

The application of different techniques to determine activated sludge kinetic parameters in a food industry wastewater

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Abstract

In the present work, a continuous-feed system under steady state conditions (classical method) and a respirometric technique based on oxygen consumption measurements, were used to compare microbial parameters using a wastewater model system of a potato processing plant. The effects of the operating conditions in the continuous aerobic reactor on microbial growth and flora composition were also analysed.

Continuous-feed experiments allowed for the calculation of the following biodegradation parameters: maximum substrate consumption specific rate ($q_{s,max}$) = 0.19 mgCOD (mgVSS)⁻¹·h⁻¹, saturation constant (K_s) = 8.3 mgCOD·ℓ⁻¹, biomass yield ($Y_{x/s}$) = 0.61 mgVSS (mgCOD)⁻¹, biomass decay constant (k_d) = 0.04·h⁻¹ and maximum oxygen consumption specific rate ($q_{O_2,max}$) = 0.03 mgCOD (mgVSS)⁻¹·h⁻¹.

The respirometric technique also allowed for the calculation of kinetic parameters. However, these parameters depended on dilution rate (D) and/or on dissolved oxygen concentration (DO). Values of $q_{O_2,max}$ and K_s increased with D; $q_{O_2,max}$ ranged between 0.05 and 0.13 mgO₂ (mgVSS)⁻¹·h⁻¹ and K_s between 2 and 26 mgCOD·ℓ⁻¹ for D values varying between 0.01 and 0.15·h⁻¹.

Microscope observations showed that sludge composition was a function of dilution rate. Low D values (low soluble organic matter (S_s) and high DO concentrations) yielded sludges mainly formed by floc-forming bacteria; high D values (high S_s and low DO concentrations) yielded sludges mainly formed by filamentous micro-organisms.

Since the low substrate/biomass ratios used in the respirometric method limit the growth of micro-organisms maintaining the initial physiological state of the original biomass, the observed differences in the respirometric parameters reflected the actual microbial composition.

Notation

COD	=	chemical oxygen demand (mg·ℓ ⁻¹)
D	=	dilution rate (h ⁻¹) = Q/V
DO	=	dissolved oxygen concentration (mgO ₂ ·ℓ ⁻¹)
f _M	=	biomass stirring factor (dimensionless)
k _d	=	biomass decay constant (h ⁻¹)
K _s	=	saturation constant (mgCOD·ℓ ⁻¹)
OC	=	oxygen consumed (mgO ₂ ·ℓ ⁻¹)
OUR	=	oxygen uptake rate (mgO ₂ ·ℓ ⁻¹ ·h ⁻¹)
P	=	microbial product concentration in the reactor (mgCOD·ℓ ⁻¹)
Q	=	continuous flow (ℓ·h ⁻¹)
q	=	measured substrate consumption specific rate (mgCOD (mgVSS) ⁻¹ ·h ⁻¹)
q _{O₂}	=	oxygen consumption specific rate (mgO ₂ (mgVSS) ⁻¹ ·h ⁻¹)
q _{O_e}	=	endogenous oxygen consumption specific rate (mgO ₂ (mgVSS) ⁻¹ ·h ⁻¹)
q _{O_{2,max}}	=	maximum oxygen consumption specific rate (mgO ₂ (mgVSS) ⁻¹ ·h ⁻¹)
q _{O_t}	=	total oxygen consumption specific rate (mgO ₂ (mgVSS) ⁻¹ ·h ⁻¹)
q _p	=	product formation specific rate (mgCOD (mgVSS) ⁻¹ ·h ⁻¹)

q _s	=	substrate consumption specific rate (mgCOD (mgVSS) ⁻¹ ·h ⁻¹)
q _{s,max}	=	maximum substrate consumption specific rate (mgCOD (mgVSS) ⁻¹ ·h ⁻¹)
r _{O_e}	=	endogenous oxygen consumption rate (mgO ₂ ·ℓ ⁻¹ ·h ⁻¹)
r _{O_t}	=	total oxygen consumption rate (mgO ₂ ·ℓ ⁻¹ ·h ⁻¹)
S	=	substrate concentration in the reactor (mgCOD·ℓ ⁻¹)
S _a	=	substrate concentration before the pulse in the respirometric technique (mgCOD·ℓ ⁻¹)
S _s	=	soluble organic matter concentration (mgCOD·ℓ ⁻¹)
S _o	=	feed substrate concentration (mgCOD·ℓ ⁻¹)
t	=	time (min)
V	=	volume (ℓ)
VSS	=	volatile suspended solids (mg·ℓ ⁻¹)
X	=	biomass concentration (mgVSS·ℓ ⁻¹)
X _r	=	biomass concentration in the respirometer (mgVSS·ℓ ⁻¹)
Y _{O₂/S}	=	oxidation coefficient (mgO ₂ (mgCOD) ⁻¹)
Y _{P/S}	=	product yield (mgCOD (mgCOD) ⁻¹)
Y _{X/S}	=	biomass yield (mgVSS (mgCOD) ⁻¹)
m	=	specific microbial growth rate (h ⁻¹)
m _{max}	=	maximum specific microbial growth rate (h ⁻¹)

Introduction

Among aerobic biological wastewater treatments, activated sludge systems play an important role. Waste is discharged into large aeration basins in which atmospheric oxygen is diffused by releasing compressed air into the waste or by mechanical surface aerators. Both substrate consumption kinetics and floc-forming capacity of the sludge determine process efficiency. The operation mode of the aeration unit affects the physical properties of the flocs and may

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