



SUBJECT PROPOSAL

2019 – 2020

Title: CFD Modelling of residence time distribution in surface flow treatment wetland: seasonality effects and compartmental approaches

Themes	Computational Fluid Dynamics, water sanitation
Level	Master 2 or equivalent
Supervisors	Loïc Maurer, Julien Laurent et Adrien Wanko
Skills	Scientific literature, Computational Fluid Dynamics
Duration	6 months Starting from January/February 2020
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Surface flow treatment wetlands (SFTW) are considered as ecological engineering treatment wetlands used for wastewater and stormwater treatment. SFTWs have water flowing above the surface of a permanently saturated soil in a horizontal direction, through macrophytic vegetation. In France, since 2009, there is an increase of SFTW commonly known as “Planted Discharge Areas” built between the wastewater treatment plant (WWTP) and the receiving aquatic environment. They are considered as a complementary treatment to WWTP but there is no regulatory removal efficiencies envisioned.

The main expected ecosystem services from SFTWs are: (i) particulate matter retention, (ii) limitation of hydraulic and pollutants loads to surface waters through infiltration, evapotranspiration or evaporation, (iii) hydraulic peak attenuation in order to protect surface water bodies from erosion and washout, (iv) complementary pollutant mitigation. Their efficiencies are highly dependent of the hydraulic residence time inside the system. However, there is no established design and sizing rule for this kind of treatment wetland due to the field constraints and the non-uniformity of process. Furthermore, these SFTWs are nature-based system, subject to high variability and complex interactions. Resulting surfaces and shapes may not be optimal and lead to strong non-idealities of the flow: preferential pathways, mixed zones, dead-zones as well as internal recirculation could occur and affect the wetland mitigation capacity.

The main goal of this proposal is to check and to validate the ability of computational fluid dynamics to simulate the residence time distribution through a surface flow treatment wetland. From scientific literature, it appears that 3D modelling based on CFD allows a comprehensive understanding of various hydraulic systems. Finally specific objectives of this work could be summarized as follows:

- i) Establish a robust protocol to simulate water flow and solute transport through SFTW using a CFD model;
- ii) Validate this approach by comparing the results of virtual tracer tests and experimental Residence Time Distribution (RTD) data from 4 tracer campaigns in field conditions at different seasons,
- iii) Study the sediments filling up impact on the hydraulic efficiency
- iv) Propose retrofitting strategies to increase the hydraulic efficiency (e.g. by using baffles) and simulate these configurations
- v) Derive a compartmental model from the CFD results in order to optimize the modelling process of (bio)kinetics occurring in the system;
- vi) Analyze the ability of CFD modelling to predict the fate of contaminants using simple kinetics by comparison with classical RTD and compartmental models

The key steps of this work should be:

- Scientific literature on CFD modelling in water sanitation framework using OpenFoam,
- Mesh implementation by taking into account the real geometry of the case study,
- Solving Navier-Stokes equations with adequate initial and boundaries conditions,
- Solving Passive Scalar Transport to mimic the SFTW RTD,
- Analyzing the effects of seasons and sediments deposit on SFTW hydraulic behaviors,
- Build a network a compartments based on the CFD results in order to adequately simulate the RTD with less computational effort.