40-Deepsoil:Groundwater:-60	0,446	0,134	-0,050	0,941
Deepsoil:Groundwater:-20-Deepsoil:Groundwater:-60	0,880	0,000	0,385	1,375
Deepsoil:Groundwater:0-Deepsoil:Groundwater:-60	0,918	0,000	0,423	1,414
Deepsoil:Groundwater:-20-Deepsoil:Groundwater:-40	0,434	0,166	-0,061	0,930
Deepsoil:Groundwater:0-Deepsoil:Groundwater:-40	0,472	0,081	-0,023	0,968
Deepsoil:Groundwater:0-Deepsoil:Groundwater:-20	0,038	1,000	-0,457	0,534
Deepsoil:Surfacewater:-40-Deepsoil:Surfacewater:-60	0,257	0,924	-0,242	0,757
Deepsoil:Surfacewater:-20-Deepsoil:Surfacewater:-60	0,717	0,000	0,221	1,212
Deepsoil:Surfacewater:0-Deepsoil:Surfacewater:-60	0,872	0,000	0,377	1,368
Deepsoil:Surfacewater:-20-Deepsoil:Surfacewater:-40	0,459	0,113	-0,040	0,959
Deepsoil:Surfacewater:0-Deepsoil:Surfacewater:-40	0,615	0,003	0,115	1,115
Deepsoil:Surfacewater:0-Deepsoil:Surfacewater:-20	0,156	0,999	-0,340	0,651

Ammonium (mg/L)

Sampling Depth : Water table	diff	p	lwr	upr
			95% confidance	
Deepsoil:0-Topsoil:0	1,919	0,000	1,426	2,411
Deepsoil:-20-Topsoil:-20	1,756	0,000	1,263	2,249
Deepsoil:-40-Topsoil:-40	1,022	0,000	0,526	1,519
Deepsoil:-60-Topsoil:-60	-0,246	0,796	-0,739	0,247
Topsoil:-40-Topsoil:-60	0,018	1,000	-0,476	0,513
Topsoil:-20-Topsoil:-60	0,348	0,386	-0,145	0,840
Topsoil:0-Topsoil:-60	0,325	0,476	-0,168	0,818
Topsoil:-20-Topsoil:-40	0,329	0,466	-0,166	0,824
Topsoil:0-Topsoil:-40	0,307	0,560	-0,188	0,801
Topsoil:0-Topsoil:-20	-0,022	1,000	-0,515	0,470
Deepsoil:-40-Deepsoil:-60	1,287	0,000	0,792	1,782
Deepsoil:-20-Deepsoil:-60	2,349	0,000	1,857	2,842
Deepsoil:0-Deepsoil:-60	2,490	0,000	1,997	2,983
Deepsoil:-20-Deepsoil:-40	1,063	0,000	0,568	1,557
Deepsoil:0-Deepsoil:-40	1,203	0,000	0,708	1,698
Deepsoil:0-Deepsoil:-20	0,140	0,989	-0,352	0,633

Water source : Water table	diff	p	lwr	upr
			95% confidance	
Surfacewater:0-Groundwater:0	-0,33256	0,4455225	-0,82518	0,160048
Surfacewater:-20-Groundwater:-20	-0,01074	1	-0,50335	0,481875
Surfacewater:-40-Groundwater:-40	0,293635	0,6206647	-0,20321	0,790475
Surfacewater:-60-Groundwater:-60	0,289609	0,6270917	-0,203	0,782221
Groundwater:-40-Groundwater:-60	0,648659	0,0020708	0,151819	1,1455
Groundwater:-20-Groundwater:-60	1,498689	0	1,006077	1,991301
Groundwater:0-Groundwater:-60	1,718592	0	1,22598	2,211204
Groundwater:-20-Groundwater:-40	0,850029	0,0000079	0,353189	1,34687
Groundwater:0-Groundwater:-40	1,069932	0	0,573092	1,566773
Groundwater:0-Groundwater:-20	0,219903	0,8750414	-0,27271	0,712515
Surfacewater:-40-Surfacewater:-60	0,652685	0,0016396	0,160073	1,145297
Surfacewater:-20-Surfacewater:-60	1,198342	0	0,70573	1,690954
Surfacewater:0-Surfacewater:-60	1,096418	0	0,603807	1,58903
Surfacewater:-20-Surfacewater:-40	0,545657	0,0182069	0,053045	1,038269
Surfacewater:0-Surfacewater:-40	0,443733	0,1126324	-0,04888	0,936345
Surfacewater:0-Surfacewater:-20	-0,10192	0,9984529	-0,59454	0,390688

Sampling depth: Nutrient application	diff	p	lwr	upr
			95% confidance	
Deepsoil:LowNA-Topsoil:LowNA	1,417679	0	1,016728	1,81863
Deepsoil:HighNA-Topsoil:HighNA	1,251113	0	0,850162	1,652064
Deepsoil:NoNA-Topsoil:NoNA	0,664906	0,0000469	0,261425	1,068387
Topsoil:LowNA-Topsoil:NoNA	-1,48741	0	-1,88963	-1,0852
Topsoil:HighNA-Topsoil:NoNA	-1,43402	0	-1,83624	-1,03181
Topsoil:HighNA-Topsoil:LowNA	0,05339	0,9989538	-0,34756	0,454341
Deepsoil:LowNA-Deepsoil:NoNA	-0,73464	0,0000039	-1,13686	-0,33242
Deepsoil:HighNA-Deepsoil:NoNA	-0,84782	0,0000001	-1,25004	-0,4456
Deepsoil:HighNA-Deepsoil:LowNA	-0,11318	0,9660424	-0,51413	0,287775

Water table: Nutrient application	diff	p	lwr	upr
			95% confidance	
0:LowNA-0:NoNA	-0,30802	0,9240474	-0,95892	0,342879
0:HighNA-0:NoNA	-0,61815	0,0808574	-1,26905	0,032748
0:HighNA-0:LowNA	-0,31013	0,9205834	-0,96103	0,340767
-20:HighNA:-20:NoNA	-0,85582	0,0011514	-1,50672	-0,20493
-20:LowNA:-20:NoNA	-1,23556	0,0000001	-1,88646	-0,58466
-20:HighNA:-20:LowNA	0,379735	0,7484074	-0,27116	1,030632
-40:LowNA:-40:NoNA	-1,42742	0	-2,08683	-0,76802
-40:HighNA:-40:NoNA	-1,5699	0	-2,2293	-0,91049
-40:HighNA:-40:LowNA	-0,14247	0,9998973	-0,79337	0,508424
-60:LowNA:-60:NoNA	-1,48627	0	-2,13716	-0,83537
-60:HighNA:-60:NoNA	-1,53297	0	-2,18387	-0,88207
-60:HighNA:-60:LowNA	-0,0467	1	-0,6976	0,604194
-40:NoNA:-60:NoNA	0,662303	0,0478608	0,002897	1,32171
-20:NoNA:-60:NoNA	1,039231	0,0000154	0,388334	1,690129
0:NoNA:-60:NoNA	0,709816	0,0192327	0,058918	1,360713
-20:NoNA:-40:NoNA	0,376928	0,7724802	-0,28248	1,036335
0:NoNA:-40:NoNA	0,047513	1	-0,61189	0,706919
0:NoNA:-20:NoNA	-0,32942	0,8840652	-0,98031	0,321482
-40:LowNA:-60:LowNA	0,721147	0,015803	0,070249	1,372044
-20:LowNA:-60:LowNA	1,289938	0	0,639041	1,940836
0:LowNA:-60:LowNA	1,888063	0	1,237166	2,538961
-20:LowNA:-40:LowNA	0,568792	0,1550729	-0,08211	1,219689
0:LowNA:-40:LowNA	1,166917	0,0000005	0,516019	1,817814
0:LowNA:-20:LowNA	0,598125	0,1064629	-0,05277	1,249023
-40:HighNA:-60:HighNA	0,625377	0,0729548	-0,02552	1,276274
-20:HighNA:-60:HighNA	1,716377	0	1,065479	2,367275
0:HighNA:-60:HighNA	1,624636	0	0,973738	2,275534
-20:HighNA:-40:HighNA	1,091	0,000004	0,440102	1,741898
0:HighNA:-40:HighNA	0,999259	0,0000422	0,348361	1,650157
0:HighNA:-20:HighNA	-0,09174	0,9999989	-0,74264	0,559157

Nitrogen oxide (uM)

Sampling depth: Water table			95% confidance	
	diff	p	lwr	upr
Deepsoil:0-Topsoil:0	-0,788	0,846	-2,492	0,916
Deepsoil:-20-Topsoil:-20	-1,025	0,588	-2,728	0,679
Deepsoil:-40-Topsoil:-40	2,100	0,005	0,396	3,804
Deepsoil:-60-Topsoil:-60	4,068	0,000	2,364	5,771
Topsoil:-40-Topsoil:-60	-1,701	0,051	-3,404	0,003
Topsoil:-20-Topsoil:-60	-0,872	0,765	-2,576	0,832
Topsoil:0-Topsoil:-60	-1,913	0,016	-3,617	-0,209
Topsoil:-20-Topsoil:-40	0,829	0,809	-0,875	2,532
Topsoil:0-Topsoil:-40	-0,212	1,000	-1,916	1,491
Topsoil:0-Topsoil:-20	-1,829	0,026	-3,533	-0,125
Deepsoil:-40-Deepsoil:-60	-3,668	0,000	-5,372	-1,965
Deepsoil:-20-Deepsoil:-60	-5,965	0,000	-7,668	-4,261
Deepsoil:0-Deepsoil:-60	-6,769	0,000	-8,472	-5,065
Deepsoil:-20-Deepsoil:-40	-2,296	0,001	-4,000	-0,592
Deepsoil:0-Deepsoil:-40	-3,100	0,000	-4,804	-1,397
Deepsoil:0-Deepsoil:-20	-0,804	0,831	-2,508	0,899

Water source : Nutreint application			95% confidance	
	diff	p	lwr	upr
Surfacewater:LowNA-Groundwater:LowNA	-1,039	0,044	-2,057	-0,021
Surfacewater:HighNA-Groundwater:HighNA	0,153	0,980	-0,865	1,171
Groundwater:HighNA-Groundwater:LowNA	-0,322	0,844	-1,340	0,696
Surfacewater:HighNA-Surfacewater:LowNA	0,869	0,123	-0,149	1,887

Sulphate (mg/L)

Sampling depth: Water table			95% confidance	
	diff	p	lwr	upr
Deepsoil:-60-Topsoil:-60	479,7781	0,003	103,0803	856,47579
Deepsoil:-40-Topsoil:-40	965,2208	0,000	607,8539	1322,5876
Deepsoil:-20-Topsoil:-20	727,474	0,000	370,1072	1084,8409
Deepsoil:0-Topsoil:0	798,3156	0,000	440,9488	1155,6824
Topsoil:-40-Topsoil:-60	-578,657	0,000	-945,816	-211,49709
Topsoil:-20-Topsoil:-60	-444,111	0,006	-811,271	-76,95148
Topsoil:0-Topsoil:-60	-483,57	0,002	-850,73	-116,41076
Topsoil:-20-Topsoil:-40	134,5456	0,945	-222,821	491,91245
Topsoil:0-Topsoil:-40	95,08632	0,992	-262,281	452,45317
Topsoil:0-Topsoil:-20	-39,4593	1,000	-396,826	317,90756
Deepsoil:-40-Deepsoil:-60	-93,2139	0,994	-460,373	273,94561
Deepsoil:-20-Deepsoil:-60	-196,415	0,730	-563,575	170,74446
Deepsoil:0-Deepsoil:-60	-165,033	0,869	-532,192	202,12677
Deepsoil:-20-Deepsoil:-40	-103,201	0,988	-460,568	254,1657
Deepsoil:0-Deepsoil:-40	-71,8188	0,999	-429,186	285,548
Deepsoil:0-Deepsoil:-20	31,38231	1,000	-325,985	388,74915

Aluminium (mg/kg)

Water source : Water table				
	diff	p	lwr	upr
Surfacewater:0-Groundwater:0	-0,29881	0,0525316	-0,59932	0,001698
Surfacewater:-20-Groundwater:-20	-0,01308	1	-0,31359	0,287432
Surfacewater:-40-Groundwater:-40	0,031697	0,9999843	-0,27265	0,336045
Surfacewater:-60-Groundwater:-60	0,135618	0,8687081	-0,16489	0,436126
Groundwater:-40-Groundwater:-60	0,242536	0,2214019	-0,05924	0,544315
Groundwater:-20-Groundwater:-60	0,431165	0,0004082	0,130656	0,731673
Groundwater:0-Groundwater:-60	0,34055	0,0140545	0,040042	0,641059
Surfacewater:-40-Surfacewater:-60	0,138615	0,8605365	-0,16447	0,441703
Surfacewater:-20-Surfacewater:-60	0,28247	0,0828989	-0,01804	0,582979
Surfacewater:0-Surfacewater:-60	-0,09388	0,980689	-0,39439	0,20663
Groundwater:-20-Groundwater:-40	0,188629	0,5494214	-0,11315	0,490408
Groundwater:0-Groundwater:-40	0,098015	0,9758974	-0,20376	0,399794
Surfacewater:-20-Surfacewater:-40	0,143856	0,8356283	-0,15923	0,446944
Surfacewater:0-Surfacewater:-40	-0,23249	0,2765473	-0,53558	0,070595
Groundwater:0-Groundwater:-20	-0,09061	0,984264	-0,39112	0,209894
Surfacewater:0-Surfacewater:-20	-0,37635	0,0038553	-0,67686	-0,07584

Iron (mg/kg)

Sampling depth: Water table

	diff	p	lwr	upr
			95% confidance	
Surfacewater:0-Groundwater:0	-0,596218	0,0393527	-1,17686	-0,01557
Surfacewater:-20-Groundwater:-20	0,2227637	0,941791	-0,36034	0,805864
Surfacewater:-40-Groundwater:-40	0,0119697	1	-0,57609	0,600033
Surfacewater:-60-Groundwater:-60	0,2559076	0,8822256	-0,32474	0,836553
Groundwater:-40-Groundwater:-60	1,7394447	0	1,156344	2,322545
Groundwater:-20-Groundwater:-60	3,0983921	0	2,517747	3,679037
Groundwater:0-Groundwater:-60	4,118567	0	3,537922	4,699212
Groundwater:-20-Groundwater:-40	1,3589474	0	0,775847	1,942048
Groundwater:0-Groundwater:-40	2,3791223	0	1,796022	2,962223
Groundwater:0-Groundwater:-20	1,0201749	0,0000039	0,43953	1,60082
Surfacewater:-40-Surfacewater:-60	1,4955068	0	0,909877	2,081136
Surfacewater:-20-Surfacewater:-60	3,0652482	0	2,482148	3,648349
Surfacewater:0-Surfacewater:-60	3,2664411	0	2,685796	3,847086
Surfacewater:-20-Surfacewater:-40	1,5697414	0	0,981678	2,157805
Surfacewater:0-Surfacewater:-40	1,7709343	0	1,185305	2,356564
Surfacewater:0-Surfacewater:-20	0,2011929	0,9662111	-0,38191	0,784293

Sampling depth : Water quality: Nutrient application

	diff	p	lwr	upr
			95% confidance	
Topsoil:Surfacewater:NoNA-Topsoil:Groundwater:NoNA	-0,152926	0,9999622	-0,92505	0,619195
Topsoil:Surfacewater:LowNA-Topsoil:Groundwater:LowNA	-0,381658	0,899663	-1,15378	0,390463
Topsoil:Surfacewater:HighNA-Topsoil:Groundwater:HighNA	0,2993804	0,9810577	-0,46784	1,066599
Deepsoil:Surfacewater:NoNA-Deepsoil:Groundwater:NoNA	0,3275665	0,9626924	-0,43965	1,094785
Deepsoil:Surfacewater:LowNA-Deepsoil:Groundwater:LowNA	-0,274789	0,9904826	-1,04201	0,49243
Deepsoil:Surfacewater:HighNA-Deepsoil:Groundwater:HighNA	1,019651	0,0010634	0,24753	1,791772
Deepsoil:Groundwater:NoNA-Topsoil:Groundwater:NoNA	1,2183685	0,0000178	0,45115	1,985587
Deepsoil:Groundwater:LowNA-Topsoil:Groundwater:LowNA	1,0816792	0,0002942	0,31446	1,848898
Deepsoil:Groundwater:HighNA-Topsoil:Groundwater:HighNA	1,1671079	0,0000722	0,38986	1,944356
Deepsoil:Surfacewater:NoNA-Topsoil:Surfacewater:NoNA	1,9275929	0	1,155472	2,699714
Deepsoil:Surfacewater:LowNA-Topsoil:Surfacewater:LowNA	0,5075102	0,5700717	-0,25971	1,274729
Deepsoil:Surfacewater:HighNA-Topsoil:Surfacewater:HighNA	-0,005469	1	-0,78272	0,771779
Topsoil:Groundwater:LowNA-Topsoil:Groundwater:NoNA	-0,208465	0,9992207	-0,98059	0,563656
Topsoil:Groundwater:HighNA-Topsoil:Groundwater:NoNA	-0,152287	0,9999638	-0,92441	0,619834
Topsoil:Groundwater:HighNA-Topsoil:Groundwater:LowNA	0,056178	1	-0,71104	0,823397
Deepsoil:Groundwater:LowNA-Deepsoil:Groundwater:NoNA	-0,009748	1	-0,77697	0,757471
Deepsoil:Groundwater:HighNA-Deepsoil:Groundwater:NoNA	-0,090259	0,9999998	-0,85748	0,67696
Deepsoil:Groundwater:HighNA-Deepsoil:Groundwater:LowNA	-0,080511	1	-0,84773	0,686707
Topsoil:Surfacewater:LowNA-Topsoil:Surfacewater:NoNA	-0,437197	0,7831134	-1,20932	0,334924
Topsoil:Surfacewater:HighNA-Topsoil:Surfacewater:NoNA	0,3000189	0,9807406	-0,4672	1,067238
Topsoil:Surfacewater:HighNA-Topsoil:Surfacewater:LowNA	0,7372163	0,0771393	-0,0349	1,509338
Deepsoil:Surfacewater:LowNA-Deepsoil:Surfacewater:NoNA	0,3232877	0,9692041	-0,45396	1,100536
Deepsoil:Surfacewater:HighNA-Deepsoil:Surfacewater:NoNA	-0,359579	0,9346265	-1,13683	0,417669
Deepsoil:Surfacewater:HighNA-Deepsoil:Surfacewater:LowNA	-0,682866	0,1359726	-1,45009	0,084352

Calcium (mg/kg)

Sampling depth : Water table

	diff	p	lwr	upr
			95% confidance	
Deepsoil:0-Topsoil:0	4,624	0,0000087	1,911218	7,336783
Deepsoil:-20-Topsoil:-20	7,235053	0	4,522271	9,947835
Deep soil:-40-Topsoil:-40	3	0	2	4
Deepsoil:-60-Topsoil:-60	5,851881	0	3,127628	8,576133
Topsoil:-40-Topsoil:-60	-5,02858	0,0000012	-7,77602	-2,28114
Topsoil:-20-Topsoil:-60	-3,53854	0,0022397	-6,2628	-0,81429
Topsoil:0-Topsoil:-60	0,268055	0,9999894	-2,4562	2,992308
Topsoil:-20-Topsoil:-40	1,490038	0,7142418	-1,24603	4,226106
Topsoil:0-Topsoil:-20	3,806598	0,0006156	1,093816	6,51938
Topsoil:0-Topsoil:-40	5,296636	0,0000002	2,560567	8,032704
Deepsoil:-40-Deepsoil:-60	-0,73073	0,9921523	-3,45498	1,993522
Deepsoil:-20-Deepsoil:-60	-2,15537	0,2344627	-4,86815	0,557411
Deepsoil:0-Deepsoil:-60	-0,95983	0,9612753	-3,67261	1,752957
Deepsoil:-20-Deepsoil:-40	-1,42464	0,7548934	-4,14889	1,299613
Deepsoil:0-Deepsoil:-40	-0,22909	0,9999964	-2,95335	2,495158
Deepsoil:0-Deepsoil:-20	1,195545	0,8823126	-1,51724	3,908328

Sampling depth : Measuring moment

	diff	p	lwr	upr
			95% confidance	
Deepsoil:March-Topsoil:March	8,498002	0	6,276044	10,71996
Deepsoil:May-Topsoil:May	4,834538	0	2,619535	7,049541
Deepsoil:April-Topsoil:April	7,520339	0	5,305337	9,735342
Topsoil:April-Topsoil:March	-0,11601	0,9999896	-2,33796	2,10595
Topsoil:May-Topsoil:March	2,655291	0,0088756	0,433333	4,877248
Topsoil:May-Topsoil:April	2,771298	0,0052741	0,549341	4,993256
Deepsoil:April-Deepsoil:March	-1,09367	0,7191846	-3,30867	1,121333
Deepsoil:May-Deepsoil:March	-1,00817	0,7836486	-3,22318	1,20683
Deepsoil:May-Deepsoil:April	0,085496	0,9999977	-2,12253	2,293523

pH

Sampling depth: Water table		95% confidance		
	diff	lwr	upr	p
Deepsoil:0-Topsoil:0	-0,40279	-0,65388	-0,15169	3,97E-05
Deepsoil:-20-Topsoil:-20	-0,42993	-0,6767	-0,18317	0,000005
Deepsoil:-40-Topsoil:-40	-0,75641	-1,02278	-0,49003	0
Deepsoil:-60-Topsoil:-60	-0,42065	-0,68737	-0,15392	5,86E-05
Topsoil:-40-Topsoil:-60	0,371524	0,093638	0,649409	0,001423
Topsoil:-20-Topsoil:-60	0,224314	-0,03582	0,484446	0,149269
Topsoil:0-Topsoil:-60	0,527651	0,264376	0,790925	1E-07
Topsoil:-20-Topsoil:-40	-0,14721	-0,41358	0,119163	0,698125
Topsoil:0-Topsoil:-40	0,156127	-0,11332	0,42557	0,64419
Topsoil:0-Topsoil:-20	0,303337	0,052244	0,554431	0,006362
Deepsoil:-40-Deepsoil:-60	0,035761	-0,21895	0,290475	0,99988
Deepsoil:-20-Deepsoil:-60	0,215025	-0,03868	0,468732	0,165516
Deepsoil:0-Deepsoil:-60	0,54551	0,290797	0,800223	0
Deepsoil:-20-Deepsoil:-40	0,179264	-0,0675	0,426026	0,346066
Deepsoil:0-Deepsoil:-40	0,509749	0,261952	0,757545	0
Deepsoil:0-Deepsoil:-20	0,330485	0,083722	0,577247	0,001383

Electroconductivity (uS)

Sampling depth: Water table			95% confidance	
	diff	p	lwr	upr
Deepsoil:0-Topsoil:0	803,1463	0,0000039	346,1956	1260,097
Deepsoil:-20-Topsoil:-20	1090,557	0	641,4892	1539,626
Deepsoil:-40-Topsoil:-40	1339,213	0	851,3402	1827,086
Deepsoil:-60-Topsoil:-60	628,5537	0,0023596	143,1484	1113,959
Topsoil:-40-Topsoil:-60	-919,229	0,0000018	-1427,92	-410,534
Topsoil:-20-Topsoil:-60	-755,081	0,0000453	-1228,48	-281,681
Topsoil:0-Topsoil:-60	-262,885	0,7059046	-742,003	216,2337
Topsoil:-20-Topsoil:-40	164,1481	0,9705403	-323,725	652,021
Topsoil:0-Topsoil:-40	656,3442	0,0015451	162,9204	1149,768
Topsoil:0-Topsoil:-20	492,1961	0,0245828	35,24542	949,1468
Deepsoil:-40-Deepsoil:-60	-208,57	0,8702129	-672,108	254,9685
Deepsoil:-20-Deepsoil:-60	-293,077	0,5285804	-754,784	168,6293
Deepsoil:0-Deepsoil:-60	-88,2923	0,9990918	-551,831	375,2458
Deepsoil:-20-Deepsoil:-40	-84,5076	0,9991607	-533,576	364,5605
Deepsoil:0-Deepsoil:-40	120,2773	0,9923927	-330,674	571,2284
Deepsoil:0-Deepsoil:-20	204,785	0,8620612	-244,283	653,8531

Alkalinity

Sampling depth: Water quality			95% confidance	
	diff	p	lwr	upr
Deepsoil:Groundwater-Topsoil:Groundwater	-0,0195	0,99027	-0,18522	0,146214
Topsoil:Surfacewater-Topsoil:Groundwater	-0,03589	0,9462	-0,2039	0,132113
Deepsoil:Surfacewater-Deepsoil:Groundwater	0,175334	0,019315	0,020406	0,330261
Deepsoil:Surfacewater-Topsoil:Surfacewater	0,191723	0,009688	0,03435	0,349095

Sampling depth: Water table			95% confidance	
	diff	p	lwr	upr
Deepsoil:0-Topsoil:0	-0,102	0,922001	-0,3543	0,150291
Deepsoil:-20-Topsoil:-20	0,294863	0,008298	0,045796	0,54393
Deepsoil:-40-Topsoil:-40	0,277197	0,116525	-0,03214	0,586529
Deepsoil:-60-Topsoil:-60	0,080601	0,989591	-0,20642	0,367626
Topsoil:-40-Topsoil:-60	0,059546	0,999289	-0,26519	0,384278
Topsoil:-20-Topsoil:-60	0,329331	0,006908	0,055077	0,603586
Topsoil:0-Topsoil:-60	1,041753	0	0,765505	1,318001
Topsoil:-20-Topsoil:-40	0,269786	0,125958	-0,03483	0,574402
Topsoil:0-Topsoil:-40	0,982207	0	0,675796	1,288619
Topsoil:0-Topsoil:-20	0,712422	0	0,460126	0,964717
Deepsoil:-40-Deepsoil:-60	0,256142	0,076039	-0,01334	0,525622
Deepsoil:-20-Deepsoil:-60	0,543594	0	0,280531	0,806657
Deepsoil:0-Deepsoil:-60	0,859148	0	0,595096	1,1232
Deepsoil:-20-Deepsoil:-40	0,287452	0,014864	0,032638	0,542266
Deepsoil:0-Deepsoil:-40	0,603006	0	0,347171	0,858842
Deepsoil:0-Deepsoil:-20	0,315554	0,003288	0,066487	0,564621

Appendix E

Weekly pH and electroconductivity tank water measurements

Weekly pH was measured using an ion-specific electrode (WTW pH meter 3110, Sentix 41 electrode) and electrical conductivity (EC) with a conductivity meter (WTW COND 3110). The tank water pH and EGV measurements were used to ensure consistency in the independent variables and to enable the interpretation of the results and explain possible deviations.

pH in tanks (weekly measurment)

Date	Measuring moment	Tank 1	Tank 2	Tank 3	Tank 4	Tank 5	Tank 6	Tank 7	Tank 8	Tank 9	Tank 10	Tank 11	Tank 12	Tank 13	Tank 14	Tank 15	Tank 16	Tank 17	Tank 18	Tank 19	Tank 20
18-feb	1	6,633	7,235	6,753	7,025	6,853	7,422	6,762	7,398	6,76	7,423	6,777	7,618	6,808	7,513	6,65	7,426	6,73	7,502	6,713	7,617
25-feb	2	6,465	7,168	6,604	6,794	6,794	7,169	6,644	7,155	6,733	7,408	6,779	7,551	6,846	7,448	6,57	6,969	6,942	7,561	6,749	7,479
4-mrt	3	7,169	7,197	7,159	7,161	7,157	7,44	7,082	7,236	7,112	7,295	7,094	7,446	7,158	7,272	6,834	7,203	7,121	7,287	7,049	7,543
19-mrt	4	7,24	7,224	7,364	7,222	7,421	7,155	7,462	7,15	7,328	7,111	7,447	7,115	7,43	7,126	7,393	7,185	7,394	7,234	7,549	7,273
20-mrt	5	7,419	7,602	7,397	7,48	7,52	7,416	7,523	7,447	7,499	7,29	7,442	7,329	7,518	7,358	7,466	7,324	7,487	7,325	7,444	7,332
1-apr	6	7,266	7,684	7,383	7,58	7,433	7,584	7,447	7,601	7,261	7,53	7,423	7,711	7,432	7,649	7,433	7,593	7,426	7,601	7,427	7,597
9-apr	7	7,261	8,258	7,321	7,942	7,407	7,756	7,402	7,752	7,343	7,802	7,383	8,075	7,488	7,757	7,375	7,726	7,463	7,79	7,467	7,763
16-apr	8	7,4	7,58	7,427	7,589	7,341	7,4	7,305	7,414	7,3	7,235	7,324	7,369	7,353	7,297	7,274	7,338	7,4	7,399	7,347	7,41
30-apr	9	7,307	7,789	7,271	7,876	7,339	7,763	7,289	7,771	7,294	7,7	7,315	7,711	7,339	7,67	7,209	7,682	7,325	7,742	7,328	7,744
6-mei	10	7,292	7,847	7,281	7,847	7,422	7,861	7,337	7,821	7,362	7,666	7,355	7,831	7,308	7,748	7,252	7,787	7,735	7,972	7,343	8,028
13-mei	11	7,189	7,925	7,35	7,977	7,396	7,988	7,627	7,903	7,586	7,529	7,562	7,51	7,545	7,684	7,424	7,873	7,505	8,146	7,43	8,245
20-mei	12	7,024	7,132	7,142	7,106	7,113	7,01	7,189	6,935	6,996	7,008	6,906	7,036	7,028	7,132	7,037	7,05	7,183	7,188	7,209	7,513

Change between measuring moments	Tank 1	Tank 2	Tank 3	Tank 4	Tank 5	Tank 6	Tank 7	Tank 8	Tank 9	Tank 10	Tank 11	Tank 12	Tank 13	Tank 14	Tank 15	Tank 16	Tank 17	Tank 18	Tank 19	Tank 20
1-2	0,168	0,067	0,149	0,231	0,059	0,253	0,118	0,243	0,027	0,015	-0,002	0,067	-0,038	0,065	0,080	0,457	-0,212	-0,059	-0,036	0,138
2-3	-0,704	-0,029	-0,555	-0,367	-0,363	-0,271	-0,438	-0,081	-0,379	0,113	-0,315	0,105	-0,312	0,176	-0,264	-0,234	-0,179	0,274	-0,300	-0,064
3-4	-0,071	-0,027	-0,205	-0,061	-0,264	0,285	-0,380	0,086	-0,216	0,184	-0,353	0,331	-0,272	0,146	-0,559	0,018	-0,273	0,053	-0,500	0,270
4-5	-0,179	-0,378	-0,033	-0,258	-0,099	-0,261	-0,061	-0,297	-0,171	-0,179	0,005	-0,214	-0,088	-0,232	-0,073	-0,139	-0,093	-0,091	0,105	-0,059
5-6	0,153	-0,082	0,014	-0,100	0,087	-0,168	0,076	-0,154	0,238	-0,240	0,019	-0,382	0,086	-0,291	0,033	-0,269	0,061	-0,276	0,017	-0,265
6-7	0,005	-0,574	0,062	-0,362	0,026	-0,172	0,045	-0,151	-0,082	-0,272	0,040	-0,364	-0,056	-0,108	0,058	-0,133	-0,037	-0,189	-0,040	-0,166
8-9	-0,139	0,678	-0,106	0,353	0,066	0,356	0,097	0,338	0,043	0,567	0,059	0,706	0,135	0,460	0,101	0,388	0,063	0,391	0,120	0,353
9-10	0,093	-0,209	0,156	-0,287	0,002	-0,363	0,016	-0,357	0,006	-0,465	0,009	-0,342	0,014	-0,373	0,065	-0,344	0,075	-0,343	0,019	-0,334
10-11	0,015	-0,058	-0,010	0,029	-0,083	-0,098	-0,048	-0,050	-0,068	0,034	-0,040	-0,120	0,031	-0,078	-0,043	-0,105	-0,410	-0,230	-0,015	-0,284
11-12	0,103	-0,078	-0,069	-0,130	0,026	-0,127	-0,290	-0,082	-0,224	0,137	-0,207	0,321	-0,237	0,064	-0,172	-0,086	0,230	-0,174	-0,087	-0,217
12-13	0,165	0,793	0,208	0,871	0,283	0,978	0,438	0,968	0,590	0,521	0,656	0,474	0,517	0,552	0,387	0,823	0,322	0,958	0,221	0,732

EC (uS) in tanks (weekly measurment)

Date	Measuring moment	Tank 1	Tank 2	Tank 3	Tank 4	Tank 5	Tank 6	Tank 7	Tank 8	Tank 9	Tank 10	Tank 11	Tank 12	Tank 13	Tank 14	Tank 15	Tank 16	Tank 17	Tank 18	Tank 19	Tank 20
18-feb	1	996	1227	966	1306	686	1245	690	1207	638	1315	610	1277	629	1291	759	1283	751	1306	767	1225
25-feb	2	1092	1273	1030	1553	675	1287	628	1248	651	1297	604	1271	617	1290	763	1366	755	1315	764	1217
4-mrt	3	950	1430	968	1421	706	1326	753	1340	675	1424	674	1328	637	1405	878	1400	780	1419	809	1284
19-mrt	4	597	1255	569	1280	543	1242	547	1256	545	1254	532	1245	535	1249	542	1243	543	1258	543	1256
20-mrt	5	635	1302	627	1332	548	1261	562	1265	554	1258	541	1250	542	1258	557	1257	552	1262	554	1257
1-apr	6	667	1320	624	1320	554	1266	569	1282	563	1274	546	1261	548	1280	572	1265	562	1281	560	1285
9-apr	7	650	1295	619	1287	550	1259	575	1273	562	1260	547	1235	548	1298	582	1261	563	1249	565	1266
16-apr	8	614	1306	609	1310	600	1283	604	1283	606	1296	599	1290	598	1292	605	1276	601	1277	609	1277
30-apr	9	603	1295	595	1281	595	1263	605	1234	605	1267	592	1268	599	1250	614	1249	603	1271	616	1276
6-mei	10	585	1251	544	1265	578	1234	603	1230	595	1279	593	1258	593	1252	605	1245	596	1249	616	1264
13-mei	11	559	1177	700	1225	565	1193	592	1206	755	1312	662	1283	579	1210	598	1208	587	1221	604	1235
20-mei	12	617	1068	573	1178	563	1292	538	1360	640	1277	716	1233	543	1124	544	1193	531	1132	540	1065

Change between measuring moments	Tank 1	Tank 2	Tank 3	Tank 4	Tank 5	Tank 6	Tank 7	Tank 8	Tank 9	Tank 10	Tank 11	Tank 12	Tank 13	Tank 14	Tank 15	Tank 16	Tank 17	Tank 18	Tank 19	Tank 20
1-2	-96	-46	-64	-247	11	-42	62	-41	-13	18	6	6	12	1	-4	-83	-4	-9	3	8
2-3	142	-157	62	132	-31	-39	-125	-92	-24	-127	-70	-57	-20	-115	-115	-34	-25	-104	-45	-67
3-4	353	175	399	141	163	84	206	84	130	170	142	83	102	156	336	157	237	161	266	28
4-5	-38	-47	-58	-52	-5	-19	-15	-9	-9	-4	-9	-5	-7	-9	-15	-14	-9	-4	-11	-1
5-6	-32	-18	3	12	-6	-5	-7	-17	-9	-16	-5	-11	-6	-22	-15	-8	-10	-19	-6	-28
6-7	17	25	5	33	4	7	-6	9	1	14	-1	26	0	-18	-10	4	-1	32	-5	19
8-9	36	-11	10	-23	-50	-24	-29	-10	-44	-36	-52	-55	-50	6	-23	-15	-38	-28	-44	-11
9-10	11	11	14	29	5	20	-1	49	1	29	7	22	-1	42	-9	27	-2	6	-7	1
10-11	18	44	51	16	17	29	2	4	10	-12	-1	10	6	-2	9	4	7	22	0	12
11-12	26	74	-156	40	13	41	11	24	-160	-33	-69	-25	14	42	7	37	9	28	12	29
12-13	-58	109	127	47	2	-99	54	-154	115	35	-54	50	36	86	54	15	56	89	64	170