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Vehicle Emission is the Cause of Increased Particulate Matter at the Bottleneck Site in Lahore, Pakistan.

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Abstract

**Background:** The particulate matter (PM) emitted by heavy traffic is the major cause of pollution in the air. Lahore is Pakistan's second largest provincial capital and the most polluted city. This study was conducted to analyze the PM concentration in a heavy traffic site at Data Gunj Baksh Town in Lahore.

**Materials and Methods:** PM concentration was analyzed from 15 October 2021 to 31 March 2022 by installing a low-cost PurpleAir sensor at the sampling site.

**Results:** The maximum concentration of PM1.0 (341.73 ± 63.39 µg/m3), PM2.5 (1635.56 ± 152.85 µg/m3) and PM10 (2975.64 ± 286.79 µg/m3) was recorded in December 2021, while the minimum concentration of PM1.0 (10.475 ± 13.66 µg/m3) PM2.5 (16.29 ± 21.53 µg/m3), and PM10 (18.61 ± 25.34 µg/m3) were analyzed in October 2021. In comparison to the standard WHO guidelines, the measured levels of PM2.5 and PM10 are 109 and 66 times higher, respectively.

**Conclusion:** It is imperative to implement effective measures to reduce the air pollution, by implementing the legislation related to fitness of commercial vehicles so as to minimize the emission of the PM.

**Key words:** Heavy Traffic site, Particulate Matter, Pollution, PurpleAir Sensor

Introduction

The atmospheric level of a particular compound both gaseous and particulate matter (PM) beyond the permissible standard threshold, leads to air pollution that interferes with both the ecological system as well as human health (Bai et al., 2018). Clinical research has demonstrated that PM has a higher impact on health than gaseous components (Hamanaka & Mutlu, 2018). The big cities of Pakistan are experiencing the smog issue most of the time throughout the year. In the winter season for the past few years, Lahore is covered by a thick layer of smog. An increase in air pollutants (both primary and secondary) is thought to be the cause of the smog in Lahore (Yousaf et al., 2021). Vehicle emissions, such as oxides of nitrogen, volatile organic compounds, carbon monoxide (CO), and PM have emerged as the most prevalent causes of this air pollution. PM in the air reduces visibility with increased risk of health issues while breathing in this polluted air (Olukanni et al., 2021). Transboundary air pollution (TAP) and local air pollution (LAP), both have an impact on the environmental quality of metropolitan areas (Yoshino et al., 2021). Industrialization and urbanization have become a major concern that is attributed to the increase in atmospheric pollution in economically advanced countries (Jung et al., 2022). The majority of PM species are emitted by anthropogenic sources such as road traffic, combustion processes, and industrial processes (Schneider et al., 2022).

In 2015, 21% of stroke deaths, 24% of ischemic heart disease deaths, and 19% of all cardiovascular deaths were related to air pollution by the Global Burden of Diseases study (Lee et al., 2018). Fine particulate matter (PM2.5) has been associated with around 0.31 million lung cancer deaths (Yang et al., 2022). PM2.5 has been linked to acute infections, lung cancer risk, pulmonary disease, and cardiovascular issues. The neuronal death of the olfactory bulb (OB) has been found due to ambient PM2.5 exposures (Ji et al., 2022). Increasing concentrations of atmospheric fine PM are strongly related to the incidences of papillary thyroid cancer (Karzai et al., 2022).
Airborne bioaerosols and PM have been linked to asthma incidence (Bukhari & Ali, 2021). Early myocardial damage, cardiovascular consequences like acute inflammation, vascular stiffness, hyperlipidemia, and increased blood viscosity are all possible short-term effects of PM2.5 exposures (Gonet et al., 2021; Hu et al., 2022). PM10 was linked to the maximum possible reducible fraction in in-hospital case fatality in counterfactual analyses, accounting for 10% for acute exposure and 21.1% for chronic exposure, subsequently followed by PM1.0 and PM2.5 (Cai et al., 2022). PM has also been reported as a risk factor for childhood and adolescent hypertension (HBP) (Chen et al., 2022).

Pakistan has some of the worst urban air pollution in the world, which has a disastrous impact on both the public health and economy of the nation (Mir et al., 2022). Elevated PM levels in Pakistan contribute to higher mortality rates (Anjum et al., 2021). Traffic emissions are a major factor in the deterioration of air quality in developing countries such as Pakistan (Haider et al., 2021).

The smog crisis in Lahore, Pakistan, which was known as "The City of Gardens" is the city's worst environmental catastrophe (Shahid et al., 2020). PM2.5 and PM10 levels in this city season exceed Pakistan's National Environmental Quality Standards (NEQS) (Bhatti et al., 2021). The roadside Callistemon (bottlebrush) trees were found to have Anthropogenic magnetic particulate matter (MPM) on their foliage. The source of this MPM is the PM emitted by moving vehicles at busy intersections (Sheikh et al., 2022). The city has epidemiological problems like asthma with a high prevalence of harming public health (Aslam et al., 2023).

The current study attempts to assess the ambient levels of PM along a heavy traffic area in Lahore to highlight the impact of traffic density on ambient air pollution by characterizing the PM.

**Materials and Methods**

The City of Lahore is the second largest and most populous metropolitan area in Pakistan and the capital of the Punjab Province. Its coordinates are 31°15'-31°45' N and 74°01'-74°39' E (Figure 1). It is administratively divided into 9 towns and a cantonment region (Bukhari & Ali, 2021). The study area that is Data Gunj Baksh Town is located near Data Darbar Road, Lahore, Punjab.

The PM generated from heavy traffic at Data Gunj Baksh Town was measured during the study period from October 15, 2021, to March 31, 2022, using PurpleAir Sensor (Sensor). A sensor was installed at the study site to record the concentration of PM.

The Sensor is equipped with two PMS5003 sensors, a BME280 environmental sensor, and an ESP8266 microcontroller. The units’ internal pressure, temperature, and humidity are all monitored by the BME280 sensor. The PM concentration can be seen in real-time on the PurpleAir map (https://www.purpleair.com/map) due to communication between the PMS5003 sensors and the ESP8266 microcontroller via Wireless Fidelity (Wi-Fi). The analysis was carried out by collecting sensor data at 10-minute intervals.

The recorded data was obtained from the PurpleAir website (www.purpleair.com) along with the operational PA-II units during the study period. The data was statistically analyzed using Microsoft Excel in the form of an average of PM1.0, PM2.5, and PM10 along with standard deviation. The average, maximum, and minimum values have all been computed.

**Results**

The Sensor recorded the PM1.0, PM2.5, and PM10 levels during the study period. The PM1.0 levels were low in October 2021. On October 23, 2021, the lowest average value was 33.16 ± 13.66 µg/m³. The highest average value of PM1.0 239.53 ± 36.81 µg/m³ was recorded on December 24, 2021. Earlier in November 2021 there was a period of relatively high and frightening PM1.0 levels because of the smog cover from November 2021 to December 2021 (Figure 2A). The recorded PM1.0 levels in October 2021 ranged from a maximum of 260.535 ± 73.49 µg/m³ to a minimum of 10.475 ± 13.66 µg/m³. Smog and hazy conditions caused elevated levels that were exceedingly hazardous and above the AQI-specific guideline in November 2021 and December 2021 (Figure 2B).

The PM2.5 level had an average value of 50.99 ± 21.53 µg/m³, lowest in October 2021, reaching to the maximum of 1635.56 ± 152.85 µg/m³ on December 26, 2021. There was a time when PM2.5 levels were unusually high and unsettling around the beginning of November 2021 (Figure 2C). PM2.5 levels were consistently higher than usual in November and December 2021 due to haze. The measured PM2.5 concentration levels in October 2021 ranged from a maximum of 524.815 ± 134.31 µg/m³ to a minimum of 16.29 ± 107.43 µg/m³ (Figure 2D). The level of PM2.5 is 109 times higher than the usual WHO recommendations. PM10 levels varied from a maximum of 644.02 ± 157.29 µg/m³ in October 2021 to 656.87 ± 88.33 µg/m³ in March 2022. The low levels i.e., of 18.61 ± 25.34 µg/m³ to 31.705 ± 31.58 µg/m³ were recorded from October 2021 to March 2022 (Figure 2E). Like PM1.0 and PM2.5 the PM10 levels were persistently higher than usual due to haze from November 19, 2021, to December 25, 2021. The observed PM10 concentration levels in October 2021 ranged from a maximum of 644.02 ± 157.29 µg/m³ to a minimum of 18.61 ± 25.34 µg/m³. The average PM10 concentration was 368.48 ± 152.03 µg/m³ on January 1, 2022, and 140.00 ± 71.30 µg/m³ on 9 January 2022. The highest level of PM10 2975.64 ± 286.79 was detected on December 25, 2021 (Figure 2F). The concentration of PM10 was recorded as 66 times higher than the standard WHO guidelines.

In comparison, PM10 levels were higher than that of PM2.5 and PM1.0. The PM levels had a lower average in October 2021 with
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Figure 2: Average values of PM$_{1.0}$ (A) PM$_{2.5}$ (C), PM$_{10}$ (E) in µg/m$^3$. Maximum and minimum PM$_{1.0}$ (B) PM$_{2.5}$ (D), PM$_{10}$ (F) in µg/m$^3$ in Data Gunj Baksh Town during the study period from October 2021 to March 2022.
a hike from November 2021 to January 2022 because of elevated levels of smog. From February 2022 to March 2022 the average PM levels declined gradually (Figure 3).

Discussion

One of the biggest factors in the deterioration of air quality in developing countries like Pakistan is traffic pollution (Haider et al., 2021). Developing nations are dealing with serious health issues because of worsening air quality (Bukhari & Ali, 2021). In comparison to non-working days, working days had much higher levels of PM10, SO2, and CO due to the number of vehicles on the road. A large number of the contaminants discovered were linked to road traffic (Azhari et al., 2018). The pollution level has been worsened by the exponential development in traffic and industry, and it is anticipated to rise more in the future (Ahmad et al., 2021). The Positive Matrix Factorization (PMF) model revealed five potential sources of PM10, coal combustion, vehicular emissions, re-suspended road/soil dust, biomass burning, and industrial dust. Industrial dust is the leading source of PM10 (23.2%), followed by biomass combustion (23%), coal combustion (21.7%), re-suspended dust (9.9%), and vehicular emissions (22.2%) (Shahid et al., 2018).

Pakistan's most polluted city, Lahore, has high levels of PM in the atmosphere. According to the black carbon spatial distribution and concentration-weighted trajectory (CWT) calculation. The primary causes of air pollution in Lahore were local emission sources (Ahmad et al., 2021). At Lahore's Niazi and Daewoo bus stops, PM2.5 and PM10 particle levels were measured, and vehicles are the main source of PM2.5 and PM10 pollution, both of which are harmful to the environment and human health (Abbas et al., 2017).

It has also been discovered that public vehicles, such as rickshaws and vans, contribute significantly more to air pollution than other vehicle types in the city (Kashif et al., 2019). High levels of PM2.5 in Gulberg Station and Jail Road Station areas were due to higher vehicle emissions, industrial emissions, and crop residue burning (Basheer et al., 2019). Around the world, PM from traffic is a significant source of outdoor air pollution. The active components in traffic-related PM could include black carbon, metals, elemental carbon, diesel exhaust particles, and polyaromatic hydrocarbons (Ahmed et al., 2018).

The main sources of traffic-related PM2.5 emissions were non-exhaust emissions like brake wear and road dust resuspension as well as exhaust emissions (Jeong et al., 2019). Total suspended particulate (TSP), PM10, PM2.5, and CO concentrations in ambient air in Faisalabad exceeded National Environmental Quality Standards (NEQs) and U.S. Environmental Protection Agency (USEPA) air quality standards (Das & Chellam, 2020). Our findings suggest that elevated PM concentrations negatively impact the community’s quality of life, health, and other similar urban areas.

Conclusion

Taken together these findings, it can be concluded that traffic emission is the main contributor to the poor air quality of the city due to the emitted PM and gases by vehicles. It is recommended that the authorities ensure the implementation of legislation regarding vehicle inspection, safety, and environmental safety. Only those vehicles which pass the fitness test should come on the road.

Author contributions

SSIB; perceived the idea, designed the study, analyzed the data, and corrected and approved the manuscript, SM, AN, KN, executed the study, compiled the data, and prepared the manuscript draft.

References


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