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## Efficacité des parkings perméables végétalisées pour la gestion de l'eau et des micropolluants

### Efficiency of green permeable parking lot for the management of urban runoff micropollutants

Lucie Varnède<sup>1</sup>, David Ramier<sup>2</sup>, Pierre Georgel<sup>1</sup>, Marie-Christine Gromaire<sup>3</sup>

<sup>1</sup>ECOVEGETAL, les grandes pièces, Broué (lvarnede@ecovegetal.com, pgeorgel@ecovegetal.com)

<sup>2</sup>Cerema, équipe de recherche TEAM, Trappes (david.ramier@cerema.fr)

<sup>3</sup>LEESU (MA102), Ecole des Ponts ParisTech, UPEC, Marne la Vallée (marie-christine.gromaire@enpc.fr)

#### RÉSUMÉ

L'imperméabilisation des surfaces urbaines augmente les volumes de ruissellement et favorise l'accumulation de polluants dans ces eaux. La gestion de ce ruissellement par des ouvrages perméables végétalisés tels que les parkings végétalisés peut permettre d'abattre les volumes ainsi que les concentrations et masses de polluants. Le suivi pendant une année d'un parking perméable végétalisé (PP) et d'un parking de référence avec un revêtement en bitume (PRef) a ainsi montré que le PP était capable de retenir 90% de la pluie annuelle. Si les résultats sont variables selon les événements, la part de la pluie qui s'écoule du PP n'a jamais excédé 32%. Les débits spécifiques sont aussi considérablement réduits, 80% des volumes rejetés par le PP ne dépassent jamais le débit spécifique de 2l/s/ha (contre 20% pour PRef). Parmi les polluants analysés (MES, COD, COP, nutriments, 12 métaux, HAP, alkylphénols, bisphénol A, phtalates), les concentrations sont généralement inférieures en sortie du PP mais les résultats sont aussi variables suivants les polluants et les événements. En revanche, du fait de sa capacité à réduire fortement les volumes d'eau, les masses de polluants sont largement plus faibles pour le PP que pour le PRef. Les parkings perméables végétalisés sont donc des solutions intéressantes pour la gestion des eaux de ruissellement urbaines.

#### ABSTRACT

The sealing of urban surfaces increases runoff volumes and contributes to the accumulation of pollutants in this water. The management of runoff by green permeable surfaces such as green parking lots can reduce the volumes, concentrations and masses of pollutants. One year's monitoring of a green permeable parking lot (PP) and a reference parking lot with a bituminous surface (PRef) showed that the PP was able to retain 90% of the annual rainfall. Although the results vary according to the events, the proportion of rainfall transformed in discharge never exceeds 32%. The specific flow rates are also considerably reduced, with 80% of the volumes discharged by PP never exceeding the specific flow rate of 2l/s/ha (compared to 20% for PRef). Among the pollutants analyzed (SS, DOC, POC, nutrients, 12 metals, PAHs, alkylphenols, bisphenol A, phthalates), the concentrations are generally lower for PP, but the results vary according to the pollutants and the events. However, due to its capacity to strongly reduce water volumes, the masses of pollutants are much lower for PP than for PRef. Green permeable parking lots are thus interesting solutions for the management of urban runoff water.

#### MOTS CLÉS

Experiments, green parking lot, micropollutant, urban runoff, permeable pavement

## 1 CONTEXT AND OBJECTIVES

In urban areas, sealed surfaces increase runoff during rain events leading to both hydraulic disorders and increased pollutants discharges with impacts on aquatic ecosystems. Runoff from trafficked areas is known for its metal and hydrocarbons contamination, yet recent studies underlined that numerous other organic and mineral micropollutants are also present (Gasperi et al, 2022). If, it was observed that green permeable pavement can reduce the volume of runoff by 93% compared to an asphalt parking lot (Dreelin et al., 2006), previous studies have focused on densely trafficked highways and few information are still available specially for green parking lots. Objectives of this work are to study if green permeable parking lots can be efficient for manage volume and quality of rainwater in a low traffic context.

## 2 MATERIALS AND METHODS

A green permeable parking lot (PP) constructed in 2015 in a residential area in Villeneuve-le-Roi (20km south of Paris, close to the international airport Paris-Orly) and mainly used by local residents, was studied. Its 630m<sup>2</sup> is composed of ECOVEGETAL® Mousses parking places and a driveway in concrete pavers with vegetated joints (Figure 1, left). The ECOVEGETAL® Mousses structure consists from the top to the bottom of: a 5cm thick plastic grid filled with a mineral substrate (0/15 mm) and planted with extensive low-growing vegetation (sedums, thymes, white clovers, fescues); a 4cm substrate (0/15mm crashed ceramics, compost, pozzolan), a geotextile, a draining sub-base layer of 20cm (20/40 crushed stone); a sub-base layer of 30cm (40/60 crushed stone) and a geotextile to prevent the fines of the underlying soil from rising up in the structure. Underlying natural soil was compacted at construction and showed very low permeability ( $10^{-7}$ - $10^{-8}$ m/s). A 100mm diameter underdrain drains the whole parking lot. Water drainage volumes were monitoring with a 2x5L tipping bucket. A conventional bituminous parking lot of 730m<sup>2</sup> (reference parking lot, PRef) situated nearby was also monitored for comparison (Figure 1, right). Runoff from the bituminous surface was measured, inside the sewer, with a triangular weir.

For both parking lots, event mean water sample were collected for chemical analysis with sampler controlled by flow rates, in 20L, plastic and glass (depending on the pollutant), containers.



Figure 1: Photography of the studied parking lots. Left: green permeable parking lot (PP). Right: reference parking lot (PRef)

Efficiency of the parking lots was assessed by hydrological and pollutants indicators according to the guideline recommended by Flanagan et al., (2019). Considered hydrological indicators are discharge coefficient ( $C_e$ ) and volume reduction ( $V_r$ ) which are calculated at different time-steps (event, season or annual) as well as the comparison of flow rate distribution curves between rainfall, PRef and PP. The studied pollutants include global parameters (SS, DOC, POC), nutrients, 12 metals and three families of organic micropollutants (PAH, alkylphenols and bisphenol A, phtalates).

Data was recorded from 2018, August 11<sup>th</sup> till 2019, August 6<sup>th</sup>. Cumulated rainfall over this period was 482 mm. Due to missing data, 82 events were recorded for PRef and only 52 for PP. 51 common rainfall events were recorded simultaneously on both parking which represents 336 mm of rainfall. For 11 of these 51 events, water samples were collected for pollutant analyses.

### 3 RESULTS

#### 3.1 Hydrological performances

At the annual scale, 90% of rainfall is retained by PP ( $C_e$  of 0.1) while 80% of the rainfall is converted into runoff for PRef ( $C_e=0.8$ ). Monthly trends show that the discharge coefficient increases during the winter for PRef but remains inferior to 0.2 for PP. At the rain event scale, data presents higher variability. Figure 1 shows boxplots of discharge coefficients and volume reductions (expressed as a water depth) at the rain event scale.  $C_e$  mean values are respectively 0.64 for PRef and 0.05 for PP, with a maximum  $C_e$  of only 0.32 for PP whereas PRef exhibits 14 events without volume reduction (i.e  $C_e=1$ ). In terms of runoff volume reduction, mean water depth reductions are three times higher for PP (6 mm) than for PRef (2mm). For PRef, 90% of the events have volume reductions inferior to 4.6 mm. This value reaches 14.8 mm for PP.

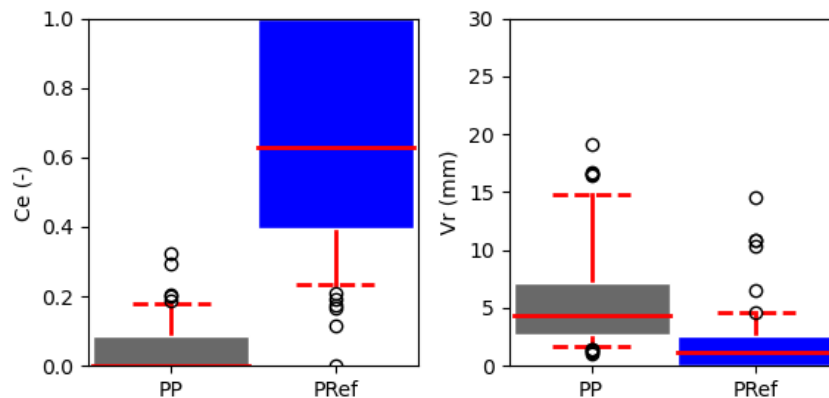


Figure 1: Boxplot for discharge coefficient ( $C_r$ ) and volume reduction ( $V_r$ ) for PP and PRef at rainfall events scale (boxes represent 50% of data between quantiles 25 and 75; solid red lines = median; horizontal dotted red lines = quantiles 10 and 90; circles = outliers)

In addition to a larger reduction in discharge volumes, green permeable parking lot presents best performances in flow rate attenuation. As shown in Figure 2, 80% of the cumulated PP discharge is associated to flow rates of less than 2 l/s/ha and the maximum flow rate never reaches 10 l/s/ha. By comparison, for PRef, 60% of the runoff volume is associated with a flow rate between 2 and 10 l/s/ha and 20% with a flow rate greater than 10 l/s/ha. PRef did not smooth out the intensity of the rain.

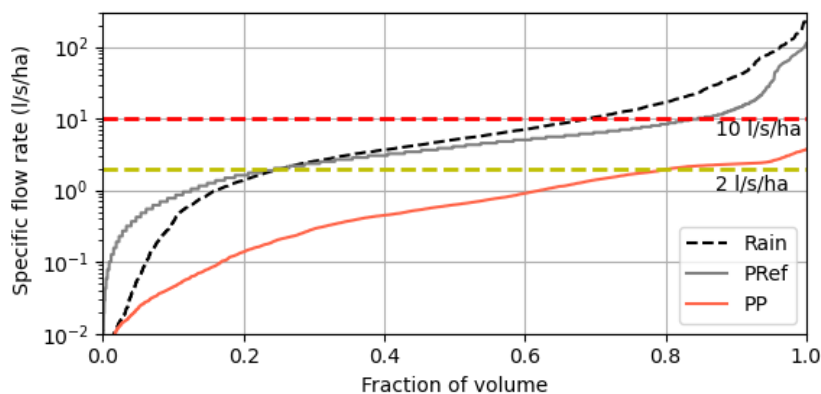


Figure 2: Curve of flow rates classified by volume

#### 3.2 Pollutant performances

The ability of a green permeable parking lot to reduce pollutant concentrations and loads is estimated by comparisons with the bituminous parking. For Zn, phenantrene (Phen), dimethylphtalate (DMP) and DEHP event mean concentrations are always lower for PP than for PRef. On the contrary As, Cr, Mo, Sr, V, bisphenol A (BPA) and nonylphenoxy acetic acid (NP1EC) present concentrations generally

higher for PP than for PRef. For other pollutants, it's variable according to the event. However, when results are looked in mass, it can be observed that due to the strong volume reduction of PP, the mass of pollutants leaving PP are mainly lower than those of PRef. As an illustration, Figure 3 shows event median concentrations (EMC) and event median masses for 8 emblematic pollutants of runoff water contamination. Two of them, Cr and nonylphenol (NP) have higher event median concentrations for PP than PRef. These contaminants are probably emitted by the components of the parking. For example, the origin of the emission of NP could be the drain made in PVC (Lamprea et al., 2017). But same results expressed in terms of masses show that all the masses are lower for PP than for PRef.

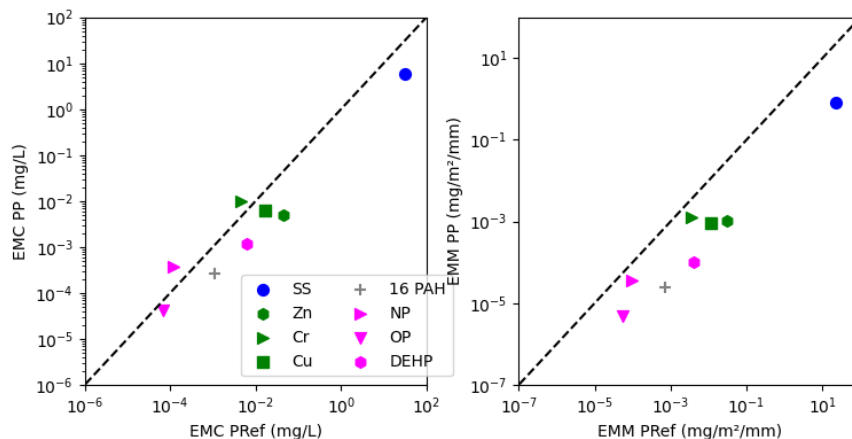


Figure 3: Event median concentrations (EMC) and event median masses (EMM) for 8 selected pollutants

## 4 CONCLUSION

One year of water volume and quality monitoring were performed for two parking lots. The classical parking lot with a bituminous surface (PRef) presents high discharge coefficients and no attenuation of the flow rate. On the contrary, important volume retention and low discharge coefficient are obtained with the green permeable parking lot (PP). Flow rates are also significantly reduced. While pollutant concentrations are lower in PP discharge than in PRef runoff for most contaminants, it was also observed that some metals and organic pollutants may leach from the PP structure leading to concentration increases. However, the ability of PP to reduce concentrations is further enhanced by the reduction in volumes, leading to very significant pollutants loads reductions for most contaminants, compared to a bituminous surface. To conclude green permeable parking lot can be considered as an efficient solution for sustainable stormwater management.

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