Constructed wetlands in Ireland

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Domestic wastewater treatment in Ireland

In comparison to other European countries, Ireland has a very large rural population. As of 2006, 42% of Irish people lived in rural areas. In cities and towns, wastewater is generally treated by centralised treatment plants. However in rural areas, wastewater from domestic treatment is typically decentralised, i.e., wastewater is treated on-site. The most common method of on-site wastewater treatment is private septic tanks and associated percolation areas. In all, there are 400,000 septic tanks in use around the country.

These septic tanks and percolation areas are in various states of maintenance. Often, septic tanks are leaking or incorrectly constructed. Percolation areas are frequently clogged and do not treat the wastewater adequately. Typical treatment efficiencies of this system are of the order of 40% removal of organic matter, and 15% removal of nitrogen and phosphorus. Faulty septic tanks and percolation areas are viewed as a major environmental concern by the EU. In Ireland, there is no legal obligation to monitor the effluent from septic tanks and percolation areas. In October 2009, Ireland was taken to the European Court of Justice by the European Commission for failure to put in place adequate legislation to cover septic tanks and percolation areas. Recently, in May 2011, the Commission brought Ireland to the European Court of Justice for a second time, seeking to have a fine of €2.7m imposed, along with a daily penalty of over €26,000 for Ireland, as no legislation had been put in place.

Clearly, the government will be forced to act to address this issue. A likely solution is the upgrading of existing septic tanks and percolation areas. This cost is likely to be borne by the homeowner. With this in mind, it is obvious that an effective and affordable domestic wastewater treatment method is required in Ireland.

Nature's kidneys

In our bodies, kidneys serve many functions. A primary function of the kidneys is to filter blood to remove waste materials. This process also occurs on a very large scale in wetlands, where wastes are removed from the waters that pass through them. For this

reason, wetlands are frequently referred to as “nature’s kidneys”. There are many types of natural wetlands, including marshes and swamps.

A natural wetland is an area that is submerged by water for periods long enough to keep the soil conditions saturated. There are a number of physical characteristics of natural wetlands that contribute to their waste-removal abilities.

Firstly, water moves slowly through wetlands. This allows the settling of suspended materials and the adsorption (attachment) of pollutants to the soil substrate. The phosphorus in wastewater has a high affinity for iron, aluminium and calcium in soils. Phosphorous binds to these elements in the soil, and over time the amount of phosphorus in a wetland steadily increases.

Secondly, high levels of microorganisms are present in wetlands. These microorganisms utilise and transform nutrients and pollutants in the water as part of the nitrogen cycle. For example, nitrifying bacteria in the wetland soil convert ammonium to nitrate, which can be taken up by plants. At the same time, denitrifying bacteria convert nitrate in the soil to nitrogen gas, which enters the atmosphere.

Finally, wetland plant species use large amounts of water during their growing season. Bulrushes, for example, are known to triple their biomass (the weight of the above-ground material) in one year.

Constructed wetlands

Constructed wetlands are engineered systems designed to replicate the wastewater treating ability of natural wetlands. Most constructed wetlands are similar in make-up. A basin approximately 1 m deep and 5-25 m wide is excavated from the ground. It is lined with an impermeable plastic membrane, or semi-permeable clay soil. A mixture of soil, sand and gravel is used to fill the basin. Aquatic/wetland plant species, e.g., rushes and reeds, are planted on the surface. Wastewater enters at one end and flows slowly across the surface or through the substrate. As it does so, it is treated by the plants, substrate and microorganisms. The treated wastewater is then discharged at the end to a receiving water body (Figure 1).

There are a number of advantages to using constructed wetlands. Treatment efficiencies are typically very good. Removal rates of up to 95% of organic matter, nitrogen and phosphorus have been reported. Running costs are quite low as the plants and soil microorganisms treating the wastewater do not need any fuel/electrical supply. The biomass can be harvested and changed in to wood-chip pellets. The system can be regarded as sustainable and wetlands can be built to fit the landscape.

There are, however, disadvantages. During winter, many plants are dormant and soil

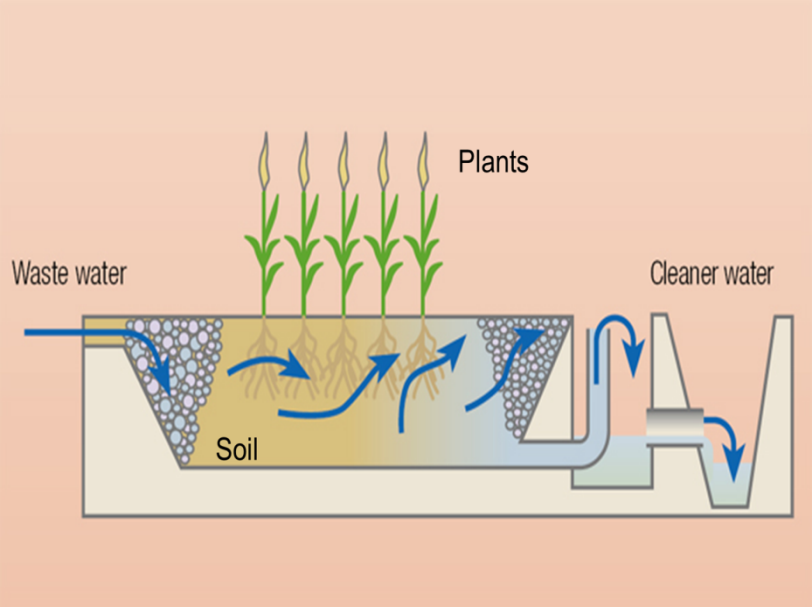

Figure 1: Schematic of wastewater flow through wetland © United Nations Environment Programme 2003

microbial action decreases due to lower temperatures. This limits both the amount of wastewater that can be used by the plants, and the level of treatment that can be achieved. Unlike septic tanks and percolation areas, the effluent from constructed wetlands must be monitored. This imposes a financial cost on the wetland owner, and has hampered the spread in popularity of wetlands in Ireland.

The biggest issue facing constructed wetlands is the large area of ground or "footprint" that is required to achieve the desired treatment levels. Many constructed wetlands for individual houses require the same footprint as that of the house itself. This limits the uptake of the system due to inadequate space availability or high land prices.

Zero-discharge constructed wetlands

A zero-discharge constructed wetland is similar to a conventional constructed wetland system, with one major difference; there is no effluent output at the end of the treatment process. All the wastewater is used up by plants *via* transpiration, or by evaporation from the soil/water surface. The system is sealed by an impermeable liner, so there is no seepage to groundwater.

As mentioned above, currently in Ireland there is no legal obligation to monitor output from septic tanks and percolation areas, even though treatment efficiencies are known to be low. While it is widely accepted that treatment efficiencies from constructed wetlands are much higher, effluent from these systems must be monitored. With no effluent to monitor, zero-discharge constructed wetland systems are ideally placed to offer high treatment

efficiencies without the associated monitoring costs.

Research goals

My research focuses on the application of constructed wetlands for domestic wastewater treatment. In particular, I wish to explore how to increase the efficiency of wastewater treatment and use by wetlands. This will hopefully lead to a decrease in the footprint required. A smaller footprint would make this system more attractive to homeowners. This would then hopefully increase the uptake of the system.

I will be exploring the applicability of zero-discharge wetlands in Ireland. Very limited research on this system has been carried out in Ireland to date and it will be interesting to compare the applicability of this type of system in Ireland with areas where it is more widespread, e.g., Denmark.

My research to date has largely been focussed on wastewater use. The more wastewater that can be processed by the system, the more efficient the system can be. A more efficient system requires a smaller footprint to treat the same volumes of wastewater.

Currently, I am investigating water use by willow trees. The use of willow species in constructed wetlands is widespread. Willows are fast-growing wetland species, capable of growing up to 3m in one growing season. A characteristic of willow trees that makes them very suitable for wastewater treatment systems is the fact that they are tolerant of coppicing. Coppicing is the cutting-back of trees to stump level to produce many new shoots. The coppicing of willows during their inactive winter period produces high levels of regrowth in the ensuing spring. The willow species I am working with is *Salix viminalis*. This species is common across northern Europe. Currently, I am investigating the difference in water use between coppiced and un-coppiced willows. I will also be investigating the use of water by willows across a 3-4 year life cycle.

In the future, I will be investigating the optimum plant assemblages for use in constructed wetlands, with a view to getting year-round treatment of wastewater.

Conclusions

There is a clear need for a small-scale wastewater treatment method in Ireland to replace the septic tank and percolation area system. Constructed wetlands are capable of delivering the desired treatment efficiencies. The low maintenance costs and aesthetic qualities of wetlands contribute to their suitability for domestic settings. Research into reducing the footprint required for constructed wetlands, and into zero-discharge wetlands which

do not require monitoring, could lead to a greater uptake of this sustainable treatment system.

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