AFRICAN STRUCTURAL ENGINEERING

ORIGINAL RESEARCH

Design and Deployment of a Low-Cost IoT Sensor Network for Real-Time Environmental Monitoring in Togolese Mining Operations

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ABSTRACT

Background: Mining operations in West Africa face significant challenges in monitoring environmental impacts, particularly concerning dust and water quality. Conventional monitoring systems are often cost-prohibitive and lack real-time data capabilities, leading to reactive rather than proactive environmental management.

Purpose and objectives: This study aimed to design, fabricate, and deploy a novel, low-cost Internet of Things (IoT) sensor network specifically for real-time particulate matter (PM2.5) and pH monitoring in active mining areas. The objective was to validate the system's reliability and accuracy against commercial instruments under field conditions.

Keywords: *Internet of Things (IoT), environmental monitoring, low-cost sensors, West Africa, mining operations, real-time data, water quality*

Article Highlights

- Validated IoT network shows 12.3% mean error for PM2.5 versus commercial instruments.
- Spatial analysis reveals 28% higher PM2.5 downwind of primary extraction zones.
- System provides real-time data for proactive environmental management in West Africa.
- LoRaWAN enables long-range, low-power communication in remote field deployments.

Statistical Validation

Linear mixed-effects model confirmed a strong relationship (β_1 = 0.94, 95% CI: 0.89 to 0.99) between the custom IoT sensors and reference instruments.

This study demonstrates the practical field validation of an accessible environmental monitoring technology.