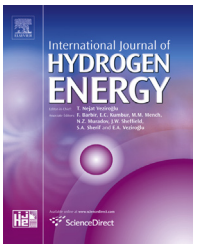
INTERNATIONAL JOURNAL OF HYDROGEN ENERGY XXX (2017) 1–10

Available online at www.sciencedirect.com

ScienceDirect

journal homepage: www.elsevier.com/locate/he



Respirometric evaluation of S_0/X_0 ratio effect on the kinetic and stoechiometric parameters of activated sludge

Mahfoud Sakhraoui[*], *R. Zamouche-Zerdazi*, *M. Bencheikh-Lehocine*, *A.-H. Meniai*

Laboratoire de l'Ingénierie des Procédés d'Environnement (LIPE), Faculté de Génie des Procédés, Université Constantine 3, Constantine 25000, Algeria

ARTICLE INFO

Article history:
Received 2 August 2016
Received in revised form
1 January 2017
Accepted 16 January 2017
Available online xxx

Keywords:
Respirometry
S_0/X_0 ratios
Stoechiometric-kinetic parametres
Activated sludge

ABSTRACT

Respirometry has been used in this work to assess the effect of S_0/X_0 ratio, knowing that this ratio is a very important operational parameter in the conduct of wastewater treatment plant. It affects its design and operation; part of the respirometry calculations, dissolved oxygen transfer coefficient K_La is calculate for each respirometric experiment, due to the fact that operational condition change. Under endogenous conditions OUR_{end} is calculated using the linear portion of the variation of *DO* concentration under no aeration conditions. Then the OUR_{end} is used in the endogenous phase at a no oxygen concretion variation to calculate the K_La. Samples of wastewater, with different S_0/X_0 ratios in the range between 0.01 and 0.23, containing sometimes *ATU*, a nitrification inhibitor, were injected in the respirometer with *DO* concentration variation recording. Exogenous OUR_{exo} were calculated from the *DO* data and they show that as S_0/X_0 ratio increased total OUR_t increased too as well as total oxidation time. However when, *COD* is present alone the removal kinetics is more rapid than when both substrates (nitrogen and carbonaceous) are present. It has been shown that the use of respirometry in biomass activation assessment is a sound approach because of the celerity, the reliability and the limited cost. Consequently it has been extended in to the assessment of biomass activation when it is exposed to antibiotics.

Introduction

Activated sludge biomass activity has been studied in a batch respirometer [1–4] through *DO* consumption. This method is one of the most frequently used to optimize biological reactions and to evaluate kinetic and stoechiometric parameters [5–10] such as the substrate affinity constant (K_S), the maximum specific growth rate (μ_{max}), the yield ($Y_{X/S}$) [11] etc. This technique consists of measuring biological oxygen consumption rate under well-defined conditions [12]. Particular thought has been paid to the influence of the initial substrate to biomass ratio S_0/X_0 [13] on wastewater treatment performance [14–18]. This S_0/X_0 ratio is an important [10,11] parameter in batch experiments because it reflects the initial energy level, to investigate the consumption of

* *Corresponding author*. LIPE, Constantine 3 University, 25000, Algeria.
E-mail address: mahfoudsakh@yahoo.com (M. Sakhraoui).

http://dx.doi.org/10.1016/j.ijhydene.2017.01.097
0360-3199/

Symbols used

COD	Chemical Oxygen Demand, mg L^{-1}
BOD	Bio-Chemical Oxygen Demand, mg L^{-1}
DO	Dissolved Oxygen concentration, mg L^{-1}
OUR	Oxygen Uptake Rate, $mg_{O2}L^{-1}$ s^{-1}
TSS	Total Suspended Solids, mg L^{-1}
VSS	Volatile Suspended Solids, mg L^{-1}
V	Volume, L
SVI	Sludge Volume Index, mg L^{-1}
K_La	Oxygen Transfer Coefficient, h^{-1}
Ks	Substrate Affinity Constant, mg L^{-1}
μ	Growth Rate, d^{-1}
Yx/s	Yield, mg_{VSS} L^{-1}
S_0/X_0	Initial Substrate to Biomass Ratio, g_{COD}/g_{VSS}
ATU	AllulThioUrea
WWTP	Waste Water Treatment Plant
Index	
eff	Effluent
b	Sludge
t	Total
s	Soluble
end	Endogenous
exo	Exogenous
max	Maximum
30	After thirty minutes
5	After five days

substrate compounds [19,20] and it allows knowing of whether or not cell duplication can take place during the exogenous substrate removal, under given conditions, or if it is inhibited by a lack of substrate [21]. Many authors [2] were highlighted the importance of S_0/X_0 ratio, this ratio key to affect the analysis and the respirometric response [10], first aerobic batch biodegradation testing and also on the relationship between preliminary acclimatization and biodegradation of different compounds (organic or refractory such as inhibitors) [14]. Moreover, S_0/X_0 ratio, could also influence the *OUR* shape curve reliability and other kinetics parameters [9,39].

The initial substrate-to-biomass ratio will directly affect the growth patterns of microorganisms and the values of the kinetics and stoechiometric parameters [14,22]. However, there is no common agreement on this S_0/X_0 ratio and the experimental procedures. Generally, testing at low ratios S_0/X_0 (<0.2 g_{COD}/g_{VSS}) demonstrate the existence of a threshold below which the reactor performance is seriously affected. The stressed biomass can survive under lack of substrate condition better than unstressed biomass which cell duplication is strongly inhibited [7]. In addition, working under low ratio prevents possible variations in the composition and the physiological form of biomass population due to the different growth velocities of the various microorganisms present in the consortium [10,33]. Besides, several authors ascertain that it seems that only the kinetic parameters obtained at low S_0/X_0 ratios, can be correctly used in the design and the study of activated sludge plants. Furthermore, it should be taken into account that in actual municipal wastewater treatment plants S_0/X_0 ratio is always kept very low: 0.01 for aerobic completely mixed systems and 0.13 for plug-flow systems [15]. When the ratio is sufficiently high (S_0/X_0 > 2 mg_{COD}/mg_{VSS}), biomass conditions itself to limitless growth, since it will be on the exponential growth phase, and the measured kinetic parameters can be independent of the retrospective feeding of the biomass [35–38]. Kinetic parameters obtained at these conditions show maximum activity [9].

This work aims at studying the influence of various S_0/X_0 ratios (= 0.01, 0.02, 0.03, 0.04, 0.06, 0.09, 0.15 and 0.23) on the response of non acclimated biomass growth and synthetic *COD* substrate composed of sodium acetate removal [23,24] in a batch aerated respirometer [3–6]. Short-term Oxygen Uptake Rate, *OUR*, can provided much information about the treatment process, their determination is detailed in several studies [27–33]; it requires the Volumetric Oxygen Transfer Coefficient K_La determination in the solution which is necessary for the interpretation of respirometric data [34]. *OUR* experiments can be successfully used to measure the activated sludge response [25] and the determination of biological removal performance for Heterotrophic and Autotrophic biomass on the one hand; and on the other hand, the Heterotrophic biomass only.

Two series of batch experiments were carried out, using sodium acetate as a single source of carbon, in the presence or not of the nitrification inhibitor *Allyl-Thio-Urea* (*ATU*, in order to determine the optimal) S_0/X_0 ratio to be used in the assessment of inhibitory effect of pharmaceutical products [24,26–29].

Materials and methods

The respirometer

The respirometer used in this experimental work is an open and aerated 0.5 L volume glass reactor (09). The air is supplied by an aquarium pump '*SHARK-RS-510*' (10), with a maximum air flow of 150 L/h connected to a plastic air diffuser (06). The liquid phase is mixed by a magnetic bar (07) and a magnetic stirrer '*AGIMATIC-N*' (08). A syringe is used to inject the substrate (02). The *pH*, *DO* and temperature were measured using a *pH* probe '*IDS-WTW*' (03) and a *WTW* oxygen probe '*FDO-925 IDS*' (04), which was connected to a *WTW* Oxymeter '*Multi-3430*' (05). The system was maintained at a fixed temperature (20 °C ± 0.5 °C) (01) in a thermostatic enclosure of *WTW* (11). Fig. 1 represents the set up used during the test.

Synthetic effluent (substrate)

The composition of the synthetic wastewater used in this work is reproduced in Table 1.

The compositions of the synthetic wastewater was chosen so that its theoretical *COD* is of 2000 *mg/L*, stored at a temperature of 4 °C and allowed to reach 20 °C ± 1 °C before use.

Analytical methods

All analyses were done according to standard methods [24,27,40]. Soluble Chemical Oxygen Demand, *CODs*, was

Please cite this article in press as: Sakhraoui M, et al., Respirometric evaluation of S_0/X_0 ratio effect on the kinetic and stoechiometric parameters of activated sludge, International Journal of Hydrogen Energy (2017), http://dx.doi.org/10.1016/j.ijhydene.2017.01.097