PM2.5 Sensor Intercomparisons and Regional Trend Assessments from Low-Cost Sensor Networks in Accra, Ghana and Lomé, Togo

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BACKGROUND Metropolises in sub-Saharan Africa experience high levels of ambient air pollution and related health burdens, but are scarcely measured by reference-grade monitors. Combining insights from three years of data collected by newly established Purple Air and Clarity sensor networks, with recently published correction factors for low-cost sensors in this region based on collocation with reference monitors, we present measurements of PM2.5 concentrations in Accra, Ghana and Lomé, Togo.

METHODS For Accra, Ghana, we utilize a network of 18 Clarity (low-cost) sensors deployed in August 2018 through present to analyze regional trends, and assess the reductions in PM2.5 caused by clean air interventions as well as the COVID19 pandemic. In neighboring Lomé, Togo, our 5-node PurpleAir network deployed in 2019 represents the first ever long-term ambient PM2.5 measurements in the city to our knowledge. We also present the results from one year of intercomparison between various low-cost (PurpleAir, Clarity, MODULAIR) monitors and reference-grade (BAM-1020, Teledyne T-640) monitors, the first such multi-sensor long-term intercomparison in Africa to our knowledge.

RESULTS In Accra, we find that the calibrated daily averaged PM2.5 is 26.4 µg m-3 and is within the EPA Ghana standard for 24-hour mean of 35 µg m-3. Sensors near major roadways see the largest reductions during the April-May 2020 COVID lockdowns, with two busy interchanges recording 17.7% and 22.2% reductions respectively. In Lomé, we find the daily PM2.5 average is 23.5 µg m-3, which is 1.6 times the WHO daily average guideline of 15 µg m-3. In both Accra and Lomé, sensor sites show diurnal patterns with morning peaks 2.5 times stronger than evening peaks (with notable exceptions linked to areas that experience intense rush hour traffic jams), as well as annual patterns with mean PM2.5 concentrations 1.5 times higher during the Harmattan period. We find that Clarity monitors show the best correlation with reference-grade monitors, with an R2 = 0.76 and Mean Absolute Error = 3.36 µg m-3.

CONCLUSION In Accra, we find that on average 94.8% of days exceed the WHO daily standard, with the lowest being 69% at the East Legon site and the highest being 77-100% at sites in the Jamestown district. In Lomé, we find that, at all sites, more than 87% of measured days surpass WHO PM2.5 Daily Guidelines. Exposure to high levels of air pollution poses risks for residents, particularly during the annual Harmattan. Finally, the sensor intercomparison research feeds into our development of a globally-transferable model for calibrating and correcting low-cost sensors, using the Gaussian Mixture

Regression technique. Future work includes collaborating with environmental health scientists to link exposure to air pollution in Ghana and Togo to health outcomes.

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