

Integrated Fixed-Film Activated Sludge (IFAS) IFAS Promotes Biological Nutrient Removal (BNR)



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The Environmental Biotechnology lab in the Civil Engineering Department at Northeastern University

The lab directed by Professor April Gu seeks to study an Integrated Fixed Film Activated Sludge System and determine the conditions necessary for optimal removal of nitrogen and phosphorus. In addition, the lab hopes to isolate the bacteria responsible for optimal phosphorus removal.

INTRODUCTION:

Nutrient loading is a problem that coastal and freshwater systems increasingly are facing. The introduction of excess nutrients into these ecosystems can result in eutrophication. Eutrophication causes excessive plant growth, which as a result, decreases the levels of dissolved oxygen in the water, thus killing the vertebrate and invertebrate life there.

What is wastewater treatment?

Wastewater treatments consists of a number of stages: pretreatment (physical removal), primary (physical and chemical removal), secondary (biological removal), tertiary and advanced (biological, physical, and chemical removal).

What is removed?

Treatment hopes to remove microorganisms, disinfectants, radionuclides, organic and inorganic chemicals.

What is an IFAS?

Continuous flow activated sludge system which has fixed media integrated in it. Wastewater is initially brought into the system by the influent. Once the water is in the system, it is brought through a series of stages. Biological reactions occur in each stage which act to remove nitrogen and phosphorus.

BACKGROUND:

During the anaerobic phase the bacteria take in acetate and release most of the P-PO₄ they have in their system. Between the anaerobic and aerobic phases, phosphorus removal occurs. During the anoxic phase nitrogen fixation occurs (denitrifying bacteria are present in this zone). Keeping a balance between the nitrifying and denitrifying bacteria is critical.

OBJECTIVES:

- Determine the amount of phosphorus removed by the microbial life within the system.
- Determine the effectiveness of having fixed-film (media) in the aerobic tank for the bacteria to attach to.
- Identify and quantify the PAOs populations using the fluorescent *in situ* hybridization (FISH) technique.



METHODS:

Feeding

Chemicals needed to make the synthetic feed were measured on an electronic scale. Stock for feed was prepared in falcon tubes and stored in the cold fridge to be used in future feedings.

Wastewater Characteristics

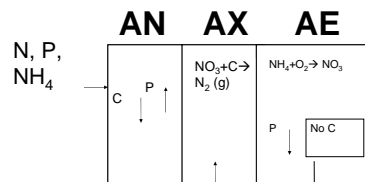
Total ammonia calculation was conducted on a regular basis using an electronic probe. Standards were made using ammonia chloride. The machine was calibrated on a daily basis. Samples were taken from the "INF", "AN", "AX", "AE1", "AE2" and "EFF" zones and concentration of ammonia was recorded.

Sample Analysis

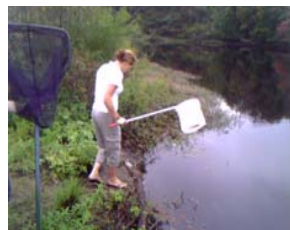
Samples of wastewater were taken from the system and evaluated. Small samples were applied to slides and stained, using the *Neisser Staining* procedure. Slides were observed under the microscope at 10x and 100x. Abundance of polyphosphorus accumulating organisms (PAO's) were observed.

Samples were also stained using the fluorescent *in situ* hybridization (FISH) technique. Slides were observed under the microscope and pictures were taken. Percentage of "bugs" were calculated by comparing stained vs. unstained area in 20 random fields of view.

The spectrophotometer method was used for the analysis of total phosphorus in samples taken from the various tanks of the reactor. Molybdate reagent and stannous chloride were added to each sample and the sample absorbance was recorded under the spectrophotometer set at 690nm wavelength. The absorbance of phosphate was obtained at 690nm. Concentrations were obtained from a standard calibration curve obtained from the absorbance of standard samples.



"Water passes through in hours but bacteria works in days..." (A. Onnis-Hayden)



The diagram to the left demonstrates the concept behind the IFAS system:

In the anaerobic zone of the reactor bacteria take in carbon as their main food source due to its abundance in the influent. Phosphorus is released by the bacteria as a result. Water from the anaerobic zone enters the anoxic zone where denitrification occurs. Here denitrifying bacteria reduce nitrates and nitrites that are present in the water into nitrogen gas. Water then passes into the aerobic zone of the reactor. Since there is no carbon present here, the nitrifying bacteria that are present use the phosphorus in the water as an energy source. Ammonia is also converted into nitrates by the nitrifying bacteria. Ammonia in the water is transferred to the anoxic zone by the "recycle" connector.

The final water to exit the system via the effluent is low in nitrogen and phosphorus content.

CLASSROOM CONNECTION:

Incorporating what I have learned this summer, I would like to teach my students about the bacteria that specifically remove P and N from water and relate it to eutrophication. The lesson I have designed is specifically geared for my upperclassmen zoology students. The goal is to have students understand the ramifications of eutrophication, which can occur due excess N and P entering an aquatic system. In addition, the background knowledge I have gained in the lab will be used to enhance my teaching of the Nitrogen Cycle to my freshman biology students.

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- Researchers of the April Gu's Civil and Environmental Engineering Lab at Northeastern University, Boston, MA
- April Gu, Assistant Professor of Civil and Environmental Engineering, Northeastern University, Boston, MA
- P Taru, D Mlambo and A.T Kuvarega. *Modeling biological phosphorus removal in activated sludge systems*. <http://web.deu.edu.tr/atiksu/ana58/phobio2.pdf>. July 29, 2008