DANMARKS OG GRØNLANDS GEOLOGISKE UNDERSØGELSE **RAPPORT 2025/12**

Inventory of pollutants in urban stormwater – documentation report

D4RUNOFF deliverable 1.3

Anders R. Johnsen, Cecilie I.K. Hansen, Thomas M.M. Karlsson, Jan H. Christensen & Ulla E. Bollmann

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DANISH MINISTRY OF CLIMATE, ENERGY AND UTILITIES

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Preface

This report represents work carried out in the Horizon Europe project "Data driven implementation of hybrid nature-based solutions for preventing and managing diffuse pollution from urban water runoff – D4RUNOFF", work package 1 "Novel detection methods for urban runoffs pollutants characterization", task 1.3 "Screening for CECs, pathogenic indicators, and microbial resistance in urban runoff".

Together with the draft inventory file (Inventory_source stormwater_D4RUNOFF_version 2-03.xlsx), this report constitutes deliverable 1.3 "Library of pollutants from urban runoff in Nature Based Solutions". The draft inventory covers identified pollutants in stormwater samples from the project's case studies together with stormwater samples from across Europe. The inventory contains both quantitative and semi-quantitative data. The inventory file is formatted so that it can be imported in common databases such as Microsoft Access and used in work package 4 "AI-Assisted urban runoff management platform". At the time of publication of this report, the inventory will be present in a draft version as some of the analytical methods, especially HRMS-methods, and interpretation of HRMS data, will be refined during the remaining part of task 1.3. The draft inventory will only be accessible for the project partners, whereas the final inventory will be open access. The draft inventory will continuously be updated with new data so that the most updated data set is always available for the project partners.

Urban stormwater was sampled by Vandcenter Syd (Odense stations), University of Copenhagen, Department of Plant and Environmental Sciences (Copenhagen stations), Geological Survey of Denmark and Greenland, Department of Geochemistry (Copenhagen stations), University of Cantabria (Santander stations), Aqualia, Innovation and Technology Department (Santander stations), Aque (Pontedera stations), Jožef Stefan Institute, Department of Environmental Sciences (Ljubljana stations) and University of Latvia, Faculty of Chemistry (Riga stations).

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Introduction

The overall aim of the inventory was to answer the questions: 1) Which pollutants are present in European stormwater and at which concentration levels? 2) Are there major differences between mixed stormwater and local storm water sources? The last question is especially important as most previous stormwater studies have analyzed mixed urban stormwater collected from large areas, but the stormwater to be handled in nature-based solutions (NBS) is often of very local origin such as in street rain beds and infiltration ponds in residential areas.

The purpose of this report is to document the methodological- and analytical approaches for sampling urban stormwater and quantifying pollutants and other parameters reported in the inventory to aid users of the inventory with respect to data interpretation. This report and the inventory include detailed data on different types of urban stormwater origins such as inner-city street runoff, highway runoff, roof- and façade runoff, artificial football field drainage, overflow from combined sewers, by-pass of mixed stormwater at wastewater treatment plants etc.

Composition and concentrations may vary over time for each station, the aim of our sampling campaign was not to capture this variation as most stations were sampled only once. By sampling many more stations than in previous reports, we instead aimed at describing the variation within- and between different types of source stormwater rather than repeated sampling of few single stations. For consistent sampling by different project partners and external partners, it was necessary first to develop protocols for stormwater sampling and station characterization and provide standardized ready-to-use sampling- and shipping kits. Thorough descriptions are given in annex 3 for each station. Some of the analytical methods needed method development and testing, this is presented in a form that should allow the general inventory user to evaluate the results and methods. Additional information on the chemical analysis workflows will be presented in deliverable 1.2 "Standard Operating Protocols (SOP) for suspect screening and nontarget screening (NTS) analysis workflows for stormwater" and deliverable 1.6 "Standard operating protocols (SOP) for identification in non-target sceening (NTS) methods and quantification in suspect screening" that will be submitted in M22 and M30 of the project.

Overview of analyses.

The inventory has the following main data categories that are presented in this report:

Basic characterization: Conductivity, turbidity, pH, dissolved organic carbon (DOC) and total organic carbon (TOC) were analysed by GEUS. **Inorganic components:** Anions and cations were analysed by GEUS. Trace elements were analysed by Eurofins Denmark.

Microbial indicators: *E. coli*, cultivable antibiotic resistant *Enterobacterales*, antibiotic resistance genes, and integron integrase genes (mobile genetic elements) were quantified by GEUS.**Organic micropollutants** (contaminants of emerging concern): Target- and suspect screening using reversed-phase liquid chromatography high-resolution mass spectrometry (RP-LC-HRMS) was done by UCPH. Suspect screening using hydrophilic interaction chromatography high-resolution mass spectrometry (HILIC-HRMS) was done by GEUS.

Origin of urban stormwater pollutants - literature overview.

The origin of pollutants can be viewed at several levels. The immediate source relates to the type of urban stormwater, this is the subject of the following report chapters. The sources may, however, also be seen as the sources within the urban environment that releases specific pollutants.

Sources are evident for many of the potential stormwater pollutants. Pesticides and their transformation products are used in agriculture and to some extend in private gardens and public areas such as squares, streets, and parks. Pharmaceuticals and their transformation products in the urban environment probably originate mainly from domestic sewage that contaminates stormwater by sewer bypass, sewer overflow, pipe leakage etc. Aliphatic hydrocarbons and alkylated low-molecular-weight aromatics originate mainly from petroleum products, non-alkylated polycyclic aromatic compounds (PACs) originate mainly from combustion processes in traffic and domestic heating. Rubber chemicals come from the wear of car tires, etc. Sources for other contaminants are less obvious. In this overview, we have assembled data from technical reports to aid the method development and the interpretation of the inventory data. The cited references are non-English technical reports that often do not show up in searches of the scientific literature. The identified pollutants and their sources are listed in annex 1. The following sources were reviewed:

1. Biocides leached from building materials (Bester, 2022).
2. Organic compounds and inorganics leached from crushed concrete, brick, and roof tile (Hjelmar et al., 2018).
3. Organic compounds and inorganics leached from surface-treated roof tile, concrete, and fiber-cement (Hjelmar et al., 2020).
4. Inventory of biocides used in Denmark up to 2000 (Lassen et al., 2001), only compounds judged relevant for the urban environment were added to annex 1.
5. Mapping and environmental assessment of cleaning agents for outdoor use (Pedersen et al., 2023).
6. Particle-bound biocides (Vianello et al., 2021).

For the organic micropollutants (e.g. industrial chemicals and biocides), we have added the compounds to HRMS suspect-screening lists together with runoff pollutants identified in the Danish project "Byer i Vandbalance" (Jensen et al., 2015) and scientific articles (Gasperi et al., 2022; Masoner et al., 2019; Zgheib, 2011; Peter et al., 2022; Eriksson et al., 2007; Page et al., 2014).

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Stormwater sampling and stations

First, we decided on a common strategy for representative sampling of source stormwater, needed volumes and distributing of subsamples among partners for the different analyses. Water was sampled from stations at six cities across Europe: Odense (Denmark), Copenhagen (Denmark), Santander (Spain), Pontedera (Italy), Ljubljana (Slovenia), and Riga (Latvia). Three to 12 stations were sampled within each city (Table 1). A station was defined as the specific sampling point in the city environment, for instance the inlet to an inner-city storm drain, the inlet to a nature-based solution (e.g., street rain bed or detention pond), a point where mixed stormwater bypasses a wastewater treatment plant, etc. The stations were sampled as composite samples consisting of up to eight subsamples sampled from the start of a rain event and every 15 min for the following two hours. Each subsample was analysed only for the basic parameters: conductivity, turbidity and pH to indicate how NBS-source water changes during a rain event. The composite samples were analysed for all parameters.

Figure 1. Sample kit for one station.

All samples were cooled and shipped to GEUS (Copenhagen) in custom-made sample kits that were distributed to the project partners (Figure 1). Each partner received five sample kits containing a rain gauge (Bresser art. no. 7002530), sample bottles (closed 500-ml red-cap bottles with Teflon liners in the lids), a 100-ml closed red-cap bottle (with Teflon-liner in the lid) for transferring water from the source to the sample bottles, cooling elements, water-proof station characterization form and sampling protocol, and vinyl gloves to reduce sample contamination with bacteria from the skin or rubber compounds from latex- or nitrile gloves.

Samples from Danish stations were in most cases processed in the lab within 5-26 hours after sampling. Shipping times were longer for samples from other stations. These samples were generally processed in the laboratory 30-72 hours after sampling, except for the Po01 and Po05 samples that were stuck during shipping and consequently processed 6 days after sampling. The prolonged shipping should be considered when interpreting results from these two stations.

Initially, we tested the efficiency of the sampling kits with respect to temperature. Temperature profiles for water samples in a sampling kit with three cooling elements frozen to -17 °C and 8 bottles cooled to 5 °C was determined by placing a temperature logger in a center bottle followed by storage of the closed sample kit at room temperature (20-22°C). The temperature profile for the first four days is shown in Figure 2. Initially, the temperature dropped from 5,4 °C to 3,8 °C. After 24 hours, the temperature increased to 4.8 °C, after 48 hours it was 6.0 °C, after 72 hours it was 8.7°C, and after 96 hours it was 12.9°C. Shipping for 48 hours therefore is unproblematic with respect to temperature when ambient temperature is 20-22°C. Most samples, however, were sampled during October-March where ambient temperatures during shipping (storage and transport) were probably considerably lower, which would slow the warming of the samples. Up to 72 hours shipping was therefore considered acceptable with respect to temperature during October to March where outside temperatures are low.

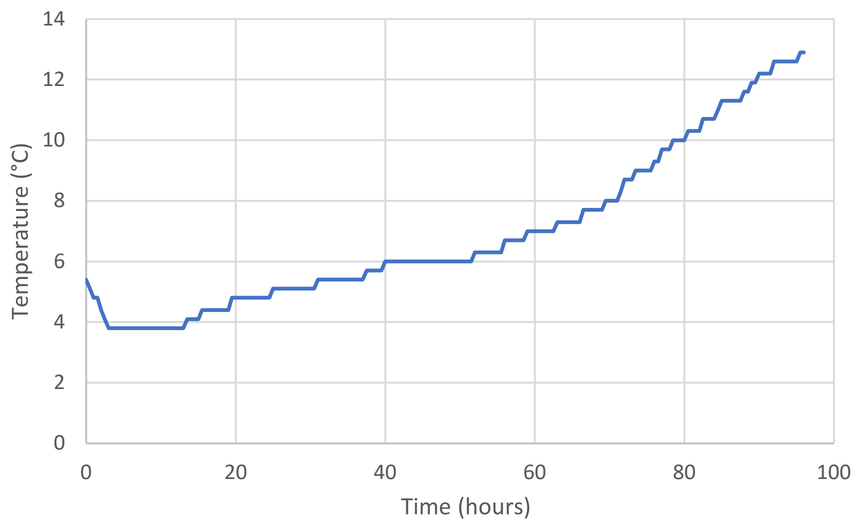


Figure 2. Temperature profile for a subsample in a full sample kit incubated at room temperature (20-22 °C).Temperature profile for a subsample in a full sample kit incubated at room temperature (20-22 °C).

Cleaning procedure for glassware

All glassware for sampling in the field and subsampling in the laboratory was cleaned with an elaborate cleaning procedure that minimized the risk of false positive results for CECs and trace metals. The cleaning procedure had the following steps:

1. Rinse glassware with ethanol.
2. Rinse glassware thoroughly with DI water.

3. Soak glassware in hydrochloric acid bath (1% in DI water) overnight.
4. Fill three separate baths with DI water and one with Millipore water. Rinse glassware two times in each of the baths.
5. Rinse thoroughly with HPLC-grade methanol.
6. Bake 2.5h at 550°C in a muffle furnace.
7. When cooled, close with cleaned plastic lids with Teflon liner.

Plastic lids with Teflon liners: Same cleaning procedure as above, but without the heating step (6).

Characterization of stations

Each station was thoroughly characterized and documented with respect to station type and sources of contaminants at each station such as the different types of building materials, pavements, catchment area, precipitation during sampling etc. All station documentation reports are shown in annex 1. The stations can be divided into 4 major types:

Sewage. Overflow from combined/mixed stormwater sewer, wastewater treatment plant (WWTP) bypass of mixed stormwater, or mixed stormwater from inlet of large retention basins/NBS. This is a very common situation across Europe where mixed overflow is discharged from sewers or bypasses WWTPs during heavy rain. We expected a high load of pharmaceuticals, industrial compounds, enteric indicators and antibiotic resistances. Medium to large scale catchments, typically sewage and runoff from urban districts.

Residential. Inlet to retention/infiltration ponds and trenches in suburban residential areas, often with newer buildings from 1950'ties onwards. This is an increasingly popular strategy for local handling of stormwater in suburbs. Stormwater pipes collecting surface water from city centers were included in this category. This type of stormwater may contain a mixture of biocides from buildings, combustion products, petroleum products, pesticides from spraying, sewage from misconnected or leaking pipes, household products etc. Possibly also containing pharmaceuticals, pathogenic indicators and antibiotic resistant bacteria when contaminated with domestic wastewater. Medium scale catchments, typically, runoff from 10-100 houses.

Street runoff to storm drains in city centers or street runoff to street rain beds, permeable pavements or similar NBS. Infiltration in rainbeds and through permeable surfaces are increasingly popular strategies for very local handling of stormwater in cities and suburban areas. Street runoff stations may have a high load of metals, rubber compounds, petroleum products, combustion products and possibly pesticides from private use in gardens, driveways etc. Some stations may be high in enteric pathogen indicators due to dog feces and bird droppings. Small scale stations, typically runoff from 30-100 m of street.

Artificial football field drainage. These stations may be high in rubber compounds if the filling is granulated rubber. Football fields often drain to nature. Small scale stations with runoff from single football fields

Roof. Runoff from roofs with no other sources.

Table 1. Overview of sites and stations.

City (Country)	Station	Type
Odense (Denmark)	Od01, Træøen. Inlet to street rain bed in residential area rain bed in residential area.	Street
Odense (Denmark)	Od02, Hørdumsgade. Inlet to street rain bed in central residential area.	Street
Odense (Denmark)	Od03, Kallerupvej. Inlet to street rain bed in residential area.	Street
Odense (Denmark)	Od04, Søparken North. Inlet to infiltration pond, surface water from residential area.	Residential
Odense (Denmark)	Od05, Søparken South, inlet to infiltration pond, surface water from residential area.	Residential
Odense (Denmark)	Od06, Odense Boldklub. Drainage water from artificial grass football court with granulated rubber filling.	Football
Odense (Denmark)	Od07, Thulevej. Stormwater overflow from combined sewers in industrial area	Sewage
Odense (Denmark)	Od08, Gartnerbyen. Inlet to retention pond at a newly constructed residential area.	Street
Copenhagen (Denmark)	Co01, Nybrogade, Older innercity area, manhole receiving combined roof and street runoff from stormwater drains.	Street
Copenhagen (Denmark)	Co02, Rigensgade, Street runoff samples from a storm drain inlet receiving runoff from street and roof, Copenhagen city center	Street
Copenhagen (Denmark)	Co03, Fields. Roof runoff from Field's shopping mall	Roof
Copenhagen (Denmark)	Co04, Rolighedsvej, Street runoff samples from a storm drain inlet, residential area	Street
Copenhagen (Denmark)	Co05, Metro. Roof runoff from newly constructed residential buildings sampled from separate sewage network.	Roof
Copenhagen (Denmark)	Co06, Enebærvej. Inlet to street rain bed receiving water from driveways, pavement and street in a suburban residential area.	Street
Copenhagen (Denmark)	Co07, Drabæk Huse. Infiltration ditch in suburban residential area with terraced houses.	Street
Copenhagen (Denmark)	Co08, Fælledparken. Drain water from artificial grass football court with granulated rubber filling.	Football
Copenhagen (Denmark)	Co09, Brønshøj. Drain water from artificial grass football court with granulated cork filling.	Football
Copenhagen (Denmark)	Co10, Øster Voldgade. Roof runoff from buildings in city center.	Roof
Copenhagen (Denmark)	Co11, Pile Alle. Street runoff sampled from a storm drain inlet at a highly trafficked street in a densely built area.	Street
Copenhagen (Denmark)	Co12, Damhus. Combined sewer bypass at WWTP.	Sewage
Santander (Spain)	Sa01, Wetland. Reconstructed wetland in "Parque de Las Llamas". Manual sampling from the wetland influent (small river).	Residential
Santander (Spain)	Sa02, Car Park. Permeable car park in Parque de Las Llamas. Manual sampling from a storm drain inlet.	Street
Santander (Spain)	Sa03, Polígono Industrial Candina. At the city outskirts (industrial area). Sampling from a storm drain inlet.	Street

Santander (Spain)	Sa04, Calvo Soltelo. Street at the city center. Sampling from a storm drain inlet.	Street
Santander (Spain)	Sa05, Pumping Station. mixed wastewater overflow at La Maruca II pumping station at Parque de Las Llamas.	Sewage
Pontedera (Italy)	Po01 Via Hangar. Large scale mixed urban stormwater overflow. Main final overflow of all the network at inlet to pilot-scale of NBS.	Sewage
Pontedera (Italy)	Po02, Via Agnoletti. Small scale mixed urban stormwater overflow. Handcraft industries and domestic wastewater.	Sewage
Pontedera (Italy)	Po03, Via Roma. Inlet to road storm drain. Hospital + commercial activities related to a hospital.	Street
Pontedera (Italy)	Po04, Piazza Cavour. Inlet to storm drain at no-traffic square - only pedestrian. Historical City Center.	Street
Pontedera (Italy)	Po05 Shopping Mall. Road runoff to infiltration trench that leads to a retention pond. Sampled from entry to trench. Only traffic input.	Street
Ljubljana (Slovenia)	Lj01, Grosuplje. Roof runoff from a roof on a sawmill building in a suburban area.	Roof
Ljubljana (Slovenia)	Lj02, Bizovik. Runoff from highway with a very high traffic load. The stormwater is drained via collection channel into a retention pond. Sampled from inlet to pond.	Street
Ljubljana (Slovenia)	Lj03, Logatec. Mixed stormwater overflow from bypass of a wastewater treatment plant	Sewage
Ljubljana (Slovenia)	Lj04, Brinje stormwater pipe. Surface water from outlet pipe that drains a residential area, a primary school and parking lots.	Residential
Ljubljana (Slovenia)	Lj05, Brinje football field. drainage from artificial football field plus one with a natural grass	Football
Riga (Latvia)	Ri01, Vienības Av. Stormwater from a city street (asphalt surface) with rather heavy traffic, samples collected at inlet to NBS.	Street
Riga (Latvia)	Ri02, Balasta Dambis. Street runoff from city street sampled at a storm drain.	Street
Riga (Latvia)	Ri03, Turaidas street. Runoff from roof and yard sampled at a runoff drainage pipe at inlet to NBS.	Residential

Definition of rain event and planning of sampling.

Sampling was preferably done when the weather had been dry for at least three days and the weather forecast predicted a rain event where the start of the event was clearly defined for instance when a front zone passed or a cloud burst. During winter, however, it was often impossible to have three dry days before sampling and the start of the event could be fuzzy for long, low-intensity events.

We preferred rain events where the forecast predicted ≥4 mm in the first two hours of the event, but this is uncommon in winter, so any clearly defined winter rain event was used. The samples included the first run-off to have the initial peak concentrations washed off surfaces followed by more dilute concentrations. Therefore, we sampled for up to 120 minutes after the stormwater started running, but the first four samples (0, 15, 30 and 45 min.) were sufficient for short, intense summer events.The stations were sampled manually as described below. For one station (Od07, Thulevej), we used an auto-sampler that was already installed at the station.

Materials needed.

Sample kit from GEUS (insulated box for shipping, sample flasks, cooling elements, cable strips), digital rain gauge (from GEUS), permanent marker for labelling bottles, mobile phone with google maps for GPS coordinates, frozen cooling elements.

Preparations.

1. Order sample kits from GEUS (arj@geus.dk).
2. Put cooling elements in freezer.
3. Check weather forecast for heavy rain (> 5mm). Sampling should preferably be Monday-Thursday (DK) or Monday-Wednesday (EU) to avoid samples being stuck in a warehouse over the weekend.
4. If needed, order courier shipping to DK.
5. Email a notification that samples may be coming to Anders R. Johnsen (arj@geus.dk), Pernille Stockmarr (ps@geus.dk) and Thomas M. Karlsson (tmmk@plen.ku.dk)
6. Fill out the station characterization form with the relevant info, more boxes may be ticked off for each category. Find GPS coordinates by opening google maps on smartphone, press on location to place a red marker, scroll down to see coordinates.
7. Take pictures to document the sampling site and the drained area (may not be relevant for mixed stormwater overflow).

Sampling.

1. Be present on the sampling site at the predicted date and time for the rain event.
2. Label bottles with date, station name, sample numbers and sampling times.
3. Insert batteries in Bresser rain gauge monitor, the monitor will now connect to sampler within 3 min. Reset to zero mm by pressing “SINCE” for five seconds.
4. When it rains, put on vinyl gloves to avoid contaminating the stormwater with personal care products or skin bacteria when sampling.
5. When water starts running (or flow increases for a continuous source) fill 0.5-L bottles for up to 2 hours (0, 15, 30, 45, 60, 75, 90 and 120 minutes), a minimum of 4 full bottles is needed. It is OK if some time points are missing if rain pauses and then resumes. If possible, fill the bottle directly from the source, otherwise use the 250-ml bottle to transfer stormwater to the bottles. If using the 250-ml bottle, wash in the runoff water before collecting the sample. Avoid touching bottle edges and the inside of bottle caps.
6. Immediately after collecting every individual sample, read rain gauge by shortly pressing “SINCE”, write down reading.
7. Return to lab/office and cool samples in refrigerator.

Shipping.

1. On the sampling day (or the following day if not possible on the sampling day), add frozen cooling elements, seal the transport box with strips.
2. Send sample box with courier shipping (fragile freight) to GEUS.
3. Email pictures and station characterization form and rain gauge data to GEUS.

Subsampling in the lab.

At GEUS, samples were processed within two hours after arrival. All subsamples from a station were shaken and aliquots transferred to 50-mL Sarstedt centrifuge tubes for measurements of pH, conductivity, and turbidity. These parameters were measured the same day as the sample arrived. The subsamples were then combined in a 4-L glass beaker to make a composite sample. The composite sample was placed on a magnetic stirrer and subsampled using 20-ml glass pipettes for the various analyses. 1-L subsamples for RP-LC-HRMS were transferred to 1-L bottles for solid phase extraction. 250 mL subsamples for HILIC-HRMS were transferred to 0.5-L bottles and stored frozen. 30-mL subsamples for trace metal analyses were transferred to 40-mL plastic vials acidified with HNO_3 (provided by Eurofins according to the standard DS 259:2003) and stored at room temperature. 50-mL subsamples for pH, conductivity, and turbidity were transferred to 50-mL Sarstedt centrifuge tubes and processed within a few hours. 15 mL-subsamples for anions, cations, ammonium and dissolved organic carbon were filtered through 0.45 µm PES syringe filters into plastic scintillation vials and stored frozen until analysis. 15-mL subsamples for total organic carbon were filtered through 5 µm PVDF syringe filters into plastic scintillation vials and stored frozen until analysis. 200-ml subsamples were decanted into 250 ml Duran bottles and DNA was extracted within two hours using PALL 300 filters (0.22 µm). 50-ml subsamples for microbial counts were decanted into 100 ml Duran bottles and counts were initiated within 3 hours. All glassware was cleaned as described above, except the bottles for DNA that were either washed and autoclaved (first 20 samples) or washed and baked for 2 hours at 200° C, and the bottles for microbial counts that were washed and autoclaved.

General characterization of stormwater samples

Precipitation

The precipitation was determined for the first two hours of the sampled rain events. Precipitation was in most cases measured during sampling using a standard tipping bucket rain gauge (BRESSER Professional Rain Gauge) provided with the sampling kits. For stations where precipitation was not measured during sampling, precipitation was instead estimated from local data from the national meteorological services. Precipitation varied from 1.2 mm to 10.1 mm for two hours of sampling.

Turbidity, pH, conductivity

These three parameters were determined for all composite samples as well as all subsamples used to make the composite samples. The parameters therefore show the variation at each station during the first two hours of the rain events (5-8 subsamples from each station) as well as the variation between stations (composite samples). pH and conductivity were measured using standard multimeters. Turbidity was measured using a WTW Photo Flex Turb that was calibrated with Kalkit P Photoflex Turb 430IR. Turbidity is reported in Formazin Turbidity Units (FTU), i.e., referring to formazin as the primary reference standard. Turbidity and conductivity varied between samples. Two examples of the subsamples of composite samples are shown in Figure 3. The variation during first flush at a street rain bed was, however, minimal, when the previous rain event was only one day before (Figure 3 and Figure 4).

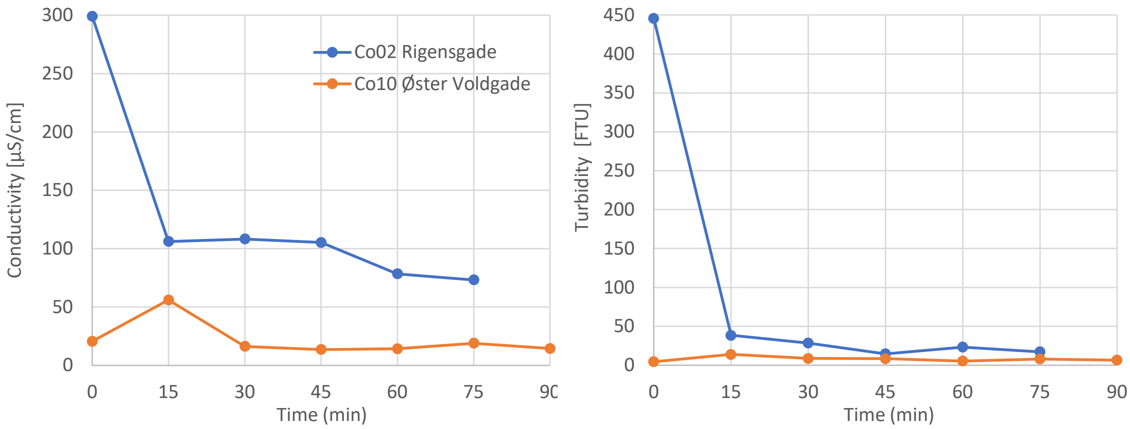


Figure 3. Changes in conductivity and turbidity during rain events. Co02 Rigensgade: roof and street runoff (5.0 mm) from central Copenhagen after 34 dry days, Co10 Øster Voldgade: roof runoff (7.5 mm) from central Copenhagen after 1 dry day.

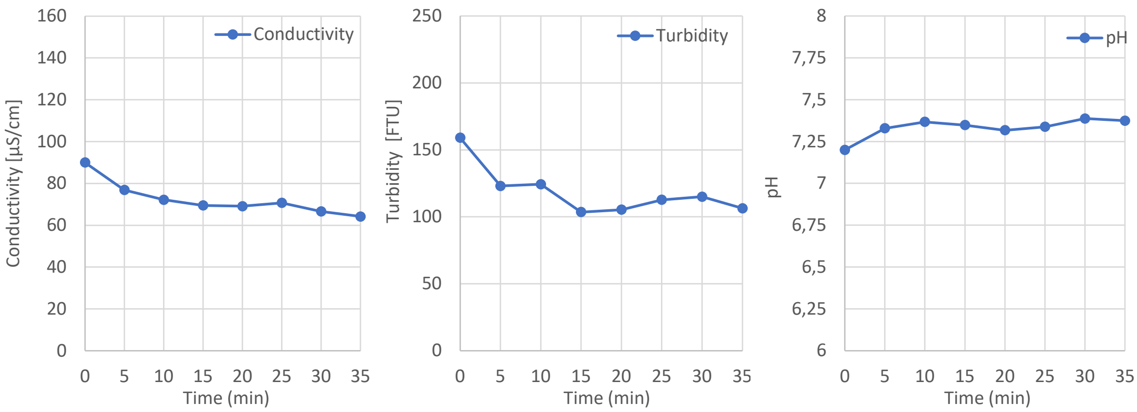


Figure 4. Variation during first flush at a street rain bed (Od03, Kallerupvej) where the previous rain event was the day before.

DOC and TOC

Dissolved organic carbon (DOC) and total organic carbon (TOC) were determined for all composite sample on a TOC-analyser (Shimadzu – Total Carbon analyzer – Vcph) after filtration through either a 0,45-µm QMAX PES filter (DOC) or through a 5-µm PVDF filter (TOC). Highest DOC-concentrations were found in samples with a long dry period before sampling (Figure 5, Od01 and Co02: 34 days, Co01: 17 days, Po02 and Po04: 12 days). This is more clearly seen when DOC is plotted against the number of dry days before sampling (Figure 6) for stations without WWTP bypass or combined sewer overflow.

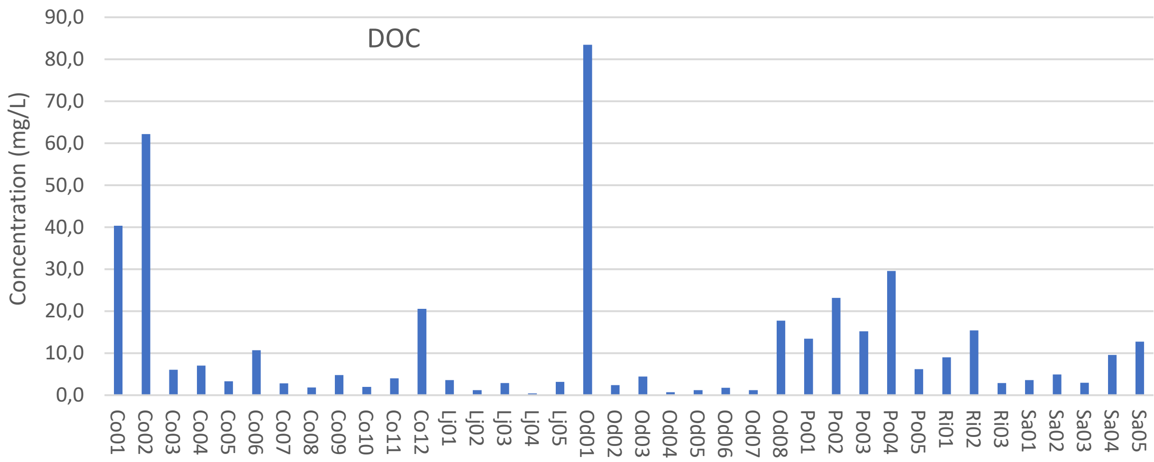


Figure 5. Dissolved organic carbon (DOC) in stormwater from the cities Copenhagen (Co, Denmark), Ljubljana (Lj, Slovenia), Odense (Od, Denmark), Pontedera (Po, Italy), Riga (Ri, Latvia), and Santander (Sa, Spain).

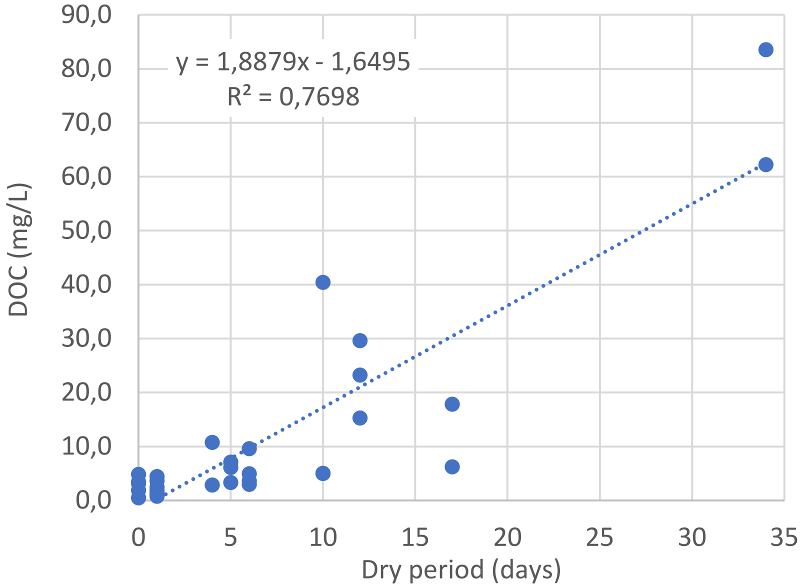


Figure 6. Dissolved organic carbon concentration versus the number of dry days before sampling. Only stations without WWTP bypass or sewer overflow.

Anions and cations

The following soluble anions and cations were determined for the composite samples: F^-, Cl^-, Br^-, NO_3^-, PO_4^{--}, SO_4^{--}, Na^+, K^+, Ca^{++}, Mg^{++}, and NH_4^+. Anions were determined by Metrohm 930 Compact IC Flex, Collum A supp. 5 – 150/4.0 after filtration through 0.45-µm filter. Soluble cations were determined by Metrohm 930 Compact IC Flex, Collum Metrosep. C6- 250/4.0 after filtration through 0.45-µm filter. Soluble ammonium was determined after filtration through 0.45-µm filter by a FIA Star 5000 analyzer – AN5220. Examples are shown in Figure 7 and Figure 8. Highest ammonium concentrations were found in samples containing sewage (Co12, Po01, Po02 and Sa05). Highest chloride concentrations were found in samples from a motorway retention pond (Lj02) and samples containing sewage (Co12, Po01 and Po02).

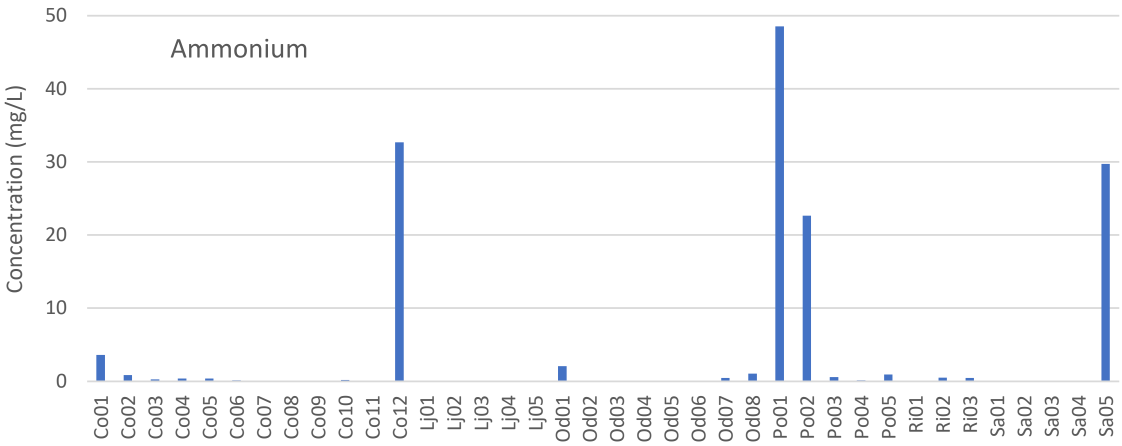


Figure 7. Dissolved ammonium in stormwater from the cities Copenhagen (Co, Denmark), Ljubljana (Lj, Slovenia), Odense (Od, Denmark), Pontedera (Po, Italy), Riga (Ri, Latvia), and Santander (Sa, Spain).

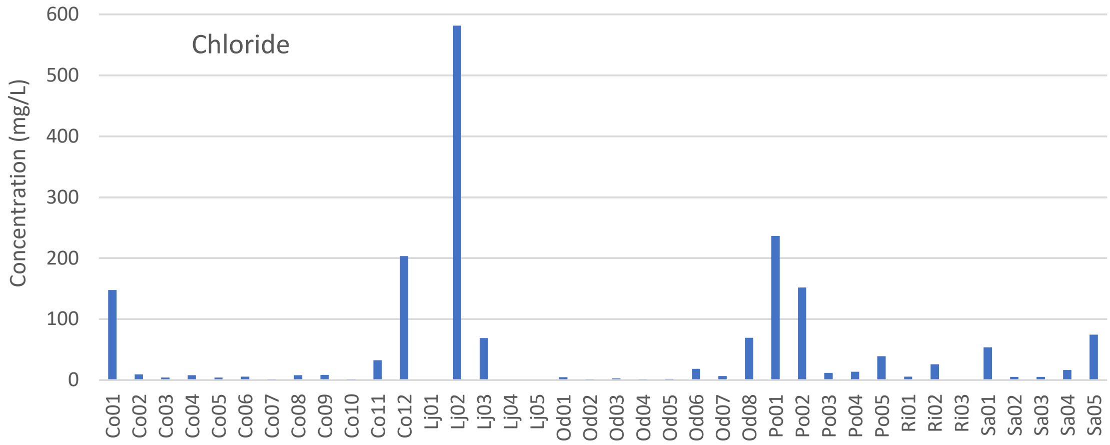


Figure 8. Dissolved chloride in stormwater from the cities Copenhagen (Co, Denmark), Ljubljana (Lj, Slovenia), Odense (Od, Denmark), Pontedera (Po, Italy,) Riga (Ri, Latvia), and Santander (Sa, Spain).

Trace elements

The stormwater samples were analyzed for trace elements that are relevant for drinking water quality, either according to the EU Drinking Water Directive or according to Danish national standards for elements not listed in the Drinking Water Directive. It should be noted that comparison to drinking water criteria is a conservative approach that may be too conservative for some ecological recipients. We also included vanadium (V), that does not have standards. This is because V is often considered a signature metal for bitumen/asphalt, which has a high content of V (e.g. El Beze et al., 2012). The samples were analyzed by the accredited lab Eurofins Miljø A/S. The samples were analyzed for acid-soluble trace elements. Eurofins provided 30-ml vials acidified with HNO_3 according to the standard DS 259:2003. Eurofins analyzed the samples by ICP-MS according to the standard EN ISO 17294m:2016.

The concentrations of Sb, As, B, Cd, Cr, Cu, Co, Hg, Ni, Se, V, Zn were low at most stations (Table 2) with one notable exception (Po05) that was high on almost all parameters. Al exceeded the EU drinking water quality at 28 out of 38 stations with a maximum concentration of 23,000 µg/l. Pb exceeded the EU drinking water quality threshold of 10 µg/L at 11 out of 38 stations with a maximum concentration of 51 µg/L, the future threshold of 5 µg/L was exceeded at 17 stations. Highest concentrations were found in a roof runoff sample (Co10) and street runoff samples (e.g. PO05, Figure 9).

Table 2. Acid-soluble trace elements in stormwater.

Element	Quantification limit, µg/l	Drinking water threshold value, µg/l	No of samples.	No. of samples above threshold value	Maximum concentration, µg/l
Al, aluminium	30	200**	38	28	23000
Sb, antimony	1	10*	38	2	18
As, arsenic	0.3	10*	38	0	8,6
Pb, lead	0.5	10 (5)*	38	11 (17)	51
B, boron	10	1500*	38	0	130
Cd, cadmium	0.05	5*	38	0	0,56
Cr, chromium	0.5	25*	38	4	110
Cu, copper	0.5	2000*	38	0	290
Co, cobalt	0.5	(5***)	38	2	15
Hg, mercury	0.05	1*	38	0	0,14
Ni, nickel	1	20*	38	3	100
Se, selenium	1	20*	38	0	<1
V, vanadium	1		38	-	50
Zn, zinc	5	(3000***)	38	0	2600

*Drinking water directive. Directive (EU) 2020/2184 of the European Parliament and of the Council of 16 December 2020 on the quality of water intended for human consumption. *Part B, Chemical parameters. ** Part C, Indicator parameters. ***Danish national threshold according to BEK nr 1023 af 29/06/2023 – Drikkevandsbekendtgørelsen.

Lead has many sources in the city environment. The most well-known is the former use of leaded gasoline that has caused a general, diffuse lead contamination of surface soil in city environments. Lead also originates from roofing, thermos windows (1950'ties and 1960'ties), sewer fittings, cable coatings, ceramic glaze, outdoor paint, and as a stabilizer in PVC plastics (annex 1 and renover-sikkert.dk, 2024).

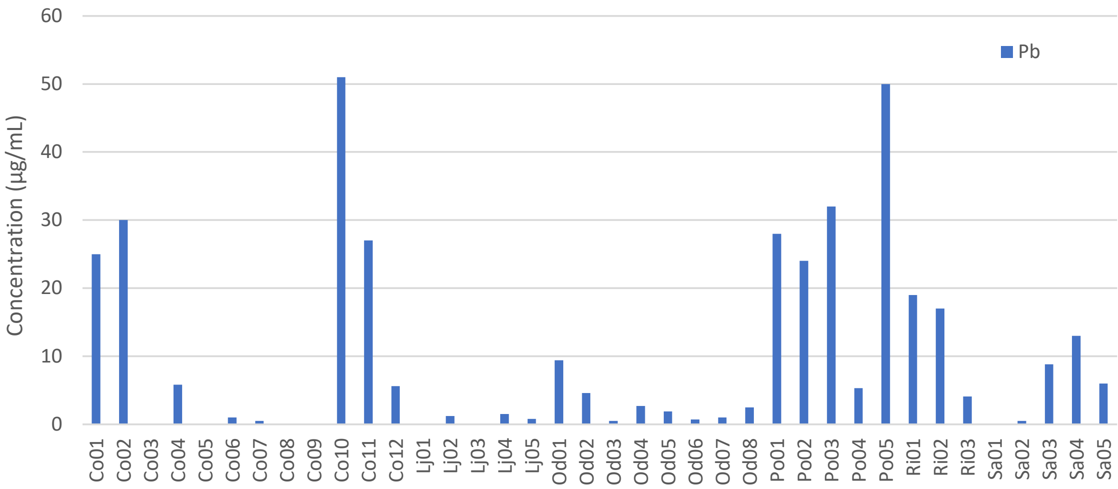


Figure 9. Acid-soluble lead in stormwater from the cities Copenhagen (Co, Denmark), Ljubljana (Lj, Slovenia), Odense (Od, Denmark), Riga (Ri, Latvia), and Santander (Sa, Spain).

Conclusions:

The concentrations of Sb, As, Pb, B, Cd, Cr, Cu, Co, Hg, Ni, Se, V, Zn were low at most stations. Pb concentrations were elevated at 17 out of 38 analyzed stations with a maximum concentration of 51 µg/l. Highest concentrations were found in a roof runoff sample and in street runoff samples.

Microbial indicators of metal and antibiotic resistance and fecal microbial indicators

Introduction

Faecal contamination of water in the urban water cycle poses risks to the health of the urban populations if not managed properly. A first step in this risk management is to identify the sources of fecal contaminants and associated antibiotic resistances in the urban environment. In D4Runoff we have measured the levels of microbial resistance to antibiotics in urban stormwater and there are good reasons for this. According to the World Health Organization: "Antimicrobial resistance in infectious agents represents a global health security threat and continues to be a serious threat to human, animal and environmental health, as well as the well-being of the global economy" (WHO, 2022). Urban stormwater certainly is not the major exposure route for antibiotic resistant bacteria, but we suspected that some types of stormwater may be an overlooked reservoir of microbial antibiotic resistance. When designing nature-based solutions for handling stormwater, it is therefore important to know the levels and sources of antibiotics resistance, so that the solutions can be designed to reduce exposure to fecal and antibiotic resistant bacteria.

We have two approaches for measuring antibiotic resistance, one is based on classical growth of antibiotic resistant bacteria on selective medium, the other is based on direct quantification of selected antibiotic resistance genes. The load of potentially pathogenic enterobacteria was quantified by developing a cultivation-based phenotypic method for screening water samples for the presence of *Enterobacterales* that were resistant to commonly used antibiotics. The load of antibiotic resistance genes in urban storm water was quantified by developing a digital droplet PCR (ddPCR) protocol from which it is possible to precisely quantify the copy-numbers of antibiotic resistance genes within different groups of bacteria.

Metal resistance

Metal-exposure has been suggested as a possible driver of the spread of antibiotic resistance by co-selecting for antibiotic resistance genes on plasmids that also contained metal resistance genes (e.g. Romero et al., 2017; Roberto et al., 2019). In an initial experiment, we therefore tested whether we could detect elevated resistance to the common metals copper and zinc in the urban environment, to test whether it was likely that the urban environment generally selects for metal resistance and possibly associated antibiotic resistances. Copper and zinc are two metals that have numerous sources in the urban environment. Zinc may for instance come from all galvanized metal objects such as light posts, city lamps, gutters, signs, railings, roofs etc. Cupper may come from gutters, roofs, impregnated wood in light posts, facades and fences, paint, non-coated wires etc.

Methods for determine phenotypic metal resistance in bacteria have no standard methods and thus vary widely in the limited number of studies. In this experiment, we tested the metal resistance levels by carrying out dose-response curves for resistance to copper and zinc. This was done by comparing dose-responses for three soil samples with varying in-situ exposure to copper and zinc. The copper and zinc soils were samples where we would expect urban hotspots with increased exposure. The Cu-soil was soil from the foundation of a copper statue in a park in central Copenhagen (Kastellet 21/3-2022). The soil was sampled as 20 subsamples (0-3 cm depth) distributed around the statue foundation at 0-10 mm from the foundation. The statue foundation was green from leaching of copper from the statue. The Zn-soil was soil from five galvanized light posts in a suburban area north of Copenhagen (Trevangsvej, 19/3-2022). The soil was sampled around each light post 0-10 mm from the galvanized metal surface at 0-3 cm depth. The light posts had been in place for at least 15 years. A natural control soil (BG-soil) was collected in a forest with only background exposure to copper and zinc (North of Farum Overdrev, 19/3-2022).

For each soil, 10 g (dry weight) was suspended in 50 ml 10 mM fosfate buffer (pH =7.0) and shaken for one min. The suspensions were diluted to 10^{-7} in the fosfate buffer. Mueller-Hinton agar was autoclaved and cooled to <50 °C. $CuSO_4$ or $ZnSO_4$ was added from concentrated aqueous stock solutions to 200 ml agar aliquots to give final Cu^{++} or Zn^{++} concentrations of 0, 0.63, 1.0, 1.6, 2.6, 4.1, 6.6, 10.5 and 16.8 mM. To inhibit fungal growth, natamycin was added (0.4 ml) from a Delvocid stock where 5 g Delvocid (50/50 natamycin/lactose) was suspended in 50% methanol, and the agar was poured in petri-dishes. The dilution series of the soils were drop-plated on the agar plates (6 × 15 µl of each dilution on each metal concentration) to test the number of CFU that could grow at each metal concentration. CFU was counted after 7 days incubation at 25 °C (Figure 10).

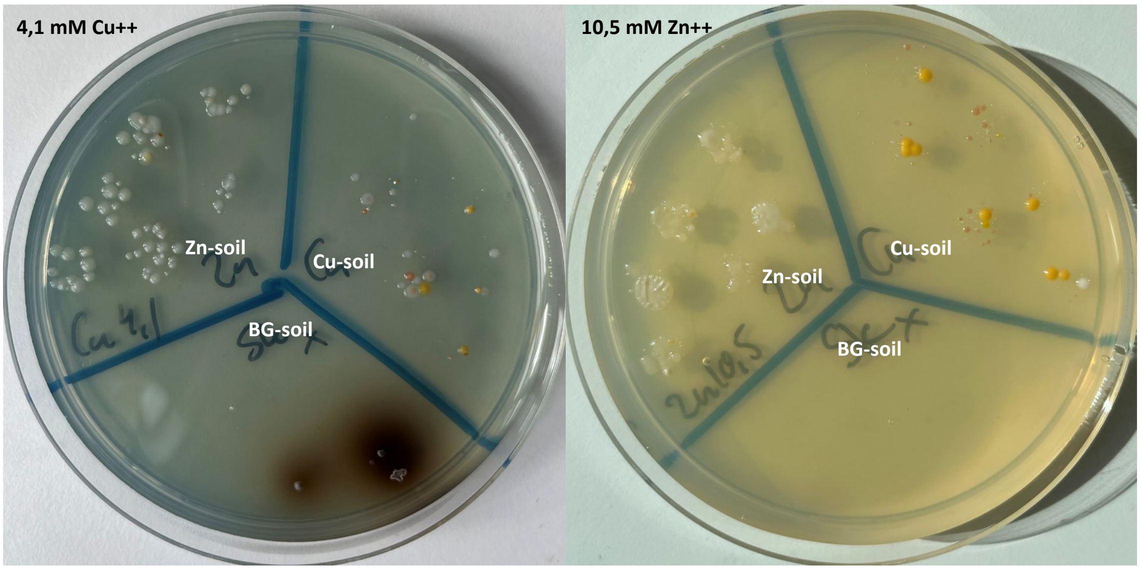


Figure 10. Examples of selective agar plates from dose-response experiment for bacterial cupper- and zinc resistance levels. Bacteria were extracted from three soils with different in-situ exposures and drop-plated on the agar.

CFU in the three soils varied slightly (Cu-soil: 1.41×10^8 CFU/g; Zn-soil: 1.61×10^8 CFU/g; BG-soil: 3.03×10^7 CFU/g), the CFU was therefore normalized to a density of 10^8 at zero mM metal to allow direct visual comparison of the dose-response curves (Figure 11). For copper, the difference between the soils was surprisingly small. There seems to have been very limited selection for copper resistance in the Cu-soil compared to the others. The city soils had elevated resistant CFU from 6.6 mM Cu^{++} compared to the natural soil, but the difference between the Cu-soil and the Zn-soil was visible only at 10.5 mM Cu^{++} and resistant bacteria were absent already at 16.8 mM Cu^{++}. The difference between the three soils was smaller for zinc-tolerant CFU where even 16.8 mM could not inhibit all CFU (Figure 11).

Conclusion: Based on the high tolerance to cupper and especially to zinc in all three soils, it seemed unlikely that we would see clear differences in stormwater samples of different origins. Efforts were therefore focused on direct indicators of the presence or absence of antibiotic resistance in stormwater instead of quantifying metal resistances.

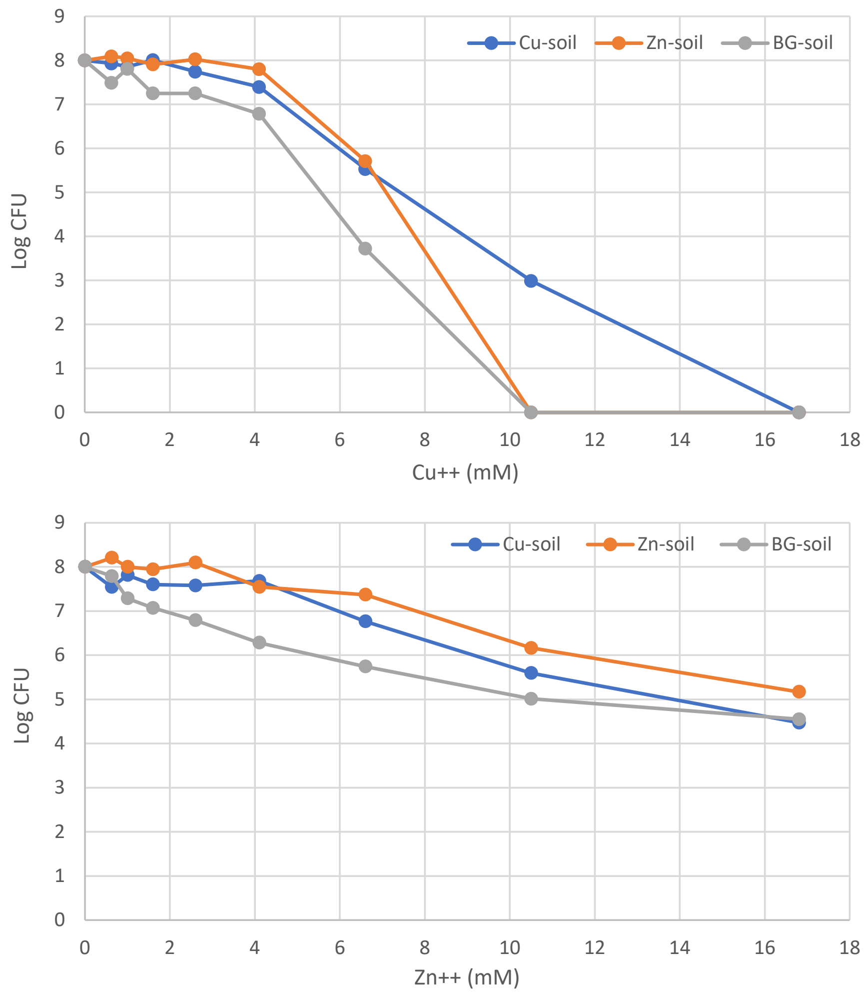


Figure 11. Copper and zinc dose-response curves for bacterial communities from three soils with different in-situ exposures. The metal concentrations indicate the concentrations in the agar plates used for CFU-counts. CFU: colony-forming units per g of dry soil.

Fecal contamination

Fecal contamination was tested with standard test for the presence of *E. coli*. The test was based on serial dilution of the samples in 10 mM fosfate-buffer (pH =7,0) containing natamycin to inhibit growth of fungi and yeasts. Natamycin was added as 2 ml/l of Delvocid (half natamycin, half lactose) suspended in water:methanol (1:1; 50 g/l). One-ml aliquots of the sample dilutions were added to coliform-selective petrifilms (3M Petrifilm E. coli/Coliform

Count Plate) and the petrifilms were incubated at 44.5°C for 22-24 hours. To avoid desiccation, petrifilm stacks were wrapped in a plastic bag and placed in a sealed box with a wet paper towel to saturate the atmosphere with water. The number of colony-forming units (CFU) was determined from the number of blue colonies associated with gas bubbles (Figure 12) according to the manufacturer's instructions. Colonies without gas bobbles were not counted.

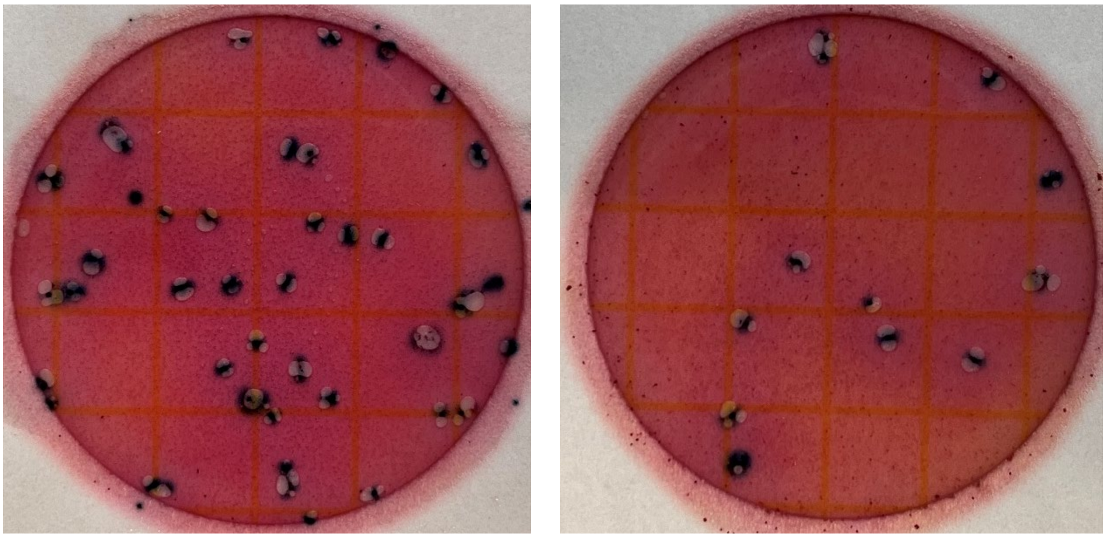


Figure 12. E. coli/Coliform petrifilms showing E. coli with characteristic gas bubbles (lactose fermention) and blue color (glucuronidase-positive). Left: station Co01, right station Od01.

E. coli indicate fecal contamination and is generally applied as an indicator of wastewater pollution of the water environment. This was evident for the samples from combined sewer overflow and WWTP stormwater bypass (Figure 13). High counts were also observed for some of the city center stormwater pipes and suburban retention ponds, suggesting leakage of wastewater into the surface water drains and/or misconnected pipes that mixed wastewater into the surface stormwater pipes. Some samples without obvious wastewater contamination also showed detectable *E. coli*. This was especially the suburban road runoff, probably contaminated with dog feces (Figure 14).

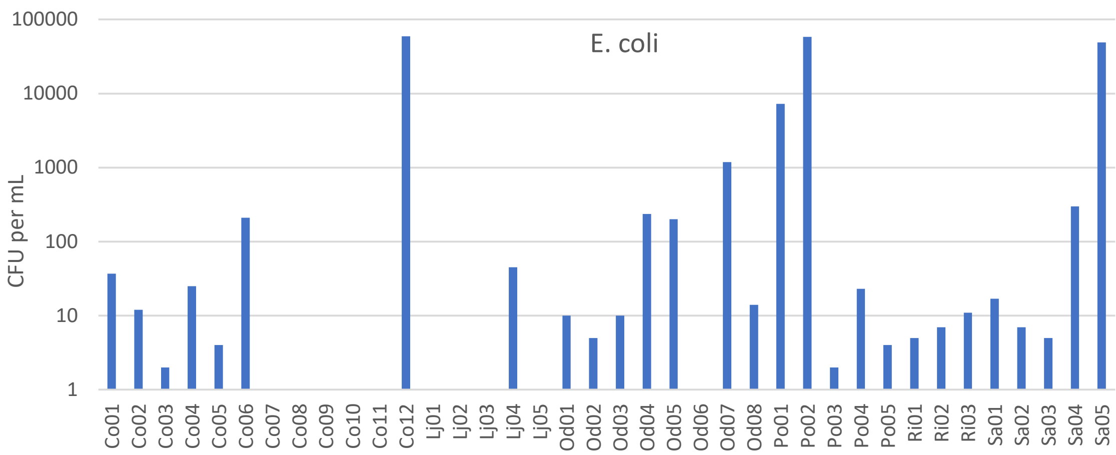


Figure 13. Quantification of E. coli in stormwater from the cities Copenhagen (Co, Denmark), Ljubljana (Lj, Slovenia), Odense (Od, Denmark), Pontedera (Po, Italy, Riga (Ri), Latvia)),and Santander (Sa, Spain). CFU: colony-forming units.

Figure 14. Streets and rain beds often had dog feces in different degrees of disintegration. Left: Od02 – Hørdumsgade; right: Od03 - Kallerupvej.

Quantification of cultivable, antibiotic resistant *Enterobacterales* using petrifilms

As indicator organisms, we chose *Enterobacterales* which is a large family of Gram-negative gamma-proteobacteria that covers a range of pathogenic or opportunistic pathogenic gut bacteria for instance *Shigella*, *Salmonella*, *Escherichia, Yersinia* and *Klebsiella*, as well as harmless environmental bacteria. In 2020, the broad group *Enterobacteriaceae* was split into seven separate families belonging to the order *Enterobacterales* that is equivalent to the old *Enterobacteriaceae sensu lato* (Adeolu et al., 2020). Ready-to-use petrifilms selective for *Enterobacteriaceae* (now *Enterobacterales*) are available from 3M. To our knowledge, these petrifilms have not previously been used in combination with antibiotics, but the somewhat similar 3M coliform petrifilms have been used to screen and discriminate *E. coli* resistant for ampicillin, cephalothin, streptomycin, chloramphenicol, cefotaxime and gentamicin. The minimum inhibitory concentrations (MICs) were at the same levels as for conventional Mueller-Hinton II agar (Wu et al., 2008). The *E. coli* petrifilm method required higher oxytetracycline break-point concentrations than typically used in Mueller-Hinton media due to higher calcium and magnesium concentrations in the petrifilms. The *E. coli* petrifilm metod was not suitable for sulphamethoxazole (Wu et al., 2008). We used the results from this study to extend the petrifilm method to the order *Enterobacterales* (*Enterobacteriaceae sensu lato*) instead of only the species *E. coli.*

The European Committee on Antimicrobial Susceptibility Testing (EUCAST, 2024) gives minimum inhibitory concentrations (MICs) for antibiotics that are effective against *Enterobacterales*. Within each class of these antibiotics, we aimed at compounds sold in large quantities in the Danish primary sector to test antibiotics with high probability of producing resistant bacteria that may end up in the urban environment after sewer overflow and WWTP bypass. We therefore started the method development with a survey of antibiotics used in Denmark to choose compounds relevant for counting resistant *Enterobacterales* in the stormwater samples. In annex 2, we have listed sales statistics for antibiotics used in Denmark in the primary, medical sector for systemic use in 2021. This means antibiotics used in private homes which is the most likely source of antibiotics and antibiotic resistant bacteria in local stormwater and local nature-based solutions for handling the stormwater such as rain beds, infiltration ditches and retention ponds. Sales of main groups of antibiotics in the primary sector in 2021 were identified in medstat.dk. Active compounds in different groups were identified at promedicin.dk.

Penicillins (beta-lactams) were some of the most sold antibiotics in Denmark. Of the penicillins effective against *Enterobacterales* amoxicillin was chosen because it was sold in the largest quantities (annex 2). For amoxicillin, we used 4 x MIC R as selective concentration in petrifilms and Mueller-Hinton agar plates (Table 3). Of the fluoroquinolones effective against *Enterobacterales*, ciprofloxacin was chosen because it was the most sold in Denmark (annex 2). **Ciprofloxacin** is a second-generation fluoroquinolone (beta-lactam) and was previously the standard treatment for *Salmonella* infections. For ciprofloxacin, we used a high concentration compared to the MIC R breakpoint (Table 3) to avoid background growth of non-resistant bacteria. The aminopyrimidine antibiotic trimethoprim is used to treat *Enterobacterales* urinary tract infections (EUCAST, 2024). We therefore included **trimethoprim** in the storm-water screening. Trimethoprim was applied in concentrations four times the EUCAST *Enterobacterales* MIC R breakpoint (Table 3). The common **tetracyclines** doxycycline and tetracycline are not recommended by EUCAST against *Enterobaceterales*. However, we still chose tetracycline as screening compound because tetracycline resistance genes were included in the screening of stormwater resistance genes. Tetracycline (oxytetracycline) has furthermore been used in *E. coli*-selective petrifilms, which meant that we could draw on this method (Wu et al., 2008). The selective concentration in *E. coli*-petrifilm is high due to divalent Mg and Ca ions, which lower the effect of tetracyclines (Wu et al., 2008). In the *Enterobacterales* petrifilm screening of stormwater, we used the same tetracycline concentration as recommended for oxytetracycline in the *E. coli* petrifilm (Wu et al., 2008), but half the concentration in Mueller-Hinton agar due to low Mg and Ca content. **Sulfamethoxazole** is the only sulfonamide recommended by EUCAST for *Enterobacterale*s and applied together with trimethoprim for urinary tract infections (EUCAST, 2024). Sulfonamides were not selected as coliform petrifilm cannot be used with sulfamethoxazole (Wu et al., 2008) which likely also applies to *Enterobacterales* petrifilm and probably also other sulfonamides. **Carbapenems** were not applied as they are “last resort antibiotics” with very limited use in Denmark and therefore with limited selection pressure in the sources of urban stormwater. Carbapenems are furthermore unstable in aqueous solution (Fawaz et al., 2018.).

Table 3. Antibiotics concentrations used in the petrifilms and agar plates.

Stof	EUCAST *Enterobacterales* MIC (breakpoint R), mg/l	Concentration in *Enterobacteriaceae* petrifilm mg/l	Concentration in Mueller-Hinton agar mg/l
Amoxicillin	8	32	32
Trimethoprim	4	16	16
Tetracycline	-	64	32
Ciprofloxacin	0.5	4	4

The antibiotics were stored at minus 80 °C. 100-fold concentrated stock solutions were prepared in autoclaved water (amoxicillin 3.2 mg/ml and ciprofloxacin 0.4 mg/ml) or methanol (trimethoprim 1.6 mg/ml and tetracycline 6.4 mg/ml), distributed in eppendorf tubes and stored at minus 80 °C until use. The antibiotics were thawed right before use and any remaining, thawed antibiotic was discarded after use.

1.5-ml subsamples of dilution series from the *E. coli* counts, containing natamycin to limit growth of yeasts and fungi, were added 15 µl of antibiotic stock solution, mixed, and 1-ml aliquots were added to *Enterobacteriaceae* petrifilm. The Petrifilms were incubated in closed plastic bags for 22-24 hours at 36°C. (Figure 15). According to the manufacturer's instructions "Enterobacteriaceae are red colonies with yellow zones and/or red colonies with gas bubbles with or without yellow zones ", but the formation of yellow zones was difficult to clearly identify (Figure 15). *Enterobacterales* CFU was therefore counted only as colonies with gas production, which means that the counts are minimum estimates.

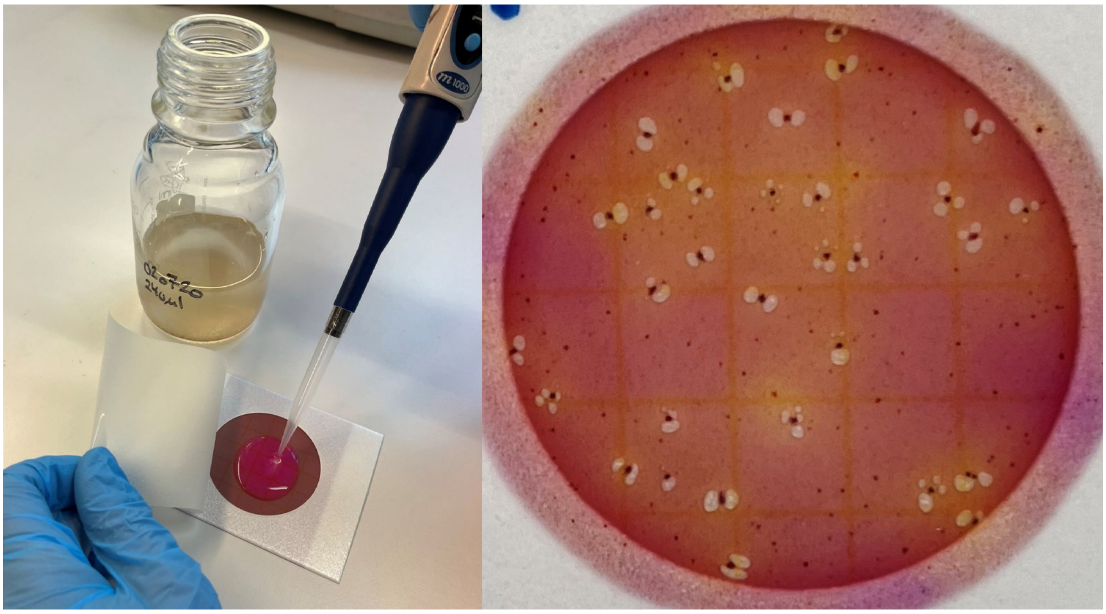


Figure 15. Inoculation of petrifilm with stormwater (left) and petrifilm with ciprofloxacin-resistant Enterobacterales bacteria (the gas producers) from Po01 stormwater containing sewer overflow at (right).

The resistant CFU varied between the antibiotics from detectable amoxicillin-resistant *Enterobacterales* in stormwater from most of the stations to tetracycline-resistant *Enterobacterales* mostly in the few stations impacted by domestic sewage (Figure 16). The variation between stations was up to four orders of magnitude for amoxicillin-resistant CFU.

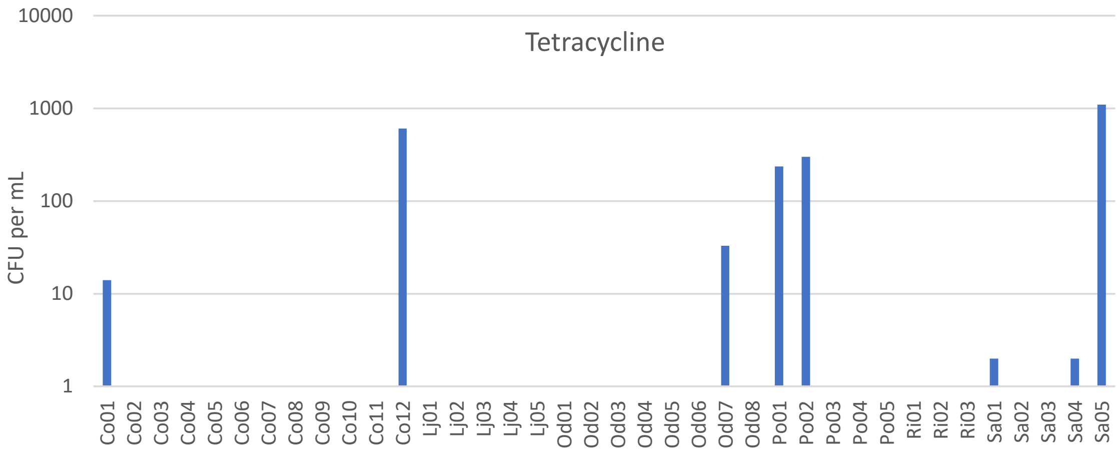


Figure 16. Prevalence of cultivable tetracycline-resistant Enterobacterales in stormwater from the cities Copenhagen (Co, Denmark), Ljubljana (Lj, Slovenia), Odense (Od, Denmark), Pontedera (Po, Italy,) Riga (Ri, Latvia), and Santander (Sa, Spain). CFU: colony-forming units.

Petrifilm *Enterobacterales* colonies from Copenhagen, Odense and Santander stations were tested for growth on conventional agar plates to confirm that the counted colonies were indeed resistant. The picked colonies represented different types of stations at the three sites as well as all four antibiotics. Mueller-Hinton agar was autoclaved and cooled to <45 °C before addition of antibiotics and immediately poured into petri-dishes on the days of counting petrifilms. 140 colonies were picked from the petrifilms, suspended in 1 ml fosfate buffer (10 mM, pH=7,0) and streaked on the agar followed by incubation for 22-24 hours at 36°C (Figure 17). Colonies from the agar plates were picked and suspended in glycerol (25% v/v) and stored frozen at minus 80 °C.

To identify the colonies, 48 selected isolates were re-streaked from the frozen stocks on Mueller-Hinton agar with natamycin and the relevant antibiotic. Colonies from the MH agar plates were picked, and their DNA extracted by using the Powerlyzer Ultraclean Microbial DNA Isolation Kit (MO BIO Laboratories). The 16S-rRNA gene was amplified using the 27F and 1492R primers (Weisburg et al., 1991) and sequenced by Macrogen Europe using the forward primer. The sequences were BLAST'ed to identify the isolates to the genus level. (Table 4). The tests confirmed that the petrifilm colonies were resistant to the antibiotics and that they, except two *Pseudomonas*, belonged to the order *Enterobacterales*, i.e., that the developed petrifilm method is indeed suitable for counting resistant *Enterobacterales* bacteria in stormwater.

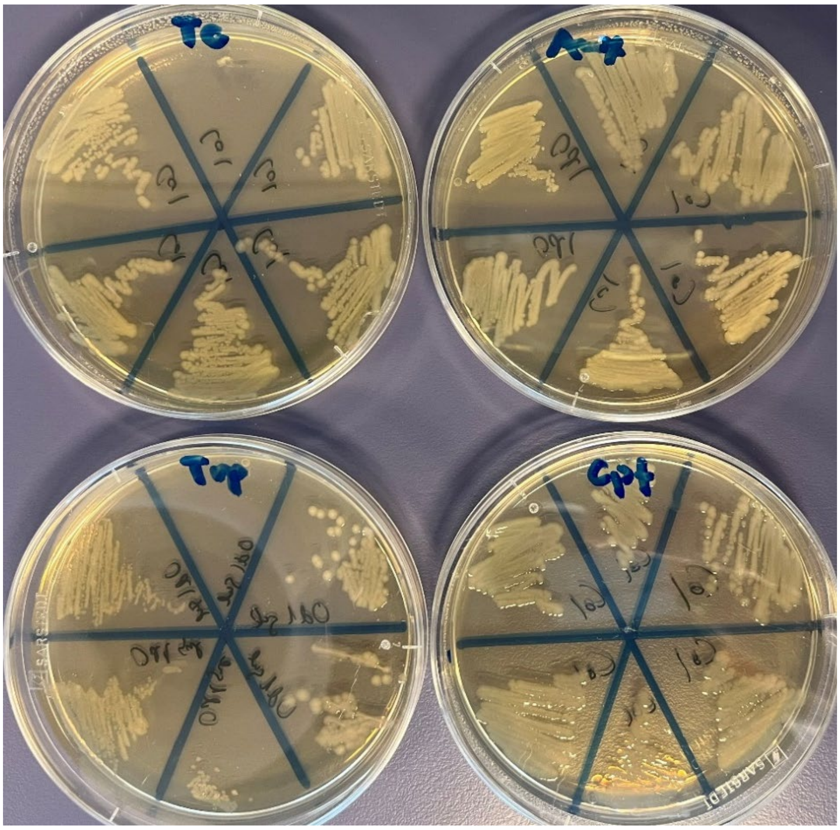


Figure 17. Confirmation or antibiotic resistance in petrifilm isolates streaked on Mueller-Hinton-natamycin agar with tetracycline (Tc), amoxicillin (Amx), trimethoprim (Trp) or ciprofloxacin (Cpf).

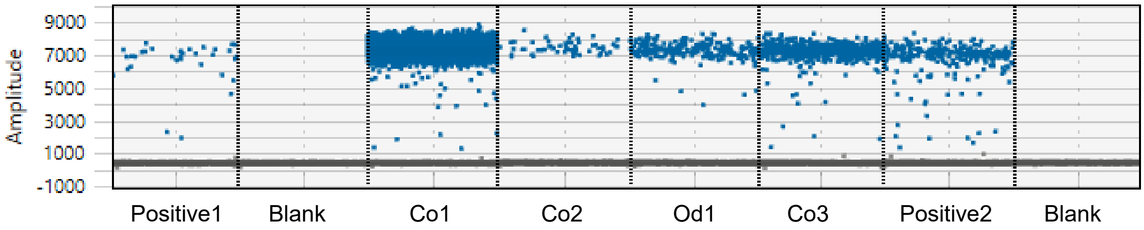
Table 4. Identification to the genus level by sequencing of the 16S rRNA gene from 48 petrifilm isolates.

Genus (closest match)	No. of isolates	Pct. of isolates
Escherichia	16	35
Shigella	9	20
Klebsiella	7	15
Enterobacter	5	11
Kosakonia	5	11
Pseudomonas	2	4
Citrobacter	1	2
Pectobacterium	1	2
Pseudescherichia	1	2
Raoultella	1	2

Quantification of antibiotic resistance genes by digital droplet PCR

We used a method called digital droplet PCR (ddPCR), where we could count the number of copies of each of the resistance genes. With this method, we got a much broader view than with the petrifilm method because we detected many other types of bacteria than the petrifilm enterobacteria and because we also detected bacteria that are hard to grow in the lab. ddPCR is a new method that allows absolute quantification of gene copy number in contrast to the conventional real-time qPCR that is only semi-quantitative. ddPCR is based on the principle that the sample is split in 15,000-20,000 nanodrops and the presence or absence of the target gene is determined by PCR for each nanodrop (Figure 18). From the numbers of positive and negative drops, the gene copy number is calculated from the Poisson distribution to compensate for drops containing more than one gene copy.

Figure 18. ddPCR detection of Sul1 genes in four stormwater samples including positive controls and reagent blanks. Blue dots represent nanodrops with a positive PCR-signal. Grey dots are PCR-negative nanodrops.



Cells were filtered from 200-250 ml stormwater using sterile 100-ml PALL 0.2 µm filter funnels (Pall Corporation cat no. 4803). Filters were then stored at -20°C until DNA extraction. DNA was extracted from the filters using the DNeasy PowerWater Kit (Qiagen) according to the manufacturer's instructions. The amount of DNA was determined using an Invitrogen Qbit 2.0 fluorimeter. DG8 cartridges (Bio-Rad) were loaded with 20 µL PCR reaction and 70 µL droplet generation oil for probes or EvaGreen droplet generation oil (Bio-Rad) and droplets were subsequently generated in a QX200 droplet generator (Bio-Rad). ddPCR reactions with antibiotic-specific templates (Table 5) were analyzed on a QX200 droplet reader (Bio-Rad). Synthetic gene strands (Eurofins Genomics) were used as positive controls. Reagent blanks and bottle blanks (Milli-Q water treated as storm water) were used as negative controls (no-template controls).

Table 5. Targets of ddPCR quantification of resistance genes in stormwater.

Gene	Reference	Target
Intl1	Barraud et al., 2010	Class1 integron integrase, mobile genetic element proxy for resistance/pollution.
Bla$_{\text{CTX-M-1 group}}$	Birkett et al., 2007	Extended spectrum beta-lactam resistance, beta-lactamase.
Bla$_{\text{NDM}}$ (variants 1,3,4,5,6,16)	Kazi et al., 2018	Carbapenem resistance, carbapenemase, broad spectrum beta-lactam resistance, penicillins, cephalosporins and carbapenems.
tetM	Peak et al., 2006	Tetracycline resistance, ribosome protection proteins.
tetB	Peak et al., 2006	
Sul1	Heuer and Smalla, 2007	Sulfonamide resistance.
Sul2	Heuer et al., 2008	

The most common resistance gene was the Sul1 gene that was detected in all samples but in very different concentrations ranging from only 64 copies/ml in roof runoff to 1200000 copies/ml in bypass from a wastewater treatment plant. At the other end of the spectrum was Bla_{NDM} that was non-detectable in most samples (<1.9 copies/ml), and when detected, ranged from 3.4 to 4453 copies/ml. bla_{NDM} was closely correlated to samples with domestic sewage. Copy numbers of resistance genes were, as expected, much higher than the corresponding petrifilm counts of resistant *Enterobacterales* (Figure 16 and Figure 19).

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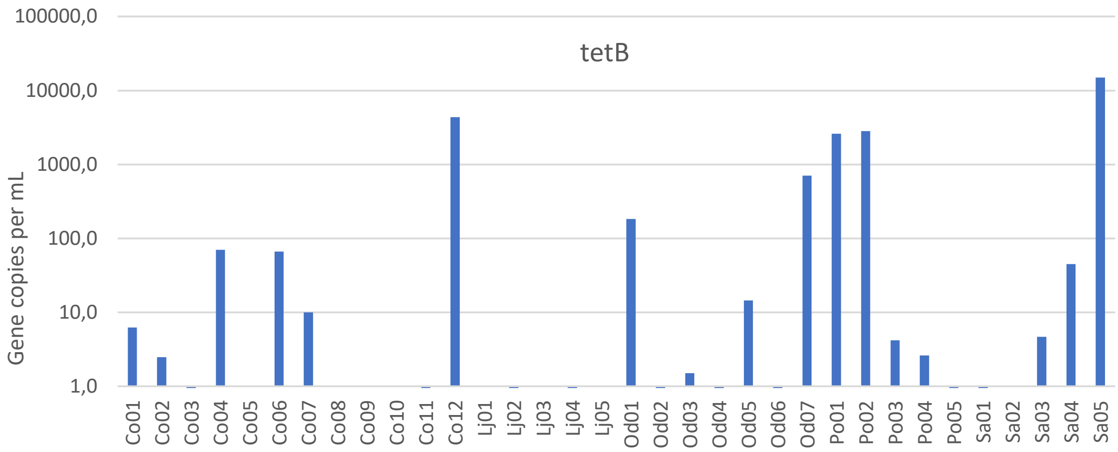

Figure 19. Quantification of tetB tetracycline resistance genes in stormwater from the cities Copenhagen (Co, Denmark), Ljubljana (Lj, Slovenia), Odense (Od, Denmark), Pontedera (Po, Italy) and Santander (Sa, Spain).

Conclusions

We found that the load of antibiotic resistance is high in some types of urban stormwater. The highest levels were in sewer overflow and wastewater treatment plant bypass. This is not surprising as both stormwater types are rainwater mixed with domestic sewage. It was more surprising that we also found some antibiotic resistance genes in surface stormwater in residential areas. These samples presumably were only surface runoff from streets and roofs with no wastewater, but our counts of fecal *E. coli* suggest that that there indeed was some degree of wastewater or other fecal contamination, probably from misconnected pipes and possibly from dog feces. The highest variation was seen for Sul1 and Sul2 genes that were detected in most samples and varied more than five orders of magnitude.

Organic micropollutants

Organic micropollutants in urban stormwater are anthropogenic, organic compounds found in low concentration, typically in µg/L or ng/L. They comprise many classes of organic compounds such as pesticides/biocides, industrial compounds for instance PFAS and rubber chemicals, pharmaceuticals typically found where stormwater is polluted with sewage, and hydrocarbons originating from combustion processes and fuels. For decades, the focus was mostly on the persistent micropollutants that accumulated in the food chain (bioaccumulative), but less than 10 years ago, attention was drawn to a large group of organic micropollutants called persistent, mobile organic compounds (PMOC) (Reemtsma et al., 2016). Since then, more attention has been paid to the mobile substances that are transported in solutions throughout the aquatic environment and are thus of high concern regarding urban stormwater. In 2022, the two classifications, PMT (persistent, mobile, and toxic) and vPvM (very persistent and very mobile) were added to the European chemical authorization REACH as analogies to PBT (persistent, bioccaumulative and toxic) and vPvB (very persistent and very bioaccumulative) (EU, 2023). In D4RUNOFF, the organic micropollutant in source stormwater were analysed with reversed-phase liquid high-resolution mass spectrometry (RP-LC-HRMS) and hydrophilic interaction liquid high-resolution mass spectrometry (HILIC-HRMS) to cover a wide range of compound mobilities. RP-LC-HRMS was applied for full quantification of selected compounds and for suspect screening. HILIC-HRMS was applied only for suspect screening. Suspect screening is searching for compounds in the HRMS-data based only on mass spectra and retention times (i.e. no standards) by comparison to a list of predefined suspect pollutants.

Chemical analysis workflows for RP-LC-HRMS

The workflows used for target, suspect screening, and non-target screening by RP-LC-HRMS have been described elsewhere (see deliverable 1.1) and will be further elaborated in deliverable 1.2 and deliverable 1.6. In short, stormwater samples were filtered using a vacuum flask, and the liquid and solid fractions were extracted with solid-phase extraction (SPE) and pressurized liquid extraction (PLE), respectively, to clean-up and pre-concentrate samples for analysis.

RP-LC-HRMS analysis of the SPE extracts was done on an Acquity Ultra-Performance Liquid Chromatograph equipped with a Synapt G2S quadrupole time-of-flight mass spectrometer (Waters). MS-detection was done with data independent acquisition (DIA) using alternating collision energy in MS^E mode to generate information about the precursor ions with low energy collision and simultaneously run high collision energy to provide information about product ions for identification. Gradient elution using acetonitrile with 0.1 % formic acid and LC-MS grade water with 0.1 % formic acid was done with a Acquity UPLC BEH C18 100mm column (Waters) with 1.7 µm particle size and 2.1 mm inner diameter.

Target analysis with RP-LC-HRMS

Target analytes were quantified based on the response factor determined by external calibration with internal standards. Compounds were identified based on their m/z and retention time matching the reference standards. For RP-LC-HRMS data, peak integration was done using TargetLynx (Waters). Instrument performance was monitored with quality control (QC) samples, consisting of two types: An in-house mix of compounds used to test the between-batch performance and an in-batch mix made by pooling SPE extracts. Quantification was done with an in-house Excel worksheet using the most appropriate calibration fit for each analyte (either linear regression or second-order polynomial regression). In general, weighted regression was used since this gave the lowest uncertainty, especially at the low concentration range. Limit of detection (LOD) and limit of quantification (LOQ) were calculated based on the calibration curve.

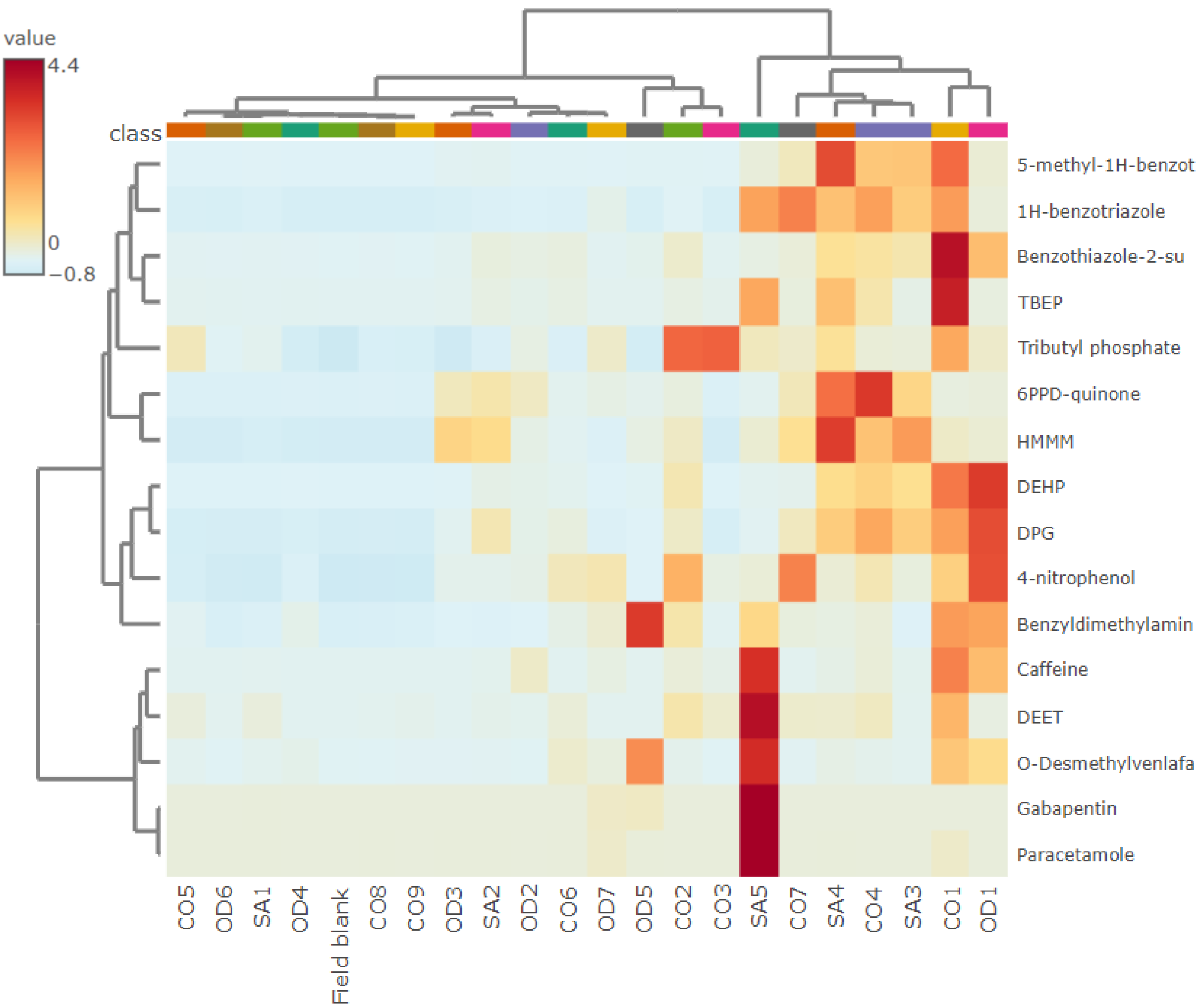

Figure 20. Heatmap of selected target analytes quantified with RP-LC-HRMS, auto-scaled for analytes. Red and blue color indicates high versus low relative abundance respectively.

The target analysis of the first 21 runoff samples covered 109 compounds, 27 of these were detected in at least one sample. The target analysis showed characteristic clustering of samples (Figure 20). SA5 is characteristic for pollutants typical for domestic sewage, such as caffeine and the pharmaceutical paracetamol. Also, CO1 and OD1 show elevated concentrations of these compounds, which suggests an input of domestic sewage, whereas OD7 – that is collected from a combined sewer overflow – has low concentrations of typical wastewater pollutants, possibly because of dilution with rainwater. Another overall group is characterized by industry and rubber compounds, such as 1,3-diphenylguanidine (DPG), 6PPD-quinone, and benzothiazole-2-sulfonic acid. Further data analysis will be done to investigate whether 6PPD-quinone and other compounds might, as suspected, be related to traffic as suggested by Tian et al. (2021).

Suspect screening with RP-LC-HRMS

For suspect screening, an in-house identification system was used, previously described in deliverable 1.1. In short, the workflow, which is presented in Figure 21, consisted of data-processing steps (blue boxes) to ensure reliable data, prioritization (green box), and finally identification of priority compounds based on the software MSDial suggested matches with suspect screening (red boxes). The workflow will be further described in deliverable 1.2 and deliverable 1.6.

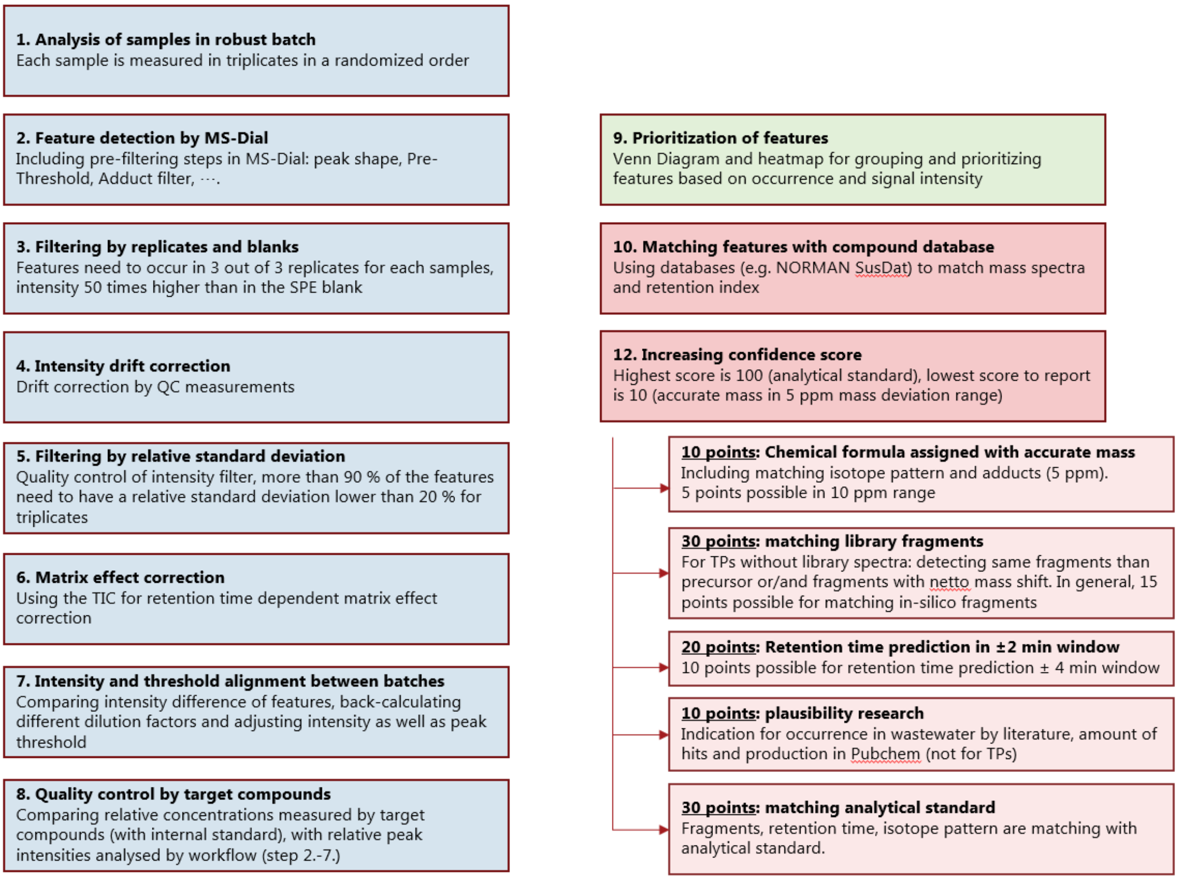

Figure 21. Workflow for suspect screening of LC-HRMS data.

In the inventory, the confidence of the suspect screening identification is presented as a score from 10-100. Suspects features (chromatographic peaks with mass spectra and retention times) with scores below 10, i.e., no accurate mass match below 5 ppm deviation, were excluded. Only features with suggested matches from MSDial were included in suspect screening results.Signal intensities of suspects are reported as maximum peak intensities. However, it is important to note that these do not necessarily indicate actual concentrations, since ionization efficiencies vary greatly depending on the elution conditions and chemical structure of the compounds. The suspect screening results show many features in the samples. Tentatively identified pollutants include the industry compound bisphenol S, the pesticides 2-methyl-4,6-dinitrophenol (DNOC) and terbucarb, among others. Further analysis will be performed to assign unambiguous identity to these and other suspect pollutants, and to prioritize features based on occurrence and signal intensities in all runoff samples.

Suspect screening using HILIC-HRMS

The D4Runoff-screening directs a special focus also towards the mobile and very mobile compounds, which have a very high risk to leach through the NBS-systems, if they are not degraded, and end up in urban surface and groundwater. Hydrophilic interaction liquid chromatography (HILIC) aims at retaining these mobile and very mobile compounds, which are not or only poorly retained in reversed phase liquid chromatography (RP-LC). Consequently, we included the HILIC chromatography type coupled to HRMS to identify very mobile suspects. For analysis by RP-LC-HRMS (above), the samples were extracted using solid phase extraction (SPE). By SPE extraction, there is, however, a high risk of losing the very mobile compounds as it is challenging to find an SPE-material, which can retain them. Thus, to avoid loss of mobile compounds during extraction, the samples for HILIC-HRMS were instead concentrated by vacuum evaporation. In this process, water is removed at low temperature (55°C) and vacuum (20 mbar), and the sample are then redissolved in acetonitrile and analyzed using the HILIC-HRMS platform. The results are reported as normalized peak intensities – peak intensity divided by the peak intensity of an internal standard (atrazine-desethyl-d5), which was added to each sample prior evaporation. Level of confidence is displayed according to Schymanski et al. (2014).

Suspect screening results of the first 21 samples showed widespread presence of various quaternary ammonium compounds (QACs), e.g. benzalkonium chlorides. Of these, only benzyldimethyldodecylammonium chloride (BAC C12) was verified with an analytical standard (i.e., confidence level 1). Based on structural similarities, BAC C14, BAC C16 and BAC C18 were identified as probable compounds (confidence level 2b). Street runoff samples from city centers showed very high normalized peak intensity of BAC C12 (Figure 22; Od05 & Sa04). Quaternary ammonium compound (Arnold et al., 2023) are a compound group of biocidal surfactants used for indoor disinfection and in cleaning products for outdoor surfaces. A major application in the urban environment is removal of algae from facades and terraces (Figure 23).

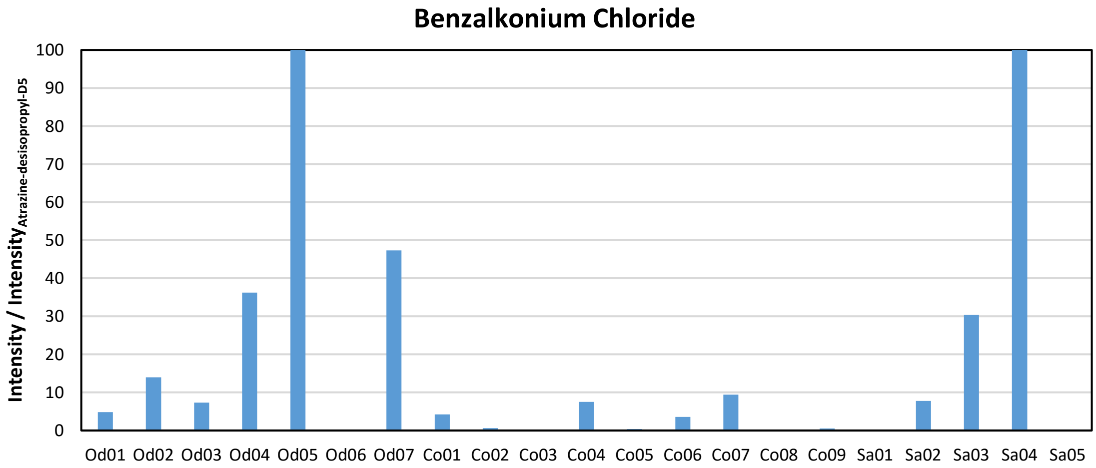

Figure 22. Occurrence of C12-benzalkonium chloride (BAC C12) in stormwater samples; peak intensity was normalized to the internal standard atrazine-desisopropyl-D5.

Figure 23. Algicide for sale at a Danish supermarket. The active substance is the quaternary ammonium compound didecyldimethylammoniumchloride (0,5% w/w). The product is intended for removing algae from: "hard surfaces such as cement, fiber-cement, concrete, terracotta, wood, glass, metal, plastic, solar panels, brick, roofs, facades, wooden terraces, garden furniture, fences and so on. For annual maintenance".

Melamine is another compound often found in the urban surface runoff. The highest normalized peak intensity was found in a sample from a surface runoff infiltration trench between terraced houses (Co07). Melamine is used together with formaldehyde and methanol to produce hexa(methoxymethyl)melamine (HMMM). HMMM is further used as a crosslinking agent in the production of coatings and rubber items for instance in car tires. Both, melamine and HMMM, are also monomeric intermediates in the formation of melamine resin. Melamine resins are durable plastics used in various building materials e.g. in laminate flooring or insulation, as superplasticizer in high-resistant concrete as well as fire-retardant additive in paints, plastics, and paper.

Conclusions

Until now, 21 runoff samples have been analyzed for the inventory. Further chemical analysis will be done once all runoff samples are collected in task 1.3. The target analyses of runoff samples showed the presence of pollutants that indicate specific pollution sources such as domestic sewage, rubber, and traffic. Suspect screening furthermore indicated the occurrence of various quaternary ammonium compounds, and a wide range of additional suspect compounds.

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Annex 1. Potential stormwater pollutants identified in reports from the Danish Environmental Protection Agency.

	CAS RN	Building materials (Bester et al., 2022)	Crushed concrete, brick and roof tile (Hjelmer et al., 2018)	Surface-treated roof tile, concrete, fiber-cement (Hjelmar et al., 2020)	Biocides used in Denmark (Lassen et al., 2001)	Outdoor cleaning agents (Pedersen 2023)	Particle-bound biocides (Vianello 2021)
1,2-Benzisothiazolin-3-one	2634-33-5			x		x	x
1,2-Propylene glycol	57-55-6					x	
1,3,5-Triazine-2,4,6-(1H,3H,5H)-trione, 1,3-dichloro-,	2893-78-9						
1,3-Bis(hydroxymethyl)-5,5-dimethylimidazolidine-2,4-dione	6440-58-0	x					
1-H-benzotriazole	95-14-7				x		
2-(dimethylamino)-2-methylpropan-1-ol	7005-47-2				x		
2,2′,2″-(Hexahydro-1,3,5-triazine-1,3,5- triyl)triethanol	4719-04-4	x			x		
2,2′-Dithiobis[N-methylbenzamide]	2527-58-4	x					
2,2-Dibromo-2-cyanoacetamide	10222-01-2	x					
2,2'-Dithiobis[N-methylbenzamide]	2527-58-4	x					
2-(2-Butoxyethoxy)/2-(2-butoxy-ethoxy) ethanol	112-34-5					x	
2,6-Di-tert-butyl-p-cresol	128-37-0				x		
2-Bromo-2-(bromomethyl)pentanedinitrile	35691-65-7	x					
2-Bromo-2-nitro-1,3-propanediol	52-51-7				x		
2-Butylbenzo[d]isothiazol-3-one		x					
2-Chloroacetamide	79-07-2				x		
2-Chloro-N-(hydroxymethyl)acet-amide	2832-19-1				x		
2-Ethylhexanol polyglycol ether phosphoric acid ester,	111798-26-6					x	
2-Methyl-1,2-benzothiazol-3(2H)-one	2527-66-4	x					
2-Methyl-4-isothiazolin-3-one	2682-20-4					x	x
2-Methylphenol	95-48-7			x			

(2-Methoxymethylethoxy)propanol	34590-94-8					x	
2-Phenoxyethanol	9004-78-8	x		x	x	x	
(2-(Tert-butylamino)-4-(cyclo-propylamino)-6-(methylthio)-1,3,5-triazine)							x
3,5,7-Triaza-1-azoniatricyclo[3.3.1.13,7]decane, 1-(3-chloro-2-propenyl)-, chloride	4080-31-3				x		
4,4-Dimethyloxazolidine	51200-87-4				x		
4-Chloro-3,5-dimethylphenol	88-04-0				x		
4-Chloro-3-methylphenol	59-50-7				x		
4-Methylphenol	106-44-5			x			
Al							x
Alcohols C12-14, ethoxylated	68439-46-3					x	
Alcohols,_C9-11_ethoxylated	68424-85-1					x	
Alkyldimethylbenzylammoniumchlorid	85409-22-9					x	
Alkylimidazoliniumcarboxylat	68604-71-7					x	
Alkylpolyglykosid C10-16	110615-47-9					x	
Ametryne	834-12-8		x				
Anthraquinone	84-65-1			x			
As			x	x			x
Azoxystrobin	131860-33-8	x					
B				x			
Ba			x				x
Benzalkoniumchloride	63449-41-2	x					
Benzenesulfonamide, N-chloro-4-methyl-, sodium	127-65-1				x		
Benzenesulfonic,acid,1-methylethyl	28348-53-0					x	
Benzoic acid, 2-hydroxy-, methyl ester	119-36-8				x		
benzoic acid, 4-hydroxy-, methyl ester	99-76-3				x		
Benzoic acid, 4-hydroxy-, propyl ester	94-13-3				x		
(Benzyloxy)methanol	14548-60-8	x					
Benzothiazol-2-ylthio)methyl thiocyanate	21564-17-0	x					
Benzylalkohol	100-51-6					x	
Benzyl isothiazolinone	2634-33-5	x	x				
Benzyl salicylate	118-58-1					x	
Biphenyl-2-ol	90-43-7	x			x		
Bronopol	52-51-7						
Carbamic acid, butyl-, 3-iodo-2-propynyl ester	55406-53-6				x		
Carbendazim	10605-21-7	x		x			x
Cd				x			
Ce				x			

Co				x			
Cocoamidopropylbetaine	61789-40-0					x	
Cr			x	x			x
Cu			x	x			x
Cybutryne	28159-98-0			x			
Denatonium benzoate	3734-33-6				x		
Dichloro-N-[(dimethylamino)sulphonyl] fluoro-N-(ptolyl)methanesulphenamide	731-27-1	x		x			
Dichlorooctylisothiazolinone	64359-81-5	x		x			x
Didecyldimethylammoniumchlorid	7173-51-5					x	
Dimethyldithiocarbamate	128-04-1				x		
Diuron		x					x
DNOC	534-52-1			x			
Dodecyldimethylaminoxid	1643-20-5					x	
EDTA	64-02-8					x	
Fenuron	101-42-8			x			
Fludioxonil	131341-86-1	x		x			
Folpet	133-07-3	x			x		
Hexahydro-1,3,5-triazine	110-90-7				x		
Hexahydro-1,3,5-tris(hydroxyethyl)-s-triazine	4719-04-4				x		
Imidazo[4,5-d]imidazole-2,5(1H,3H)-dione, tetrahydro-1,3,4,6-tetrakishydroxymethyl	5395-50-6				x		
Iodocarb	55406-53-6	x				x	x
Isotridecanolethoxylat	61827-42-7					x	
Isoproturon	34123-59-6			x			x
Mecoprop	93-65-2	x		x			x
Mercaptobenzothiazole	149-30-4				x		
Methyl salicylate	199-36-8				x		
methylchloroisothiazolinone	26172-55-4		x	x			
Methylisothiazolinone	2682-20-4	x	x				
Morpholine	110-91-8				x		
Myristalkonium chloride	39-08-2				x		
N-(3-aminopropyl)-N-1,3-diamine	2372-82-9				x		
N,N′-Methylenebismorpholine	5625-90-1	x		x			
Naphthalen				x			
Natriumlaurylethersulfat	68585-34-2					x	
Nitrilotriacetate, trisodium	5064-31-3					x	
Nonanoic acid	112-05-0					x	
Pyrithione	1121-30-8			x			
Ni			x				
Octylisothiazolinone	26530-20-1	x				x	x
Octylphenoxypolyetoxyethanol	9002-93-1			x			
Para-tert-octylphenol	140-66-9			x			
Pb			x	x			x
PCB 101			x	x			
PCB 118			x				

PCB 138			x				
PCB 153			x				
PCB 180			x				
PCB 28			x				
PCB 52			x				
Penflufen	494793-67-8	x					
Poly(oxy-1,2-ethanediyl), α-(2-propylheptyl)-ω-hydroxy	160875-66-1					x	
Pr				x			
Propiconazole	60207-90-1	x					x
Quarternary C12-14 alkyl methyl amine ethoxylate methyl chloride	1554325-20-0					x	
Se			x	x			
Sn				x			
Sulfamic acid	5329-14-6					x	
dimethyldithiocarbamate	137-30-4	x					
Tebuconazole	107534-96-3	x					x
Terbutryne	886-50-0	x		x			x
Tetranatrium-N,Nbis(carboxyla-tomethyl)-Lglutamate	51981-21-6					x	
Thiabendazole	148-79-8	x		x			
Thiacloprid	111988-49-9	x					
Thiamethoxam	153719-23-4	x					
Thiocyanic acid 2-benzothiazol-ylthio)methyl ester	21564-17-0				x		
Thiram	137-26-8	x					
Ti							x
Triethanolamin	102-71-6					x	
Trimethyl-3[{-1-oxo-10-unde-cenyl) amino]propylammonium methyl sulphate						x	
V				x			
Zinc pyrithione	13463-41-7	x					
Zn			x	x			x

Annex 2. Antibiotics sales statistics

Sales statistics of antibiotics in Denmark in 2021 in the primary sector (i.e., not hospitals).

Antibiotic class	Compound and WHO ATC code	Amount (1000 units)
Penicillins	Phenoxymethylpenicillin (V-penicillin) J01CE02	6156,4
	Amoxillin and amoxillin + betalactamaseinhibitor	2615
	Flucloxacillin J01CF05	72,2
	Ampicillin J01CA01	32,5
	Benzylpenicillin (G-penicillin) J01CE01	6,6
	Cloxacillin J01CF02	0,1
	Mecillinam J01CA11	0
Tetracyclines	Doxycycline A01AB22, J01AA02	1963,7
	Tetracycline A01AB13, J01AA07	917,7
	Lymecycline	624,5
Macrolids	Azithromycin J01FA10, S01AA26	1048,1
	Roxithromycin J01FA06	768,1
	Clarithromycin J01FA09	490,1
	Erythromycin, J01FA01	66,4
Fluoroquinolones	Ciprofloxacin J01MA02, S01AE03, S02AA15	618,9
	Moxifloxacin J01MA14, S01AE07	82,8
	Levofloxacin J01MA12, S01AE05	4,3
Sulfonamides	Sulfametizol J01EB02, S01AB01	201,3
	Sulfametoxazol + trimetoprim	8,1
	Sulfapyridin J01EB04	0,2
	Sulfadiazin	0
Cephalosporins	Cefuroxim J01DC02, S01AA27	35,2
	Ceftriaxon J01DD04	9,8
	Cefalexin J01DB01	4,6
	Ceftazidim J01DD02, J01DD02	1,4
	Ceftarolin fosamil	0
Monobactams	Aztreonam J01DF01	4,7
Carbapenemes	Meropenem J01DH02	0,5
	Ertapenem J01DH03	0,1
	Imipenem + cilastatin	0

Annex 3 - Descriptions of sampled stations

The following station descriptions were provided by the project partner that carried out the sampling at the specific station. The descriptions are based on a station characterization protocol provided in the sampling kits. Station data in the inventory file is based on the data provided in the station descriptions.

Co01 - Nybrogade

Date of sampling: 26/06/2023	
Name of the person who carried out the sampling and institution: Thomas Karlsson, UCPH	
Short description of site and mode of sampling: Nybrogade. Manual sampling with subsurface sampler from manhole receiving combined roof and street runoff from stormwater drains. Older inner city area (predominantly 19th century buildings) with light traffic, urban squares, pedestrian shopping streets. Total catchment area: 1,05 Ha. More information: Tidsbegrænset Udledningstilladelse til UØ60, Pilotprojekt om "Low flow diversion" som renseløsning ved udledning af almindeligt belastet regnvand til Københavns Havn 2/19	
Country: Denmark	
City/town: Copenhagen	
Position: 55.6758856019551, 12.575312432869598	
Estimated time since previous rain event (>1 mm per day) if known: 10 **days, otherwise estimate**	
	7-14 days
	15-21 days
	21-28 days
	>28 days
Sources, drained area	
	Single houses/terraced residential area, estimate decade(s) for dominant buildings:
X	Inner city, old buildings (typically <1930) estimate decade(s) for dominant buildings: **18th-19th century**
	Inner city, new buildings (typically >1950) estimate decade(s) for dominant buildings:
	Small industry, if possible, specify type:
X	Traffic/street
	Parking lots
	Mixed stormwater
X	Risk of mixing with municipal sewage
X	Other (describe) Urban squares & pedestrian shopping streets
Pavement, drained area (if relevant for drained area, major components only)	
X	Concrete/concrete slabs/cement slabs
X	Asphalt/bitumen
	Gravel
X	Cobble stones
	Lawn (cut grass)
	Other (describe)
Building facades, drained area (if relevant for drained area, major components only)	
X	"Raw" bricks
X	Mortar plaster/painted mortar plaster/painted bricks
	Wood/painted wood/impregnated wood
	Concrete
	Metal/painted metal

	Fiber cement plates/painted fiber cement/ceramic tiles
	Other (describe)
Roofing (if relevant for drained area, major components only)	
X	Roof tiles (terracotta-, clay- or cement/concrete tiles)
	Fiber cement plates/eternit
X	Metal roofing/metal shingles/painted metal
	Rolled asphalt roofing/bitumen roofing felt/asphalt composite shingles
X	Shale slate shingles (natural)
	Plastic/PVC
Precipitation readings (accumulated): Not available	
	0 min: 15 min: 30 min: 45 min: 60 min: 75 min: 90 min: 120 min: ARJ: According to DMI's weather archive: 6,9 mm

Manhole used for sampling, in the background discharge point into Slotsholmskanalen.

View of catchment area from sampling point.

Catchment area description.

Bilag 3

Nedenfor angives det afkoblede areal i projektet til samlet 0.85 ha og udgøre derved 25% af det samlede areal på 3.5 ha som renderne betjener.

Tabel 3: Opgørelse af oplandsarealer til udløb UØ60 placeret for enden af Rådhusstræde, København.

Overfladekategori	**Samlet areal [m2]**
Tage af kobber, kobbertagrender el. -inddækning	105
Tage af zink, zinktagrender el. -inddækning	1.697
Veje (ÅDT 5.000 - 15.000 køretøjer)	2.693
Centrale bymiljøer (pladser)	4.083

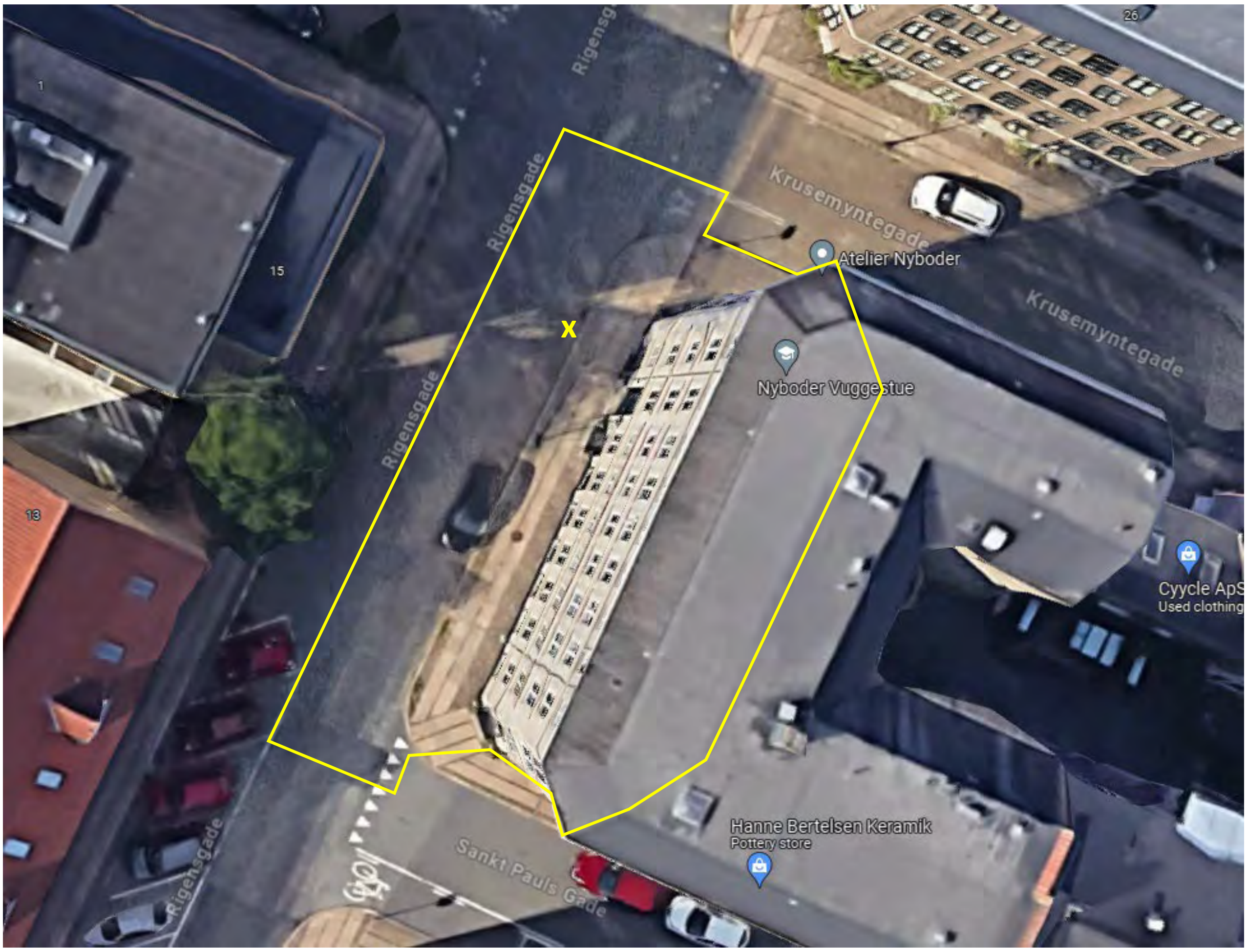
Co02 - Rigensgade

Date of sampling: 26/6-2023	
Name of the person who carried out the sampling and institution: Anders Johnsen, GEUS	
Short description of site and mode of sampling: Rigensgade, Street runoff from city street, sampled where water enters a storm drain. Storm drain, central Copenhagen (behind GEUS). Older multi-storey buildings, downpipes from roofs lead directly onto the street, rolled asphalt roofs, plastered facades, cobblestone road, concrete slabs pavement, parking spaces. Manual sampling	
Country: Denmark	
City/town: Copenhagen	
Position: GPS coordinates from Google Maps on a mobile phone: 55.6883901 12.5835269	
Estimated time since previous rain event if known: 34 **days,** Determined from DMI's weather archive where it rained a lot on 23 May (5mm), smaller rainfall events according to DMI on 16 and 17 June (3 and 1 mm) are not registered by the rain collector on GEUS' roof. **otherwise estimate**	
	7-14 days
	15-21 days
	21-28 days
	>28 days
Sources, drained area	
	Single houses/terraced residential area, estimate decade(s) for dominant buildings:
x	Inner city, old buildings (typically <1930) estimate decade(s) for dominant buildings: 1853 https://www.hovedstadshistorie.dk/ny-koebenhavn/rigensgade/
	Inner city, new buildings (typically >1950) estimate decade(s) for dominant buildings:
	Small industry, if possible, specify type:
x	Traffic/street
x	Parking lots
	Mixed stormwater
	Risk of mixing with municipal sewage
	Other (describe)
Pavement, drained area (if relevant for drained area, major components only)	
x	Concrete/concrete slabs/cement slabs
	Asphalt/bitumen
	Gravel
x	Cobble stones
	Lawn (cut grass)
	Other (describe)

Building facades, drained area (if relevant for drained area, major components only)	
	"Raw" bricks
x	Mortar plaster/painted mortar plaster/painted bricks
	Wood/painted wood/impregnated wood
	Concrete
	Metal/painted metal
	Fiber cement plates/painted fiber cement/ceramic tiles
	Other (describe)
Roofing (if relevant for drained area, major components only)	
	Roof tiles (terracotta-, clay- or cement/concrete tiles)
	Fiber cement plates/eternit
	Metal roofing/metal shingles/painted metal
x	Rolled asphalt roofing/bitumen roofing felt/asphalt composite shingles
	Shale slate shingles (natural)
	Plastic/PVC
Precipitation readings (accumulated): Sampling startet 15:29 (start of rain event, t0), samples taken every 15 min. No rain gauge. A short intense event (10 min) followed by light precipitation until 17:05. A total of 5 mm (measured by sampler on GEUS roof).	

7 samples (0-90 min, no t120 sample). Estimated 70% of the water came from the roofs, the rest from the street (cobble stones, no asphalt) and the pedestrian pavement (concrete slabs).

Drained area and sampling point:



View from storm drain, SSW (main drained area)

View from storm drain, NNE

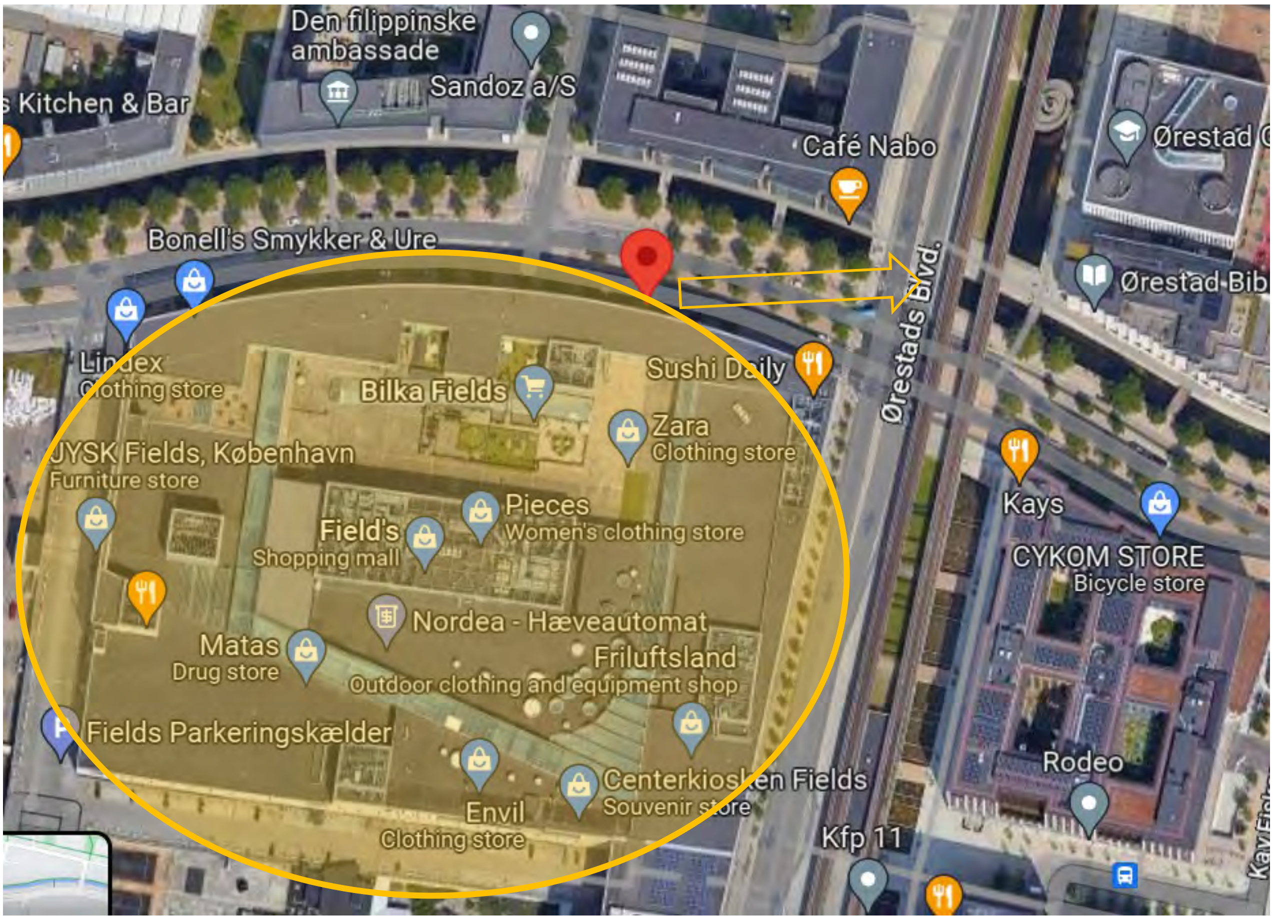
Water from roof at storm drain.

Samples

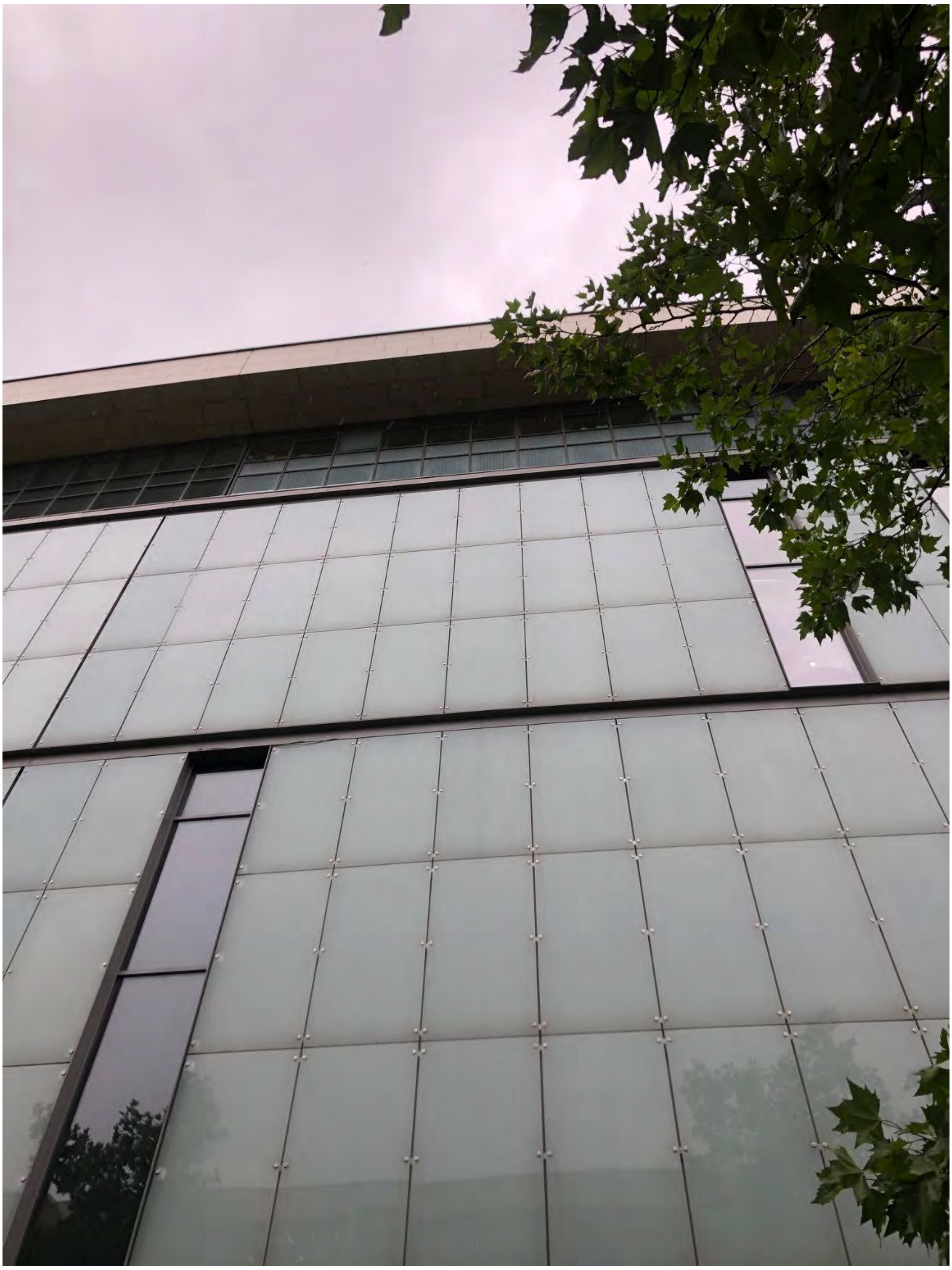
Co03 – Field’s

Date of sampling: 31/08/2023	
Name of the person who carried out the sampling and institution: Thomas Karlsson, UCPH	
Short description of site and mode of sampling: Roof runoff from Field’s shopping mall. Runoff from the roof is led in separate sewage network and released in the nearby canal (Hovedkanal City). Sampling: Manual sampling with sub-surface grab sampler from separate sewage line (roof runoff only).	
Country: Denmark	
City/town: Copenhagen	
Position: 55.63128413284998, 12.578583036845984	
Estimated time since previous rain event (>1 mm per day) if known: 5 **days, otherwise estimate** Determined from DMI weather archive for Copenhagen	
	7-14 days
	15-21 days
	21-28 days
	>28 days
Sources, drained area: Single building, shopping mall constructed in 2004	
	Single houses/terraced residential area, estimate decade(s) for dominant buildings:
	Inner city, old buildings (typically <1930) estimate decade(s) for dominant buildings:
	Inner city, new buildings (typically >1950) estimate decade(s) for dominant buildings:
	Small industry, if possible, specify type:
	Traffic/street
	Parking lots
	Mixed stormwater
X	Risk of mixing with municipal sewage Not suspected, but potentially there could be mis-connection in sewage network.
	Other (describe)
Pavement, drained area (if relevant for drained area, major components only)	
	Concrete/concrete slabs/cement slabs
	Asphalt/bitumen
	Gravel
	Cobble stones
	Lawn (cut grass)
	Other (describe)
Building facades, drained area (if relevant for drained area, major components only)	
	“Raw” bricks
	Mortar plaster/painted mortar plaster/painted bricks
	Wood/painted wood/impregnated wood
	Concrete
	Metal/painted metal

	Fiber cement plates/painted fiber cement/ceramic tiles
	Other (describe)
Roofing (if relevant for drained area, major components only)	
	Roof tiles (terracotta-, clay- or cement/concrete tiles)
	Fiber cement plates/eternit
	Metal roofing/metal shingles/painted metal
X	Rolled asphalt roofing/bitumen roofing felt/asphalt composite shingles Roofing felt (tagpap) based on Google Maps satellite photos
	Shale slate shingles (natural)
	Plastic/PVC
Precipitation readings (accumulated): Not available	
	0 min: 0,5 15 min: 3,0 30 min: 3,7 45 min: 4,2 60 min: Rain stopped – only very light rain after this point with no visible runoff flow 75 min: 90 min: 120 min:



Sampling station with drainage into nearby canal.



View of Field's from sampling station.

View of the street from sampling station. NB: Samples consist only of roof runoff.

Sampling setup with sub-surface grab sampler.

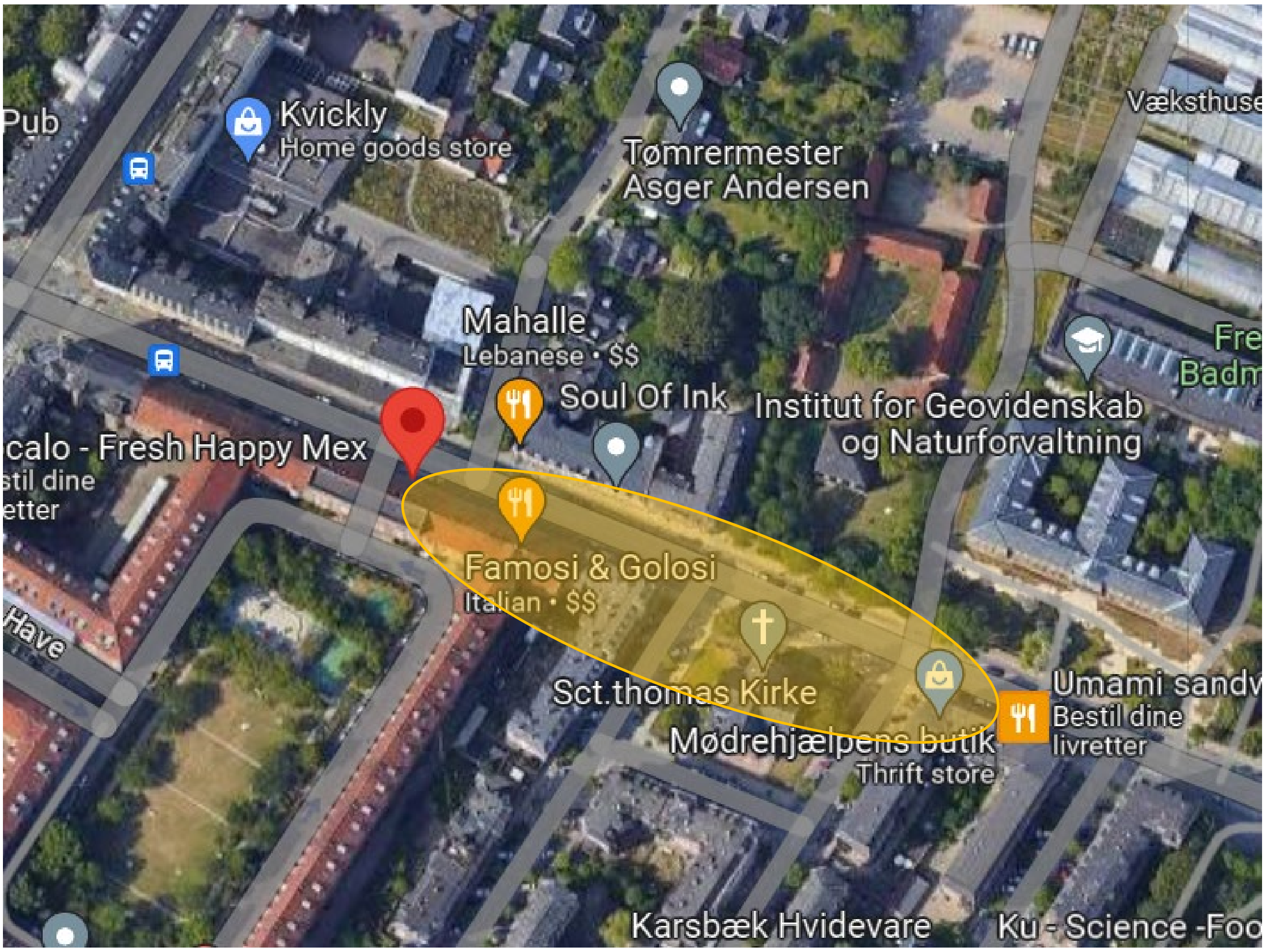
Manhole where samples were collected, at peak flow (approximately 10 minutes after rain started).


Manhole where samples were collected. Picture taken towards the end of the rain event.

Co04 - Rolighedsvej

Date of sampling: 31/08/2023	
Name of the person who carried out the sampling and institution: Daniele Martuscelli, UCPH/ITS	
Short description of site and mode of sampling: Residential area. Manual sampling of stormwater entering the drain at the side of the road. Because of the topography of the road, runoff mainly drains from one side of the road (see picture). Buildings from around 1930's, parked cars and medium trafficked roads. Local shops include a dry-cleaner, bike repair shop, and restaurants.	
Country: Denmark	
City/town: Copenhagen	
Position: 55.68488499192096, 12.540308007021087	
Estimated time since previous rain event (>1 mm per day) if known: 5 **days, otherwise estimate** Determined from DMI weather archive for Copenhagen	
	7-14 days
	15-21 days
	21-28 days
	>28 days
Sources, drained area	
	Single houses/terraced residential area, estimate decade(s) for dominant buildings:
X	Inner city, old buildings (typically <1930) estimate decade(s) for dominant buildings: 1930's
	Inner city, new buildings (typically >1950) estimate decade(s) for dominant buildings:
	Small industry, if possible, specify type:
X	Traffic/street
X	Parking lots
	Mixed stormwater
	Risk of mixing with municipal sewage
X	Other (describe) Shops, including dry-cleaner and bicycle repair shop
Pavement, drained area (if relevant for drained area, major components only)	
X	Concrete/concrete slabs/cement slabs
X	Asphalt/bitumen
	Gravel
	Cobble stones
	Lawn (cut grass)
	Other (describe)
Building facades, drained area (if relevant for drained area, major components only)	
X	"Raw" bricks
	Mortar plaster/painted mortar plaster/painted bricks

	Wood/painted wood/impregnated wood
	Concrete
	Metal/painted metal
	Fiber cement plates/painted fiber cement/ceramic tiles
	Other (describe)
Roofing (if relevant for drained area, major components only)	
X	Roof tiles (terracotta-, clay- or cement/concrete tiles)
	Fiber cement plates/eternit
	Metal roofing/metal shingles/painted metal
	Rolled asphalt roofing/bitumen roofing felt/asphalt composite shingles
X	Shale slate shingles (natural)
	Plastic/PVC
Precipitation readings (accumulated): Not available	
	0 min: 0 15 min: 2,5 30 min: 4,5 45 min: 5,7 60 min: 6,2 75 min: Rain stopped. 90 min: 120 min:



Map of catchment area.

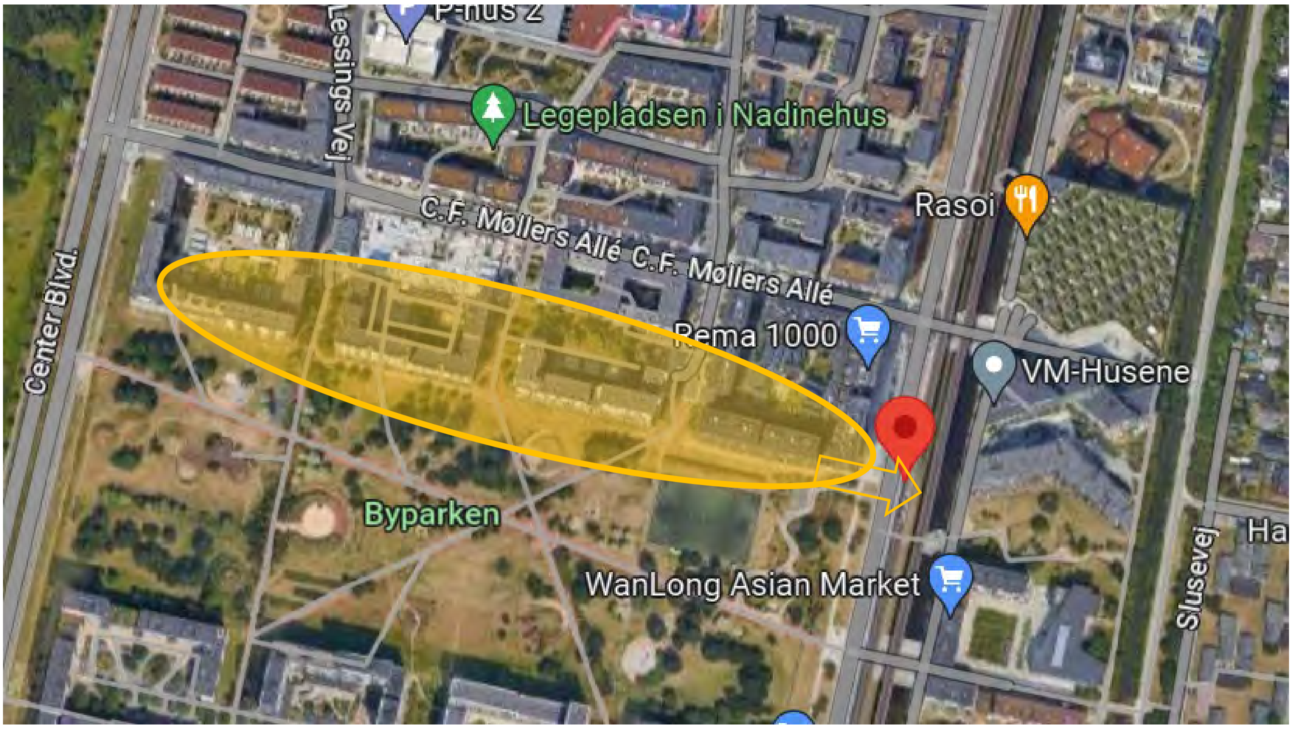
View of sampling station. Catchment area and sampling point marked. Because of the topography of the road, runoff flow predominantly from one side of the road and uphill from the sampling point.

Sampling point during sampling.

Co05 – Metro

Date of sampling: 31/08/2023	
Name of the person who carried out the sampling and institution: Flavia Gravina UCPH	
Short description of site and mode of sampling: Roof runoff from newly constructed residential buildings. Runoff from the roofs is led in separate sewage network and released in the nearby canal (Hovedkanal City). Sampling: Manual sampling with sub-surface grab sampler from separate sewage line (roof runoff only).	
Country: Denmark	
City/town: Copenhagen	
Position: 55.63398317287694, 12.581168231816752	
Estimated time since previous rain event (>1 mm per day) if known: 5 **days, otherwise estimate** Determined from DMI weather archive for Copenhagen	
	7-14 days
	15-21 days
	21-28 days
	>28 days
Sources, drained area:	
X	Single houses/terraced residential area, estimate decade(s) for dominant buildings: 2005-2010
	Inner city, old buildings (typically <1930) estimate decade(s) for dominant buildings:
	Inner city, new buildings (typically >1950) estimate decade(s) for dominant buildings:
	Small industry, if possible, specify type:
	Traffic/street
	Parking lots
	Mixed stormwater
X	Risk of mixing with municipal sewage Not suspected, but potentially there could be mis-connection in sewage network.
	Other (describe)
Pavement, drained area (if relevant for drained area, major components only)	
	Concrete/concrete slabs/cement slabs
	Asphalt/bitumen
	Gravel
	Cobble stones
	Lawn (cut grass)
	Other (describe)
Building facades, drained area (if relevant for drained area, major components only)	
	"Raw" bricks
	Mortar plaster/painted mortar plaster/painted bricks
	Wood/painted wood/impregnated wood

	Concrete
	Metal/painted metal
	Fiber cement plates/painted fiber cement/ceramic tiles
	Other (describe)
Roofing (if relevant for drained area, major components only)	
	Roof tiles (terracotta-, clay- or cement/concrete tiles)
	Fiber cement plates/eternit
	Metal roofing/metal shingles/painted metal
X	Rolled asphalt roofing/bitumen roofing felt/asphalt composite shingles Roofing felt (tagpap) based on satellite photos from Google Maps
	Shale slate shingles (natural)
	Plastic/PVC
Precipitation readings (accumulated):	
	0 min: 0,5 15 min: 3,0 30 min: 3,7 45 min: 4,2 60 min: Rain stopped – only very light rain afte this point with no visible runoff flow 75 min: 90 min: 120 min:



Map of sampling station, catchment area and discharge into nearby canal.

Manhole where samples were collected with catchment area behind.

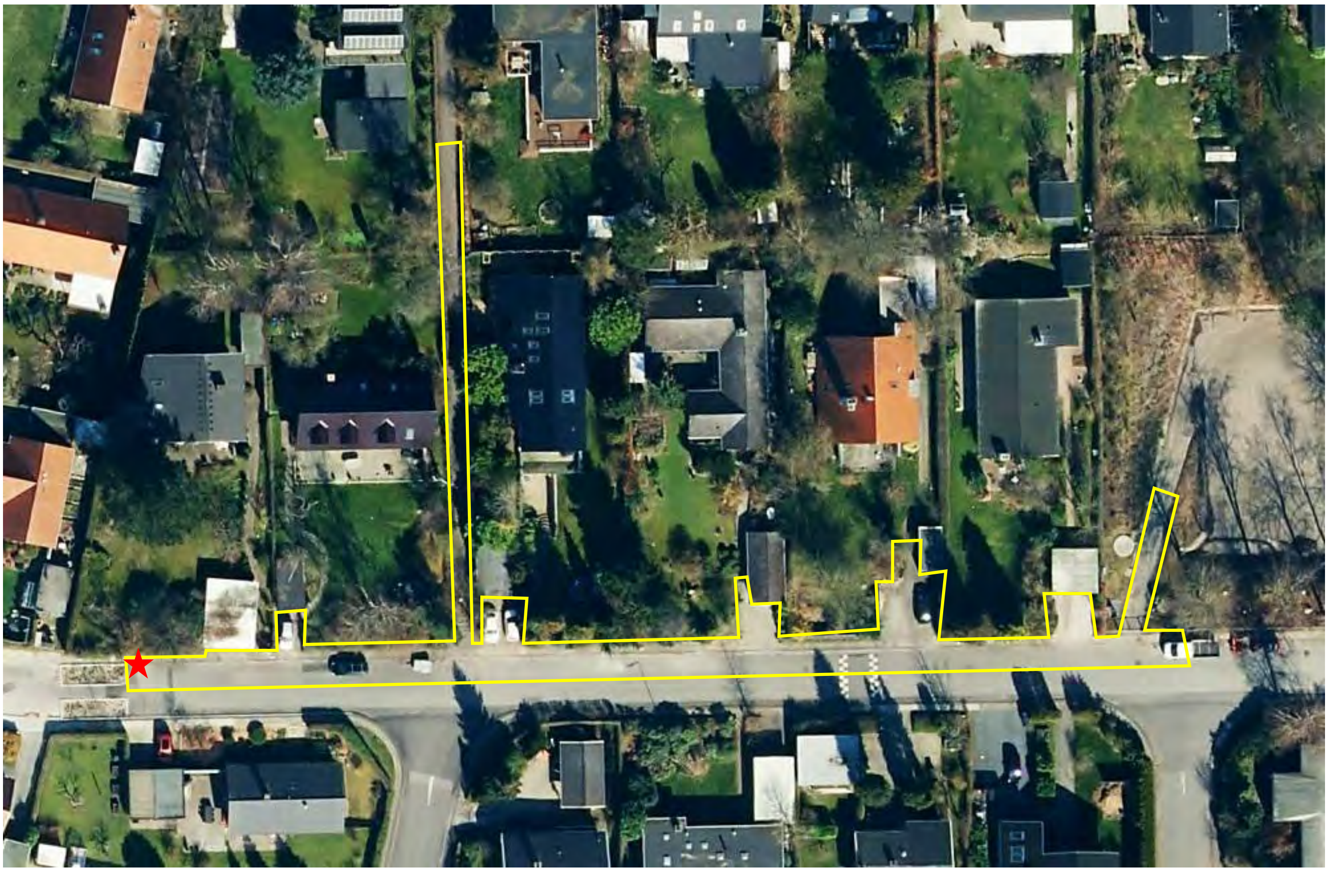
View of discharge point into canal.

Co06 - Vaerlose

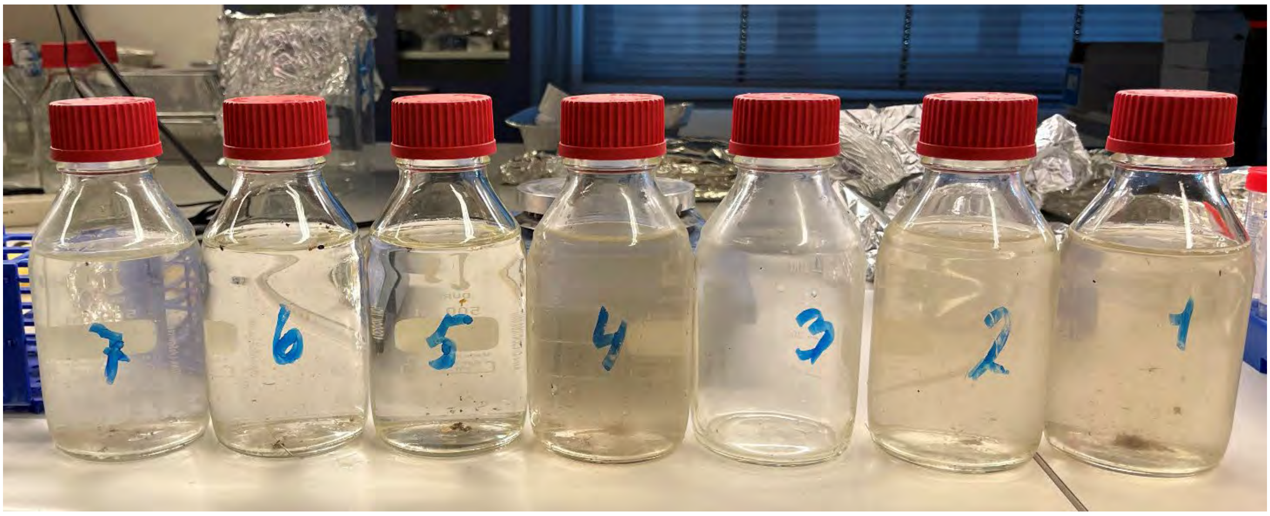
Date of sampling: 31/8-2023	
Name of the person who carried out the sampling and institution: Anders Johnsen, GEUS	
Short description of site and mode of sampling: Suburban residential area. Inlet to street rain bed receiving water from driveways, pavement and street, sampled from inlet to rainbed. Manual sampling	
Country: Denmark	
City/town: Værløse	
Position: GPS coordinates from Google Maps on a mobile phone: 55.7809192 12.3558112	
Estimated time since previous rain event if known: 4 **days,** Determined from DMI's weather archive (Furesø Municipality) **otherwise estimate**	
	7-14 days
	15-21 days
	21-28 days
	>28 days
Sources, drained area	
x	Single houses/terraced residential area, estimate decade(s) for dominant buildings: 1970'ties
	Inner city, old buildings (typically <1930) estimate decade(s) for dominant buildings:
	Inner city, new buildings (typically >1950) estimate decade(s) for dominant buildings:
	Small industry, if possible, specify type:
x	Traffic/street
x	Parking lots
	Mixed stormwater
	Risk of mixing with municipal sewage
	Other (describe)
Pavement, drained area (if relevant for drained area, major components only)	
x	Concrete/concrete slabs/cement slabs
x	Asphalt/bitumen
x	Gravel
	Cobble stones
	Lawn (cut grass)
	Other (describe)
Building facades, drained area (if relevant for drained area, major components only)	
	"Raw" bricks
	Mortar plaster/painted mortar plaster/painted bricks
	Wood/painted wood/impregnated wood

	Concrete
	Metal/painted metal
	Fiber cement plates/painted fiber cement/ceramic tiles
	Other (describe)
Roofing (if relevant for drained area, major components only)	
	Roof tiles (terracotta-, clay- or cement/concrete tiles)
	Fiber cement plates/eternit
	Metal roofing/metal shingles/painted metal
	Rolled asphalt roofing/bitumen roofing felt/asphalt composite shingles
	Shale slate shingles (natural)
	Plastic/PVC
Precipitation readings (accumulated): Sampling startet 10:10 (start of rain event, t0), samples taken every 15 min. Sample 1 0 min: 1,2mm Sample 2 15 min: 1,7 mm Sample 3 30 min: 1,7 mm, no sample Sample 4 45 min: 2,7 Sample 5 60 min: 3,5 mm Sample 6 75 min: 5,5 mm Sample 7 90 min: 6,7 mm Sample 8 120 min: 7,1 mm: no sample Rain stopped at 10:30 -> no t30 sample, rain resumes at 10:55 Rain stopped at 10:04 -> no t120 sample, total precipitation during 120 min: 7,1 mm	

Drained area and sampling point:



Samples



View from East to West towards rainbed

View from rain bed towards East

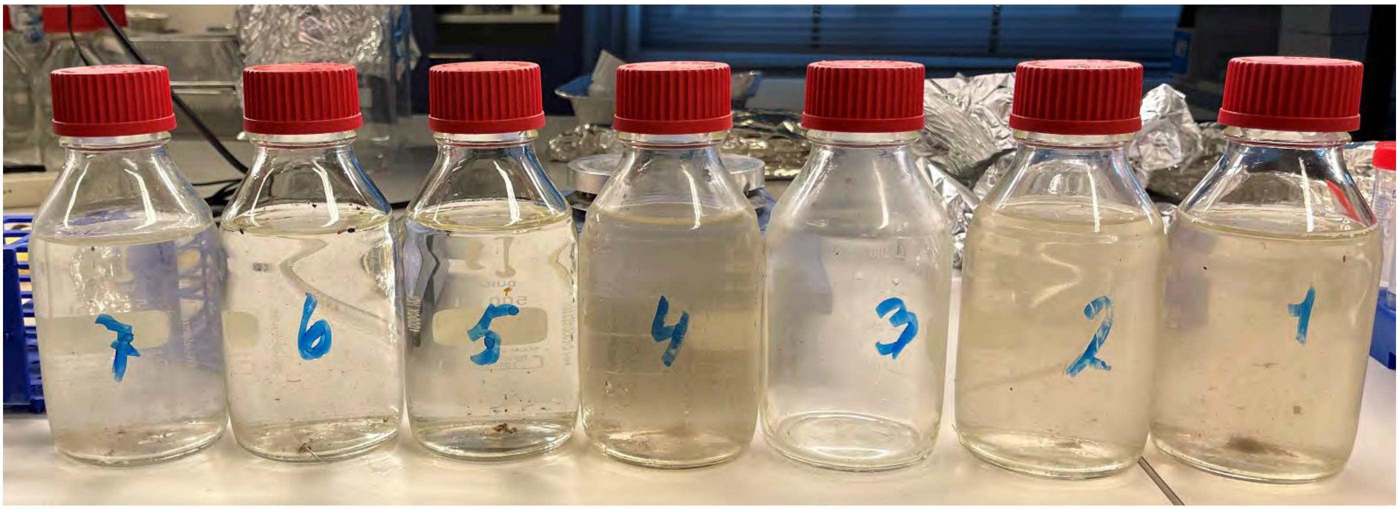
Drained path

Drained driveway

Drained driveway

Drained driveway

Samples



Co07 – Drabæk Huse

Date of sampling: 29/10-2023	
Name of the person who carried out the sampling and institution: Anders R. Johnsen, GEUS	
Short description of site and mode of sampling: Infiltration ditch/trench in suburban residential area with terraced houses. Manual sampling from inlet to the trench.	
Country: Denmark	
City/town: Blovstrød north of Copenhagen	
Position: GPS coordinates from Google Maps on a mobile phone: 55.861422, 12.387789	
Estimated time since previous rain event (>1 mm per day) if known: 4 days, otherwise estimate	
	7-14 days
	15-21 days
	21-28 days
	>28 days
Sources, drained area	
x	Single houses/terraced residential area, estimate decade(s) for dominant buildings: 2017
	Inner city, old buildings (typically <1930) estimate decade(s) for dominant buildings:
	Inner city, new buildings (typically >1950) estimate decade(s) for dominant buildings:
	Small industry, if possible, specify type:
x	Traffic/street
x	Parking lots
	Mixed stormwater
	Risk of mixing with municipal sewage
	Other (describe)
Pavement, drained area (if relevant for drained area, major components only)	
x	Concrete/concrete slabs/cement slabs
x	Asphalt/bitumen
	Gravel
	Cobble stones
x	Lawn (cut grass)
	Other (describe)
Building facades, drained area (if relevant for drained area, major components only)	
	"Raw" bricks
	Mortar plaster/painted mortar plaster/painted bricks
x	Wood/painted wood/impregnated wood
	Concrete
	Metal/painted metal
x	Fiber cement plates/painted fiber cement/ceramic tiles

	Other (describe)
Roofing (if relevant for drained area, major components only)	
	Roof tiles (terracotta-, clay- or cement/concrete tiles)
	Fiber cement plates/eternit
	Metal roofing/metal shingles/painted metal
x	Rolled asphalt roofing/bitumen roofing felt/asphalt composite shingles
	Shale slate shingles (natural)
x	Plastic/PVC
Precipitation readings (accumulated):	
	Sampling started 9:03. Sample 1 0 min: 0 mm Sample 2 15 min: 1 mm Sample 3 30 min: 1 mm Sample 4 45 min:1,5mm Sample 5 60 min: 2,0mm Sample 6 75 min: 2,2 mm Sample 7 90 min: 2,7 mm Sample 8 120 min: 3,7 mm Total during sampling: 3,7 mm

Further characterization of station:

Terraced houses with many infiltration ponds and infiltration ditches. The drained area had street, driveways, terraces, and parking lots that drain to a ditch at a single point. When full, the ditch has overrun to a small stream (South).

Dotted lines: water from roofs is first lead to cobble beds halfway to the street. The water runs to the street and further to the NBS only during heavy rain (not during the sampled rain event).

The trench receives overrun from upstream ponds and ditches downstream the sampling point.

Catchment area

View from sampling point towards South.

Sampling point

Infiltration trench with overrun pipe from upstream ponds and trenches

Facade

Samples

Co08 – Fælledparken

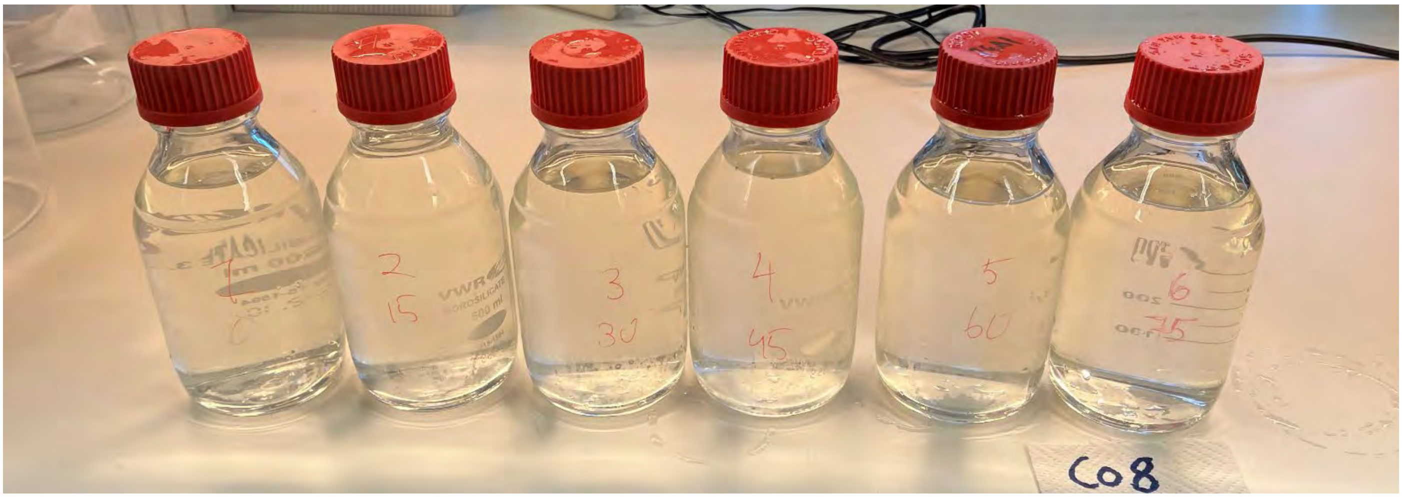
Date of sampling: 23/11-2023	
Name of the person who carried out the sampling and institution: Thomas Karlsson (UCPH)	
Short description of site and mode of sampling: Drain from football field with rubber granulate infill, constructed in 2012. Sampling from bottom of manhole using sub-surface grab sampler. NB: Heavy shower (approximately 2-3 mm) during the morning before sampling. Light rain during sampling with continuous flow into manhole.	
Country: Denmark.	
City/town: Copenhagen.	
Position: 55.706363623451736, 12.570442380423584	
Estimated time since previous rain event (>1 mm per day) if known: 0 days, otherwise estimate Rain during the morning before sampling.	
	7-14 days
	15-21 days
	21-28 days
	>28 days
Sources, drained area	
	Single houses/terraced residential area, estimate decade(s) for dominant buildings: 2017
	Inner city, old buildings (typically <1930) estimate decade(s) for dominant buildings:
	Inner city, new buildings (typically >1950) estimate decade(s) for dominant buildings:
	Small industry, if possible, specify type:
	Traffic/street
	Parking lots
	Mixed stormwater
	Risk of mixing with municipal sewage
x	Other (describe) Artificial football field with rubber granulate infill.
Pavement, drained area (if relevant for drained area, major components only)	
	Concrete/concrete slabs/cement slabs
	Asphalt/bitumen
	Gravel
	Cobble stones
	Lawn (cut grass)
x	Other (describe) Artificial football field with rubber granulate infill.
Building facades, drained area (if relevant for drained area, major components only)	
	“Raw” bricks

	Mortar plaster/painted mortar plaster/painted bricks
	Wood/painted wood/impregnated wood
	Concrete
	Metal/painted metal
	Fiber cement plates/painted fiber cement/ceramic tiles
	Other (describe)
Roofing (if relevant for drained area, major components only)	
	Roof tiles (terracotta-, clay- or cement/concrete tiles)
	Fiber cement plates/eternit
	Metal roofing/metal shingles/painted metal
	Rolled asphalt roofing/bitumen roofing felt/asphalt composite shingles
	Shale slate shingles (natural)
	Plastic/PVC
Precipitation readings (accumulated):	
	NB: Not measured on-site – data from DMI for Copenhagen area. High uncertainty because of highly local precipitation patterns. From DMI: Total during sampling: 1,9 mm (seems approximately correct from estimation on-site). Sampling started: 10.25.

Drainage area.

Sampling point

Sampling area with sampling point



Samples

Co09 – Brønshøj

Date of sampling: 23/11-2023	
Name of the person who carried out the sampling and institution: Flavia Gravina (UCPH)	
Short description of site and mode of sampling: Drain from football field with kork infill, constructed in 2020. Samples from continuous flow into manhole (i.e. not from the bottom) using sub-surface grab sampler. NB: Heavy shower (approximately 2-3 mm) during the morning before sampling. Varying precipitation with occasional heavy showers during sampling with continuous flow into manhole for the whole duration.	
Country: Denmark	
City/town: Brønshøj.	
Position: GPS coordinates from Google Maps on a mobile phone: 55.71935114083969, 12.495103198985248	
Estimated time since previous rain event (>1 mm per day) if known: 0 days, otherwise estimate Rain during the morning before sampling.	
	7-14 days
	15-21 days
	21-28 days
	>28 days
Sources, drained area	
	Single houses/terraced residential area, estimate decade(s) for dominant buildings: 2017
	Inner city, old buildings (typically <1930) estimate decade(s) for dominant buildings:
	Inner city, new buildings (typically >1950) estimate decade(s) for dominant buildings:
	Small industry, if possible, specify type:
	Traffic/street
	Parking lots
	Mixed stormwater
	Risk of mixing with municipal sewage
x	Other (describe) Artificial football field with kork infill.
Pavement, drained area (if relevant for drained area, major components only)	
	Concrete/concrete slabs/cement slabs
	Asphalt/bitumen
	Gravel
	Cobble stones
	Lawn (cut grass)
x	Other (describe)

	Artificial football field with kork infill.
Building facades, drained area (if relevant for drained area, major components only)	
	"Raw" bricks
	Mortar plaster/painted mortar plaster/painted bricks
	Wood/painted wood/impregnated wood
	Concrete
	Metal/painted metal
	Fiber cement plates/painted fiber cement/ceramic tiles
	Other (describe)
Roofing (if relevant for drained area, major components only)	
	Roof tiles (terracotta-, clay- or cement/concrete tiles)
	Fiber cement plates/eternit
	Metal roofing/metal shingles/painted metal
	Rolled asphalt roofing/bitumen roofing felt/asphalt composite shingles
	Shale slate shingles (natural)
	Plastic/PVC
Precipitation readings (accumulated):	
	NB: Not measured on-site – data from DMI for Copenhagen area. High uncertainty because of highly local precipitation patterns. From DMI: Total during sampling: 1,9 mm (estimated to be a lot more). Sampling started: 10.15

Drainage area.

Sampling point

Sampling area with sampling point

Samples

Co10, Øster Voldgade

Date of sampling: **5/4-2024**	
Name of the person who carried out the sampling and institution: Anders R. Johnsen, GEUS	
Short description of site and mode of sampling: Roof runoff X Manual sampling Autosampler	
Country: Denmark	
City/town: Copenhagen	
Position: 55.689712773720814, 12.584292960365906 Rigensgade 32, 34 and 36	
Estimated time since previous rain event (>1 mm per day) if known: 1 days, otherwise estimate	
	7-14 days
	15-21 days
	21-28 days
	>28 days
Sources, drained area	
	Single houses/terraced residential area, estimate decade(s) for dominant buildings:
x	Inner city, old buildings (typically <1930) estimate decade(s) for dominant buildings: 1801, 1839, 1770
	Inner city, new buildings (typically >1950) estimate decade(s) for dominant buildings:
	Small industry, if possible, specify type:
	Traffic/street
	Parking lots
	Mixed stormwater
	Risk of mixing with municipal sewage
	Roofs, each subsample is a mix of water from five roof runoff pipes representing 3 buildings
Pavement, drained area (if relevant for drained area, major components only)	
	Concrete/concrete slabs/cement slabs
	Asphalt/bitumen
	Gravel
	Cobble stones
	Lawn (cut grass)
	Other (describe)
Building facades, drained area (if relevant for drained area, major components only)	
	“Raw” bricks
	Mortar plaster/painted mortar plaster/painted bricks
	Wood/painted wood/impregnated wood
	Concrete

	Metal/painted metal
	Fiber cement plates/painted fiber cement/ceramic tiles
	Other (describe)
Roofing (if relevant for drained area, major components only)	
x	Roof tiles (terracotta-, clay- or cement/concrete tiles)
	Fiber cement plates/eternit
x	Metal roofing/metal shingles/painted metal
	Rolled asphalt roofing/bitumen roofing felt/asphalt composite shingles
x	Shale slate shingles (natural)
	Plastic/PVC
Precipitation readings (accumulated):	
	Sampling started at time: 17:40 Sample 1 0 min: 0,6 mm <- Light rain before runoff started. Sample 2 15 min: 1,7 mm Sample 3 30 min: 2,7 mm Sample 4 45 min: 3,7 mm Sample 5 60 min: 4,5 mm Sample 6 75 min: 6,1 mm Sample 7 90 min: 7,5 mm 120 min: 7,5 mm Rain stopped after sample 7

Further characterization of station: Roofs, each subsample is a mix of water from five roof runoff pipes representing 3 buildings from old Copenhagen. For the “double pipes” only one of them gave water.

Sampled roof runoff pipes

Samples

Co11 – Pile Alle

Date of sampling: 5/4/2024	
Name of the person who carried out the sampling and institution: Paula Toma (UCPH)	
Short description of site and mode of sampling: Road runoff from a large hill (Valby Bakke) with a lot of traffic. Sampling from side of the road with bicycles and car/bus traffic.	
Country: Denmark	
City/town: Copenhagen	
Position: 55.670806527385665, 12.530530640007786	
Estimated time since previous rain event if known: 1 days, otherwise estimate	
	7-14 days
	15-21 days
	21-28 days
	>28 days
Sources, drained area	
	Single houses/terraced residential area, estimate decade(s) for dominant buildings:
	Inner city, old buildings (typically <1930) estimate decade(s) for dominant buildings:
	Inner city, new buildings (typically >1950) estimate decade(s) for dominant buildings:
	Small industry, if possible, specify type:
x	Traffic/street
	Parking lots
	Mixed stormwater
	Risk of mixing with municipal sewage
	Other (describe)
Pavement, drained area (if relevant for drained area, major components only)	
	Concrete/concrete slabs/cement slabs
x	Asphalt/bitumen
	Gravel
	Cobble stones
	Lawn (cut grass)
	Other (describe)
Building facades, drained area (if relevant for drained area, major components only)	
	"Raw" bricks
	Mortar plaster/painted mortar plaster/painted bricks
	Wood/painted wood/impregnated wood
	Concrete
	Metal/painted metal
	Fiber cement plates/painted fiber cement/ceramic tiles
	Other (describe)

Roofing (if relevant for drained area, major components only)	
	Roof tiles (terracotta-, clay- or cement/concrete tiles)
	Fiber cement plates/eternit
	Metal roofing/metal shingles/painted metal
	Rolled asphalt roofing/bitumen roofing felt/asphalt composite shingles
	Shale slate shingles (natural)
	Plastic/PVC
Precipitation readings (accumulated):	
	0 min: 1.0 ← Light rain before runoff started 15 min: 1.5 30 min: 2.5 45 min: 3.5 60 min: 4.5 75 min: 6.5 - Rain stopped 90 min: Not collected 120 min: Not collected

Further characterization of station: Road with lots of traffic from cars and buses. Sampled from side of the road where water flow primarily downhill from Valby Bakke. Beside the road is a park on one side and the zoo on the other.

Samples

Sampling spot (NB: view is downhill, not the direction of the primary runoff flow)

Catchment area

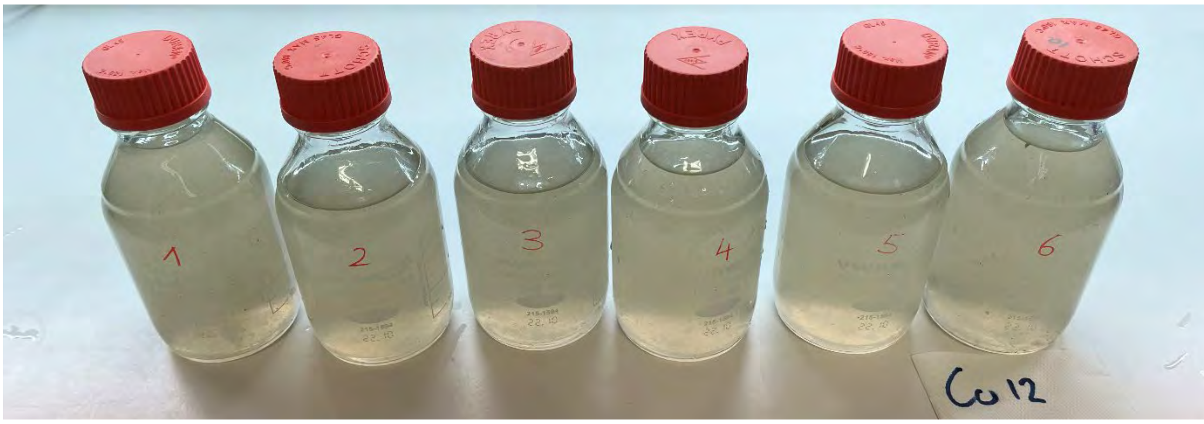
Co12 - Damhus

Date of sampling: 5/4/2024	
Name of the person who carried out the sampling and institution: Thomas Karlsson (UCPH)	
Short description of site and mode of sampling: Combined sewer overflow from Damhusåen Renseanlæg, Copenhagen. Sampled from inlet to biological treatment basin (bypass where overflow most commonly happens at this WWTP).	
Country: Denmark	
City/town: Copenhagen	
Position: Large-scale site (see map of catchment area below). Sampling was done at: 55.63824464346471, 12.506972585125107	
Estimated time since previous rain event if known: 1 days, otherwise estimate	
	7-14 days
	15-21 days
	21-28 days
	>28 days
Sources, drained area	
	Single houses/terraced residential area, estimate decade(s) for dominant buildings:
	Inner city, old buildings (typically <1930) estimate decade(s) for dominant buildings:
	Inner city, new buildings (typically >1950) estimate decade(s) for dominant buildings:
	Small industry, if possible, specify type:
	Traffic/street
	Parking lots
x	Mixed stormwater
	Risk of mixing with municipal sewage
	Other (describe)
Pavement, drained area (if relevant for drained area, major components only)	
	Concrete/concrete slabs/cement slabs
	Asphalt/bitumen
	Gravel
	Cobble stones
	Lawn (cut grass)
	Other (describe)
Building facades, drained area (if relevant for drained area, major components only)	
	“Raw” bricks
	Mortar plaster/painted mortar plaster/painted bricks
	Wood/painted wood/impregnated wood
	Concrete
	Metal/painted metal
	Fiber cement plates/painted fiber cement/ceramic tiles
	Other (describe)

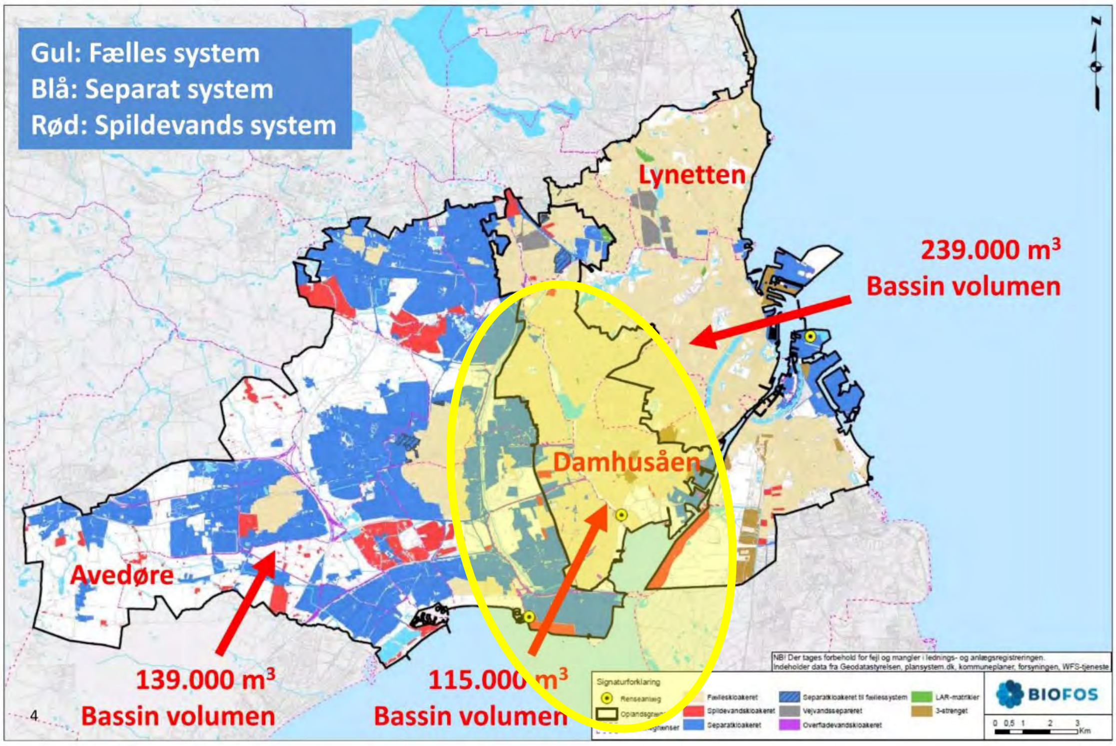
Roofing (if relevant for drained area, major components only)	
	Roof tiles (terracotta-, clay- or cement/concrete tiles)
	Fiber cement plates/eternit
	Metal roofing/metal shingles/painted metal
	Rolled asphalt roofing/bitumen roofing felt/asphalt composite shingles
	Shale slate shingles (natural)
	Plastic/PVC
Precipitation readings (accumulated):	
17:45 18:00 18:15 18:30 18:45 19:00	0 min: 1.0 mm 15 min: 2.0 30 min: 2.5 45 min: 3.5 60 min: 4.7 75 min: 6.0 - Rain stopped 90 min: Not collected 120 min: Not collected

Further characterization of station: Combined sewage from Western part of the larger Copenhagen area including Valby, Hvidovre, Rødovre, Brønshøj, and Vanløse. Sampling from bypass at inlet to biological treatment basin, which is where wastewater overflow is most often discharged from during heavy rain events at this WWTP. Manual sampling by collecting from sink with a continuous flow of wastewater.

Samples



WWTP catchment area



Sampling done by collecting from this sink which has a continuous flow of wastewater from the inlet to biological treatment basin.

Lj1 - Grosuplje

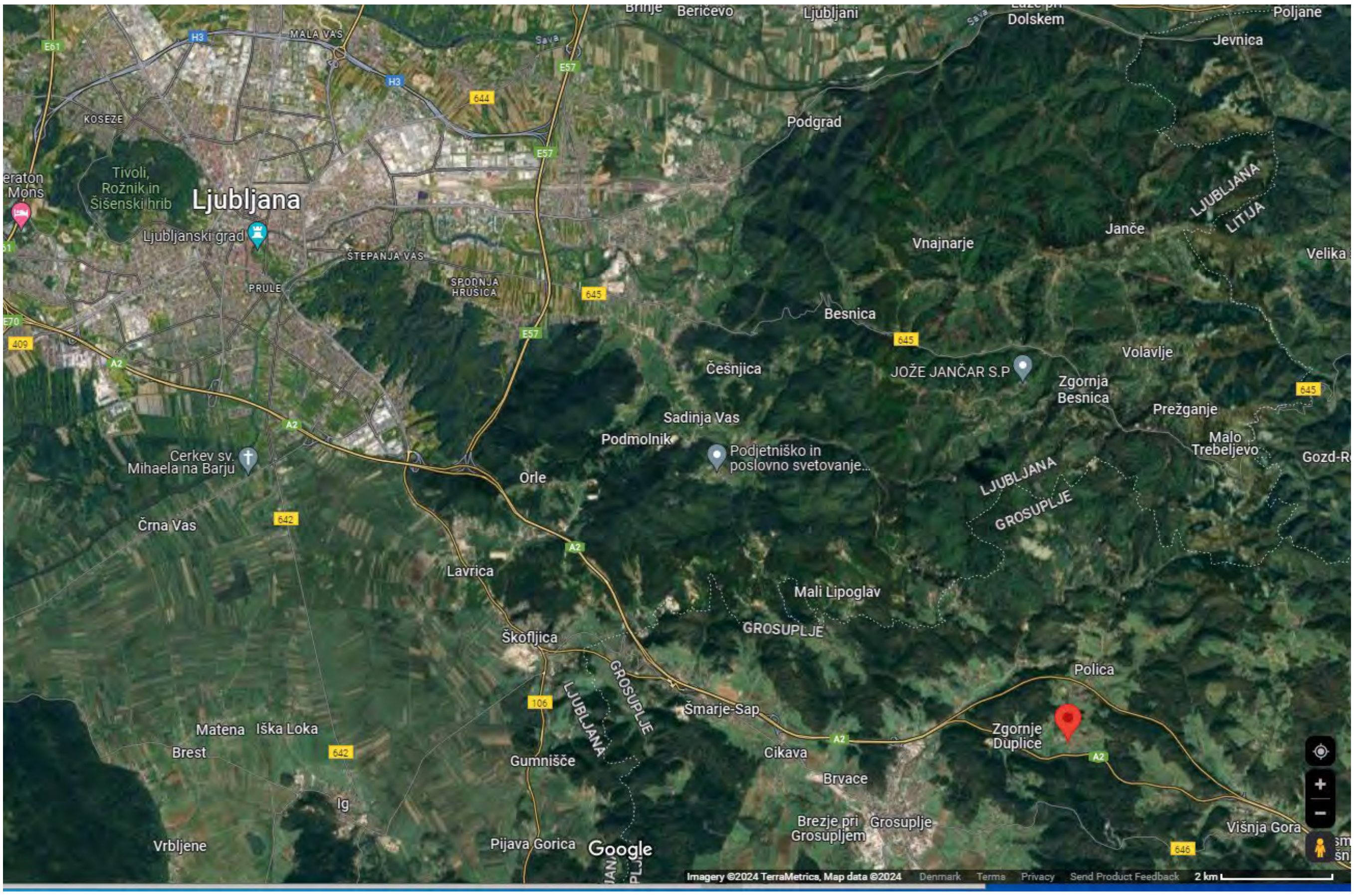
Date of sampling: 11/02/2024	
Name of the person who carried out the sampling and institution: Tina Kosjek, Jožef Stefan Institute	
Short description of site and mode of sampling: Roof runoff. Manual sampling of a runoff from a ≈50 yrs old roof on a sawmill building in a suburban area, nearby highway. Vicinity of individual fireplaces, hence deposited particles, combustion products are expected in the samples.	
Country: Slovenia	
City/town: Grosuplje, approximately 17 km from Ljubljana city center	
Position: 45.969323, 14.698148	
Estimated time since previous rain event (>1 mm per day) if known: < 1 day (with no clear start of the rain event), **otherwise estimate**	
	7-14 days
	15-21 days
	21-28 days
	>28 days
Sources, drained area	
	Single houses/terraced residential area, estimate decade(s) for dominant buildings:
	Inner city, old buildings (typically <1930) estimate decade(s) for dominant buildings:
	Inner city, new buildings (typically >1950) estimate decade(s) for dominant buildings:
X	Small industry, if possible, specify type:
	Traffic/street
	Parking lots
	Mixed stormwater
	Risk of mixing with municipal sewage
	Other (describe)
Pavement, drained area (if relevant for drained area, major components only)	
	Concrete/concrete slabs/cement slabs
	Asphalt/bitumen
	Gravel
	Cobble stones
	Lawn (cut grass)
	Other (describe)
Building facades, drained area (if relevant for drained area, major components only)	
	"Raw" bricks
	Mortar plaster/painted mortar plaster/painted bricks
X	Wood/painted wood/impregnated wood
	Concrete
	Metal/painted metal
	Fiber cement plates/painted fiber cement/ceramic tiles
	Other (describe)
Roofing (if relevant for drained area, major components only)	

	Roof tiles (terracotta-, clay- or cement/concrete tiles)
X	Fiber cement plates/eternit
	Metal roofing/metal shingles/painted metal
	Rolled asphalt roofing/bitumen roofing felt/asphalt composite shingles
	Shale slate shingles (natural)
	Plastic/PVC
Precipitation readings (accumulated): Not available	
	0 min: 15 min: 30 min: 45 min: 60 min: 75 min: 90 min: 120 min: Precipitation: According to https://vreme.arso.gov.si/: 1,0 mm/hr -> Approximately 2 mm during sampling T = 8 °CP = 990 hPa, Humidity = 99 %
Samples collected / time of sampling	
	ROOF1 / 8:26 ROOF 2 / 8:42 ROOF 3 / 8:59 ROOF 4 / 9:14 ROOF 5 / 9:32 ROOF 6 / 9:51 ROOF 7 / 10:16

Further characterization of station: If available, please also provide a map of the catchment area and a general description.

Roof runoff sampling site. Grosuplje – Peč, sawmill, 11.2.2024, Foto: Tina Kosjek

Larger Roof runoff sampling site. Grosuplje – Peč, sawmill, 11.2.2024, Foto: Tina Kosjek



Ljubljana
Ljubljanski grad
Tivoli, Rožnik in Šišenski hrib
Podgrad
Vnajnarje
Janče
Besnica
Češnjica
JOŽE JANČAR S.P
Zgornja Besnica
Volavlje
Prežganje
Malo Trebeljevo
Sadinja Vas
Podmolnik
Podjetniško in poslovno svetovanje...
Orle
Cerkev sv. Mihaela na Barju
Črna Vas
Lavrica
Mali Lipoglav
GROSUPLJE
LJUBLJANA
Škofljica
Polica
Šmarje-Sap
Zgornje Duplice
Cikava
Brvace
Matena
Iška Loka
Brest
Gumnišče
Ig
Vrbljene
Pijava Gorica
Brezje pri Grosupljem
Grosuplje
Višnja Gora
Google
Imagery ©2024 TerraMetrics, Map data ©2024

Konjeniški klub Giovanni
ŽAGA Gioahin
Turistična kmetija Darja Gioahin
Društvo hlev peški
Zgornje Duplice
Peč

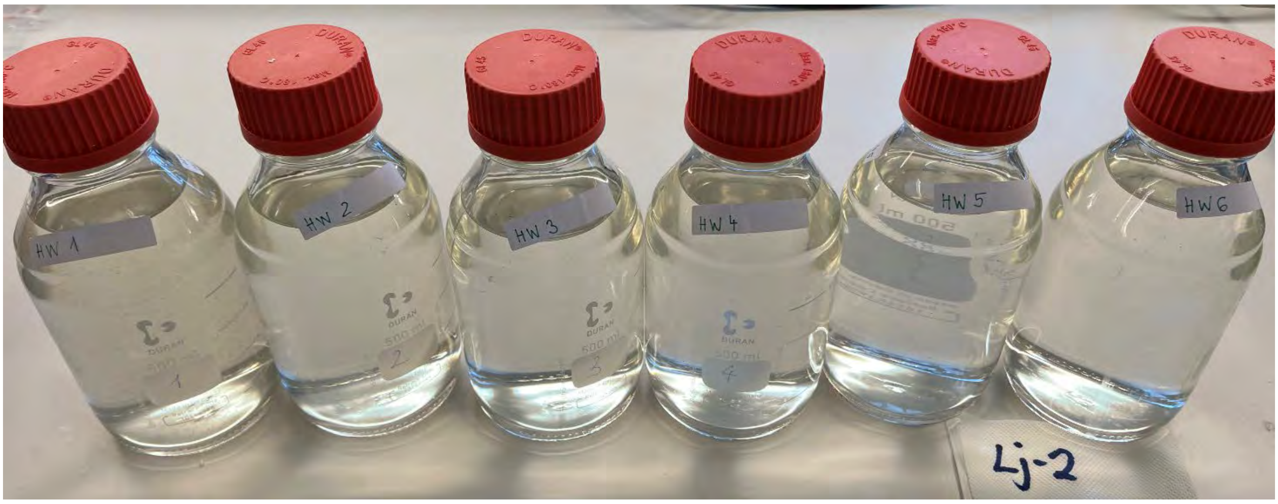
Lj2 - Bizovik

Date of sampling: 11/02/2024	
Name of the person who carried out the sampling and institution: Dušan Žigon, Jožef Stefan Institute	
Short description of site and mode of sampling: Ljubljana Bizovik. Manual sampling of a runoff from highway with a very high traffic load. The stormwater is drained via collection channel from A1 highway into a retention pond. Sample collection point: on the inlet, i.e. before the retention pond.	
Country: Slovenia	
City/town: Ljubljana	
Position: 46.02364231968477, 14.565230701653851	
Estimated time since previous rain event (>1 mm per day) if known: < 1 day (with no clear start of the rain event), **otherwise estimate**	
	7-14 days
	15-21 days
	21-28 days
	>28 days
Sources, drained area	
	Single houses/terraced residential area, estimate decade(s) for dominant buildings:
	Inner city, old buildings (typically <1930) estimate decade(s) for dominant buildings:
	Inner city, new buildings (typically >1950) estimate decade(s) for dominant buildings:
	Small industry, if possible, specify type:
X	Traffic/street
	Parking lots
	Mixed stormwater
	Risk of mixing with municipal sewage
	Other (describe)
Pavement, drained area (if relevant for drained area, major components only)	
	Concrete/concrete slabs/cement slabs
X	Asphalt/bitumen
	Gravel
	Cobble stones
	Lawn (cut grass)
	Other (describe)
Building facades, drained area (if relevant for drained area, major components only)	
	"Raw" bricks
	Mortar plaster/painted mortar plaster/painted bricks
	Wood/painted wood/impregnated wood
	Concrete
	Metal/painted metal
	Fiber cement plates/painted fiber cement/ceramic tiles
	Other (describe)
Roofing (if relevant for drained area, major components only)	
	Roof tiles (terracotta-, clay- or cement/concrete tiles)
	Fiber cement plates/eternit

	Metal roofing/metal shingles/painted metal
	Rolled asphalt roofing/bitumen roofing felt/asphalt composite shingles
	Shale slate shingles (natural)
	Plastic/PVC
Precipitation readings (accumulated): Not available	
	0 min: 15 min: 30 min: 45 min: 60 min: 75 min: 90 min: 120 min: Precipitation: According to https://vreme.arso.gov.si/: 1,0 mm/hr -> approximately 2 mm during sampling T = 8 °C, P = 990 hPa, Humidity = 99 %
Samples collected / time of sampling	
	HW1 / 7:45 HW2 / 8:00 HW3 / 8:15 HW4 / 8:30 HW5 / 8:45 HW6 / 9:00

Inflow into the retention pond. Ljubljana Bizovik, 11.2.2024, Foto: Dušan Žigon

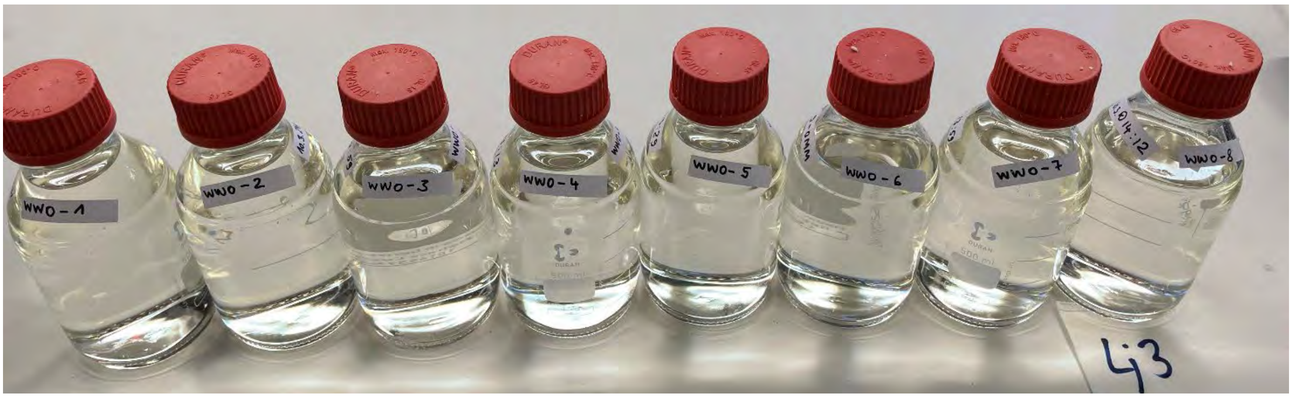
Larger catchment area, Ljubljana Bizovik, 11.2.2024, Foto: Dušan Žigon


HW 1
HW 2
HW 3
HW 4
HW 5
HW 6
Lj-2

Lj03, Logatec - municipal WWTP bypass

Date of sampling: 10/03/2024	
Name of the person who carried out the sampling and institution: Tina Kosjek, JSI	
Short description of site and mode of sampling: WWTP Logatec, outlet. This is a municipal WWTP with a capacity of 14900 PE, which receives domestic wastewaters and wastewaters from paper printing industry. The WWTP uses a mixed stormwater bypass during heavy rains. It is thus expected to load enteric indicators, anthropogenic biomarkers, dyes and possibly antibiotic resistance.	
Country: Slovenia	
City/town: Logatec	
Position: 45.91472275101508, 14.231678215774858	
Estimated time since previous rain event (>1 mm per day) if known: < 1 day (with no clear start of the rain event), **otherwise estimate**	
	7-14 days
	15-21 days
	21-28 days
	>28 days
Sources, drained area	
	Single houses/terraced residential area, estimate decade(s) for dominant buildings:
	Inner city, old buildings (typically <1930) estimate decade(s) for dominant buildings:
	Inner city, new buildings (typically >1950) estimate decade(s) for dominant buildings:
X	Small industry, if possible, specify type: paper printing industry
	Traffic/street
	Parking lots
X	Mixed stormwater
X	Risk of mixing with municipal sewage
	Other (describe)
Pavement, drained area (if relevant for drained area, major components only)	
	Concrete/concrete slabs/cement slabs
	Asphalt/bitumen
	Gravel
	Cobble stones
	Lawn (cut grass)
	Other (describe)
Building facades, drained area (if relevant for drained area, major components only)	
	"Raw" bricks
	Mortar plaster/painted mortar plaster/painted bricks
	Wood/painted wood/impregnated wood
	Concrete
	Metal/painted metal
	Fiber cement plates/painted fiber cement/ceramic tiles
	Other (describe)
Roofing (if relevant for drained area, major components only)	

	Roof tiles (terracotta-, clay- or cement/concrete tiles)
	Fiber cement plates/eternit
	Metal roofing/metal shingles/painted metal
	Rolled asphalt roofing/bitumen roofing felt/asphalt composite shingles
	Shale slate shingles (natural)
	Plastic/PVC
Precipitation readings (accumulated):	
	0 min: 0.0 mm ZERO 30 min: 0.2 mm SINCE START 60 min: 0.7 mm SINCE START 105 min: 1.7 mm SINCE START T = 7 °C
Samples collected / time of sampling	
	WWO-1 / 12:31 WWO-2 / 12.47 WWO-3 / 12:59 WWO-4 / 13:13 WWO-5 / 13:29 WWO-6 / 13:44 WWO-7 / 13:59 WWO-8 / 14:12



WWTP outlet. Logatec, 10.3.2024, Photo: Tina Kosjek

Larger area: WWTP outlet. Logatec, 10.3.2024, Photo: Tina Kosjek

Lj04- Brinje stormwater pipe

surface water, residential area

Date of sampling: 10/03/2024	
Name of the person who carried out the sampling and institution: Tina Kosjek, JSI	
Short description of site and mode of sampling: Collected at recipient canal from outlet pipe that drains surface water from a residential area in Grosuplje – Brinje. There is a primary school with a parking lot in front and an athletic stadium and a playground. Next to it there is a residential area with new houses (from after 2010) and back a bit up the hill a bit older single houses (from 1980's) . After the rain stopped, the water from the black pipe that leads into the Grosupeljščica stream ceased very quickly so the collection of the very last sample was not possible anymore.	
Country: Slovenia	
City/town: Grosuplje	
Position: 45.96245450459853, 14.658800499670006	
Estimated time since previous rain event (>1 mm per day) if known: < 1 day (with no clear start of the rain event), **otherwise estimate**	
	7-14 days
	15-21 days
	21-28 days
	>28 days
Sources, drained area	
X	Single houses/terraced residential area, estimate decade(s) for dominant buildings: 1980-2015
	Inner city, old buildings (typically <1930) estimate decade(s) for dominant buildings:
	Inner city, new buildings (typically >1950) estimate decade(s) for dominant buildings:
	Small industry, if possible, specify type
X	Traffic/street
X	Parking lots
X	Mixed stormwater
	Risk of mixing with municipal sewage
	Other (describe)
Pavement, drained area (if relevant for drained area, major components only)	
	Concrete/concrete slabs/cement slabs
X	Asphalt/bitumen
X	Gravel
	Cobble stones
X	Lawn (cut grass)
	Other (describe)
Building facades, drained area (if relevant for drained area, major components only)	
	"Raw" bricks
X	Mortar plaster/painted mortar plaster/painted bricks
	Wood/painted wood/impregnated wood
	Concrete
	Metal/painted metal
	Fiber cement plates/painted fiber cement/ceramic tiles
	Other (describe)

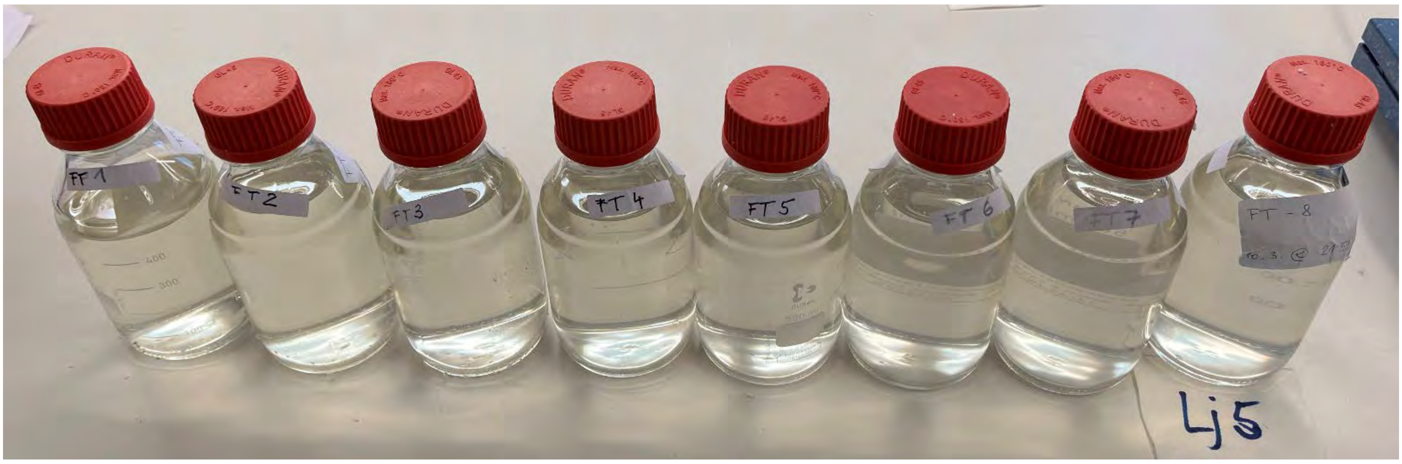
Roofing (if relevant for drained area, major components only)	
	Roof tiles (terracotta-, clay- or cement/concrete tiles)
	Fiber cement plates/eternit
X	Metal roofing/metal shingles/painted metal
	Rolled asphalt roofing/bitumen roofing felt/asphalt composite shingles
	Shale slate shingles (natural)
	Plastic/PVC
Precipitation readings (accumulated):	
	19:50 START: 0.0 mm ZERO 20:10 min: 4.2 mm SINCE START 20:24 min: 5.7 mm SINCE START 20:39 min: 7.0 mm SINCE START 20:48 min: 7.7 mm SINCE START 21:09 min: 9.0 mm SINCE START 21:16 min: 9.2 mm SINCE START – RAIN STOPPED T = 5 °C
Samples collected / time of sampling	
	ST-1 / 19:52 ST -2 / 20:06 ST -3 / 20:20 ST -4 / 20:36 ST -5 / 20:51 ST -6 / 21:06 ST -7 / 21:21

At the time of sampling it was already dark, so I couldn't take a photo, but here is one from earlier. Grosuplje-Brinje, 11.2.2024, Photo: Tina Kosjek

Lj05 – Brinje football field

Date of sampling: 10/03/2024	
Name of the person who carried out the sampling and institution: Tina Kosjek, JSI	
Short description of site and mode of sampling: Grosuplje – Brinje: drainage from artificial football field plus one with a natural grass next to it. Right next to the field two pipes open alternately every few minutes (on a heavy rain occasion) and water is discharged down the drain into the stream (Grosupeljščica).	
Country: Slovenia	
City/town: Grosuplje	
Position: 45.961860663631015, 14.658894376981424	
Estimated time since previous rain event (>1 mm per day) if known: < 1 day (with no clear start of the rain event), **otherwise estimate**	
	7-14 days
	15-21 days
	21-28 days
	>28 days
Sources, drained area	
	Single houses/terraced residential area, estimate decade(s) for dominant buildings:
	Inner city, old buildings (typically <1930) estimate decade(s) for dominant buildings:
	Inner city, new buildings (typically >1950) estimate decade(s) for dominant buildings:
	Small industry, if possible, specify type
	Traffic/street
	Parking lots
	Mixed stormwater
	Risk of mixing with municipal sewage
X	Other (describe): artificial football field plus one with a natural grass next to it
Pavement, drained area (if relevant for drained area, major components only)	
	Concrete/concrete slabs/cement slabs
	Asphalt/bitumen
	Gravel
	Cobble stones
X	Lawn (cut grass)
	Other (describe)
Building facades, drained area (if relevant for drained area, major components only)	
	"Raw" bricks
	Mortar plaster/painted mortar plaster/painted bricks
	Wood/painted wood/impregnated wood
	Concrete
	Metal/painted metal
	Fiber cement plates/painted fiber cement/ceramic tiles
	Other (describe)
Roofing (if relevant for drained area, major components only)	
	Roof tiles (terracotta-, clay- or cement/concrete tiles)
	Fiber cement plates/eternit

	Metal roofing/metal shingles/painted metal
	Rolled asphalt roofing/bitumen roofing felt/asphalt composite shingles
	Shale slate shingles (natural)
	Plastic/PVC
Precipitation readings (accumulated):	
	19:50 START: 0.0 mm ZERO 20:10 min: 4.2 mm SINCE START 20:24 min: 5.7 mm SINCE START 20:39 min: 7.0 mm SINCE START 20:48 min: 7.7 mm SINCE START 21:09 min: 9.0 mm SINCE START 21:16 min: 9.2 mm SINCE START – RAIN STOPPED 22:03 min: 9.2 mm SINCE START – RAIN STOPPED – last read T = 5 °C
Samples collected / time of sampling	
	FT-1 / 20:29 FT -2 / 20:44 FT -3 / 20:59 FT -4 / 21:13 FT -5 / 21:26 (until this point I didn't realise that only one pipe opened at the time - right pipe) FT -6 / 21:39 (left pipe) FT -7 / 21:47 (right pipe) FT -8 / 21:59 (left pipe)



At the time of sampling it was already dark , so I couldn't take a photo, but here is one from earlier. Grosuplje-Brinje football field – two pipes that open alternately every few minutes and water is discharged down the drain into the stream, 11.2.2024, Photo: Tina Kosjek

At the time of sampling it was already dark , so I couldn’t take a photo, but here is one from earlier. Grosuplje-Brinje football field –the drain leading from the pipes into the stream, 11.2.2024, Photo: Tina Kosjek

Od1 – Træøen

Date of sampling: 26/6-2023	
Name of the person who carried out the sampling and institution: Thor Hougaard, VCS	
Short description of site and mode of sampling: For instance: Rain bed in residential area, sampled from inlet. Manual sampling	
Country: DK	
City/town: Odense	
Position: GPS coordinates from Google Maps on a mobile phone: 55.3949499 ; 10.3449509	
Estimated time since previous rain event if known: DMIs vejrarkiv for Odense Kommune: forrige event 23. maj 2,5 mm, 34 dage **days, otherwise estimate**	
	7-14 days
	15-21 days
	21-28 days
x	>28 days
Sources, drained area	
x	Single houses/terraced residential area, estimate decade(s) for dominant buildings:
	Inner city, old buildings (typically <1930) estimate decade(s) for dominant buildings:
	Inner city, new buildings (typically >1950) estimate decade(s) for dominant buildings:
	Small industry, if possible, specify type:
x	Traffic/street
	Parking lots
	Mixed stormwater
	Risk of mixing with municipal sewage
	Other (describe)
Pavement, drained area (if relevant for drained area, major components only)	
	Concrete/concrete slabs/cement slabs
	Asphalt/bitumen
	Gravel
	Cobble stones
	Lawn (cut grass)
	Other (describe)
Building facades, drained area (if relevant for drained area, major components only)	
x	"Raw" bricks
	Mortar plaster/painted mortar plaster/painted bricks
x	Wood/painted wood/impregnated wood
	Concrete
	Metal/painted metal
	Fiber cement plates/painted fiber cement/ceramic tiles

	Other (describe)
Roofing (if relevant for drained area, major components only)	
x	Roof tiles (terracotta-, clay- or cement/concrete tiles)
	Fiber cement plates/eternit
	Metal roofing/metal shingles/painted metal
	Rolled asphalt roofing/bitumen roofing felt/asphalt composite shingles
	Shale slate shingles (natural)
	Plastic/PVC
Precipitation readings (accumulated):	
	0 min: 11:58 15 min: 12:13 30 min: 12:28 45 min: 12:43 60 min: 75 min: 90 min: 120 min: Danish Meteorology Institute's weather archive for Odense Kommune 26/6-2023: 10,1 during 2 hours from 12:00.

Note: sample no 1 contained a cigarette butt

Od1 – Træøen

Date of sampling: 26/6-2023	
Name of the person who carried out the sampling and institution: Thor Hougaard, VCS	
Short description of site and mode of sampling: For instance: Rain bed in residential area, sampled from inlet. Manual sampling	
Country: DK	
City/town: Odense	
Position: GPS coordinates from Google Maps on a mobile phone: 55.3949499 ; 10.3449509	
Estimated time since previous rain event if known: DMIs vejrarkiv for Odense Kommune: forrige event 23. maj 2,5 mm, 34 dage **days, otherwise estimate**	
	7-14 days
	15-21 days
	21-28 days
x	>28 days
Sources, drained area	
x	Single houses/terraced residential area, estimate decade(s) for dominant buildings:
	Inner city, old buildings (typically <1930) estimate decade(s) for dominant buildings:
	Inner city, new buildings (typically >1950) estimate decade(s) for dominant buildings:
	Small industry, if possible, specify type:
x	Traffic/street
	Parking lots
	Mixed stormwater
	Risk of mixing with municipal sewage
	Other (describe)
Pavement, drained area (if relevant for drained area, major components only)	
	Concrete/concrete slabs/cement slabs
	Asphalt/bitumen
	Gravel
	Cobble stones
	Lawn (cut grass)
	Other (describe)
Building facades, drained area (if relevant for drained area, major components only)	
x	"Raw" bricks
	Mortar plaster/painted mortar plaster/painted bricks
x	Wood/painted wood/impregnated wood
	Concrete
	Metal/painted metal
	Fiber cement plates/painted fiber cement/ceramic tiles

	Other (describe)
Roofing (if relevant for drained area, major components only)	
x	Roof tiles (terracotta-, clay- or cement/concrete tiles)
	Fiber cement plates/eternit
	Metal roofing/metal shingles/painted metal
	Rolled asphalt roofing/bitumen roofing felt/asphalt composite shingles
	Shale slate shingles (natural)
	Plastic/PVC
Precipitation readings (accumulated):	
	0 min: 11:58 15 min: 12:13 30 min: 12:28 45 min: 12:43 60 min: 75 min: 90 min: 120 min: DMIs vejrarkiv for Odense Kommune 26/6-2023: 10,1 mm i løbet af 2 timer fra kl 12.

Note: sample no 1 contained a cigarette butt

Od02, Hørdumsgade

Date of sampling: 29/10/2023	
Name of the person who carried out the sampling and institution: Rikke Hansen VCS	
Short description of site and mode of sampling: For instance: Rain bed in residential area, sampled from inlet Manual sampling X	
Country: Denmark	
City/town: Odense	
Position: GPS coordinates from Google Maps on a mobile phone: 55.409271, 10.393100	
Estimated time since previous rain event (>1 mm per day) if known: 1 days, otherwise estimate	
	7-14 days
	15-21 days
	21-28 days
	>28 days
Sources, drained area	
x	Single houses/terraced residential area, estimate decade(s) for dominant buildings: 1930
	Inner city, old buildings (typically <1930) estimate decade(s) for dominant buildings:
	Inner city, new buildings (typically >1950) estimate decade(s) for dominant buildings:
	Small industry, if possible, specify type:
	Traffic/street
	Parking lots
	Mixed stormwater
	Risk of mixing with municipal sewage
	Other (describe)
Pavement, drained area (if relevant for drained area, major components only)	
X	Concrete/concrete slabs/cement slabs
X	Asphalt/bitumen
	Gravel
	Cobble stones
	Lawn (cut grass)
	Other (describe) Pavement tiles
Building facades, drained area (if relevant for drained area, major components only)	
x	"Raw" bricks
	Mortar plaster/painted mortar plaster/painted bricks
	Wood/painted wood/impregnated wood
	Concrete

x	Metal/painted metal
	Fiber cement plates/painted fiber cement/ceramic tiles
	Other (describe)
Roofing (if relevant for drained area, major components only)	
	Roof tiles (terracotta-, clay- or cement/concrete tiles)
	Fiber cement plates/eternit
	Metal roofing/metal shingles/painted metal
	Rolled asphalt roofing/bitumen roofing felt/asphalt composite shingles
	Shale slate shingles (natural)
	Plastic/PVC
Precipitation readings (accumulated):	
	Sample 1 0 min: Sample 2 15 min: Sample 3 30 min: Sample 4 45 min: Sample 5 60 min: Sample 6 75 min: Sample 7 90 min: Sample 8 120 min: Rain gauge forgotten, Odense precipitation from DMI weather archive: 4,4 mm in 2 hours.

Further characterization of station: Receives water from street, pavement, and parking lots.





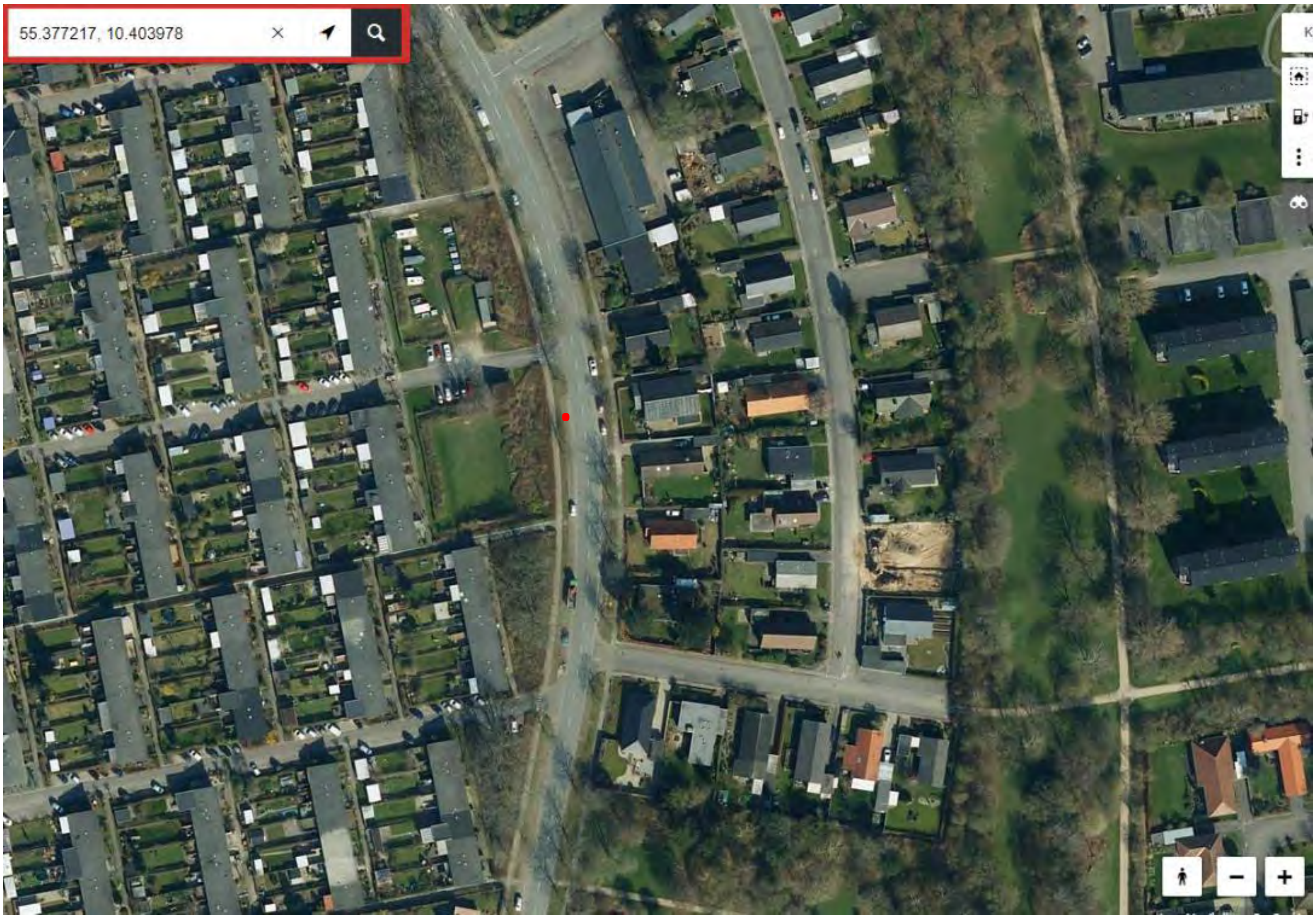
RUNOFF
29/10
No 5
No 6
No 8
Od2

Od03 - Kallerupvej

Date of sampling: **29/10/2023**	
Name of the person who carried out the sampling and institution: **Nana Benthien, VCS**	
Short description of site and mode of sampling: For instance: Rain bed in residential area, sampled from inlet. Receives water only from street and parking lots. Manual sampling X	
Country: Denmark	
City/town: Odense	
Position: GPS coordinates from Google Maps on a mobile phone: 55.377217, 10.403978	
Estimated time since previous rain event (>1 mm per day) if known: 1 days, otherwise estimate	
	7-14 days
	15-21 days
	21-28 days
	>28 days
Sources, drained area	
x	Single houses/terraced residential area, estimate decade(s) for dominant buildings: 1970
	Inner city, old buildings (typically <1930) estimate decade(s) for dominant buildings:
	Inner city, new buildings (typically >1950) estimate decade(s) for dominant buildings:
	Small industry, if possible, specify type:
	Traffic/street
	Parking lots
	Mixed stormwater
	Risk of mixing with municipal sewage
	Other (describe)
Pavement, drained area (if relevant for drained area, major components only)	
X	Concrete/concrete slabs/cement slabs
X	Asphalt/bitumen
	Gravel
	Cobble stones
	Lawn (cut grass)
	Other (describe)
Building facades, drained area (if relevant for drained area, major components only)	
	"Raw" bricks
	Mortar plaster/painted mortar plaster/painted bricks
	Wood/painted wood/impregnated wood
	Concrete
	Metal/painted metal
	Fiber cement plates/painted fiber cement/ceramic tiles

	Other (describe)
Roofing (if relevant for drained area, major components only)	
	Roof tiles (terracotta-, clay- or cement/concrete tiles)
	Fiber cement plates/eternit
	Metal roofing/metal shingles/painted metal
	Rolled asphalt roofing/bitumen roofing felt/asphalt composite shingles
	Shale slate shingles (natural)
	Plastic/PVC
Precipitation readings (accumulated):	
	Sample 1 0 min: 7:20 Sample 2 15 min: 7:35 Sample 3 30 min: 7:50 Sample 4 45 min: 8:05 Sample 5 60 min: 8:20 Sample 6 75 min: 8:35 Sample 7 90 min: 8:50 Sample 8 105 min: 9:05 Rain gauge forgotten, Odense precipitation from DMI weather archive: 4,4 mm in 2 hours.


1
2
3
4
5
6
7
8


55.377217, 10.403978

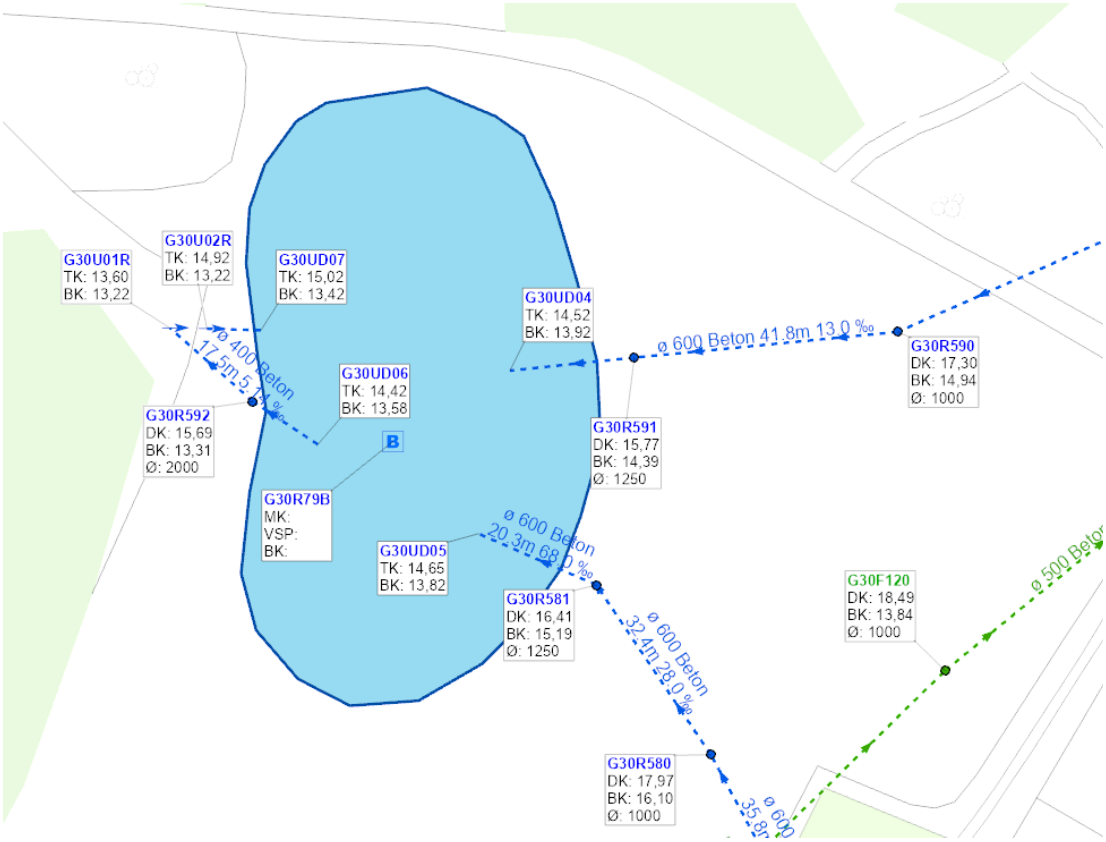
Od04 Søparken North (TN); Od05 Søparken South (TS)

Date of sampling: 29/10/2023	
Name of the person who carried out the sampling and institution: **Thor Hougaard, VCS**	
Short description of site and mode of sampling: Inlet to retention pond at a residential area, sampled from inlet pipes, two pipes – North and South. Most water is evaporated or infiltrated from the pond, runoff from pond only in extreme rain events. Manual sampling X	
Country: Denmark	
City/town: Odense	
Position: GPS coordinates from Google Maps on a mobile phone: TN: 55.352902, 10.366980 Brønd G30R591 TS: 55.352590, 10.366814 Brønd G30R581	
Estimated time since previous rain event (>1 mm per day) if known: 1 days, otherwise estimate	
	7-14 days
	15-21 days
	21-28 days
	>28 days
Sources, drained area	
x	Single houses/terraced residential area, estimate decade(s) for dominant buildings: 1970
	Inner city, old buildings (typically <1930) estimate decade(s) for dominant buildings:
	Inner city, new buildings (typically >1950) estimate decade(s) for dominant buildings:
	Small industry, if possible, specify type:
	Traffic/street
	Parking lots
	Mixed stormwater
	Risk of mixing with municipal sewage
	Other (describe)
Pavement, drained area (if relevant for drained area, major components only)	
X	Concrete/concrete slabs/cement slabs
X	Asphalt/bitumen
	Gravel
	Cobble stones
X	Lawn (cut grass)
	Other (describe)
Building facades, drained area (if relevant for drained area, major components only)	
X	"Raw" bricks
X	Mortar plaster/painted mortar plaster/painted bricks
	Wood/painted wood/impregnated wood
	Concrete
	Metal/painted metal

	Fiber cement plates/painted fiber cement/ceramic tiles
	Other (describe)
Roofing (if relevant for drained area, major components only)	
X	Roof tiles (terracotta-, clay- or cement/concrete tiles)
X	Fiber cement plates/eternit
X	Metal roofing/metal shingles/painted metal
	Rolled asphalt roofing/bitumen roofing felt/asphalt composite shingles
	Shale slate shingles (natural)
	Plastic/PVC
Precipitation readings (accumulated):	
	Sample 1 0 min: Sample 2 15 min: Sample 3 30 min: Sample 4 45 min: Sample 5 60 min: Sample 6 75 min: Sample 7 90 min: Sample 8 120 min: Rain gauge forgotten, Odense precipitation from DMI weather archive: 4,4 mm in 2 hours.

Further characterization of station:


South inlet



G30U01R
TK: 13,60
BK: 13,22
G30U02R
TK: 14,92
BK: 13,22
G30UD07
TK: 15,02
BK: 13,42
G30UD04
TK: 14,52
BK: 13,92
ø 600 Beton 41,8m 13,0 ‰
G30R590
DK: 17,30
BK: 14,94
Ø: 1000
ø 400 Beton
G30UD06
TK: 14,42
BK: 13,58
G30R592
DK: 15,69
BK: 13,31
Ø: 2000
B
G30R591
DK: 15,77
BK: 14,39
Ø: 1250
G30R79B
MK:
VSP:
BK:
ø 600 Beton
G30UD05
TK: 14,65
BK: 13,82
G30R581
DK: 16,41
BK: 15,19
ø 600 Beton
32,4m 28,0 ‰
G30F120
DK: 18,49
BK: 13,84
Ø: 1000
ø 500
G30R580
DK: 17,97
BK: 16,10
Ø: 1000
ø 600

Od4 Søparken North, samples

Od5 Søparken South, samples

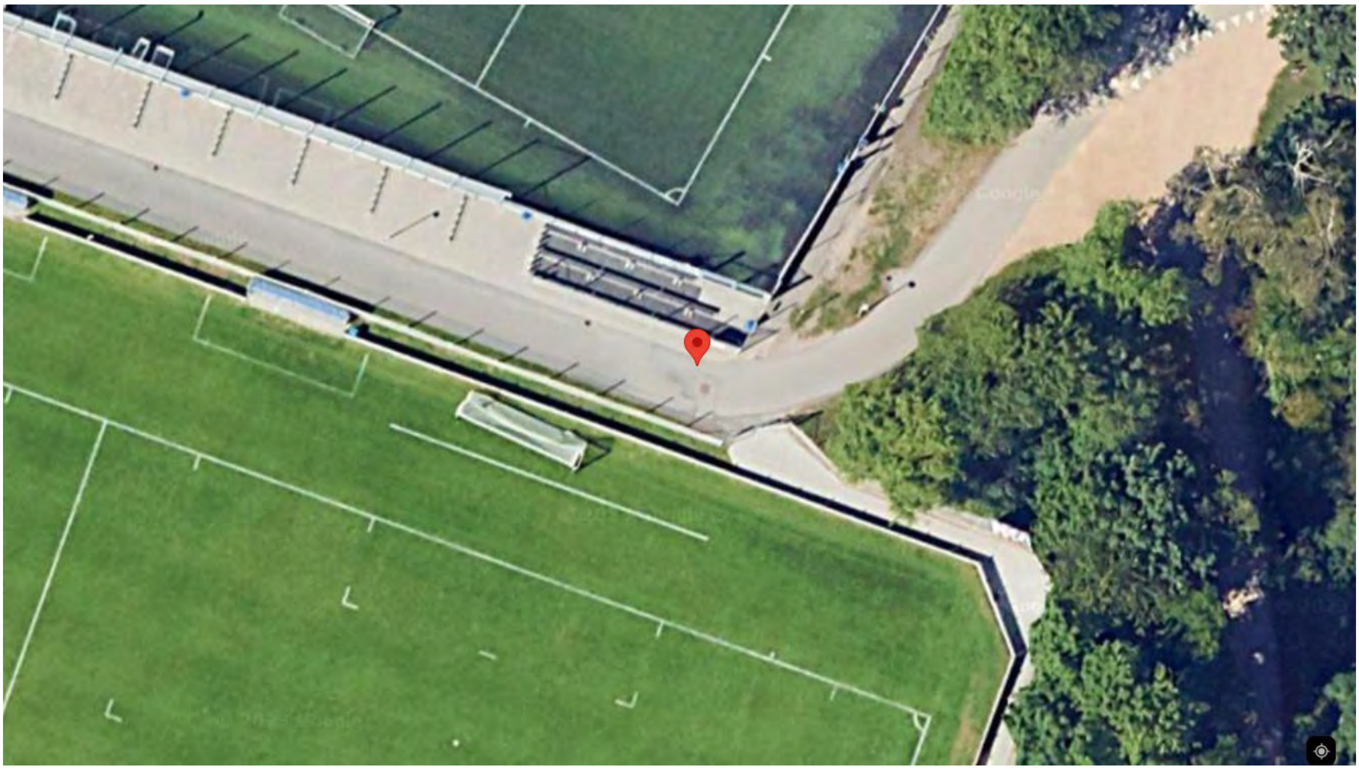
Od5 Søparken South outlet to basin.

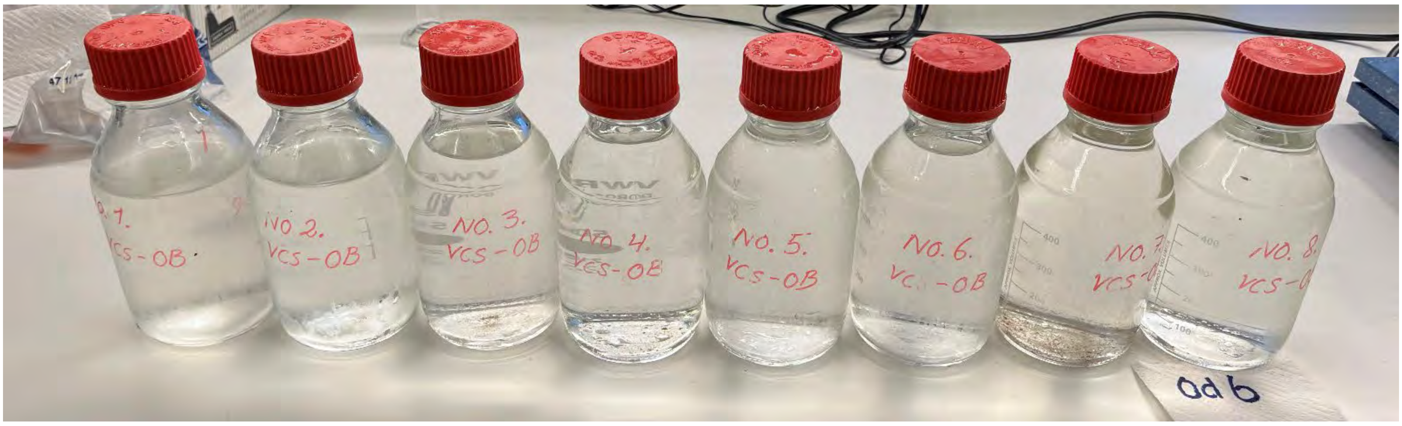
Od06 - Odense Boldklub

Date of sampling: 15/11/2023	
Name of the person who carried out the sampling and institution: **Rikke Hansen VCS**	
Short description of site and mode of sampling: Artificial football field in the city, with rubber granulates and outlet to Odense Å Manual sampling X	
Country: Denmark	
City/town: Odense	
Position: GPS coordinates from Google Maps on a mobile phone: 55.385377, 10.375870	
Estimated time since previous rain event (>1 mm per day) if known: 1 days, otherwise estimate	
	7-14 days
	15-21 days
	21-28 days
	>28 days
Sources, drained area	
	Single houses/terraced residential area, estimate decade(s) for dominant buildings:
	Inner city, old buildings (typically <1930) estimate decade(s) for dominant buildings:
	Inner city, new buildings (typically >1950) estimate decade(s) for dominant buildings:
	Small industry, if possible, specify type:
	Traffic/street
	Parking lots
	Mixed stormwater
	Risk of mixing with municipal sewage
	Other (describe)
Pavement, drained area (if relevant for drained area, major components only)	
	Concrete/concrete slabs/cement slabs
	Asphalt/bitumen
	Gravel
	Cobble stones
	Lawn (cut grass)
	Other (describe) Football field made up of several layers, including gravel, sand, rubber granulates.
Building facades, drained area (if relevant for drained area, major components only)	
	"Raw" bricks
	Mortar plaster/painted mortar plaster/painted bricks
	Wood/painted wood/impregnated wood
	Concrete
	Metal/painted metal

	Fiber cement plates/painted fiber cement/ceramic tiles
	Other (describe)
Roofing (if relevant for drained area, major components only)	
	Roof tiles (terracotta-, clay- or cement/concrete tiles)
	Fiber cement plates/eternit
	Metal roofing/metal shingles/painted metal
	Rolled asphalt roofing/bitumen roofing felt/asphalt composite shingles
	Shale slate shingles (natural)
	Plastic/PVC
Precipitation readings (accumulated):	
	Sample 1 0 min: Sample 2 15 min: Sample 3 30 min: Sample 4 45 min: Sample 5 60 min: Sample 6 75 min: Sample 7 90 min: Sample 8 120 min: No precipitation data from this station. Thulevej was sampled during the same rain event (20:35-22:35). Precipitation in this time interval according to Danish Meteorological Institute: 6,0 mm

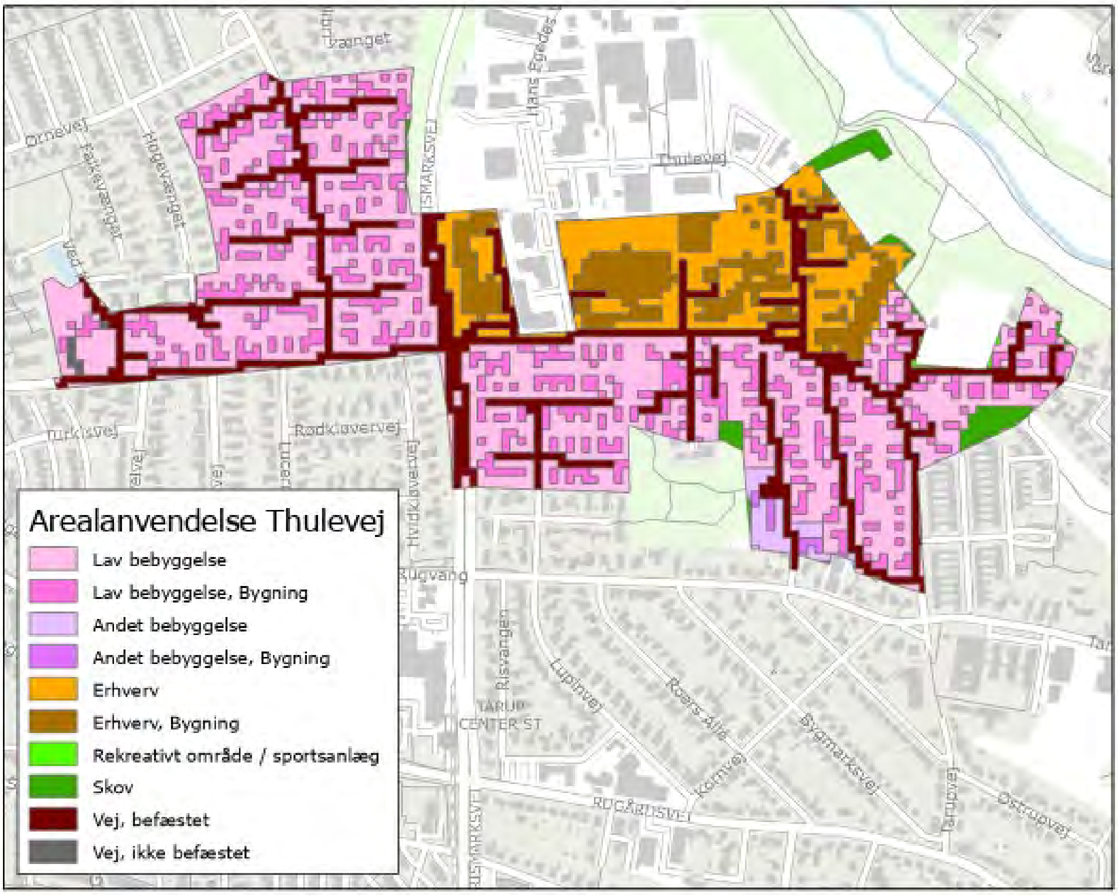
Further characterization of station: sampled from drainpipe collecting drainage only from the southern artificial football field.



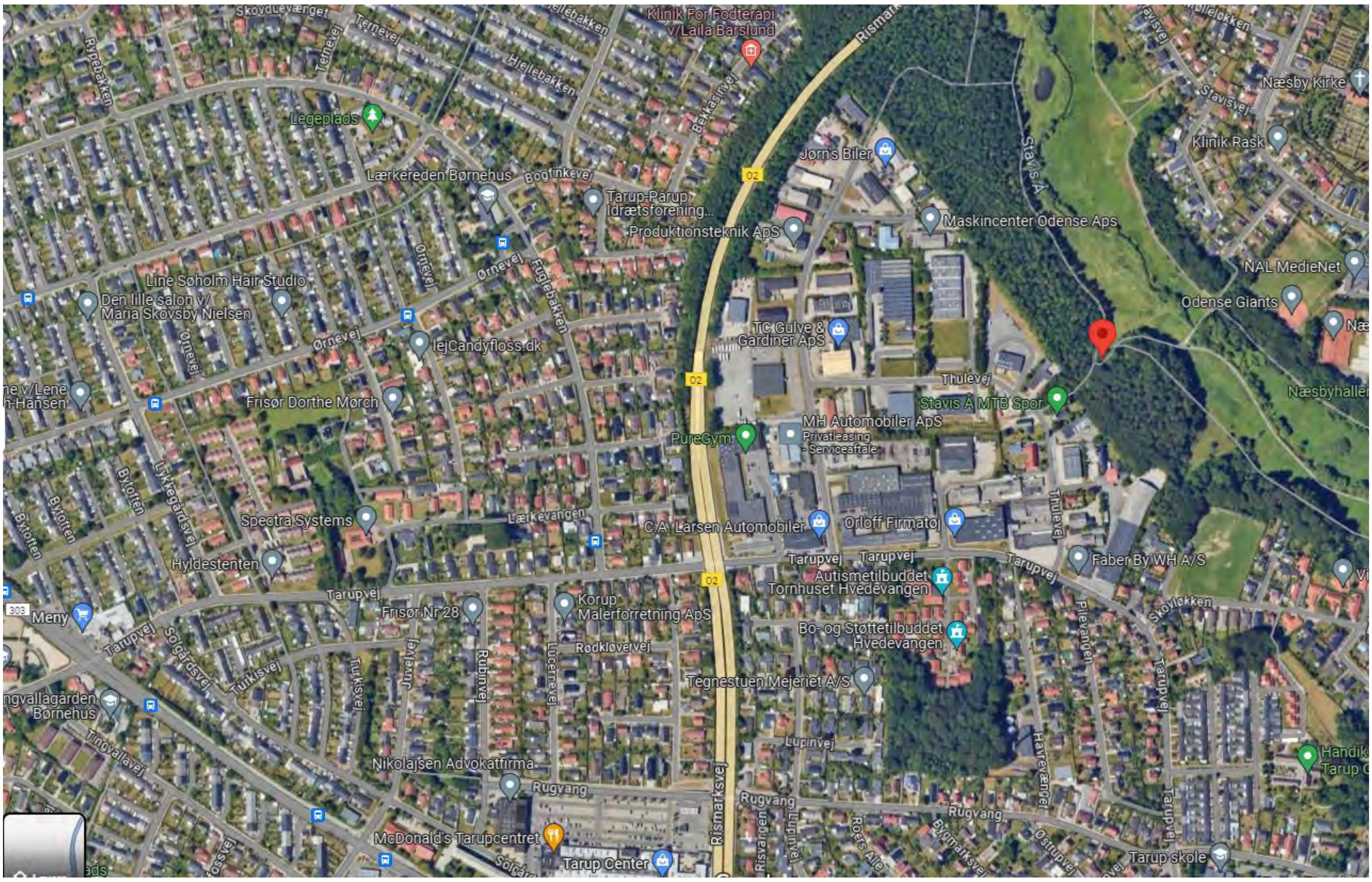

NO. 2. VCS-OB
NO. 3. VCS-OB
NO. 4. VCS-OB
NO. 5. VCS-OB
NO. 6.
Od 6

Od07 - Thulevej

Date of sampling: **15/11/2023**	
Name of the person who carried out the sampling and institution: **Per Rasmussen VCS**	
Short description of site and mode of sampling: Overflow/bypass from municipal WWTP, sampled from bypass pipe X Autosampler X	
Country: Denmark	
City/town: Odense	
Position: GPS coordinates from Google Maps on a mobile phone: 55.415476, 10.348006	
Estimated time since previous rain event (>1 mm per day) if known: 1 days, otherwise estimate	
	7-14 days
	15-21 days
	21-28 days
	>28 days
Sources, drained area	
X	Single houses/terraced residential area, estimate decade(s) for dominant buildings:
	Inner city, old buildings (typically <1930) estimate decade(s) for dominant buildings:
	Inner city, new buildings (typically >1950) estimate decade(s) for dominant buildings:
X	Small industry, if possible, specify type:
X	Traffic/street
X	Parking lots
X	Mixed stormwater
X	Risk of mixing with municipal sewage
	Other (describe)
Pavement, drained area (if relevant for drained area, major components only)	
X	Concrete/concrete slabs/cement slabs
X	Asphalt/bitumen
	Gravel
	Cobble stones
X	Lawn (cut grass)
	Other (describe)
Building facades, drained area (if relevant for drained area, major components only)	
	“Raw” bricks
	Mortar plaster/painted mortar plaster/painted bricks
	Wood/painted wood/impregnated wood
	Concrete
	Metal/painted metal
	Fiber cement plates/painted fiber cement/ceramic tiles
	Other (describe) Large catchment area, properly all of the above

Roofing (if relevant for drained area, major components only)	
	Roof tiles (terracotta-, clay- or cement/concrete tiles)
	Fiber cement plates/eternit
	Metal roofing/metal shingles/painted metal
	Rolled asphalt roofing/bitumen roofing felt/asphalt composite shingles
	Shale slate shingles (natural)
	Plastic/PVC
Precipitation readings (accumulated):	
	Sample 1 0 min: Sample 2 15 min: Sample 3 30 min: Sample 4 45 min: Sample 5 60 min: Sample 6 75 min: Sample 7 90 min: Sample 8 120 min: No data from this station. Sampling time: 20:35-22:35 Precipitation in this time interval according to Danish Meteorological Institute : 6,0 mm
	


Stavis Å
Biltilsyn Odense
VVS Experten ApS
Stavis Å MTB Spor
Thulevej
Basen Fyn
Dagbehandling
Google


Klinik For Fodterapi
V/Laila Barslund
Legeplads
Lærkereden Børnehus
Bogfinkevej
Tarup-Parup
Idrætsforening...
Produktionsteknik ApS
Jørn's Biler
Maskincenter Odense Aps
Stavis Å
Næsby Kirke
Klinik Rask
NAL MedieNet
Odense Giants
Næsbyhallen
Line Soholm Hair Studio
Den lille salon v/
Maria Skovsby Nielsen
lejCandyfloss.dk
TC Gulve &
Gardiner ApS
Thulevej
Stavis Å MTB Spor
Frisør Dorthe Mørch
PureGym
MH Automobiler ApS
Spectra Systems
C.A. Larsen Automobiler
Orloff Firmatøj
Faber By WH A/S
Hyldestenten
Tarupvej
Autismetilbuddet
Tornhuset Hvedevangen
Meny
Frisør Nr 28
Korup
Malerforretning ApS
Bo- og Støttetilbuddet
Hvedevangen
Rødkløvervej
Tegnestuen Mejeriet A/S
Lupinvej
Nikolajsen Advokatfirma
Rugvang
McDonald's Tarupcentret
Tarup Center
Risvangen
Rismarksvej
Tarup skole

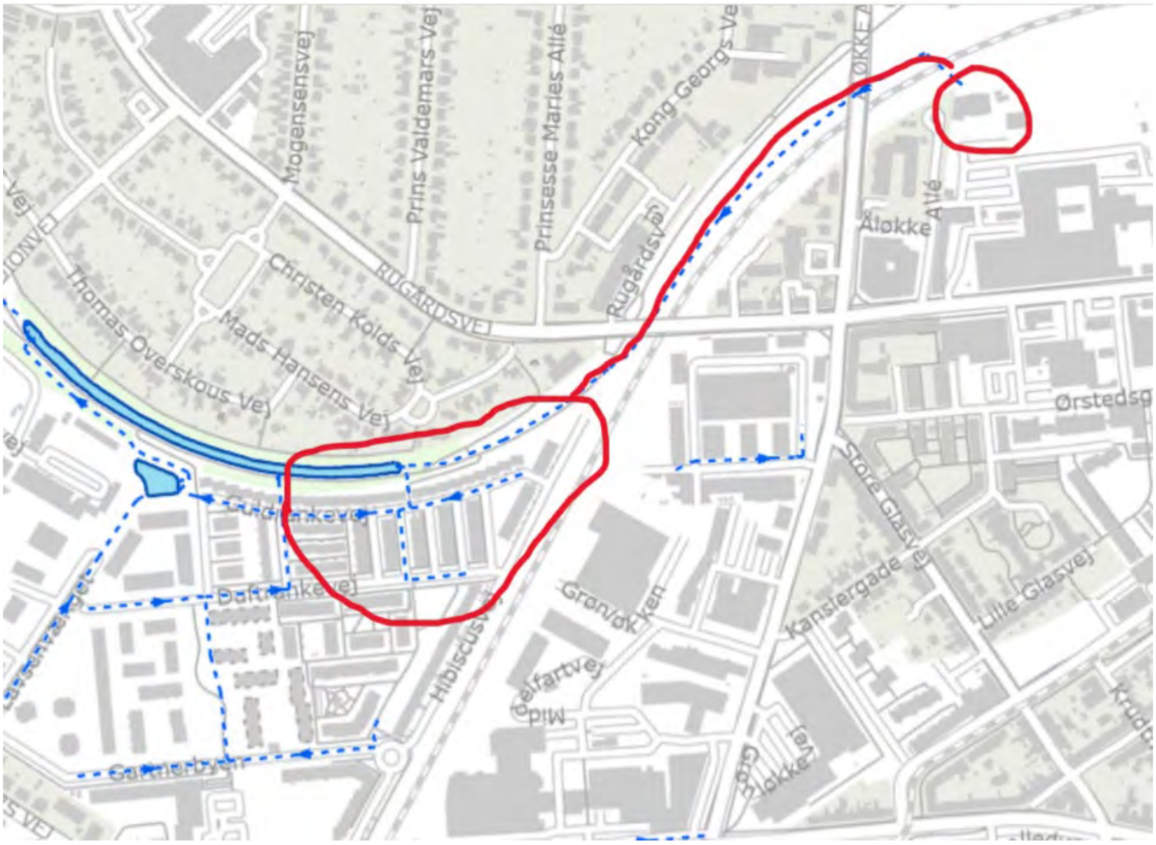
Od08 Gartnerbyen

Date of sampling: 23.05.2024	
Name of the person who carried out the sampling and institution: Nina Almind Jørgensen, VCS Thor Hougaard, Anura	
Short description of site and mode of sampling: Inlet to long narrow retention pond at a newly constructed residential area, sampled from pond water at inlet pipe Manual sampling	
Country: DK	
City/town: ODENSE	
Position: GPS coordinates from Google Maps on a mobile phone: 55.397692, 10.360869	
Estimated time since previous rain event (>1 mm per day) if known: 17 days	
	7-14 days
X	15-21 days
	21-28 days
	>28 days
Sources, drained area	
X	Single houses/terraced residential area, estimate decade(s) for dominant buildings: new (2 years)
	Inner city, old buildings (typically <1930) estimate decade(s) for dominant buildings:
	Inner city, new buildings (typically >1950) estimate decade(s) for dominant buildings:
	Small industry, if possible, specify type:
	Traffic/street
X	Parking lots
	Mixed stormwater
	Risk of mixing with municipal sewage
	Other (describe)
Pavement, drained area (if relevant for drained area, major components only)	
X	Concrete/concrete slabs/cement slabs
X	Asphalt/bitumen
	Gravel
	Cobble stones
X	Lawn (cut grass)
	Other (describe)
Building facades, drained area (if relevant for drained area, major components only)	
X	"Raw" bricks
	Mortar plaster/painted mortar plaster/painted bricks
X	Wood/painted wood/impregnated wood
X	Concrete
	Metal/painted metal
	Fiber cement plates/painted fiber cement/ceramic tiles
	Other (describe)

Roofing (if relevant for drained area, major components only)	
	Roof tiles (terracotta-, clay- or cement/concrete tiles)
	Fiber cement plates/eternit
	Metal roofing/metal shingles/painted metal
X	Rolled asphalt roofing/bitumen roofing felt/asphalt composite shingles
	Shale slate shingles (natural)
	Plastic/PVC
Precipitation readings (accumulated):	
09:55	Sample 1 0 min:
10:10	Sample 2 15 min:
10:25	Sample 3 30 min:
10:40	Sample 4 45 min:
10:55	Sample 5 60 min:
11:10	Sample 6 75 min:
11:25	Sample 7 90 min:
11:40	Sample 8 120 min:
	Read from the Danish national weather archive (dmi.dk, Årslev) 9:40 (start of rain) to 11:40: 13,1 mm

Further characterization of station:

Before industrial area, now new residential area. Catchment area also includes an office building with parking slots to the northeast (TV2).




Od 08

Po01 - Via Hangar

Date of sampling: 09/02/2024	
Name of the person who carried out the sampling and institution: Francesca Marvulli, Acque SpA – Tutela della Risorsa Idrica, Via A. Bellatalla ,1 - 56121 Ospedaletto (PI)	
Short description of site and mode of sampling: Overflow/bypass from municipal WWTP, sampled from bypass pipe Manual sampling YES	
Country: Italy	
City/town: Pontedera	
Position: GPS coordinates from Google Maps on a mobile phone: 43.663722, 10.615019	
Estimated time since previous rain event (>1 mm per day) if known: 22/01/2024 - 17 days	
	7-14 days
X	15-21 days
	21-28 days
	>28 days
Sources, drained area	
X	Single houses/terraced residential area, estimate decade(s) for dominant buildings:
X	Inner city, old buildings (typically <1930) estimate decade(s) for dominant buildings:
X	Inner city, new buildings (typically >1950) estimate decade(s) for dominant buildings:
X	Small industry, if possible, specify type: automotive/motorcycle (Piaggio &C.)
X	Traffic/street
X	Parking lots
X	Mixed stormwater
X	Risk of mixing with municipal sewage
	Other (describe)
Pavement, drained area (if relevant for drained area, major components only)	
X	Concrete/concrete slabs/cement slabs
X	Asphalt/bitumen
	Gravel
	Cobble stones
X	Lawn (cut grass)
	Other (describe)
Building facades, drained area (if relevant for drained area, major components only)	
	"Raw" bricks
X	Mortar plaster/painted mortar plaster/painted bricks
	Wood/painted wood/impregnated wood
X	Concrete
X	Metal/painted metal
	Fiber cement plates/painted fiber cement/ceramic tiles
	Other (describe)
Roofing (if relevant for drained area, major components only)	
X	Roof tiles (terracotta-, clay- or cement/concrete tiles)
	Fiber cement plates/eternit
X	Metal roofing/metal shingles/painted metal

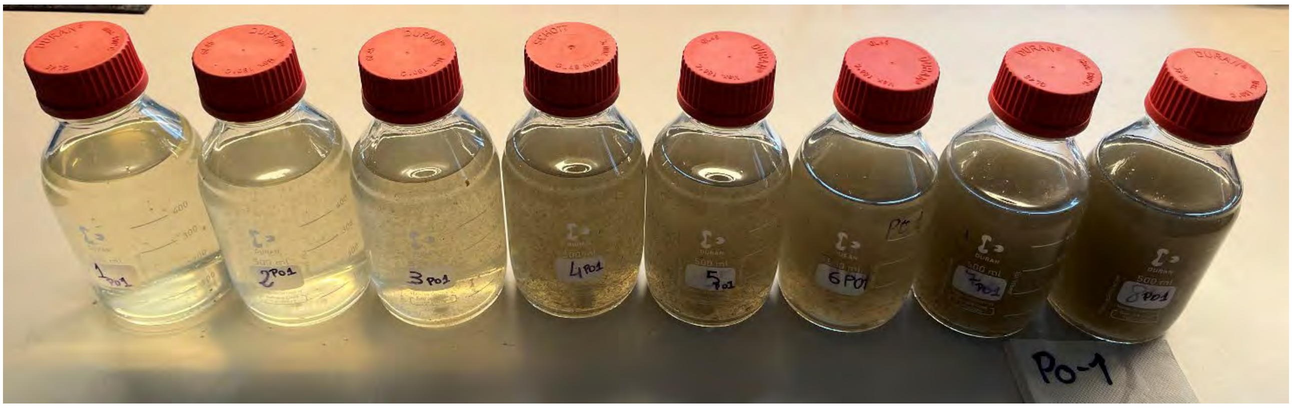
	Rolled asphalt roofing/bitumen roofing felt/asphalt composite shingles
	Shale slate shingles (natural)
	Plastic/PVC
Precipitation readings (accumulated):	
	time 18:10 Sample 1 0 min:1,3 mm time 18:25 Sample 2 15 min: 2,3 mm time 18:40 Sample 3 30 min: 3,3 mm time 18:55 Sample 4 45 min: 3,6 mm time 19:10 Sample 5 60 min: 3,6 mm time 19:25 Sample 6 75 min: 3,6 mm time 19:40 Sample 7 90 min: 3,6 mm time 19:55 Sample 8 105 min: 3,7 mm

Aerial view.

Sampling Site

Before Rain Event

During rain event



Samples

Sampling

Po2 - Via Agnoletti

Date of sampling: 23/02/2024	
Name of the person who carried out the sampling and institution: Stefano Tempestini, Acque SpA – Tutela della Risorsa Idrica, Via A. Bellatalla ,1 - 56121 Ospedaletto (PI)	
Short description of site and mode of sampling: Overflow/bypass from municipal WWTP, sampled from bypass pipe Manual sampling YES	
Country: Italy	
City/town: Pontedera	
Position: GPS coordinates from Google Maps on a mobile phone: latitude 43°40'6.23"N (43.668397) latitude 10°36'44.20"E (10.612278)	
Estimated time since previous rain event (>1 mm per day) if known: 11/02/2024 - 12 days.	
X	7-14 days
	15-21 days
	21-28 days
	>28 days
Sources, drained area	
X	Single houses/terraced residential area, estimate decade(s) for dominant buildings:
	Inner city, old buildings (typically <1930) estimate decade(s) for dominant buildings:
	Inner city, new buildings (typically >1950) estimate decade(s) for dominant buildings:
X	Small industry, if possible, specify type: small commercial area, craft shops.
X	Traffic/street
X	Parking lots
X	Mixed stormwater
X	Risk of mixing with municipal sewage
	Other (describe)
Pavement, drained area (if relevant for drained area, major components only)	
X	Concrete/concrete slabs/cement slabs
X	Asphalt/bitumen
	Gravel
	Cobble stones
X	Lawn (cut grass)
	Other (describe)
Building facades, drained area (if relevant for drained area, major components only)	
X	"Raw" bricks
X	Mortar plaster/painted mortar plaster/painted bricks
	Wood/painted wood/impregnated wood
X	Concrete
	Metal/painted metal
	Fiber cement plates/painted fiber cement/ceramic tiles
	Other (describe)
Roofing (if relevant for drained area, major components only)	

	Roof tiles (terracotta-, clay- or cement/concrete tiles)
	Fiber cement plates/eternit
X	Metal roofing/metal shingles/painted metal
X	Rolled asphalt roofing/bitumen roofing felt/asphalt composite shingles
	Shale slate shingles (natural)
	Plastic/PVC
Precipitation readings (accumulated):	
	Time 11:45 Sample 1 0 min: 2,0 mm Time 12:00 Sample 2 15 min: 2,8 mm Time 12:15 Sample 3 30 min: 4,8 mm Time 12:30 Sample 4 45 min: 5,6 mm Time 12:45 Sample 5 60 min: 6,0 mm Time 13:00 Sample 6 75 min: 6,2 mm Time 13:15 Sample 7 90 min: 6,8 mm


Site


Active bypass


Sampling

Po3 - Via Roma

Date of sampling: 23/02/2024	
Name of the person who carried out the sampling and institution: Francesca Marvulli, Acque SpA – Tutela della Risorsa Idrica, Via A. Bellatalla ,1 - 56121 Ospedaletto (PI)	
Short description of site and mode of sampling: Street runoff from city street, sampled before the storm drain Manual sampling: YES	
Country: Italy	
City/town: Pontedera	
Position: GPS coordinates from Google Maps on a mobile phone: latitude 43°39'32.96"N (43.659156) longitude 10°37'59.11"E (10.633086)	
Estimated time since previous rain event (>1 mm per day) if known: 11/02/2024 - 12 days	
X	7-14 days
	15-21 days
	21-28 days
	>28 days
Sources, drained area	
	Single houses/terraced residential area, estimate decade(s) for dominant buildings:
	Inner city, old buildings (typically <1930) estimate decade(s) for dominant buildings:
	Inner city, new buildings (typically >1950) estimate decade(s) for dominant buildings:
	Small industry, if possible, specify type
X	Traffic/street
	Parking lots
	Mixed stormwater
	Risk of mixing with municipal sewage
	Other (describe)
Pavement, drained area (if relevant for drained area, major components only)	
X	Concrete/concrete slabs/cement slabs
X	Asphalt/bitumen
	Gravel
	Cobble stones
	Lawn (cut grass)
	Other (describe)
Building facades, drained area (if relevant for drained area, major components only)	
	"Raw" bricks
X	Mortar plaster/painted mortar plaster/painted bricks
	Wood/painted wood/impregnated wood
	Concrete
X	Metal/painted metal
	Fiber cement plates/painted fiber cement/ceramic tiles
	Other (describe)
Roofing (if relevant for drained area, major components only)	
	Roof tiles (terracotta-, clay- or cement/concrete tiles)
	Fiber cement plates/eternit

	Metal roofing/metal shingles/painted metal
	Rolled asphalt roofing/bitumen roofing felt/asphalt composite shingles
	Shale slate shingles (natural)
	Plastic/PVC
Precipitation readings (accumulated):	
	time 11:35 Sample 1 0 min: 0,7 mm time 11:50 Sample 2 15 min: 2,3 mm time 12:05 Sample 3 30 min: 2,8 mm time 12:20 Sample 4 45 min: 5,1 mm time 12:35 Sample 5 60 min: 5,7 mm time 12:50 Sample 6 75 min: 6,1 mm time 13:05 Sample 7 90 min: 6,4 mm

Samples

Sampling station


During rain event

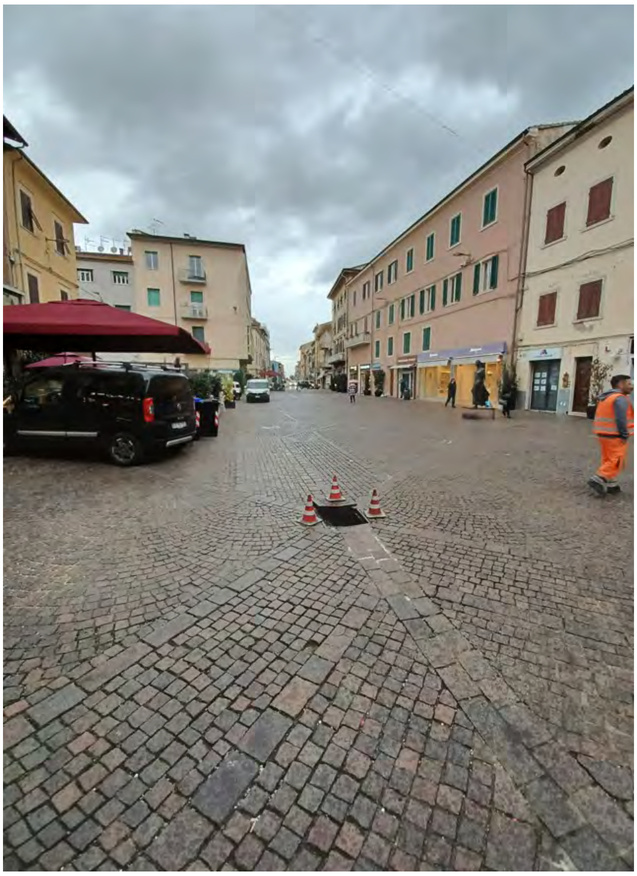
Sampling

Po4 – Piazza Cavour

Date of sampling: 23/02/2024	
Name of the person who carried out the sampling and institution: Natalino Di Nunzio, Acque SpA – Tutela della Risorsa Idrica, Via A. Bellatalla ,1 - 56121 Ospedaletto (PI)	
Short description of site and mode of sampling: Street runoff from city street, sampled before the storm drain Manual sampling: YES	
Country: Italy	
City/town: Pontedera	
Position: GPS coordinates from Google Maps on a mobile phone: latitude 43°39'49.49"N (43.663747) longitude 10°38'7.33"E (10.635369)	
Estimated time since previous rain event (>1 mm per day) if known: 11/02/2024 - 12 days	
X	7-14 days
	15-21 days
	21-28 days
	>28 days
Sources, drained area	
X	Single houses/terraced residential area, estimate decade(s) for dominant buildings:
	Inner city, old buildings (typically <1930) estimate decade(s) for dominant buildings:
	Inner city, new buildings (typically >1950) estimate decade(s) for dominant buildings:
	Small industry, if possible, specify type
	Traffic/street
	Parking lots
	Mixed stormwater
	Risk of mixing with municipal sewage
X	Other (describe): Only pedestrian zone
Pavement, drained area (if relevant for drained area, major components only)	
	Concrete/concrete slabs/cement slabs
	Asphalt/bitumen
	Gravel
X	Cobble stones
	Lawn (cut grass)
	Other (describe)
Building facades, drained area (if relevant for drained area, major components only)	
	"Raw" bricks
X	Mortar plaster/painted mortar plaster/painted bricks
	Wood/painted wood/impregnated wood
	Concrete
	Metal/painted metal
	Fiber cement plates/painted fiber cement/ceramic tiles
	Other (describe)
Roofing (if relevant for drained area, major components only)	
	Roof tiles (terracotta-, clay- or cement/concrete tiles)
	Fiber cement plates/eternit
	Metal roofing/metal shingles/painted metal

	Rolled asphalt roofing/bitumen roofing felt/asphalt composite shingles
	Shale slate shingles (natural)
	Plastic/PVC
Precipitation readings (accumulated):	
	time 11:30 Sample 1 0 min: 0,0 mm time 11:45 Sample 2 15 min: 2,0 mm time 12:00 Sample 3 30 min: 2,8 mm time 12:15 Sample 4 45 min: 4,8 mm time 12:30 Sample 5 60 min: 5,6 mm time 12:45 Sample 6 75 min: 6,0 mm

Samples



Sampling Site

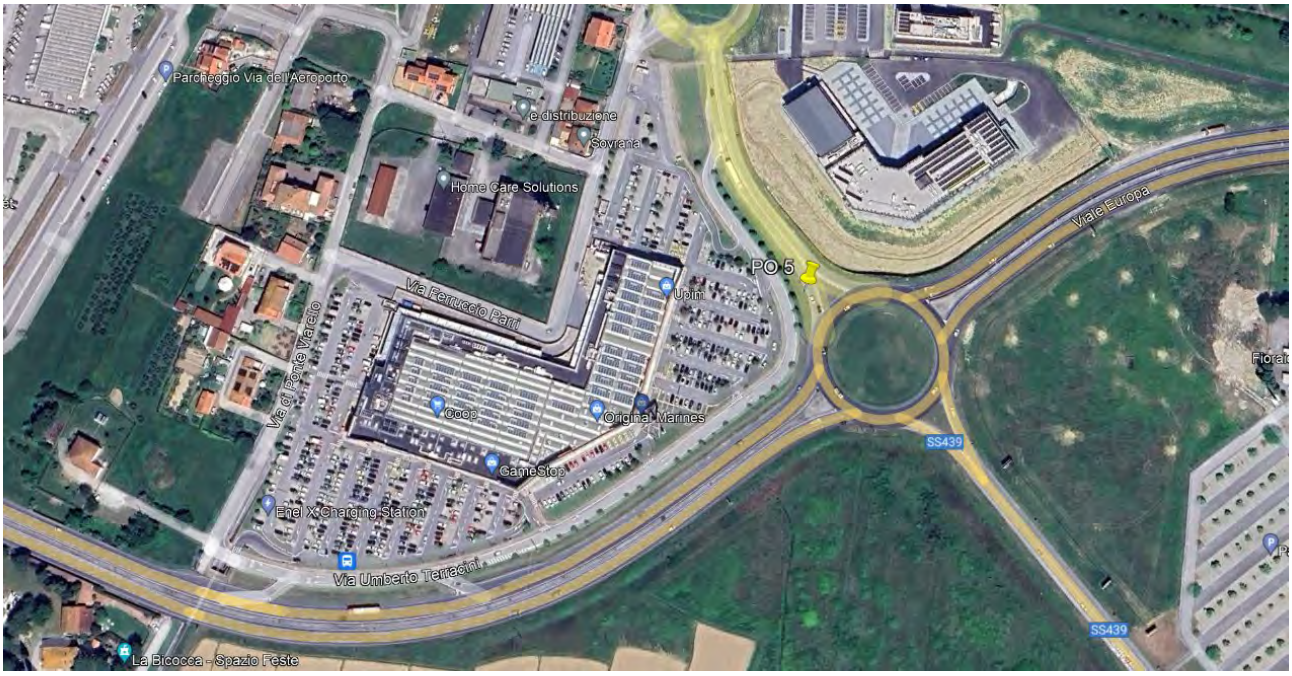
During rain event

Po5 - Shopping Mall

Date of sampling: 09/02/2024	
Name of the person who carried out the sampling and institution: Stefano Tempestini | Acque SpA – Tutela della Risorsa Idrica | Via A. Bellatalla ,1 - 56121 Ospedaletto (PI)	
Short description of site and mode of sampling: Street runoff from city street, sampled before the storm drain Manual sampling YES Autosampler NO	
Country: Italy	
City/town: Pontedera	
Position: GPS coordinates from Google Maps on a mobile phone: 43.653558, 10.627081	
Estimated time since previous rain event (>1 mm per day) if known: 22/01/2024 - 17 days.	
	7-14 days
X	15-21 days
	21-28 days
	>28 days
Sources, drained area	
	Single houses/terraced residential area, estimate decade(s) for dominant buildings:
	Inner city, old buildings (typically <1930) estimate decade(s) for dominant buildings:
	Inner city, new buildings (typically >1950) estimate decade(s) for dominant buildings:
	Small industry, if possible, specify type
X	Traffic/street
	Parking lots
	Mixed stormwater
	Risk of mixing with municipal sewage
	Other (describe)
Pavement, drained area (if relevant for drained area, major components only)	
	Concrete/concrete slabs/cement slabs
X	Asphalt/bitumen
	Gravel
	Cobble stones
X	Lawn (cut grass)
	Other (describe)
Building facades, drained area (if relevant for drained area, major components only)	
	"Raw" bricks
	Mortar plaster/painted mortar plaster/painted bricks
	Wood/painted wood/impregnated wood
	Concrete
	Metal/painted metal
	Fiber cement plates/painted fiber cement/ceramic tiles
	Other (describe)

Roofing (if relevant for drained area, major components only)	
	Roof tiles (terracotta-, clay- or cement/concrete tiles)
	Fiber cement plates/eternit
	Metal roofing/metal shingles/painted metal
	Rolled asphalt roofing/bitumen roofing felt/asphalt composite shingles
	Shale slate shingles (natural)
	Plastic/PVC
Precipitation readings (accumulated):	
	Sample 1 0 min: 0,7 mm 17:20 Sample 2 15 min: 0,9 mm 17:35 Sample 3 30 min: 1,0 mm 17:50 Sample 4 45 min: 1,3 mm 18:05 Sample 5 60 min: 2,3 mm 18:20 Sample 6 75 min: 3,3 mm 18:35 Sample 7 90 min: 3,6 mm 18:50

Map of the catchment area and a general description.



Road run off – Inlet of NBS

Pictures showing the sampling sites Po5 and the drained area.

1.

2. Sampling

Samples

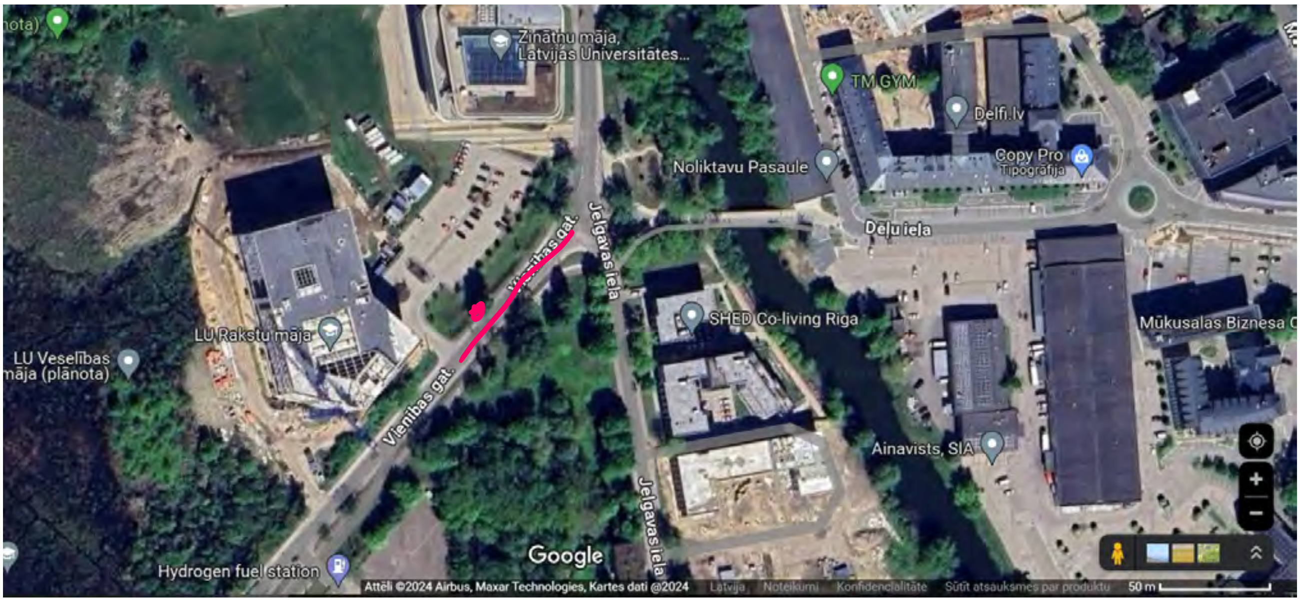
Ri01 – Vienības Av.

Date of sampling: 12/06/2024	
Name of the person who carried out the sampling and institution: Agnese Arāja, University of Latvia	
Short description of site and mode of sampling: Vienības av., Street runoff from city street, sampled at a storm drain Stormwater from a city street (asphalt surface) with rather heavy traffic, samples collected directly from the pipe at inlet to NBS.	
Country: Latvia	
City/town: Riga	
Position: GPS coordinates from Google Maps: 56.9350256,24.097359	
Estimated time since previous rain event if known: 0 days (10.06.; 11.06. - brief episodes of light, short rain 0.3-0.6mm)	
	7-14 days
	15-21 days
	21-28 days
	>28 days
Sources, drained area	
	Single houses/terraced residential area, estimate decade(s) for dominant buildings:
	Inner city, old buildings (typically <1930) estimate decade(s) for dominant buildings:
	Inner city, new buildings (typically >1950) estimate decade(s) for dominant buildings:
	Small industry, if possible, specify type:
x	Traffic/street
	Parking lots
	Mixed stormwater
	Risk of mixing with municipal sewage
	Other (describe)
Pavement, drained area (if relevant for drained area, major components only)	
	Concrete/concrete slabs/cement slabs
x	Asphalt/bitumen
	Gravel
	Cobble stones
	Lawn (cut grass)
	Other (describe)
Building facades, drained area (if relevant for drained area, major components only)	
	"Raw" bricks
	Mortar plaster/painted mortar plaster/painted bricks
	Wood/painted wood/impregnated wood
x	Concrete
	Metal/painted metal
	Fiber cement plates/painted fiber cement/ceramic tiles
	Other (describe)

Roofing (if relevant for drained area, major components only)	
	Roof tiles (terracotta-, clay- or cement/concrete tiles)
	Fiber cement plates/eternit
	Metal roofing/metal shingles/painted metal
	Rolled asphalt roofing/bitumen roofing felt/asphalt composite shingles
	Shale slate shingles (natural)
	Plastic/PVC
Precipitation readings (accumulated): Start of rain event 11:55 (t0) Sampling started 12:10, 5 (1-5) samples taken every 15 min until 13:10 (rain stopped), a total of 2.2mm. At 18:02 it continued to rain 3 (6-8) samples taken every 15 min until 18:45(rain stopped), a total of 1.2 mm.	

Estimated 100% of the water came from the street.

Drained area and sampling point:



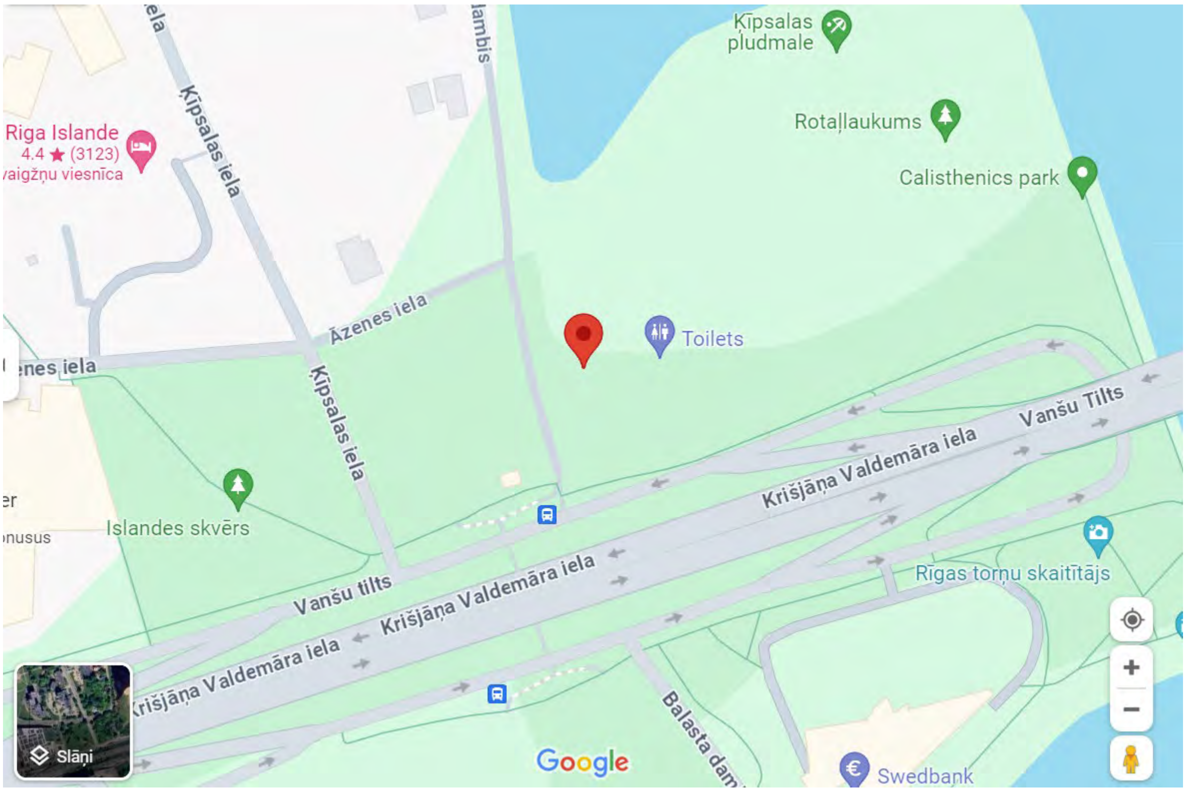



Ri02 - Balasta dambis

Date of sampling: 19/6-2024	
Name of the person who carried out the sampling and institution: Māris Bērtiņš, University of Latvia	
Short description of site and mode of sampling: Balasta dambis, Street runoff from city street and Vanšu bridge sampled at a storm drain	
Country: Latvia	
City/town: Riga	
Position: GPS coordinates from Google Maps on a mobile phone: 56.9504904, 24.0873400	
Estimated time since previous rain event if known **otherwise estimate (last heavy rain 09.06.; 14.06.; 17.06.<1mm)**	
x	7-14 days
	15-21 days
	21-28 days
	>28 days
Sources, drained area	
	Single houses/terraced residential area, estimate decade(s) for dominant buildings:
	Inner city, old buildings (typically <1930) estimate decade(s) for dominant buildings:
	Inner city, new buildings (typically >1950) estimate decade(s) for dominant buildings:
	Small industry, if possible, specify type:
x	Traffic/street
	Parking lots
x	Mixed stormwater
	Risk of mixing with municipal sewage
	Other (describe)
Pavement, drained area (if relevant for drained area, major components only)	
	Concrete/concrete slabs/cement slabs
x	Asphalt/bitumen
	Gravel
	Cobble stones
	Lawn (cut grass)
	Other (describe)
Building facades, drained area (if relevant for drained area, major components only)	
	"Raw" bricks
	Mortar plaster/painted mortar plaster/painted bricks
	Wood/painted wood/impregnated wood
	Concrete
	Metal/painted metal
	Fiber cement plates/painted fiber cement/ceramic tiles
	Other (describe)
Roofing (if relevant for drained area, major components only)	
	Roof tiles (terracotta-, clay- or cement/concrete tiles)
	Fiber cement plates/eternit
	Metal roofing/metal shingles/painted metal
	Rolled asphalt roofing/bitumen roofing felt/asphalt composite shingles
	Shale slate shingles (natural)

	Plastic/PVC
Precipitation readings (accumulated): Sampling started 12:05 (start of rain event, t0), samples taken every 15 min. An intense event (20 min) followed by light precipitation until ~14:00. A total of 5 mm.	

It was possible to take 5 samples, after ~ 1h flow was negligible. Runoff water came from the streets and Vanšu bridge.



Ri03 - Turaidas street

Date of sampling: 19/6-2024	
Name of the person who carried out the sampling and institution: Agnese Arāja, University of Latvia	
Short description of site and mode of sampling: Turaidas street, runoff from the building's roof and yard sampled at a runoff drainage pipe at inlet to NBS.	
Country: Latvia	
City/town: Riga	
Position: GPS coordinates from Google Maps on a mobile phone: 56.967699,24.158381	
Estimated time since previous rain event if known: **otherwise estimate (last heavy rain 09.06.; 14.06.; 17.06.<1mm)**	
x	7-14 days
	15-21 days
	21-28 days
	>28 days
Sources, drained area	
	Single houses/terraced residential area, estimate decade(s) for dominant buildings:
	Inner city, old buildings (typically <1930) estimate decade(s) for dominant buildings:
x	Inner city, new buildings (typically >1950) estimate decade(s) for dominant buildings: 2020
	Small industry, if possible, specify type:
	Traffic/street
(x)	Parking lots
	Mixed stormwater
	Risk of mixing with municipal sewage
	Other (describe)
Pavement, drained area (if relevant for drained area, major components only)	
x	Concrete/concrete slabs/cement slabs
	Asphalt/bitumen
	Gravel
	Cobble stones
	Lawn (cut grass)
	Other (describe)
Building facades, drained area (if relevant for drained area, major components only)	
	"Raw" bricks
	Mortar plaster/painted mortar plaster/painted bricks
	Wood/painted wood/impregnated wood
x	Concrete
	Metal/painted metal
	Fiber cement plates/painted fiber cement/ceramic tiles
	Other (describe): concrete blocks filled with concrete; external thermal insulation - polystyrene foam with stone wool strips; with decorative plaster and painting
Roofing (if relevant for drained area, major components only)	
	Roof tiles (terracotta-, clay- or cement/concrete tiles)

<table>
<tr><td></td><td>Fiber cement plates/eternit</td></tr>
<tr><td>x (tin cover)</td><td>Metal roofing/metal shingles/painted metal</td></tr>
<tr><td></td><td>Rolled asphalt roofing/bitumen roofing felt/asphalt composite shingles</td></tr>
<tr><td></td><td>Shale slate shingles (natural)</td></tr>
<tr><td></td><td>Plastic/PVC</td></tr>
<tr><td colspan="2">Precipitation readings (accumulated):

Sampling started 11:50 (start of rain event, t0), samples taken every 15 min.

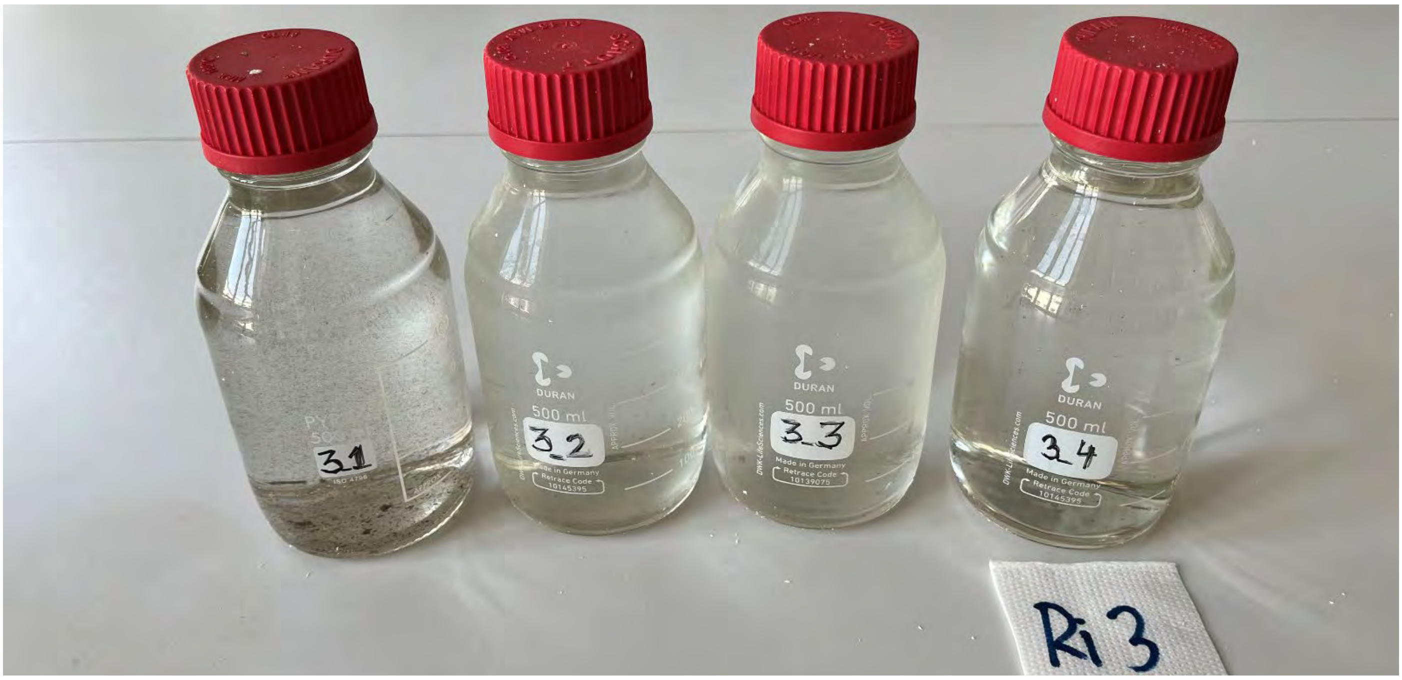
An intense event (20 min) followed by light precipitation until ~14:00.
A total of 5 mm.</td></tr>
</table>

It was possible to take 4 samples, after 1h flow was negligible. Runoff water came from the roof, the cobblestone pavement and to a lesser extent from the parking lot.

Drained area and sampling point:


KI - 1624

Samples



Station: Sa01, wetland

Short description of site and mode of sampling: Reconstructed wetland in "Parque de Las Llamas". Manual sampling from the wetland influent (small river).	
Country: Spain.	
City/town: Santander.	
Position: 43.472577, -3.805824	
Sources, drained area	
x	Risk of mixing with municipal sewage
x	Other (describe): vegetated area with a small group of houses, with some animals and orchards.
Pavement, drained area (if relevant for drained area, major components only)	
x	Asphalt/bitumen
x	Other (describe): mainly vegetated slopes.
Building facades, drained area (if relevant for drained area, major components only)	
x	Mortar plaster/painted mortar plaster/painted bricks
Roofing (if relevant for drained area, major components only)	
x	Roof tiles (terracotta-, clay- or cement/concrete tiles)

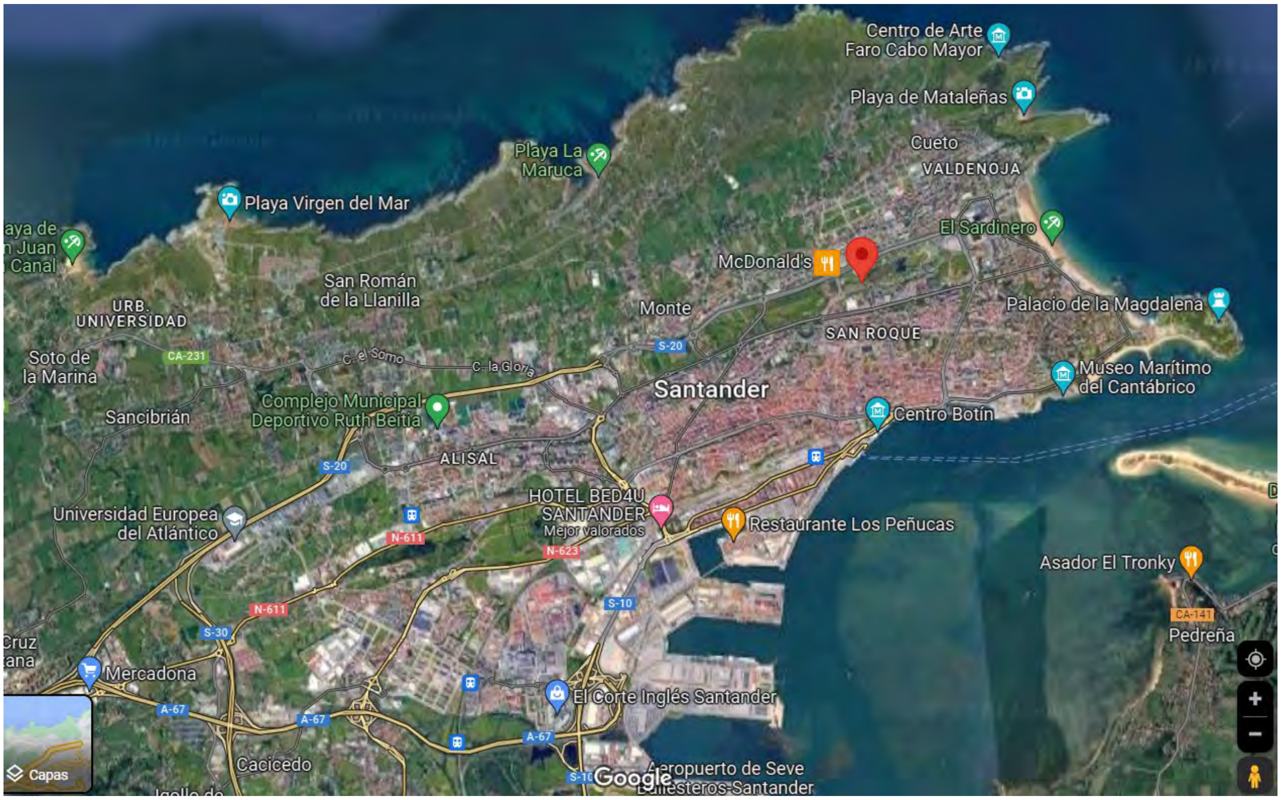
Sample times 1: 9:10, 2: 9:26, 3: 9:42, 4: 9:58, 5: 10_15, 6: 10:32, 7: 10:49, 8:11:03

Start time	**Station**	**Name of the persons and institutions**
09:10	**Sa01**, Reconstructed wetland in "Parque de Las Llamas". Manual sampling from the wetland influent (small river).	Sara García (UC) and Itzayana González (UC).

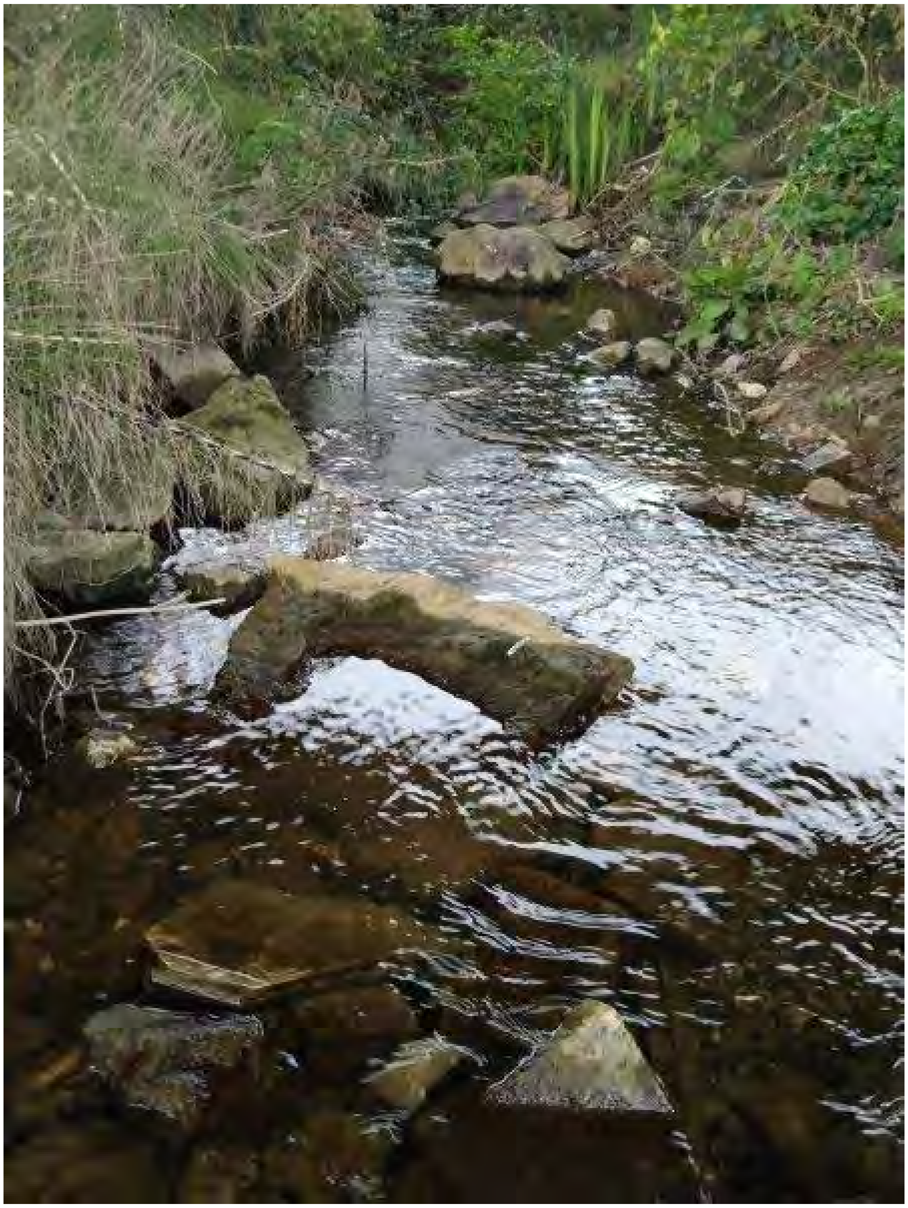
Date: 27/11-2023

Time since previous rain event: 6 days

Rain event of sampling (official AEMET rain gauge in Santander): 1,6 mm


Centro de Arte Faro Cabo Mayor
Playa de Mataleñas
Cueto
VALDENOJA
Playa La Maruca
Playa Virgen del Mar
El Sardinero
McDonald's
San Román de la Llanilla
URB. UNIVERSIDAD
Monte
Palacio de la Magdalena
SAN ROQUE
Soto de la Marina
Santander
Museo Marítimo del Cantábrico
Complejo Municipal Deportivo Ruth Beitia
Sancibrián
Centro Botín
ALISAL
Universidad Europea del Atlántico
HOTEL BED4U SANTANDER
Restaurante Los Peñucas
Asador El Tronky
Pedreña
Mercadona
El Corte Inglés Santander
Cacicedo
Capas
Google


Parque (La Pereda)
Firenze Comunicación
C. Ernest Lluch
Av. de la Constitución
Lupa Supermercados
McDonald's
Comida rápida · €
C. Libertad
Parque Atlántico de Las Llamas
Marismas, senderos y una cafetería
Escenario Santander
Torre A Edificio Tres Torres
C. Marino Fernández-Fontecha
Parking de Autocaravanas
ESN Santander (Asoc. Universitaria Erasmus...
Universidad de Cantabria (UniCan)
Ministerio Jesús el Rey de Gloria
Servicio de informática
Pabellón de Gobierno, Universidad de Cantabria
Edificio Interfacultativo
Oficina de Relaciones Internacionales (ORI)
Facultad de Derecho
Av. de los Castros
CEIP Dionisio García Barredo
Facultad de Ciencias Económicas y...
Bar La Conchita
Capas
Google




Sa 1

Station: Sa02, Carpark

Short description of site and mode of sampling: Permeable carpark in "Parque de Las Llamas". Manual sampling from a runoff inlet. Only water from the surface of the carpark showed in the picture, i.e., surface water entering the drain at that specific point (the pipe collect the water from the 2 previous drains without any connection with the waste water system). No sample 8.
Country: Spain.
City/town: Santander.
Position: 43.473209, -3.797802
Sources, drained area

x	Parking lots
Pavement, drained area (if relevant for drained area, major components only)	
x	Asphalt/bitumen
x	Gravel
x	Cobble stones
x	Lawn (cut grass)
x	Other (describe): Concrete pavement.
Building facades, drained area (if relevant for drained area, major components only)	
	There are no buildings in the drained area.
Roofing (if relevant for drained area, major components only)	
	There are no buildings in the drained area.

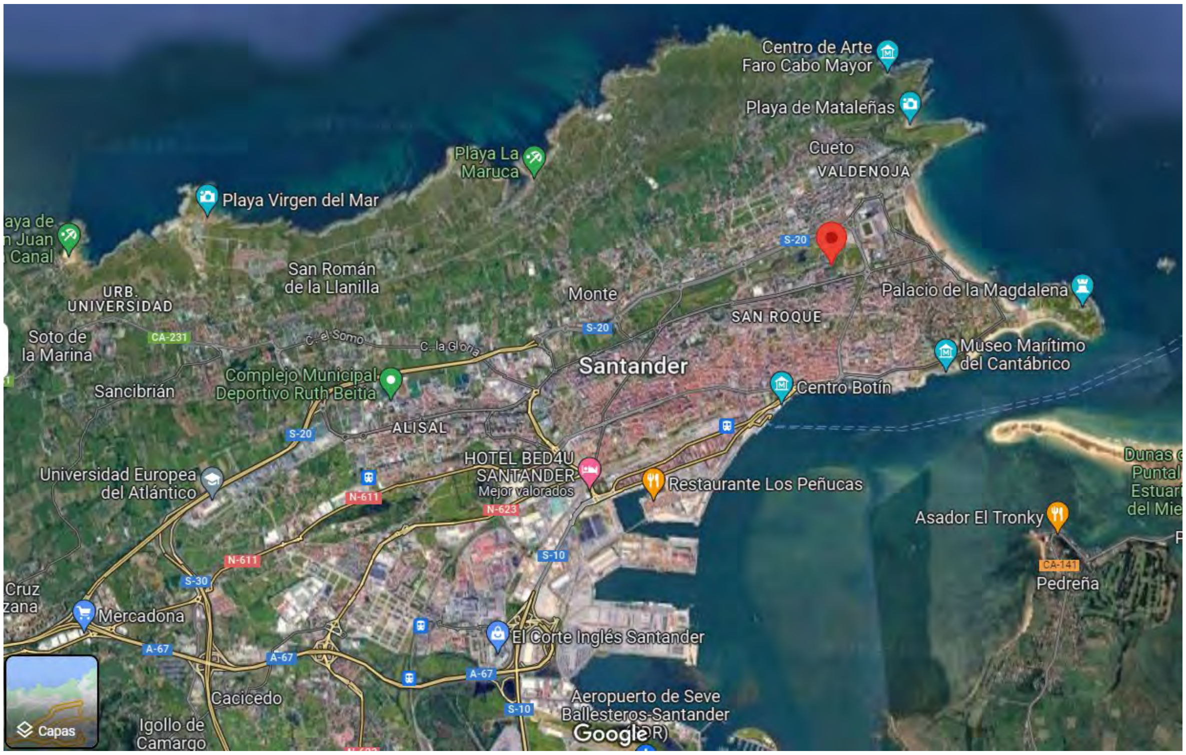
Sample times 1:10:12, 2: 10:31, 3: 10:46, 4: 11:01, 5: 11:14, 6: 11:31, 7: 11:53

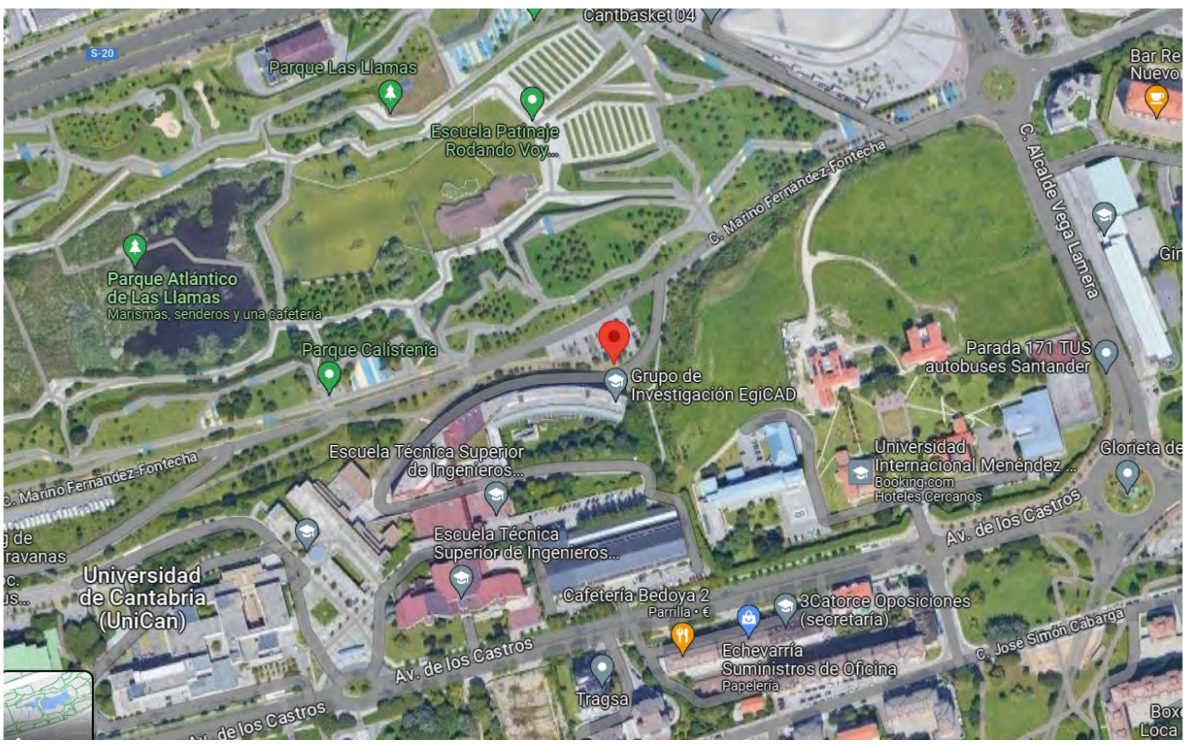
Start time	Station	Name of the persons and institutions
10:15	**Sa02**, Permeable carpark in "Parque de Las Llamas". Manual sampling from a runoff inlet.	Valerio Andrés (UC).

Time since previous rain event: 6 days

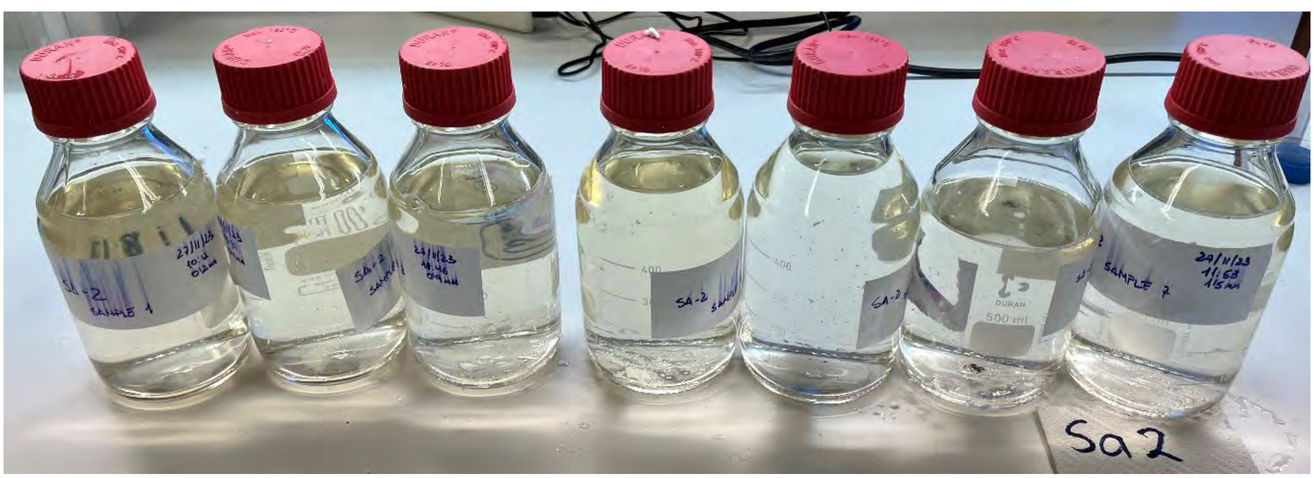
Data from the rain gauge:

SA-2, Permeable car park in "Parque de Las Llamas".		
Time	**Reference**	**Precipitation readings (accumulated):**
10:15	0 min	0.2 mm
10:30	15 min	0.4 mm
10:45	30 min	0.9 mm
11:00	45 min	1.1 mm
11:15	60 min	1.3 mm
11:30	75 min	1.5 mm
11:45	90 min	1.5 mm
12:00	105 min	1.5 mm (empty bottle)


Centro de Arte
Faro Cabo Mayor
Playa de Mataleñas
Cueto
VALDENOJA
Playa La
Maruca
Playa Virgen del Mar
San Román
de la Llanilla
URB.
UNIVERSIDAD
Soto de
la Marina
Monte
SAN ROQUE
Palacio de la Magdalena
Museo Marítimo
del Cantábrico
Santander
Centro Botín
Sancibrián
Complejo Municipal
Deportivo Ruth Beitia
ALISAL
HOTEL BED4U
SANTANDER
Mejor valorados
Restaurante Los Peñucas
Universidad Europea
del Atlántico
Asador El Tronky
Pedreña
Mercadona
El Corte Inglés Santander
Cacicedo
Igollo de
Camargo
Aeropuerto de Seve
Ballesteros-Santander
Capas
Google


Cantbasket 04
Parque Las Llamas
Escuela Patinaje
Rodando Voy...
C. Marino Fernández-Fontecha
C. Alcalde Vega Lamera
Parque Atlántico
de Las Llamas
Marismas, senderos y una cafetería
Parque Calistenia
Grupo de
Investigación EgiCAD
Parada 171 TUS
autobuses Santander
Escuela Técnica Superior
de Ingenieros...
Universidad
Internacional Menéndez ...
Booking.com
Hoteles Cercanos
Av. de los Castros
Escuela Técnica
Superior de Ingenieros...
Universidad
de Cantabria
(UniCan)
Cafetería Bedoya 2
Parrilla · €
3Catorce Oposiciones
(secretaría)
Echevarría
Suministros de Oficina
Papelería
C. José Simón Cabarga
Tragsa


40


SAMPLE 7
500 ml
Sa2

Station: Sa03, Polígono Industrial Candina

Short description of site and mode of sampling: “Polígono Industrial Candina” at the city outskirts (industrial area). Manual sampling from a runoff inlet (stormdrain). Mainly water from the puddle showed in the picture (in the manhole also enter water from the roof of the building but not waste water), i.e., surface water entering the drain at that specific point. No sample 6.	
Country: Spain.	
City/town: Santander.	
Position: 43.451258, -3.835035	
Sources, drained area	
	Small industry, if possible, specify type: mechanical workshops.
	Traffic/street
	Parking lots
Pavement, drained area (if relevant for drained area, major components only)	
	Concrete/concrete slabs/cement slabs
	Asphalt/bitumen
Building facades, drained area (if relevant for drained area, major components only)	
	Mortar plaster/painted mortar plaster/painted bricks
	Concrete
	Metal/painted metal
Roofing (if relevant for drained area, major components only)	
	Metal roofing/metal shingles/painted metal
	Rolled asphalt roofing/bitumen roofing felt/asphalt composite shingles
	Plastic/PVC

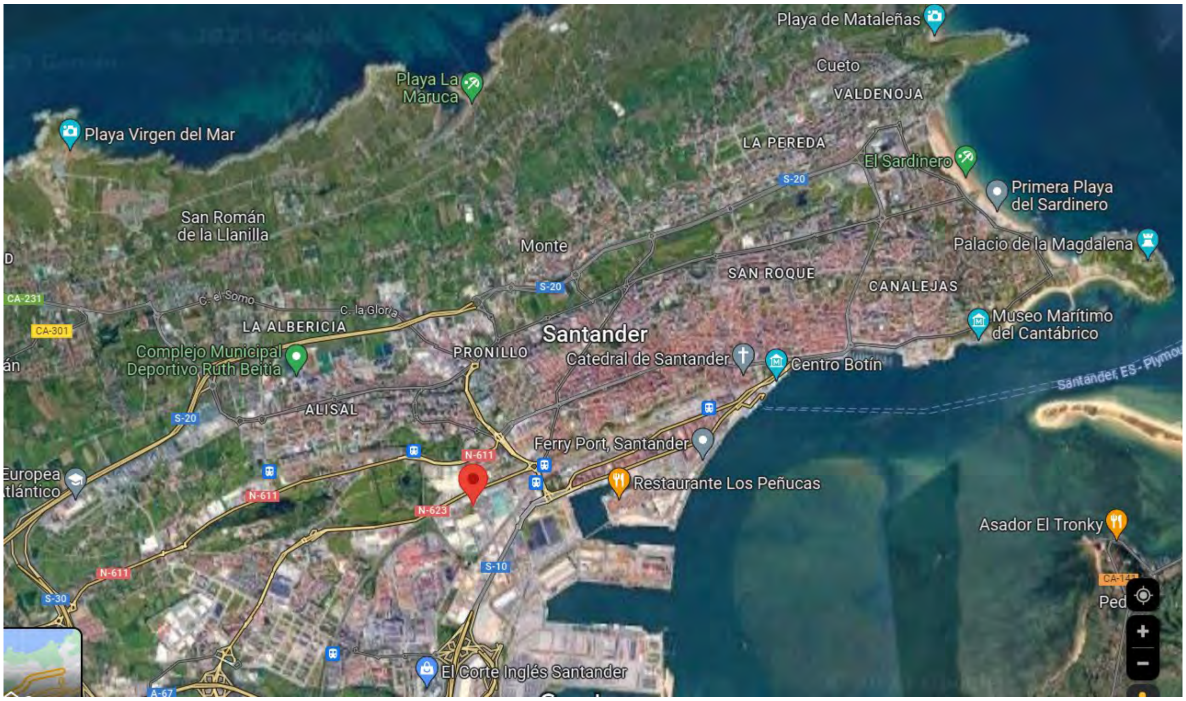
Sample times: every 15 min from 9:00 (sample 8 after 1:45 hours)

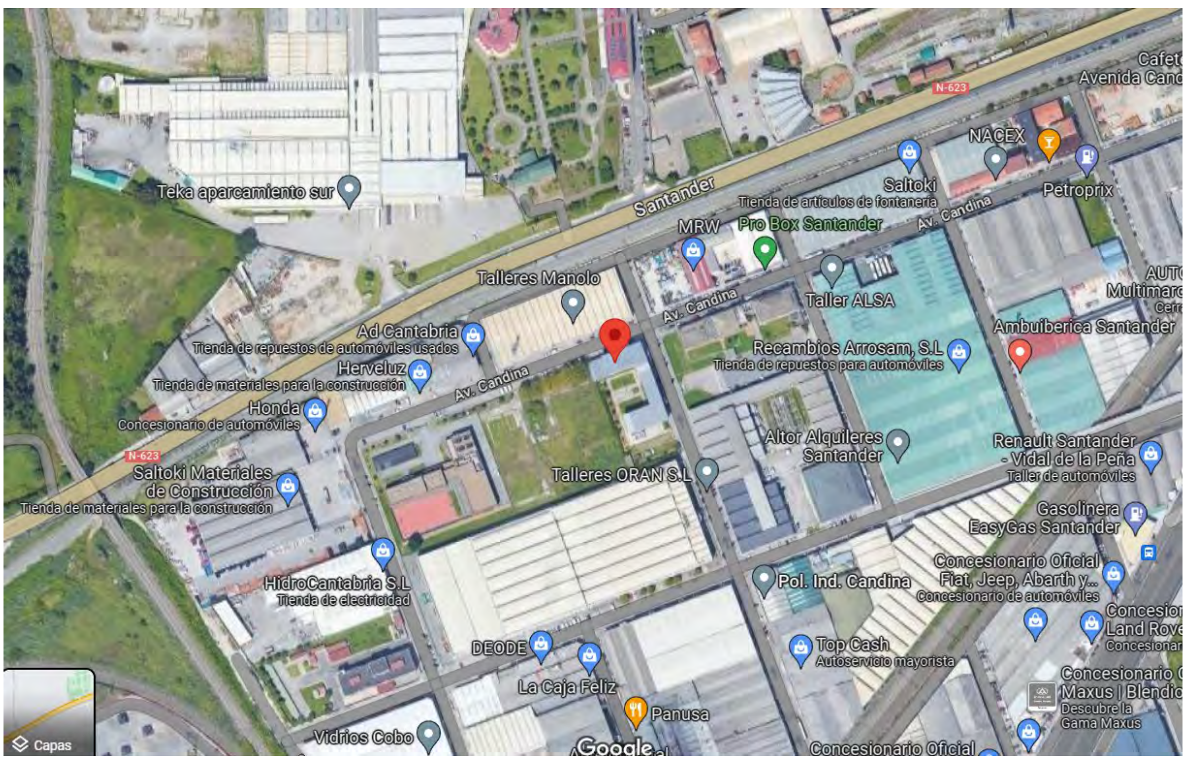
Start time	Station	Name of the persons and institutions
09:00	**Sa03**, “Polígono Industrial Candina” at the city outskirts (industrial area). Manual sampling from a runoff inlet.	Jorge Rodríguez (UC).

Time since previous rain event: 6 days

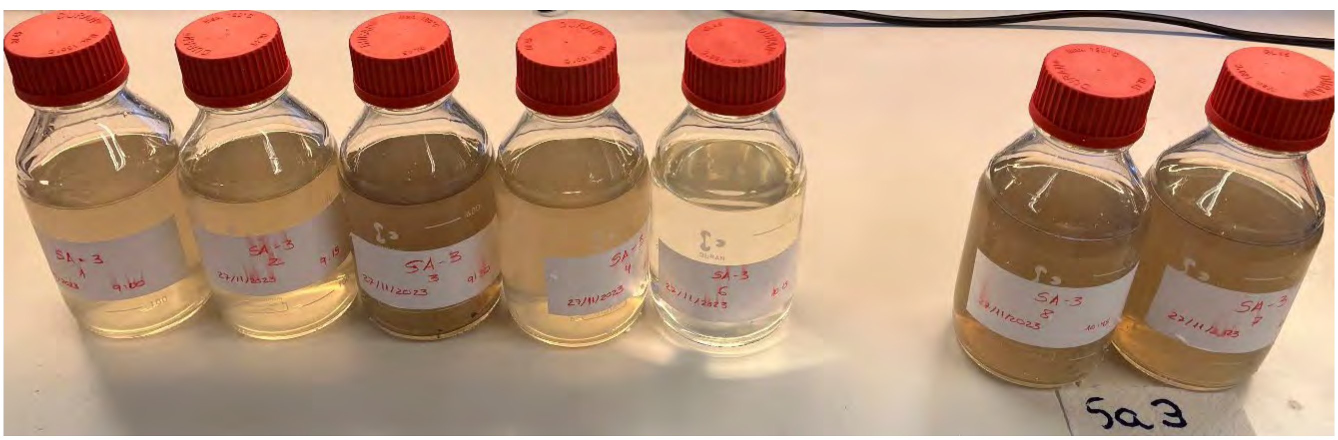
SA-3, “Polígono Industrial Candina” at the city outskirts (industrial area).		
Time	**Reference**	**Precipitation readings (accumulated):**
09:00	0 min	0.5 mm
09:15	15 min	0.5 mm
09:30	30 min	0.5 mm
09:45	45 min	0.7 mm
10:00	60 min	1.0 mm (empty bottle)
10:15	75 min	1.0 mm
10:30	90 min	1.2 mm

10:45	105 min	1.2 mm






MOTUL


SA-3
1
9:00
SA-3
2
27/11/2023
9:15
SA-3
3
27/11/2023
SA-3
4
27/11/2023
SA-3
6
27/11/2023
SA-3
8
27/11/2023
SA-3
7
Sa3

Station: SA-4, Calvo Sotelo, storm drain, city center

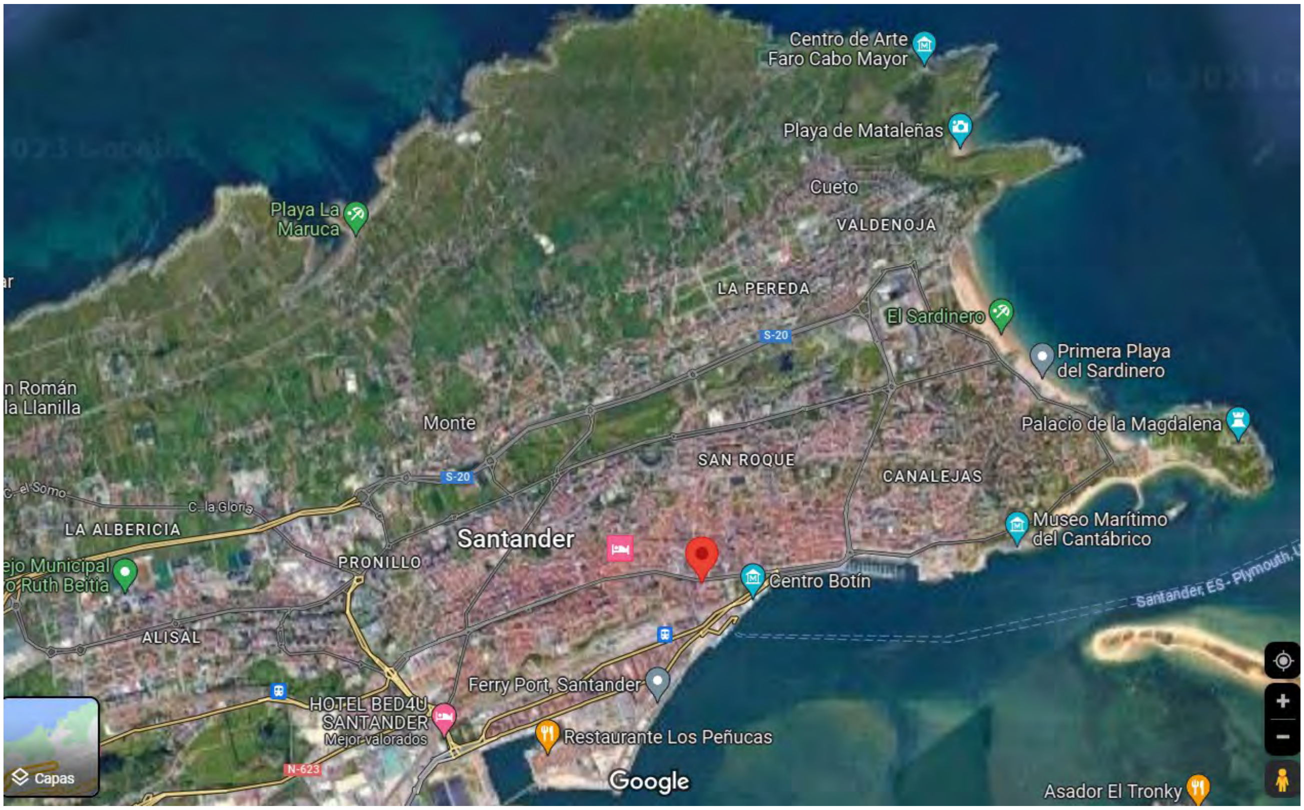
Short description of site and mode of sampling: Street "Calvo Sotelo" at the city center. Manual sampling from a runoff inlet. Only water from the surface of the street (some shops and building receptions pour the water from cleaning in the drains, but not waste water), surface water entering the drain at that specific point.	
Country: Spain.	
City/town: Santander.	
Position: 43.461394, -3.808064	
Sources, drained area	
	Inner city, new buildings (typically >1950) estimate decade(s) for dominant buildings:
	Traffic/street
Pavement, drained area (if relevant for drained area, major components only)	
	Concrete/concrete slabs/cement slabs
	Asphalt/bitumen
Building facades, drained area (if relevant for drained area, major components only)	
	Mortar plaster/painted mortar plaster/painted bricks
	Concrete
Roofing (if relevant for drained area, major components only)	
	Roof tiles (terracotta-, clay- or cement/concrete tiles)
	Rolled asphalt roofing/bitumen roofing felt/asphalt composite shingles

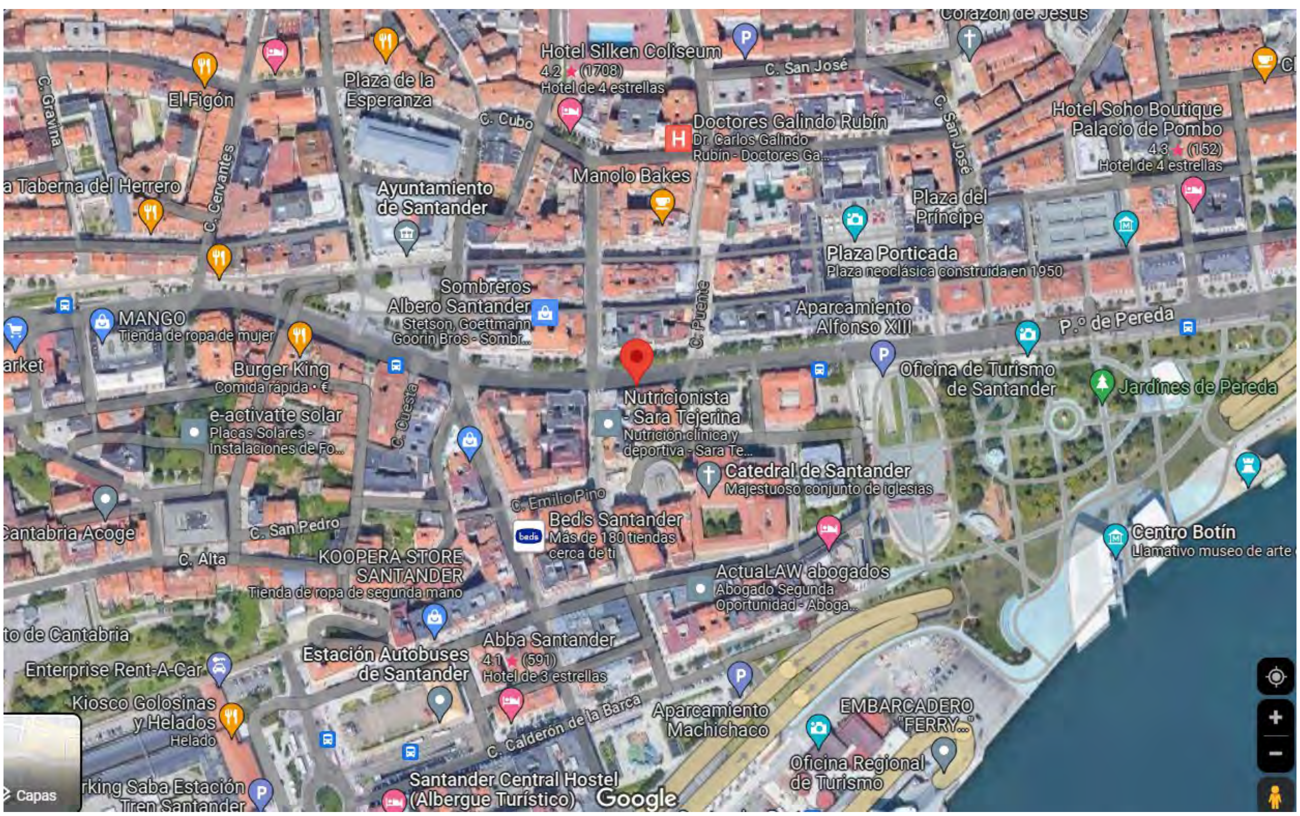
Sample times: every 15 min from 11:00 (sample 8 after 1:45 hours)

Start time	Station	Name of the persons and institutions
11:00	**Sa04,** Street "Calvo Sotelo" at the city center. Manual sampling from a runoff inlet.	Alejandro Roldán (UC) and Miguel García (AQUALIA).

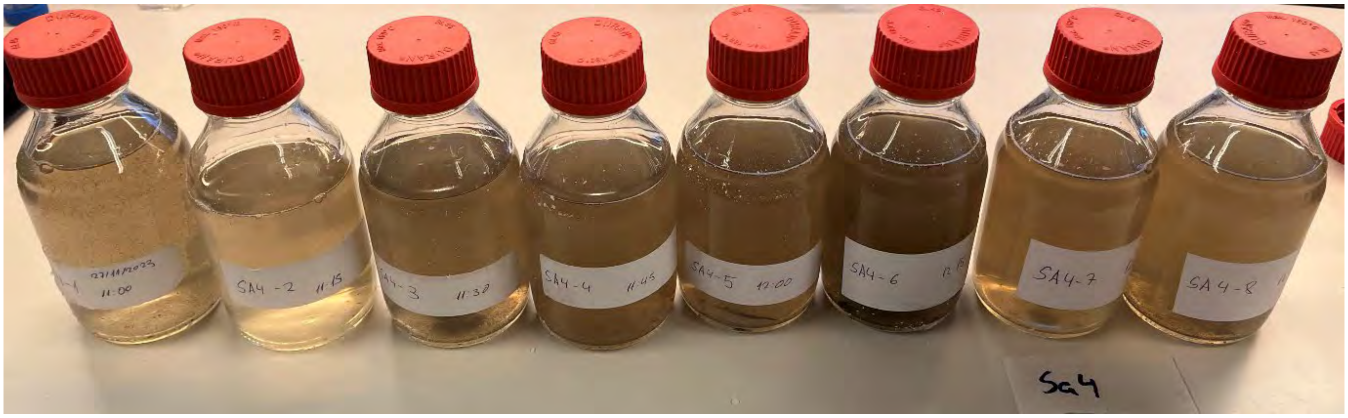
Time since previous rain event: 6 days

Rain event of sampling (official AEMET rain gauge in Santander): 2,0 mm


Centro de Arte
Faro Cabo Mayor
Playa de Mataleñas
Cueto
VALDENOJA
Playa La
Maruca
LA PEREDA
El Sardinero
S-20
Primera Playa
del Sardinero
Monte
SAN ROQUE
Palacio de la Magdalena
CANALEJAS
LA ALBERICIA
C. la Gloria
Santander
Museo Marítimo
del Cantábrico
PRONILLO
Centro Botín
ALISAL
Ferry Port, Santander
HOTEL BED4U
SANTANDER
Mejor valorados
Restaurante Los Peñucas
N-623
Capas
Google
Asador El Tronky


Hotel Silken Coliseum
C. San José
El Figón
Plaza de la
Esperanza
C. Cubo
Doctores Galindo Rubín
Hotel Soho Boutique
Palacio de Pombo
Hotel de 4 estrellas
Manolo Bakes
Ayuntamiento
de Santander
Plaza del
Príncipe
Plaza Porticada
Plaza neoclásica construida en 1950
Sombreros
Albero Santander
MANGO
Tienda de ropa de mujer
Aparcamiento
Alfonso XIII
P.º de Pereda
Burger King
Comida rápida · €
Oficina de Turismo
de Santander
Jardines de Pereda
Nutricionista
Sara Tejerina
e-activatte solar
Catedral de Santander
Majestuoso conjunto de iglesias
C. Emilio Pino
Beds Santander
C. San Pedro
C. Alta
Centro Botín
KOOPERA STORE
SANTANDER
Tienda de ropa de segunda mano
ActuaLAW abogados
Abba Santander
Estación Autobuses
de Santander
Enterprise Rent-A-Car
Kiosco Golosinas
y Helados
Aparcamiento
Machichaco
EMBARCADERO
Oficina Regional
de Turismo
C. Calderón de la Barca
Santander Central Hostel
(Albergue Turístico)
Capas
Google


VALENTINO
UGLAS
-15%


SA4-2 11:15
SA4-3 11:30
SA4-4 11:45
SA4-5 12:00
SA4-6
SA4-7
SA4-8
Sa4

D4RUNOFF

Station: Sa05, Pumping Station, WWTP bypass

Short description of site and mode of sampling: "Las Llamas" pumping station. Manual sampling of mixed wastewater from the entrance of the pumping station (there were no overflow).	
Country: Spain.	
City/town: Santander.	
Position: 43.474866, -3.799404	
Sources, drained area	
	Mixed stormwater
	Other (describe): wastewater diluted with stormwater.
Pavement, drained area (if relevant for drained area, major components only)	
	End-of-line pumping station (near to the treatment plant).
Building facades, drained area (if relevant for drained area, major components only)	
	End-of-line pumping station (near to the treatment plant).
Roofing (if relevant for drained area, major components only)	
	End-of-line pumping station (near to the treatment plant).

Sample times: every 15 min from 9:50 (sample 8 after 1:45 hours)

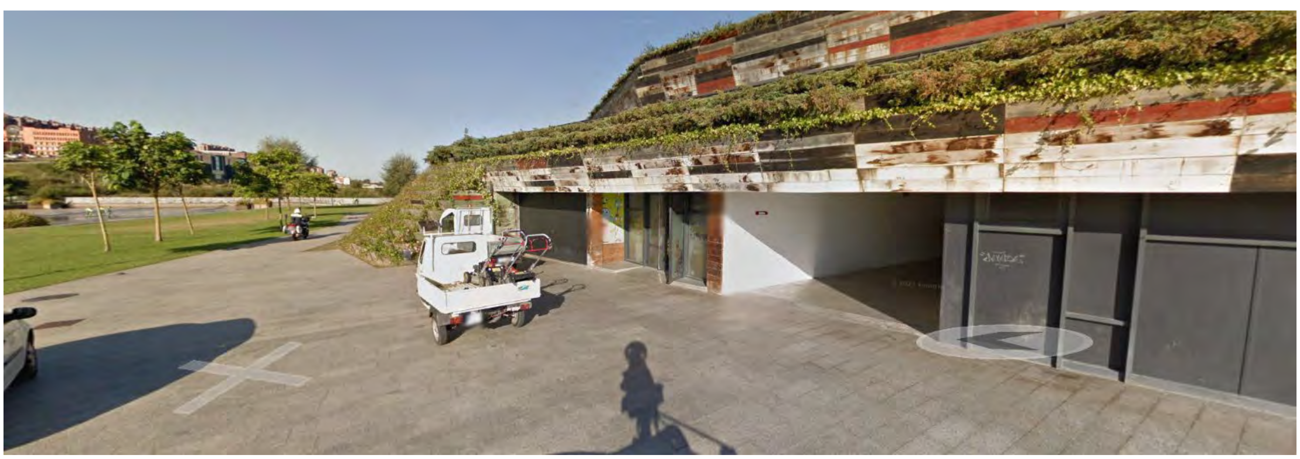
Start time	**Station**	**Name of the persons and institutions**
09:50	**Sa05**, "Las Llamas" pumping station. Manual sampling from the mixed wastewater.	Rubén Díez (UC) and David Navarrete (AQUALIA).

Time since previous rain event: 6 days

Precipitation during sampling: 1,2 mm (data from the nearby Sa02 station)


Centro de Arte Faro Cabo Mayor
Playa de Mataleñas
Cueto
VALDENOJA
Playa La Maruca
Parque La Maruca
The Bright Side Producciones
LA PEREDA
El Sardinero
Parque Atlántico de Las Llamas
Primera playa de El Sardinero
Estación de Servicio Repsol
LOS PINARES
San Román de la Llanilla
Monte
Palacio de la Magdalena
SAN ROQUE
Bar restaurante La Ventana
URB. ELISEO GOMEZ
Recambios RESAN
CANALEJAS
Playa de los Peligros
LA ALBERICIA
Museo Marítimo del Cantábrico
LA ROCA
PRONILLO
Santander
Campo de Municipal Deportivo Autobelbia
Catedral de Santander
Centro Botín
Carrefour
CDAD. JARDÍN
Santander, ES - Plymouth, UK
PLAYA DE "EL PUNTAL"
ALISA
Hospital Universitario Marqués de Valdecilla
Decathlon Santander
Ferry Port Santander
Mercadona
Bahía de Santander
CAJO
LA REMONTA
Restaurante Los Peñucas
PEÑACASTILLO
Pol. Ind. Candina
Asador El Tronky
Carrefour
Pedreña


Cantabria Económica
Héctor Barrero
La Pereda Residencial
Centro Residencial Virgen del Faro
Av. de la Constitución
Parking palacio de los deportes
Palacio de Deportes de Santander
Zona Infantil Parque de las Llamas
Tusbi
Subestación eléctrica de las Llamas
After Gourmet
Norterapia
Parque de Las Llamas
Escuela Patinaje Rodando Voy
Firenze Comunicación
Parque Atlántico de Las Llamas
Explanada del... del Parque
Escenario Santander
Parque Calistenia
C. Mario Fernández Fontecha
Facultad De Telecomunicaciones
Escuela Técnica Superior de Ingenieros...
Universidad Internacional Menéndez Pelayo (UIMP)
Torre A Edificio Tres Torres
Parking de Autocaravanas
Edificio Ingeniería de Telecomunicación
CISE
Servicio de Gestión Académica
ESN Santander
Universidad de Cantabria (UniCan)
Escuela Técnica Superior de Ingenieros
Av. de los Castros
Servicio de Informática




27/11/23 Los Llanos pumping station
27/11/23 Los Llanos t=45 pumping st. SA-5
27/11/23 Los Llanos t=60 (10:50)
27/11/23 Los Llanos t=75 (11:05)
t=90 (11:20)
27/11/23 t=120 (11:50)
Sa5