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Sensitivity analysis of a model that describes the biofiltration of TRS compounds

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Abstract

A sensitivity analysis of a model that describes the biooxidation of Total Reduced Compounds (TRS) using a biotrickling filter is presented. Consistent results are obtained using three methodologies; Standard Regresion Coefficients (SRC), Variance-based sensitivity index (VSI) and the method of Morris. The model presents a highly linear behavior of the uncertain parameters. It is shown that the properties of the biofilm and the parameters related with the kinetics have the highest influence on the behavior of the model, on the other hand the properties related with mass transfer have a low influence.

Keywords: biofiltration; sensitivity analisys; TRS; modelling biofilter; biotrickling filter

1. Main text

Biofilters are an interesting alternative for removing pollutants from industrial gaseous emissions, especially when the pollutants are at very low concentrations and big flows or volumes. In these systems, the contaminant is transferred from the gas phase to a biofilm, containing a population of pollutant degrading microorganism. Among the most common uses of these systems is the depletion of odours caused by gaseous effluents containing low levels of concentration of total reduced sulphur (TRS) and H_2S, that are usually found in processes where there are heating or anaerobic decomposition of organic matter.

For the design of a biofilter, it is necessary the identification of unknown parameters related with microbial kinetic and specific values of the physicochemical properties. In some cases these values can be estimated, in others they must be determined by experimental data and nonlinear techniques (Alonso et al, 2000). In the simulation of biofilters the effect of these parameters is not clear, so many authors fit these values using experimental data (Devinny & Ramesh, 2005).

In this work a model describing the mass transfer and the biooxidation of TRS is used (Spigno et al, 2004). The modelling is carried out considering a fixed-bed system with a packing material that supports a biofilm. When the contaminated air flows through out the bed, the pollutants are transferred continuously from the gas phase to the

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liquid phase reaching the biofilm, where the contaminant diffuses and is oxidized aerobically by the microbial population.

Dimensionless general Mass balance for compound i in the gaseous phase:

$$\frac{1}{Pe}\cdot\frac{\partial^2 C_g}{\partial\zeta^2}-\frac{\partial C_g}{\partial\zeta}+v_b\cdot Ti\cdot\left.\frac{\partial C_b}{\partial\psi}\right|_{\psi=O}=0 \qquad (1)$$

Where C_g is the dimensionless concentration of the pollutant in the gas phase, Pe is the Péclet number, ζ is the dimensionless axial co-ordinate along the bed height, v_b is the specific volume of the support, Ti is the residence to diffusion time ratio, C_b is the dimensionless concentration in the biofilm and ψ is the dimensionless spatial co-ordinate in the biofilm.

Dimensionless general mass balance for the i compound in the liquid phase

$$\frac{\partial^2 C_b}{\partial\psi^2}-Th^2\cdot\kappa=0 \qquad (2)$$

Where Th is the Thiele modulus and κ is the dimensionless specific degradation rate. The kinetic equation for the dimensionless rate of biooxidation is:

$$\kappa_{H_2S}=\frac{1}{Y_{x/S}}\cdot\frac{C_b}{\sigma+C_b} \qquad (3)$$

Where Y is the yield coefficient of biomass (g biomass g−1 substrate), σ is the dimensionless Monod constant.

The **SRC** method and has a computational cost of 4096. The cost for the Morris method was of 64 runs (8minutes of computing time of a single model run). According to the Standard Regresion Coefficients method (**SRC**), 94% of the variation in the outlet concentration is capture with a correlation coefficient of 0.84, it means that the effect of each parameter on the output is highly linear. In most of the parameters it is observed there is a low standard deviation except in those with a high sensitivity. Such deviations confirm that the model has a considerable linearity related to uncertain parameters and the values obtained by the method of Morris are a good approximation to the relation between the uncertain parameter and the output obtained.

In the modelling of the biofiltration of TRS, the parameters related with the kinetic have a greater influence on the removal capacity, then the characteristics of the biofilm and well below the transport properties. For the latter, the regime of the operation conditions is not decisive in determining the performance of these systems. We conclude that a reliable kinetic model and the knowledge of the properties of the biofilm are determinants when simulating a biofilter removing TRS.

2. References

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