Sujet de thèse 2021 – ED chimie de Lyon

Etude du comportement de micro-particules plastiques modèles dans des dispositifs expérimentaux représentatifs d'hydrosystèmes urbains

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Study of the behavior of model plastic micro-particles in urban combined sewer overflows

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Problematic statement, and objectives

Combined sewer systems (CSS) are sanitation infrastructures that drain in the same pipes waste water and stormwater towards waste water treatment plant (WWTP) during wet periods. In order to avoid flooding problem at WWTP, Combined Sewer Overflow structures (CSOs) are implemented to divert exceeded volumes (named combined sewer overflows – CSO) without any treatment to receiving water bodies. CSO convey contaminants and strongly impact receiving water bodies (water courses, rivers, marine environment)[1]. Their ability to transfer microplastics (MPs), which production is particularly high in urbanized areas, represent a major concern as MPs concentrations in receiving water bodies are at least 40 times higher during wet periods, particularly due to CSO[2]. Interactions of MPs with organic and inorganic matters remain poorly understood, with probable effects on ecotoxicty. Hence, fundamental investigations are needed: (i) to collect data on MPs in CSO allowing to characterize their spatial and temporal variabilities; (ii) to better understand the mechanisms involved in their transport particularly through the sewer structures including pipes, CSOs (that divert directly MPs to urban streams) and open channel junctions (that lead to retention and dispersion of MPs) widely implemented in CSS.

These synthetic micro-particles are likely to be transferred by the water carrier from one compartment to another. On an urban scale, rainwater management systems drive transfer particles to natural ecosystems.

The objective of this research project is to study the behavior of plastic micro-particles in experimental devices representative of urban hydrosystems. A methodology combining the development and characterization of model plastic microparticles, experiments at different scales for the study of physical and chemical interactions, and modeling (analytical and numerical models) of transport will be implemented.

Methodology

The thesis is based on 3 main tasks:

- Task 1: identification and quantification of MPs in CSO to select. One of the key challenge is to design representative microparticles able to mimic MPs behavior in CSOs. For this purpose, preliminary campaigns will enable to analyze MPs in sediments and liquid samples collected on Fontaine-sur-Saône catchment (Rhône department) where CSO events occur frequently;
- Task 2: physical and chemical interactions of DMP with dissolved and particulate matter from urban effluents The motion of particles within urban waters depends on the interactions between micro-particles, water and the constituent elements of the urban effluent. The aim of this task is to determine the main physicochemical interaction mechanisms between MPs and dissolved and particulate organic or inorganic matters, and the consequences on their transfer properties (settling, advection, resuspension, etc.);
- Task 3: study of the transport of model plastic microparticles in devices representative of stormwater runoff and urban water flows (from production surfaces and water flow transfer to the compartments of the natural environment).

The thesis will be based on an experimental approach at different scales combining measurements:

- Full- scale: development of liquid and solid matrix sampling procedures, in order to quantify the masses and sizes of plastic microparticles;
- Lab-scale:
    - development of a procedure for preparing model plastic micro-particles; development of complementary analytical methods for the identification, characterization and quantification of plastic micro-particles in liquid matrices;
    - Interactions of synthetic micro-particles and organic and inorganic materials, depending on pH and ionic strength conditions: development of a batch operating protocol and testing, in order to identify and discuss the mechanisms involved: adsorption, agglomeration;
- Pilot-scale: study of particle transport with the use of a pilot Combined Sewer Overflow structure (DEEP).

Parteners (under negociation) :

- ANR
- Agence de l'Eau Rhône-Méditerranée-Corse.

DEEP Laboratory

DEEP - INSA-Lyon is one of the leading laboratories in France in environmental engineering, aiming to develop cross-disciplinary research on waste and urban waters management, contaminated soil and sediments remediation, involving scientific fields such as bio-physico-chemistry, urban hydrology, CFD modelling, transfer and process engineering.