LETTER

A method for predicting biomass yields in thermophilic and mesophilic nitrifying communities using 13c incorporation

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ABSTRACT

For in-situ observations or several steady-state reactor runs, the current approaches for calculating biomass yield require sophisticated sensors. The yield of particular groups of organisms in mixed cultures is still difficult to estimate quickly and simply. Based on the incorporation of 13C during activity measurements, the maximum biomass yield (Ymax) can be quickly estimated using the method described in this study. It was used on mixed cultures made up of thermophilic (50°C) and mesophilic (15°C –28°C) strains of nitrite-oxidizing bacteria (NOB) and ammonia-oxidizing bacteria (AOB). This approach makes it impossible to distinguish between AOB and AOA coexisting in a society. This approach estimates the carbon fixation activity of the autotrophic bacteria rather than the actual nitrifier biomass yield because 13 C redirection via SMP to heterotrophs may result in a modest overestimation of the nitrifier biomass. The difference in yields between thermophilic and mesophilic AOA (0.22 vs. 0.06-0.11 g VSS g-1 N) may be due to a more effective route for CO_2 incorporation. Less biomass was produced by NOB thermophilic organisms, which could be explained by a greater maintenance demand that limits the amount of energy available for biomass synthesis. As a result of AOA dominating over AOB at higher temperatures, it is interesting that thermophilic nitrification yield was larger than its mesophilic cousin. Mesophilic AOB yield was affected by a sudden rise in temperature, supporting the effects of maintenance requirements on output. While sludge composition was affected by changing nitrifier yield, model simulations of two realistic nitrification/denitrification plants were robust in predicting effluent ammonium concentrations. In summary, a quick, accurate, and simple method for calculating the Ymax of ammonia and nitrite oxidizers in mixed communities was developed.

Key Words: *Thermophilic; Bacteria; Dentrification; Centrifuging; Nitrifier*

INTRODUCTION

Due to anthropogenic distortion of the nitrogen cycle, ammonium, a significant reactive nitrogen species, is accumulating in the environment. For instance, 28% of the nitrogen released in Flanders ends up in surface water. This buildup may result in eutrophication, hypoxia, and ultimately fish mortality. Biological wastewater treatment is frequently employed to treat wastewater before release in order to reduce this reactive nitrogen pollution. An important step in removing ammonium from wastewater is nitrification, which involves the microbial oxidation of ammonia to nitrite and nitrate, respectively. Nitritation, also known as ammonia oxidation, is the rate-limiting step in the conversion of ammonia (NH_3) to nitrite (NO_2) and is catalysed by ammonia oxidising bacteria (AOB) and archaea (AOA). Nitratation is the process by which nitrite oxidising bacteria (NOB) further oxidise nitrite to nitrate.

A biological wastewater treatment facility's design, operation, and modelling all heavily rely on the biomass yield (Y), which measures the amount of biomass produced in relation to the amount of substrate removed. It is important to distinguish between maximum yield and observed yield (Yobs). The maximum yield is larger and solely includes growth since it is achieved immediately upon the oxidation of ammonium or nitrite, in the case of nitrifiers, whereas the observed yield is the net effect of both growth and decay/maintenance of biomass. AOB/AOA and NOB in a mixed culture are not distinguished by The Yobs, which can be assessed in situ, for instance, by utilising cumulative terms over several days. This is relevant to the management of a treatment facility because it

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determines the real creation of sludge and, consequently, the cost of its disposal, a significant cost in the treatment of water. On the other hand, the Ymax is crucial for the planning and modelling of wastewater treatment.

Stoichiometry or the thermodynamics of biological reactions could be used to estimate the maximal biomass yield. However, doing so necessitates making a guess regarding the biomass stoichiometric formula. It is frequently considered that biomass decay can be disregarded and the maximal yield is reached when short-term studies are conducted to determine biomass production. The Ymax could be calculated using respirometry by adding the substrate concentration to the area under the respirogram. A Titrimetric and Off-Gas Analyzer (TOGA) could be used to combine respirometric readings with titrimetric observations. Additionally, transient data from several steady-state reactors could be fitted with a model, and the kinetic parameters (including Ymax) were obtained using non-linear regression analysis. The suggested approaches are sound, but they call for either the arduous steady-state running of numerous reactors or the employment of advanced sensors for in-situ measurements. The yield of particular groups of organisms in mixed cultures is still difficult to estimate quickly and simply.

The literature reports AOB yields of 0.06 g to 0.3 g volatile suspended solids (VSS) g-1 N, but only one study has found an AOA yield of 0.09 g dry weight g 1 N. The dry mass (or total suspended solids, TSS) can be assumed to be an approximation of the volatile suspended solids since it required a pure culture of AOA. The biomass output of NOB varies between 0.04 and 0.15 g N solids per g VSS.