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ORIGINAL RESEARCH

A Randomised Field Trial for the Cost-Effectiveness Diagnostics of Municipal Water Treatment Systems in South Africa

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ABSTRACT

{ "background": "Municipal water treatment systems in South Africa face persistent challenges regarding operational efficiency and financial sustainability. There is a recognised lack of robust, field-based methodologies for diagnosing cost-effectiveness that account for the varied local conditions across treatment facilities.", "purpose and objectives": "This study aimed to develop and implement a novel randomised field trial (RFT) framework to diagnose the cost-effectiveness of municipal water treatment systems. The primary objective was to quantify the operational cost per megalitre of potable water produced against key performance indicators.", "methodology": "A stratified randomised field trial was conducted across a representative sample of municipal water treatment works. Facilities were randomly assigned to a diagnostic protocol involving detailed technical audits and cost analysis. Cost-effectiveness was modelled using a generalised linear model: $Ci = \beta 0 + \beta 1 Ti + \beta 2 Qi + \epsilon i$, where Ci is cost per megalitre, Ti is treatment technology type, and Qi is raw water quality index. Robust standard errors were used for inference.", "findings": "The RFT identified significant variance in cost-effectiveness, with operational costs per megalitre ranging from ZAR 1,200 to ZAR 3,850. A key finding was that facilities employing advanced membrane filtration were, on average, 22% more cost-effective than conventional coagulation plants when controlling for raw water turbidity (95% CI: 15% to 29%).", "conclusion": "The randomised field trial provides a rigorous methodological framework for diagnosing cost-effectiveness in water treatment, revealing substantial inefficiencies linked to specific treatment technologies.", "recommendations": "Municipalities should adopt targeted diagnostic audits based on the RFT framework to identify and prioritise cost-saving interventions. Policy should support the conditional implementation of advanced treatment technologies where raw water conditions justify the investment.", "key words": "randomised field trial, cost-effectiveness, water treatment, municipal engineering, performance diagnostics", "contribution statement":

Keywords: *Municipal water treatment, Cost-effectiveness analysis, Randomised field trial, Sub-Saharan Africa, Process optimisation, Water quality management, Developing countries*

Article Highlights

- Operational costs per megalitre ranged from ZAR 1,200 to ZAR 3,850 across facilities.
- A novel randomised field trial framework diagnoses cost-

Methodological Note

The study employed a stratified randomised field trial across a representative sample of municipal water treatment works, using a generalised linear model for cost-effectiveness

effectiveness in varied local conditions. • Cost-effectiveness was modelled against treatment technology type and raw water quality index. • Findings reveal substantial inefficiencies linked to specific treatment technologies.	analysis with robust standard errors. *This study provides a rigorous diagnostic framework for municipal water treatment efficiency.*