Attachment of Nitrifying Bacteria

Wastewater Treatment System Application

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BACKGROUND

Ammonia is a toxic compound effecting natural waters. Toxic concentrations of ammonia are due to anthropological effects. Canadian communities are under pressure to treat ammonia in their wastewaters due to pending federal regulations.

Moving bed bioreactors (MBBRs) are an emerging treatment technology where bacteria create a biofilm attached to a media that moves through the wastewater The MBBR can treat a magnitude of pollutants by hosting the appropriate microorganisms. The bacteria biodegrade the pollutants as they use them as substrate. Ammonia is broken down in a two step biologically mediated process:

1. *Nitrosomonads* oxidize ammonia into nitrite
2. *Nitrobacters* oxidize the nitrite into nitrate

A strong attachment of the bacteria is vital for MBBRs to function properly.

OBJECTIVE

The study will investigate the reactor conditions that induce rapid growth of nitrifying bacteria. Specifically, it will study the affect of high ammonia loading, high phosphorous concentrations and the use of new media versus conditioned media.

EXPERIMENTAL SETUP

Five semi-batch reactors are used in this study. The reactors are 600mL, with 17% fill. The media are Kaldnes K3, shown in Figure 1. The media are constantly circulated by aeration . The reactors are attached to a single air supply which is split using a gang valve to distribute the air supply evenly. The air supply leads into a stone aerator placed at the bottom of the tank; the aerator creates medium sized bubbles that rise to the surface. To limit evaporation the tanks are covered in parafilm. The tanks are also covered in tin foil to prevent algae blooms by limiting photosynthesis.

Figure 1: Kaldnes K3 media

Five reactors were run under ideal conditions with characteristics shown in Table 1. The reactors are semi-batch reactors so the ammonia concentration and pH change with time. Approximately every week the reactor water is changed, thereby starting the reactor at the ideal conditions again.

Table 1: Reactor Conditions

	Control	Control duplicate	High Phosphorous synthetic wastewater	High ammonia feed	Clean media
pH	7.5	7.5	7.5	7.5	7.5
Temperature (°C)	20	20	20	20	20
Inoculated	Yes	Yes	Yes	Yes	Yes
Ammonia Concentration (mg - N/L)	15	15	15	**25**	15
Phosphorous (mg -P/L)	23	23	**62**	23	23
Initial growth on media	Yes	Yes	Yes	Yes	**No**

PRELIMINARY RESULTS

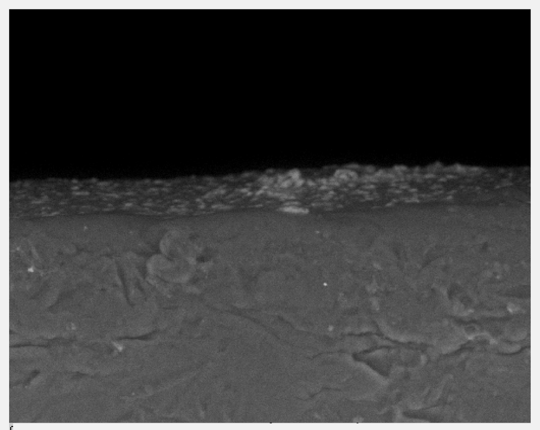
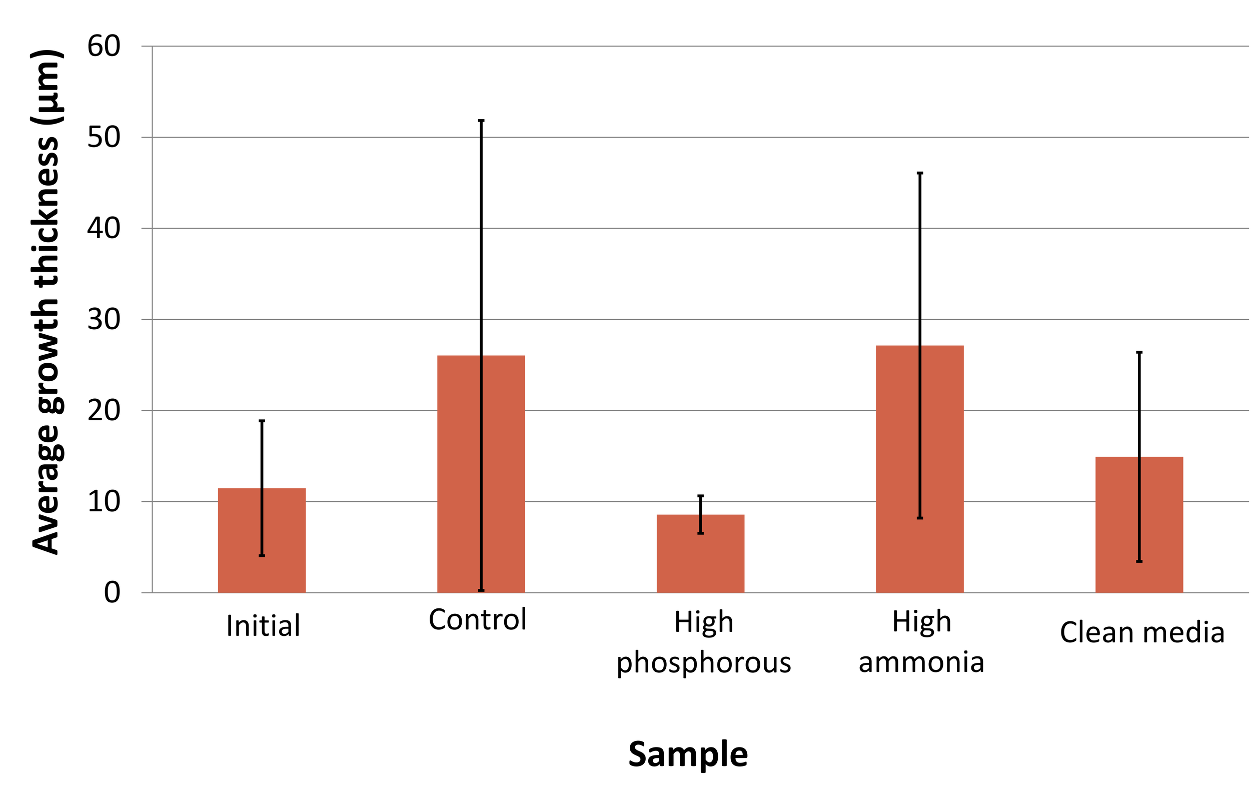


Figure 2: Growth along inner wall of media

The reactors are accumulating biomass, which indicates growth. The Environmental Scanning Electron Microscope (ESEM) photos taken on day 13 show growth. As we can see in Figure 2, the growth along the inner wall is not uniform. To accommodate the different rates of colony growth, the thickness of the biofilm was measured at several places on the media. Samples of the photos can be seen in Figures 3. The average thicknesses for biofilm thickness are shown in Graph 1. The error bars indicate the standard deviation.

The reactor with the high phosphorus concentration demonstrates a slower growth rate than the others. In fact, it demonstrates less growth than the starting point. The aeration for the reactor may be causing biofilm to detach growth, but since it's average attachment is above the lower error bar of the starting point it is concluded that its growth has merely been stunted by the high phosphorous concentrations. The relatively low standard deviation in the thickness of the film indicates that the growth is progressing uniformly.

Graph 1: A comparison of the film thickness – 14 Days



The clean media reactor had no initial growth. After thirteen days the growth on this media has surpassed the thickness of the starting point of the sample that developed in the high phosphorous concentration synthetic waste water. The speed of this growth suggests the lower phosphorous waste water is more effective in inducing attachment.

The standard deviation for control reactors and the high ammonia concentration reactor is relatively large: This indicates that while established colonies of bacteria are growing, new ones are also developing. The two reactors differ only in their ammonia concentration; the control has 15mg/L while the high ammonia reactor has 25mg/L. At this point in the experiment the effect of the ammonia concentration cannot be determined because the growth pattern is too similar.

Comparing the morphology of the control reactor to that of a mature sample clearly shows that the current growth is not as dense as required. The density of the growth will be carefully examined in future ESEM photos to see how it adjusts with time.

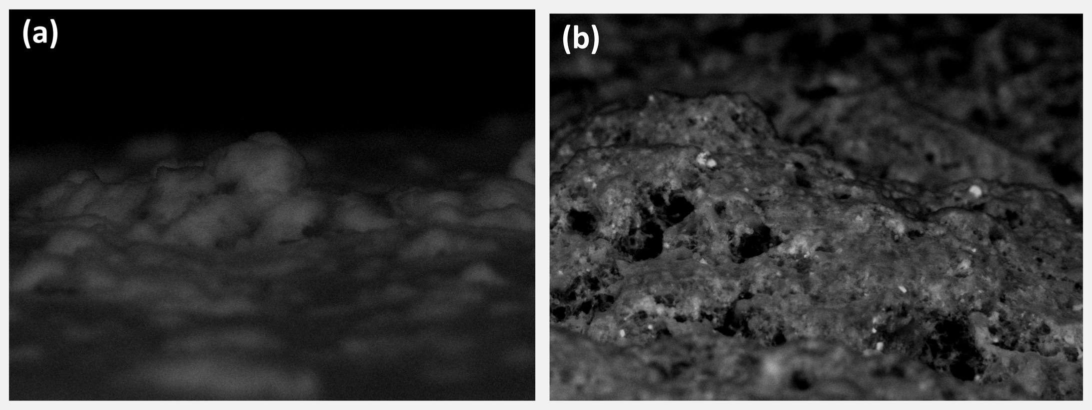


Figure 4: Biofilm images: (a) young biofilm and (b) mature biofilm

Figure 3: Biofilm images of (a) control reactor, (b) high phosphorous, (c) high ammonia concentration reactor and (d) clean media reactor