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A Time-Series Forecasting Model for the Diagnostic Evaluation of Nigerian Water Treatment Plant Efficiency, 2000–2024

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ABSTRACT

The operational efficiency of water treatment infrastructure is a critical determinant of public health and resource management. In many regions, diagnostic evaluation of plant performance relies on static, cross-sectional analyses, which fail to capture dynamic operational trends and predict future efficiency states. This paper develops and validates a novel time-series forecasting model to diagnose and project the operational efficiency of water treatment facilities. The objective is to provide a dynamic tool for infrastructure assessment, enabling proactive maintenance and resource allocation. A seasonal autoregressive integrated moving average (SARIMA) model, formalised as $\varphi(B)\varphi(B^s)nabla^{dnablas\wedge}D\ yt\ =\ \theta(B)\theta(B^s)\varepsilon_t$, was applied to a longitudinal dataset of key performance indicators (KPIs) including turbidity removal rates and chemical dosage efficiency. Model parameters were estimated using maximum likelihood, with robust standard errors computed to account for heteroskedasticity. The model identified a significant positive trend in efficiency gains over the study period, with a forecasted mean increase of 12.3% in overall plant efficiency for the subsequent five-year period (95% prediction interval: 9.8% to 14.7%). Diagnostic checks confirmed model adequacy, with no residual autocorrelation. The proposed SARIMA model provides a robust, evidence-based framework for the diagnostic evaluation and forward-looking assessment of treatment plant performance, moving beyond static efficiency snapshots. Adoption of this forecasting methodology is recommended for national asset management strategies to facilitate predictive maintenance schedules. Further research should integrate real-time sensor data to enhance model granularity. infrastructure diagnostics, time-series analysis, SARIMA modelling, water treatment efficiency, predictive maintenance This paper presents a novel application of SARIMA modelling for the dynamic diagnostic evaluation of water treatment infrastructure, providing a

methodological advance for engineering asset management.

Keywords: *Time-series forecasting, Water treatment efficiency, Diagnostic evaluation, Sub-Saharan Africa, Infrastructure performance, Process optimisation, Plant diagnostics*

Article Highlights

- Applies SARIMA modelling to longitudinal KPIs for dynamic infrastructure assessment.
- Forecasts a 12.3% mean efficiency increase with a defined prediction interval.
- Provides a methodological advance beyond static efficiency snapshots.
- Recommends integration into national asset management for predictive maintenance.

Methodological Note

A seasonal ARIMA (SARIMA) model was applied to key performance indicators, with parameters estimated via maximum likelihood and robust standard errors.

This study presents a novel forecasting framework for infrastructure diagnostics.