D4RUNOFF

Urban runoff in Europe

SPOTLIGHT SERIES

What we found and why it matters

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Introduction

This report summarises a study conducted as part of the EU-funded D4RUNOFF project, by researchers from the Jožef Stefan Institute, (Slovenia) and the University of Riga, Faculty of Medicine and Life Sciences (Latvia).

The study investigates the presence of chemicals of emerging concern (CECs) in urban runoff collected in 6 European cities—Copenhagen, Odense, Santander, Pontedera, Riga, and Ljubljana.

Urban runoff, which forms when rainwater washes over streets, roofs, and other hard surfaces, carries not only well-known pollutants but also lesser-known substances originating from traffic, building materials, consumer products, and even wastewater that inadvertently enters stormwater systems.

Using advanced analytical techniques, the D4RUNOFF project applied both targeted and non-target chemical screening to identify which substances are present and which may pose environmental risks.

The findings reveal a complex mixture of contaminants and highlight the importance of recognising emerging pollutants, many of which are not currently monitored but may influence urban water quality and ecosystem health. This special report provides an accessible overview of these results and their implications for more sustainable and informed urban water management.

THE FULL STUDY IS AVAILABLE AT:
www.d4runoff.eu

PREPARED BY
Three o'clock

Understanding urban runoff

Urban runoff forms when rainwater flows over streets, roofs, pavements, and other hard surfaces. As it moves, it picks up particles, chemicals, and residues from cars, buildings, and everyday human activity. This runoff often enters rivers and lakes without treatment, carrying pollutants that can affect aquatic life and water quality.

With cities expanding and rainfall patterns shifting due to climate change, managing urban runoff has become essential. This study examined what pollutants are present in runoff collected from several types of urban environments across Europe.

How our study was conducted

To understand the chemical composition of urban runoff, researchers collected samples from:

- Road surfaces and traffic areas
- Building roofs
- Urban drainage systems
- Combined sewer overflows (CSOs)

Each sample was analysed for a broad set of substances, including metals, pharmaceuticals, industrial chemicals, plastic-related compounds, and chemicals linked to vehicle wear.

This comprehensive screening allowed researchers to identify both well-known pollutants and emerging contaminants that are not yet part of routine monitoring.

How we screened for chemicals

We used a combination of targeted analysis, checking for known pollutants, and non-targeted screening, which searches broadly for unknown compounds.

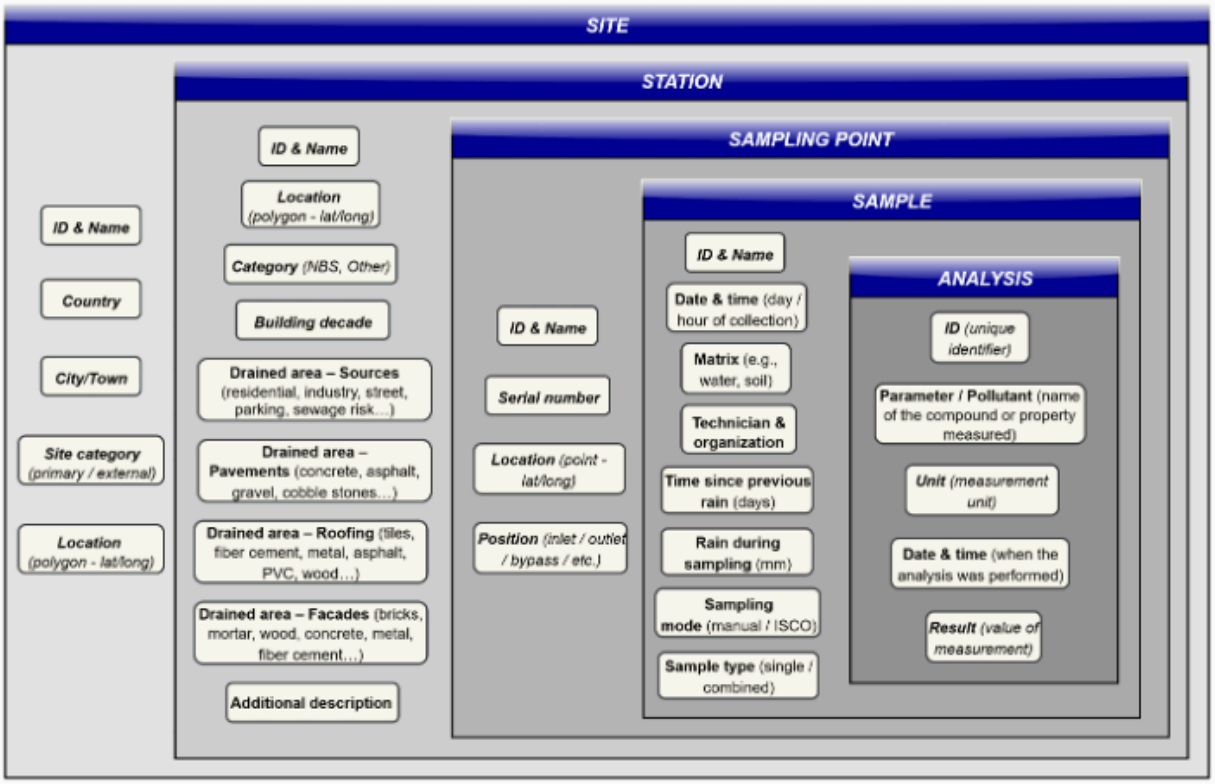
Highly water soluble chemicals were captured by one method (chromatography and mass spectrometry), while metals were measured with another (inductive coupled plasma mass spectrometry).

This multi-method approach reveals a much wider chemical landscape than traditional monitoring.

Chemical fingerprints reveal sources

By analysing how chemicals correlate with each other, we identified clusters pointing to their sources. One cluster represents traffic emissions, another shows wastewater-related substances, and a third reflects general urban background inputs.

These clusters help cities understand where their pollution is coming from, and where interventions will be most effective.



Key Findings

Metals are among the most common pollutants

Metals such as zinc, copper, and aluminium were detected frequently and in high concentrations. These typically originate from:

Vehicle components

Building materials

Road surfaces

In several runoff samples—especially those collected near busy streets or CSOs—metal concentrations reached levels that may harm aquatic organisms. This suggests that traffic remains a major source of metal contamination in cities.

Traffic-related chemicals are prevalent

Urban runoff carried many substances linked to tire and brake wear. One compound, 6PPD-quinone, formed through the degradation of tire rubber, is of particular concern as it is highly toxic to certain fish species.

The consistent presence of these chemicals highlights how everyday mobility contributes to chemical loads in surface waters.

Wastewater traces appeared in unexpected samples

Several chemicals typically found in household wastewater—such as pharmaceuticals, artificial sweeteners, and flame retardants—were identified even in samples that were not connected to sewer systems.

An emerging pollutant requires urgent attention

One chemical, benzothiazole-2-sulfonic acid, was detected in almost all samples and often in high concentrations. Despite its widespread presence, little is known about:

- Its sources
- Environmental behaviour
- Toxicity

This compound should be prioritised for further scientific investigation.

Even roof runoff contains pollutants

Runoff from rooftops—often considered cleaner than street runoff—still contained chemicals at levels that could affect algae, plants, and aquatic animals.

This underscores the need to treat runoff from a wide variety of surfaces, not just roads.

Environmental implications

Urban runoff is not simply rainwater; it is a mixture of substances from traffic, buildings, consumer products, and human activity. When released untreated into natural waters, this mixture can:

- Affect the health of fish, algae, insects, and other organisms
- Reduce overall water quality
- Accumulate downstream, contributing to long-term ecosystem changes

Mixtures of pollutants can also interact in unpredictable ways, sometimes increasing toxicity beyond what each chemical would cause on its own.

With more frequent heavy rainfall events due to climate change, these issues are likely to intensify if not addressed.

Recommendations for improved management

While this report presents scientific findings, it also points toward practical actions that cities and policymakers can take.

01 **Improved monitoring**

Many of the substances found are not included in routine water quality assessments. Monitoring programmes should be expanded to cover these emerging pollutants.

02 **Better treament of infrastructure**

Street runoff and CSOs contain some of the highest concentrations of contaminants. These systems should be prioritised for upgraded treatment or nature-based solutions that reduce pollutant loads.

03 **Address particle-bound contamination**

A significant portion of pollutants is attached to particles such as tire debris. Capturing and treating this particulate matter is essential for reducing pollution at its source.

04 **Public awareness and behaviour change**

Actions such as proper disposal of chemicals, reduced street littering, and responsible vehicle maintenance can help lower contamination levels.

05 **Further reseach is needed**

Certain substances require more detailed study, particularly benzothiazole-2-sulfonic acid and other emerging contaminants that are not yet regulated.

Conclusion

This study clearly demonstrates that urban runoff carries a complex mixture of pollutants that can affect the health of our rivers and urban ecosystems. Metals, traffic-related chemicals, pharmaceuticals, and emerging pollutants were consistently detected across all sampling types, including rooftops.

As cities grow and climate change alters rainfall patterns, the need to manage urban runoff becomes ever more pressing. By improving monitoring, upgrading drainage systems, and increasing public awareness, European cities can take meaningful steps toward protecting the environment and ensuring healthier water systems for future generations

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