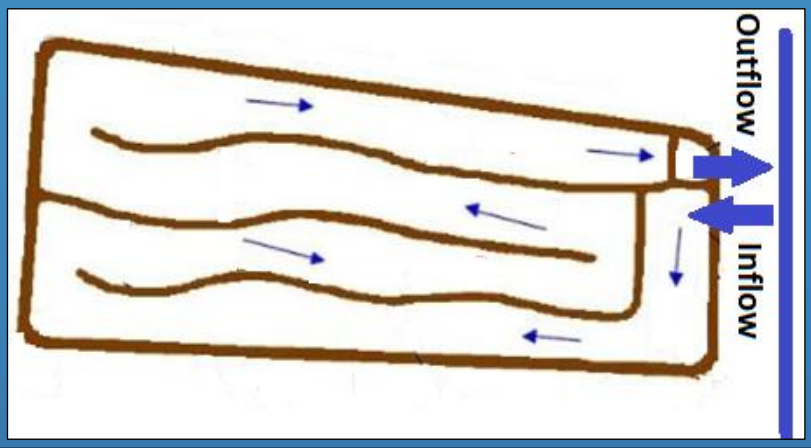
WATERAGRI

FACTSHEET

FARM CONSTRUCTED WETLANDS FOR NUTRIENT RECOVERY



Key information

A Farm Constructed Wetland has the ability to retain and reduce nutrients from the inflow through various biogeochemical processes as the water passes through.

Target audience: farmers, general public.

This project has received funding from the European Union's Horizon 2020 research and innovation program under Grant Agreement No 858735.

A. Brief Introduction:

Farm Constructed Wetlands (FCW) is a type of Nature Based Solution (NBS) which can be used for retaining and reducing nutrient concentrations in water affected by agriculture. Phosphorous (P) is mainly retained by sedimentation of particles to which P tends to be adsorbed. Nitrogen (N) is mainly retained through biochemical processes (nitrification-denitrification) as bacteria convert mineral N to gas which returns to the atmosphere. Nutrients are also, to some extent, taken up by plants growing in the wetland, or accumulated in the soil.

The objective of FCW for nutrient retention is to reduce the eutrophication effects of agricultural drainage water or water affected by agriculture on downstream watercourses, lakes and sea. Another potential benefit of FCW is the possibility for managing the flow of water through farmland. Wetlands can thus be used to save water in order to use it for irrigation when needed, and to provide temporary storage during intensive rain events in order to reduce peaks and associated downstream problems. This aspect of FCW is covered in a separate factsheet.

The innovative aspect of FCW for nutrient retention is the fact that it is an NBS which provides a number of ecosystem services as beneficial side effects, and that it can deal with variable flows typical of agricultural drainage water, also managing variable fluxes of different contaminants.

The wetland should be designed to be optimal for local conditions and the specific case/farm. Important parameters, among others, are the size of the catchment area which generates the inflow to the FCW, the expected inflow nutrient concentrations and target outflow concentrations, as well as hydraulic retention time of the system.

B. Design concept:

There are a few important **design criteria** which follow logically from the nutrient retaining mechanisms. A deeper part, around 2 meters, near the inlet with low velocities might be useful in order to let particles settle to the bottom. Also, certain parts with depths of 0.1 – 1.0 meter can provide areas which are favorable for vegetation development, both submerged and emergent species. The plants have dual functions providing a substrate for denitrification bacteria as well as taking up nutrients when they grow. The former process (denitrification) is dominant, while the latter process (plant uptake) depends on removal of plant material in order to give substantial net effects. In case of high nitrate load, too low concentration of DOC (Dissolved Organic Carbon) can be a limiting factor, resulting in less than maximum nutrient (N) removal efficiency.

As a rule of thumb, given by the Swedish Board of Agriculture, the hydraulic retention time of the wetland should be minimum two days. The design should ascertain that the flow of water is well distributed over the whole area. Since some of the nutrients are captured in the vegetation itself, it might be needed to provide access for machinery which can harvest the plants after a few years. In order to speed up the process of making the wetland mature and efficient, it is necessary to introduce vegetation in a newly constructed wetland.

The actual design of a wetland for nutrient reduction should be made by experienced consultants.

C. Technical information:

The **requirement for construction** of a Farm Constructed Wetlands (FCW) for nutrient retention is primarily accessible land, preferably with soil of lower quality so that it does not affect negatively agricultural production. Also there should be land nearby where the excavated soil can be moved. Part of this soil can be used in order to construct embankments of the system. The equipment needed is excavation machinery. A more detailed investigation and design is necessary to take into account local topography and the need for special structures at inlet and outlet.

Operation and maintenance of the FCW would normally not require any manpower or skills more than what is available on a farm. With an interval of a couple of years it is necessary to harvest the wetland vegetation which captures and holds nutrients in the biomass.

Monitoring of the FCW involves checking the status of the vegetation, as well as observing the flow patterns in the wetland. Any sign of preferential flow (short-circuiting) should lead to increased monitoring, and preventive actions if necessary. The even flow of water over the whole wetland area is crucial for achieving the desired nutrient removal efficiency.

Performance of a FCW depends on a multitude of factors, reflecting external conditions such as loading climate, as well as internal conditions i.e. the wetland itself. Therefore, estimates of performance have to be made on a case-to-case basis. Some performance data for a specific wetland are found in the reference given at the end of this document.

D. Costs and Benefits:

The **cost of construction** of a Farm Constructed Wetlands (FCW) is dominated by the cost of excavation and transport of removed soil. On a farm it is normally possible to shift the soil within the property, and therefore the excavation costs dominate. Typical rough estimates for Sweden (2022) mention a cost of 100 00 – 200 000 SEK/ha. Subsidies (90%) can be received, see section E.

Cost of operation and maintenance are usually quite low. Depending on the design of inlet and outlet there will be no or only limited actions necessary to regulate the flow. Maintenance involves supervision of the dam structure and harvesting vegetation as necessary. In Sweden also these costs are subsidized at 5000 – 8000 SEK/ha.

The direct **farming benefits** of wetlands for nutrient retention are limited. The gains are to be found in positive side effects, such as increased possibilities for recreation, fishing, and hunting.

The **environmental consequences** of a constructed wetland are beneficial. It would normally contribute to increased biodiversity. Moreover, these systems become semi-natural after a certain

period of time, meaning that flora and fauna start to regulate themselves and no interventions from that point of view are needed.

The **social consequences** of a constructed wetland are beneficial. It offers a variation in the landscape, a demonstration site that can be used for teaching or research activities, and a possibility for increased leisure activities. Depending on the accessibility of the land, these positive effects may affect the general public or the landowner only.

E. Challenges and opportunities

The potential technical limitations for Farm Constructed Wetlands (FCW) are few. The main restriction concerns the soil type. If the soil has high hydraulic conductivity it will be necessary to line the wetland with an impermeable film. A small slope from the inlet towards the outlet point is necessary in order to enable water flow. These systems are usually long-term solutions and can be used for several decades.

The legal requirements vary from country to country. In Sweden the construction of an FCW is considered to be a "water activity" (Swedish: vattenverksamhet). This requires a permit from the Environmental Court for wetlands with area > 5 ha, while for wetlands with area < 5 ha only a report to the County Board is required.

Sometimes it is possible to get subsidies for the construction of wetland. Also in this case procedures vary between countries. In Sweden it is possible to apply for construction or restoration of wetlands. Normally the subsidy would cover 90 % of the costs. At present (November, 2022) there are three programmes, which support wetlands. Swedish national funding is available from LONA (https://www.naturvardsverket.se/lona) or LOVA. Support from EU is funneled via the Swedish "Landsbygdsprogrammet". It should be noted that, in order to get subsidies in Sweden, it is necessary that the wetland is designed to fulfil its environmental objectives.

Evidence-base for using wetlands for nutrient retention is solid (TRL 9). However, the actual efficiency in the amount of removed P and N is rather difficult to predict with high accuracy.

F. Reference and demonstration:

Lavrnić S., Braschi I., Anconelli S., Blasioli S., Solimando D., Mannini P. and Toscano A. (2018) Long-term monitoring of a surface flow constructed wetland treating agricultural drainage water in Northern Italy. Water 10(5), 644. https://doi.org/10.3390/w10050644

Lavrnić S., Alagna V., Iovino M., Anconelli S., Solimando D., Toscano A. (2020) Hydrological and hydraulic behaviour of a surface flow constructed wetland treating agricultural drainage water in northern Italy. Science of the Total Environment 702, 134795. https://doi.org/10.1016/j.scitotenv.2019.134795

Lavrnić S., Nan X., Blasioli S., Braschi I., Anconelli S., Toscano A. (2020) Performance of a full scale constructed wetland as ecological practice for agricultural drainage water treatment in Northern Italy. Ecological Engineering 154, 105927. https://doi.org/10.1016/j.ecoleng.2020.105927

The short video "Wetlands in the WATERAGRI Project – Lund University" gives an introduction to wetlands with a focus on nutrient reduction.
https://www.youtube.com/watch?v=TpemgfRuCaE

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