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Study of particulate matter of Akure, Nigeria using a sharp-cut inertial filter combined with an impactor-a preliminary study

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ABSTRACT

In this study, the particulate matter (PM_{10}) was studied over a six month period (from August 2017 to January 2018) at an urban and a suburban site (Akure, Ondo State, Nigeria). Three different sites were used, namely: Federal University of Technology, Akure (FUTA); the National Commission for Museum and Monuments, Akure, and Science and Education Development Institute (SEDInst), Oba Ile. The monthly PM_{10} in these locations during the studied period ranged from 60.73 to 287.97 μm^3 at FUTA, 96.1–175.63 μm^3 for the National Commission for Museum and Monuments, Akure, while it ranged from 92.72 to 204.48 μm^3 at SEDInst. The results were compared with national and international standards. It was observed that the PM_{10} were above the recommended limits. Meteorological parameters (Rainfall, relative humidity (RH), temperature, precipitation, wind speed and direction) were obtained from a meteorological center and analyzed statistically. The essence in the study was to find out their relationship with $PM_{10.}$ The value of R of the PM_{10} samples had positive correlation with rain (r = 0.561, 0.820, 0.408), RH (r = 0.487, 0.799, 0.318), and precipitation (r = 0.388, 0.486, 0.784). There were strong correlations between RH and temperature (r = 0.741) and RH and wind (r = 0.977). This study suggested that individual meteorological factors had effects on PM_{10} concentration.

1. Introduction

According to WHO (2018), over 80% of people residing in urban areas are exposed to air quality levels that surpasses the standard limits. About, 97% of cities in low- and middle income countries do not meet WHO air quality guidelines. Many cities in the world have known the effects of air pollution levels and the associated health impacts (the risk of stroke, heart disease, lung cancer, and chronic and acute respiratory diseases, including asthma), thereby resulting into constant air monitoring.

Particulate matter with *aerodynamic* diameter of 10 mm is a major air quality concern because of its attendant problems on human health. PM_{10} concentrations depend on meteorological factors, suggesting that climate change could have effects on PM_{10}. In the air pollution study, meteorological parameters play important roles in PM concentrations due to their mixing, dispersion, transportation and formation of aerosol particles (Odat and Alodat, 2017). Temporal differences in a pollutant concentration come from the variations in the meteorological conditions (wind speed, wind direction, temperature and relative humidity) (Elminir, 2005). An understanding of the causes of air pollution, provide clearly, the influences of meteorological parameters on the pollutants. It is on record that meteorological parameters play an important role in PM_{10} concentration reduction strategies. Analysis of local and regional meteorology is important to fully understand the processes responsible for the spatial and temporal distribution of PM (Tecer et al., 2008).

Anthropogenic and non-anthropogenic activities can introduce aerosols into the atmosphere/Akure, capital of Ondo State is one of the largest cities in Nigeria with a population of 556,300, making 0.305% of Nigerian population (Population.city, 2015). Like many large cities in the world, Akure needs to tackle the problem of a large concentration of $PM_{10.}$ This problem is of particular importance in Africa, especially in Nigerian cities which are among the polluted in terms of PM_{10} concentrations (Obioh et al., 2013). In the data presented by Obioh et al. (2013) the issue of elevated PM_{10} concentrations in Nigeria is not restricted only to the mega cities of the country, but a widespread problem, most especially in areas with cases of burning of biomass, agricultural and construction activities.

It is paramount to collect air samples before various quantitative chemical analyses of atmospheric particles can be determined. The

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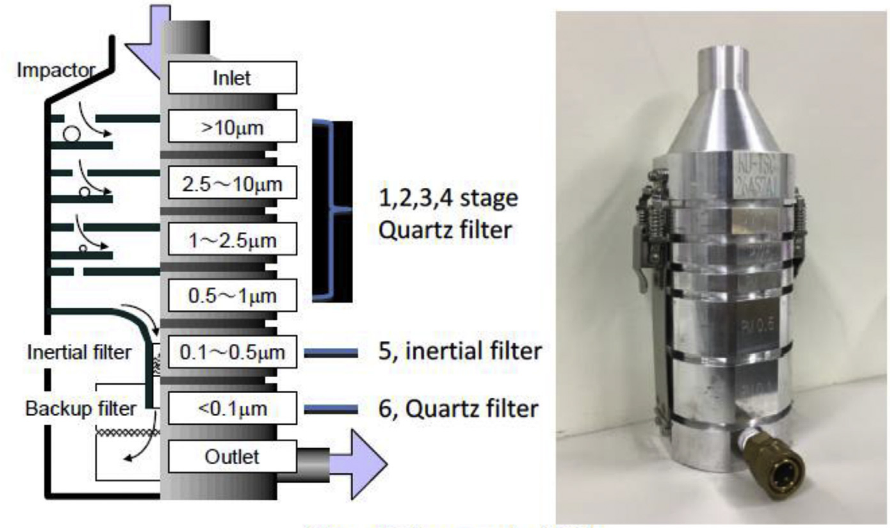

Fig. 1. Nano sampler (NS).

samples are collected from the air by filtration (in the order of mg). For a small mass of the particle (< 0.1 μm) to be collected a nanoparticles sampler is needed. It is on record that there are many samplers available for achieving nano sampling (pressure impactors (LPI) and nano-multi orifice uniform deposit impactor (nano-MOUDI) (Kauppinen and Hillamo, 1989). All of these devices, however, have shortfalls, which include a small sampling rate, a low charging efficiency for nanoparticles, the production of artifacts and the loss of unstable chemicals by evaporation due to the large pressure drop (Hata et al., 2009).

In this present study, a Nanosampler developed by a research team from Japan was used for this assessment of PM_{10} in Akure, Nigeria. The schematic drawing and picture of the Nanosampler are depicted in Figs. 1 and 2. The sampler consists of a six-stage impactor of (> 10, 2.5–10, 1–2.5, 0.5–1, 1–0.5, and < 0.1 μm and an inertial filter with an aerodynamic cutoff diameter of *dp50* ~65 nm. The sampler was developed and designed to operate at a flow rate of 40 L/min, which allows both the sufficiently fast sampling of atmospheric nanoparticles and portability as a field sampling device (Furuuchi et al., 2010). According to the developers, the designed sampling flow rate is more than twice that of commercial low-volume samplers (16.7 L/min) but less than that of high volume air samplers (500–1000 L/min). The benefit of the Nanosampler is that the sampling flow rate can be readily changed, depending on the requirements in the field (Furuuchi et al., 2010). Each impactor stage has specifications shown in Table 1. The filter diameter is 47 mm for all stages. The sampler can be used with quartz fiber, glass and Teflon filters. The air flow was designed to leave an impaction plate from the peripheral of the impaction plate and is similar to the Andersen cascade impactor (Furuuchi et al., 2010).

The Nanosampler is relatively new in Africa. It would be far more relevant to evaluate the correlations of PM_{10} obtained with this sampler

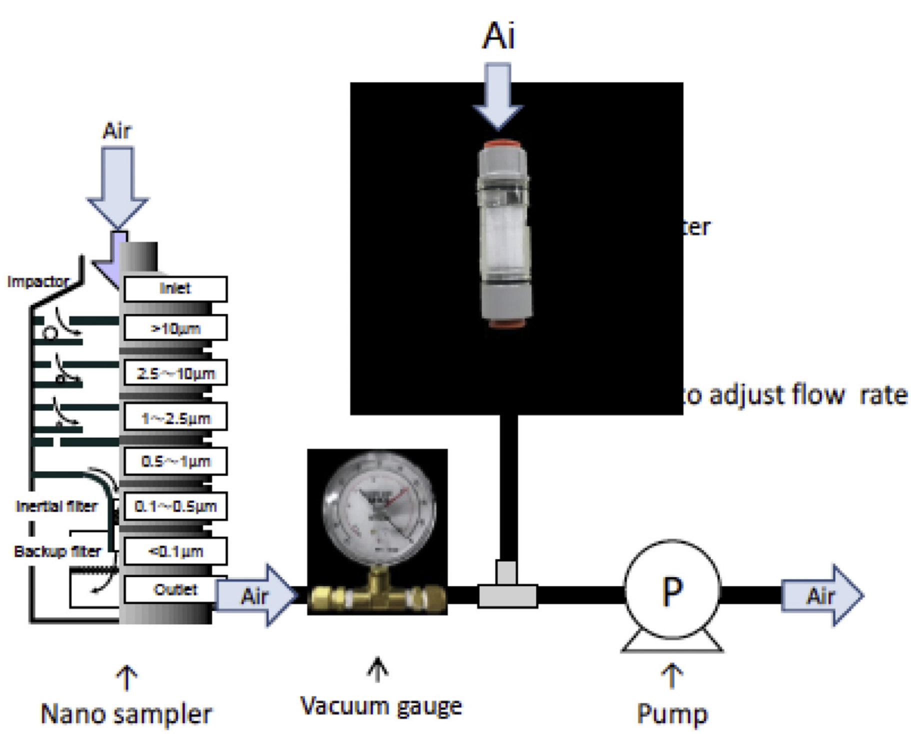

Fig. 2. The sampler set-up.