Urban Climate 26 (2018) 51–59

Contents lists available at ScienceDirect

Urban Climate

journal homepage: www.elsevier.com/locate/uclim

Reviewing the local and global implications of air pollution trends in Zaria, northern Nigeria

Yahaya A. Aliyu[a,c,*], Joel O. Botai[b,a]

[a] Department of Geography, Geoinformatics and Meteorology, University of Pretoria, Pretoria 0002, South Africa
[b] South African Weather Service, 442 Rigel Avenue South, Erasmusrand, Pretoria 0001, South Africa
[c] Department of Geomatics, Ahmadu Bello University, Zaria, Kaduna 810282, Nigeria

ARTICLE INFO

Keywords:
Air pollution
Air quality index
MSA Altair 5× gas detector
Chinaway CW-HAT200 particulate counter
Nigeria

ABSTRACT

Air pollution is an unnoticed problem in many Nigerian urban cities. This is mainly attributed to the usage of power generating sets, indiscriminate refuse burning, biomass consumption and import/recycle of timeworn automobiles, which dominates the Nigerian automobile fleet. Reduced economic infrastructure and the Nigerian climate, are a major factor for the dense outdoor population activities. This is contributing to the increasing population health risk resulting from pollution exposure. Literature on the seasonal spatial-temporal distribution of air pollutants within Nigerian urban cities is presently scanty. This study evaluates the local and global implications of air pollution trends in northern Nigeria's educational hub. The study utilized validated cost-effective devices (MSA Altair 5× gas detector and the CW-HAT200 particulate counter) to assess the outdoor air quality in Zaria. The findings revealed the one-year daytime weighted average concentration level for CO, SO_2 $PM_{2.5}$ and PM_{10} as 29.22 ppm, 0.32 ppm, 219.73 and 451.96 μgm^{-3} respectively. These concentration levels were above the locally and globally stipulated air quality indices. In particular, the concentration levels of the particulate matter pollutants ($PM_{2.5}$ and PM_{10}) were high enough to place Zaria amongst the World Health Organization's list of polluted cities. We are optimistic that our findings would instigate Nigerian policy makers to take decisive steps for air quality management across its cities.

1. Introduction

Urban air pollution is a major ecological threat in most developing countries (Gorai et al., 2017). The consistent rise in greenhouse gas emissions is also intensifying and therefore affects the earth's climate system (Nsubuga et al., 2013). Studies have expressed concerns over outdoor air pollution especially since the anthropogenic sources in the urban cities are positioned at ground level, thus aggregating exposure profile of the population within (Aliyu et al., 2014; Patton et al., 2016).

In Africa, air quality studies are very challenging especially when it comes to accessing observed station series data. This is due to difficulties regarding the availability, accessibility and consistency of pollution datasets. Some of the cited studies revealed that they depended on remote sensing re-analysis data (e.g. top-down estimates), to fill this gap (DeMott et al., 2003; Hopkins et al., 2009; Marais et al., 2014; Marais and Chance, 2015). Proper management of city-scale air pollution can be complex, especially when there is no accurate and organized geospatial data for up-to-date identification of specie pollutants, distribution of sample sites, regularity/period of sampling, sampling methods, infrastructural amenities, man power and maintenance expenditures (Al-Awadi et al., 2015).

* Corresponding author at: Department of Geography, Geoinformatics and Meteorology, University of Pretoria, Pretoria 0002, South Africa.
E-mail address: u15221408@tuks.co.za (Y.A. Aliyu).

https://doi.org/10.1016/j.uclim.2018.08.008
Received 19 October 2017; Accepted 12 August 2018

Table 1
Threshold of selected air pollutants, modified after (FEPA, 1999; SANS, 2011; WHO, 2017).

Pollutant	AQIs		
	WHO[a]	SANS[b]	FEPA[c]
CO	9 ppm	26 ppm	20 ppm
$PM_{2.5}$	25 μgm^{-3}	–	–
PM_{10}	50 μgm^{-3}	75 μgm^{-3}	150 μgm^{-3}
SO_2	0.01 ppm	0.13 ppm	0.1 ppm

[a] 24-hour time weighted average for listed pollutants except CO (8-h).
[b] 1-hr time weighted average for listed pollutants.
[c] time weighted average is not indicated; ppm (parts per million); μgm^{-3} (microgram per meter cube).

Nigeria is Africa's leading economy. It has a rapidly growing population with little information available about its air quality (Marais et al., 2014). Air pollution is a serious threat to public health in most Nigerian urban cities resulting from poorly managed private/commercial vehicles, unregulated recreational activities, trash burning, traffic congestions and biomass consumption. These often leads to high air pollution from unproductive fuel combustion in the socio-economical scheme (Hopkins et al., 2009; Aliyu et al., 2014). The challenges with urban air pollution in Nigerian urban cities is well-known, however the attitude towards tackling it remains uncertain. Air quality studies across Nigerian cities demonstrate that pollution measurements are collected on makeshift basis and in most cases, the monitoring network is scantily distributed. With such situation, it is therefore difficult to develop an air quality management plan for its cities. To instigate this process, we appraise the ramifications of air quality for northern Nigeria's educational hub, Zaria.

The Intergovernmental Panel on Climate Change (IPCC) guideline continues to reflect on the need for policy makers to create emission inventories that are accurate and consistent. This will encourage continuous improvement of emission inventory compilation to international standards (Francesco et al., 2014). For effective air pollution management, there must be collaboration between various key sector players including transportation, energy, water resources, urban planning and health (Hasenfratz et al., 2015). In addition, air pollution is usually regulated by air quality guidelines. Presently, organizations and countries e.g. World Health Organization (WHO); South African National Standards (SANS); Nigeria's Federal Environmental Protection Agency (FEPA), have adopted varying air quality indices (AQIs) (Table 1). These AQIs are centred on the ambient concentrations of criteria pollutants including, but not limited to – CO (Carbon Monoxide), PM_{10} (Particulate Matter of $< 10\,\mu m$ in aerodynamic diameter) and SO_2 (Sulphur Dioxide), while in some cases $PM_{2.5}$ ($< 2.5\,\mu m$ in aerodynamic diameter) is taken into consideration (Cairncross et al., 2007).

2. Materials and methods

2.1. Study area

Zaria metropolis is the educational hub of Northern Nigeria (Fig. 1). It occupies an area of approximately 296.04 km^2. It has an estimated population of 938, 521 from the 2006 census considering its growth rate of 3.0% per year. The study area is stationed at an altitude of mainly about 670 m above mean sea level (MSL) (NPC, 2010). Its climate is characterized by 2 seasons: dry (October – May) and rainy (June – September). The respective seasonal average values for dry and rainy seasons are: precipitation (24.6 mm and 213.8 mm), minimum temperature (14.1 °C and 19.5 °C) and maximum temperature (35.2 °C and 28.9 °C) (Grace et al., 2015).

2.2. Method and instrumentation

The nineteen sampling sites were identified across study area (Table 2). All the sites are located along major road intersections. 16 sites are positioned within dense population activities which cuts across the residential and commercial settlements, while the remaining 3 control sites are positioned strategically at the outskirts of the city with minimal population activity. The control sites were used to aid in result comparison. The most convenient route across the 19 sample stations for effective cost and timing was identified and tagged serially as 1–19 (Fig. 1). This covers a distance of 42.8 km.

Four criteria air pollutants CO, SO_2, $PM_{2.5}$, and PM_{10} were monitored to achieve study objectives. The MSA Altair 5× gas detector (Fig. 2a) and CW-HAT200 particulate counter (Fig. 2b) were used to collect ground level pollution concentrations, for December 2015 – November 2016. Ground in-situ samples were retrieved daily across three epochs. They are: morning (0730–0845 h), afternoon (1300–1415 h) and evening (1700–1815 h). The reason for adopting these epochs is to ensure adequate representation of pollution related activities at peak (morning and evening) and less peak (afternoon) periods (Pattinson et al., 2014; Wang et al., 2014; Yazdi et al., 2015). The observed concentration levels for the criteria pollutants were recorded based on instrument configuration (Table 3). To ensure assurance and control of data quality, detectors were calibrated using the procedures described in the manufacturer manual. The instrument background and pump flow were also examined prior to conducting each monitoring session. Pollutant concentration levels for CO and SO_2 were obtained using the MSA Altair 5× in parts per million (ppm) units, while the CW-HAT200 collected particulate matter ($PM_{2.5}$ and PM_{10}) in microgram per meter cube ($\mu g\,m^{-3}$). The day-time observations were