Water-Renew: Wastewater Tertiary Treatment Using Renewable Energy Crops

By Alex Hutchinson,
Environmental Scientist, WRc Group

Email: pr@wrcplc.co.uk

Water-Renew is an EU LIFE Environment[1] funded portfolio collaborative research project led by WRc Group in partnership with Queen’s University Belfast and Cranfield University. The project aims to move the concept of tertiary wastewater treatment using renewable energy crops closer to commercial application in the UK.

The UK Government needs to meet the demands of society to prevent the potential adverse effects of climate change and water pollution from society as a whole. A major legislative driver is the Water Framework Directive (WFD) (EC, 2000) which came into force on 22nd December 2000 and is “*the most substantial piece of EC water legislation to date,"* requiring *"all inland and coastal waters to reach "good status" by 2015. It will do this by establishing a river basin district structure within which demanding environmental objectives will be set, including ecological targets for surface waters*” (Defra, 2005).

The fundamental aim of the WFD is to promote the sustainable use of water, while progressively reducing or eliminating pollutants for the long-term protection and enhancement of the aquatic environment. The major implication of implementing the WFD for the water industry is the likelihood of more stringent discharge consents and will, in certain circumstances, require tertiary treatment systems (wastewater polishing) to be implemented to enable more effective removal of nitrogen and phosphorus from wastewater. The Urban Wastewater Directive will be a less significant driver within the UK but it is interesting to note that the majority of catchments in the UK have been classified as having a large or excessive supply of plant nutrients (nitrates and phosphates i.e. eutrophic).

In situations where increased nutrient removal from sewage is required to meet these more stringent discharge consents under the WFD, there are a number of tertiary treatment options available including denitrification and Reed Bed systems. In comparison to these and other commercially available systems Water-renew systems have the advantages of not requiring chemical additions, do not generate a sludge requiring disposal, they have lower operational energy requirements and result in the generation of a commodity crop for renewable energy production. However, water renew systems may not be suitable where baseline river flows are heavily dependant on treatment works discharges.

[1] EU LIFE Funding – Launched in 1992, LIFE (The Financial Instrument for the Environment) is one of the spearheads of community environment policy. In the framework of sustainable development LIFE should contribute to the implementation, development and enhancement of the Community's environmental policy and legislation as well as the integration of the environment into other EU policies. LIFE should also lead new solutions facing EU environmental problems being explored.

Alongside this, the ratification of the Kyoto agreement by the UK government in 2002 means that 20% of the UK's electricity supplies must come from renewable sources by 2020. One such renewable source is that of energy crops. The UK government is legally obliged under the Kyoto Protocol, by 2010, to reduce its CO_2 emissions to 12.5% below the 1990 levels. In addition, the current Renewable Obligation arrangements state that existing power stations powered by fossil fuel and biomass co-firing must source 75% of their biomass from dedicated energy crops from 1st April 2006. There are currently 167 such stations in the UK, generating 877,670 kW from the biomass fraction. If 75% of this capacity were to be generated from energy crops, approximately 1000,000 oven-dry tonnes of wood chips would be required per annum. As a result of these and other drivers, markets for renewable energy crops are developing rapidly in the UK.

There is potential to combine the requirements of both the WFD and Kyoto agreement in a system whereby tertiary treatment is achieved through application of wastewater to energy crops. Such integrated systems, known as Water-renew systems, offer the dual benefits of a cost-effective wastewater tertiary treatment system, and a renewable bioenergy (or energy crop) source. The improved yields in crops and the re-use and recovery of nutrients from the wastewater can help to reduce greenhouse gas emissions, the requirements for inorganic fertilisers, nutrient enrichment of surface waters, and the costs associated with these activities**.**

The project aims to investigate methods to optimise this system, using different species, application rates, soils, climates and compare greenhouse gas emissions and energy use to conventional wastewater treatment. A model will be developed to improve the operational performance of such systems using detailed results from a controlled environment and field trails established for this project to develop an operational demonstration system and provide industry focussed operational guidelines and investigate concerns over potential long-term environmental effects.

The application of wastewater to renewable energy crops may provide a practical solution to tertiary wastewater treatment and provide an economically viable biomass crop for the renewable energy industry. This differs from other land-based water polishing systems such as rapid infiltration basins or constructed wetlands as it relies on the export of nutrients from the site in the harvested crop. Bioenergy or renewable energy crops include trees e.g. willow, poplar and eucalyptus grown under short rotation coppice (SRC), and fast growing grass such as *Miscanthus*. There is great potential for the supply of energy crops to increase in the UK due to large areas of suitable land, the diversification of farming away from food production and Government / European incentives for renewable energy crops. The Energy White paper (DTi, 2002) set out its implementation strategy and detailed several financial incentives for renewable energy in general and more specifically for bioenergy production and energy crops and the fact that 15% of the land currently under UK agricultural regime would require conversion to biomass crops to supply the 20% renewable energy required by 2020.

While bioenergy crops have relatively low nutritional requirements compared to arable crops, the removal of large amounts of biomass from the land, results over time, in the depletion of soil nutrients, reducing yields in the absence of fertiliser. In addition, their high demand for water has the potential to deplete potable groundwater resources or reduce yields when the crop is unable to access groundwater.

There has been considerable international interest in this type of technology. Pilot-scale trials at the Swedish municipality of Kågeröd concluded that wastewater irrigation increased the growth of willows by up to 5 times and that the removal rate of nitrogen and phosphorus in the willow-soil system was higher than conventional nitrification/denitrification and phosphate chemical precipitation treatment processes (Hasselgren, 1998). The pilot trials were so successful that the municipality decided to scale-up the trials to develop a full-scale application. A 13 ha plantation of willow Short Rotation Coppice is currently being used to treat 40,000 m^3 $year^{-1}$ secondary effluent, which is 12% of the wastewater produced by the 1500 occupants of the town. It is anticipated that the system will eventually accept the entire 135,000 m^3 $year^{-1}$ flow from the towns sewage treatment works.

In New Zealand, research has focussed on the radiata pine although other species including Eucalyptus have been evaluated (McGuire et al, 2003). Several large trials have been conducted in Australia including at Wagga Wagga and Shepparton. The IEA Task 30 report suggested that despite the very high growth rates observed (with crops growing at approximately twice the rate of the UK), bioenergy production from wastewater-irrigated plantations can at most contribute only a very small proportion of total energy production in Australia simply because of the limited volume of the wastewater resource. The reports carried on, however, to state that the development of such plantations could make a relatively large contribution to solving a wastewater disposal problem, which was particularly applicable to rural Australia. (IEA, 2002).

The results of previous studies suggest that the use of renewable energy crops for sewage effluent treatment, offers a cost effective alternative to conventional methods of tertiary sewerage effluent treatment, along with the added advantage of generating a commodity crop as an output. This has important benefits and applications within the UK Water Industry as well as in the EU at smaller, often more rural treatment works where tertiary treatment installations maybe costly. The outputs of the Water Renew project will bring this technology close to commercial scale implementation within the UK and provide another alternative to traditional tertiary wastewater treatment and a renewable energy source for future generations.

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For further information, contact Alex Hutchinson or Dr. A R Godley at WRc Group, Frankland Road, Blagrove, Swindon, Wilts, SN5 6AG, UK, +44 1793 865000 or hutchinson_a@wrcplc.co.uk , godley_ar@wrcplc.co.uk

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The projects in Portfolio are focused on meeting business/environmental needs including:

- Reducing risk
- Anticipating and influencing legislation/regulation
- Improving capital & operating efficiency and reducing costs
- Strategic asset management and investment planning.

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For further information, please contact:
Jayne Matwiejczyk, PR Department on +44 (0) 1793 865075 or email pr@wrcplc.co.uk