2026 Helmholtz – OCPC – Programme

for the involvement of postdocs in bilateral collaboration projects

PART A

Title of the project:

Assessing Regional Solutions for Clean Water Quality in European Landscapes

Helmholtz Centre and/or institute:

Helmholtz Centre for Environmental Research - UFZ

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Description of the project (max. 1 page)**:**

Agricultural losses of nutrients (N, P) is one of the major causes of eutrophication, driving harmful algal blooms to oxygen depletion (hypoxia) in downstream waters. Across Europe, nutrient pollution remains a persistent pressure despite decades of regulation and mitigation. This is happening in a policy landscape that is committed to nutrient reduction, from the Nitrates Directive to Green Deal ambitions such as cutting nutrient losses by at least 50% by 2030. Yet observed improvements in water quality are often modest and spatially uneven, which weakens confidence, complicates river-basin planning, and increases the risk of unintended trade-offs with food production. Riverine nutrient concentrations remain high even after current inputs are reduced is exemplified due to nutrient legacy effect.

Decades of excess nutrient inputs have created long-lived stores in soils, sediments, and groundwater that continue to leak into streams over multi-year to multi-decadal timescales. Critically, however, legacy understanding remains asymmetric across European river basins. While our current nutrient modelling framework provided by Multiscale water quality model (mQM), with an existing spatially explicit nitrogen capability, provides a robust terrestrial view of Nitrogen (N) losses and their delayed impacts. Yet a N-only diagnosis is not sufficient as environmental impacts - especially in riverine can be Phosphorus (P)-limited or co-limited; *and therefore, demands for improved understanding on synergies and feedbacks between these two major nutrients dynamics across terrestrial systems.*

This project addresses this gap by **first** proposing the co-development of a phosphorus module in existing mQM modelling framework, synergised with the existing N framework, to deliver an integrated, multi-scale nutrient fate for European river systems. To this end, the project will fully utilise our modelling capabilities and existing pre-compiled nutrient (N and P) surface budget databases. The coupled model will represent nutrient dynamics across soil, groundwater and river systems, enabling consistent source-to-sink accounting of contemporary versus legacy contributions, and providing an evidence base for chronic regional pollution hotspots. **Secondly**, the modelling framework will help in mapping Europe's safe operating space for nutrient management. Crucially, we will investigate this by explicitly addressing trade-offs with food security and agricultural production, so that "*clean water*" strategies are not framed as a zero-sum choice, but as a set of regionally tailored pathways that can deliver both environmental and societal benefits. Overall out project *will provide a legacy-aware, coupled N and P modelling platform and a set of regionally differentiated, evidence-based options that make nutrient policy more predictable, transparent, and effective.*

Objective and Expected outcomes:

1. **Framing of Mechanistic Model Implementation:** Design and implement a phosphorus module representing soil P pools, mobilisation processes, dissolved and particulate transport pathways, retention mechanisms, and delivery to stream networks, fully integrated with the water quality modelling framework (mQM) and European nutrient budget datasets.
2. **Hotspot Attribution and Legacy Diagnostics:** Develop diagnostic framework to attribute nutrient sources, quantify pathway dominance, and assess legacy phosphorus impacts. The project will generate spatially explicit maps of regional nutrient-loss hotspots, limiting nutrients, and recovery trajectories under alternative management scenarios.
3. **European Nutrient Solution-Spaces:** Produce a continental-scale analysis identifying robust, region-specific intervention strategies that maximise water-quality improvements for different management efforts (e.g., reduction of mineral fertilizer applications) while

safeguarding agricultural productivity to support European nutrient-loss reduction ambitions.

Description of existing or sought Chinese collaboration partner institute (max. half page)**:**

At present, no formal Chinese collaboration partner institute has been established for this project, and the Helmholtz-OCPC Programme is therefore regarded as an opportunity to initiate a new bilateral collaboration with a leading Chinese research organisation active in large-scale water quality modelling, biogeochemistry, nutrient cycling, agricultural-environment interactions. The project seeks to engage with an institute possessing strong expertise in process-based water-quality continental-scale environmental assessments, and the integration of climate and socioeconomic scenarios, with particular interest in groups working on nitrogen and phosphorus dynamics, agricultural nutrient budgets, and decision-support frameworks for sustainable nutrient management.

An ideal partner institute would complement Helmholtz capabilities through access to national-scale environmental datasets, long-term agricultural management statistics, and scenario development under future climate and land-use trajectories. The envisaged partnership could focus on joint development of model components, coordinated scenario experiments, reciprocal doctoral and postdoctoral exchanges, and co-authored publications. These activities could lay the foundation for longer-term cooperation between UFZ and Chinese research institutions in the field of nutrient management and freshwater sustainability.

Required qualification of the postdoc:

- PhD in hydrology, biogeochemistry, environmental modelling, Earth system science, agricultural systems science, environmental engineering, or a closely related discipline.
- Demonstrated experience with large-scale process-based water-quality models, including model development, parameterisation, sensitivity analysis, and uncertainty quantification; nutrient cycling (phosphorus and r nitrogen) in terrestrial systems; climate and socioeconomic scenario simulation and analysis; handling large geospatial datasets (e.g., NetCDF, CDO, NCO).
- Strong programming skills in Fortran, C, Python, or comparable scientific computing languages; Working experience with high-performance computing environments would be an assest.
- Strong publication record and experience working in international research consortia.
- Language requirements: Excellent written and spoken English.
- Knowledge of European river basin management and nutrient-reduction policy contexts would be an assest.