Evapotranspiration in urban stormwater planter boxes: A study of eight lysimeters under temperate climate

Ahmeda Assann Ouédraogo[1], Emmanuel Berthier[1], Brigitte Durand[2], and Marie-Christine Gromaire[3]

[1]*Centre d'études et d'expertise sur les risques, l'environnement, la mobilité et l'aménagement (Cerema), Equipe TEAM, 12 rue Teisserenc de Bort, Trappes F-78190, France*

[2]*Division Etudes et Ingénierie, Direction de la Propreté et de l'Eau, Service Technique de l'Eau et de l'Assainissement (DPE-STEA), 27 rue du Commandeur, F 75014 Paris, France*

[3]*Leesu, Ecole des Ponts, Univ Paris Est Creteil, Marne-la-Vallee, France*

Cerema

leesu
laboratoire eau environnement systèmes urbains

OPUR
Un observatoire d'hydrologie urbaine en Île-de-France

École des Ponts
ParisTech

CONTEXT

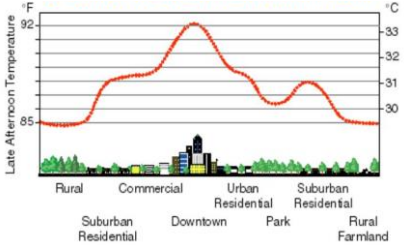
Accurate estimation of evapotranspiration (ET) flux is an important issue in sustainable urban drainage systems (SUDS)

ET involved in mechanisms

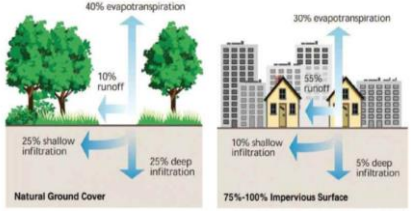
- ❑ ***Runoff volume reduction***
- ❑ ***Urban heat-island reduction***
- ❑ ***Restoration of natural water balances***

- Especially true in context where infiltration possibilities are limited
- ET assessment in SUDS suffers from insufficient understanding

Sketch of an urban heat-island profile



Imbalance in water balances due to urbanization



(Bechet et al. 2017)

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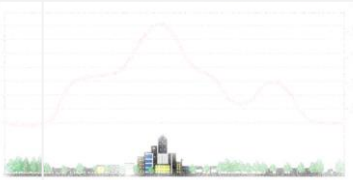


Imbalance in water balances due to urbanization

Stormwater planter box

- capture runoff and filter out sediment and pollutants
- "rain gardens in a box"

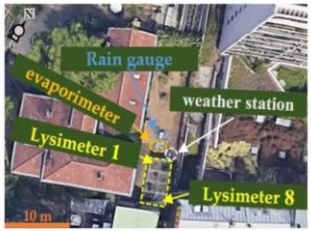
Photo: Christine Johnson, © Oregon State University

Stormwater planter at City Hall in Arlington, Oregon.

Two main objectives:

- Estimate the actual ET in urban stormwater planter boxes at daily steps
- Assess the impact of different configurations on ET fluxes

Study area, Experimental Set Up and water balance

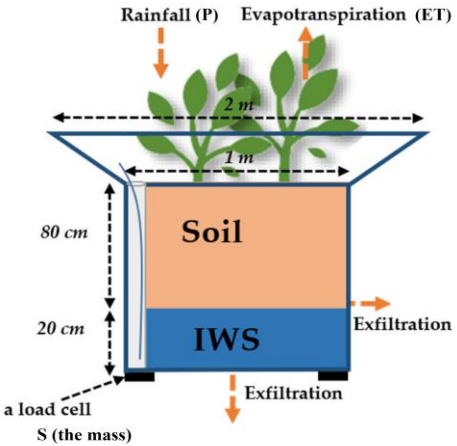


(a)

(b)

A top and panoramic views of the site in figures (a) (Source: google earth) and (b), respectively.

- **Site**: Paris, FRANCE (Museum National d'Histoire Naturelle)
- **Data**: 2 minute interval for a period of about 3 years (24/11/2016 – 26/12/2019).
- **Measurement on each lysimeter:** exfiltration (mm), water level (mm) in the Internal water storage (IWS) and lysimeter's mass (kg)
- **Meteorological data :** temperature (◦c) , air humidity (%), rain (mm), water level in the evaporimeter (mm), incoming solar radiation (w/m^2), wind speed (m/s) and atmospheric pressure (hPa).



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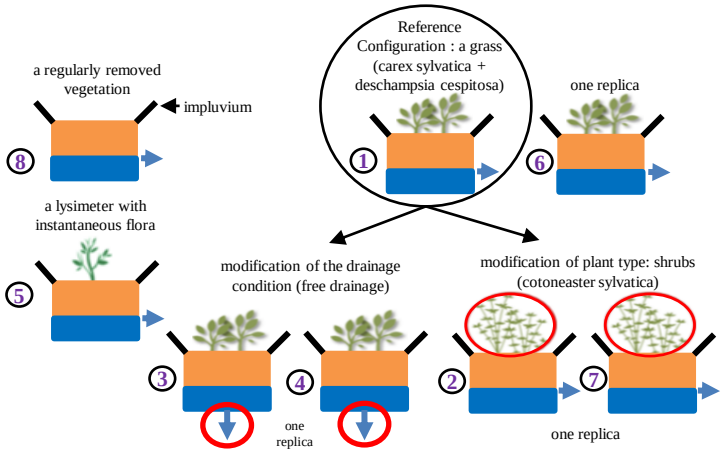
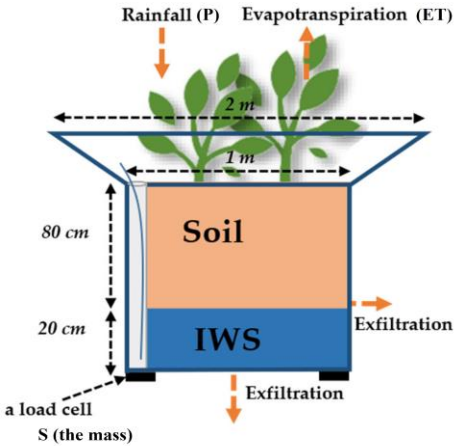
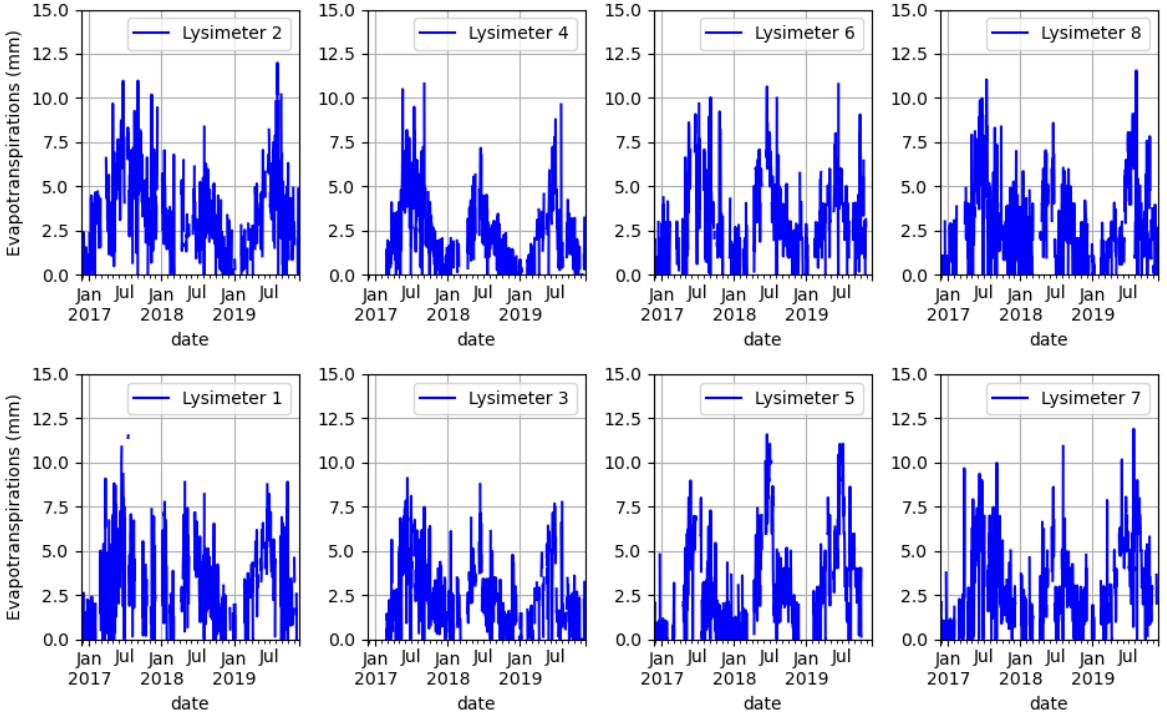


The different configurations compared to the reference. All the settings have the same soil which is silty clay that represents most of the soil in Paris region.



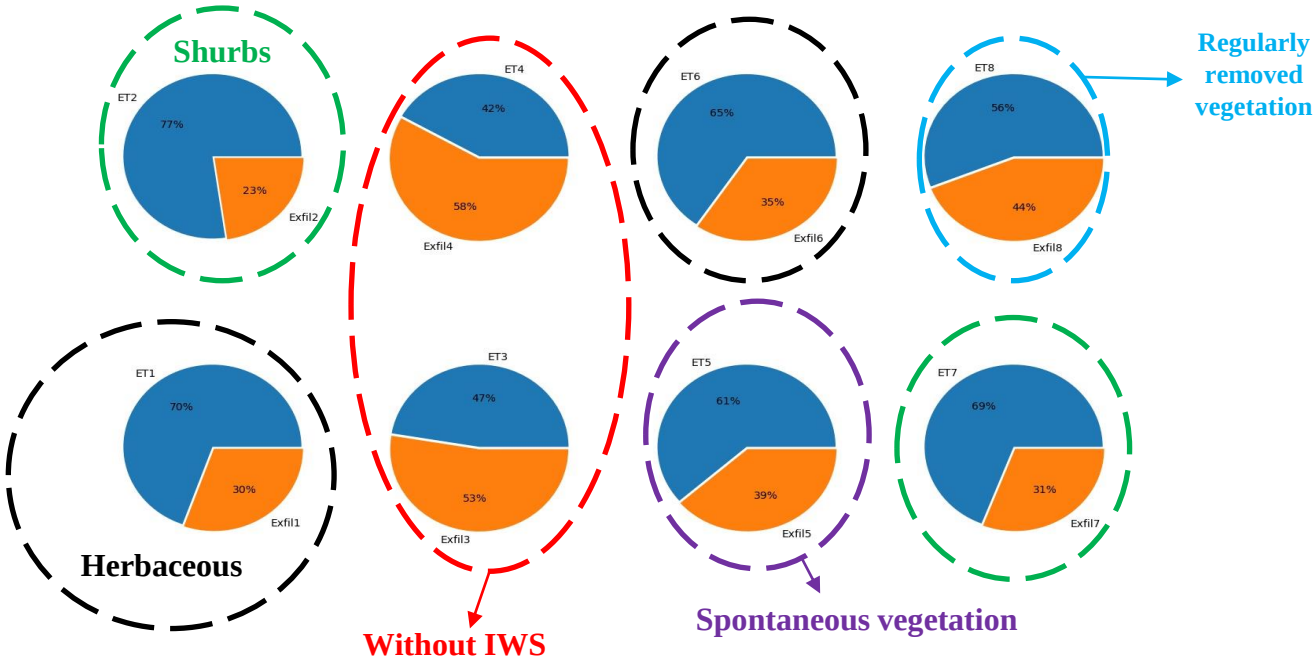
$$ET = 4*P - Exf - \Delta S$$

Daily evapotranspiration (ET) validated for lysimeters



- ET flux is significant (≥ 8 to 12 mm/d) in summer period and very low values in winter (≤2 mm/d)
- Associated daily ET uncertainties between ±0.42 to ±0.58 mm

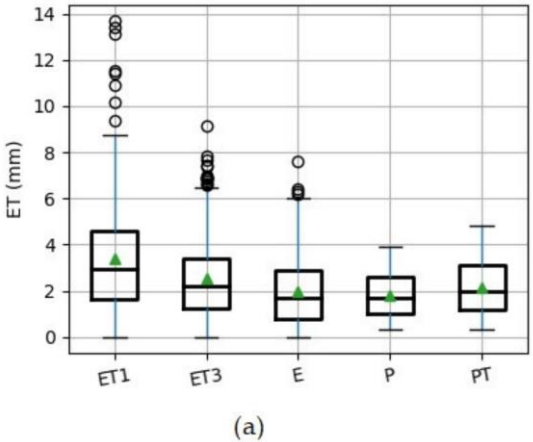
Proportions of ETs (blue) and $Exfil$ (orange) to inputs ($P - \Delta S$) over the 305 common validated days, for the 8 lysimeters. Cumulated rain (4P) is 679 ± 6 mm.



- The Internal Water Storage (IWS) at the base is the most favourable determinant
- The type of the vegetation, here, is a secondary determinant, and less marked
- The positioning of the lysimeters between them: close to (Lysimeter 7) or far from buildings (Lysimeter 2)

A comparison of actuals ETs with reference values (the near evaporimeter (E), the Penman (P) and Priestley–Taylor (PT) potential ETs)

Common validated data = 346 days



(a)

- The ET values for Lysimeter 1 are higher than the reference values (E, P, PT) (in Figure a);

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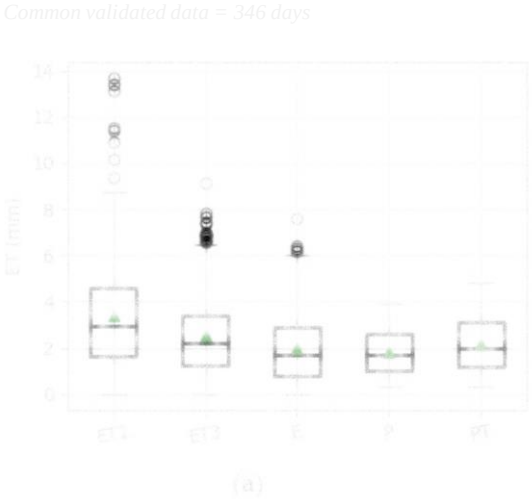

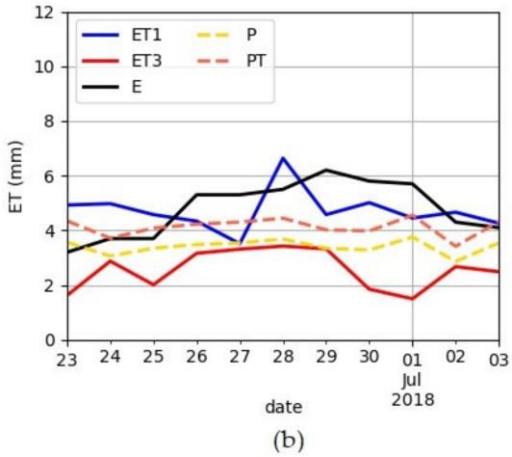

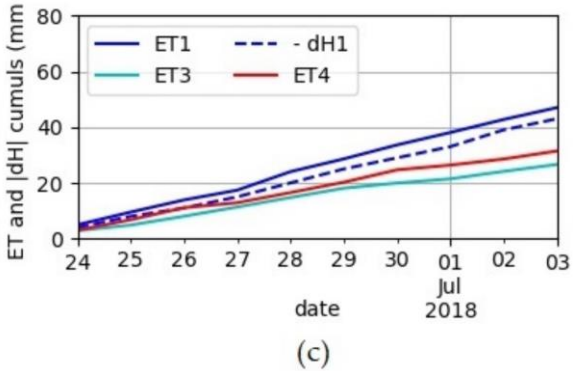

- The ET values for Lysimeter 1 are higher than the reference values (E, P, PT) (in Figure a);

- During a dry period (without rain and exfiltration), the water in the internal storage (dH1) allows lysimeter1 to have a maximum ET rate (Figures b and c).

Conclusion

- The ET process should be **included** in the design of SUDS in order to optimise their hydrological functions of stormwater management and their ability to cool the urban area in hot periods

- Experimental set-up used in this work was **pertinen**t: Assessment of the multi-annual daily ET with admissible uncertainties (±0.42 to ±0.58 mm)

- **Future studies** : Greater monitoring systems, Shading effects and Vegetation properties (stomatal resistance, LAI, roots expansion, etc.)

- *For more details :* *Ouédraogo, A.A.; Berthier, E.; Durand, B.; Gromaire, M.-C. Determinants of Evapotranspiration in Urban Rain Gardens: A Case Study with Lysimeters under Temperate Climate. Hydrology 2022, 9, 42. https://doi.org/10.3390/hydrology9030042*

The vegetation in the eight lysimeters on 21 June 2018 (Source: DPE-STEA, Paris council)

Thanks for your attention

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There are insufficient trees in Paris: the city plans to plant 20,000 (notre-planete.info)