Effect of Biochar Insertion in Denitrifying Bioreactor’s Efficiency

Introduction

Subsurface agricultural drainage can increase the agricultural productivity in areas with soils that have poor drainage. The current concern with this transference of water is the possibility of pollutants moving through these systems. Specifically nitrates and phosphates, are of concern to the water quality, due to their wide use in fertilizers. However, nitrates also increase the eutrophication of water which has led to the Hypoxic Zone in the Gulf of Mexico. Phosphorous is of concern locally, in freshwater, as a pollutant and for increases in algal blooms.

A present treatment of nitrate is the use of Denitrifying Bioreactors (DNBR), with a reduction of nitrate by 33-98% (Woli et al., 2010). Woodchips are the most widely used media for denitrification in DNBRs (Christianson et al., 2012). Biochar application is associated with improved soil function through increased cation exchange capacity and enhanced microbial growth. Biochar amendment to soil has been shown to reduce leaching of N, P, and organic C (Bock, et. al., 2015).

The objective of this project was to determine if a biochar addition can enhance P removal without effecting the N removal.

Materials and methods

Two laboratory-scale PVC columns were constructed to evaluate nutrient removal. One column was packed with woodchips with 10 kg of biochar while the other was packed with woodchips and 0.20 kg (.5 qt) of biochar. The biochar was mixed homogeneously as the woodchips dried to limit the loss of it during mixing and pouring. Influent nutrient solution containing nitrate and phosphate was pumped from a 120L container into the columns using Master Flex C/L Pumps and rubber tubing. The solution was pumped with a target hydraulic retention time (HRT) of 4 hours. The effluent solution was collected in two 20 L containers (one per column).

Daily samples (125 mL) were taken at the same time of day- each sample was collected using a composite of their respective effluent or influent container. The mass of the effluent solution was recorded daily to ensure its HRT.

Nutrient analysis was performed using a Discrete Multi-Chemistry Analyzer AQ2.

Results

Figure 1 Changes in phosphorous concentrations- column 1 had 0.10kg biochar inclusion; column 3 had 0.20 kg biochar inclusion. Data from 7/11 was omitted due to improper collection/handling.

Figure 2 Changes in nitrogen concentrations- column 1 had 0.10kg biochar inclusion; column 3 had 0.20 kg biochar inclusion. Data from 7/11 was omitted due to improper collection/handling.

Conclusions

Due to the preliminary data’s variance, this study was inconclusive. The addition of biochar in two different proportions did not have a measureable effect on P and NO₃ concentrations. The addition of biochar to the traditional woodchip media in the laboratory-scale DNBRs has seen success (Bock, et. al., 2015).

Next steps:
The repetition of this project will need to lengthen amount of days to allow the denitrifying bacteria time to establish.

The Bock study had a HRT of 18 hours, whereas ours was 2. A lengthening of the HRT would provide similar results.

Literature cited


Figure 3 Laboratory based DNBRs columns. The pump moves water from influent container to the bottom of the column, through the media inside, and out the top to the effluent containers.

Figure 4 Column 1 media: 0.10 kg of biochar mixed with mixed local hardwoods

Figure 5 Column 3 media: 0.20 kg of biochar mixed with mixed local hardwoods

Figure 6 Sample of pyrolyzed biochar from mixed hardwood chips. ARTichar made their biochar in Ames, IA from local hardwoods.

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