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Risk assessment of exposure to indoor particulate matter (PM2.5) near a Ferro-manganese smelter - Meyerton, Gauteng Province

Khoza, Goodwill Jopa Zimakazi

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Abstract

Background

Globally, over 90% of the populace have no access to clean air. Exposure to airborne contaminants is associated with adverse health risks. Studies have reported on direct correlation between industrialised settings with increased incidence of air pollution associated illnesses. Chronic exposure to $PM_{2.5}$ is linked to cardiovascular and respiratory illnesses. Exposure to particulate matter (PM) in residential settings has been studied in many big mega-cities globally. However, fewer studies were achieved in low-income settings and South Africa is no exception. Exposure and risk assessments research emanate from occupational settings with less emphasis on residential settings. Studies assessing the risk of exposure to $PM_{2.5}$ in residential settings are quite limited. This provides understanding a research knowledge gap in South African low-income societies.

Purpose

The purpose of the study is to determine indoor $PM_{2.5}$ chronic daily intake to estimate the non-carcinogenic risk in communities living adjacent industrial PM emitting sources.

Methods

Secondary data from the main study titled "Motor and cognitive health outcomes in a manganese-exposed African community" (HREC clearance certificate no. M121117), which was conducted during the period of 2019/20 was used to assess the risk of exposure to indoor $PM_{2.5}$. The secondary data used in this study was collected during winter season, and $PM_{2.5}$ was sampled using a gravimetric technique over a period of seven days. Particles were drawn into the sampling head by a Gillian Gil-Air 300plus pump (Sensidyne, St Petersburg FL, USA) which was connected using a teflon tubing. A $PM_{2.5}$ Cyclone D32 with a cut-off point of $PM_{2.5}$ attached to the sampling head to isolate larger particles from entering the inlet of the cassette. The pump was calibrated and operated at a continuous flow rate of 2.75 L/minute over a seven-days period. Pre-and-post-weighing of filters was performed to derive the final mass in a controlled laboratory environment using a micro-balance scale (model-CPA225D, Sartorius,

AG, Göttingen, Germany). The pre-weight (mass) consisted only of the mass of a filter while the post mass consisted of particulate and filters.

Results

The particulate matter (PM) mass concentration for New Sicelo, Old Sicelo and Noldick was found to be 0.0125 mg/m³, 0.0115 mg/m³ and 0.0061 mg/m³ respectively. The indoor PM mass concentrations for both New and Old Sicelo was found to be doubled as compared to that of Noldick's. An increased PM mass concentrations for the New and Old Sicelo areas implied an unavoidable risk of PM exposure to the population of New and Old Sicelo, respectively. Flowing from the identified risk; sustainable mitigation plans are fundamental to curb the risk of generational poisonous exposures which will rampantly lower the populace life expectancy tremendously if not proactively addressed especially at source.

Daily intake (DI) fractions for females and males were 22.98 m^3/kg/day and 17 m^3/kg/day for all three locations, respectively. Higher DI for females corroborate and support preceding studies' findings that women spent 80% of their instances indoors. The chronic daily intake (CDI) for males at New Sicelo, Old Sicelo and Noldick were 0.21 mg/kg/day, 0.20 mg/kg/day and 0.10 mg/kg/day and females at New Sicelo, Old Sicelo and Noldick had been 0.29 mg/kg/day, 0.26 mg/kg/day and 0.14 mg/kg/day, respectively.

The difference in CDI values for females and males tells how women are over exposed compared to men. Hazard quotients (HQ) for females throughout the three locations were 261, 240 and 127 respectively while males were 193, 178 and 94. A hazard quotients (HQ) measurement means women are over exposed compared to men. H>1 for women means that non-carcinogenic impact has been surpassed and cancer is high while men with H<1 have a negligible cancer risk in the tree areas (Old and New Sicelo, Noldick).

The findings from the study positively affirm the following aspects; i) characterization of the PM mass concentration from the three locations and, ii) how impactful is the PM exposure levels to the population health status which in turn influence the concept of exposure assessment. To support the exposure assessment process; a systematic review was conducted on time-activity patterns, the demographic data for risk assessment input variables were noted and the estimation non-carcinogenic health risk of exposure to indoor PM concentration especially for the community of Meyerton.

Conclusion

The study determined indoor $PM_{2.5}$ chronic daily intake to estimate the non-carcinogenic risk in communities living adjacent to industrial PM emitting sources.

The study may want to aid in perception of exposure and development of abatement measures to decrease exposure to $PM_{2.5}$ sources and assists in performing exposure assessments.