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Assessment of Personal Exposure to Particulate Matter among Traffic Policemen and Industrial Workers in Surat, India

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1. Introduction

Air pollution ranks as a leading cause of mortality globally, with significant health impacts, particularly in developing countries like India [1]. Rapid industrialization has exacerbated air pollution levels, creating severe health risks for the population [2]. Urban areas, in particular, experience elevated concentrations of particulate matter (PM), with numerous epidemiological studies underscoring the detrimental health effects of such exposure [3]. While recent research has increasingly focused on vehicular pollution, studies addressing exposure assessment and health risks in urban hotspots with high vehicular pollution remain scarce in India. Personal exposure studies are crucial for identifying potential exposure concentrations and pollution sources, including the effects of microenvironments, which are vital for assessing associated health risks [4]. The exposure is highly dependent on the microenvironment and time spent in the microenvironment. This study, conducted in Surat city (21°10'12.8640" N, 72°49'51.8232" E), an industrial hub in Gujarat, India, aims to evaluate the short- and long-term effects of PM exposure on two distinct groups: traffic policemen and industrial workers. The traffic policeman spends around 8 hours in a traffic microenvironment and is exposed to vehicular emissions along with the dust from the road surface. Similarly, the labourers in the industry work in extreme conditions inside the industries, where they are exposed to Particulate emissions during their working shift. This study was carried out to estimate the exposure concentration of these two groups, particularly due to PM. Prolonged exposure to PM has been linked to severe health diseases like asthma, bronchitis, and cardiovascular diseases. This makes PM exposure studies all the more important to understand the health impacts of such kind of occupational exposure.

2. Methodology

2.1 Study Area

Surat is an industrial city situated in the Gujarat state of India. The city is known for its textile and diamond cutting industries. The city also holds the title of having the world's largest diamond Bourse. The city's population is reported to be around 6 million (SMC) in the year 2024. The City experiences a hot and humid summer starting from the month of March to the end of May. The average temperature of 30 ± 5^0C was observed during the monitoring period.

2.2 Instrumentation

To measure the PM2.5 and PM2.5 personal exposure concentration personal samplers were used. The study employed an SKC model 224 PXR8 universal pump and an Envirotech APM 821 sampler to measure PM2.5 and PM5 concentrations, respectively. The sampling was done for a period of 30 days, 15 days for each group. The sampling was done in the month of April to May 2022. The meteorological parameters were also obtained from the website of the central pollution control board. The personal exposure levels for traffic policemen were assessed by sampling air over an 8-hour period at an inflow rate of 2.0 liters per minute (ppm) using both instruments [5,6]. Similarly, the exposure of laborers

working in the textile industry was measured during their work shifts (8 hours). Glass fiber filter papers were used for sampling. The filter papers were pre-weighted and post-weighted on the same microbalance

2.3 Quality Assurance and Quality Control

To ensure robust data quality assurance and control, both instruments were calibrated according to the manufacturers' guidelines. Prior to initiating monitoring, the flow rates were verified. Filter papers were weighed until consistent readings were achieved. Following monitoring, the filter papers were transported to the lab for post-weighing using the manufacturer's designated cassette. Additionally, the date and time of each monitoring session were meticulously recorded in a logbook to maintain a comprehensive tracking system. This systematic approach helps guarantee the accuracy and reliability of the collected data.

3. Results and Discussions

3.1 Ambient Air Quality in Industrial Area

The Ambient Air Quality of the Industrial area was measured using a high-volume sampler for fine particulate matter. The mean concentration of PM2.5 in Ambient air of industrial area was found to be 127.92 $\mu g/m^3$. The maximum ambient concentration of PM2.5 obtained during the study period was 227 $\mu g/m^{3,}$ and the minimum value was 69.24 $\mu g/m^3$.

The ambient mean concentration of PM2.5 is lower than the mean personal exposure of PM2.5 but higher than the NAAQS permissible limit of 60 $\mu g/m^3$.

3.2 Personal Exposure of Traffic Policemen

The average PM2.5 and PM5 exposure concentrations for traffic policemen were found to be 103.87 ± 20.71 $\mu g/m^3$ and 154.05 ± 39.68 $\mu g/m^3$, respectively. The maximum recorded concentrations of PM2.5 and PM5 during the study were 135.42 $\mu g/m^3$ and 244.44 $\mu g/m^3$, respectively. The highest PM2.5 and PM5 values observed were 583.33 $\mu g/m^3$ and 604.17 $\mu g/m^3$, respectively. The higher value of Pm concentration is due to vehicular emissions and road dust resuspensions.

The study revealed that the average PM2.5 exposure for traffic policemen was approximately 80% higher than the World Health Organization (WHO) recommended limits. This elevated exposure is attributed to the high background pollution and vehicular emissions in the area. The variation is provided in figure 1.

3.3 Personal exposure of labourers

The average PM2.5 exposure for industrial workers was several times higher than WHO limits. These workers face heightened exposure due to operating machinery in poorly ventilated environments with minimal air circulation, leading to increased concentrations of particulate matter at respiratory levels. The variation is provided in figure 1.

Furthermore, the ratio of PM2.5 to PM5 was observed to be 0.67 for traffic policemen and 0.82 for industrial workers, indicating a higher proportion of finer particles in the total PM concentration. These finer particles can penetrate deeper into the lungs, potentially causing severe health issues for the exposed population [7].

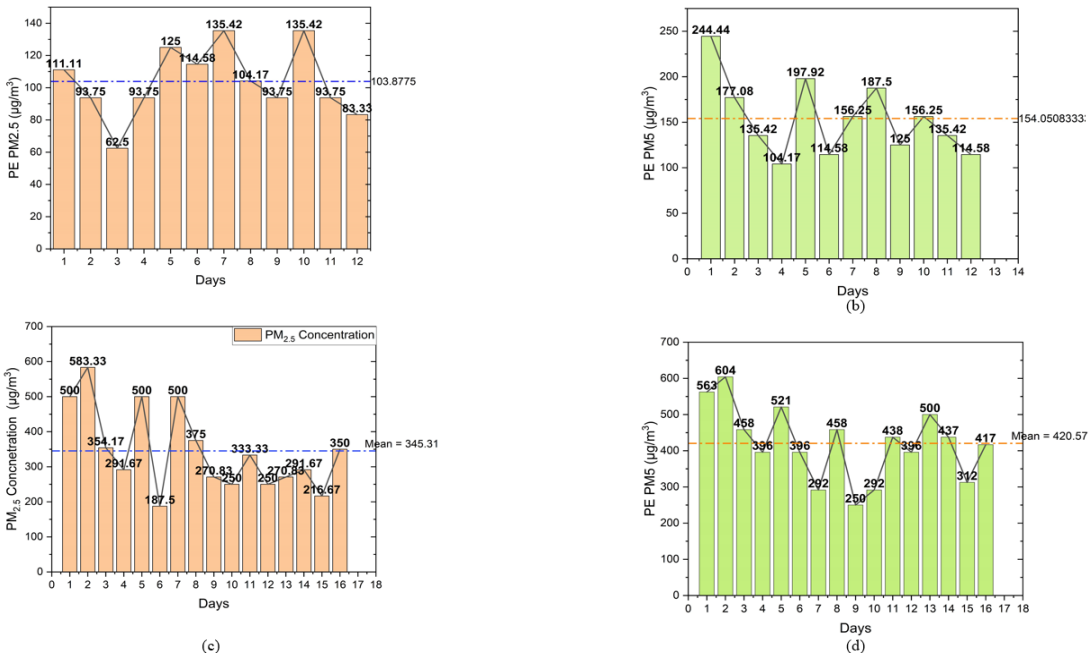

Figure 1: (a) The variation of $PM_{2.5}$ exposure of traffic policemen during the study period.
(b) The variation of PM_5 exposure of traffic policemen during the study period.
(c) The variation of $PM_{2.5}$ exposure of workers in Industry during the study period.
(d) The variation of PM_5 exposure of workers in Industry during the study period.

Conclusion

The study involves monitoring the personal exposure of two groups of people working in different microenvironments. The exposure to particulate matter, namely, PM2.5 and PM5, is measured using personal samplers, and the ambient air in the industrial area has been monitored using a high-volume sampler. The exposure concentration was high in case of workers as they are working inside an industry which has different operations of textile industry running. Workers are working on machines which performs functions like bleaching, dying, washing, printing, cutting, movement of loading vehicles, exhaust emission from vehicles inside industry premises, dust from fabrics and lack of proper ventilation (air circulation) contribute to higher concentration of personal exposure.

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