Report as of FY2006 for 2006ND99B: "Using Entrapped Cell Systems for Treating Supernatant from Anaerobic Digester of the Moorhead Wastewater Treatment Plant"

Publications

- Conference Proceedings:
  - Hill, Christopher and Eakalak Khan, 2007, "Application of Entrapped Cell Systems for Treatment of Anaerobic Sludge Digester Supernatant", Third International Water Conference, International Water Institute, Grand Forks, March 13-15.

Report Follows

Using Entrapped Cell Systems for Treating Supernatant from Anaerobic Digester of the Moorhead Wastewater Treatment Plant

Project Description

The scope of this research consists of studying the use of entrapped cells to treat supernatant from Moorhead Wastewater Treatment Plant sludge digesters. There are a number of benefits to side stream treatment of this supernatant: Accommodation of lower flows; prevention of shock to the mainstream biological process; and prevention of the bypass of ammonia to the river. Cell entrapment is a process which has been applied to domestic wastewater for the removal of both organic carbon and nitrogen. This is the first study to apply the cell entrapment process to highly concentrated wastewater. The main focus of this research is on the removal of nitrogen from Moorhead Wastewater Treatment Plant supernatant. Typically nitrogen is removed through a series of biological processes, nitrification followed by denitrification. Entrapped cell systems can follow this conventional configuration or nitrification/denitrification can be performed in a single reactor. The oxygen diffusion limitation of the entrapment matrix creates an environment in which both nitrifying and denitrifying bacteria can coexist. Both conventional two-step and simultaneous nitrogen removal are investigated in this research.

Progress of Work

In addition to the comprehensive literature review which began before and will continue throughout this fellowship, a substantial amount of time and energy has been spent in the Environmental Engineering Laboratory, North Dakota State University and at the Moorhead Wastewater Treatment Plant. The research progress thus far is briefly described below.

The characteristics of the supernatant are of importance. Therefore, a statistical analysis was performed, using the SAS Enterprise Guide, on data obtained from the plant. The results are presented in Table 1. The data used were based on the total population of samples collected and tested between January 1, 2005 and September 19, 2005.

Table 1 Statistical Analysis Results

sas | Enterprise Guide®

The Power to Know.

Summary Statistics Results

The MEANS Procedure

Variable	Label	Mean	Std Dev	Minimum	Maximum	N	Lower 95% CL for Mean	Upper 95% CL for Mean
TS	TS	0.2319048	0.0247476	0.2100000	0.3300000	63	0.2256722	0.2381374
TVS	TVS	55.8555556	3.1936822	50.0000000	61.0000000	63	55.0512371	56.6598740
COD	COD	2426.73	324.3843403	1624.00	3400.00	63	2345.04	2508.43
TBOD5	TBOD5	49.3555556	18.4147187	27.6000000	87.6000000	63	44.7178687	53.9932424
TSS	TSS	464.7619048	100.2393449	260.0000000	940.0000000	63	439.5169527	490.0068569
NH3-N	NH3-N	2055.75	301.1676721	1535.00	2348.00	63	1979.90	2131.59

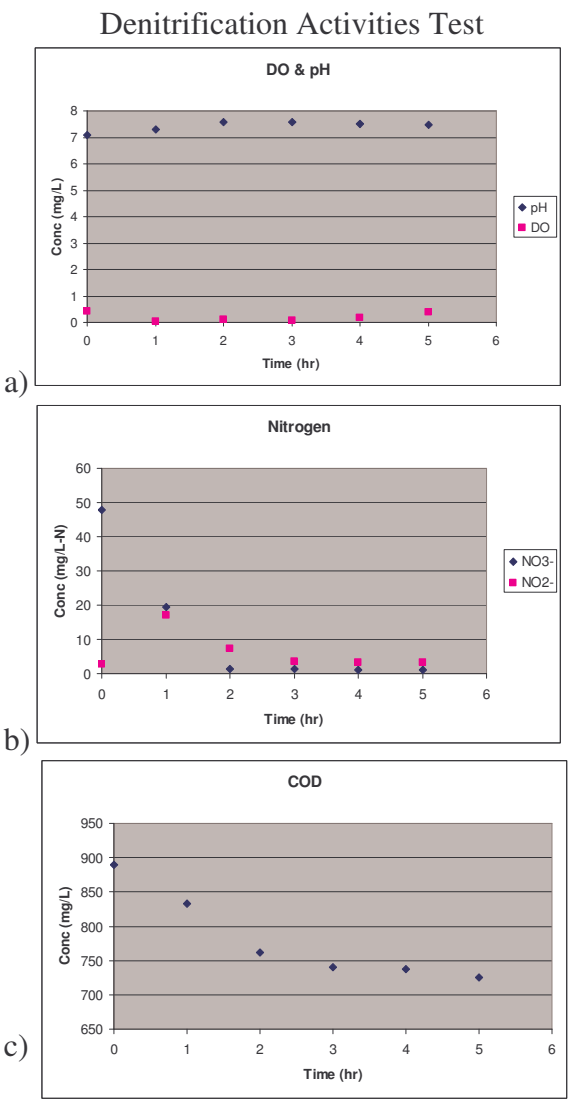
Note: TS, are in %; TVS, are in % of TS; COD, are in mg/L; TBOD5, are in mg/L; TSS, are in mg/L; NH3-N, are in mg/L as nitrogen

Nitrifying and denitrifying bacteria were cultivated initially using synthetic wastewater until sufficient biomass was obtained, approximately 3 months. After testing the activity of the bacteria (data not shown), they were then entrapped both separately and combined (1.5 nitrifier mass:1 denitrifier mass) into a cellulose triacetate matrix. The activity of the nitrifying bacteria after entrapment was virtually zero and suggests that the procedures for entrapping nitrifying bacteria in cellulose triacetate may substantially reduce their activity. It was decided that calcium alginate matrix should be explored in further entrapment experiments.

Once again, nitrifying and denitrifying bacteria were cultivated until sufficient biomass was obtained, approximately 3 months. For the denitrifying bacteria, synthetic wastewater was used as before but for the nitrifying bacteria the supernatant from Moorhead Wastewater Treatment Plant was used. After testing the activity of the bacteria, they were entrapped, both separately and combined, into a calcium alginate matrix. The pre-entrapment activity test results are shown in Figures 1 and 2.

Both activity tests illustrate that the bacteria are performing as expected. It should be noted that the nitrifying culture appears to be composed of mainly ammonia oxidizing bacteria because there is an accumulation of nitrite. This is often seen in high concentrated ammonia wastewater due to the fact that ammonia levels are toxic to nitrite oxidizing bacteria.

Denitrifying bacteria require organic carbon as electron donors to remove nitrogen from wastewater. It can be seen from the statistical analysis (Table 1) that there is a significant amount of chemical oxygen demand (COD) in the supernatant. However, based on corresponding biochemical oxygen demand (BOD), which was very low, most of COD was biorecalcitrant. “Hard” COD is the description typically given to the COD found in sludge digester supernatant. “Hard” referring to the difficulty microorganisms have in consuming this organic carbon. The source of organic carbon is currently being investigating for the denitrifying bacteria in an entrapped cell system. A study of the co-entrapped systems for nitrogen removal with and without the addition of methanol as a carbon source is the latest experiment. Due to the fact that the experiment is not complete the results will be reported at a later date.



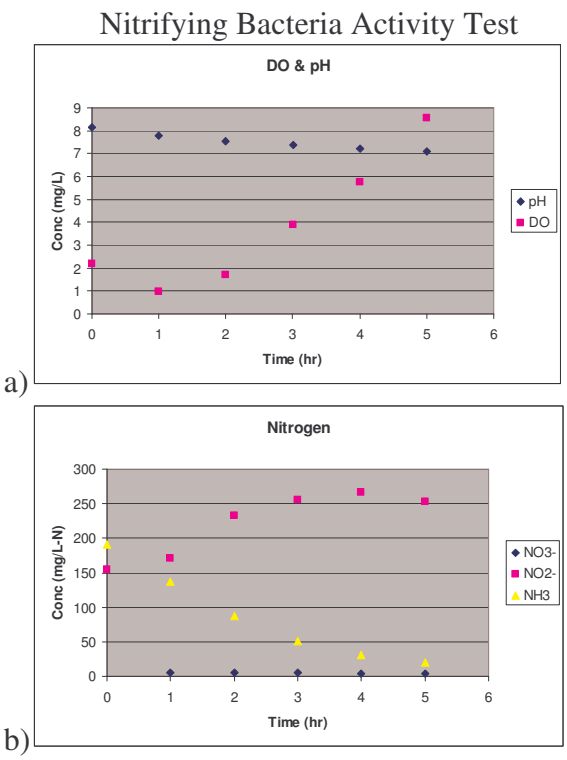


Figure 2 Nitrification Activity Test a) pH & DO b) Nitrogen

Figure 1
Denitrificaiton Activity Test a) pH & DO b) Nitrogen c) COD

Work Remaining

The work remaining for this fellowship includes the completion of the activity and carbon utilization kinetics. Two experiments for the activity and carbon utilization kinetics have been complete. It is estimated that two or three more experiment are require to obtain solid data for analysis. After each experiment, a representative sample of entrapped cells is collected and stored. These samples are to be analyzed using fluorescence-antibody labeling, detecting the spatial location of nitrifying and denitrifying bacteria and possible shedding light on the interaction between the bacteria in the entrapped cell system. After or during the fluorescence experiments, the reactors will be setup and operated in a CSTR configuration and data collected. The data shall be analysis to determine to most feasible configuration and a paper will be submitted to report the findings.