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Airborne particulate matter monitoring in Nairobi, Kenya using calibrated low cost sensors

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This study investigated the use of low cost optical particle counters (OPCs) to measure particulate matter (PM) pollution in Nairobi, Kenya, between February and March 2017. Measurements were performed in three locations, an urban background and urban roadside site in Nairobi (at the top of a tower block and a busy roadside location, respectively) and one in a rural location, Nanyuki, at an aerial distance of 110 km north of Nairobi. The concentration of PM2.5 and PM10 regularly exceeded WHO daily guidelines at the urban sites, with an exceedance often double the WHO guidelines at the roadside site. This study provides much needed calibrated data, of high temporal resolution, on the PM loadings in a rapidly developing and urbanising East African country.

PM poses a significant risk to human health by increasing the likelihoods of respiratory and cardiovascular disease. There is typically a lack of PM data for cities located in low to middle income countries (LMICs). Although measurements of PM loadings in Nairobi exist, there is a paucity of long-term measurements with appropriate calibration. Existing measurements in the city highlight that PM concentrations regularly exceed WHO guidelines, both in the PM10 and PM2.5 mass fractions. Low cost sensors offer the possibility of long term measurements in Nairobi and other LMIC cities.

OPC sensors (Alphasense OPC-N2) had their data logged using Raspberry Pi 3 minicomputers, housed in weather resistant casing and placed in areas free from obstruction. The measured OPC-N2 particle number concentrations were calibrated using a regression curve obtained from a co-location measurements that provided gravimetric concentrations of PM2.5 and PM10. Meteorological measurements were also taken at the tower block site, which were also appropriate for the roadside location. Previous measurements indicate that high relative humidity (RH) can lead to inaccurate measurements. Nairobi in the season of the measurement period is typically dry (RH < 80%) and the measurements were not affected by changes in RH.

The urban roadside site had the highest number of days in excess of WHO guidelines for PM2.5 and PM10, with average mass concentrations of 36.6 μg m-3 for PM2.5 with 85% days in exceedance (13% of which were at least double the guidelines) and 93.7 μg m-3 for PM10 with 90% days in exceedance (40% of which were at least double the guidelines). The urban background site only exceeded the guidelines approximately one third of the sample time. The roadside site shows a clear diurnal pattern consistent with vehicular traffic being a major source of PM in Nairobi.

This study provides high temporal resolution PM2.5 and PM10 measurements that can be utilised for health related assessments and the implementation of transport and land use policy. It shows that low cost sensors can be used for monitoring LMIC countries along as the appropriate calibration approach is taken.