UNIVERSITY OF HELSINKI

LOMONOSOV MOSCOW STATE UNIVERSITY

Russian MegaGrant “Megapolis – heat and pollution island”

Results on WP 5. CHEMICAL COMPOSITION OF ATMOSPHERIC PRECIPITATION, SOIL, DUST AND SURFACE WATER

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WP 5. Chemical composition of atmospheric precipitation, soil, dust and surface water

- Task 5.1 Component-based geochemical assessment of various environments
- Task 5.2 Water surface geochemistry observational network to study daily and seasonal chemical flux variability in Moscow

The main positions of the work plan of the reporting year

1 Partitioning of potentially toxic elements in road dust of Moscow megacity in areas under traffic and industrial impact.

2 Surface water monitoring.

3. Component-based geochemical assessment of the river Setun watershed.

4 Creation of information support for modeling runoff and erosion for the river Setun watershed.

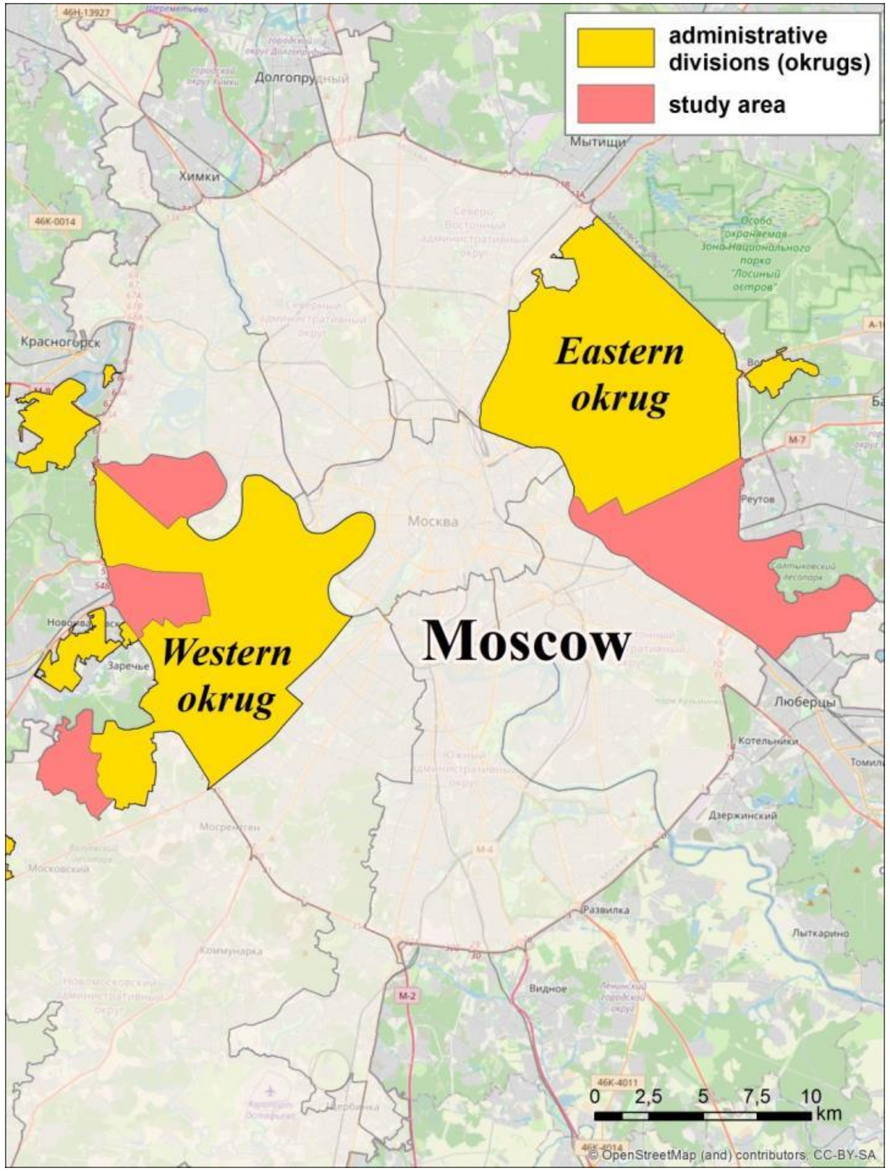
Modeling approach: **Enviro-HIRLAM + SWMM**

Task 1: *To estimate non-point pollution loading in the Setun basin due to atmospheric deposition*

Enviro-HIRLAM		SWMM
Meteorological output: rainfall, relative humidity, wind speed, temperature	→	**Meteorological input**: rainfall, relative humidity, wind speed, temperature
Atmospheric composition output: concentrations, wet/dry deposition, sedimentation	→	**Atmospheric deposition input**

Partitioning of potentially toxic elements in road dust of Moscow megacity in areas under traffic and industrial impact

Potentially toxic elements in particle-size fractions of road dust

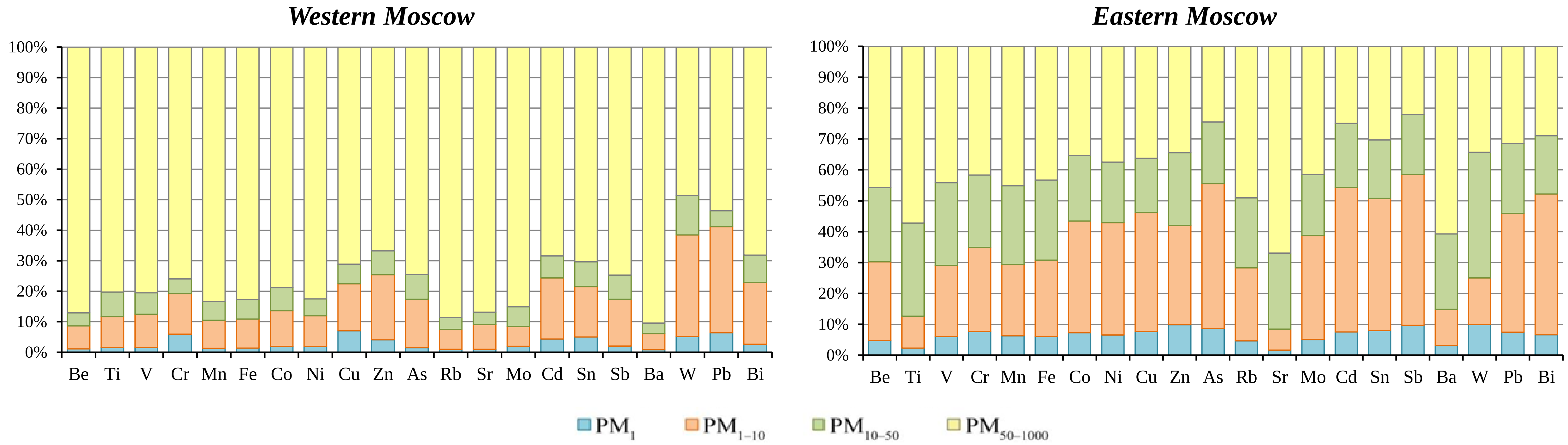


- **Differences in the particle size distribution in road dust in the *Eastern* (under industrial impact) and *Western* (mainly under traffic impact) Moscow**
- **Potentially toxic elements (PTEs) in size-fractionated road dust**
- **Enrichment of road dust particles with PTEs on roads of different sizes**

An article “Source apportionment by PCA/APCS-MLR and partitioning of potentially toxic elements in road dust of Moscow megacity in areas under traffic and industrial impact” has been prepared for publishing (planned to be submitted to the "Journal of Environmental Sciences" (Q1 WoS, Q1 Scopus)).

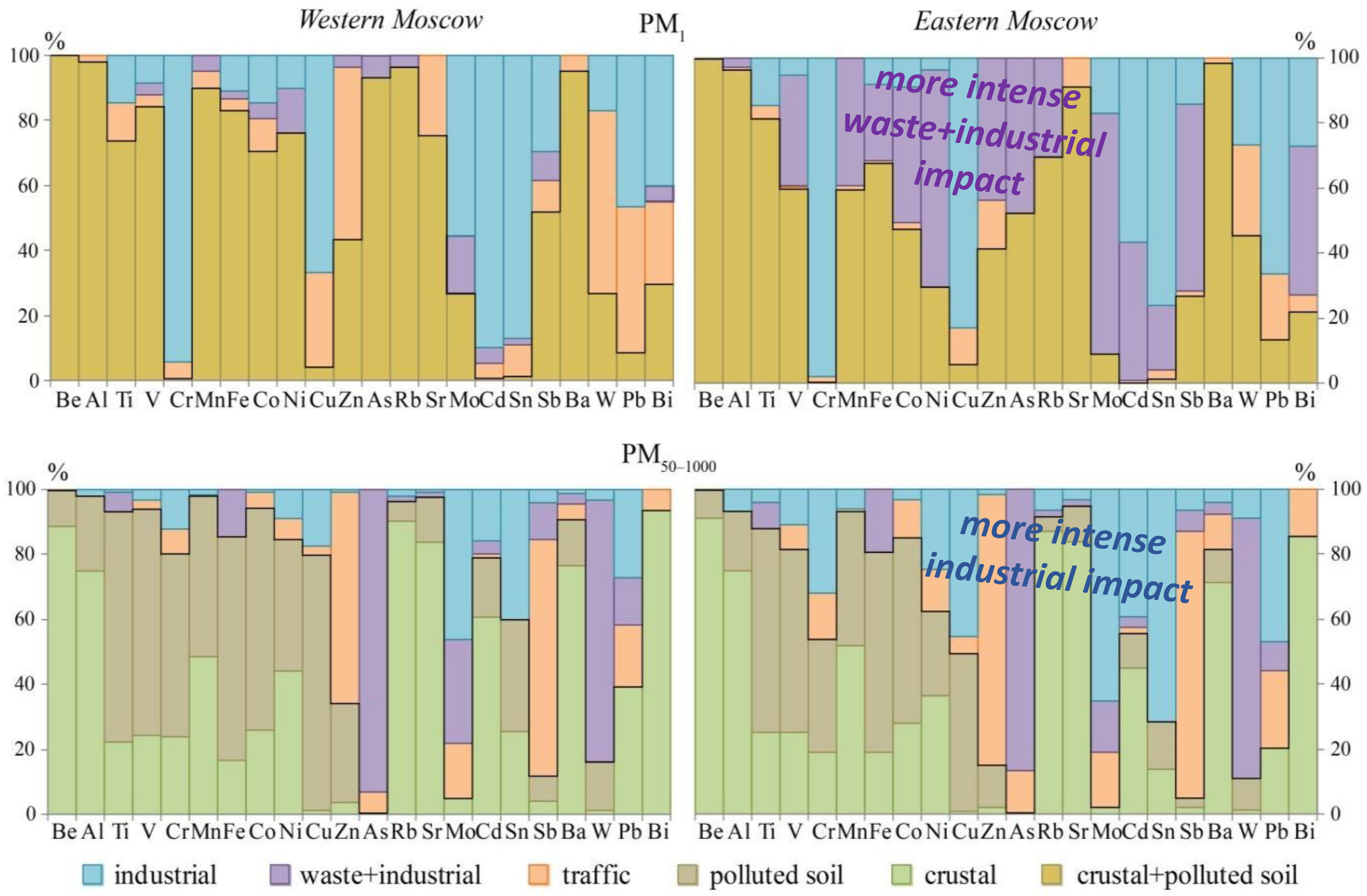
Partitioning of potentially toxic elements in road dust of Moscow megacity in areas under traffic and industrial impact

Potentially toxic elements in size fractions of road dust on small roads and courtyards with parking lots in the *Western* ('traffic') and *Eastern* ('industrial') parts of Moscow



Partitioning of potentially toxic elements in road dust of Moscow megacity in areas under traffic and industrial impact

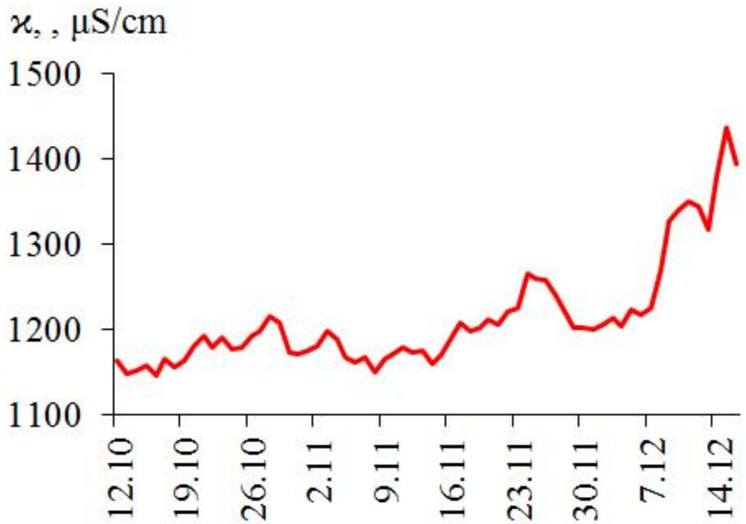
Source apportionment of heavy metals and metalloids in PM_1 and $PM_{50-1000}$ of road dust, PCA/APCS-MLR results

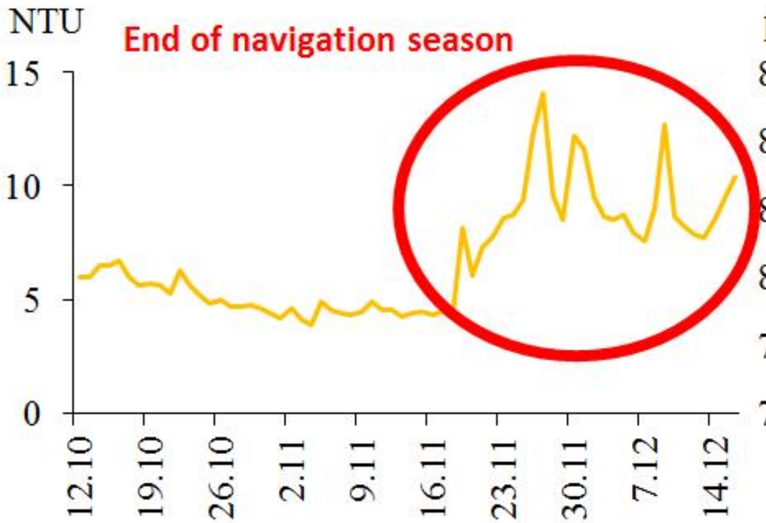


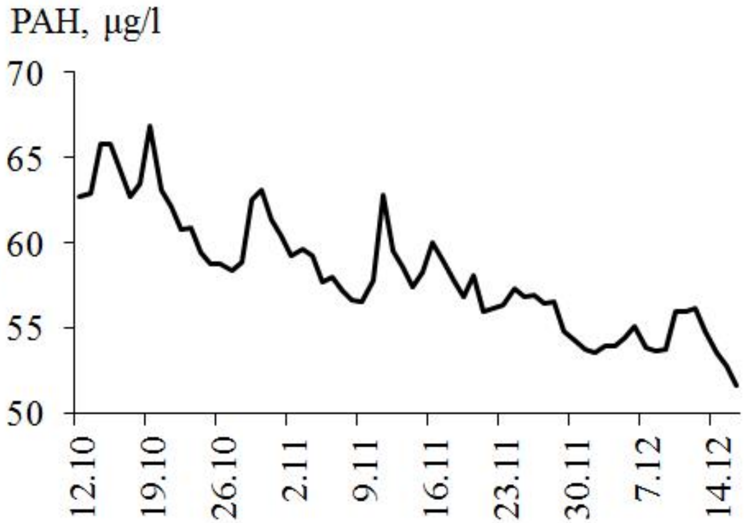
Surface water monitoring

High-frequency monitoring at the Moskva (Moscow) river outlet

- **Multiparametric buoy (TSS, pH, level-water discharge, TDS, PAH) collected data for about 3 months in 2021.**

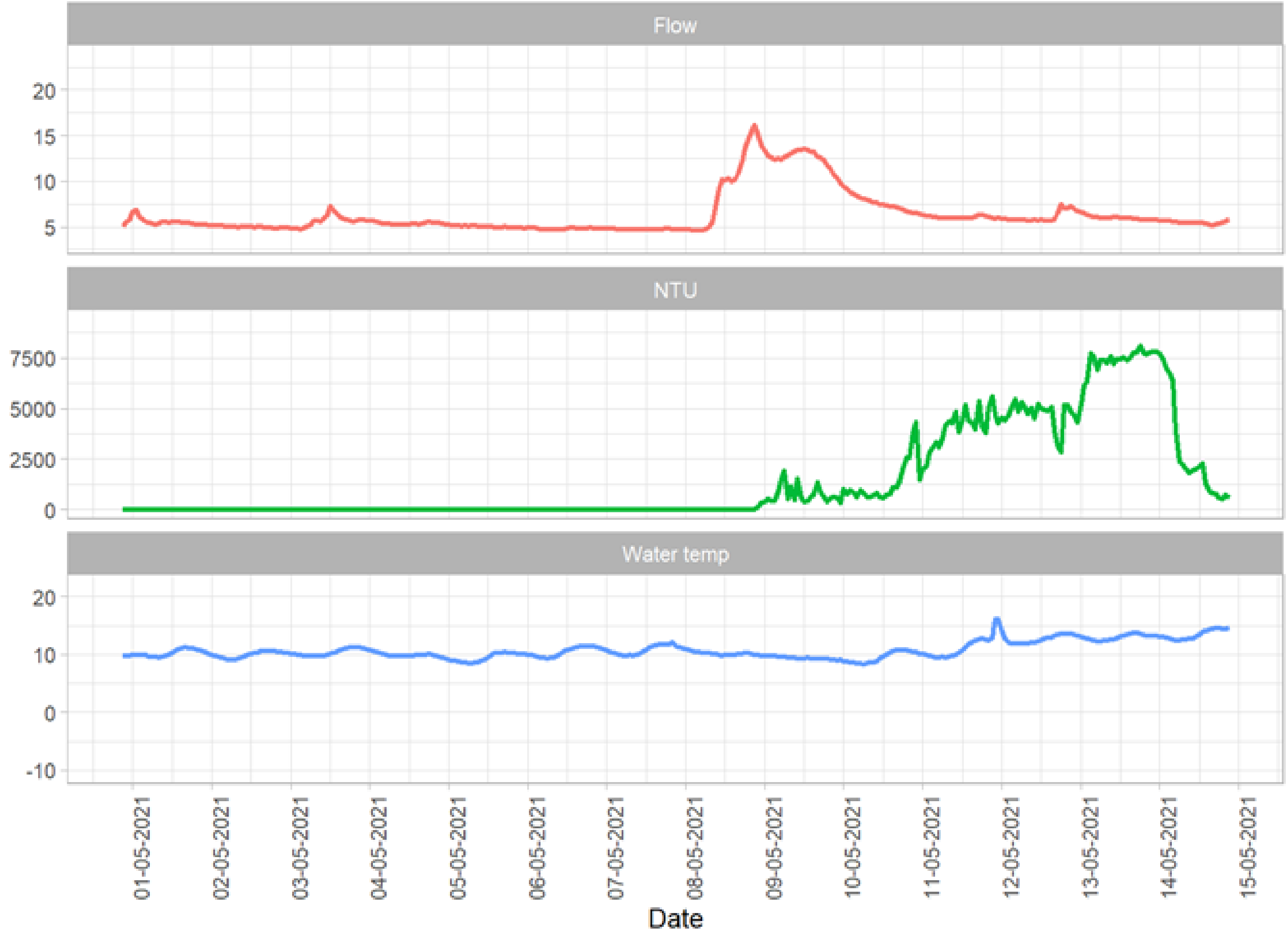






Surface water monitoring

High-frequency monitoring network in the urban watershed (the Setun river case study)



Rain event in May 2021 and its impact on hydrology and turbidity at the Setun outlet

Logging network:

- **4 Onset Hobo Level-Discharge loggers (3 – at the Setun and 1 – at the most polluted tributary)**
- **In-Situ Optical Turbidity Logger at the Setun outlet**

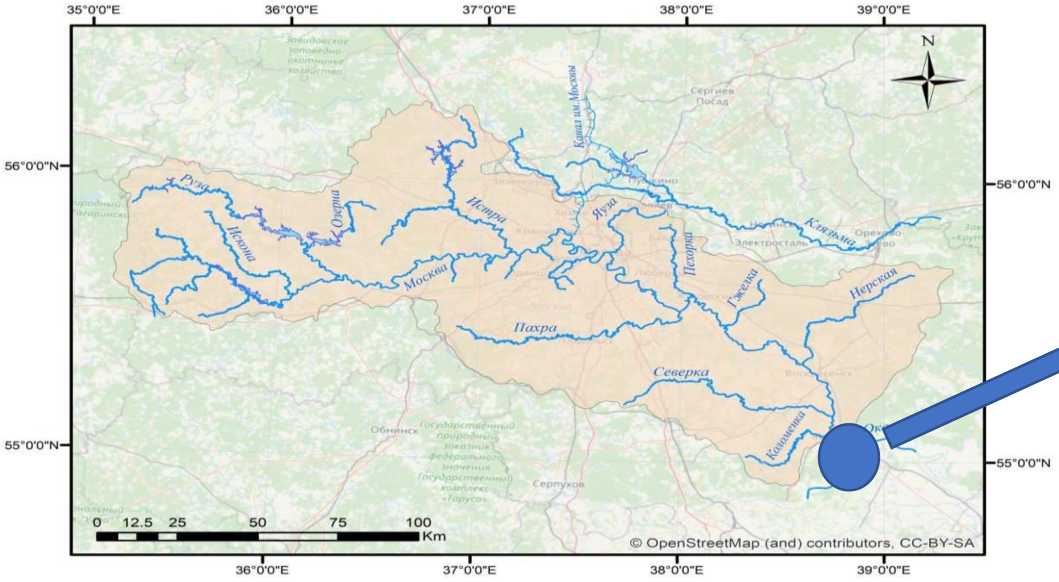
Monitoring approach: evaluation of the rate of atmospheric deposition in the chemical fluxes of the Moscow River

- High-frequency monitoring based on logging (TSS, pH, level-water discharge, TDS + ammonia, PAH, petroleum products)

COMBINED WITH

- Manual monthly sampling at the Moscow River outlet (to estimate concentrations of toxic elements in suspended sediments)

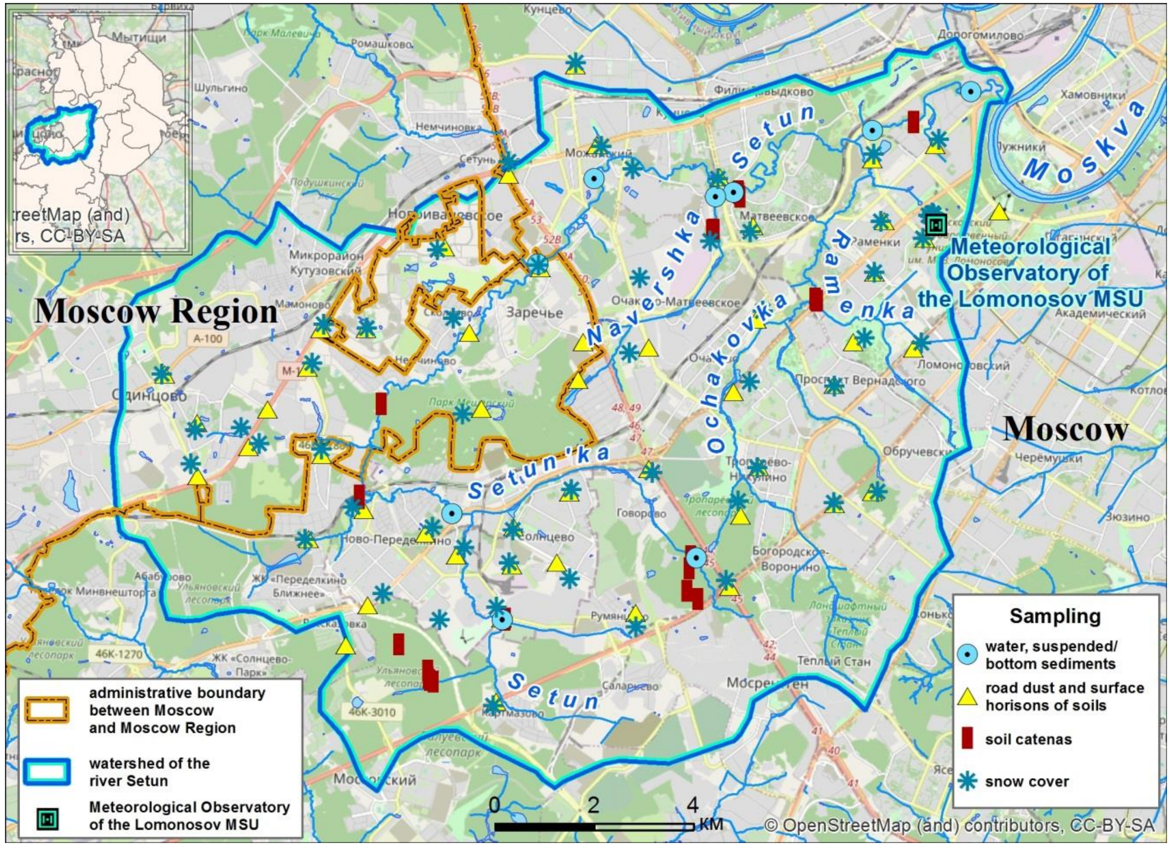
Deliverable 6. pollutants delivery at the outlet of the Moscow River and connection with atmospheric accumulation



Component-based geochemical assessment of the river Setun watershed

The small urban Setun River watershed is set as a model one due to the location of the Meteorological Observatory of the Lomonosov MSU, the variety of land use zones, anthropogenic sources of different intensity of environmental impact and various geochemical specialization of emissions and effluents.

Sampling in the small urban river Setun watershed



Properties measured:

Solid phase of snow, road dust, and soils were analyzed for polycyclic aromatic hydrocarbons (PAHs).

- **Snow cover: 60 points (56 – in the basin and 4 – at the background site).**

Properties measured:

- **Dissolved and suspended potentially toxic elements (PTEs) (bulk samples);**
- **Ionic composition.**

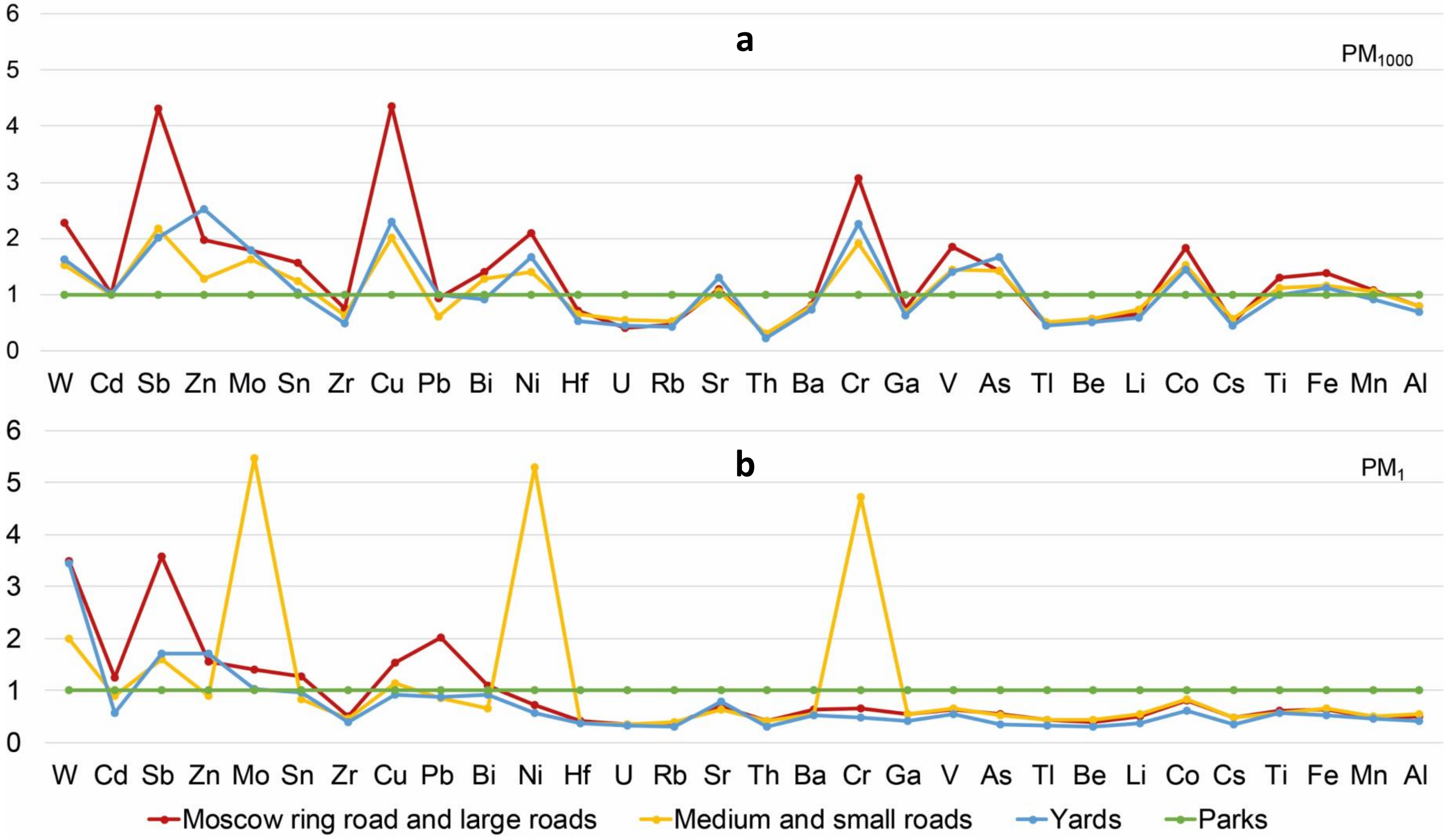
- **Road dust and surface horizons of road-side soils: 53 points in pairs.**
- **Soils in catenas: 94 points.**
- **River bottom sediments: 9 points.**

Properties measured:

- **PTEs in bulk samples;**
- **PTEs in PM_1 and PM_{10} of road dust and bottom sediments.**

Component-based geochemical assessment of the river Setun watershed

Potentially toxic elements (PTEs) in road dust



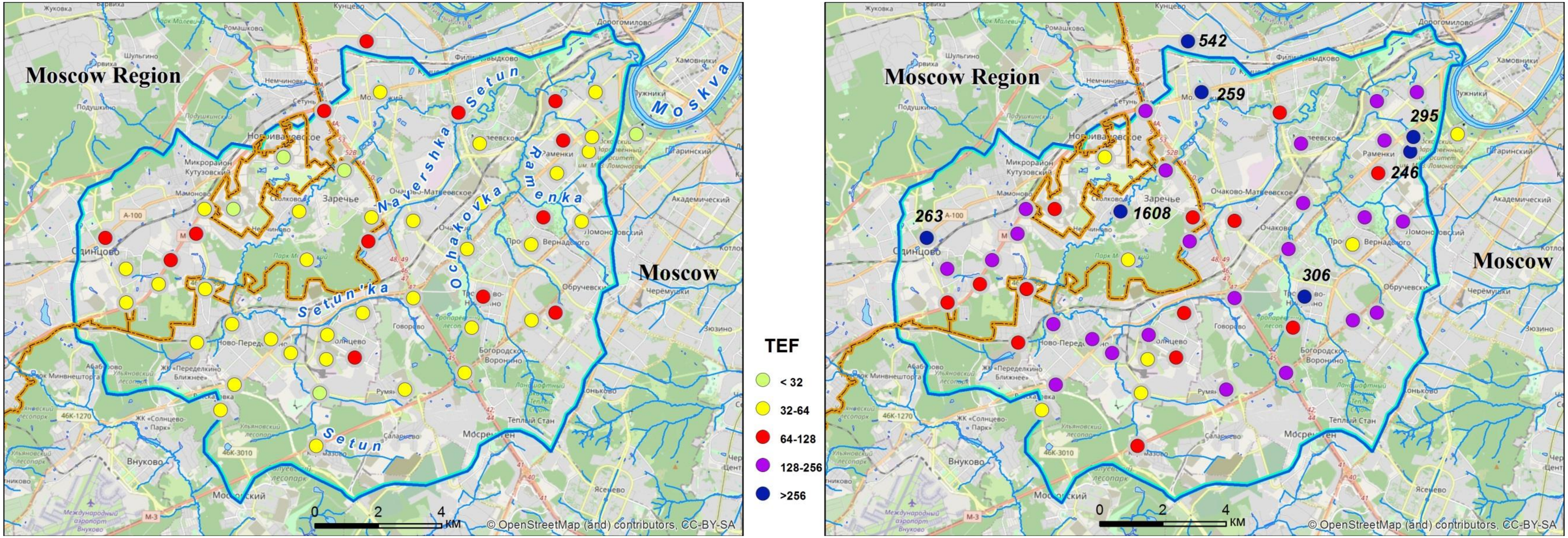
(a) In PM_{1000} the highest concentrations of technogenic W, Sb, Sn, Cu, Ni were determined for large roads with intensive traffic.

(b) In PM_1 high concentrations of W, Cd, Sb, Cu, Pb, Mo, Sn were determined for roads of different types.

Component-based geochemical assessment of the river Setun watershed

Total enrichment factor of road dust

TEF for PM_{1000} **TEF for PM_1**



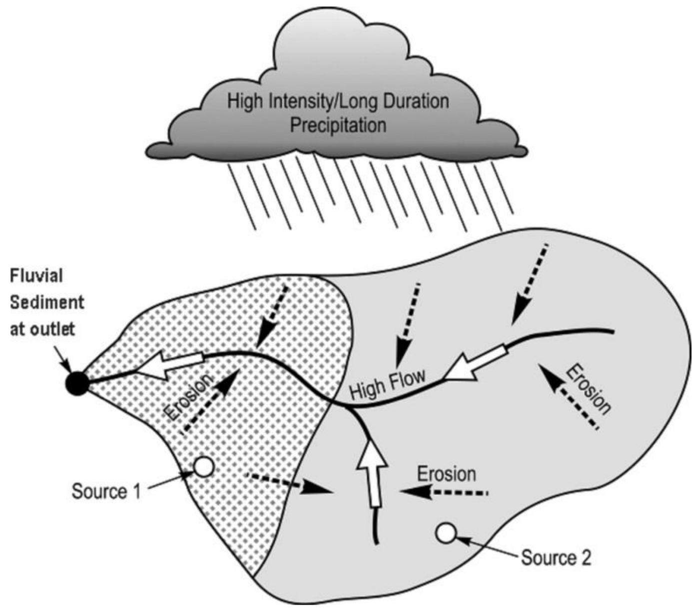
Total Enrichment Factor: *TEF* = ∑*EF*–(*n*–1), where *n* – number of chemical elements with *EF* > 1.

Levels of TEF: <32 – low, non-dangerous; 32-64 – medium, moderately dangerous; 64-128 – high, dangerous; 128-256 – very high, very dangerous; >256—maximum, extremely dangerous (Saet et al., 1990; Kasimov et al., 2017).

Creation of information support for modeling runoff and erosion for the river Setun watershed

Modeling the formation of water runoff, the balance of sediments and pollutants

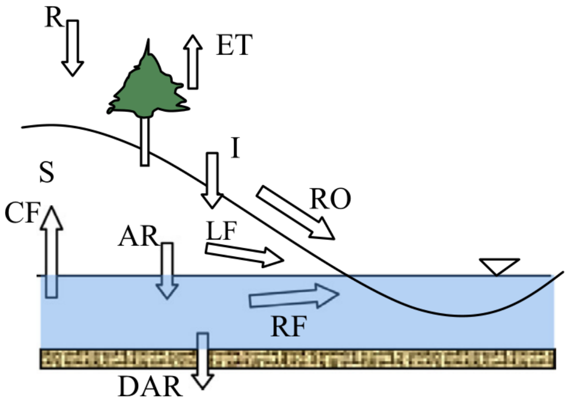
Fingerprinting — a tool to quantify the provenance of sediments/contaminants



Suspended sediments in fluvial systems originate from a myriad of diffuse and point sources, with the relative contribution from each source varying over time and space. The process of sediment fingerprinting focuses on developing methods that enable discrete sediment sources to be identified from a composite sample of suspended material.

SWAT is the acronym for Soil and Water Assessment Tool, a river basin, or watershed, scale model developed by Dr. Jeff Arnold for the USDA Agricultural Research Service (ARS). SWAT was developed to predict the impact of land management practices on water, sediment and agricultural chemical yields in large complex watersheds with varying soils, land use and management conditions over long period of time.

$$SW_t = SW_0 + \sum^{t} (R_{day} - Q_{surf} - E_a - w_{seep} - Q_{gw})$$



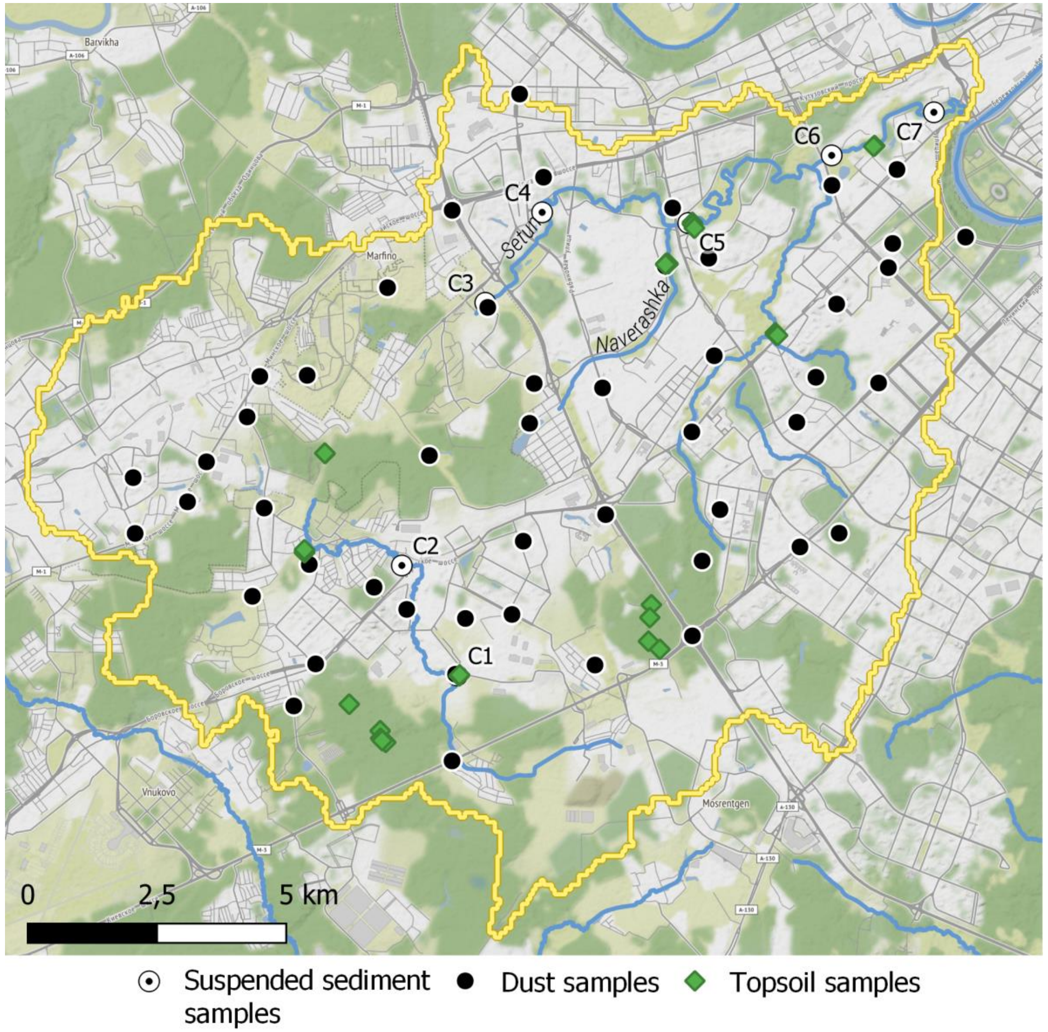
R=rainfall,
ET=evapotranspiration,
I=infiltration,
RO=runoff,
RF=return flow,
LF=Lateral flow
CF=capillary flow,
AR=aquifer recharge,
DAR=deep aquifer recharge
S=Soil moisture

Fig. 1. Schematic illustration of the conceptual water balance model in SWAT.

Creation of information support for modeling runoff and erosion for the river Setun watershed

Tracing sediment sources

Where are particulate matter came from? Fingerprinting approach



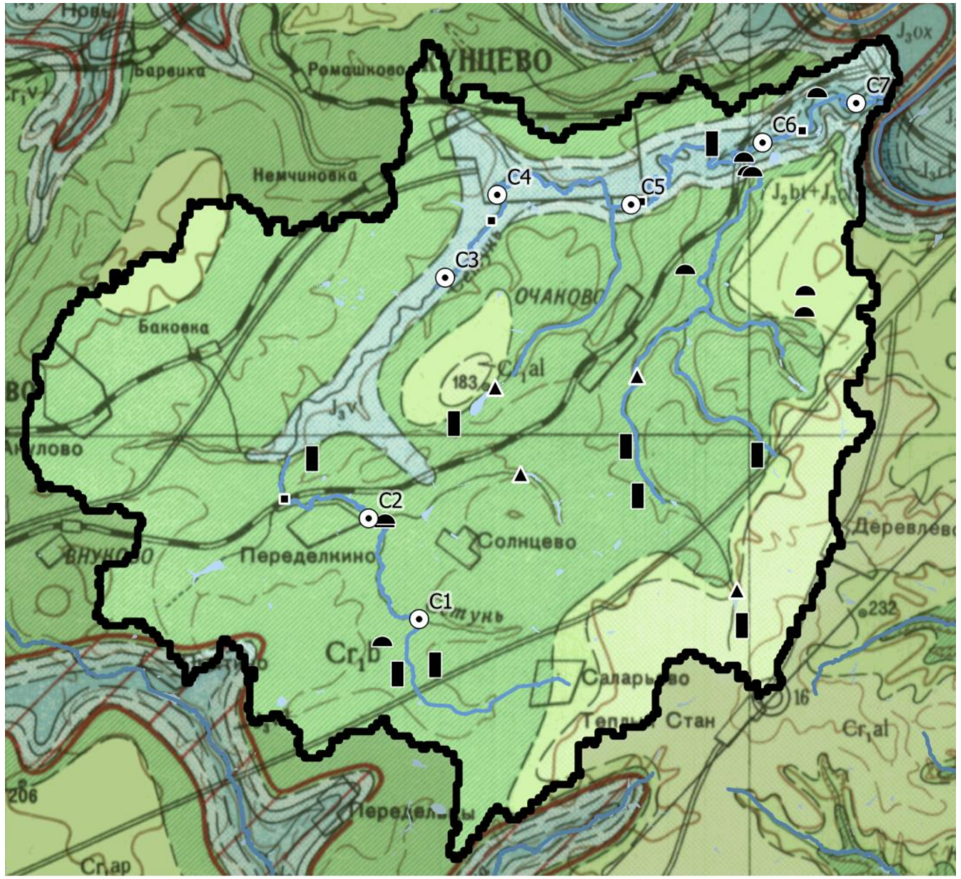
- > 150 source samples
  - 94 soil samples
  - 104 road dust samples
  - > 4 stream bank sediment samples
- 7 particulate matter sampling points (mixture samples)
  - Equipped with Phillips tube integral sampler
  - 3-month sample rotation
- Unmixing particulate matter with SIFT: SedIment Fingerprinting Tool (Pulley & Collins, 2018)

ROTHAMSTED RESEARCH

Creation of information support for modeling runoff and erosion for the river Setun watershed

Tracing sediment sources

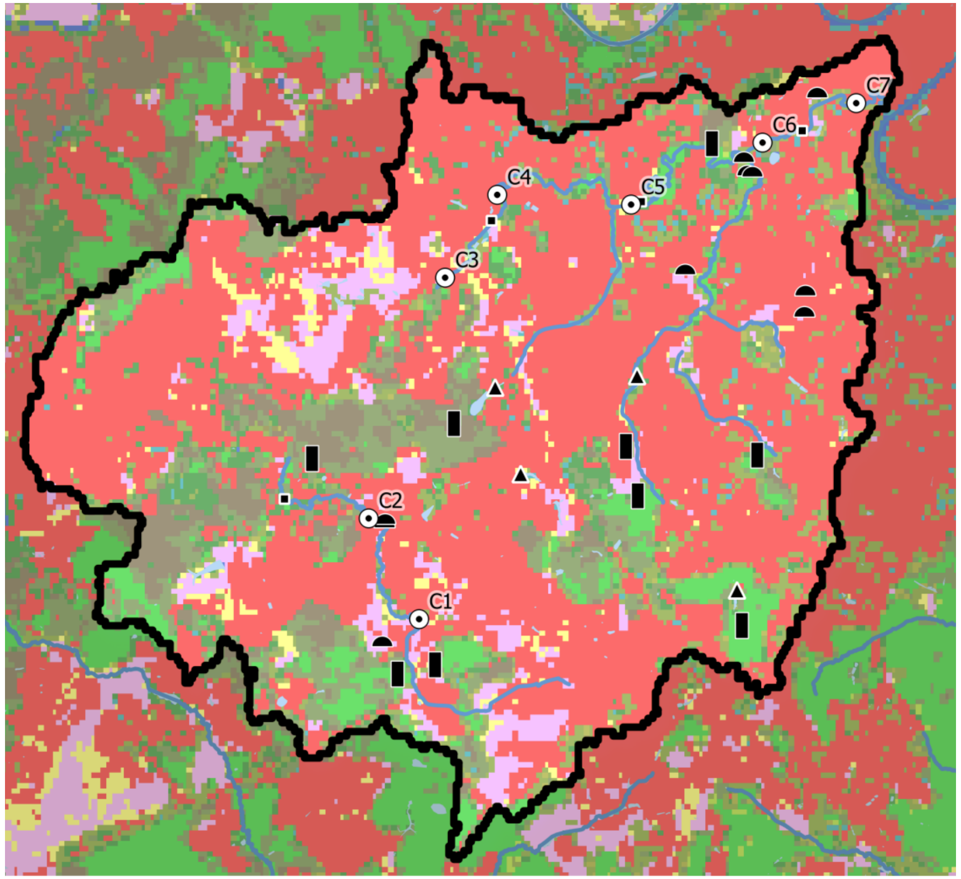
Possible sources: various geology and landuse/landcover



Samples
- Construction
- Pond sediments
- Stream banks samples
- Topsoil samples
- Suspended sediment samples

Geology
- Cr_1b — Sandy clay and sandstones with phosphorite
- Cr_1al — Quartz-Glauconite sands
- J_3v_1 — Sandy clays and clays with Glauconite
- J_3ox — Clays

0 2,5 5 km



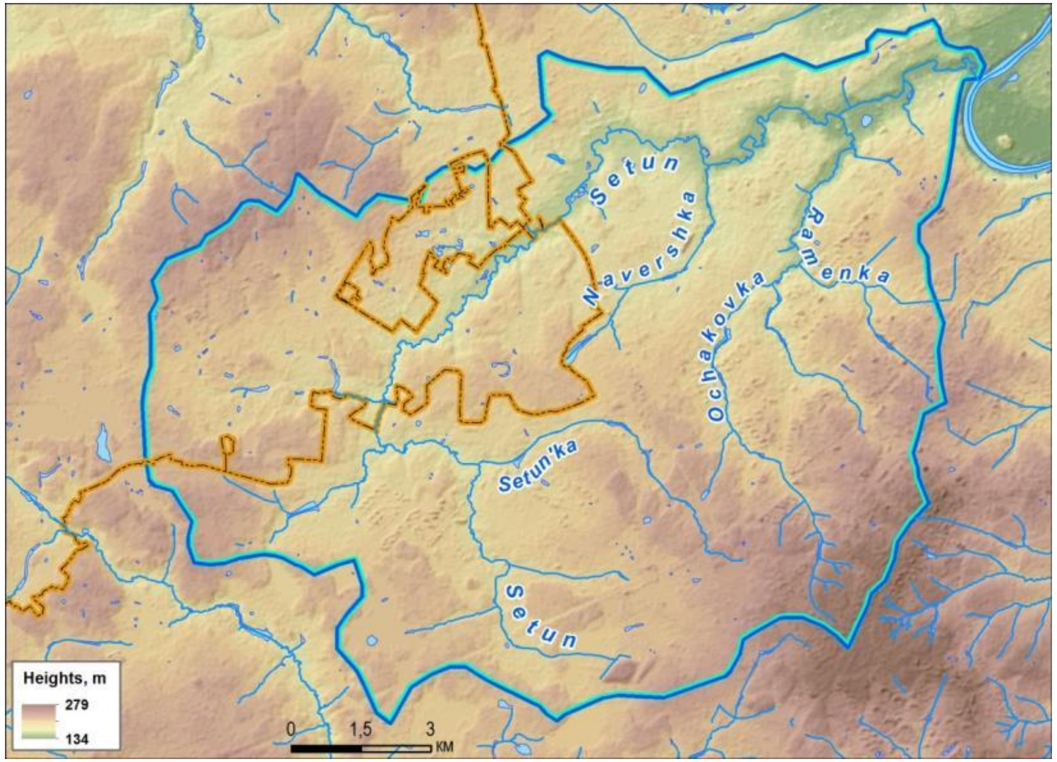
Samples
- Construction
- Pond sediments
- Stream banks samples
- Topsoil samples
- Suspended sediment samples

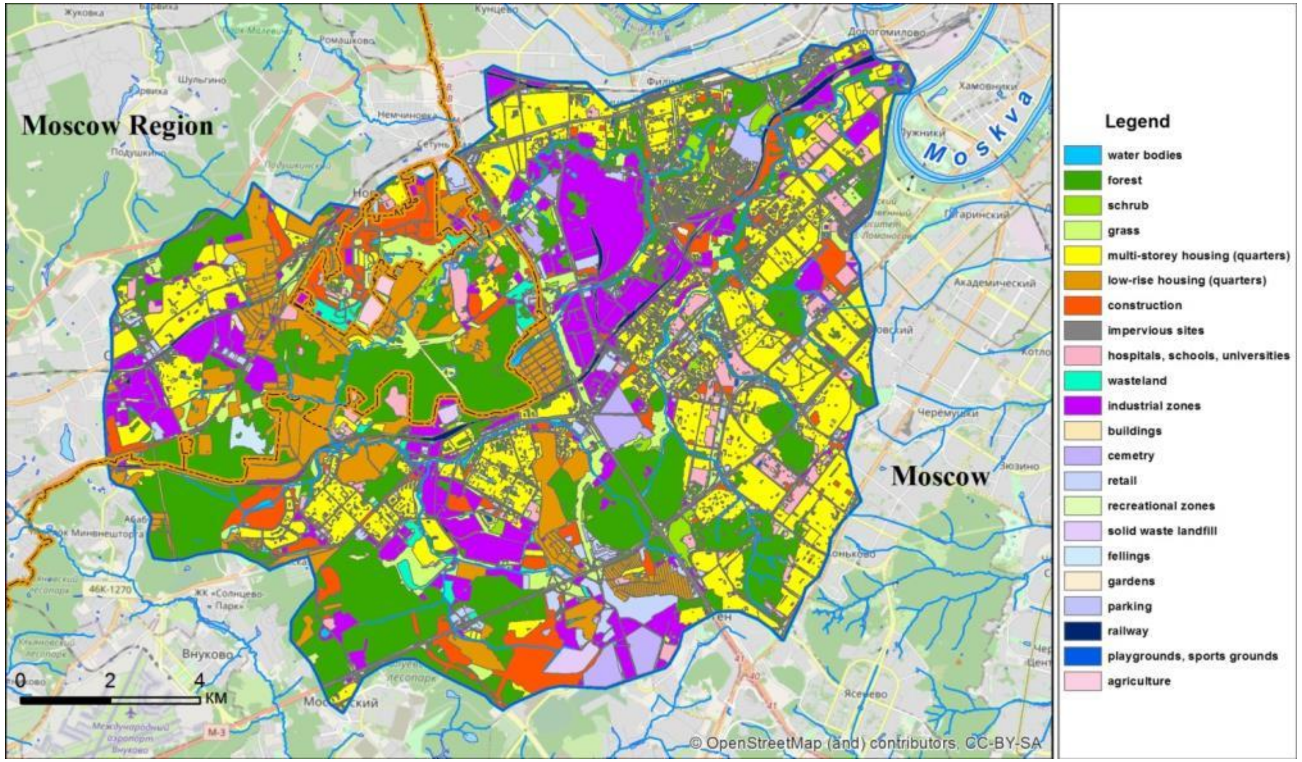
Landuse
- Herbaceous vegetation
- Managed vegetation
- Built up
- Closed forest, evergreen, broad leaf
- Closed forest, deciduous broad leaf

0 2,5 5 km

Creation of information support for modeling runoff and erosion for the river Setun watershed

GIS-project for the spatially distributed parameters





- **Daily meteodata at the Lomonosov MSU station (air temperature, precipitation, total solar radiation, wind speed, relative humidity) for the period of 1978-2021;**
- **Digital elevation model for delineating hydrological response units (HRU);**
- **Land use/land cover layer refined by high-resolution images, corresponding to map scales 1:5000-1:10000.**
- **Soil map showing soil groups determined by the potential of surface runoff (mapping in progress).**

Conclusions

1) A comparative analysis of partitioning of potentially toxic elements in road dust showed that in the Eastern Moscow the contribution of industrial sources to the content of toxic elements is 10-30% higher, and in the Western Moscow the contribution of transport is greater. Particles $PM_{10\text{-}50}$ are useful in assessing urban pollution.

2) Work has begun on the environmental geochemical assessment of the urban watershed (snow cover, soils, road dust, bottom and suspended sediments) with a study of the distribution of potentially toxic elements and PAHs in various microparticles. Main pollutants are W, Cd, Sb, Zn, Mo, Sn, Cu, Pb, Bi, Fluoranthene, phenanthrene, Homologous of naphthalene, Biphenyl, Benzo(a)pyrene.

3) High frequency surface water monitoring is being performed at the Moskva (Moscow) river outlet and in the urban watershed (the Setun river).

4) Two approaches for modeling the formation of water runoff and the balance of sediments and pollutants are used, fingerprinting and the Soil and Water Assessment Tool (SWAT). GIS-project for handling meteorological, geochemical, and landscape information has been created.