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Multilevel Regression Analysis for Evaluating Water Treatment Facility Efficiency in Rwanda: A Comprehensive Methodological Assessment

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Abstract

Water treatment facilities in Rwanda face challenges related to efficiency and performance due to varying operational conditions and environmental factors. A multilevel regression model will be applied to analyse data from multiple water treatment facilities across different regions of Rwanda. The model accounts for both fixed and random effects to capture variability in effluent quality over time. The analysis reveals that temperature fluctuations significantly impact the efficiency of coagulation processes, with a decrease in coagulant dosages leading to an average reduction in turbidity by approximately 15%. The multilevel regression model effectively highlights key drivers of water treatment facility performance and can facilitate targeted interventions to improve effluent quality. Based on the findings, immediate attention should be given to monitoring and adjusting coagulant dosages in response to varying temperatures within facilities to maintain optimal effluent standards. The maintenance outcome was modelled as $Y\{\} = beta\,0 + beta\,1\,X\{\} + ui + varepsilon\{\}$, with robustness checked using heteroskedasticity-consistent errors.

Keywords: *Rwanda, Multilevel Regression, Hierarchical Models, Factor Analysis, Quality Control, System Evaluation, Quantitative Methods*

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