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Randomised Field Trial for the Performance Diagnostics and Yield Optimisation of Rural Water Treatment Systems in Kenya

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ABSTRACT

Rural water treatment systems in sub-Saharan Africa frequently underperform, but evidence-based, field-validated methodologies for systematic performance diagnostics and optimisation are scarce. This study aimed to develop and test a randomised field trial methodology to diagnose operational failures and quantify the potential yield improvement of small-scale water treatment facilities. We conducted a randomised controlled trial involving 120 community-managed water treatment facilities. The intervention arm received a structured diagnostic protocol and targeted engineering interventions, while the control arm continued with routine operation. Performance was measured via volumetric yield and water quality testing. The treatment effect was estimated using a linear mixed-effects model: $Y\{ij\} = beta0 + beta1\,Ti + \gamma\,X\{ij\} + uj + \varepsilon\{ij\}$, where Ti is the treatment assignment and u_j is a random intercept for region. The diagnostic protocol identified coagulation-flocculation unit under-dosing as the predominant failure mode (68% of facilities). The intervention increased mean daily treated water yield by 42% (95% CI: 34% to 50%; p<0.001) compared to the control group. A structured, field-based diagnostic approach can significantly enhance the functional performance of rural water treatment infrastructure. We recommend integrating the diagnostic protocol into routine maintenance schedules by local water service providers and for its adoption in national performance benchmarking frameworks. water treatment, randomised controlled trial, performance diagnostics, yield, rural water supply, maintenance This paper provides a novel methodological framework for the randomised field evaluation of water treatment system performance, generating a robust dataset on remediable inefficiencies.

Keywords: *Randomised controlled trial, Performance diagnostics, Rural water treatment, Sub-Saharan Africa, Yield optimisation, Field trial methodology, Point-of-use systems*

Article Highlights

- Randomised trial of 120 community-managed water treatment facilities in Kenya.
- Diagnostic protocol pinpointed under-dosing as the

Methodological Contribution

Presents a novel randomised field trial framework for diagnosing and quantifying remediable performance gaps in

predominant failure mode. • Targeted interventions increased mean daily treated water yield by 42%. • Framework supports integration into routine maintenance and national benchmarking.	rural water infrastructure. *This study provides a field-validated protocol for performance optimisation.*