

The background of the slide is a photograph of a rural landscape. In the foreground, there is a narrow, shallow ditch or stream filled with water, surrounded by tall grasses and wildflowers. To the right of the ditch, there is a field of tall, green corn plants. In the background, there is a line of trees and a cloudy sky.

## **CONTROLLED DRAINAGE AND OTHER SCIENCE DRAINAGE TECHNOLOGIES**

Technologies that benefit environment and plant production  
by reducing loss of nutrients and water by drainage

## Controlled drainage and other SCIEN drainage technologies

Technologies that benefits environment and plant production by reducing loss of nutrients and water by drainage

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Cover Drainage canal on fields belonging to Stiftelsen Hofmansgave. The drainage water is gathered in the canal and led into Odense Fjord via a pumping station. Photo: Henning Lyngsø Foged.

Front and back page Odense Fjord off Stiftelsen Hofmansgave. Photo: Henning Lyngsø Foged.

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Baltic Compass is a strategic project that aims to foster solutions of benefit to both agriculture and environment in the Baltic Sea Region. The 22 partners of the project represent national authorities, NGO's, scientific institutions and innovation centers from the countries in the Baltic Sea Region. Learn more at [www.balticcompass.org](http://www.balticcompass.org).



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## Agricultural drainage in an environmental perspective

>> Drainage is often requisite for the plant production, but at the risk of having negative effects on the water environment. Furthermore, in relation to the climate changes it is unfortunate for the plant production that conventional drainage with its passive drainage of water can enhance the water deficiency during certain periods and increase the risk of flooding during others. It does not have to be that way and this pamphlet tells about technologies, which can make drainage a means of benefit to both environment and agriculture.

### Conventional drainage

There are no official statistics, but it is reckoned that more than half of the cultivated fields are drained, and that goes for the entire Baltic Sea Region. The drainage is established to enable necessary traffic to cultivate the fields. The drainage is also made in order to protect the crops from drowning in waterlogged fields.



PERFORATED PVC HOSES, LIKE THIS, PLACED IN THE FIELDS AT A DEPTH OF 80-120 CM ARE OFTEN USED FOR DRAINAGE.

Drainage is carried out differently with either a drainage pipe, typically at a depth of 80-120 cm, or with open drainage canals. The drainage water is led into the water environment, e.g. creeks, fjords or lakes. If the fields are placed on dammed up land or in other ways situated low, the drainage to the water environment can happen via a pumping station.



DRAINAGE WATER RUNNING FROM DRAINAGE PIPE INTO A DRAINAGE CANAL.



PUMPING STATION.

## Controlled drainage and other SCIEN drainage technologies

>> SCIEN drainage stands for technologies, which make drainage sustainable, intelligent, and environmentally friendly, and which can also mitigate the loss of nutrients (sustainable, controlled, intelligent, environmental friendly and nutrient loss mitigating). SCIEN drainage are technologies, which can be added-on to existing drainage systems. Common for the SCIEN drainage technologies is that in various ways they, to some extent, enable the farmer to control the water and its content of nutrients in his fields. It contributes to close the nutrient cycle in agriculture. SCIEN drainage transforms drainage from merely being a way of getting rid of excess water to becoming a concept for intelligent management of water and nutrients in the fields.

### Controlled drainage

Controlled drainage is carried out by installing regulation wells in order to raise the water table approximately  $\frac{1}{2}$  a meter.

In the Baltic Sea Region, controlled drainage is only used in Finland and Sweden. According to Swedish research results, it is expected that the outflow of water as well as nitrogen and phosphorus can be reduced with 50 - 80%. The yield could possibly be increased due to improved availability of water and nutrients. The effects depend on the climate conditions each year, choice of crops, and on the topographical, geological, and the hydrologic conditions in the field.

The higher ground water level in the field gives increased denitrification. It also has the effect that a larger amount of the nitrogen is led through the

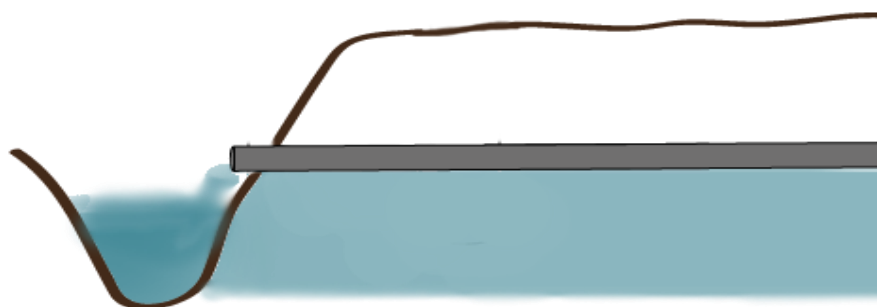
reducing/denitrifying layers under the root zone, and that a corresponding reduced amount of water is led through the drainage system.

The nitrogen emission to the water environment will be reduced in the order of 25 kg pr. ha per year. It is also expected that there will be an extra 10-15 kg N available for the crops.

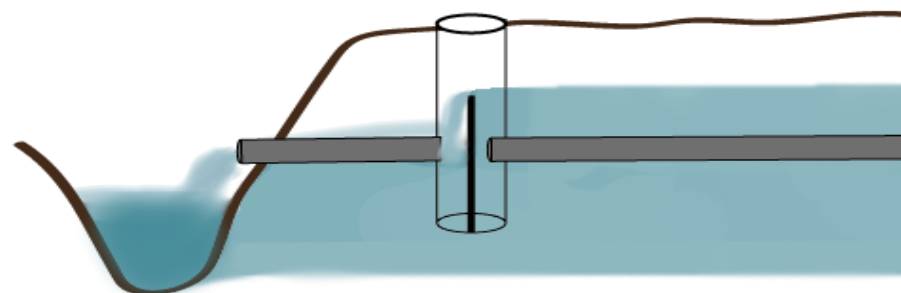
In periods where the higher water table would be inconvenient to the field work, the farmer has the possibility to adjust the regulation well to let the water pass.

The disadvantages of controlled drainage are the startup expenses, especially the expenses for the regulation wells, and also the need for manual regulation, and the possible inconvenience for the field work.

Learn more at e.g. <http://www.balticdeal.eu/measure/controlled-drainage/>.



SKETCH OF CONVENTIONAL DRAINAGE. THE WATER OVER THE DRAINAGE PIPES IS LED AWAY INCLUDING THE WATER'S CONTENT OF NITROGEN AND PHOSPHORUS.



SKETCH OF CONTROLLED DRAINAGE. REGULATION WELLS MAKE THE FARMER CAPABLE OF CONTROLLING THE WATER LEVEL IN THE FIELD.

## Other SCIEN drainage technologies

>> Controlled drainage appears to be one of the most obvious technologies in fields drained by pipes. If this is not the case or if the topography or other conditions in the field mean that controlled drainage cannot be used, other SCIEN drainage technologies could be considered.

### On/off drainage

On/off drainage means that you only use the drainage system when it is necessary. This means, that if you have a pumping station it is possible to use the pumps to regulate the water level to some extent in the drained area. If there are additional drainage pipes these can be shut (in several places if necessary) during winter and in other periods without much traffic in the fields, and where drainage is not needed. This will prevent loss of N and P most of the year and increase the possibility for denitrification, and possibly give higher yields as a result of better water availability for the crops.

In connection with their participation in Baltic Compass the Landesamt für Landwirtschaft, Umwelt und ländliche Räume in Kiel have found detailed descriptions, pictures, legislation, etc. on a system intended for being used along with drainage pipes. The system works mechanically by means of a floater, and automatically opens up for the water flow in the drainage pipes when the water level is high and vice versa. The system has the advantages that once the regulation unit is installed it does not require further adjustments, plus it is installed lower than the ploughing depth and therefore do not interfere with the field work



REGULATION UNIT FOR ON/OFF DRAINAGE DEVELOPED IN FORMER EASTERN GERMANY IN 1989.

### Production of water plants in drainage water

It is known that the liquid fractions from slurry separation can be used as a substrate for algae production. Another option, which is currently being tested in Denmark, is to grow water plants in drainage water.

The drainage water is collected in reservoirs with water plants before it runs out into the nature. The harvested plants are meant to be used for biogas production or as a fodder component for wet feeding pigs, and it can also be used as food supplement or fertiliser.

Learn more about the project at <http://agrotech.dk/projekter/draenvand-til-proteinfoder-og-bioenergi>.



DIGGING OF RESERVOIRS FOR CULTIVATION OF ALGAE IN DRAINAGE WATER (FROM [HTTP://2.NATURERHVERV.FVM.DK](http://2.naturerhverv.fvm.dk)).

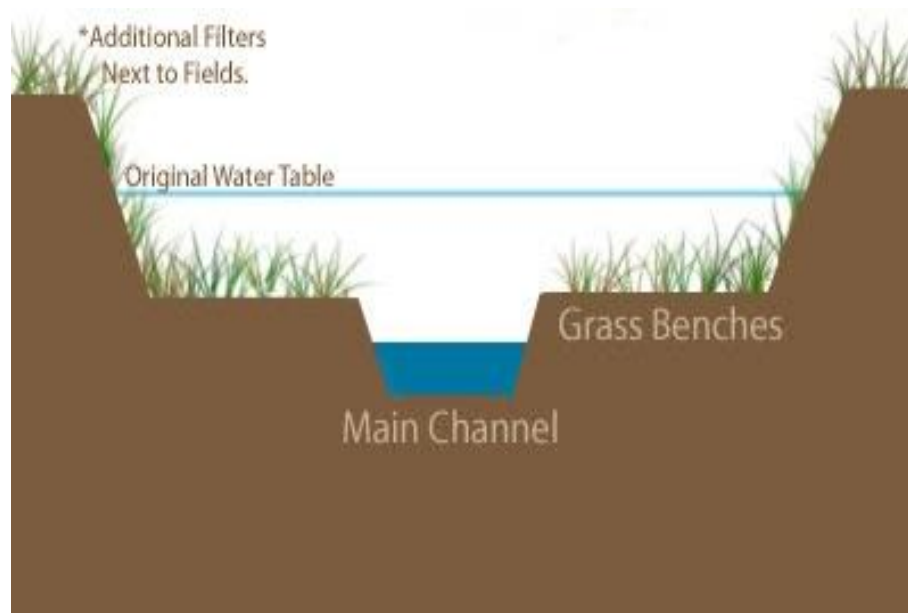


## Two-stage ditch drainage

The traditional open drainage ditches can be reconstructed creating a plateau on each side of the ditch.

Drainage canals with plateaus will promote the denitrification, i.e. the conversion of nitrogen in the drainage water to nitrogen gas (N<sub>2</sub>).

One could say that the plateaus give the drainage canals environmental effects similar to the ones in wetlands. The technology is especially known from the US, and here studies have shown that the design could reduce the content of nitrogen and phosphorus in the drainage water with 17 and 33 % respectively.



SKETCH OF TWO-STAGE DITCH DRAINAGE, A DRAINAGE TECHNOLOGY, WHICH IS ESPECIALLY KNOWN FROM THE US. FIGURE FROM [HTTP://WWW.NATURE.ORG](http://www.nature.org).

## Drainage filters and constructed mini-wetlands

Drainage filters and constructed mini-wetlands are new cost-effective technologies, which can alleviate the loss of nutrients through the drainage system. As for two-stage ditch drainage, the idea is to achieve some of the same effects as wetlands provide, given that they are installed and connected to the respective drainage systems.

Currently, various projects are carried out to document the costs and environmental effects of drainage filters and mini-wetlands, and furthermore of the different ways they can be established in correlation with the specific fields. There are two main types of constructed wetlands; one has a shallow water flow, while the other creates a water flow by infiltration through a matrix of filter material.

According to "Environmental measures in Denmark", which has been produced by Knowledge Centre for Agriculture, mini-wetlands are more effective than natural wetlands, and a mini-wetland covering approximately 3% of the drained area could remove 42 % of the nitrogen in the drainage water.

Read more about the tests with drainage filters and mini-wetlands at e.g. <http://www.supremetech.dk/SUPREMETECH.htm> and <http://www.balticsea2020.org/bibliotek/32-oevergoedning/240-just-nu-i-dikesprojektet>.

## Management and monitoring

The farmer should monitor the amount of drainage water plus the nutrient content before and after it passes the SCIEN drainage technology in order to make full use of the drainage technologies. Of course, the insight this provides should be used to manage the technology, e.g. to decide when to raise or lower the water level in a field with controlled drainage.

A higher degree of intelligent management and monitoring of the SCIEN drainage technologies are probably prerequisites for the general breakthrough for the technologies.

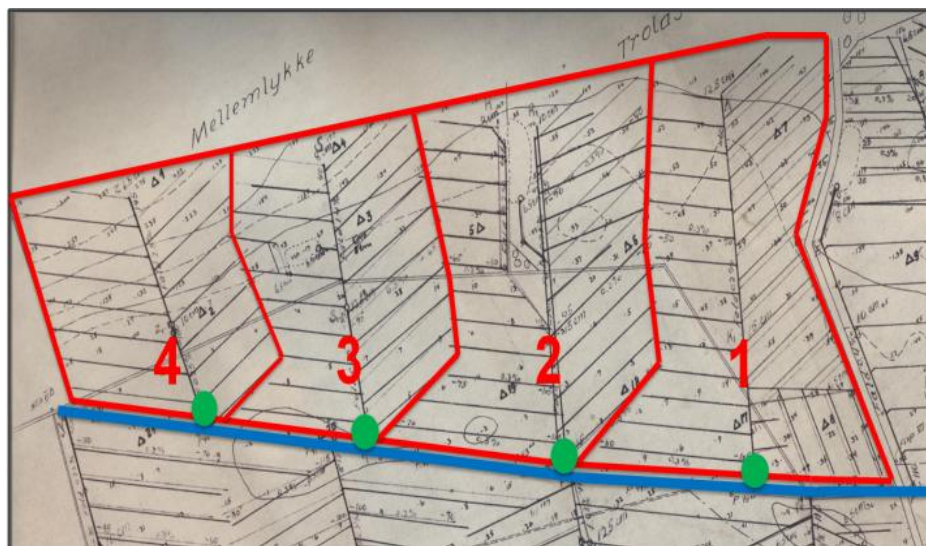
## Pilot project at Stiftelsen Hofmangave

>> A pilot project is currently being carried out at Hofmangave where controlled drainage is installed in a field of 16 ha with four main drains. The installation makes it possible to assess the effect of controlled drainage with the other main drains functioning as control units. Besides from regulation wells, equipment for measuring of water flow and analysis of the nutrient content has been installed. Follow the pilot project at <http://www.vfl.dk/hofmangave>.

### The project

The pilot project includes a demonstration plant with controlled drainage. Two different types of treatment are compared in the demonstration field, i.e. conventional drainage without any regulation and controlled drainage with a raised water level during the winter season.

The purpose of the project is to demonstrate both the environmental and agronomical effects of crop cultivation using controlled drainage.



**DRAINAGE MAP OF THE FIELD AT HOFMANGAVE, WHERE THE PILOT PROJECT IS SITUATED. THE FOUR SECTIONS INDICATE THE AREAS COVERED BY THE FOUR MAIN DRAINS, AND THE BLUE LINE MARKS THE OPEN DRAINAGE CANAL.**

The demonstration field of around 16 ha has already been systematically drained, and has four main drains with separate outflow of drainage water to a drainage canal. Controlled drainage is established in all four main drains, and it is possible to regulate for instance two of them while the two

remaining main drains function as control units with no regulation of the water level.

Four control wells for managing the water level are established plus wells equipped with flowmeters to measure the outflow of drainage water from both the regulated and non-regulated main drains.



**AT THE RIGHT, THE MAIZE FIELD AT HOFMANGAVE IN AUGUST 2011, WHERE THE PILOT PROJECT IS SITUATED. THE DRAINAGE CANAL IS HIDDEN UNDER THE VEGETATION AT THE LEFT. THE FIELD IS IDEAL FOR CONTROLLED DRAINAGE SINCE IT IS NOT HILLY AND HAS A MINOR AND EVEN SLOPE TOWARDS THE DRAINAGE CANAL.**

The demonstration field is situated right outside an EU habitat area. The drainage water flows through a drainage canal directly to the marine part of this EU habitat area in Odense Fjord. The fjord is relatively shallow and environmentally very vulnerable. The rare sea eagle has its breeding ground at a protected island in the fjord, situated less than one kilometre away from the demonstration field.

## The investment

The investment has included

- 4 regulation wells and 4 measuring wells
- Pipes for observation of the water level
- Contractors
- 4 flowmeters
- 4 data loggers
- Data communication equipment
- 1 weather station
- Homepage with online data presentation

Total investment: 73,000 €.

Coordinating and managing of the establishment has been handled by the Knowledge Centre for Agriculture, Plant Production.



REGULATION WELLS LIKE THIS IS BEING USED FOR CONTROLLED DRAINAGE AT HOFMANSGAVE.



## Monitoring, registrations and analyses

**>> To be able to assess the financial and environmental effects of controlled drainage, including whether it is expected to achieve a reduction of the outflow of both water and nutrients with 50-80 %, a number of registrations will be made during the next couple of years financed by “Grønt Udviklings- og Demonstrations Program”, GUDP under the Ministry of Food, Agriculture and Fisheries of Denmark.**

### Measuring the drainage outflow

Four measuring wells with battery-powered flowmeters have been established. Thus, the outflow of drainage water can be measured continuously. A data logger with wireless data communication is installed at every measuring well. The data logger collects data from the flowmeter and sends the data to a server at the Knowledge Centre for Agriculture once a day. The collected data will be presented online at the project homepage.

### Analyses of the drainage water

A water sample from each of the four drainage outflows is collected every week throughout the outflow period. The drainage water's nitrogen (total-N and nitrate-N) and phosphorus level is analysed. The samples from the drainage water are sent to analysis at University of Aarhus, Institute for Bioscience.

### Measuring of water levels

A location pipe with a pressure transducer in the bottom is placed in the field, 25 meters opposite from each measuring well. The pressure transducer is connected to the data loggers at the measuring well via a cable buried deeper than the ploughing depth. The pressure transducer in the sounding pipes continuously measures the water level in the field. It is important to know and be able to monitor the water level. It is the raised water level that should ensure that less nitrogen is emitted with the drainage water. However, the water level may not be too high since this could damage an overwintering crop. The water table will also be measured several other places in the acreage.

### Measuring of precipitation

It is important to know the precipitation on the field as precisely as possible. A precipitation gauge, which is connected to one of the data loggers on the

field, has been put up. However, the measuring of precipitation should take place where there is shelter from the wind. Thus, a weather station has been put up in the garden at Hofmansgave.

### Soil investigations

The soil has been mapped with EM 38. Furthermore, the texture is determined in various places in the acreage all the way down to the drainage depth.

### N-min in the soil

N-min samples are taken both during fall and spring in order to gain knowledge about the level of nitrogen accessible to plants in the soil concerning each of the four sections. It is expected that controlled drainage will increase the level of nitrogen accessible for plants in the soil during spring.

### Measuring of yield

The yield is measured each year. The measuring is carried out using a combine harvester with GPS if the crop is winter wheat. A yield map of the entire acreage will be drawn up. The yield is measured on a weighbridge when maize is the crop.

### Crop analysis and nutrient balance

The nutrient content in the harvested crops is analysed to be able to determine the nutrient balance in each of the drained sections.

The investment project will be mutually beneficial by providing results and experience regarding controlled drainage as a tool to reduce the emission of nitrogen into the water environment. The host for the demonstration is Stiftelsen Hofmansgave that supports the development of mutually beneficial cultivation methods in agriculture. Knowledge Centre for

Agriculture, Plant Production, provides non-profit advisory and ensures that the results and experiences created through the investment project are available to the public.

#### **Subsidy for analyses and studies from GUDP**

The demonstration field at Hofmansgave is part of a larger GUDP project regarding controlled drainage as a means for reducing the nitrogen emission into the water environment. As of 2012 there are a total of four demonstration fields with controlled drainage situated in different places in Denmark. Learn more about this project at [www.vfl.dk/kontrolleretdraening](http://www.vfl.dk/kontrolleretdraening).

A subsidy has been provided by “Grønt Udviklings- og Demonstrations Program”, GUDP under the Ministry of Food, Agriculture and Fisheries of Denmark, for the completion of analyses and studies regarding the demonstration field at Hofmansgave.



**A WELL FOR MEASURING WATER FLOW (LEFT) AND A REGULATION WELL FOR CONTROLLED DRAINAGE BEING INSTALLED AT HOFMANSGAVE.**



## Further information

>> Literature, webpages etc., where further information on controlled drainage and other SCIEN drainage technologies is to be found

- AgroTechnologyATLAS - <http://agro-technology-atlas.eu/>.
- Baltic DEAL's mention on controlled drainage - <http://www.balticdeal.eu/measure/controlled-drainage/>.
- Controlled drainage - a rediscovered approach for water management - <http://www.balticcompass.org/BlogRetrieve.aspx?PostID=304523&A=SearchResult&SearchID=503666&ObjectID=304523&ObjectType=55>.
- GUDP-financed project on controlled drainage - [www.vfl.dk/kontrolleretdraening](http://www.vfl.dk/kontrolleretdraening).
- Monitoring of controlled drainage at Hofmansgave - <http://www.vfl.dk/hofmansgave>.
- Project on water plant production in drainage water - <http://agrotech.dk/projekter/draenvand-til-proteinfoder-og-bioenergi> plus <http://2.naturerhverv.fvm.dk/visningsside.aspx?ID=83063&PID=686752&year=undefined&NewsID=8448>.
- Sector Study concerning prioritised innovative agro-environmental technologies for sustainable food production in the Baltic Sea Region - [http://agro-technology-atlas.eu/docs/repo20905\\_Baltic\\_Compass\\_Sector\\_Study.pdf](http://agro-technology-atlas.eu/docs/repo20905_Baltic_Compass_Sector_Study.pdf).
- SUPREMETECH / project on drainage filters and mini wetlands - <http://www.supremetech.dk/SUPREMETECH.htm>.
- The Dikes project - <http://www.balticsea2020.org/bibliotek/32-oevergoedning/240-just-nu-i-dikesprojektet>.
- Two-stage ditch drainage – <http://www.nature.org>.
- “Win-win technologies for nutrient management” – a mobile and partly virtual exhibition with video clips and PowerPoints - [http://agro-technology-atlas.eu/win\\_win\\_technologies\\_for\\_nutrient\\_management.aspx](http://agro-technology-atlas.eu/win_win_technologies_for_nutrient_management.aspx).



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