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Integrated Strategies to Improve Drinking Water Quality: A Comparative Assessment of Source Protection and Drinking Water Treatment

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What did this research aim to address?

This research addresses the challenge of ensuring safe, sustainable drinking water by investigating how integrating source protection (SP) measures with advanced drinking water treatment (DWT) technologies can potentially improve water quality across diverse Irish catchments. SP measures (e.g. riparian buffers, artificial wetlands) offer environmental benefits like biodiversity protection and flood resilience, but their effectiveness varies due to maintenance, site suitability and community engagement challenges. In contrast, DWT technologies provide centralised control over water quality, but often incur higher financial and environmental costs.

Based on six Irish case studies representing a variety of hydrological and geological contexts, catchment attributes, local pressures, water quality and socio-economic factors are evaluated in terms of their influence on the effectiveness of SP measures and DWT technologies, supported by a review of national and international best practices.

The most suitable DWT technologies and SP measures were selected using multi-criteria analysis (MCA) (focusing on technical, economic, social and environmental criteria) combined with a cost assessment to ensure feasibility.

By combining expert insights with real-world case studies, this research supports integrated strategies, balancing immediate water quality needs with long-term sustainability, and aligning research findings with practical treatment conditions.

What did this research find?

The research suggests that integrating SP measures with advanced DWT technologies can improve water quality by bridging technological and environmental gaps. Cost estimations show that while DWT technologies require high capital and operational investments, combining them with effective SP measures can reduce long-term costs and environmental impacts.

Key findings highlight critical trade-offs:

- SP measures rely on community buy-in and adaptive governance, with success varying due to social and maintenance challenges.
- DWT technologies ensure regulatory compliance, but involve high costs and energy use, affecting sustainability.

The six case studies demonstrated that site-specific hydrological and socio-economic factors influence the effectiveness of these measures. Tailored solutions proved most effective in meeting water quality regulations. SP measures were more sensitive to the social context than DWT technologies. Public awareness initiatives were identified as essential for driving behavioural change and sustaining water protection efforts.

The study's MCA framework offers policymakers a tool to balance technical, economic and social criteria. However, quantitative validation is needed to strengthen recommendations, emphasising the need for integrated, sustainable approaches.

How can the research findings be used?

This research offers evidence-based insights for investors, policymakers and water resource managers on strategies to improve water quality. The methodology integrates economic, technical, social and environmental considerations to support balanced, long-term decision-making for SP measures and DWT technologies.

By incorporating industry experience from case studies, this study highlights site-specific challenges, empowering stakeholders to implement solutions that protect public health, preserve ecosystems and secure long-term water resource viability. A phased approach is recommended to balance urgent needs with sustainability goals. Integrating research-based and real-life scenarios enables practical, data-driven water quality strategies.

The effectiveness of the selection framework relies on robust raw water monitoring to assess contaminant risks and overall water quality, aligning with the Water Framework Directive and Drinking Water Regulations. Further refinement of cost data and investigation into SP–DWT interactions, such as cost savings, are recommended to enhance decision-making.

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