

Research brief

Quantifying the effect of air quality offsets on household air pollution and thermal comfort on the South Africa Highveld

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South Africa, like other developing countries, has been facing air quality challenges. As a highly industrialised country, industrial emissions both from power generations and mining activities contribute significantly to ambient air pollution. Other sources of emissions come from the agricultural sector (including dust and biomass burning) and veld fires, especially during winter and spring. In both small and large townships, the major source of air pollution is domestic solid fuel burning both for cooking and space warming. Air quality management, therefore, has to struggle with the complex mix of these sources of emissions.

On the regional scale, emissions from industrial and agricultural sectors pose greater challenges than domestic combustion, but on the local scale, the reverse is the case. Research has shown that air pollution is linked to adverse effects on human health. In particular, particulate matter (PM) is said to be highly detrimental to health. PM is a major pollutant from residential fuel burning. There is widespread use of residential solid fuel burning on the South Africa Highveld contributing significantly to ambient air pollution.

When the Department of Environmental Affairs (DEA) published guidelines for air quality offsets, residential fuel burning was one of the main challenges addressed. To test the effectiveness of air quality offset programs, pilot studies were carried out in the densely populated low-income areas on the Highveld. Eskom conducted such a pilot study in Kwazamokuhle, a low-income community situated near three coal-fired plants in Mpumalanga.

To better understand the impact of indoor and ambient PM concentrations as a result of solid fuel burning, this follow up study was conducted to (i) understand the temporal variation of PM concentrations with respect to the meteorology of the location (ii) explore the relationship between indoor and outdoor air quality (iii) comprehend the processes, activities and energy usage patterns that affect the local air quality.

The study, which was carried out during summer and winter, made use of two formal reconstruction and development programme (RDP) houses classified as solid fuel burning (SFB) and non-solid fuel burning (NSFB). The NSFB house has wall and ceiling insulation. It depends on electricity as the major source of energy for cooking and space heating. The SFB house has no insulation and depends solely on solid fuel burning for cooking

and space heating. PM₄ continuous measurements were carried out indoors and outdoors at both houses in summer and winter. PM₄ has been shown previously to approximate PM_{2.5}.

The study revealed that the daily mean indoor PM₄ concentrations range between 60.9 µg/m³ and 207.5 µg/m³ at the SFB house, while the range was 15.3 µg/m³ to 84.2 µg/m³ at the NSFB house during the winter. During the summer, the range was between 17.4 µg/m³ and 36.6 µg/m³ at the SFB house, and between 14.2 µg/m³ and 39.9 µg/m³ at the NSFB house. The daily mean concentrations exceeded the National Ambient Air Quality Standard (NAAQS) 24-hour PM_{2.5} limit of 40 µg/m³ on some of the days during the winter at the NSFB house but on all the days at the SFB house. No cases of exceedance of the PM_{2.5} daily limit were recorded during the summer at either house. During some days in the winter, the indoor PM₄ concentration at the SFB house went as high as six times that of the NSFB. As to the mean hourly PM₄ concentration, the maximum indoor concentration at the NSFB was about 200 µg/m³, while that at the SFB house was well above 1200 µg/m³. This high concentration is very common for the cooking and space heating hours, especially in the evenings. When a comparison is made of the indoor to outdoor diurnal concentrations during winter, the average outdoor concentration was about half that of the indoor concentration. While there were good correlations between the indoor and outdoor PM₄ concentration during the summer, the correlations were very poor during the winter at both houses. This may be as a result of the closing of major house ventilations apart from the chimney in order to aid space heating.

A very important deduction from the indoor to outdoor PM₄ concentration relationship is that the elevated value during the winter is mostly due to the solid fuel combustion and not from the power plants in proximity to the community. The study also has shown that the air quality offset programme, if fully implemented, can be of tremendous benefit to the community in terms of reducing household PM concentration and improving thermal comfort especially during the winter season.

Reference

Adesina, J.A., Piketh, S.J., Qhekwana, M., Burger, R., Language, B. and Mkhathshwa, G. Contrasting indoor and ambient particulate matter concentrations and thermal comfort in coal and non-coal burning households at South Africa Highveld. *Science of the Total Environment* 2020, 699: 134403