Micropollutants removal efficiency of stormwater source control measures

Mesure de l'éfficacité des systèmes de gestion de eaux pluviales à la source en matière d'abattement de micropolluants.

Garnier R.[1], Castebrunet H.[1], Barraud S[1]

[1] Laboratoire DEEP, INSA Lyon, 7-11 rue de la Physique, F 69621 Villeurbanne (robin.garnier@insa-lyon.fr ; helene.castebrunet@insa-lyon.fr ; sylvie.barraud@insa-lyon.fr)

RÉSUMÉ

Nombre de collectivités territoriales promeuvent depuis plusieurs années l'implantation de systèmes de gestion des eaux pluviales alternatifs à la collecte par tuyau habituellement mise en place. Ces ''nouveaux'' systèmes ont pour but de diminuer les rejets d'eau et de polluants provenant de pluies afin de mieux protéger les milieux naturels. Si leurs capacités de rétention des flux d'eau et de certains micropolluants particulaires (métaux, HAPs) ont été bien documentées au fil des ans, leur action dépolluante face à de nouveaux micropolluants émergents (Pesticides, Alkylphénols, PBDEs, Bisphénols A) n'est aujourd'hui pas réellement avérée. Basant leurs études sur le suivi in situ de trois ouvrages de gestion des eaux pluviales à la source (une tranchée infiltrante, une noue d'infiltration et une chaussée à structure réservoir en béton infiltrant), les projets Micromégas et MicreauPluie cherchent justement à apporter de nouveaux éléments permettant d'assoir les performances de ces ouvrages vis-à-vis de la dépollution d'une large gamme de micropolluants aujourd'hui peu documentées. Les analyses des flux d'eaux, ainsi que des concentrations et masses en micropolluants à l'exutoire des systèmes, comparés à celles d'un parking imperméable traditionnel, montrent que l'action épuratoire bien avérée de ces ouvrages tient à la fois à leur filtration intrinsèque qu'à leur potentiel de rétention des flux d'eau.

ABSTRACT

Municipalities nowadays encourage the implementation and use of stormwater control measures infiltrating runoff water on site, instead of the classical pipe network, in order to reduce water and pollutants flows into receiving bodies and thus pollution. Many studies assessed the efficiency of SCMs regarding water retention and particulate pollutants removal (heavy metals, metalloids and PAHs) but not regarding new emergent micropollutants such as Alkylphenols, pesticides, flame retardant or Bisphenol A. The Micromegas and MicreauPluie projects tend here to demonstrate, through in situ monitoring and sampling, the efficiency of three source control systems (a swale, a trench and a porous pavement with reservoir structure) regarding pollution reduction over previous broad range of micropollutants. Comparison of water flows, pollutants concentrations and masses emissions at the outlet of these systems with a similar more classical asphalted parking, shows that the existing withdrawal of micropollution in releases rely on both filtration and waterflows reduction.

MOTS CLÉS

Micropollutants, purification efficiency, source control systems, stormwater control measures

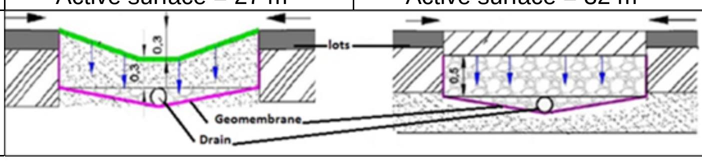
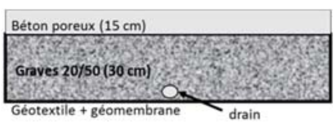
INTRODUCTION

Urban runoff contamination is nowadays a known fact and many studies document it regarding suspended solids and particulate pollutants such as metals, metalloids and PAHs. New recommendations and obligations regarding receiving bodies' pollution were implemented through the European Water Framework Directive (EWFD 2000) and led to a wide increase of studies which highlighted new micropollutants (MP) comtamination (flame retardant, alkylphenols, pesticides, phthalates, PCBs, Bisphenol A) (Gasperi et al. 2014) suspected to present health and environmental risks. Moreover, while French municipalities promote the implementation of stormwater control measures (SCM) such as trenches, swales, green roofs, porous roads… which efficiency regarding water flows and particulate pollution reductions had been assessed (Strecker et al. 2004) literature is still very poorly armed to evaluate SCM efficiency regarding the removal of a wider range of MP (Sebastian et al. 2015). The Micromegas (2015-2019) and MicreauPluie (2018-2019) projects try to participate to palliate this lack of knowledge by studying the performances of three source control systems (a swale, a trench and a porous pavement with reservoir structure) to remove a broad range of MP (metals and metalloids, PAHs, alkylphenols, pesticides, flame retardant and PBDEs, in particular and dissolved phases) from runoff water to their outlet. Their effluents will hereby be compared to a similar more classical asphalted parking in terms of water flows, concentration and masses.
The communication claim to present the first results of the treatment efficiency of the different source control systems and their comparison for a shorter list of MP : Cu,Pb,Zn, light PAHs, heavy PAHs, Bisphenol A (BPA), Glyphosate (Gly) and PBDE-209. Efficiency is discussed regarding water volumes removal, total concentrations in MP and masses per m² of active surface.

2 METHODOLOGY

The study rely on in situ monitoring and sampling of three source control systems draining runoff water from parking lots in Villeurbanne (69, France) (See Tab 1). Two of them are similarly built with catchments of 300 m² and 260 m² where runoff water is respectively catch by an infiltration vegetated swale and an infiltration trench. The last site is a porous pavement with reservoir structure (PPRS) draining 90m² of parking lots. For the experimental needs (monitoring and sampling), these three systems are impervious at the bottom and drained in order to catch all the infiltrated waters. Runoff water from a nearby 90 m² impervious asphalted parking are also collected and serve as a reference in order to compare water flows and pollutants loads with the source control systems.
Each site is monitored and sampled with its own metrology installation at the oulet of the systems (flow measurement, conductivity, temperature, sampling) (Garnier et al. 2017 for more details) and the samples are acquired flow proportionally for an event mean concentration analysis.

Tableau 1. Source control storm water measures specification of Micromegas project

Location	EcoCampus Lyon Tech de la Doua (Villeurbanne - 69)		
	Vegetated Swale	Gravel Trench	Porous pavement with reservoir structure
System			
Catchment Surface	302 m² Active surface = 27 m²	260 m² Active surface = 32 m²	94 m² Active surface = 94 m²
Structure side view			

3 RESULTS

3.1 Quantities

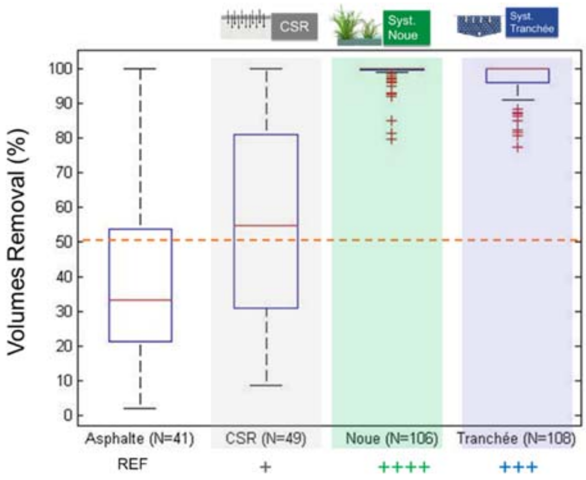


Figure 1: Volume removal tendencies of the three source control systems (compared to the reference) for 140 rain events between Apr 2016 - Sep 2018 є [1mm – 52mm]

Based on volume data at the outlet of the systems, it appeared that the PPRS tends to release water with a huge delay (see Table 2) and diminish maximum flows very efficiently (not showed in this paper) but is not that performant to decrease water volumes from rain events (see Fig. 1) when compared to a classical asphalted impervious parking. On the other hand, the swale and the trench seem to be very efficient to restrain water (only rain event above 8mm induce an answer at the outlet of this systems). Still, on the very few event with an outflow, these two sites do not delay it as well as the PPRS. This flow analysis confirm what previous studies demonstrated and show us that a huge part of the pollution removal potential of these systems comes from their ability to restrain and/or delay water flows.

Tableau 2: Lagtimes and "no outlet flows" proportion of the three source control systems (compared to the reference) for 140 rain events between Apr 2016 - Sep 2018 Є [1mm – 52mm]

	Asphalted parking		*PPRS*		*Swale*		*Trench*	
	Med	**Mean**	**Med**	**Mean**	**Med**	**Mean**	**Med**	**Mean**
Lagtime (hh:mm)	0:21	0:46	5:10	7:10	2:08	3:36	0:51	1:31
Number of events	41		49		106		108	
% events Vout = 0m³	0%		2%		64%		52%	

3.2 Quality

The following graphs show the ranges of total concentrations and masses per active m² at the outlet of the three source control systems and the asphalted reference. The first thing that can be seen is the wide range of concentrations from one event to another and thus the impossibility to define a standard pollution concentration for the systems outflows. However, some tendencies are visible. It can be noticed for example that the PPRS tend to greatly reduce micropollutants that are mainly in particulate phase (Cu, Pb, Zn, PAHs) which can be explain by its important efficiency to withdraw TSS (MeanRemoval = 97% compared to the reference). The greater efficiency of the swale regarding all the MP, be it in concentration or loads, can partly be explain by the effects of its substrate better at filtration and its physico-chemicals reactions with the MP (adsorption).

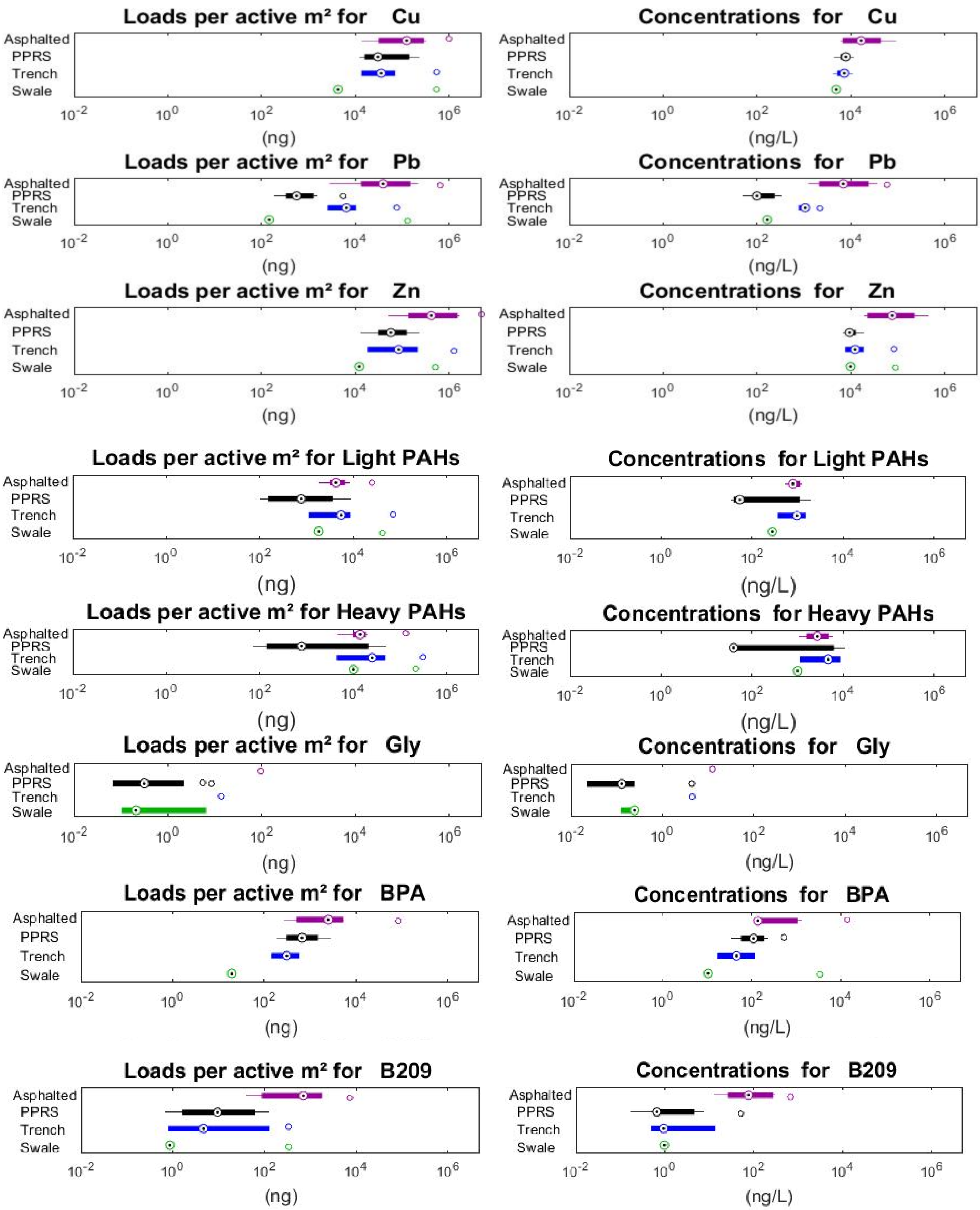


Figure 2 : Distribution of loads (left) and concentrations (right) for several micropollutants at the outlet of the source control system compared to the asphalted reference

CONCLUSION

These first results showed that runoff waters from parking lots handled by the source control systems porous pavement and reservoir structure, swale and trench are less contaminated when compared to runoff water from an asphalted impervious parking. If it has been confirmed that they tend to be efficient because of water volume removal, it is now possible to assess that their intrinsic cleaning behavior make also a great contribution to their performances, even more so for the swale which top all other sites efficiency in concentration and loads releases. More results are on hold to be exhibited regarding more micropollutants in order to strengthen these conclusions.

BIBLIOGRAPHIE

Gasperi J., Sébastian C., Ruban V., Delamain M., Percot S., Wiest L., Mirande C., Caupos E., Demare D., Diallo Kessoo M., Saad M., Schwartz J.-J., Dubois P., Fratta C., Wolff H., Moilleron R., Chebbo G., Cren C., Millet M., Barraud S., Gromaire M.-C. (2014) Micropollutants in urban stormwater: occurrence, concentrations and atmospheric contribution for a wide range of contaminants on three French catchments. Environmental Science and Pollution Research. 21(8), 5267-5281.

Garnier R., Barraud S., Castebrunet H., Cherqui F., Winiarski T., Vacherie S. (2017). Micropollutant removal efficiency: hydraulic monitoring and sampling strategy for source control stormwater control measures. *14th international Conference on urban drainage,* Prague, 10-15 September 2017. 4 p.

Sebastian C., Lipeme Kouyi G., Becouze-Lareure C., Barraud S. (2015). Event-based quantification of emerging pollutant removal for an open stormwater retention basin - loads, efficiency and importance of uncertainties, *Water Research*. 72(1), 239-250.

Strecker E, Quigley M, Urbonas B, et al (2004) Urban stormwater BMP performance: recent findings from the international stormwater BMP database project. Novatech 2004, Lyon465-472.