TITLE OF THE RESEARCH PROJECT

Water, wastewater and waste management in remote and mountainous regions: from tradition to innovation

SUPERVISORS

	First name	LAST NAME	University	Research Unit
Supervisor	Giorgio	Bertanza	University of Brescia	Department of Civil, Environmental, Architectural Engineering and Mathematics
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Fields of study

Environmental Engineering

Requirements (academic background, languages...) needed to apply for this research topic

- MSc in Environmental Engineering, Environmental Science, Environmental Studies, Sustainability Science, Ecology, environmental Architecture, Geosciences or related fields
- Ability to communicate, read and write in English

5 main KEYWORDS

Wastewater; tradition; technologies; climate; turism

ABSTRACT *(250 words max.)*

Water and waste management in mountainous and remote areas is a critical issue. Small villages and mountain shelters are often far from centralized services and infrastructure, making decentralized solutions essential. These solutions must account for accessibility challenges and environmental and

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climatic conditions, which affects resorces availability and systems functioning. In some areas, climate change and tourism increase place additional pressure on already fragile environments.
Solid waste must be collected and transported to treatment facilities requiring storage and transport capacity. Drinking water is often supplied in plastic bottles brought up from the valleys, or collected from rainfall and glaciers and then treated. Wastewater, usually requires local treatment, which can be difficult to implement, depending on its quality, space and resources availability.
Although technological innovation and stricter environmental regulations have advanced water and waste management in recent years, solutions often overlook the needs of small, decentralized communities. Mountain communities, however, have managed scarce resources for centuries.
This research aims to explore traditional practices, while exploring current approaches to these challenges. The goal is to identify synergies where tradition and innovation can converge, informing both new technologies and policy development for these areas. Nature-based solutions, such as constructed wetlands or soil infiltration systems, will be investigated as sustainable, low-energy alternatives.
Combining traditional and modern practices in water and waste management can generate cultural value. By turning these practices into part of local heritage and tourist experiences, communities can raise awareness about the fragility of mountain environments, promoting more sustainable tourism and living.

Research aims and methodology

The objective of the research is to explore traditional practices and current approach and innovations in the Alps and remote regions of Italy, Portugal, and other European countries. The goal is to identify synergies where tradition and innovation can converge, to:

- Inform the development of innovative solutions
- Inform the development of territorial policies
- Build oportunities for alternative turist experiences
- Promote sustainable tourism
- Increase community cultural heritage
- Increase environemtal protection
- Contribute to the achievement of the UN Sustainable Development Goals, particularly SDG 6, SDG 11, and SDG 12, by testing innovative, nature-based, and community-driven approaches to water and waste management

The methodology would involve:

- Desk based review of traditional and innovative solution in water and waste management
- Stakeholder mapping
- Interviews and questionnaire to key stakehlders
- Identifiction of one or more site as case studies
- Identification of one or more approach or technology to be investigated in more detail
- Data collection on case studies
- Lab or fied test of one or more nature-based solutions for decentralized wastewater treatment and reuse (e.g., constructed wetlands, vegetated filter strips, soil biofilters)

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- Data analysis
- Elaboration of results and reccomendations

Relevance and added-value of the proposed research in relation to the current state of knowledge

Climate change is projected to cause significant and irreversible losses in mountain regions, severely impacting both people and ecosystems (Kapruwan et al, 2025). Traditional knowledge is recognised to play an important role in natural resource management and ecosystems conservation in mountain environments (Jiao et al. 2024 Ramakrishnan, 2007, Ehlers Smith et al., 2021, Gómez-Baggethun et al., 2012).
Solid waste are generally collected and transported to the valley, with the organic fraction in some cases treated on site. Technological advancements foresees the use of presses to reduce the volume (and consequently, the economic and environmental cost of waste to be transported) of waste. Decentralised technologies are available for wastewater treatment, e.g., fixed bed reactors, activated sludge (Weissenbache et al, 2025), whilst in many mountains refugees drinking water is supplied in bottles transpored from the valley. Nature-based solutions (NBS), such as constructed wetlands, alpine meadows used as natural filters, or vegetated soil systems, represent a promising complement to conventional technologies. They combine low energy demand, adaptability to local climatic conditions, and the capacity to integrate traditional ecological knowledge. Their potential for wastewater treatment and reuse in remote communities strengthens the alignment with the EU Green Deal and the UN SDGs.
The relevance and added value of this research lie in rethinking how water and waste management are perceived. Traditionally, these issues have been treated merely as technical problems—“cleaning” tasks to be solved by engineers. Technologies and solutions are usually seen only as tools serving communities, without recognizing their broader role in ecosystems or the cultural significance of the ideas and traditions behind them. In recent years, practices linked to folklore, food, and agriculture have been rediscovered and celebrated by both communities and tourists. Yet other practices—equally essential for community survival, such as traditional approaches to water and waste management—have remained largely overlooked.
Our research seeks to uncover this knowledge, foster exchange between countries and cultures, and inspire new policies, technologies, and forms of awareness. By blending tradition with innovation, we aim to build more sustainable and resilient approaches to managing vital resources.

Interdisciplinary nature of the research together with the alignment with the CHORAL programme and complementarity expertise of the teams

The research would put together different disciplines such as: engineering, environmental science, ecology and ecosystem-based engineering, public health, chemistry, economics /social science and territory planning. These competencies are available within the reserach groups and Departments of University of Brescia and University of Beira Interior promoting this study. The interdisciplinary nature of the research aligns with the CHORAL program since it is functional to the development of policies for

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the development of mountainous and marginalised areas, strengthening the economies, cohesion and cultural heritage of these communities merging tradition with innovation, and fostering new pathways for tourism, territorial management and environmental and health protection.

Output plan including publication and dissemination activities

The candidate is expected to produce at least 2 publications in peer-reviewed journals and to participate in at least 2 international conferences for the dissemination of the results.
Outputs will also include a policy brief highlighting how innovative and nature-based solutions in mountain water and waste management can contribute to achieving SDG 6, 11, and 12, supporting the EU's commitments to sustainable territorial development.

Estimated schedule

Year 1: Investigation of the state of the ar; stakeholder mapping and interviews; identification of case studies

Year 2: Definition of a methododlogy for the selection of one or more approaches/technology to study in detail;Devlopment of a methodology for the case studies; data collection

Year 3: Data analysis and elaboration of results and reccomendations

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