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Analysis of Dissolved Organic Removal and Nitrification in Pilot Scale of Submerged Bio-film Reactor

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1. Introduction

Wastewater purification is a very important engineering task. Many of the designs and processes that we use currently were introduced more than 50 years ago. Biological treatment processes have been widely used for enhancing removal of dissolved organic and nitrogen compounds from wastewater. Design and operation of wastewater have been dramatically improved because regulations of all parameters in discharged water have become more stringent and the increased needs for reclaimed water in arid environments.

Two more recent studies clearly show that submerging a matrix of porous foam blocks, along with plastic spacers, effectively treats wastes and nitrifying ammonia compounds in wastewater (Tsuno et al., 1992, Lewandowski and DeFilippi, 1998). The primary advantage of this approach is the extensive surface area within the porous media. Although structures to hold the media in place were not utilized, the researchers who performed this study have conclusively shown that submerged media, when oxygenated, perform as well as alternately wetted surfaces typical of trickling filters and RBCs.

Aerated submerged bio-film (ASBF) pilot plant has been developed. The presented studies optimized an inexpensive method of enhanced wastewater treatment. This research describes pilot scale experiments for efficient removal of dissolved organic and nitrogen compounds by using aerated submerged bio-film reactors. This research explores the possibility of enhancing the performance of shallow wastewater treatment lagoons through the addition of specially designed structures. These structures are designed to encourage the growth of a nitrifying bacterial bio-film on a submerged surface. These structures also force the direct contact of rising air bubbles against the submerged bio-film.

2. Materials and Methods

The Aerated submerged bio-film (ASBF) was tested with a pilot plant installed at

Central Valley Water Reclamation Facility (CVWRF). For batch operation, loading the pilot plant on Wednesdays provided an extra boost of ammonia. The pilot test reactor is located beside an aerated ditch which was located between the primary sedimentation tanks and the trickling filters at CVWRF. This facilitated filling the reactor, as well as emptying it, as the discharge was placed back in the ditch.

The pilot plant was constructed from a commercial dumpster with dimensions of 2.4 m by 6.7 m by 0.9 m deep. Inside, 24 ASBF modules were placed so they would be submerged by 0.6 m of primary settled effluent. Each module consisted of 12 panels with a fine bubble distribution tube along the bottom. Bubbles rise up in contact with the surface area on both sides of each panel. Total surface area for bio-film colonization is 302 m^2. The pilot plant, when filled to the tops of the modules, contained 6058 liters of wastewater. Total air supply to the modules was 227 liters per minute. Air was supplied with a small shop compressor fitted with regulators and oil/water traps and a knock-out tank. Pressure to the distribution lines was roughly 17.2 kpa. The top of the pilot plant was covered with wooden panels to block the sunlight.

3. Results and Discussion

Batch #4 was started on October 15. By this time, the air temperature had cooled off enough so that the effluent water pumped into the pilot plant cooled off to below 10°C. The average water temperature in the pilot plant for Batch Run #8 was 6.0°C. Ammonia removal was not significantly affected. It is important to this research that we verify what many other researchers have indicated; suspended growth nitrifying bacteria are inhibited at temperatures below 10°C, but fixed-film nitrifying bacteria continue to thrive at temperatures approaching 0°C (Lewandowski and Defilippi, 1998; Bear and Corapcioglu, 1991).

It is also interesting to evaluate kinetics of nitrification. At high concentration of ammonia nitrogen, the system is a zero order or half order with respect to ammonia nitrogen. And the kinetic order can be first order for ammonia nitrogen at low concentrations of ammonia nitrogen. The data qualitatively indicate the tendency that there is a gradual transition from a zero order reaction at higher concentrations of ammonia nitrogen to half order to first order reaction at lower concentrations of ammonia nitrogen. The nitrification rates as a function of the bulk ammonia nitrogen concentrations plotted in log-log scale. It could be concluded that the ammonia nitrogen removal rate is first order at particularly low concentrations of ammonia nitrogen, the rate is half order around 5 - 10 mg/L of ammonia nitrogen, and the rate is zero order at high concentrations (above 11 mg/L).

4. Conclusions

The following conclusions could be drawn on the batch system research reported in the ASBF:

- Heterotrophic bacteria demonstrated a major advantage over autotrophic bacteria in utilizing dissolved oxygen in the system.
- The lag phase for autotrophic bacteria was observed to be about 16 hours.
- Dissolved organic matter is rapidly removed during the first 8 to 16 hours, but after that, it is removed much more slowly.
- Ammonia nitrogen is removed more slowly during the lag phase for autotrophic bacteria.
- At particularly low concentrations of ammonia nitrogen (below 5 mg/L), the ammonia nitrogen removal rate followed first order, the rate is half order around 5 - 10 mg/L of ammonia nitrogen, and the rate is zero order at high concentrations (above 10 mg/L).

References

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