Denitrifying woodchip bioreactors - a nature-driven technology to intercept water pollutants in tile drainage systems

A Povilaitis*
Vytautas Magnus University, Agriculture Academy, Department of Water Engineering, Studentų str. 11, Akademija, Kaunas dstr.; Lithuanian Academy of Sciences, Department of Agriculture and Forest Sciences, Gedimino av.3, Vilnius, Lithuania.
*Corresponding author: arvydas.povilaitis@vdu.lt
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Surface and groundwater quality problems occur in many areas around the world. As stated by the European Environment Agency, 38% of the EU water bodies are under significant pressure from different sources of pollution. Helsinki Commission (HELCOM, 2018) has also reported that human activity during the 20th century has greatly magnified the load of various substances entering the Baltic Sea. Therefore, owing to the excessive nutrient input, eutrophication remains one of the main threats to marine ecosystems in the Sea. Although some improvement has been observed over the last decades, the effects of past and current nutrient inputs still predominate the overall status of the Baltic Sea environment. Moreover, climate change is expected to alter the seasonal water flow pattern in the region and this may likely affect the hydrological nutrient transport pathway. Predicted changes are expected to be the most significant during the cold period of the year (November-April). Instead of the accumulation of snow, there will be more runoff expected in the winter. Surface runoff is likely to be replaced by much larger portions of lateral and subsurface runoff in particular. Therefore, while plants are ceased, higher winter runoff can significantly affect soil nutrient balance in tile-drained agricultural land.

Worldwide studies report that tile drainage serves as a direct transport pathway for water-soluble compounds from agricultural land to streams. At most, when entering drains, water leaches nutrients (inorganic forms of N and P). This phenomenon detrimentally affects waters in many countries in temperate regions. To mitigate the impacts, nutrient inflows have to be intercepted before reaching surface waters.

Therefore, a new emerging edge-of-field technology, woodchip-denitrifying bioreactors, has been proposed for nutrient as well as pesticide residues removal in tile drainage flow. The core of the bioreactor is a drainage trench filled with woodchips through which the tile flow is directed. Consequently, under anaerobic conditions, chemically bound oxygen is used by heterotrophic bacteria to oxidize carbon, while inorganic N is reduced to N gases. This environment provides an enhanced setting for denitrification to occur at higher rates than are typical in the soil. The type of carbon fill is one of the most important considerations for denitrification systems. In general, woody media are the preferred type of fill material due to their low biodegradability, availability, relevant hydraulic properties, and high practicality in different locations.

Recent research has shown that woodchip bioreactors can reduce the annual inorganic nitrogen and phosphorus loads in drainage water from 32% to 55% (up to 90%) and from 28% to 40% (up to 70%), respectively. The advantage of the bioreactors is also related to the ability to remove relatively low concentrations of P. Various adsorption technologies are commonly used to reduce inorganic P content in water. However, they are not very effective at the low P concentrations (e.g., less than 0.100 mg/L, but enough to cause eutrophication) typically found in tile drainage water. Therefore, with the use of woodchip denitrification bioreactors, this goal can be achieved. In principle, woodchip bioreactors as a “nature-driven” measure can substantially reduce nutrients in tile drainage water. This measure can be considered one of the most cost-effective edge-of-field practices used to intercept the pollutants entering surface waters through tile drainage systems.