

# Greenhouse and Nursery Water Treatment Information System

School of Environmental Sciences, University of Guelph



## Bioreactors for contaminant removal

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Dr. Youbin Zheng and Siobhan Dunets  
*University of Guelph, Guelph, Ontario, Canada*

### **Nitrate removal**

Bioreactors are used mainly for the removal of nitrate from wastewater. Nitrate is the main form of nitrogen in greenhouse/nursery effluent, and concentrations can range from 0.2 to 300ppm in nurseries and approximately 30 to 360ppm in greenhouse effluent (Prystay and Lo, 2001; Sharma et al., 2008).

The main components of these bioreactors are a community of denitrifying microorganisms, and the carbon substrate that feeds these microorganisms. Denitrification is a microbial process through which nitrate is converted to harmless nitrogen gas, effectively removing it from the water. However, nitrification is only performed by certain microbes, and can only occur in environments where no oxygen is present. As such, conditions in the bioreactor must be highly controlled.

A variety of carbon substrates have been tested in these systems including straw, newspaper, vegetable oil, wood chips etc. However, wood particles such as sawdust or woodchips have been shown to be particularly effective (Robertson, 2010). A commercial example of this technology is the Nitrex™ Groundwater Denitrification System developed by the University of Waterloo (Waterloo, Ontario).

In the past, bioreactors have been used for nitrogen removal from municipal wastewater. However, the systems used at the water treatment plants are very large scale, complex, and can cost hundreds of thousands or even millions of dollars to construct (EPA, 2007). Fortunately, several bioreactors with specific applications to nursery wastewater are in development.

A system being developed by the University of Florida/IFAS uses microorganisms captured at the nursery itself as denitrifiers (Sharma et al., 2008). The carbon source may vary. Preliminary research suggests removal rates higher than 90% are possible at a <30min residence time. Nitrate concentration and runoff flow rate will affect the residence time of water in the filter and size of filter required, and must be taken into consideration if consistently high nitrate removal is to be maintained.

Another example of a small-scale bioreactor for specific application to a nursery was constructed by Wilson and Albano (n.d.). The reactor uses Kaldness media (a buoyant material used in aquaculture) to provide surface area for native microorganisms to grow on and high porosity to facilitate effluent flow.

The carbon source used in the study was molasses. Under optimal conditions, >90% removal of nitrate was possible.

### **Phosphate removal**

Enhanced biological phosphorus removal (EBPR) is performed by an activated sludge system in which conditions have been manipulated to encourage the proliferation of P accumulating organisms (PAOs) (Meyer et al., 2005). PAOs accumulate and store phosphate within the cell as an energy source. Under anaerobic conditions, the organisms then use this phosphate to provide energy for the uptake of simple organic compounds (which serve as an energy source in aerobic conditions). In EBPR bioreactors, organisms are subjected to anaerobic and aerobic conditions, as anaerobic conditions encourage proliferation of phosphate accumulating organisms, but aerobic conditions are needed for these organisms to actually accumulate phosphate (Meyer et al., 2005).

However, EBPR systems are generally only used in large-scale water treatment plants. There has been little investigation into use of these systems for smaller-scale applications. This is likely because EBPR is often not cost effective at smaller scales (EPA, 2007).

### **Pesticide/herbicide removal**

Bioreactors may also have applications for removing pesticide/herbicides, either from water to be discharged or water to be recirculated. Pinilla et al. (2008) found that a bioreactor using an oxidiazon-degrading bacteria strain and a granular ceramic material as a substrate successfully eliminated the herbicide oxidiazon from nursery runoff.

### **Pros and Cons of Bioreactors**

Pros:

- Require smaller land area than constructed wetlands, which is important in areas where space is limited
- Seem to have the potential to effectively remove nitrate and herbicides/pesticides

Cons:

- More research still required
- Require intensive management in comparison to constructed wetland (need to accurately estimate nitrate concentrations and runoff flow rates; Wilson and Albano, 2008)
- Uncertainty regarding the effects of pesticides on denitrifying microorganisms (Wilson and Albano, 2008)
- Needs to be kept warm (particular issue in winter, may need to be kept in a greenhouse or underground)

## Summary

Although an established technology in treatment of other wastewater types, further research is needed to determine the viability of bioreactors for applications in greenhouses/nurseries. Currently, bioreactors show promise for nitrate removal, but not enough research for phosphate removal has been conducted.

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