Swedish experiences from wastewater irrigation on large-scale Short-Rotation Willow Coppice plantations

Ioannis Dimitriou*, Pär Aronsson*
*Dep. of Crop Production Ecology, Swedish University of Agricultural Sciences, Ullsväg 16, Box 7043, 75007, Uppsala, Sweden.
Email: Ioannis.dimitriou@vpe.slu.se

Short-rotation willow coppice (SRWC) is cultivated in Sweden to produce biomass for energy. The crop is commercially grown on agricultural land and the produced biomass is used in district heating plants for combined heat and power production. In recent years, nutrient-rich wastewaters, mainly municipal wastewater, landfill leachate, and industrial wastewaters as log-yard runoff, have been successfully applied to SRWC to reduce fertilisation costs and simultaneously increase biomass production and/or to facilitate alternative low-cost wastewater treatments. The content of pollutants and nutrients in waters and soils is reduced through plant uptake and microbial degradation. Simultaneously, biomass production is enhanced. There are around 30 operating SRWC plantations for utilisation and treatment of wastewaters in Sweden (Dimitriou and Aronsson 2005).

Municipal wastewater contains nitrogen (N) and phosphorus (P) and is preferable to be used as a fertiliser on non-food, non-fodder crops such as SRWC for sanitary reasons. Municipal wastewater has been reported to be a suitable and well-balanced fertiliser for willow (Perttu 1999). During the 1990s, large SRWC plantations with drip or sprinkler irrigation systems were established adjacent to wastewater treatment plants in a range of cities in Sweden to improve the N treatment efficiency while producing biomass. It was assumed that if biomass production were 10 t DM/ha and the N concentration in the willow shoots 0.5%, then 50 kg of N/ha would be removed from the field at harvest each year. Research has shown, however, that N retention can be more than 200 kg N/ha/yr because of denitrification, *i.e.* the microbial transformation of nitrate to nitrogen gas, and long-term binding of nitrogen in the soil, namely the build-up of nitrogen-rich soil organic matter (Aronsson 2000).

In Enköping, a town with 20000 inhabitants in central Sweden, a novel system based on the above idea has been introduced; Sludge is dewatered after sedimentation and centrifugation, and the N-rich water produced, which formerly was treated in the plant, is now distributed to an adjacent 75-ha SRWC plantation during the growing season, as a part of an obligation to reduce the total N outflows in an adjacent lake by 50%. This water contains approximately 800 mg N/l and accounts for about 25% of the total N treated in the wastewater treatment plant. The water is pumped into lined storage ponds during winter and used for irrigating SRWC during summer irrigated for about 120 days annually (May to September), mixed with conventionally treated wastewater to promote plant growth. The system treats about 11 t N and 0.2 t P per year in an irrigation volume of 200000 m^3 of wastewater, of which 20000 m^3 is water derived from dewatering of sludge. Irrigation ceases automatically on rainy days. Irrigation rates reach a daily mean value of 2.5 mm during the growing season. Possible environmental hazards associated with such applications, e.g. N leaching and N_2O emissions into the atmosphere, are monitored; results so far from the field but also from lysimeter trials indicate minimal risks after wastewater application, and biomass growth has proved to be higher than the average for commercial SRWC in the area (unpublished data).

Other N-rich wastewaters as e.g. landfill leachate, or industrial wastewaters with lower nutrient content but with sufficient amounts available during summer, e.g. log-yard runoff, are irrigated to SRWC in Sweden for utilisation of nutrients and treatment of hazardous compounds. At Ragnsells Avfallsbehandling AB landfill, located in Högbytorp, central Sweden, landfill leachate is stored and aerated in ponds and then pumped into a 5-ha SRWC field irrigated daily during the growing season with approximately 2-3 mm. At the Heby sawmill in central Sweden, where about 60000 m^3 per year of log-yard runoff is recycled to a 1-ha SRWC field. The field is irrigated with sprinklers during the growing season at a rate of about 4000 mm per year.

A conclusion after monitoring and evaluating a range of such systems is that pre-testing of irrigation regimes in combination with plant material under local conditions is necessary to avoid failure, in connection with continuous detailed monitoring of parameters of concern is required for successful application. For e.g. landfill leachate, stress symptoms to the plants due to high chloride concentrations or low P supply can occur, therefore laboratory pre-trials testing tolerance of different willow clones under different leachate irrigation regimes are necessary before establishing a large scale system.

References

Aronsson, P. (2000). Nitrogen Retention in Vegetation Filters in Short-Rotation Willow Coppice*, Acta Universitatis Agriculturae Sueciae, Silvestria 161*.

Dimitriou, I., Aronsson, P. (2005). Willows for energy and phytoremediation in Sweden. *Unasylva* 221(56); 46-50.

Perttu, K. L. (1999). Environmental and hygienic aspects of willow coppice in Sweden. *Biomass and Bioenergy* **16**, 291-297.