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## Monitoring and sampling methodology of source control systems for environmental assessment in Lyon, Nantes and Paris.

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**Abstract:** Stormwater control measures (SCM) are nowadays widespread and municipalities encourage their implementation in order to reduce runoff volumes and loads of micropollutants (MP), such as PAHs and metals. However, very few studies have highlighted their removal efficiency regarding less known MP such as pesticides, PBDEs, alkyphenols, etc. Several research projects in France were undertaken in order to better understand the capacity of SCMs to handle these emerging micropollutants and prescribe tools and guidelines to improve their design and construction. Three of these projects, MATRIOCHKAS (Nantes), MICROMEGAS (Lyon) and ROULÉPUR (Paris), decided to work together in order to cover the largest possible range of systems and contexts of use. The current paper presents the monitoring and sampling procedures for several different source control experimental sites across France.

**Keywords:** micropollutant; monitoring; source control; stormwater control measures

Reducing the impact of runoff water (flows and pollution) on receiving water bodies is currently one of the greatest challenges in the urban drainage research field. Since the promulgation of the Water Framework Directive (WFD 2000), many studies have been conducted, in Europe and across the world, to highlight and quantify the contamination due to micropollutants (MP) such as heavy metals and hydrocarbons (e.g. Ellis *et al.* 2005).. More recently, other studies have detected and quantified emerging chemicals, such as alkyphenols, pesticides, phthalates, Bisphenol A, PCBs and PBDEs, in runoff water (e.g., Birch 2012, Gasperi *et al.* 2014).

More and more, French municipalities encourage the implementation of stormwater control measures (SCM), and more particularly source control systems based on on-site infiltration, known to reduce water flows and heavy metal and hydrocarbon contamination (e.g. Silva *et al.* 2010, Hatt *et al.* 2009). However, insufficient knowledge of in-situ systems and their efficiency regarding MP contributes to the general lack of confidence in their true ecological potential. . Moreover, as the global environmental performance of these SCMs is not well-known, combined with a poor maintenance consideration, urban planners continue to recommend end of pipe centralized systems.

In this context, the French government, through the French Agency of Biodiversity, decided to finance several projects aiming to highlight and quantify a large range of micropollutants in stormwater runoff treated using source control systems. Three of these projects decided to work jointly to assess and quantify the MP removal

efficiency of many different types of source control systems: MATRIOCHKAS in the city of Nantes, MICROMEGAS in Lyon and ROULÉPUR in Paris (see **Figure 1**).

Across the seventeen sites (see **Table 1**), covering a wide range of existing source control systems and many different contexts of use, the three projects face similar issues intrinsic to *in-situ* data acquisition for both i) flow monitoring and ii) water sampling. Source control systems receive small flowrates, due to the small size of their catchment; consequently, usual monitoring technologies can't be implemented without huge uncertainties in the acquired data. New monitoring devices and sampling procedures have to be specifically designed and implemented on each site to address the high variability in fluxes as well as local constraints (see “situational constraints” column in **Table 1**).

Depending on the systems, various instrumentations have been implemented to monitor runoff flows. The devices acquire data using tipping bucket flowmeters, electromagnetic flowmeters, water level/speed laws, weirs... (see “flow monitoring” column in **Table 1**). However, each one of these devices is developed and implemented according to many specific constraints such as space restriction, expected flow ranges and conditions required for water collection.

Most of the micropollutants studied by the projects (more than 50 in total for the three projects) are found at trace concentrations (a few ng/L). All micropollutants analyses must thus be run in specific labs meeting several detection and quantification needs. Analytical requirements, such as water sample volume and quality, and the determination of biases and uncertainties associated with the instrumentation introduce further constraints regarding sampling procedures and devices.

The paper will present the specificities of the SCMs studied and will suggest recommendation and illustration to adapt the monitoring to small system, small catchment and associated local characteristics (e.g. What can be assimilated to an “Inlet” or an “Outlet” for a source control system?). Such monitoring is dedicated to runoff flow and micropollutants loads under high variability of events (How a harvestable rain event is defined in terms of flow and/or sampling?).

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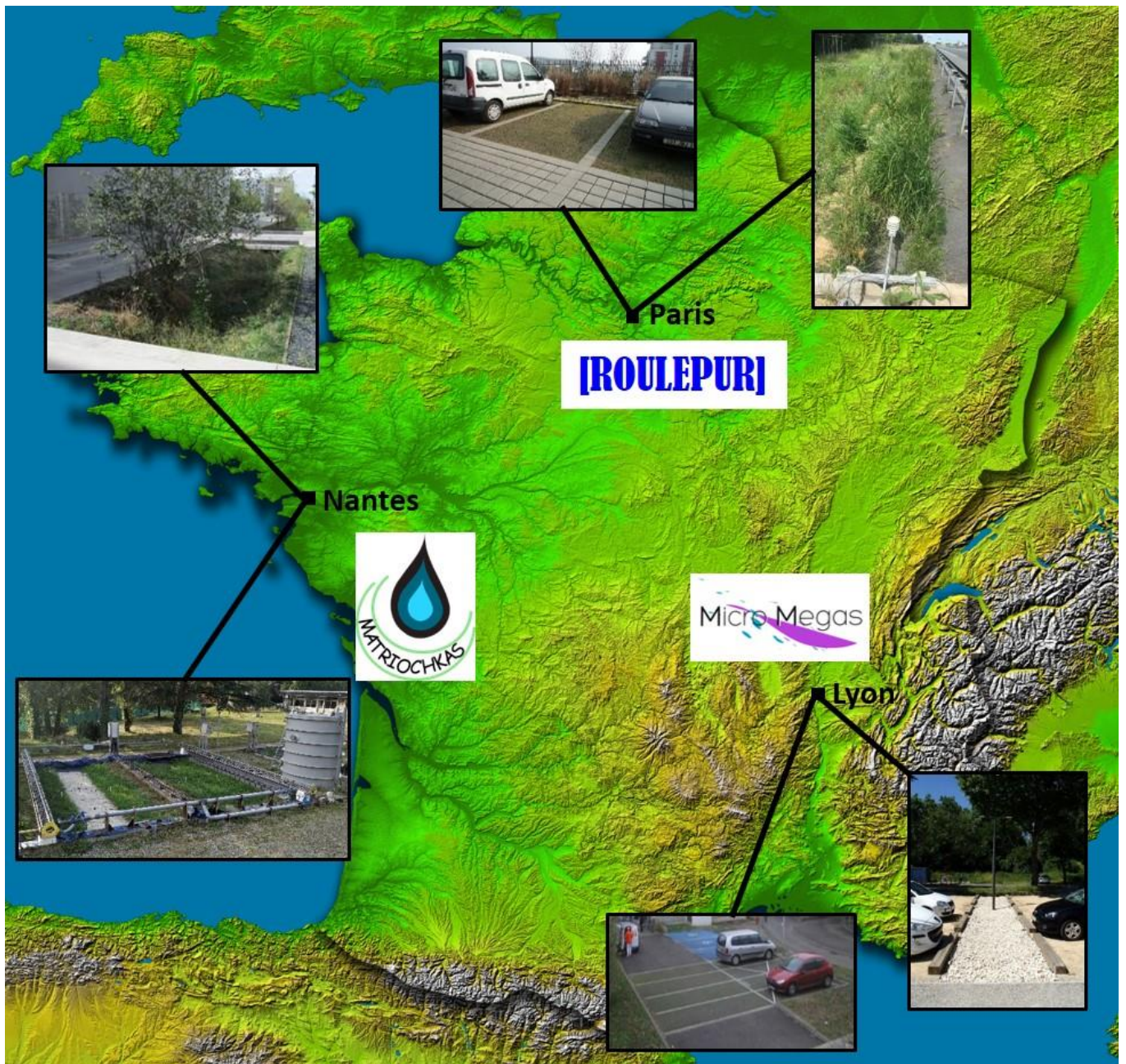


Figure 1 Map of France with locations of the three projects and examples of experimental sites.



**Table 1** Site characteristics (column 8, aspects directly monitored on the system regarding the performance characterization are in bold)

| Project     | Site                | Type                                     | Catchment surface (m <sup>2</sup> ) | Catchment uses                           | Flow monitoring  | Sampling procedure  | Performance characterization                                   | Situational constraints  |
|-------------|---------------------|--|-------------------------------------|--|--|---|--|--|
| MATRIOCHKAS | La Ville au Blanc   | Wet basin                                | 300000                              | Road with low traffic & commercial areas | Water level + speed in pipes   | Flow proportional automatic sampling  | <b>In/Out</b> comparison                                       | Low water level ; unwanted backwater   |
| MATRIOCHKAS | BO3 - Chézine       | Dry basin                                | 50000                               | Road with heavy traffic                  | Water level + speed in pipes   | Flow proportional automatic sampling  | <b>In/Out</b> comparison                                       | Excessive slope  |
| MATRIOCHKAS | Bottiere Chesnaie   | Infiltration swale                       | 17000                               | Residential housing                      | Water level in pipes   | Flow proportional manual sampling   | <b>In/Out</b> comparison                                       | Space constraints  |
| MATRIOCHKAS | Nantes 1            | Pilot swale                              | -                                   | Artificial runoff                        | 20 mL tipping bucket + electromagnetic flowmeter   | Flow proportional automatic sampling  | <b>In/Surface out/Subsurface out</b> comparison                | -  |
| MATRIOCHKAS | Nantes 2            | Pilot infiltration swale                 | -                                   | Artificial runoff                        | 20 mL tipping bucket + electromagnetic flowmeter   | Flow proportional automatic sampling  | <b>In/Subsurface out</b> comparison                            | -  |
| MICROMEGAS  | Ecocampus 1         | Infiltration swale                       | 290                                 | Parking lots                             | 100mL tipping bucket + electromagnetic flowmeter   | Flow proportional automatic sampling  | Conventional asphalt / <b>Source control outlet</b> comparison | Space constraints; flows covering a wide range   |
| MICROMEGAS  | Ecocampus 2         | Infiltration trench                      | 240                                 | Parking lots                             | 100mL tipping bucket + electromagnetic flowmeter   | Flow proportional automatic sampling  | Conventional asphalt / <b>Source control outlet</b> comparison | Space constraints; flows covering a wide range   |
| MICROMEGAS  | Ecocampus 3         | Porous pavement with reservoir structure | 90                                  | Parking lots                             | 100mL tipping bucket + electromagnetic flowmeter   | Flow proportional automatic sampling  | Conventional asphalt / <b>Source control outlet</b> comparison | No power supply ; space constraints; flows covering a wide range   |
| MICROMEGAS  | Ecocampus 4         | Asphalt runoff                           | 90                                  | Parking lots                             | 100mL tipping bucket + electromagnetic flowmeter   | Flow proportional automatic sampling  | <b>Conventional asphalt</b> / Source control outlet comparison | No power supply ; space constraints; flows covering a wide range   |
| MICROMEGAS  | Chassieu            | Dry basin                                | 1 850 000                           | Commercial suburbs                       | Water level + speed in pipes   | Flow proportional automatic sampling  | <b>In/Out</b> comparison                                       | -  |
| ROULEPUR    | Compans 1           | Vegetative filter strip                  | 507                                 | Road with heavy traffic                  | Drain outlet: 1L Tipping bucket  | Passive sampling of known % of the flow (drain) + Surface runoff sampling with a gutter | <b>In/Out</b> comparison                                       | Irregular inlet  |
| ROULEPUR    | Compans 2           | Biofiltration swale                      | 327                                 | Road with heavy traffic                  | Drain outlet: 1L Tipping bucket, Overflow: water level + triangular weir                                       | Passive sampling of known % of the flow   | <b>In/Out</b> comparison                                       | Irregular inlet ; flooding   |
| ROULEPUR    | Compans 3           | Asphalt runoff                           | 945                                 | Road with heavy traffic                  | 17L Tipping bucket   | Flow proportional automatic sampling  | <b>In/Out</b> comparison                                       | Flows covering a wide range; sedimentation   |
| ROULEPUR    | Paris               | Stoppol prototype                        | 1 040                               | Road with heavy traffic                  | 5L tipping bucket + ultrasonic flowmeter + water level   | Flow proportional automatic sampling  | <b>In/Out</b> comparison                                       | Obstacles ; flooding; water level in the device must not be changed by the flowmeter; flows covering a wide range; |
| ROULEPUR    | Rosny-sous-Bois     | Planted sand filters                     | 3 410                               | Road with medium traffic                 | Inflow: Electromagnetic flowmeter / water level; Outlet: water level+vortex law; water level + triangular weir | Flow proportional automatic sampling  | <b>In/Out</b> comparison                                       | Important sedimentation ; no power supply; space constrains at the outlet  |
| ROULEPUR    | Villeneuve-le-Roi 1 | Pervious vegetated parking lot structure | 640                                 | Parking lots                             | 4L tipping bucket  | Flow proportional automatic sampling  | <b>In/Out</b> comparison                                       | Not enough space in measurment chambers; flooding of the chamber   |
| ROULEPUR    | Villeneuve-le-Roi 2 | Asphalt runoff                           | 730                                 | Parking lots                             | Water level + triangular weir  | Flow proportional automatic sampling  | <b>In/Out</b> comparison                                       | -  |