Ecological Engineering 82 (2015) 469–473

Contents lists available at ScienceDirect

Ecological Engineering

journal homepage: www.elsevier.com/locate/ecoleng

Short communication

Impact of the contemporary environment on denitrifying bacterial communities

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ARTICLE INFO

Article history:
Received 13 October 2014
Received in revised form 7 April 2015
Accepted 23 May 2015
Available online 9 June 2015

Keywords:
Denitrifying bioreactors
Legacy effects
Microbial community composition
nosZ
Subsurface drainage
Wetlands

ABSTRACT

To engineer a microbial ecosystem, an understanding of the relative influence of legacy effects versus the contemporary environment on the microbial community is required. In this work, the influence of these factors on both the denitrifying bacterial community structure and the overall bacterial community structure was assessed through comparison of agricultural soils, denitrifying bioreactors, and natural and constructed wetlands. Terminal restriction fragment analysis (tRFLP) of the *nosZ* gene and automated ribosomal intergenic spacer analysis (ARISA) were used. The results suggest distinct communities are characteristic of soil, bioreactors, and wetlands and show a strong influence of the contemporary environment on the bacterial and denitrifying bacterial communities in the bioreactors.
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1. Introduction

Many engineered ecosystems rely on the activity of specific microbes to carry out their designed function; hence successful performance depends on the creation of environmental conditions that encourage the growth and activity of the desired microorganisms. However, microbial communities sometimes show legacy effects, defined here as persistent effects of a species or activity that is no longer present (Cuddington, 2011). For example, distinct soil microbial communities were observed between old-growth temperate forests and sites that had been logged or farmed and were returned to forest 50–75 years ago (Fraterrigo et al., 2006). Legacy effects have also been observed in microbial communities for soils cultivated seven years prior (Buckley and Schmidt, 2001) and in restored wetlands (Peralta et al., 2010). However, other studies of soil microbial communities suggest a stronger role for the contemporary environment (e.g. (Jesus et al., 2009; Waldrop et al., 2000)). If legacy effects are strong in a particular environment, changes in environmental conditions alone are unlikely to restore or achieve desired activities in ecological engineering projects. On the other hand, when the effects of the contemporary environment are dominant, designing for changes in environmental conditions should be sufficient. Understanding the relative influence of contemporary environmental parameters versus legacy effects is therefore an important consideration for ecological engineering.

To investigate the influence of environmental parameters versus legacy effects, this work focused on the engineered ecosystem of denitrifying bioreactors, which treat subsurface agricultural drainage, as reviewed by Schipper et al. (2010). Subsurface or tile drainage systems consist of perforated plastic tubes installed 0.6–1.2 m below the soil surface and are used to lower the water table; they are widespread in the Midwestern United States. While tile drainage increases the land available for agriculture, it also has the negative effect of increasing the transport of nitrate to surface waters (Blann et al., 2009). To remove nitrate from the drainage water, denitrifying bioreactors can be constructed inline with or at the outlet of the tile drainage system. These engineered systems are intended to mimic the nutrient removal service of wetland ecosystems. They provide appropriate conditions for denitrification through flow control

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http://dx.doi.org/10.1016/j.ecoleng.2015.05.005
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structures that provide sufficient retention time within the bioreactor, woodchips that provide organic carbon, and rapid depletion of oxygen through microbial activity. As currently implemented, the bioreactors are not deliberately inoculated, instead containing native microorganisms from the surrounding soil and woodchips, and receive agricultural soil microorganisms with the influent water (immigration).

The objective of this work was to test whether or not the contemporary environment controls the bacterial and denitrifying bacterial communities in denitrifying bioreactors through comparison with communities from natural and constructed wetlands and agricultural fields. The bioreactors were compared to wetlands because wetlands are environments with high rates of denitrification and because the inclusion of both natural and constructed wetlands allowed comparison with another engineered environment. Constructed wetlands achieve varying degrees of success in delivery of denitrification and other ecosystem services, and differences in ecosystem services are correlated with differences in microbial community composition between the natural and constructed ecosystems (Flanagan, 2009; Peralta et al., 2010). In one previous wetland study, 40% of the variation in denitrification potential could be accounted for by differences in bacterial community composition (Peralta et al., 2010). Agricultural fields were selected because they represent the prior land use of the bioreactor locations and contribute to inoculation of and immigration into the bioreactors. These habitats represent a succession of land uses in the Illinois landscape (wetland to agricultural field to constructed wetland or bioreactor) and provide

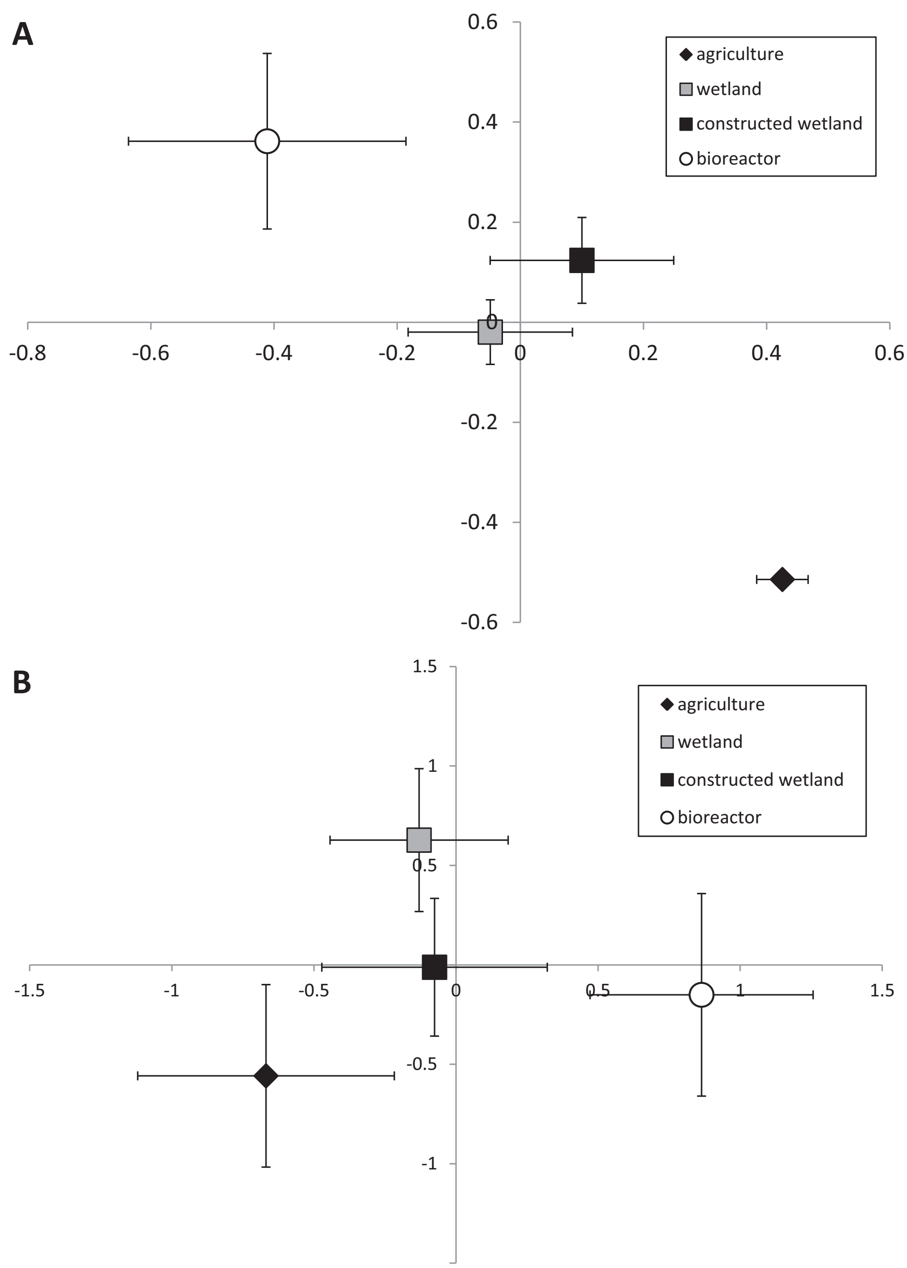

Fig. 1. Partial correspondence analysis on (a) ARISA data and (b) *nosZ* data representing microbial communities from different habitats. Points show the average location, or centroid, of all samples in the habitat group; error bars represent one standard deviation of sample scores on each axis. The vertical error bars for the field habitat in panel a are obscured by the symbol, as the standard deviation was only 0.012 in this dimension. Partial correspondence analysis removed variance explained by latitude and longitude, to allow visualization of patterns in community composition based on habitat type. The correspondence analysis axes represent theoretical environmental gradients, and the distance between points represents the dissimilarity of their microbial communities.

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