PhD proposal

Treatment and valorisation of sidestreams in wastewater treatment plants: from measurement to modelling

Summary

With the aim to recover resources contained in wastewater, the issue of treatment and recovery of sidestreams in wastewater treatment plants is crucial. These fluxes, coming mainly from the dehydration of sludge after treatment, may contain significant amounts of nitrogen and phosphorus which should be managed at best to: (i) not adversely impact the quality of the treated water and (ii) limit the extra costs of treatment.
The objective of the PhD work is to make an inventory of the proposed technologies for the treatment and recovery of effluents from sludge lines, including anaerobic digestion. The first step is to establish protocols for the characterisation of these streams that provide the data required to enlighten the choice of treatment/recovery processes. These protocols will be implemented on two or three wastewater treatment plants currently under study, and the results integrated into models. Different scenarios will then be compared, using simulation, integrating the impact of the choices made on the overall performance of the installation and the associated costs (energy and reagents consumed).

Context and challenges

In the transition from wastewater treatment to the recovery of their resources, the optimization of wastewater treatment plants can no longer be done process by process, like in the past. Modelling tools are required to consider the facilities as a whole and to take into account the impact of design and operating choices across the whole plant. Facility schemes are indeed sometimes very complex and their operation nonlinear and dynamic.
In addition, the operators of medium and large-scale wastewater treatment plants are studying the feasibility of anaerobic digestion of their sludge, considering even collecting the sludge of facilities that are geographically close to each other. Such investigations are more and more frequent since the possibility of reinjecting biomethane produced in natural gas networks.

The implementation of anaerobic digesters on wastewater treatment plants produces three fluxes: the biogas, valorised in the form of energy, the digestate, generally valued through land application, and the centrate. The latter, resulting from the dehydration of digested sludge, is sent back to the input of wastewater treatment plants and is heavily loaded with nitrogen and phosphorus. In order to reduce the impact of this feedback on the operation of the installation, several treatment/recovery solutions, including physicochemical and/or biological processes, have been proposed in recent years. In spite of the relatively numerous articles on the subject, the characterization of the returns remains very little documented in the literature and available data are rather dispersed. However, the choice of alternative solutions than treating these concentrated fluxes in the main water line, as well as the impacts on the plant performances, should be closely linked to the characteristics of these returns and to their variability.

The objective of the proposed thesis is to make an inventory of proposed technologies for the treatment and recovery of effluents from the sludge line in wastewater treatment plants, including methanisation. To this aim, protocols will be first established to characterise the flows, then providing the data required to aid the choice of specific treatment/recovery trains. These protocols will be implemented on two or three facilities currently under study, and the results integrated into the models of the treatment plants. Different scenarios will then be compared, integrating the impact of the choices made on the overall performance of the installation and the associated costs (energy and consumed reagents).

Objectives – from wastewater treatment plants to water ressource recovery facilities

The proposed project aims ultimately at integrating into the biokinetic models of wastewater treatment plants the blocks necessary for their evolution towards water resource recovery facilities (from WWTP to WRRF). The first objective is to initiate this evolution of the models, concomitant with that of the processes, starting with the management (treatment and/or valorisation) of the liquid fluxes resulting from the dehydration of sludge after treatment (sent back to the input of the installation).
From a scientific point of view, the experimental work will bring new knowledge on the characteristics of the influents and effluents returned to the facility input, in particular on the chemical species still seldom characterised despite their importance for the prediction of the acid-base equilibria and the precipitation products (Al, Cl, Ca, Fe (II), Fe (III), K, Mg, Na, SO_4, ...). In addition, these data combined with the operating data

of the plants envisaged as case studies will make it possible to test the newly proposed models in the literature. The model representing WRRF as a whole will be used to evaluate and compare different nutrient treatment and recovery strategies.
From a technical point of view, the operational objectives related to this project are, on the one hand, to better characterize the return fluxes in order to propose adapted processes, and on the other hand to study the impact of design and/or operating choices on the overall performance of the facilities (essential for the rehabilitation of wastewater treatment plants, in particular).

Description of the PhD thesis

The thesis will take place in four stages:

1/ Based on a thorough literature review: identification of missing data to model and select the appropriate processes to minimize the impacts of sidestreams returned to the facility input.

2/ Experimental characterization of the sidestreams in order to model their treatment/valorisation, by integrating in particular the ionic forms of interest.

This step will require defining and carrying out specific measuring campaigns on two to three plants. This characterization will complete the data already collected on different sites for which a reconciliation of the operation and supervision data has been carried out and a model representing the functioning of the water and sludge lines (including energy consumption) is under development.

3 / Modification of existing models from the results of the first two steps.

A sensitivity analysis will evaluate the influence of model parameters on simulation results.

4 / Development of relevant performance indicators and numerical analysis of scenarios.

Organisation

Doctoral school = ED 206 from Lyon (Chemistry, Process Engineering, Environment)

Host team = Research Unit REVERSAAL of Irstea Lyon-Villeurbanne. This unit conducts research on the processes of recovery and treatment of urban effluents (wastewater, wet weather effluents, sewage sludge). A few weeks will also be spent each year in the Irstea center of Antony. Concerning modelling aspects, a scientific collaboration with CEIT is envisaged. This research center has developed cutting-edge modelling tools for full-scale water resource recovery facilities. A visit of a few months in this research unit will be scheduled, probably during the second year of the thesis.

Codirection of the thesis: Sylvie Gillot, PhD, Senior Scientist, Irstea Lyon-Villeurbanne, France

Codirection of the thesis: Paloma Grau or Eduardo Ayesa, CEIT, San Sebastian, Spain

Cosupervision of the thesis: Ahlem Filali, PhD, Irstea Antony, France

Start of the doctoral contract: October 2019

Gross salary: 1874,41 €/month

Candidate profile

Competence in process engineering completed by a Master or an internship in (waste)water treatment and/or organic waste management. Modelling knowledge would be appreciated.
In addition, the candidate will have to master scientific English and will have to take over, with the support of the technical team, the design, the realisation and the analysis of the results for the measuring campaigns envisaged within the framework of its work.

Contact

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