Biofilters to improve road runoff quality: interactions between water, soil and the biosphere

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BIOFILTERS TO IMPROVE ROAD RUNOFF QUALITY: INTERACTIONS BETWEEN WATER, SOIL AND THE BIOSPHERE

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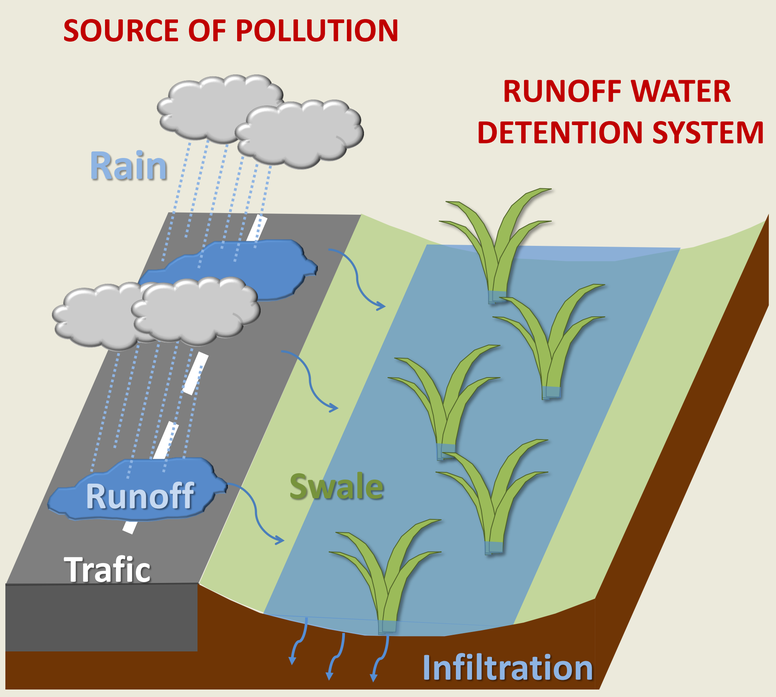
INTRODUCTION

Biofilters have been widely implemented in the past few years due to combined ecological and economic advantages, such as improved road runoff quality, impervious surface reduction and low cost. In order to integrate swales into roadway infrastructures taking into account water regulations, an assessment of the treatment performance of these systems is required. Moreover, poor is known about the role of microorganisms and plants on pollutants remediation in such infiltration systems.

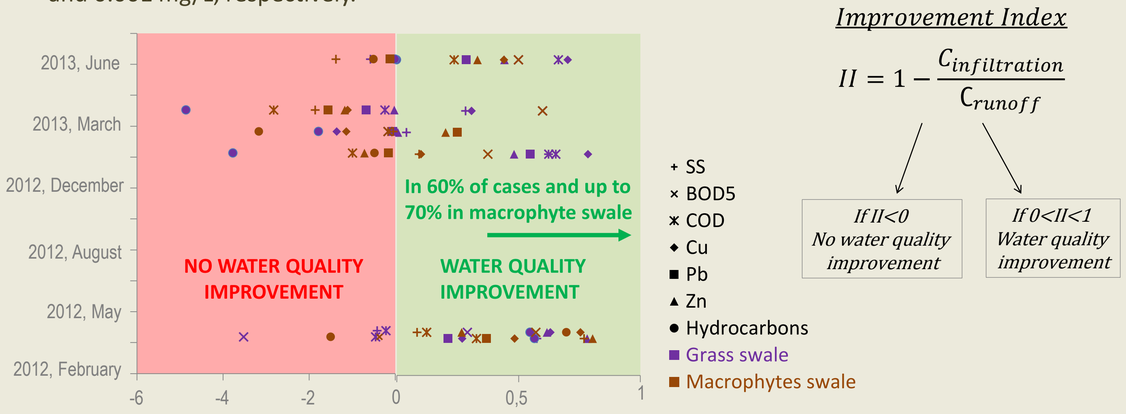


Thereby, we studied during one year trace elements (TEs), total hydrocarbons (HCs) and polycyclic aromatic hydrocarbons (PAHs) in water, soil and plants in two experimental road side swales, one covered with grass, the other one being planted with macrophytes. We also faced the challenge to build four representative large-scale outdoor mesocosms, spiked with Cd, Pb, Zn, phenanthrene, pyrene and benzo[a]pyrene, to better understand the biofilters functioning.

RESULTS

WATER QUALITY IMPROVEMENT BY INFILTRATION

Biochemical and Chemical Oxygen Demand (BOD_5 and COD), Suspended Solids (SS), trace elements, and total hydrocarbons were analysed according to ISO standards in water runoff and infiltrated water. No analysis was above the bad ecological status defined in the European framework on water except for BOD_5. Mercury, arsenic and cadmium were under detection limits, *i.e.* 0.0005 mg/L, 0.013 mg/L, and 0.001 mg/L, respectively.



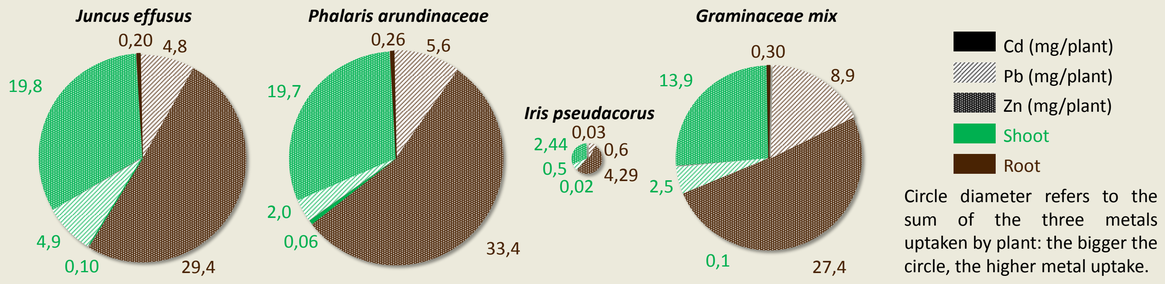
$$Improvement\ Index \qquad II = 1 - \frac{C_{infiltration}}{C_{runoff}}$$

If II<0: No water quality improvement

If 0<II<1: Water quality improvement

PHYTOREMEDIATION

Microwave-acid digestion was used to extract metals from plants grown 6 months in mesocosms. Metal extraction solution were then analysed by ICP-AES. The results show similar quantities of metal extracted by *Juncus effusus*, *Phalaris arundinaceae* and *Graminaceae*. However, *Juncus* translocate more metal than the other and this is an advantage as shoot parts are cut once a year and exported to a waste treatment plant.



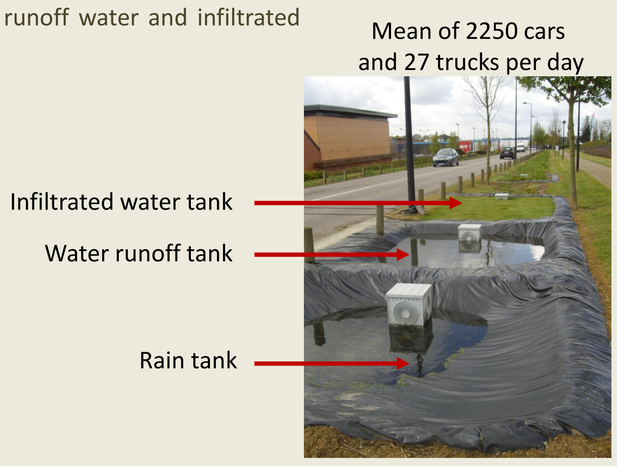
Circle diameter refers to the sum of the three metals uptaken by plant: the bigger the circle, the higher metal uptake.

METHODOLOGY

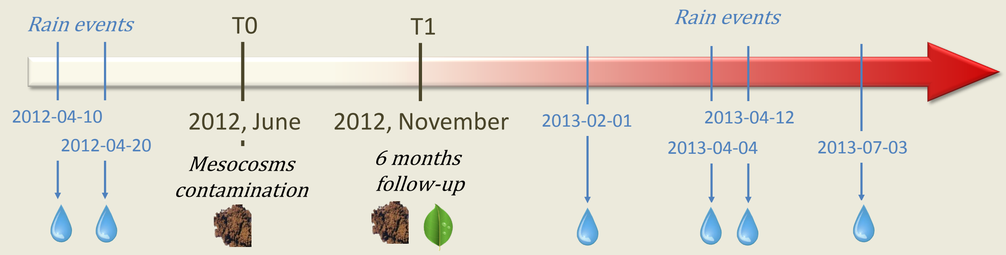
EXPERIMENTAL SWALE

An experimental swale was built to collect runoff water and infiltrated water. Six rain events were studied.

Low level of pollutants in highway runoff and roadside soils does not allow to go through bio- and phytoremediation processes. Thus, a contaminated mesocosm was built.



MONITORING OVER TIME

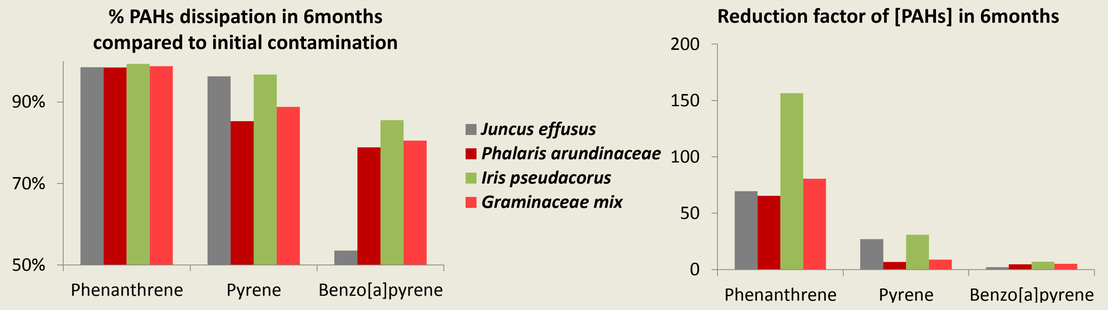


MESOCOSMS

The experiment was set up in Rouen, France (49°25'N ; 1°4'E). Four polypropylene tanks (0.56m3 : 1.55m x 0.9m x 0.4m) were divided in two parts, a contaminated part and the control, to built 8 outdoor mesocosms and covered by geomembrane to ensure water and roots impermeability. Young plants of soft rush (*Juncus effusus*), reed canary grass (*Phalaris arundinaceae*), yellow flag (*Iris pseudacorus*) were planted as monospecies. The two last mesocosms were vegetated using graminaceae mix (50% *Festuca* sp. and 50% Lolium perenne) seeds at the same time. Mesocosms were spiked with phenanthrene, pyrene, benzo[a]pyrene (1:1:1) to reach 10mg/kg DW and with heavy metals (HM) at concentrations of 2, 100, 300 mg/kg DW for Cd, Pb, Zn, respectively.

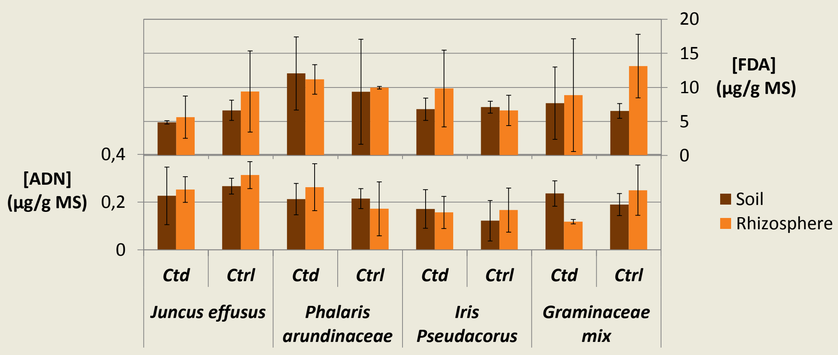
PAHs REMEDIATION

PAHs were extracted from soils by microwave assisted extractions and analyzed by gas chromatography. After 6 months, 99% of phenanthrene were dissipated whatever plant species tested, 85 to 96% of pyrene with best remediation with *J. effusus* and *I. pseudacorus* but *J. effusus* was the worst plant to remediate ben[a]pyrene (54%) against around 80% for the three others species. *I. pseudacorus* revealed to be the best for PAHs remediation.



MICROBIOLOGICAL ASSESSMENT

To better understand PAHs remediation, total biomass and global microbial activity were investigated. ADN was extracted from soil using fastDNA Spin Kit for soil and quantified by PCR. Microbial activity was approached by Fluorescein DiAcetate (FDA) enzymatic activity. Bioindicators chosen did not allow to display a significative difference between test procedures. Thus, 6 months after, the contamination didn't have an impact on total biomass and global activity. This suggests to drive our research onto specific indicators. (16S rDNA, 18S rDNA, xylanase and laccase enzymatic activities).



CONCLUSION & PERSPECTIVES

Mon0specific swale doesn't seemed to be the best strategy to improve road runoff quality. Indeed, plant species showing the higher potential regarding remediation differs from one pollutant to an other. First of all, swale planted wih macrophytes clearly favour water quality improvement better than grass. On the second hand, *Iris pseudacorus* was not of major interest concerning TEs remediation. However it seemed to be the best for PAHs remediation. Thus, we suggest that a mix of plants would be the best practice to improve water quality and favour soil remediation. Taking into account root density, a specific microbiology study on soil and rhizospheric soil could facilitate to decide between plants species about PAHs remediation.

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