THESIS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY IN NATURAL SCIENCE,

SPECIALIZATION IN CHEMISTRY

Airborne particulate matter studies from a typical Sub-Sahara African city: Nairobi, Kenya, and an Equatorial high altitude site: Mount Kenya

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Abstract

In Sub-Saharan Africa (SSA), air quality is gravely understudied despite the existing influential factors such a rapid urbanization and population growth that negatively affect the environment. Majority of urban areas in SSA face challenges that include lack of social services, poor infrastructure development, exponential increase of second-hand vehicles and extensive use of biomass-based fuel for energy needs. There is a systemic lack of continuous monitoring of air pollution in most SSA cities and hence it is yet to be seen if SSA will meet the set air quality targets of the sustainable development goals (SDGs) by the year 2030. Although the focus of air quality is on the urban areas, there is a need to monitor atmospheric composition at remote areas in SSA in order to build a baseline level and understand the influence of anthropogenic and natural aerosol sources on regional/global scale.

This thesis work sought to study physical and chemical properties of airborne particulate matter (PM) in a typical SSA urban area, Nairobi city, and a high altitude site, Mount Kenya. Results from spatial distribution of black carbon (BC) and $PM_{2.5}$ (particulate matter less than 2.5 aerodynamic diameter) showed that air quality on the road to the city and within the city is deteriorating. Factor analysis of the $PM_{2.5}$ results showed that pollution sources were traffic, mineral dust, industrial, combustion, biomass burning, secondary aerosol and aged sea salt. Traffic and mineral dust contributed about 74% of the $PM_{2.5}$ in Nairobi. Exposure to particulate pollutants was expressed in terms of deposition fractions from the size segregated PM data. The head airways region was found to receive the highest dose (about 86%) compared to the tracheobronchial and pulmonary regions. The reported high $PM_{2.5}$ and BC concentrations measured along the main street of Nairobi city, indicated the urban population is frequently exposed to elevated pollutants concentrations and thus have high risk factor to respiratory illnesses and lung cancer. Aerosol study from Mount Kenya showed air pollutants are transported from the surrounding and far away sources by local and regional meteorology dynamics. The results from this study provides insight into the air quality issues from pollution sources, exposure to the population and dispersal to remote regions.

Keywords: X-ray Fluorescence (XRF), Particle Induced X-ray Emission (PIXE), Particulate matter pollutants, Source apportionment, sub-Saharan Africa, Deposition fractions, High-altitude, Free troposphere, Spatial distribution