# Respirometric characterization of a small community wastewater for decentralized biological treatment

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## Introduction

In comparison to larger plants, decentralized small size wastewater treatment plants (DC-WWTP) face more pronounced operational constraints such as high load fluctuations, operation and maintenance problems and increased costs per capita. The scarcity of historical data on the performance of this type of plants is generally associated to largely unattended operation. Thus, it is important to gain adequate information for both performance assessment and process control, at controlled costs and adapted to centralized supervision. For this, the implementation of an expedite framework for performance monitoring and control is proposed, using on-line data obtained with robust instruments and a simplified dynamic model structure. Point, periodical determination of value ranges for some wastewater characteristics and model parameters, using respirometric assays, allows a more robust modeling of the biological treatment process in these DC-WWTP.

## DC_WWTP performance study

An extensive monitoring study was carried out at a DC-WWTP treating the domestic wastewater from a 800-inhabitant village located in inland Portugal. The WWTP is an extended aeration activated sludge plant designed for carbonaceous substrate removal. The gathered data was used in the calibration and validation of a mathematical model of the treatment system performance.

**DC-WWTP studied**

**On-line instrumentation** (1 year)

- Continuous flow measurement
- pH and dissolved oxygen
- spectroscopy in the ultraviolet-visible wavelength band

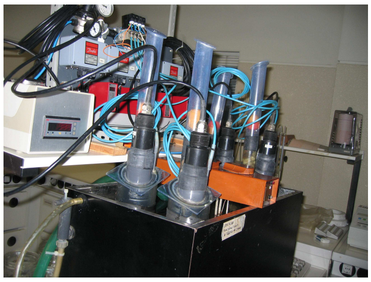
**Measuring campaigns** (five, 24 hours each)

- Instrument data gathering
- Analytical characterization of samples collected at different points in the plant

**DC-WWTP mathematical model**

- Includes a simplified description of the activated sludge biological treatment unit based on the ASM1 model (Henze *et al.*, 1987)
- Processes associated to the removal of the carbonaceous material (*i.e.*, heterotrophic growth, heterotrophic decay, hydrolysis)

### Respirometric determinations

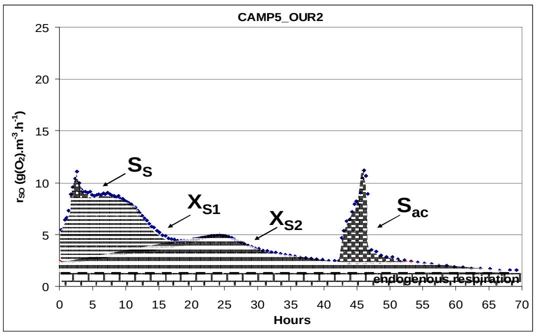


**Laboratory installation**

- Characterization of undiluted influent wastewater samples
- Duration of assays increased from 24 hours (campaign 1) to 70 hours (campaign 5)
- Addition of sodium acetate (0,2 g) after the consumption of the readily biodegradable substrate
- A respirometric method similar to that described by Wentzel *et al.* (1999) was used to estimate values for carbonaceous substrate fractions and for some of the activated sludge model parameters

## Results and conclusions

**Respirogram of domestic wastewater (Campaign 5, T= 20º C, initial $COD_t$ = 604 $gO_2.m^{-3}$)**




- In the respirogram, the curve of oxygen uptake rate (OUR) after the apparent exhaustion of the readily biodegradable substrate ($S_S$) showed a trend with two peaks, which suggests the existence of two distinct groups of slowly biodegradable substrates.
- The first group ($X_{S1}$) generally represented a higher fraction of the curve of oxygen consumption vs. time. This can be understood as reflecting the degradation of a wide range of different compounds at a similar rate Spanjers *et al.* (1999).
- For the second group ($X_{S2}$) the curve of oxygen consumption shows a shorter, less intense peak, attributed the existence of a more limited set of compounds which undergo slower biological degradation. The delay of the $X_{S2}$ peak, in relation to $X_{S1}$, may result from the need for biomass adaptation, *i.e.*, production of extra-cellular enzymes specific for the hydrolysis of $X_{S2}$.

- Direct interpretation of the respirograms and the analytical determinations carried out on wastewater samples immediately before and after each assay, enabled the estimation of values for some of the parameters and variables of the ASM1 model (Table 1).

Variables and parameters:

$Y_H$ – Yield of heterotrophic biomass on a given substrate

$\mu_H^{max}$ – Maximum specific growth rate for heterotrophic biomass on a given substrate

$X_{H0}$ – Heterotrophic biomass concentration at the start of the assay

$S_S$ – Readily biodegradable substrate (concentration)

$X_S$ – Slowly biodegradable substrate (concentration)

**Table 1 - Estimated values for ASM1 model parameters and variables for influent wastewaters at the case-study DC-WWTP**

| | $Y_H$ | $\mu_H^{max}$ | $\mu_H^{max}$ | $k_{h1}$ | $k_{h2}$ | $X_{H0}$ | $S_S$ | $X_{S1}$ | $X_{S2}$ |
|---|---|---|---|---|---|---|---|---|---|
| Units | $gO_2$ biomass.($gO_2$ substr)$^{-1}$ | $h^{-1}$ | $h^{-1}$ | $h^{-1}$ | $h^{-1}$ | $gO_2$ biomass. $m^{-3}$ | $gO_2$ substrate. $m^{-3}$ | $gO_2$ substrate. $m^{-3}$ | $gO_2$ substrate. $m^{-3}$ |
| Substrate | *acetate* | *acetate* | $S_S$ | $X_{S1}$ | $X_{S2}$ | -- | -- | -- | -- |
| Average | 0.58 | 0.47 | 0.28 | 0.33 | 0.12 | 34 | 15 | 210 | 245 |
| Standard deviation | 0.06 | 0.035 | 0.06 | 0.06 | 0.04 | 23 | 10 | 46 | 112 |

**References:**

- Henze, M., Grady, C., Gujer, W., Marais, G., Matsuo, T. "Activated Sludge Model No. 1", IAWPRC Science and Technological Report (1987) IAWPRC (now IWA): 33.
- Wentzel, M., Mbewe, A., Lakay, M., Ekama, G.A. "Batch test for characterization of the carbonaceous materials in municipal wastewaters", Water SA (1999) 25(3): 327-335.
- Spanjers, H., Takacs, I., Brouwer, H. "Direct parameter extraction from respirograms for wastewater and biomass characterization", Wat. Sci. Tech. (1999), 39(4), 137-145.