multi-Risk sciEnce for resilienT commUnities undeR a changiNg climate

Codice progetto MUR: **PE00000005** – F83C22001660002

Deliverable title: Methodology for ecological risk assessment of combined exposure to multiple chemicals.

Deliverable ID: DV 4.4.2

Due date: 30/11/2024

Submission date: 30/11/2024

AUTHORS

Stefano Albanese (UNINA); Annalise Guarino (UNINA); Sonia Manzo (ENEA); Elisa Parrella (ENEA); Alessandra Polettini (UNIROMA1); Raffaella Pomi (UNIROMA1); Elisa Chiara Bizzotto (FCF); Petra Scanferla (FCF)

1. Technical references

Project Acronym	RETURN
Project Title	multi-Risk sciEnce for resilienT commUnities undeR a changiNg climate
Project Coordinator	Domenico Calcaterra UNIVERSITA DEGLI STUDI DI NAPOLI FEDERICO II domcalca@unina.it
Project Duration	December 2022 – November 2025 (36 months)

Deliverable No.	DV 4.4.2
Dissemination level*	CO
Work Package	WP4 - Multi risk assessment, and proof of concepts
Task	T4.2 - Screening and advanced (probabilistic and uncertainty based) methodologies for risk assessment, chemical and chemical/particle mixture, individual based effect models, in silico tools and QSAR approaches
Lead beneficiary	Stefano Albanese (UNINA)
Contributing beneficiary/ies	

* PU = Public

PP = Restricted to other programme participants (including the Commission Services)

RE = Restricted to a group specified by the consortium (including the Commission Services)

CO = Confidential, only for members of the consortium (including the Commission Services)

2. Document history

Version	Date	Lead contributor	Description
0.1	22.04.2025	Stefano Albanese (UNINA)	First draft
0.2	25.04.2025		Critical review and proofreading
0.3	27.04.2025		Edits for approval
1.0	28.04.2025		Final version

3. Abstract

The deliverable presents the methodology and proof-of-concept development for an Ecological Risk Assessment (ERA) framework addressing combined exposures to multiple chemicals in complex environmental systems. The work is motivated by the need for reliable tools to evaluate ecological impacts in riverine-to-marine transitional environments, where multiple stressors interact under anthropogenic and climatic pressures. The proposed framework is designed as a tiered, decision-support system (DSS) aligned with OECD and EU guidelines, and it integrates traditional, probabilistic, and multi-stressor approaches.

The document begins with an overview of the state of the art, highlighting the evolution of ERA methodologies from simplified regulatory screening tools to advanced, site-specific assessments incorporating mixture toxicity models, biomarkers, and ecotoxicological endpoints. Key guiding principles include tiered assessment, weight-of-evidence approaches, and the incorporation of climate-related stressors. Particular attention is given to the challenges posed by chemical mixtures, for which both whole-mixture and component-based approaches are considered, as well as to the need for probabilistic models that account for variability and uncertainty.

Problem formulation is developed through a systematic review of methods for assessing soil and sediment contamination. Potentially toxic elements (PTEs) are evaluated using individual and aggregate pollution indices, including Igeo, EF, CF, PLI, and PERI. Their strengths, limitations, and requirements for analytical rigor are critically discussed, with emphasis on the role of bioavailability, geochemical baselines, and speciation analyses. Parallel to this, bioplastics are addressed as emerging contaminants, with a review of biodegradation standards across compost, soil, digestate, and marine environments. Experimental designs were defined to test the fate of selected commercial bioplastics under both controlled and uncontrolled conditions, simulating diverse environmental compartments.

Data gathering combined existing geochemical datasets from the Sarno River basin with new surveys carried out in 2024. Sediments and waters were analysed for PTEs, organic pollutants, and ecotoxicological responses. Complementary experimental studies assessed bioplastic degradation under composting, soil, and marine conditions, as well as the influence of enzymatic pre-treatment on anaerobic digestion performance. Results indicate differential degradation rates across products and environments, with implications for persistence and risk.

The final section outlines the proof-of-concept ERA framework. A novel methodological proposal integrates local geochemical baselines with traditional indices to better capture spatial variability and reduce bias in contamination assessment. Applied to Sarno River sediments, the approach improved detection of anthropogenic signals and enabled the identification of contamination sources through principal component analysis, distinguishing industrial and agricultural-urban pressures. The framework demonstrates the feasibility of coupling geochemical, ecotoxicological, and experimental data within a unified risk assessment procedure.

Overall, Chapter 5 provides an integrated methodology for ERA under multiple chemical exposures, combining regulatory guidance, innovative analytical tools, and experimental validation. The proposed DSS,

though at an early stage of technological readiness, offers a structured basis for future development of multi-stressor ecological risk assessment at regional scale, supporting adaptive management in the context of climate change and evolving environmental challenges.

4. Table of contents

List of Tables

List of Figures