Contribution ID: **315** Type: **Poster Presentation**

Predator-prey interactions in wastewater treatment plants

Monday, 9 July 2018 19:45 (15 minutes)

The activated sludge process (ASP) is the most widely used process for the biological treatment of both domestic and industrial wastewaters. Wastewater treatment plants (WWTPs) based on the ASP are in widespread use in both developed and developing countries.

The ASP uses microorganisms which grow by consuming organic pollutants that are present in the wastewater. This produces new organisms whilst simultaneously cleaning the wastewater. The microorganisms flocculate to form settleable solids, the 'activated sludge'.

Central to the success of the ASP is the activated sludge. However, a significant drawback of the ASP is the production of excess 'sludge'. The expense for treating this can account for 50–60% of the total operating costs in a WWTP. Traditional methods for disposing of excess sludge are becoming increasingly unattractive due to a combination of increasing land costs and environmental concerns about the presence of toxic elements. Thus there is a growing interest in methods that reduce the volume of excess sludge produced by the ASP.

A promising method to reduce sludge formation is to introduce a higher order organism, such as protozoa or metazoa, into the system which predate upon the microorganisms. This is potentially very attractive, since once the predators have been released into the reactor there are no 'running' costs.

Why does predation reduce sludge? The ASP can be considered to be a food-chain, in which the biomass extracts mass and energy from the substrate. The introduction of a predator introduces a new layer into the food-chain: mass and energy are now transferred from the microorganisms to the predator. At each step in the food chain not all of the available energy and material are transferred to the next level: some energy, a significant proportion of the energy, is used for maintenance processes, respiration and reproduction. Thus predation on microorganisms may lead to a lower total biomass, i.e. sludge reduction.

Predation has been shown to be an effective technique in lab-scale experiments and pilot-scale systems. Although a variety of predators could be used, much attention has focused on the use of worms. Worm growth is clearly a prerequisite for sludge reduction through predation. Relatively little is known about the growth and development of worms during sludge predation. However, it has been shown that the wrong choice of aeration rate, temperature and predator (worm) density can adversely effect worm growth and consequently sludge reduction.

One of the main barriers to the adoption of predation as a cost-effective mechanism to reduce sludge formation is the phenomenon of uncontrollable growth of predators. Predator density in full scale plants can often reach very high densities. Associated with this is the well-known phenomenon of worm blooms, in which predator population densities[display peaks followed by a sudden disappearance of the population. The development of methods to control worm proliferation is a challenging problem that needs to be overcome.

In this presentation a simplified model for a wastewater treatment plant is extended to include predators. Mechanisms which lead to the unsuccessful introduction of predators are identified.

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Session Classification: Poster Session

Track Classification: Other Mathematical Biology