Editorial
A call for action: Air Pollution, a serious health and economic hazard suffocating Africa

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https://doi.org/10.17159/caj/2022/32/2.15116

Air pollution research has been conducted in Europe and North America as well as in Asia and South America for decades, but there has, so far, only been a limited amount of studies on air pollution and its health effects conducted in Africa. Until recently, global inventories of pollutants from North America Europe and Asia have been used for air quality and climate change modelling in Africa (Bond et al., 2004, Streets et al., 2004, Bond et al., 2007, Klimont et al., 2009, Klimont et al., 2013, Lamarque et al., 2010). Research in air pollution has, however, been lagging far behind in African countries, despite the increasing health- and economic impact associated with air pollution in these nations, since systematic monitoring in Africa is often lacking. The health impact of air pollution in African cities has only been sparsely studied: a review from 2018 (Coker and Kizito, 2018) found only 3 studies outside South Africa. Earlier last year, a study showed that air pollution was responsible for 1.1 million deaths across Africa in 2019, with household air pollution—driven largely by solid biofuel used in indoor cook stoves—accounting for 697 000 fatalities (64% of the total), while increased outdoor air pollution claimed 394 000 lives (36% of the total) (Fisher et al., 2021).

Although 60% of the African population currently lives in rural areas, urbanization is ongoing across the continent at a speed unprecedented in history. Projections show that Africa have the fastest urban growth rate in the world: Africa's cities will, by 2050, be home to an additional 950 million people (OECD/SWAC, 2020), and the continent's population is anticipated to be primarily urban by 2035. Several studies summarized in November 2021 by the Washington Post, project that by the end of this century, thirteen of the world's 20 biggest urban areas will be in Africa — as compared to just two today. The population is growing faster than the supporting infrastructure, leading to changes in urban environments that are hard to control. The World Health Organization (WHO) estimates that the annual median concentration of air borne particulate matter smaller than 2.5 µm ($PM_{2.5}$) surpassed 26 µg/m³ across more than half of the African continent, greatly exceeding the WHO limit of 5 µg/m³. In a review of eight studies of outdoor air pollution in African cities (covering seven countries), $PM_{2.5}$ levels varied between 40 and 260 µg/m³ (Naidja et al., 2017), compared with an annual average of 13 µg/m³ in urban Europe (EEA, 2019) and 9 µg/m³ in urban United States (IQAir, 2020) in 2019. Air pollution monitoring in Africa is severely lacking; among the 47 countries comprising sub-Saharan Africa, only 6 provide long-term data on PM, covering a total of 16 cities. The few available emission inventories are seldom precise and are typically based on indirect data, such as surveys, for example of fuel consumption. The scarcity and lack of data can significantly limit the planning and implementation of mitigation strategies. While new advances in remote and low-cost ground sensor technology and communication can serve as important tools for developing mitigation strategies and policy, the data quality and lack of proper calibration may become a barrier to these approaches.

African PM emissions originate from sources different from those in high-income countries. In Africa, biomass burning (including agricultural burning and wild fires) is one of the major sources of aerosols after Saharan dust (Dajuma et al, 2021). Globally, biomass burning make up a majority of primary combustion aerosol emissions with ~52% originating from Africa, (Bond et al., 2013, Andreae, 2019, Brown et.al, 2021). Africa accounts for about 72% of the total global burned area and about 52% of the total carbon emissions from biomass burning, including 44% of CO emissions, 36% of CH4 emissions (van der Werf et al., 2010), and 60% of the total black carbon (BC) emissions, which is twice the global average (Bond et al, 2013). Recent estimates show that Africa's fires emission estimates are 31-101% higher than previous estimates (Ruben et al, 2021).

The predominant contributors to outdoor air pollution in urban areas are likely the extensive number of old unregulated motor vehicles, households burning biomass fuels, and domestic waste burning. The vehicle fleet is most probably the greatest contributor to outdoor urban air pollution (Hitchcock et al., 2014). The exhaust from road transport is of great concern because (1) the vehicle fleet is old and poorly maintained and do not meet emission standards of developed nations, and are imported without air filters and catalytic converters, (2) a significant increase in two-wheel two stoke engines that use gasoline and dirty oil, (3) considerable increase in the number of vehicles without adequate city planning leading to congestions and engines running idle, and (4) lack of emission standards and regulations in almost all African cities.

While wild fires are a major source of emissions in the continent contributing to ambient air quality, indoor air quality is also heavily influenced by biomass burning. Some surveys indicate that 95% of the population use solid biomass for cooking, due

to lack of access to clean energy, and the International Energy Agency have projected that over 600 million people in Sub-Saharan Africa will still remain without access to electricity in 2030 (IEA, 2017). Domestic biomass burning contributes to high indoor as well as outdoor air pollution levels. Indoor air pollution is the largest environmental health risk factor in Africa. Domestic use of biomass burning causes nearly 600 000 premature deaths in Africa annually (WHO, 2014). An additional 43 000 premature deaths in Africa are linked to biomass burning driven by agriculture (Bauer et al., 2019).

According to recent health impact assessments, sub-Saharan Africa suffers the highest burden of disease and premature deaths attributable to environmental pollution in the world. These studies, however, rely on effect estimates from other parts of the world when it comes to ambient air pollution. This could lead to an underestimation of the impacts as the continent has lower access to healthcare, prevalence of infectious diseases, and differing sources of air pollutants. More than 80% of African children live in households where unclean sources of energy are used and, consequently, air pollution is a serious threat to child health (Masekela and Vanker, 2020). A study attributed one in five infant deaths in Africa to air pollution (Heft-Neal et al., 2018). The number of deaths attributable to air pollution globally is projected to double by 2050 (Lelieveld et al., 2015) with many of these deaths predicted to occur on the African continent.

The increasing air pollution will have economic consequences not only in health care costs, due to the increasing morbidity and mortality, but also in diminished economic productivity and human capital formation, and thus undercutting development. Recent numbers have shown that the overall loss in economic output due to air pollution mortality and morbidity in 2019 was USD 3.02 billion in Ethiopia, 1.63 billion in Ghana, and 349 million in Rwanda (Fisher et al., 2021). Even though air quality is a serious issue affecting health, mortality, and productivity it does not get enough attention due to other pressing social, political, economic, and health-related problems, creating a negative feedback loop.

A recent review by Abera et al., (2021) highlights the importance of focusing on air quality in the process of sustainable urban development in Africa. The topic is timely as the African continent is now undergoing rapid urbanization with an extreme shortage of air pollution data. Immediate action is needed to address the issue of air quality, because:

- Air quality emissions in Africa affect atmospheric composition globally much as we have seen from the rapid development of economies in East and South Asia in recent decades. Africa is one of the fastest growing regions of the world and understanding its emissions in this decade will provide a baseline against which anticipated large and rapid changes may can be assessed. There is an urgent need to conduct extensive air quality monitoring and extensive field campaigns to conduct measurements and understand the chemistry and nature of pollutants in African megacities to provide mitigation strategies to policy makers. An example of such an initiative is the MAIA investigation (https://maia.jpl.nasa.gov) that will provide real time chemically speciated air pollution data from two primary target areas (Addis Ababa and Johannesburg) and six secondary target areas (Dakar, Accra, Lagos, Cape Town, Nairobi, and Harar) in Africa.

- While air pollution in India, China, and other emerging economies has become a major area of concern for scientists and policy makers, in those countries and worldwide, the issue has gained little traction in Africa where it is taking a serious toll on human health and on the economy. Air pollution kills more Africans than other major risk factors. Experience has shown that efforts to mitigate air pollution results in positive impacts on health, human well-being, the economy of the affected countries. Economic growth and viability are linked to clean air and the health benefits of clean air. The long-term economic and health benefits of clean air need to be clearly explained to policy makers so they can make short-term painful decisions to limit pollution.

- Another challenge is that the scientific capacity in Africa, though growing, is far more limited than in the more heavily sampled regions of North America, Europe, and Asia. Several research groups and agencies in Europe and the US are developing air quality monitoring capacity in several African megacities. However, the effort is likely insufficient to keep pace with the rapid growth of these urban areas and the increase in pollution. Even with the ongoing efforts there are challenges with data sharing of measurements currently conducted in Africa. An initiative to increase number of African scientists in the field and to consolidate existing data and provide easy access to this data, in order to build capacity and knowledge together, is likely as important as adding new measurements.

Acknowledgements

The group of authors work together towards mitigating the problems with indoor and outdoor air pollution in sub-Saharan Africa in a project funded by the Swedish Research Council, project 2019-04857.

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