Effectiveness of chlorination and ozonation methods on pure cultures of floc-forming micro-organisms and activated sludge: A comparative study

Alejandro Caravelli[1], Leda Giannuzzi[1] and Noemí Zaritzky[1,2]*

[1] *Centro de Investigación y Desarrollo en Criotecnología de Alimentos (CIDCA). Facultad de Ciencias Exactas, Universidad Nacional de La Plata - CONICET, 47 y 116, La Plata (1900) Argentina*

[2] *Facultad de Ingeniería, Universidad Nacional de La Plata, 48 y 115, La Plata (1900) Argentina*

Abstract

Chlorination is a very useful control method of filamentous bulking in activated sludge systems; however, it favours formation of undesirable compounds such as trihalomethanes. Other oxidants, such as ozone, could be used for bulking control. In view of the fact that chlorine and ozone are both non-selective chemical agents affecting filamentous and floc-forming micro-organisms, the determination of optimum dosage conditions becomes essential to minimise the impact produced on the activated sludge process. In this work, the effects of chlorine and ozone on the biomass concentration of activated sludge and on different parameters that characterise the microbial metabolic activity were compared. The following techniques were applied: Respirometry (oxygen uptake rate); and INT-dehydrogenase activity test carried out both by spectrophotometry (DHA_a) and image analysis (DHA_i). The respirometric technique and the DHA_a test quantified oxidants action on the total respiratory activity of flocs; the image DHA_i test was applied to evaluate the specific action of the oxidants on filamentous micro-organisms. Additionally, plate count technique, respirometry and DHA_a test were correlated using chlorine and ozone experiments on pure cultures of a floc-forming micro-organism (*Acinetobacter anitratus)* to compare the effect of the oxidising agents on the metabolic activity and the viability of the micro-organisms. Ozone was found to have more intense antimicrobial action. In activated sludge, ozone reduced total biomass concentration by oxidising various components and causing cell lysis. An equation was proposed to estimate biomass concentration of activated sludge as a function of time and ozone dose rate; in contrast, at the doses applied, chlorine did not reduce the concentration of activated sludge biomass. In activated sludge, adequate conditions for both oxidants were identified under which the respiratory activity of filamentous micro-organisms could be considerably inhibited, causing the lowest possible impact on whole floc metabolic activity. An initial chlorine dose of 7.9 $mgCl_2 \cdot gVSS^{-1}$ for a contact time of 5 min (initial pulse= 6.0 $mgCl_2 \cdot \ell^{-1}$), and a total ozone dose of 66.0 $mgO_3 \cdot gVSS^{-1}$ (ozone dose rate of 3.3 $mgO_3 \cdot gVSS^{-1} \cdot min^{-1}$ for a contact time of 20 min) were the most suitable conditions to control filamentous bulking.

Keywords: filamentous bulking, chlorine, ozone, INT-dehydrogenase activity, respirometry, image analysis, plate count

Nomenclature

A_{490}	Absorbance of the dye colorant extracted at 490 nm (AU, absorbance units)
A_c	Area occupied by intracellular INT-formazan crystals
A_T	Total area of the filamentous micro-organisms
CFU	Colony forming units ($CFU \cdot m\ell^{-1}$)
COD	Chemical oxygen demand ($mgO_2 \cdot \ell^{-1}$)
COD_B	Biomass chemical oxygen demand ($mgO_2 \cdot \ell^{-1}$)
COD_S	Soluble chemical oxygen demand ($mgO_2 \cdot \ell^{-1}$)
COD_T	Total chemical oxygen demand ($mgO_2 \cdot \ell^{-1}$)
D_{Cl}	Initial chlorine dose ($mgCl_2 \cdot gVSS^{-1}$)
DHA	INT-dehydrogenase activity
DHA_a	INT-dehydrogenase activity measured by spectrophotometry ($A.U \cdot \ell \cdot gVSS^{-1} \cdot h^{-1}$)
$DHA_{a(control)}$	INT-dehydrogenase activity measured by spectrophotometry in untreated samples ($A.U \cdot \ell \cdot gVSS^{-1} \cdot h^{-1}$)
$DHA_{a(treated)}$	INT-dehydrogenase activity measured by spectrophotometry in samples treated with chlorine or ozone ($A.U \cdot \ell \cdot gVSS^{-1} \cdot h^{-1}$)
DHA_i	INT-dehydrogenase activity measured by image analysis (dimensionless)
$DHA_{i(control)}$	INT-dehydrogenase activity measured by image analysis in untreated samples (dimensionless)
$DHA_{i(treated)}$	INT-dehydrogenase activity measured by image analysis in samples treated with chlorine or ozone (dimensionless)
D_{oz}	Total ozone dose ($mgO_3 \cdot gVSS^{-1}$)
FR	Bacterial respiratory activity fraction (dimensionless)
FR_{DHAa}	Bacterial respiratory activity fraction obtained by spectrophotometry (dimensionless)
FR_{DHAi}	Bacterial respiratory activity fraction obtained by image analysis (dimensionless)
FR_{OUR}	Bacterial respiratory activity fraction based on respirometric technique (dimensionless)
j	Correction factor for the dilution caused by formaldehyde addition
k	Specific rate of biomass decay (min^{-1})

* To whom all correspondence should be addressed.
☎ +(54-221) 4249287; fax: +(54-221) 4254853;
e-mail: zaritzky@volta.ing.unlp.edu.ar
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