

## Development of an Integrated Framework for Life-Cycle Economic, Environmental and Human Health Impact Assessment for Reclaimed Water Use in Water Systems of Various Scales

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**Abstract :** The high private cost and unquantified external cost limit the development of reclaimed water. In this study, an integrated framework comprising life cycle assessment (LCA), quantitative microbial risk assessment (QMRA), and life cycle costing (LCC) was developed to evaluate both costs of reclaimed water supply in water systems of various scales. LCA assesses the environmental impacts, and QMRA estimates the associated pathogenic impacts. These impacts are monetized as external costs and analyzed with the private cost by LCC to count the total life cycle cost. The framework evaluated the Hong Kong urban water system in the baseline scenario (BS) and five wastewater reuse scenarios (RS). They are RSI: substituting freshwater for toilet flushing only, RSII: substituting both freshwater and seawater for toilet flushing, RSIII: using reclaimed water for all non-potable uses, RSIV: using reclaimed water for all non-potable uses and indirect potable uses, and RSV: non-potable use and indirect potable use by conveying 100% reclaimed water to recharge the reservoirs. The results show that substituting freshwater and seawater for toilet flushing has the least total life cycle cost, exhibiting that it is the most cost-effective option for Hong Kong. Meanwhile, the evaluation results show that the external cost of each scenario is comparable to the corresponding private cost, indicating the importance of the inclusion of comprehensive external cost evaluation in private cost assessment of water systems with reclaimed water supply.

**Keywords :** life cycle assessment, life cycle costing, quantitative microbial risk assessment, water reclamation, reclaimed water, alternative water resources

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