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Field-Calibrated Low-Cost Sensor Networks for $PM_{2.5}$ Monitoring in West African Urban Environments: Insights from Abidjan and Accra

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Low-cost air quality sensors (LCS) offer opportunities for expanding air monitoring networks in regions where reference-grade instrumentation is limited. Within the framework of the Improving Air Quality in West Africa (IAQWA) project, we deployed Real-time Affordable Multi-Pollutant sensors (RAMPs) in Abidjan (Côte d'Ivoire) and Accra (Ghana), to characterize fine particulate matter ($PM_{2.5}$) in contrasting urban environments. Prior to field deployment, each RAMP underwent a co-location period with reference monitors, and city-specific multilinear calibration models were developed incorporating both RAMP-reported $PM_{2.5}$ and relative humidity (RH). These calibration models were applied to correct the sensor data and improve measurement reliability under varying atmospheric conditions.

From February 2020 to June 2021, five (5) measurement sites in Abidjan and four (4) sites in Accra were monitored using a 15-second temporal resolution. These sites were selected to represent the dominant pollution sources in West Africa, particularly domestic fires and road traffic. The calibrated dataset enabled comparative analysis of diurnal, daily, and seasonal $PM_{2.5}$ variability. Both cities exhibited pronounced morning $PM_{2.5}$ peaks associated with traffic, while evening increases were more visible in residential areas, indicating contributions from domestic combustion. Seasonal contrasts were marked, with highest concentrations occurring during the long dry season (Harmattan), when long-range Saharan dust transport significantly enhanced particulate loading. During an intense dust episode in January 2021, calibrated RAMP data underestimated $PM_{2.5}$ relative to reference measurements, highlighting a known limitation of optical LCS under high mineral dust conditions.

Annual mean PM□.□ concentrations ranged from 17 to 26 µg m^{-3} across sites, exceeding both the 2005 and 2021 WHO air quality guidelines. Variability within each city, especially between traffic-influenced and urban background locations, was greater than variability between the two cities. These findings demonstrate both the value of rigorously calibrated low-cost sensors for improving air quality knowledge in data-scarce urban regions, and the need for sensor performance

considerations in environments influenced by episodic dust intrusions.