Corrigendum to “Design, analysis and validation of a simple dynamic model of a submerged membrane bioreactor”

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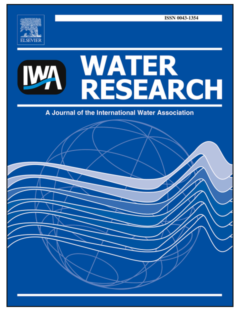

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Corrigendum to "Design, analysis and validation of a simple dynamic model of a submerged membrane bioreactor"

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Abstract

In this paper, the readers can find the corrections of the published article. The authors apologize for any inconvenience caused.

SECTION 4.2 - Three-time-scale singular perturbation

The small parameters are assumed to be $\epsilon_1 = |\gamma|$ and $\epsilon_2 = \frac{1}{V}$.

Hypothesis 1. *γ is small.*

Hypothesis 2. *The volume V is large, with $V < \frac{1}{|\gamma|}$.*

The application of the procedure introduced in the previous subsection yields:

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First: The stretched time-scale $\tau_1 = \epsilon_1 t \rightarrow \frac{1}{dt} = \frac{\epsilon_1}{d\tau_1}$

$$\frac{dx_{sl}}{d\tau_1} = sign(\gamma)x_{sl} \qquad (Slow)$$

$$\epsilon_1 \frac{dy_1}{d\tau_1} = g_1(y_1, y_2) = -\frac{1}{Y}\mu(y_1)y_2 + \frac{Q_{in}}{V}(S_{in} - y_1) \qquad (Fast)$$

$$\epsilon_1 \frac{dy_2}{d\tau_1} = g_2(x_{sl}, y_1, y_2, z) =$$

$$\mu(y_1)y_2 + \frac{Q_{in}}{V}X_{in} - \frac{Q_{in}}{V}y_2 + x_{sl}\frac{J_{air}}{V}\frac{z^2}{K_{air}+z} \qquad (Fast)$$

$$\epsilon_1 \frac{d_z}{d\tau_1} = h(x_{sl}, y_2, z) = Q_{cake}y_2 - x_{sl}J_{air}\frac{z^2}{K_{air}+z} \qquad (Fast)$$

Considering $Q_w = Q_{in} - Q_{cake}$ and letting $\bar{S}_{in} = S_{in} + \frac{X_{in}}{Y} > S_{in}$ the following slow-fast approximation can be developed:

$$0 = g_1(y_1, y_2) \rightarrow \mu(y_1) = \frac{Q_w}{V}\frac{S_{in}-y_1}{\bar{S}_{in}-y_1} \qquad (11)$$

$$0 = g_2(x_{sl}, y_1, y_2, z) \rightarrow y_2 \frac{Q_{in}(\bar{S}_{in}-Yy_1)}{Q_w} \qquad (12)$$

$$0 = h(x_{sl}, y_2, z) \rightarrow \frac{x_{sl}J_{air}z^2}{V(K_{air}+z)} = Q_{out}y_2 \qquad (13)$$

Second: The stretched time-scale $\tau_2 = \epsilon_2\tau_1 = \epsilon_2\epsilon_1 t \rightarrow \frac{1}{d\tau} = \frac{\epsilon_2}{d\tau_2}$ and x_{sl} is constant.

$$\epsilon_1 \frac{dy_1}{d\tau_2} = -\frac{1}{Y\epsilon_2}\mu(y_1)y_2 + Q_{in}(S_{in} - y_1) \qquad (Fast)$$

$$\epsilon_1 \frac{dy_2}{d\tau_2} = \left(\frac{\mu(y_1)}{\epsilon_2} - Q_w\right)y_2 + Q_{in}X_{in} - Q_{cake}y_2 + x_{sl}J_{air}\frac{z^2}{K_{air}+z} \qquad (Fast)$$

$$\epsilon_2\epsilon_1 \frac{dz}{d\tau_2} = h(x_{sl}, y_2, z) = Q_{cake}y_2 - x_{sl}J_{air}\frac{z^2}{K_{air}+z} \qquad (Ultrafast)$$

$$0 = h(x_{sl}, y_2, z) \rightarrow z = \frac{\frac{Q_{cake}Q_{in}Y\bar{S}_{in}}{Q_w} + \sqrt{Q_{cake}^2\left(\frac{Q_{in}Y\bar{S}_{in}}{Q_w}\right)^2 + 4\frac{Q_{cake}Y\bar{S}_{in}K_{air}J_{air}x_{sl}Q_{in}}{Q_w}}}{2x_{sl}J_{air}} \qquad (14)$$

TABLE 2

Table 2: Parameters with their confidence interval.

	Ultrafast [0.02 Days]	Fast [6 Days]	Slow [20 Days]	All Parameters
β_0	$(4.819 \pm 0.573) \times 10^4$	fixed value	fixed value	$(5.531 \pm 0.643) \times 10^4$
K_{air}	$(4.773 \pm 0.575) \times 10^1$	fixed value	fixed value	$(4.596 \pm 0.134) \times 10^1$
Y	fixed value	$(8.996 \pm 0.022) \times 10^{-1}$	fixed value	$(8.985 \pm 0.016) \times 10^{-1}$
$\mu_{S,max}$	fixed value	(2.004 ± 0.722)	fixed value	(2.265 ± 0.343)
γ	fixed value	fixed value	(0.001 ± 0.882)	(0.001 ± 0.535)
$min(f_{cost}(\theta))$	53.55	0.8592	6.42	22.79