



**HAL**  
open science

## Source-control infiltration practices: How to avoid creating "polluted sponges"?

Damien Tedoldi, Kelsey Flanagan, Ghassan Chebbo, Daniel Pierlot, Yves Kovacs, Marie-Christine Gromaire

### ► To cite this version:

Damien Tedoldi, Kelsey Flanagan, Ghassan Chebbo, Daniel Pierlot, Yves Kovacs, et al.. Source-control infiltration practices: How to avoid creating "polluted sponges"?. International Sponge City Conference, Sep 2018, Xi'An, China. hal-02190454

**HAL Id: hal-02190454**

**<https://enpc.hal.science/hal-02190454v1>**

Submitted on 22 Jul 2019

**HAL** is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Damien Tedoldi<sup>1,2</sup>, Kelsey Flanagan<sup>1</sup>, Ghassan Chebbo<sup>1,3</sup>, Daniel Pierlot<sup>2</sup>, Yves Kovacs<sup>2</sup>, and Marie-Christine Gromaire<sup>1</sup>

<sup>1</sup>LEESU, École des Ponts, University of Paris-Est, France  
<sup>2</sup>SEPIA Conseils, Paris, France  
<sup>3</sup>Faculty of Engineering III, Lebanese University, Lebanon

Email: damien.tedoldi@enpc.fr

## Source-control infiltration practices: How to avoid creating “polluted sponges”?

### Context & objectives

Generalization of “source-control” stormwater management (Fletcher *et al.*, 2015).

Dissemination of decentralized, infiltration-based techniques in urban areas (Zhou, 2014).

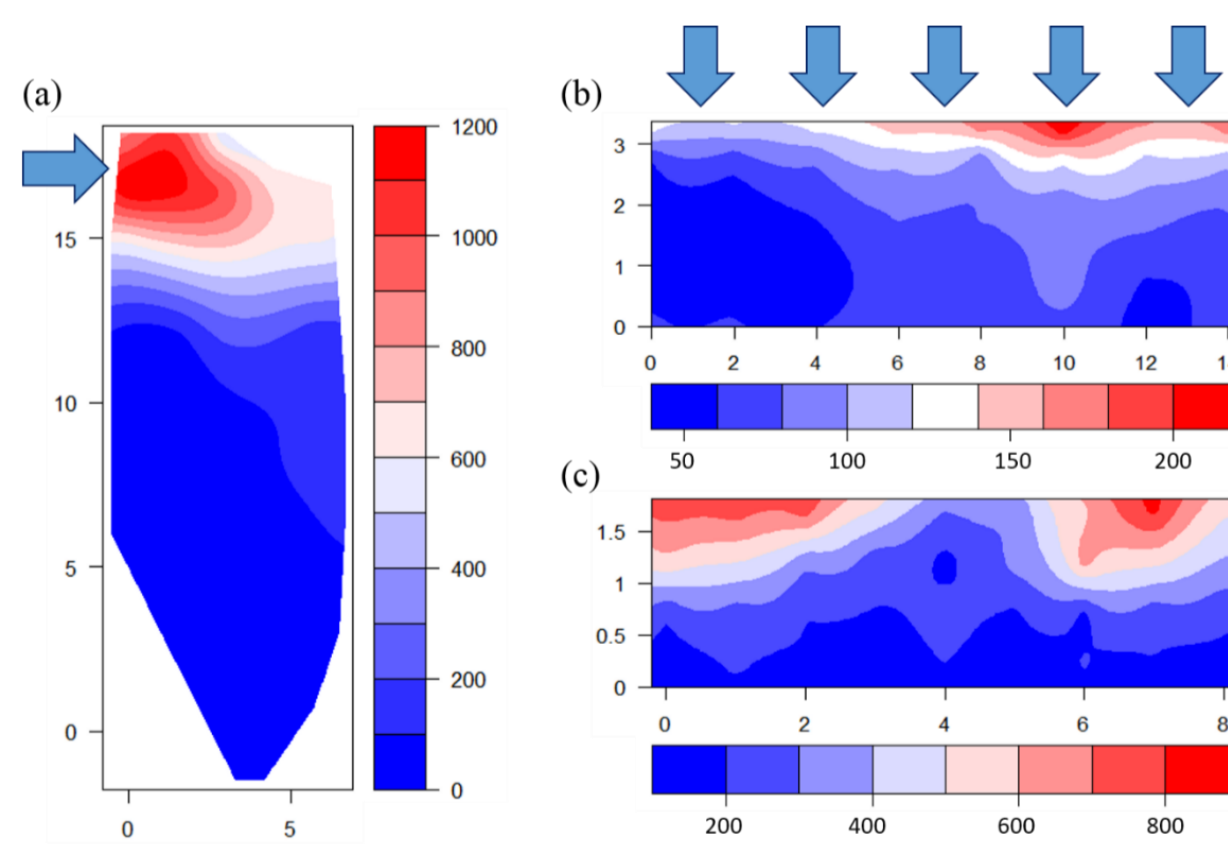
- Accumulation of contaminants in soil?
- Required maintenance to enhance long-term pollution control?

Comprehensive assessment of soil pollution by trace metals and polycyclic aromatic hydrocarbons in 11 devices of the Paris region.

### Main results

#### Horizontal distribution of contaminants

- Significant buildup in the inflow area, followed by a marked decrease in contents with increasing distance.
- Precise, “time-integrated” signature of two distinct phenomena:
  - settling of particle-bound contaminants,
  - non-uniform infiltration fluxes at the soil surface (for common rainfall events).
- At the annual scale, the greatest part of the pollutant flux is intercepted by the *first* permeable surface reached by runoff.



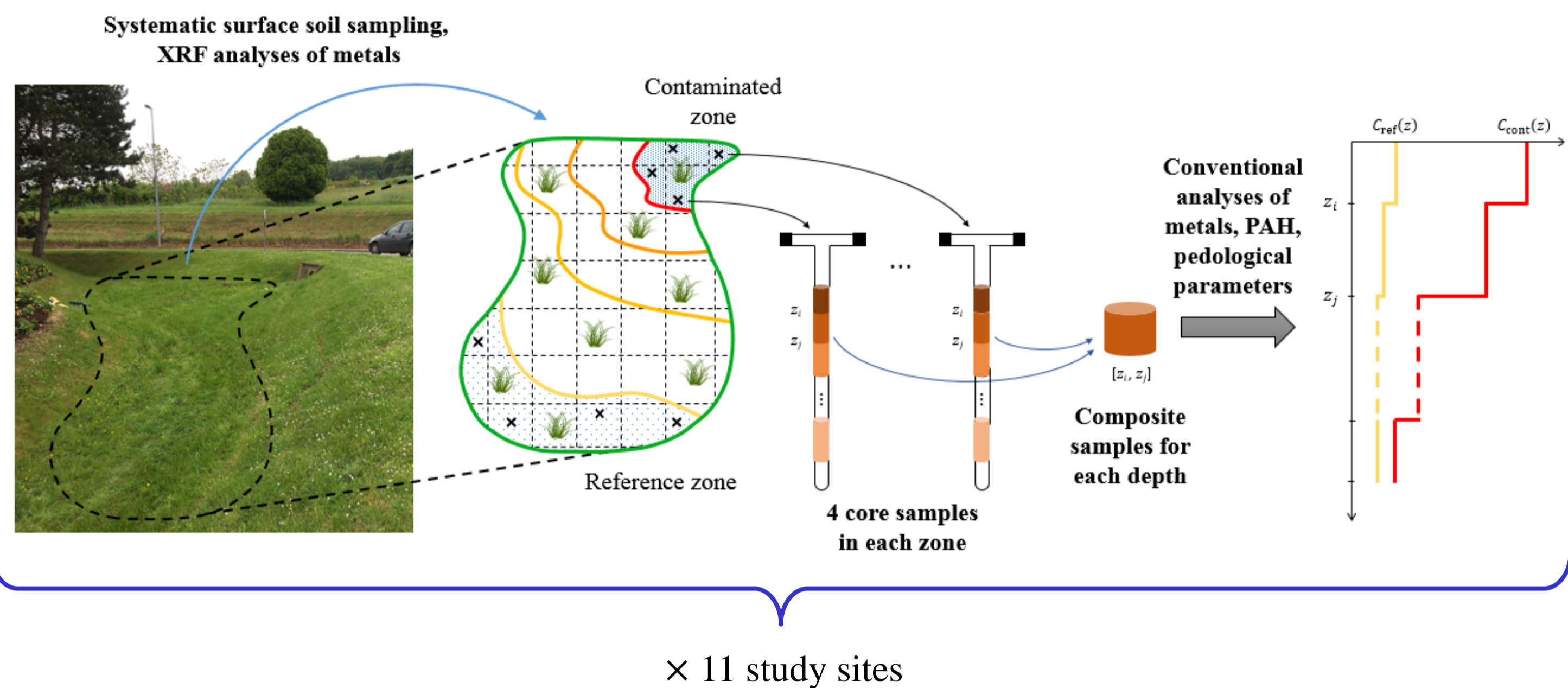
**Fig. 2** – Spatial distribution of zinc [mg/kg] in the surface soil of (a) an infiltration basin and (b-c) two grassed swales (top view). The coordinates are given in meters. The arrows indicate the water inflow (Tedoldi *et al.*, 2017b).

#### Vertical distribution of contaminants

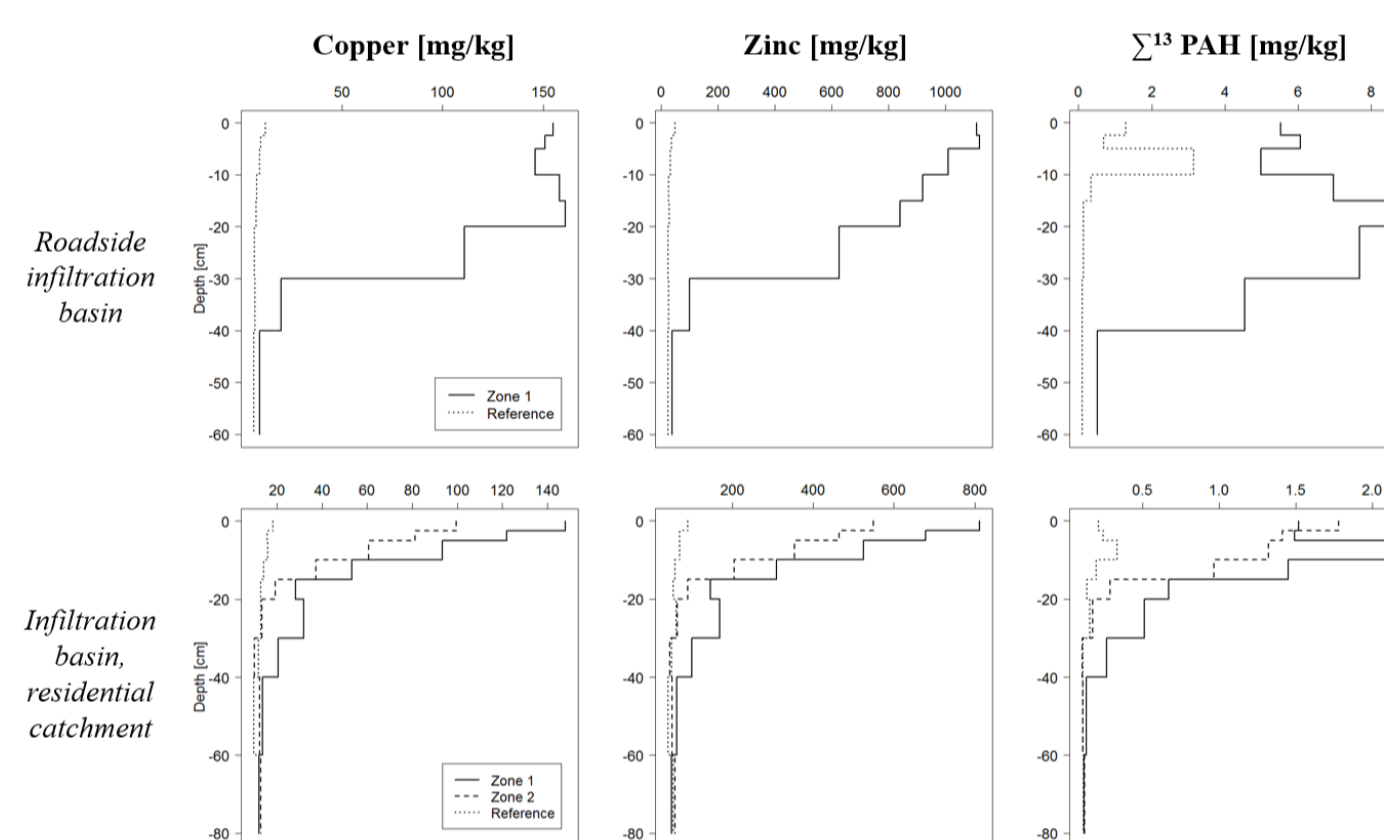
- Almost uniform profiles in the reference zone  $\Rightarrow$  marginally influenced by runoff infiltration.
- Metal and PAH accumulation is limited to the upper 5 to 40 cm of soil, even in the most contaminated part of the facilities.
- Retention results from 2 distinct mechanisms:
  - physical processes (settling and filtration),
  - physicochemical processes (sorption and precipitation of solute species).
- Dissipation mechanisms (*e.g.* biodegradation) are likely to affect PAH contents at the surface.

### Experimental methods

**Fig. 1** – Schematic representation of the two-step methodology for soil sampling and analysis (adapted from Tedoldi *et al.*, 2017a).



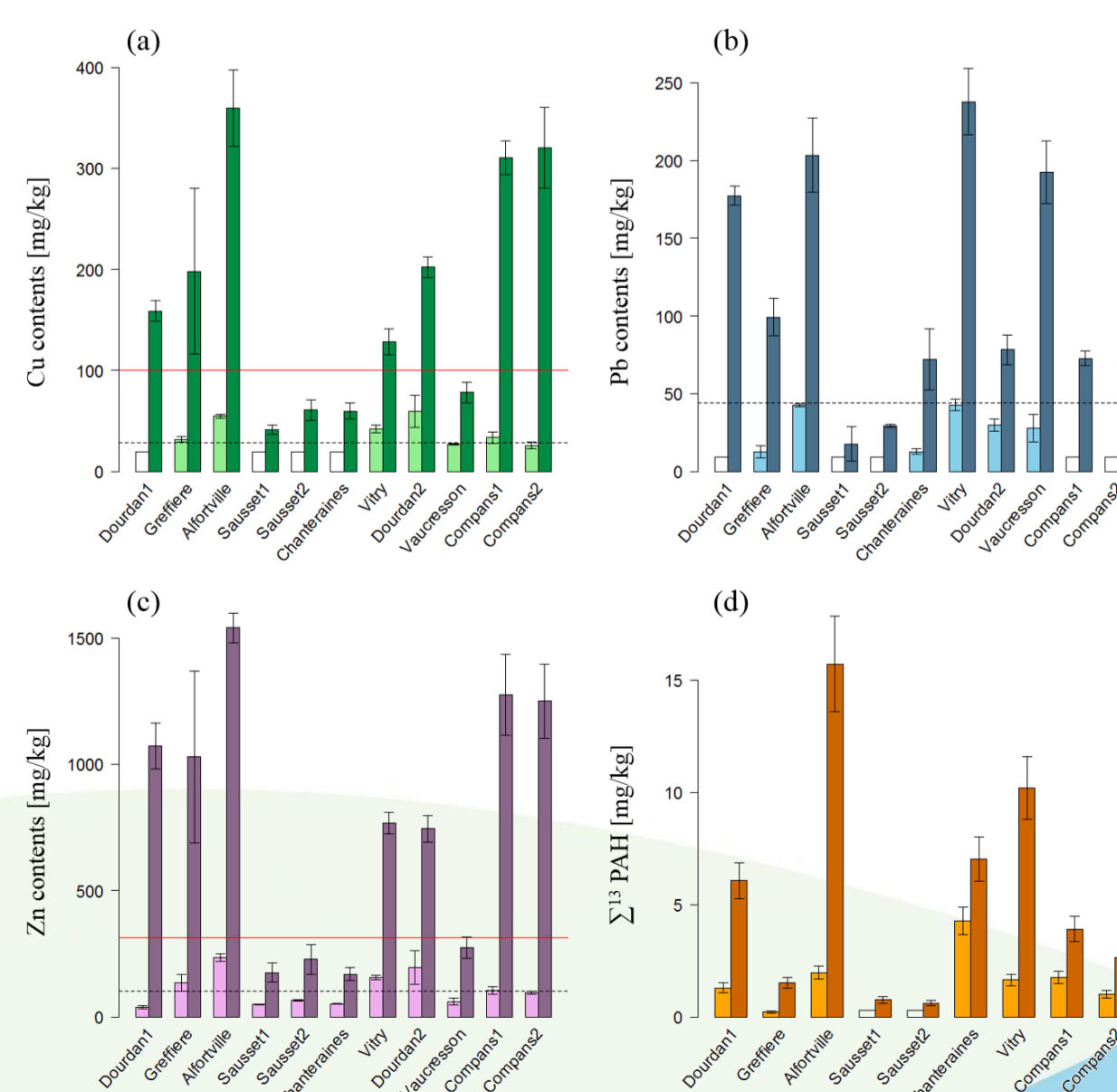
× 11 study sites  
Diversity of morphologies, soil types, urban environments...



**Fig. 3** – Vertical distribution of copper, zinc, and PAH [mg/kg] in two study sites. “Zone 1” and “Reference” respectively correspond to the most and the least contaminated areas of the devices (Tedoldi *et al.*, 2017a).

#### Contamination levels

- Inter-site variability  $\Rightarrow$  both a catchment-related and a soil-related component.
- “Intervention thresholds” for copper and zinc (1<sup>st</sup> quartile of international soil clean-up standards for residential land uses, red lines on Fig. 4) are locally exceeded in 7 sites.
- The volume of polluted soil material which should undergo either excavation or remediation was estimated (Tab. 1).



**Fig. 4** – Contents of (a) copper, (b) lead, (c) zinc, and (d) PAH [mg/kg], measured at the surface of the most and the least contaminated areas in each device.

#### Maintenance needs

**Tab. 1** – Estimated volume of polluted soil ( $V_{soil}$ ) with unacceptable metal contents for residential land uses; normalized value per unit surface of drainage area ( $V_{soil}/S_{drainage}$ ).

	$V_{soil}$	$V_{soil}/S_{drainage}$
Basins	9.4 m <sup>3</sup>	13 m <sup>3</sup> /ha
	4.0 m <sup>3</sup>	13 m <sup>3</sup> /ha
	27.5 m <sup>3</sup>	14 m <sup>3</sup> /ha
Swales	0.3 m <sup>3</sup>	9 m <sup>3</sup> /ha
	> 0.6 m <sup>3</sup>	> 5 m <sup>3</sup> /ha
Filter strips	0.6 m <sup>3</sup>	25 m <sup>3</sup> /ha
	0.3 m <sup>3</sup>	14 m <sup>3</sup> /ha

### CONCLUSIONS

- The two-step experimental methodology provided a tri-dimensional vision of the extent of soil pollution, with a suitable representativeness.
- **The soil may act as an efficient filter towards runoff-derived metals and PAH**, but this may in turn result in high contents in the upper horizon.
- However, understanding the typical distribution of contaminants may reduce the cost and efforts of **maintenance operations** to be undertaken.
- In 7 sites out of 11, an average of **~15 m<sup>3</sup> of polluted soil material per hectare** of urban area had to be managed after ~10 years of operation.

### REFERENCES

- Fletcher, T. D., Shuster, W., Hunt, W. F., Ashley, R., Butler, D., Arthur, S., Trowsdale, S., Barraud, S., Semadeni-Davies, A., Bertrand-Krajewski, J.-L., Mikkelsen, P. S., Rivard, G., Uhl, M., Dagenais, D., Viklander, M., 2015. SUDS, LID, BMPs, WSUD and more – The evolution and application of terminology surrounding urban drainage. *Urban Water Journal*, 12(7), 525-542.
- Tedoldi, D., Chebbo, G., Pierlot, D., Kovacs, Y., Gromaire, M.-C., 2017a. Assessment of metal and PAH profiles in SUDS soil based on an improved experimental procedure. *Journal of Environmental Management*, 202, 151-166.
- Tedoldi, D., Chebbo, G., Pierlot, D., Branchu, P., Kovacs, Y., Gromaire, M.-C., 2017b. Spatial distribution of heavy metals in the surface soil of source-control stormwater infiltration devices - Inter-site comparison. *Science of the Total Environment*, 579, 881-892.
- Zhou, Q., 2014. A Review of Sustainable Urban Drainage Systems considering the climate change and urbanization impacts. *Water*, 6(4), 976-992.