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Particulate matter (PM10) concentration, mineralogical characteristics and traffic-related element (TRE) composition of urban traffic particles in Ibadan, Nigeria

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Atmospheric traffic-related elements (TRE) generated from traffic-related emissions have been linked to a wide range of human diseases and also affect the ecosystem. This study focuses on data from the Nigerian air quality network along the segment of the National Highway Roads (NHR), inner-city Major Roads (MR) and Rural Roads (RR) in Ibadan. The aim of this near-road monitoring was to assess the levels of TRE, determine the particulate matter (PM_{10}) concentrations and mineralogical composition of the PM_{10} particles.

Sixty particulate matter (PM_{10}) samples were collected from 5 traffic-related stations (2-NHR; 2-MR; 1-RR) (six samples from each station) in the study area using traffic-related high-volume air sampler with PM_{10} cut-off on cellulose filter. PM_{10} concentration was calculated from the difference in weight of the filter and flow rate of the sampler while the mineralogical composition of the PM_{10} was determined by single-particle analysis using scanning electron microscopy and energy-dispersive x-ray spectroscopy (SEM/EDXS) techniques, and the TRE were determined by inductively coupled plasma-optical emission spectrometry (ICP-OES).

The results of the PM_{10} concentration showed that NHR had the highest concentration of 1194.30 µg/m^3, while the lowest concentration was observed in RR (36.33 µg/m^3), these correspond to the level of traffic density in both stations, the former having 60,000 vehicle/day while the later had <2000 vehicle/day. More than 80% of the PM_{10} concentrations in the NHR and the MR were classified as being unhealthy-hazardous to humans living very close to this environment on the basis of the air quality index (AQI). The most abundant mineral particles were clay (53%), quartz (9%) and rock-forming minerals (<3%) sourced from roadside soil and fly ash from construction rock dust. Other particles such as clay+sulphate (17%), sulphur-rich particle (8%), soot (7%) and tarballs (8%) were generated from anthropogenic input from traffic-related activities. The highest average concentration of TRE such as Ba, Cd, La, Pb, V and Zn (2.81, 1.61, 1.21, 6.92, 8.92 and 10.73 respectively all in µg/m^3) was observed in NHR, while those of Cu, Mo and Mn (5.45 µg/m^3, 6.67 µg/m^3 and 11.78 µg/m^3 respectively) was observed in MR. Principal component analysis (PCA) revealed four factors (PC1 to PC4). In PC1 26.57% of the variability was observed and loaded with Ba (0.76), Pb (0.82), V (0.85) while PC 2 could explain 17.94% variability and had La (0.67), Mn (0.83) and Mo (0.68), PC 3 explained 15.91% variance loaded with Cd (0.84) and Zn (0.77), and PC 4 gave account of 13.83% of the variance and was loaded with Cu (0.86). PC1 and PC2 were products of both gasoline and diesel engine while PC3 and PC4 were generated from engine oil, brake and tyre wares. The calculated enrichment factor classified the TRE as being moderate to highly contaminated in both NHR and MR while RR was considered relatively uncontaminated.

Keywords: Traffic-related elements; Air quality index; National highway roads; Major roads; Rural roads