PennState
College of Earth and Mineral Sciences

John and Willie Leone Family
Department of Energy and Mineral Engineering

Analyzing the Effects of Light Intensity on Ammonium Removal from Municipal Wastewater Treatment Plants

Gabriel Hiestand, Dr. Meng Wang, Tengge Zhang

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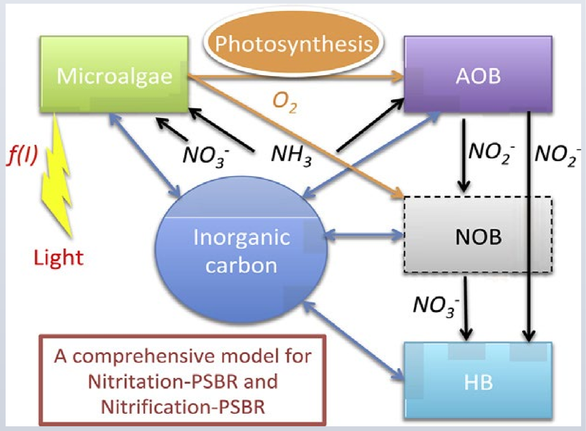
Introduction

- The Activated Sludge Model (ASM) is a mathematical model developed by the International Water Association for the purpose of designing and operating biological wastewater treatment plants.

Essential Biological Processes

- Algae-bacteria relations – Algae and bacteria have a symbiotic relationship in which they exchange nutrients, allowing for high ammonia removal.



Light Intensity Impact

- High photon flux improves microalgae performance but reaches lower efficiency at higher intensities due to damage of photosynthetic machinery.
- Higher light intensity and residence times increase chemical oxygen demand (COD) measurements and result in less nitrogen consumption.
- At higher light intensities, too much competition hinders microalgal growth, but at lower intensities, lack of light hinders microalgal growth
- Previous research suggests that an irradiance of about 50 µmol m^2 s^{-1} maximizes algal growth

Materials and Methods

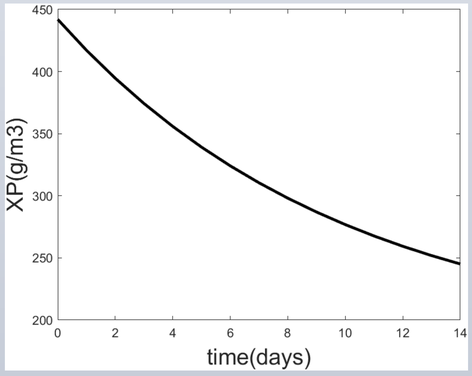
- Kinetic equations modified from the Activated Sludge Model No. 3 (ASM3) were coded into a MATLAB program, as well as all known constants.
- The stoichiometric Matrix from Arashiro et al. was used to generate differential equations for the system state variables with time.
- An equation to describe the impact of light intensity was taken from Peng et al. and incorporated into the G. Hiestand model.
- The differential equations of the system state variables were used to plot graphs of the system state variables with time to simulate ammonium removal from municipal wastewater treatment plants at various light intensities.

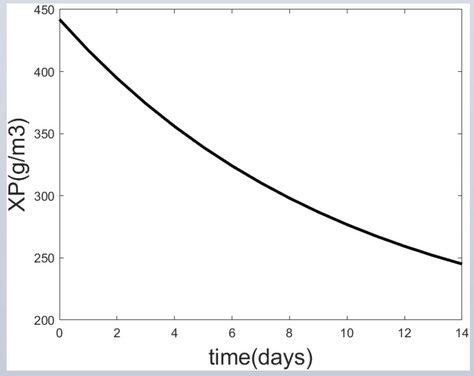
G Hiestand model phototropic growth on ammonia equation:

$$\mu_{ALG}\frac{I\cdot\left(1+\frac{\beta\cdot I}{K_I}\right)}{I+K_S+\frac{I^2}{K_I}}\frac{S_{NH4}}{S_{NH4}+K_N^{ALG}}X_{ALG}$$

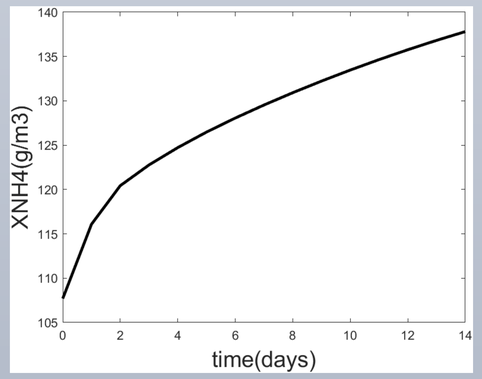
Results

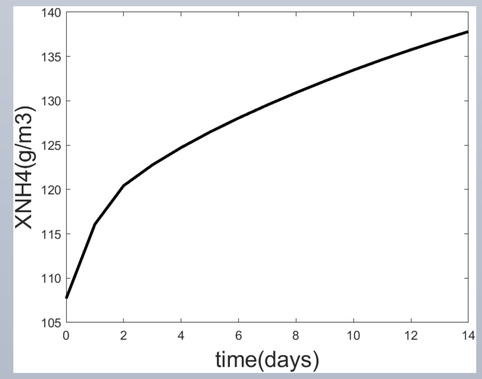
G. Hiestand model for phototropic biomass concentration at light intensities of 50 µmol photon m^2s^{-1} (left) and 500 µmol photon m^2s^{-1} (right).





G. Hiestand model for ammonia concentration at light intensities of 50 µmol photon m^2s^{-1} (left) and 500 µmol photon m^2s^{-1} (right).





Abstract

The objective of this study is to develop a model based on the Activated Sludge Model (ASM) that simulates how varying light intensity in a municipal wastewater treatment plant will impact pollutant removal. A mathematical model was developed and calibrated using MATLAB, which simulated the removal of pollutants at various light intensities. The results of the study indicate that at the light intensities tested, the model does not indicate an increase in phototropic biomass concentration or reduction in ammonia concentration, which is not consistent with previous research.

Conclusion and Future Research

The results suggest that the impact of light intensity on the removal of ammonium from municipal wastewater treatment plants depends on the role of algae in the system.

Future study involving this research could include:

- determining which light intensity is the most effective at removing ammonium
- continued refining of the role of microalgae in the Activated Sludge Model (ASM).

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Acknowledgements

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