

Short Term Scientific Mission (STSM) 2014

Extending the ADM1 with Sulfur-related Conversions for Plant-Wide Modelling and Benchmarking

September 1st, 2014 | November 28th, 2014

Objectives

Sulfate in the wastewater has been a source of operational problems for treatment plants, especially in the sewers and in the anaerobic digester, mainly due to its conversion to hydrogen sulfide (H₂S) when subjected to anaerobic conditions.

This research aims to include sulfate reduction processes in modelling of the anaerobic digestion process for future development of control strategies to minimize H₂S production, as well as for risk assessment of operational problems associated with H₂S production. The objective of this study is to compare model predictions of the Anaerobic Digestion Model No. 1 (ADM1) extended with sulfate reduction processes using two different models for a range of S:COD loads.

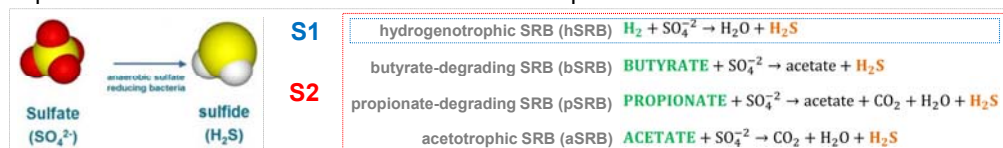
Methodology

Extension of ADM1 with sulfide production by sulfate reducing bacteria (SRB) through:

[S1] oxidation of hydrogen (Batstone, 2006), or

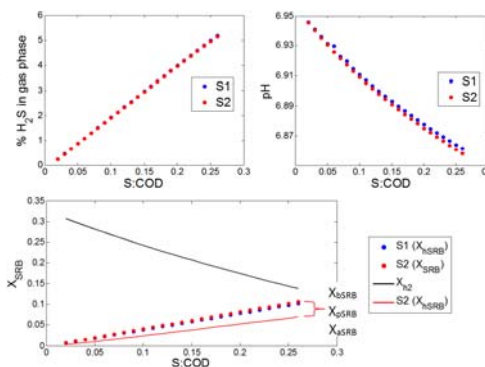
[S2] = [S1] + oxidation of butyrate propionate, and acetate (Fedorovich et al., 2003)

Implementation in the MATLAB/Simulink simulation platform



Results

At low S:COD ratios, H₂S production and pH prediction are similar for both models. At higher ratios, there is an increase in H₂S concentration in the gas phase as sulfate is converted to sulfide with an associated decrease in pH. Increasing sulfate concentration also results in an increase in the concentrations of SRBs as sulfate serves as the electron donor during conversion to sulfide. However, a decrease in hydrogen-utilising organisms is observed due to inhibitory effects as more H₂S is produced.



Highlights

- Both models [S1] and [S2] show similar predictions for H₂S production, pH, sulfate removal and concentrations of organics with insignificant differences (<1%). An observed increasing difference can be seen at higher S:COD ratios although the deviations in the predictions from the two models are still very small (<1%).
- For benchmarking purposes (i.e. BSM2 for municipal wastewater), model [S1] is sufficient to describe the sulfate reduction process and the production of hydrogen sulfide in the anaerobic digester. However, the more complex model [S2] should be used when dealing with systems with high sulfate concentrations (e.g. wastes from fermentation industry, tanneries, pulp and paper industry, etc.).

The work performed is part of an on-going research effort of improving the ADM1 – and consequently the Benchmark Simulation Models (BSM) – by including several frequently requested extensions, of which sulfur conversions represent one.

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COST is supported by the EU RTD Framework Programme



ESF provides the COST Office through a European Commission contract