UNIVERSITÀ DEGLI STUDI
DELL'INSUBRIA

"Study of the Environmental Fate of Contaminants"

Coordinator: Prof. Antonio Di Guardo

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Keywords: traditional contaminants, emerging contaminants, environmental fate models, exposure assessment, environmental risk assessment

Purpose

Study of the environmental fate of traditional and emerging contaminants through:

1. Measurement of their concentrations in environmental compartments (air, water, soil, sediments, plant biomass, animal biomass);
2. Development of laboratory experiments to investigate contaminant transport in soil, partitioning, degradation, and bioaccumulation;
3. Development of predictive models to estimate contaminant concentrations in different environmental compartments for ecosystem risk assessment purposes.

Location: Department of Science and High Technology, Via Valleggio 9 and 11, Como

Organization: The facility is hosted within the Environmental Modelling Group (EMG), directed by Prof. Antonio Di Guardo, and integrates multidisciplinary expertise in ecotoxicology, particularly in the study of aquatic and terrestrial ecosystem exposure to contaminants.

The facility is organized into three sub-units:

1. Measurement of trace organic contaminants
2. Experimental setups for studying the environmental fate of contaminants
3. Development of environmental fate models for contaminants

Connections with CRIETT Technological Platforms and University Scientific Platforms

This facility operates in collaboration with:

- The CRIETT Technological Platform for Matter Analysis and Characterization, for the use of the LC-HRMS (Orbitrap) instrument;
- The Sustainability Platform, within the thematic areas of:
    1. Environmental contaminants
    2. Sustainability and protection of natural resources

Sub-unit: "Measurement of Trace Organic Contaminants"

Head: Prof. Antonio Di Guardo

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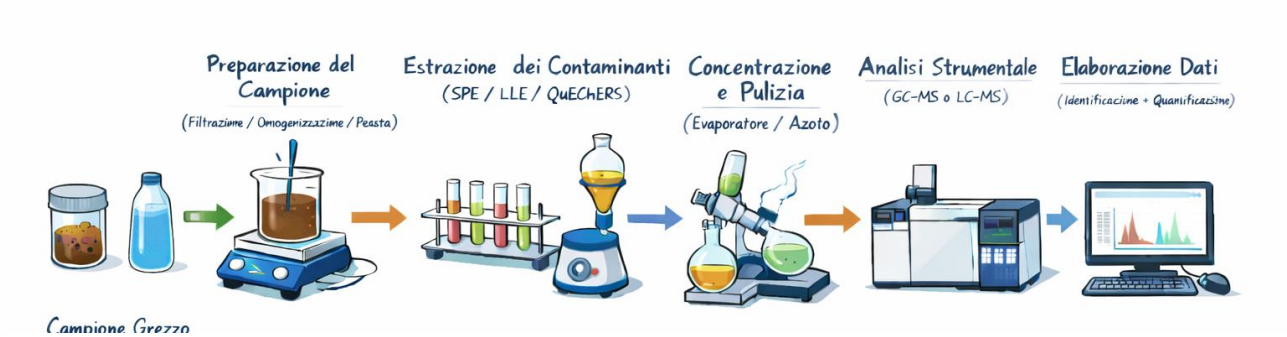
Keywords: traditional contaminants, emerging contaminants, target analysis, untargeted analysis, gas chromatography, liquid chromatography, mass spectrometry



Facility dedicated to the measurement of trace organic contaminants in various environmental matrices, including water, air, soil, plant biomass, and animal biomass.

The facility performs analysis of:

- Polychlorinated biphenyls (PCBs)
- Polycyclic aromatic hydrocarbons (PAHs)
- Organochlorine pesticides (DDT, HCB, etc.)

using low-resolution GC-MS, as well as:

- Per- and polyfluoroalkyl substances (PFAS)
- Polar metabolites (OH-PCBs, SO3H-PCBs, OH-PAHs, and di-OH-PAHs)
- Pharmaceuticals

using high-resolution LC-HRMS Orbitrap systems.

The facility also analyzes micro- and nanoplastics using a pyrolyzer (PYR-GC-MS), capable of analyzing additives and contaminants through thermal desorption (TD-GC-MS) and subsequently pyrolyzing the same sample (double-shot analysis).

In addition, an automated SPME-GC-MS system is available for direct extraction and analysis of contaminants from aqueous and solid phases.

The EMG laboratory is equipped with:

- An ultrasonic bath for contaminant extraction from solid matrices
- An SPE apparatus for contaminant extraction from liquid matrices
- Several single- and multi-sample evaporators
- A nitrogen concentrator for sample volume reduction

- A GPC (gel permeation cleanup) system for sample purification

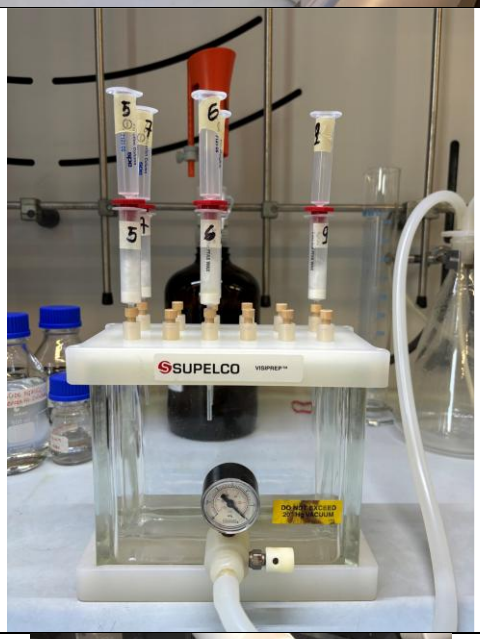
Additional equipment includes:

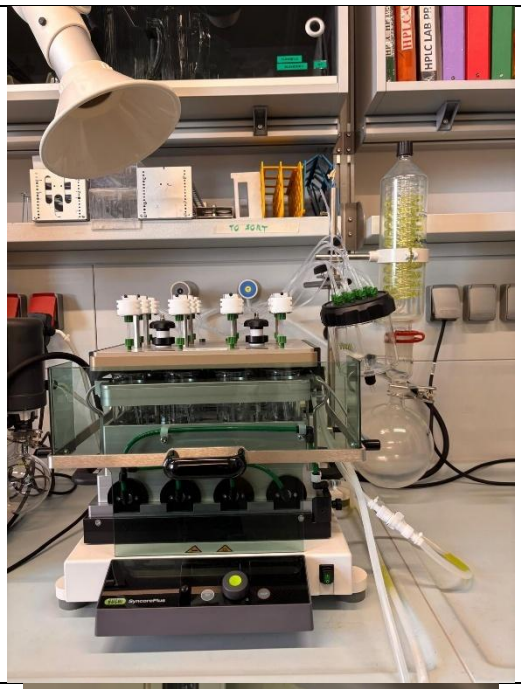
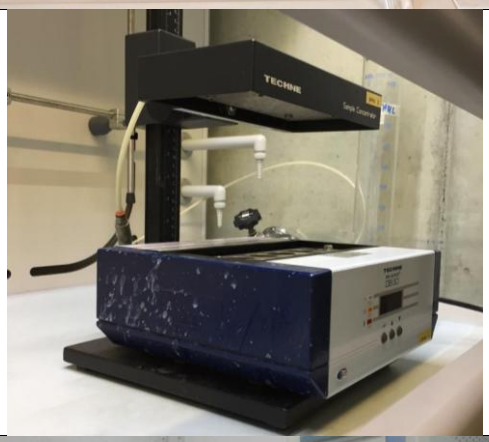
- An oven
- A large-volume muffle furnace (39 L)
- A centrifuge

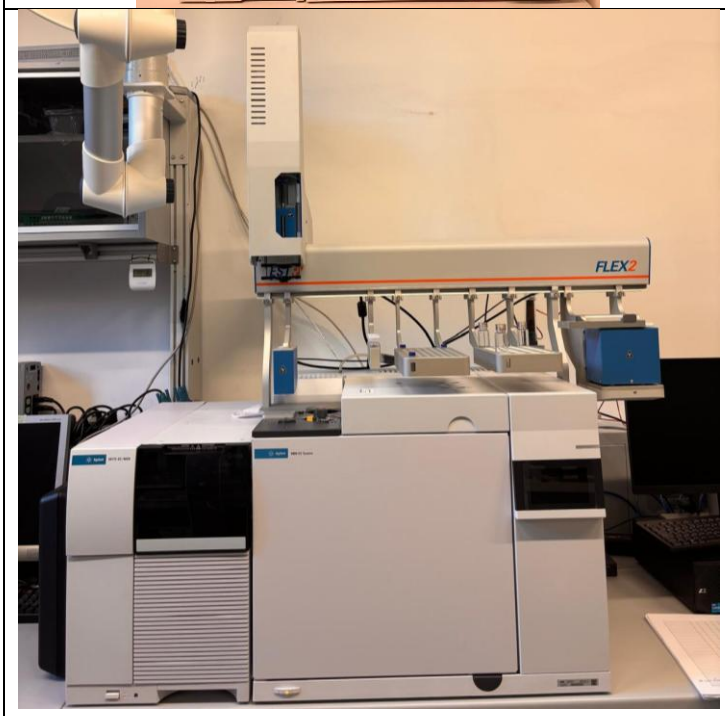
The laboratory also includes three GC-MS instruments and one LC-DAD system, and collaborates with CRIETT for the use of LC-HRMS instrumentation.

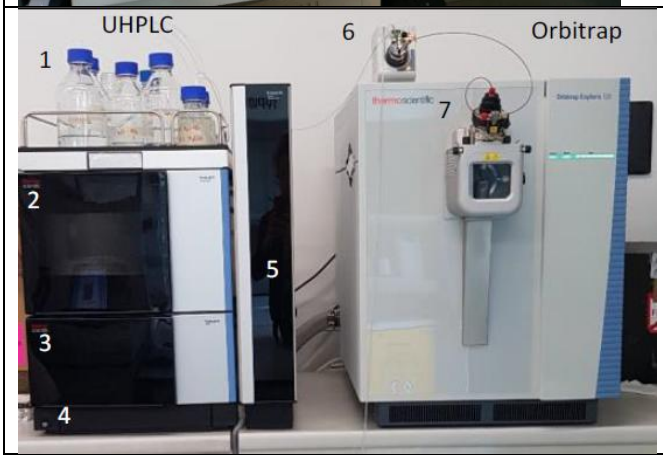
Publications:

1. Bagnati, R., Terzaghi, E., Passoni, A., Davoli, E., Fattore, E., Maspero, A., Palmisano, G., Zanardini, E., Borin, S., Di Guardo, A., 2019. Identification of Sulfonated and Hydroxy-Sulfonated Polychlorinated Biphenyl (PCB) Metabolites in Soil: New Classes of Intermediate Products of PCB Degradation? Environ. Sci. Technol. 53, 10601–10611.
2. Castiglioni, S., Zuccato, E., Fattore, E., Riva, F., Terzaghi, E., Koenig, R., Principi, P., Di Guardo, A., 2020. Micropollutants in Lake Como water in the context of circular economy: A snapshot of water cycle contamination in a changing pollution scenario. Journal of Hazardous Materials 384, 121441.
3. Falakdin, P., Lopez-Rosales, A., Andrade, J., Terzaghi, E., Di Guardo, A., Muniategui-Lorenzo, S., 2024. Comparison of microplastic type, size, and composition in atmospheric and foliage samples in an urban scenario. Environmental Pollution 349, 123911.
4. Gambino, I., Terzaghi, E., Baldini, E., Bergna, G., Palmisano, G., Di Guardo, A., 2025. Microcontaminants and microplastics in water from the textile sector: a review and a database of physicochemical properties, use in the textile process, and ecotoxicity data for detected chemicals. Environ. Sci.: Processes Impacts 10.1039.D4EM00639A.
5. Giráldez, P., Aboal, J.R., Fernández, J.Á., Di Guardo, A., Terzaghi, E., 2022. Plant-air partition coefficients for thirteen urban conifer tree species: Estimating the best gas and particulate matter associated PAH removers. Environmental Pollution 315, 120409.
6. Giráldez, P., Varela, Z., Di Guardo, A., Terzaghi, E., Celeiro, M., García-Jares, C., Fernández, J.Á., Aboal, J.R., 2024. Relationship between foliar polycyclic aromatic hydrocarbons (PAHs) concentrations and plant traits: Intracanopy variability for a broadleaf species in an urban environment. Science of The Total Environment 940, 173698.
7. Maspero, A., Vavassori, F., Penoni, A., Galli, S., Palmisano, G., Bagnati, R., Passoni, A., Davoli, E., Palladini, J., Terzaghi, E., Di Guardo, A., 2023. Synthesis of a new sulfonated-hexachlorobiphenyl standard for environmental analysis, ecotoxicological, and toxicological studies. Science of The Total Environment 882, 163445.
8. Preziati, M., Davoli, E., Di Guardo, A., Bagnati, R., Terzaghi, E., Passoni, A., 2025. Metabolic Responses of Plants to Climate-Induced Stress: A Mass Spectrometry Investigation. ACS Omega. 10, 37342−37352
9. Terzaghi, E., Falakdin, P., Fattore, E., Di Guardo, A., 2021. Estimating temporal and spatial levels of PAHs in air using rain samples and SPME analysis: Feasibility evaluation in an urban scenario. Science of The Total Environment 762, 144184

A) Facility for "Measurement of Trace Organic Contaminants"	
	**SONICATOR** for the extraction of solid samples.
	**SPE** system for the extraction of liquid samples (12 stations).
	**ROTARY EVAPORATOR** for sample concentration (up to 2 mL).

	**12-POSITION SPE CONCENTRATOR AND EXTRACTOR** for concentrating samples up to 500 µL or SPE extraction.
	**NITROGEN CONCENTRATOR** for sample concentration (up to 50/100 µL, 10 stations).
	**GC-MS** for the measurement of organic contaminants (low-resolution targeted analysis) in various environmental matrices.

	**PYR-GC-MS** for the measurement of micro- and nanoplastics (by mass) in various environmental matrices.
	**SPME-GC-MS** for the measurement of organic contaminants (low-resolution targeted analysis) in various environmental matrices using automated SPME and an autosampler for the analysis of liquid samples.
	**HPLC-DAD** for measuring contaminants in samples from laboratory experiments.

	**HPLC-UV** equipped with a GPC column for the purification of plant and animal biomass samples (lipid separation).
	**LC-HRMS (Orbitrap)** for targeted and untargeted analysis of environmental contaminants (in collaboration with CRIETT).

Sub-unit: "Experimental Setups for Studying the Environmental Fate of Contaminants"

Coordinator: Prof. Antonio Di Guardo

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Keywords: distribution, infiltration, degradation, bioaccumulation

Facilities for setting up experiments to study the environmental fate of contaminants. In the EMG laboratory, experiments are conducted on contaminant mobility in soil columns, distribution in soil (Kd measurement), degradation in various matrices, and bioaccumulation in plant and animal organisms. The EMG group's laboratory is equipped with glass columns for mobility experiments, climate chambers for the growth of plant and animal organisms, and various types of shakers used for both degradation and distribution experiments.

Publications:

1. Palladini, J., Bagnati, R., Passoni, A., Davoli, E., Lanno, A., Terzaghi, E., Falakdin, P., Di Guardo, A., 2022. Bioaccumulation of PCBs and their hydroxy and sulfonated metabolites in earthworms: Comparing lab and field results. Environmental Pollution 293, 118507. https://doi.org/10.1016/j.envpol.2021.118507.
2. Palladini, J., Gandhi, B.P., Jones, K.C., Terzaghi, E., Zanardini, E., Palmisano, G., Bagnati, R., Passoni, A., Semple, K.T., Di Guardo, A., 2025a. Environmental formation of sulfonated-PCBs and OH-sulfonated-PCBs: Is it greater under aerobic or anaerobic conditions? Environmental Pollution 382, 126735. https://doi.org/10.1016/j.envpol.2025.126735.
3. Palladini, J., Terzaghi, E., Bagnati, R., Passoni, A., Davoli, E., Maspero, A., Palmisano, G., Di Guardo, A., 2023. Environmental fate of sulfonated-PCBs: Soil partitioning properties,

bioaccumulation, persistence, and mobility. Journal of Hazardous Materials 457, 131853. https://doi.org/10.1016/j.jhazmat.2023.131853.

4. Palladini, J., Terzaghi, E., Zanardini, E., Palmisano, G., Bagnati, R., Passoni, A., Di Guardo, A., 2025b. First Evidence of Environmental Formation of Sulfonated PCBs. Environ. Sci. Technol. Lett. acs.estlett.5c00139.
5. Palladini, J., Terzaghi, E., Zanardini, E., Palmisano, G., Bagnati, R., Passoni, A., Di Guardo, A., 2025c. Sulfonated-PCBs and OH-sulfonated-PCBs: An insight into their environmental formation and identification. Science of The Total Environment 996, 180176.
6. Terzaghi, E., Bertipaglia, C., Zanardini, E., Siniscalchi, D., Bagnati, R., Passoni, A., Rampazzi, L., Corti, C., Ortega-Calvo, J.-J., Posada-Baquero, R., Di Guardo, A., 2025. Forest Filter Effect Revisited: First Evidence That Polycyclic Aromatic Hydrocarbon Metabolites Are Produced on Leaves by Biodegradation and Photodegradation. Environ. Sci. Technol. acs.est.5c09252.
7. Terzaghi, E., Posada-Baquero, R., Di Guardo, A., Ortega-Calvo, J.-J., 2021c. Microbial degradation of pyrene in holm oak (Quercus ilex) phyllosphere: Role of particulate matter in regulating bioaccessibility. Science of The Total Environment 786, 147431.
8. Terzaghi, E., Alberti, E., Raspa, G., Zanardini, E., Morosini, C., Anelli, S., Armiraglio, S., Di Guardo, A., 2021a. A new dataset of PCB half-lives in soil: Effect of plant species and organic carbon addition on biodegradation rates in a weathered contaminated soil. Science of The Total Environment 750, 141411.
9. Terzaghi, E., Raspa, G., Zanardini, E., Morosini, C., Anelli, S., Armiraglio, S., Di Guardo, A., 2022. Life cycle exposure of plants considerably affects root uptake of PCBs: Role of growth strategies and dissolved/particulate organic carbon variability. Journal of Hazardous Materials 421, 126826.

- **B) Facility for "Experimental setup to study the environmental fate of contaminants"**

	**COLUMNS** for studying the mobility of contaminants in soil (infiltration).
	**Multi-chamber shaker** with magnetic stir bars for studying the biodegradation and photodegradation of contaminants in various matrices.
	**Shaking shaker** for measuring partition coefficients, such as the soil-water partition coefficient (Kd).
	**CLIMATE CHAMBERS** (hot/cold) for bioaccumulation experiments in plant and animal organisms.

Sub-unit: "Development of Models for the Environmental Fate of Contaminants"

Principal Investigator: Prof. Antonio Di Guardo

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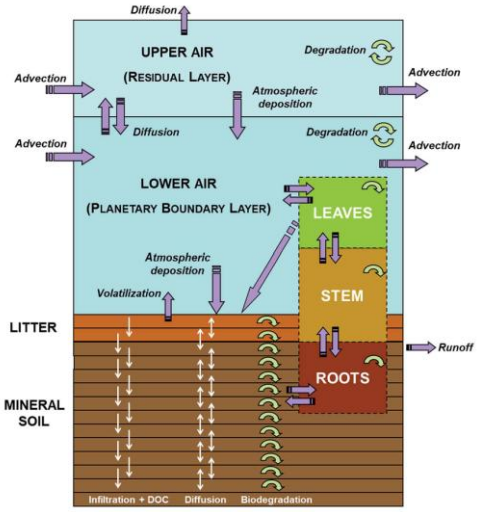
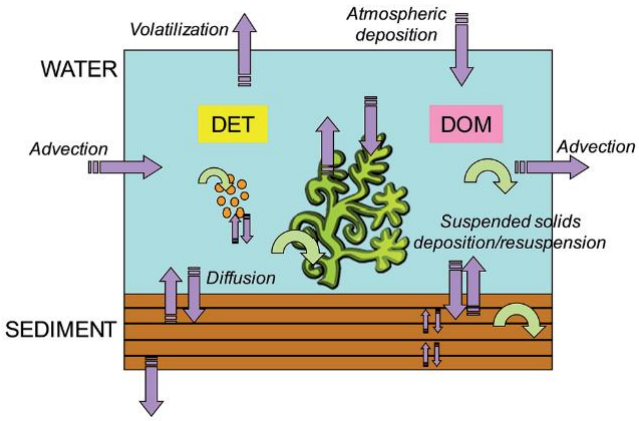
Keywords: PEC (predicted environmental concentration), box models, fugacity



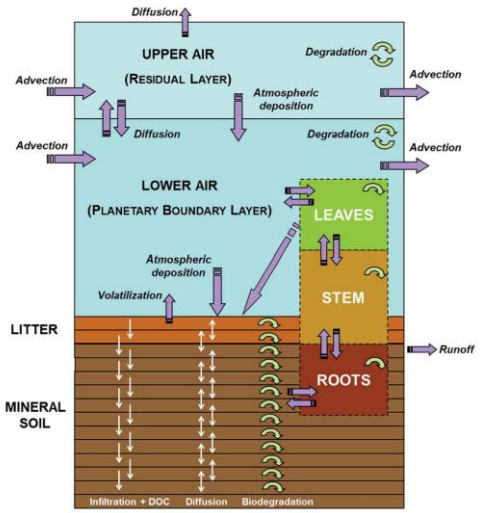


Facility for developing models of the environmental fate of contaminants. Models are essential tools for estimating environmental concentrations of contaminants (PEC, predicted environmental concentration) in the process of characterizing risks to ecosystems. The EMG Group has more than 30 years of experience in developing models based on the concept of fugacity—including both static and dynamic models, as well as spatially resolved ones—that account for various environmental compartments.

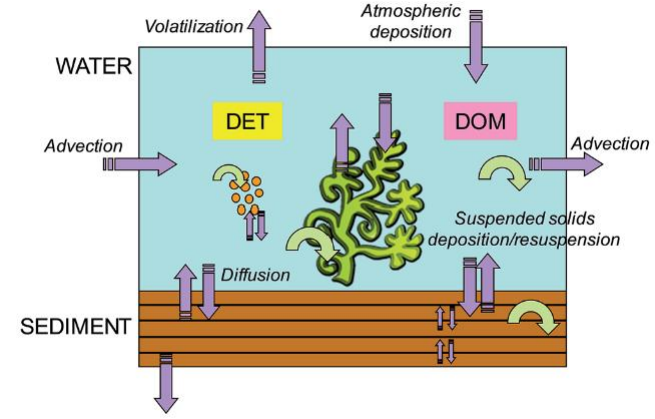
Publications:

1. Di Guardo, A., Castiglioni, S., Gambino, I., Sailis, A., Salmoiraghi, G., Schiarea, S., Vighi, M., Terzaghi, E., 2024. Modelling micropollutant cycle in Lake Como in a winter scenario: Implications for water use and reuse, ecosystem services, and the EU zero pollution action plan. Science of The Total Environment 906, 167594.
2. Falakdin, P., Terzaghi, E., Di Guardo, A., 2022a. Spatially resolved environmental fate models: A review. Chemosphere 290, 133394.
3. Falakdin, P., Terzaghi, E., Di Guardo, A., 2023. Predicting the contribution of a local emission source in mid-range transport of DDT and its deposition in terrestrial and aquatic ecosystems in Northern Italy. Science of The Total Environment 889, 164038.
4. Falakdin, P., Terzaghi, E., Raspa, G., Di Guardo, A., 2022b. Predicting the regional contamination evolution of DDT for 100-years with a new gridded spatial and dynamic multimedia fate model. Science of The Total Environment 845, 157190.
5. Hader, J.D., Lane, T., Boxall, A.B.A., MacLeod, M., Di Guardo, A., 2022. Enabling forecasts of environmental exposure to chemicals in European agriculture under global change. Science of The Total Environment 840, 156478.

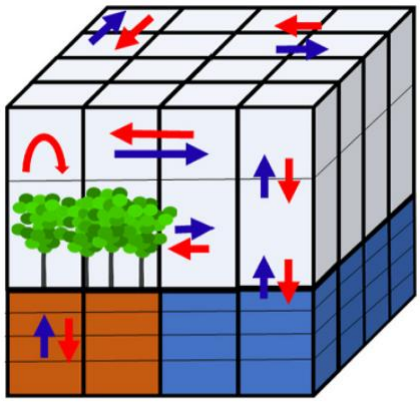
C) Facility for "Development of Models for the Environmental Fate of Contaminants"



SOILPLUSVEG model: a model that includes two air compartments, a stratified litter and mineral soil compartment, and a plant biomass compartment (roots, stems, and leaves); it is a dynamic model with hourly time resolution, which can be used to predict the environmental fate of organic contaminants.



CHIMERA fate model: a model that includes air, sediments, macrophytes, phytoplankton, detritus, and dissolved organic matter; it is a dynamic model with hourly temporal resolution and spatial resolution, which can be used to predict the environmental fate of organic contaminants.



Gridded-SoilPlusVeg: a spatialized version of the SoilPlusVeg model for assessing the environmental fate of molecules in a region, considering hourly variations in wind direction and intensity as well as other meteorological parameters.