Pergamon

Wat. Sci. Tech. Vol. 28, No. 7, pp. 139–142, 1993.

0273–1223/93 $6·00 + 0·00

DETERMINATION OF THE MAINTENANCE REQUIREMENTS OF ACTIVATED SLUDGE

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ABSTRACT

Maintenance energy plays an important role both in basic kinetic studies and in process development. Numerous studies have been devoted to the maintenance concept in various microbial fields but very few in biological wastewater treatment. Using a fermenter coupled to a mass spectrometer, we investigated the influence of the ratio So/Xo (ratio between initial substrate concentration and initial biomass concentration) on the observed sludge growth yield of an oxic-settling anaerobic (OSA) system. By measuring the substrate removed, the oxygen consumed and the carbon dioxide produced, we were able to estimate the substrate fraction used for maintenance purposes. The results indicate that at a high So/Xo ratio, a greater proportion of the substrate is devoted to maintenance thus significantly decreasing the observed growth yield. These findings are of particular importance in view of the cost associated with the disposal of excess sludge in aerobic wastewater treatment processes.

KEYWORDS

Activated sludge; maintenance requirements; growth yield; mass spectrometer.

INTRODUCTION

Organic substrate requirements have frequently been divided into requirements for growth and maintenance (Pirt, 1965). From a substrate balance, Pirt deduced a relationship between the apparent yield coefficient Y and the growth rate μ in continuous cultures :

$$1/Y = m/\mu + 1/Yx \tag{1}$$

or

$$rs/X = \mu/Yx = m \tag{2}$$

where Yx is the theoretical (maximal) value of the growth yield coefficient, m the maintenance coefficient and rs the consumption rate of the substrate. These equations have only been used in the continuous system.

Numerous studies have been devoted to the maintenance concept in various microbial fields but very few in biological wastewater treatment. The aim of this study is to apply the maintenance concept to studies of activated sludge growth for estimating their maintenance requirements.

MATERIALS AND METHODS

A respirometric system consisting of a quadrupole mass spectrometer (QMS) coupled to a 15 l fermenter (Chang, 1988; Chudoba *et al.* 1991) has been used throughout this study. All our experiments were run aerobically and the inoculated activated sludge came from a continuous oxic-settling-anaerobic system (OSA). The experimental program was based on different ratios of the initial substrate concentration (So) to the initial biomass concentration (Xo). By means of this respirometric system, oxygen uptake, carbon dioxide production, activated sludge growth and substrate removal have been measured simultaneously.

RESULTS AND DISCUSSIONS

The substrate balance has been done by:

$$\Delta S = \Delta Sm + \Delta Sx \qquad (3)$$

where ΔS is the total quantity of substrate utilization, ΔSm is the quantity of substrate utilization for maintenance and ΔSx is the quantity of substrate utilization for growth. Dividing this equation by the total quantity of biomass produced (ΔX), we obtain:

$$1/Yobs = 1/Yx + f_s * \Delta S/\Delta X \qquad (4)$$

where Yx is the theoretical (maximal) growth yield coefficient, and fs is the ΔSm/ΔS ratio. By rearranging this last equation, we obtain the following equation:

$$1/Yobs = 1/Yx - f_s * (S_{min}/XO)/(X_{max}/Xo-1) + f_s/(X_{max}/Xo-1)*(So/Xo) \qquad (5)$$

where S_{min} is the residual substrate concentration and X_{max} the final (maximal) biomass concentration. From our experimental results (Fig. 1), we have obtained a linear relationship as:

$$1/Yobs = a * So/Xo + b \qquad (6)$$

Comparing the equations (5) and (6), we obtained the following relations:

$$a = f_s (X_{max}/Xo-1)$$

and

$$b = 1/Yx - f_s*(S_{min}/Xo)/(X_{max}/Xo-1)$$

By applying equation (5), we calculated f_s and Yx. The values of f_s varied with the ratios of So/Xo (Fig. 2) and the values of Yx were constant. This theoretical value was Yx = 0.88 ± 0.095 mg SS/mg TOD, or 2.7 ± 0.22 mg SS/mg TOC.

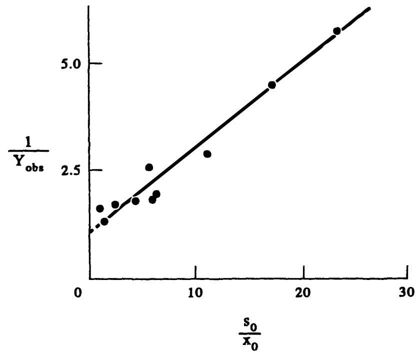

Fig. 1. Influence of So/Xo on 1/Yobs.

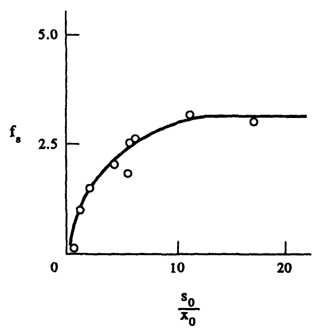

Fig. 2. Influence of So/Xo on f_S.

Using the same method, similar curves were also obtained for O_2 (fO_2) and CO_2 (fCO_2) (see Fig. 3 and 4). It means that the higher the So/Xo ratio, the greater is the proportion of the substrate used for maintenance purposes and the smaller is the observed growth yield. In our experiments we found that at a very high So/Xo ratio, 64% of substrate removed was used for maintenance requirements. This phenomenon was also observed by Pirt (1975) and Moletta (1979). Chudoba (1991) also found also in the continuous OSA system, the specific sludge production rate (g SS/g DCO) decreased with a mass loading increase.

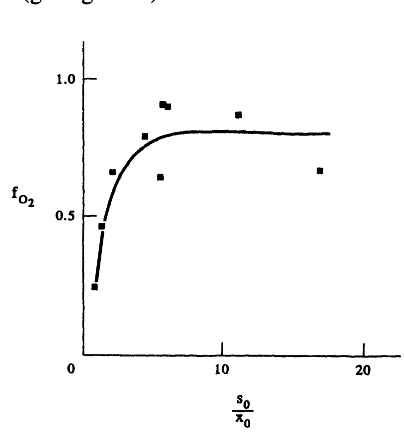

Fig. 3. Influence of So/Xo on fO_2.

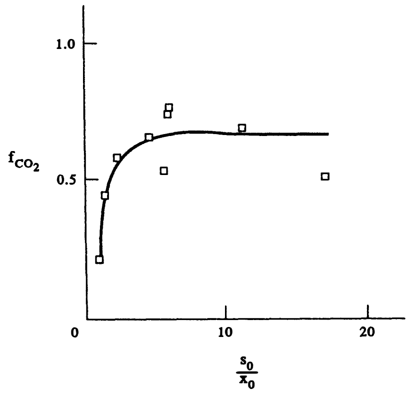

Fig. 4. Influence of So/Xo on fCO_2.

CONCLUSIONS

The results obtained in this study show that under batch conditions the observed biomass yield (Yobs) decreased with an increase in the So/Xo ratio for activated sludge samples originating from an OSA system. By applying the maintenance concept in our studies, we calculated the substrate utilization, oxygen uptake and carbon dioxide production for maintenance energy requirements. The proportion between anabolism and catabolism of the activated sludge depends on the So/Xo ratio. These observations give us another idea for reducing the excess activated sludge production since in wastewater treatment, a considerable part of the total cost is used for the treatment of excess sludge. If a treatment system can be in favour of the maintenance of activated sludge, the excess activated sludge will be much reduced.

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