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An AIoT Platform for Real-Time Community Air Quality Monitoring and Population Health Surveillance in Sub-Saharan Africa

Ambient air pollution is among the foremost environmental determinants of population health in sub-Saharan Africa, yet the density of regulatory monitoring infrastructure remains severely inadequate for real-time community-level surveillance. This paper presents AIrSynQ, an Artificial Intelligence of Things (AIoT) platform for continuous, calibrated air quality monitoring developed as a University of the Witwatersrand spin-out and supported by the South African Technology Innovation Agency (TIA). The system integrates low-cost multi-parameter sensor nodes measuring $PM_{2.5}$, PM_{10}, NOx, CO, and volatile organic compounds (VOCs) with an edge-to-cloud data pipeline built on LoRaWAN and LTE-M backhaul, Azure IoT Hub stream processing, and a machine-learning inference layer performing real-time anomaly detection and pollutant forecasting. The South African Community Air Quality Monitoring (SACAQM) network, built on the AIrSynQ platform, currently operates more than 30 active nodes across the Gauteng province, with a 500-unit rollout in progress. Diurnal $PM_{2.5}$ measurements reveal systematic exceedances of the WHO 24-hour guideline of 15~μg~m^{-3} at informal settlement nodes, with peak concentrations exceeding 70~μg~m^{-3} during morning and evening domestic combustion periods. A lightweight LSTM autoencoder deployed at the cloud inference layer demonstrates a precision-recall trade-off superior to static threshold alerting, enabling timely community and clinical notifications. The platform architecture, deployment methodology, anomaly detection performance, and public health implications are described. The AIrSynQ system constitutes a replicable AIoT e-health infrastructure model for resource-constrained urban environments across the Global South.

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