Disparities in fine particulate matter benchmarking: A study in non-industrialised urban areas of Pretoria, South Africa

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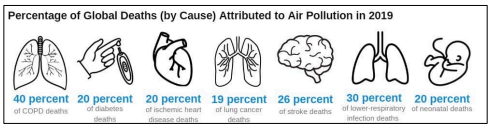
INTRODUCTION

- Air pollution is a complex mixture of airborne particles (aerosols), which exert influence on human health, climate dynamics and environmental conditions.
- Fine particulate matter ($PM_{2.5}$) presents a significant health concern worldwide.
- The State of Global Air 2024 report, which focuses on the effects of air pollution on children, states that air pollution accounted for 8.1 million deaths globally, making it the second leading risk factor for death.9
- In Sub-Saharan Africa, there is a scarcity of research on $PM_{2.5}$, in non-industrialised urban locales where anthropogenic activities are predominant.
- The 2019 South African Sustainable Development Goal report only reported PM_{10} levels attributed to a lack of available $PM_{2.5}$ data.[1]
- This study investigates the variability of $PM_{2.5}$ concentration levels in Pretoria, South Africa against the World Health Organization (WHO) standards.



Source: Health Effects Institute, 2019

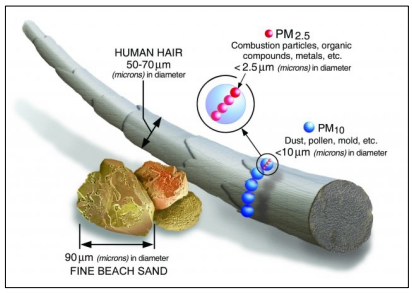
AIR QUALITY BENCHMARKING

- The ambient air quality standards define targets for monitoring concentrations of air pollutants that are permissible without causing deterioration in the environment.
- International air quality standards are set by WHO and locally, the Department of Forestry, Fisheries and the Environmental oversees the air quality management and benchmarking in South Africa.
- South Africa is one of the few African countries that has an air quality law, established in 1965.
- Although monitoring of $PM_{2.5}$ is promulgated by law in 2012, some cities do not monitor this pollutant, attributed to poor monitoring infrastructure
- Variations persist in the benchmarking of $PM_{2.5}$ concentrations at both national and international levels.

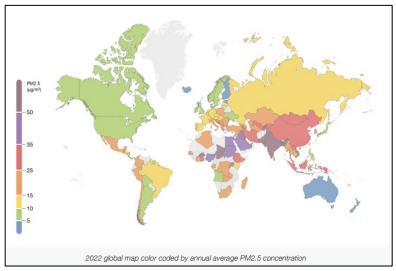
The South African ambient air quality guidelines and standards by the National Ambient Air Quality Standards of the Department of Forestry, Fisheries and the Environment

Pollutants	Average period	Concentration (µg.m-3)	Frequency of exceedance	Compliance date
NO_2	1 hour	200	88	immediate
	1 year	40	0	immediate
SO_2	10 minutes	500	526	immediate
	1 hour	350	88	immediate
	24 hours	125	4	immediate
	1 year	50	526	immediate
CO	1 year	30	88	immediate
	8 hours	10	11	immediate
PM_{10}	24 hours[1]	75	4	1 January 2015
	1 year	40	0	1 January 2015
$PM_{2.5}$	24 hours	40	4	1 January 2016 – 31 December 2029
	1 year	20	0	
Ground-level ozone (O_3)	8 hours[2]	120	11	immediate
C_6H_6	1 hour	0.5	0	immediate

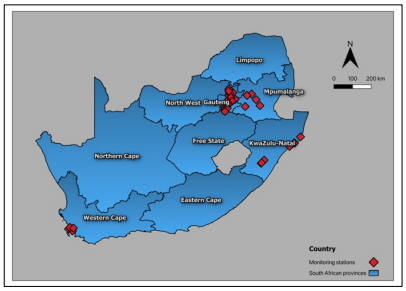
[1] 3–4 exceedance days per year
[2] Average of daily maximum 8-hour average O_3 concentration in the six consecutive months with the highest six-month running-average O_3 concentration.



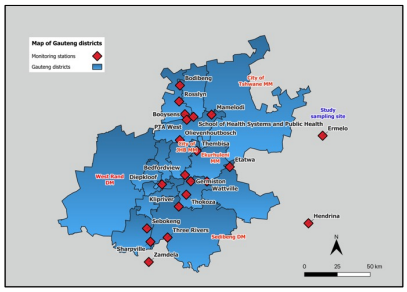
Source: United States Environmental Agency (US EPA)



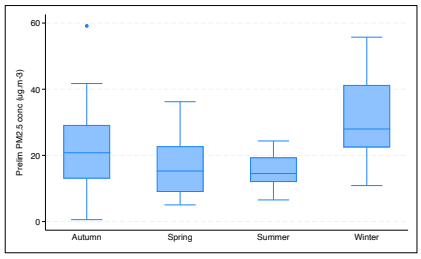
Source: IQAir



Map of monitoring stations of $PM_{2.5}$ in South Africa 19 in Gauteng, eight in KZN (four in eThekwini and Richards Bay), five in Mpumalanga and seven in Western Cape (all seven in Cape Town)



19 monitoring stations of $PM_{2.5}$ in Gauteng relative to the study's sampling site



Seasonal variation of $PM_{2.5}$ concentration levels (extreme observation in the Autumn season)

ACKNOWLEDGEMENTS

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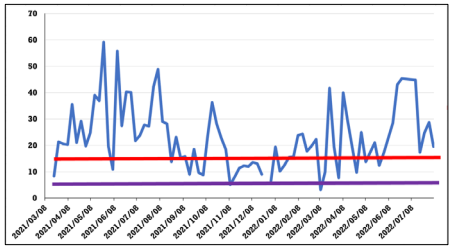
METHODS

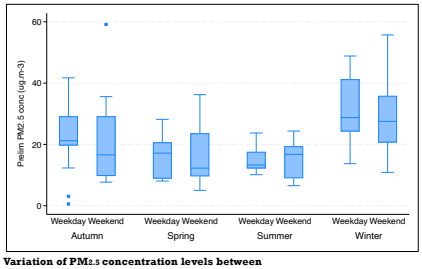
- The study design is time-series.
- The $PM_{2.5}$ filter samples were systematically collected over 24-hour intervals on a tridaily basis.



(Time plot of tridaily preliminary $PM_{2.5}$ concentration levels in 2021 and 2022 (ug.m-3)

RESULTS

- Annual μ $PM_{2.5}$ concentration = 22.41 µg/m³ (95% CI: 19.69 - 25.13).
- $PM_{2.5}$ levels exceeded the World Health Organization's (WHO) daily guideline of 15 µg/m³ for 57 out of the 83 days studied.
- Furthermore, the yearly WHO air quality guideline of 5 µg/m³ was consistently surpassed throughout the study period.
- Statistical analysis using the Kruskal-Wallis non-parametric test revealed significant seasonal variations in $PM_{2.5}$ concentrations.
- Elevated concentrations were observed during winter and late autumn, potentially linked to increased household heating activities and meteorological factors such as wind trajectories.
- Some extreme values on weekdays and weekends in the Autumn season, higher concentration during the Winter season.
- No significant differences were found between weekday and weekend concentration levels.
- To this end, the current WHO guidelines on air pollution particularly, $PM_{2.5}$, fail to contextualise the attributions of air pollution, such as seasonal and temporal variation.
- Further research is warranted to explore the influence of factors such as relative humidity on $PM_{2.5}$ concentrations during specific seasons.
- This study underscores the ubiquity of high ambient concentration levels of $PM_{2.5}$ that are extremely higher than the WHO guidelines.



Variation of $PM_{2.5}$ concentration levels between weekdays and weekends

REFERENCES

1. Statistics South Africa. South Africa SDG report. 2019
2. Health Effects Institute. State of Global Air 2024

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