HuJa Project – Enhancing the treatment of nutrient and metal containing storm water and wastewater

The use of willow-based wetlands for nutrient removal and recovery in sewage treatment for bio-energy production under Northern climate conditions

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Introduction

The use of nutrients in sewage water as fertilizers for wood-based biomass growth is a more sustainable and energy-efficient approach to wastewater treatment which takes under consideration health and environmental standards while also facilitating resource recovery [1]. Constructed wetlands offer a low-cost solution for the recovery of nutrients contained in sewage water. While purifying the water they can produce plant biomass, which can be used as biofuel e.g., via incineration. The resulting ash from the incineration process can also be recycled back in the environment as fertilizer.

Willows (*Salix spp.)* are considered excellent crops for biofuel production due to their good nutrient up-take and good biomass production. However, over fertigation can weaken they cold resistance and further intensify the detrimental effects that harsh could climate conditions can have on biomass growth due to frost burn, snow cover, etc. Cold resistance varieties have been developed and are cultivated in North America and Europe, for example, central and Southern Finland have developed and cultivated their own variety [2]. However, further investigations are required to evaluate if any of existing willow tree varieties can survive and present similar biomass yield and nutrient up-take under even harsher conditions occurring in Northern areas.

As part of HuJa project three cold resistant willow (*Salix spp.)* hybrid varieties and one local variety are evaluated for biomass growth and nutrient uptake in a pilot scale treatment wetland. The wetland receives water from the tertiary treatment phase of Toranki wastewater treatment plant in Kuusamo, Finland. The project will run for a period of three years (2015-2018).

Methods

A pilot scale treatment wetland was constructed within the Toranki wastewater treatment facilities area during fall 2015. The dimensions and other construction details are provided in Figure 1. The pilot wetland was constructed so that longitudinal and cross-section slopes could provide gravitational flow towards the installed drainage system. The wetland consists of tree layers: sand, gravel and top soil which was the original soil extracted during excavation. A HDPE membrane was used as bottom and side protection layer to prevent water infiltration.

A water distribution system was design to assure equal distribution of pumped wastewater volume throughout the wetland surface (Figure 2). Effluent of the wastewater treatment plant is first pumped from the discharge network (observation well) to a 1 m^3 container. The volume of the container is feed to the wetland four times per day. A v-notch weir was installed at the outflow of the wetland in a measuring well (Figure 3). Water level monitoring pipes (4) were placed within the wetland.

In June 2016 around 1600 willow tree brunches (20 cm) (Gudrun, Karin, Klara and a local variety) were planted.

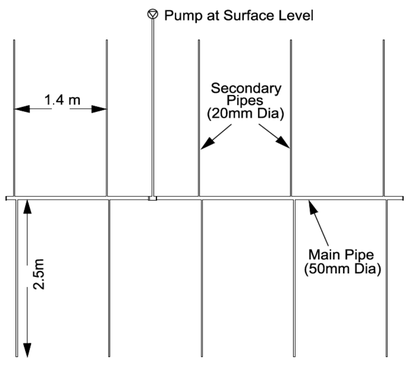

Figure 2 – Water distribution system

Preliminary results

In-flow and out-flow samples (5 occasions) were taken during the summer-autumn period 2016. Concentration of total nitrogen (tot-N), ammonium nitrogen (NH_4-N), combined nitrate and nitrite nitrogen (N_{2+3} N), total phosphorus (tot-P) and phosphate phosphorus (PO4-P) were measured.

Based on the water samples analysed, average retention was as follow:

total-N	86% (inflow 31.2 mg/L)
NH_4-N	78% (inflow 8.5 mg/L)
N_{2+3} -N	87% (inflow 9.8 mg/L)
tot-P	58% (inflow 155 µm/L)
PO4-P	69% (inflow 15 µm/L)

Regarding willow tree survival. After the first ground frost period around 75% of all trees survived. Different varieties presented different survival rates. E.g., nearly 100% of the 'Gudrun' variety survived, but only around 50% of local willow tree variety survived.

Biomass growth will be measured at the end of summer 2017.

Figure 3 – Pilot wetland

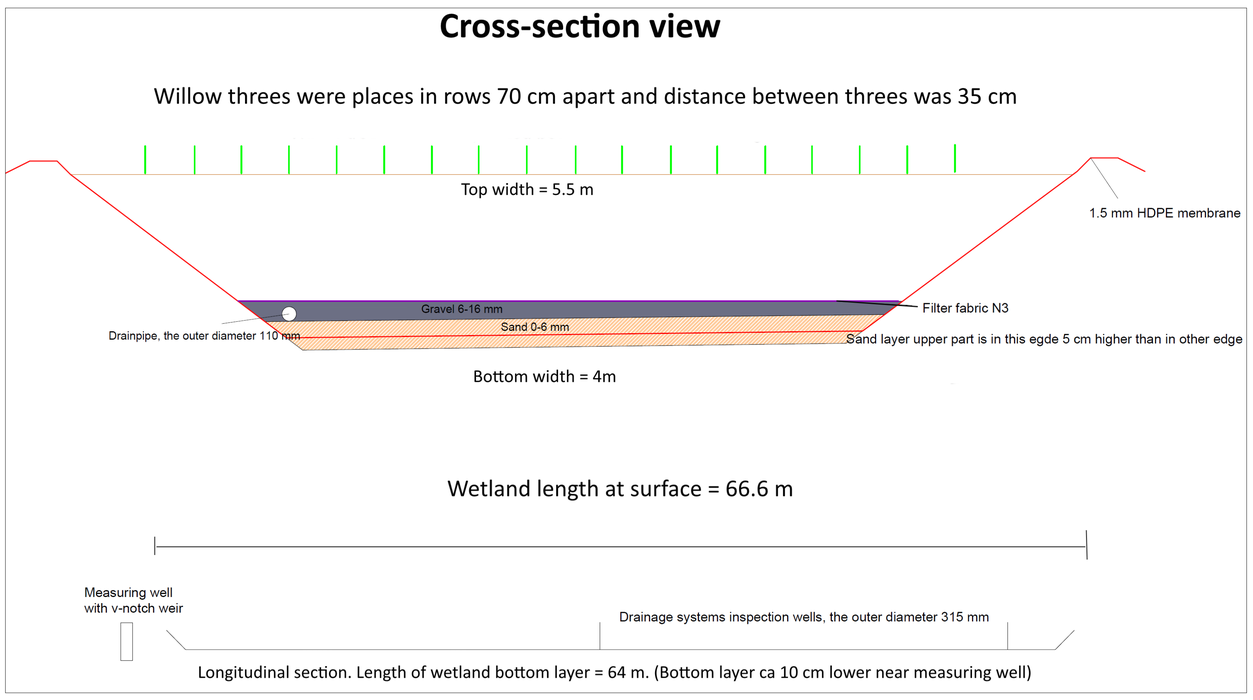

Figure 1 – Cross section view of pilot wetland design

References

[1] Amofah, L.R., Mattssoon, J., Hedström, A., Willow bed fertigated with domestic wastewater to recover nutrients in subarctic climates (2012). Ecological Engineering.
[2] Suomen energiapaju Oy, 2009. Pajunviljelyopas.

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