

Application of a new combined hydraulic and biological plant-wide model for trickling filters in a real WRRF



K. Olaciregui-Arizmendi*, S. Jaray-Valdehiero*, T. Fernández-Arevalo*, A. López***, J. Gómez***, P. Grau**, B. Elduayen-Echave* and E. Ayesa*

*CEIT-Basque Research and Technology Alliance (BRTA); Universidad de Navarra, Tecnun

**Universidad de Navarra, Tecnun

*** NILSA, Navarra de Infraestructuras Locales S.A.

Contact details: kolaciregui@ceit.es, pgrau@unav.es, belduayen@ceit.es



INTRODUCTION

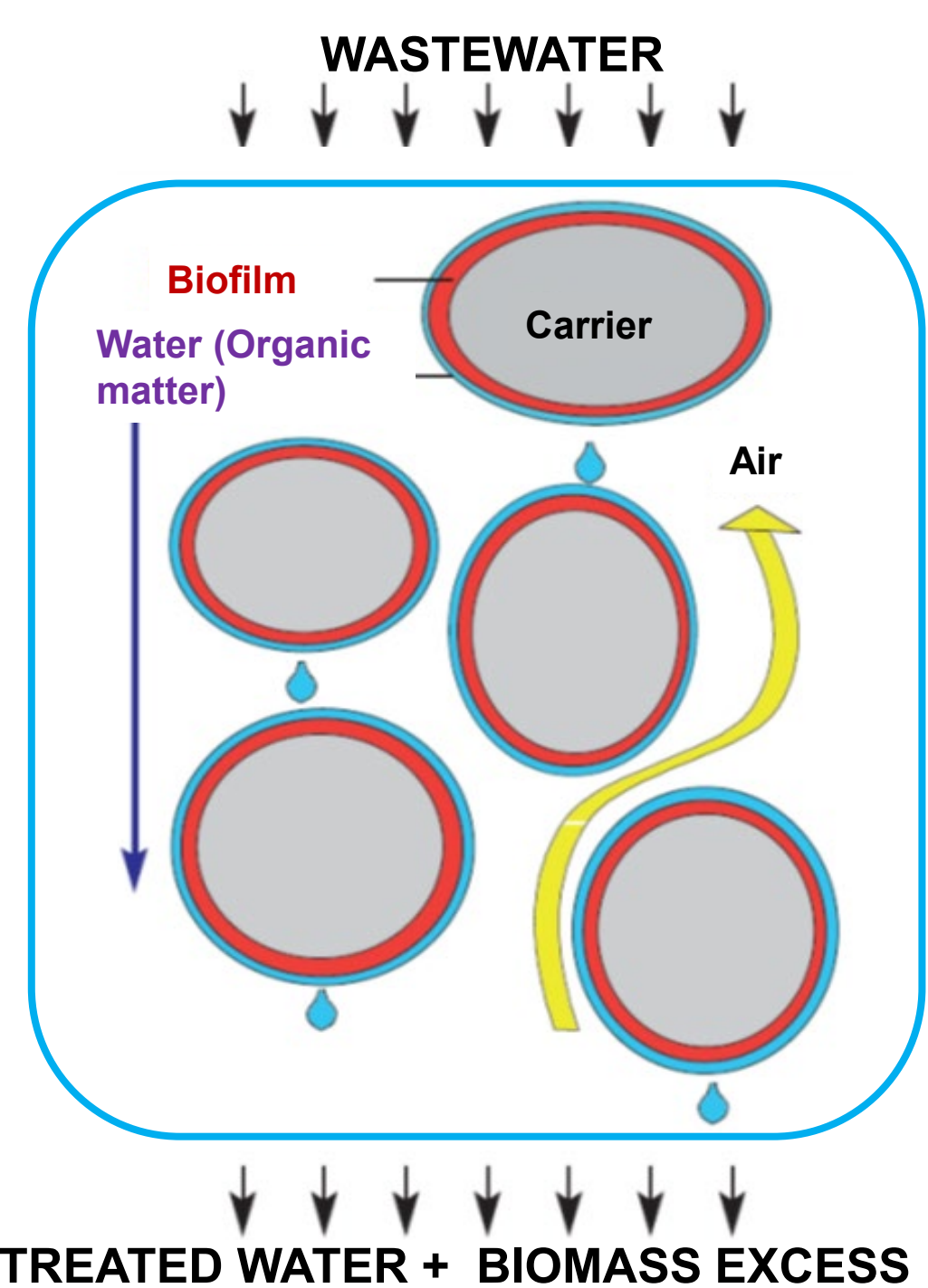


Figure 1 – Operation diagram of a trickling filter.

NILSA and Ceit-BRTA are collaborating in the development of a **mechanistic mathematical model** that describes in detail the hydraulic and biochemical behaviour of trickling filters. This model will help to **understand the operation** of the technology, as well as being a useful tool for the **design and optimisation** of both new and existing trickling filters. In this contribution:

- Simulation results** are compared with the **experimental data** obtained in the water resource recovery facility (WRRF) of Tudela, Navarra.
- Simplified models** of the trickling filters are developed to **reduce computational costs**.

Simple and robust operation



Low energy consumption



Biological and hydraulic mechanisms



Figure 2 – Trickling filter in Tudela's WRRF

METHODS

Complete model

- 8 virtual tanks.
- 4 levels of height.
- 2 differentiated paths:
 - Circulating path (C)**: fraction of water that is hardly treated.
 - Retained path (R)**: is retained and biodegraded in the biofilm.
- Mass conservation equation**, to reproduce the volume variation in each tank:

$$\frac{dV(t)}{dt} = Q_{in}(t) - Q_{out}(t)$$
- Outflows modelled with **weir equations**:

$$Q_{out}(t) = k \cdot V^\alpha$$
- Biochemical model based on the **IWA-ASM2d model**, combined with a **conventional 10-layer biofilm WEST model**.

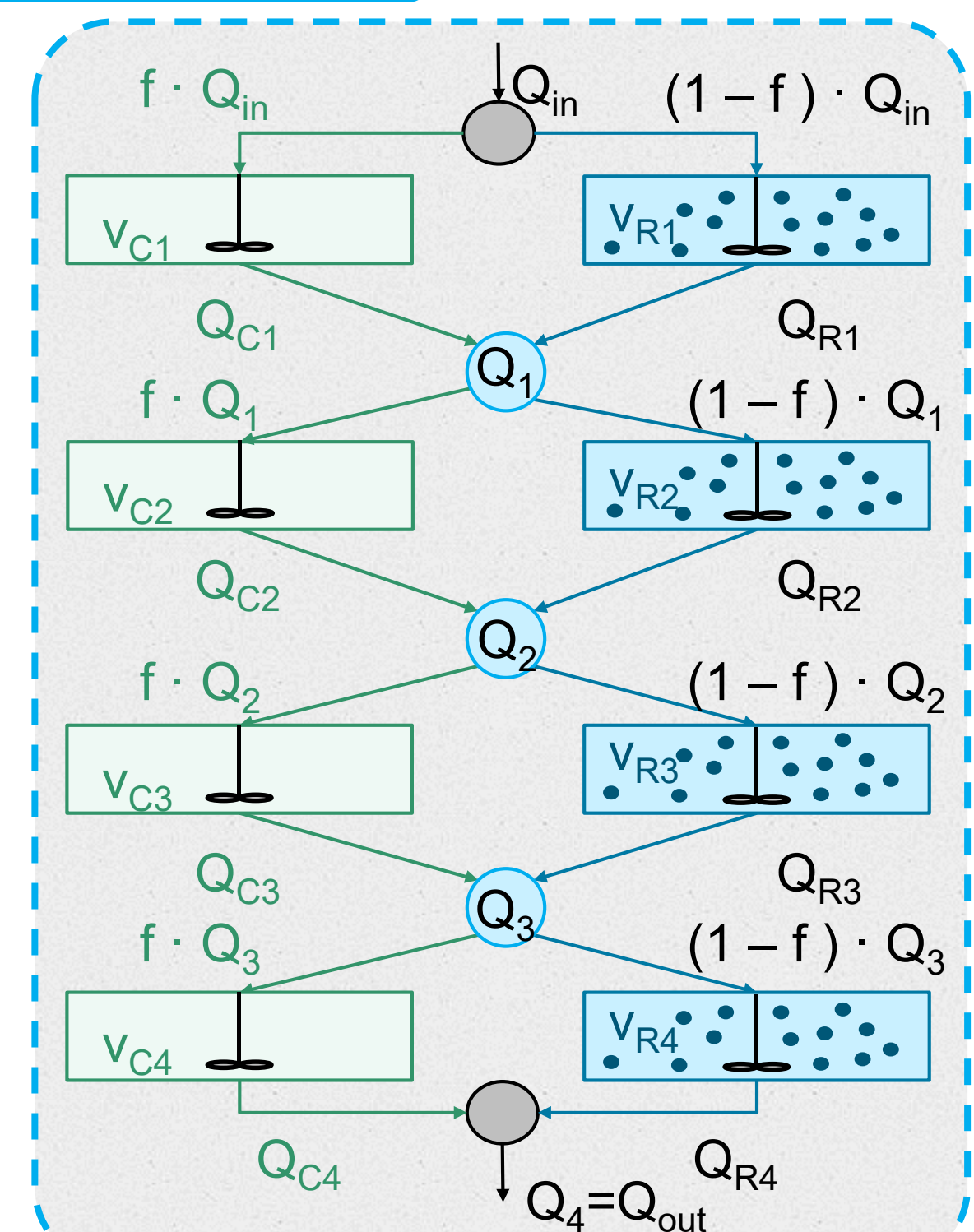


Figure 3 – Diagram of the paths and levels of the model. Circulating in green and retained in blue.

Simplifications

- By-pass** included to reproduce the **hydraulic short-circuits**.
- The **flow rate of the by-pass** is determined based on complete model calibration.

1. Biofilm reactor with a virtual settler and recirculating flow.

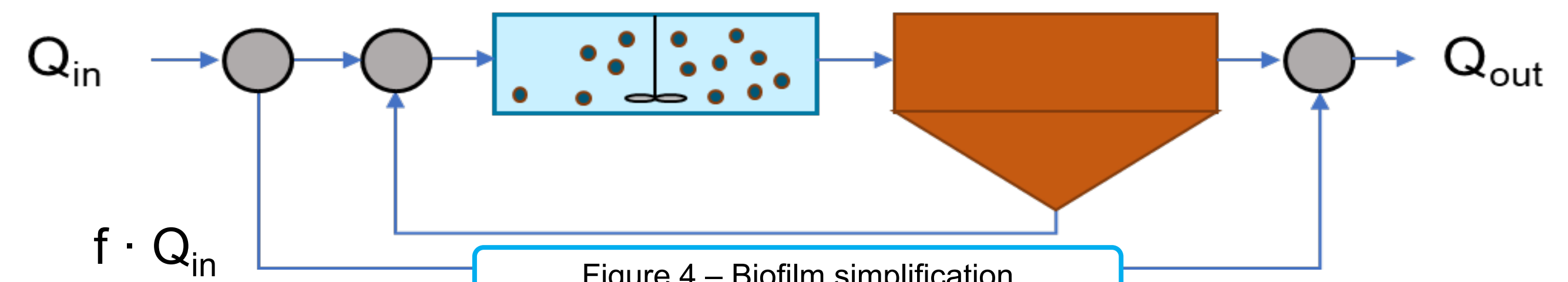


Figure 4 – Biofilm simplification

2. Activated sludge (AS) reactor with a virtual settler and recirculating flow.

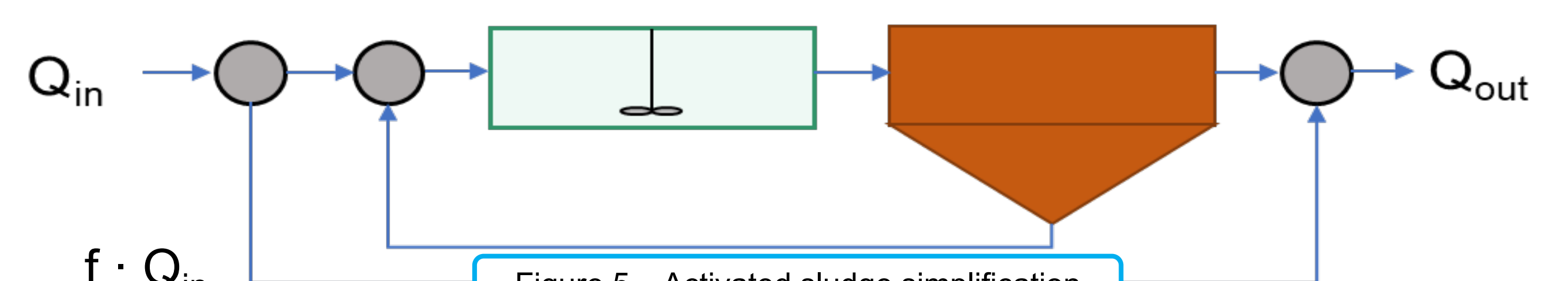


Figure 5 – Activated sludge simplification

RESULTS

- The complete model is able to reproduce the **dynamic behaviour** of the **Tudela WRRF** along a whole year. Effluent experimental data is compared with simulation results.

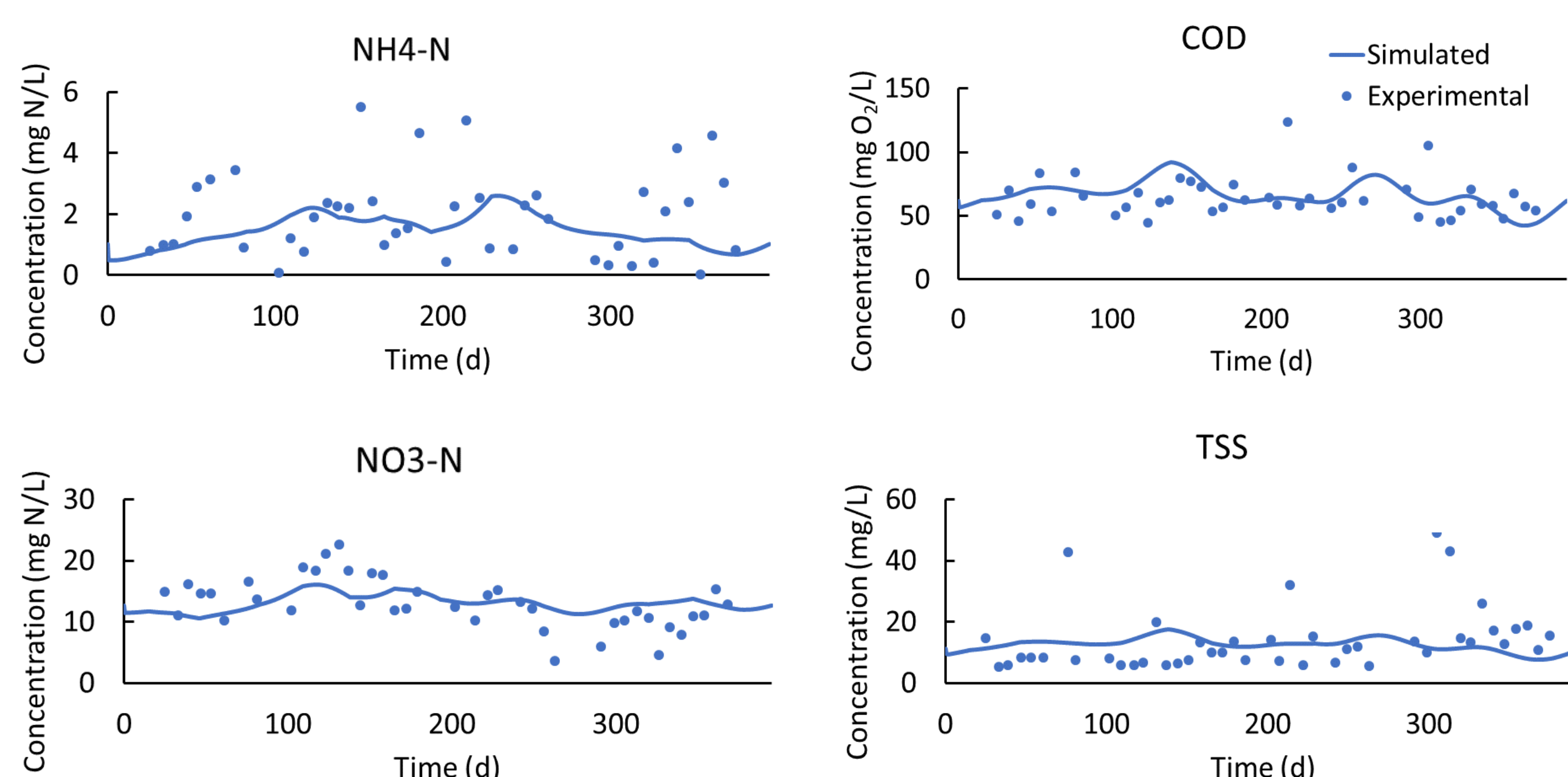


Figure 6 – Comparison between complete model results and experimental data.

- To verify that the **simplifications** are correct, the results of the steady-state simulations of the complete and simplified models are compared with the average effluent data. This is done at three different points of the WRRF: at the end of the primary settling (PS), secondary settling (SS) and final settling (FS).

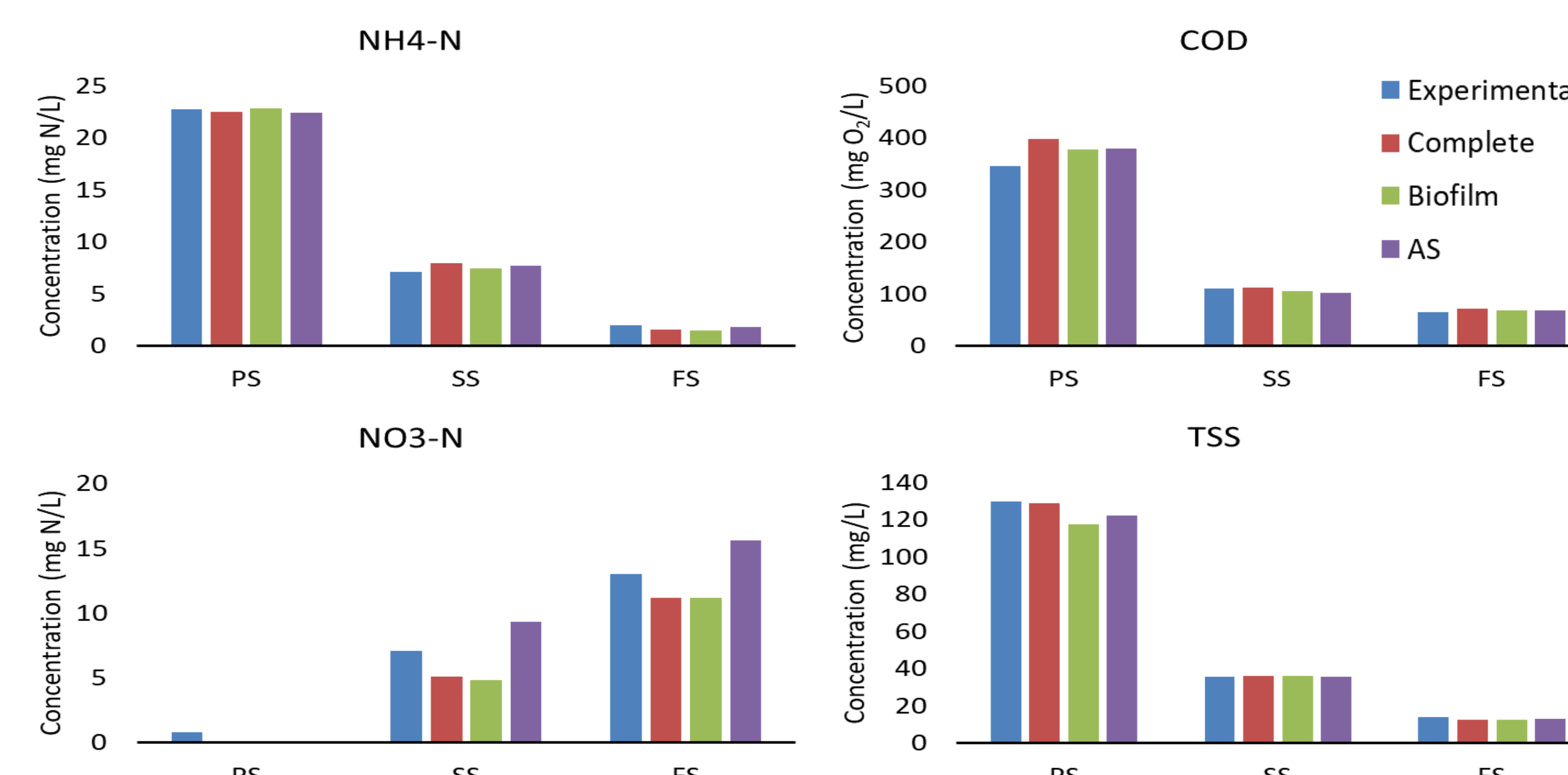


Figure 7 – Comparison between different model results and experimental data.

DISCUSSION

- The usual trickling filter models ignore the **presence of hydraulic short-circuits**.
- The circulating path proposed in the complete model describes the **existence of short-circuits** and makes it possible to reproduce in detail the performance of a real trickling filter.
- The use of 8 tanks allows to describe the **hydraulic behaviour in detail**. But at long simulation times that make it difficult to analyse the whole WRRF.
- Simplified models** meet the objective of analysing the entire plant with acceptable simulation times.

Table 1 – Simulation time comparison.

Simulation time (s)	
Complete model	284
Simplified biofilm model	4
Simplified AS model	1

CONCLUSIONS

- New model** capable of reproducing **hydraulic and biochemical** behaviour.
- Complete model** is calibrated.
- Good agreement** between the different **model results** and **experimental data**.
- Useful tool** for **optimisation of the design and operation** of NILSA trickling filters.

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