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A Study on Air Pollution Exposure on Commuters in Jaipur

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Abstract: ***One of the most important challenges that are escalating in emerging nations like India is air pollution. Motor vehicle usage has significantly increased as a result of rapid development of India. Ninety percent of all emissions are contributed by the transportation sector. A major environmental health risk to people is air pollution. The negative effects might include anything from nausea, breathing problems, skin rashes, birth defects, immunodeficiency, and cancer.***
Air pollutants can seriously impair a person's health if they are exposed to them for a lengthy period of time, therefore it is common for people to endure unpleasant travel situations and alter their travel plans, destinations, or modes of transportation. The present study is a case study of an increase in vehicular pollution in Jaipur, capital of Rajasthan which is one of the highly polluted cities in state.
Keywords: Air Pollution, Vehicular Pollution, Jaipur City Pollution, Particulate Matter

I. INTRODUCTION

Urban pollution has increased due to expanding cities, more traffic, demographic growth, rapid economic development, industrialization, and increasing levels of energy consumption (CPCB,2010). The biggest environmental health risk is poor air quality, which is thought to be responsible for 4.2 million premature deaths annually worldwide (WHO, 2021). The cause of this death is exposure to small particulate matter (PM2.5) with a diameter of 2.5 microns or less, which is linked to cancer, cardiovascular, and respiratory diseases (WHO, 2021) (Lelieveld, 2015).

In addition to its negative effects on health, air pollution also results in enormous economic losses, especially when it comes to the costs associated with the medical care that must be given to people who are affected.(Lancet, 2020)

According to a report published by a U.S. research group, air pollution is anticipated to shorten the life expectancy of approximately 40% of Indians by more than nine years.

The paper created by the Energy Policy Institute at the University of Chicago claims that more than 480 million people who reside in the broad regions of central, eastern, and northern India, including the nation's capital, New Delhi, face considerably high pollution levels (EPIC).

In Rajasthan, air pollution is the second-largest risk factor for early mortality (2016, state level disease burden estimates by IHME, ICMR, PHFI). Due to the lockdown, PM2.5 levels have been on average lower this year, however this hasn't been able to stop the winter spike: In year's overall PM2.5 average (up until December 20) has been predictably lower than last year, partly due to the unheard-of economic disruption caused by the monsoon and summer lockout. However, the resumption of the economy and the arrival of the winter, which traps pollution, caused PM2.5 levels to increase starting in October. The weekly average of PM2.5 increased seven times in Jaipur from the respective cleanest week. (cseindia.org, 2020)

A. Air Pollution

According to Indian Standards Institution IS 4167, 1996, "the presence in ambient atmosphere of substances, generally resulting from human activity, present in sufficient concentrations, present for a sufficient period of time, and under circumstances that interfere significantly with the comfort, health, or welfare of persons or with the full use or enjoyment of property." Numerous gaseous inorganic pollutants enter the atmosphere as a result of human activity. The biosphere's main component, the atmosphere, is a dynamic system that is constantly absorbing different gases from both natural and man-made sources.

There are two types of pollution sources: stationary sources and moving sources. Automobiles are the main mobile causes of air pollution, whereas industries are the main fixed sources.

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B. Ingredients of Air Pollution

1) *Sulphur oxides (SO_X):* Coal and petroleum both contain sulphur compounds, and burning them releases sulphur dioxide. H_2SO_4 is created by further oxidising SO_2, typically with the aid of a catalyst like NO_2. When breathed in, damages our mucous membranes.
2) *Nitrogen oxides (NO_X):* These vehicle pollutants can irritate the lungs and erode the body's resistance to respiratory illnesses like pneumonia and influenza. Additionally, they contribute to the creation of particulate matter and ozone.
3) *Carbon Monoxide (CO):* When fossil fuels like gasoline are burned, an odourless, colourless gas is created. Nearly two thirds of this pollutant come from cars and trucks. CO prevents oxygen from reaching the brain, heart, and other crucial body organs when it is inhaled. People with chronic conditions and new-borns are particularly vulnerable to the effects of CO.
4) *Photochemical Oxides (Ozone):* The main component of urban smog, is produced when sunlight reacts with hydrocarbons and nitrogen oxides, two pollutants emitted during the combustion of automotive fuel. Ozone may be advantageous in the high atmosphere, but it can irritate the respiratory system at ground level, leading to coughing, choking, and diminished lung capacity.
5) *Volatile Organic Compounds (VOCs):* Methane is a very potent greenhouse gas that raises the earth's temperature. Other hydrocarbons, or volatile organic compounds (VOCs), are important greenhouse gases due to their role in ozone production and their ability to prolong the atmospheric lifetime of methane. The probable carcinogens benzene, toluene, and xylene are aromatic VOCs that can lead to leukaemia in people who are exposed to them over an extended period of time.
6) *Particulate Matter (PM):* Road Dust, emissions from vehicles and factories, include PM2.5, it enters the respiratory system when breathed through the nose or mouth depends on its size; smaller particles enter the body more deeply than larger ones.

C. Air Quality Standard

A regulatory body or organisation adopts and upholds certain standards. Each standard ought to have its own definition and set of threshold values, which ought to be adequately justified (Molina, Molina, Slott & Kolbe, (December 2004). Due to a number of variables, including technical advancements, economic situations, and epidemiological studies on the effects of local air pollution, air quality standards may vary between nations. Countries including India, China, and the United States use the National Ambient Air Quality Standards (NAAQS, 2009). On the other hand, limit values are predetermined.

1) *Vehicular Emission:* The term "disease of prosperity" has been used to describe the air pollution brought on by vehicles. Automotive emissions have prompted extensive research and development. In fact, the burning of fossil fuels and the by-products that result greatly contribute to anthropogenic air pollution, which is especially severe in urban areas (Upadhyay, 2018). About 30% of all registered vehicles in the state of Rajasthan are in the Jaipur region. The Jaipur district has 446 vehicles per 1,000 people, which is significantly more than the regional average of 243 vehicles per 1,000 people. More than 70% of all registered vehicles are two-wheelers (CSE, 2020).
2) *Factors Escalating Vehicular Emission*

a) Road Infrastructure
b) Personalized Transport
c) Public Transport
d) Traffic
e) Vehicle and Fuel Efficiency

II. LITERATURE REVIEW

The perception of commuters regarding air pollution must be gathered in order to understand how they alter their choices, those who reside in large cities are more likely to recognise air pollution as a serious threat to their health (Badland et. al., 2009).

According to the results of a similar study conducted in California, those who are more concerned about the purity of the air check it more regularly. When working and exercising outside, people with respiratory conditions like asthma were shown to be more inclined to check the air quality(Veloz, 2020). An exposure analysis was carried out in Delhi utilising six different modes of transportation, walking and utilising auto rickshaws provides the highest exposure. Without any appropriate pollution control measures the elevated exposure to PM2.5 levels pose serious short- and long-term health concerns to Delhi residents. An integrated and intelligent transportation systems is essential & to inform commuters on how to reduce exposure levels and their effects on their health (Maji, 2020). Mehrdad and Alistair Woodward et. al, investigated through their studies that choosing the cleanest route from an air pollution standpoint is crucial when active commuters plan their routes and get benefit from knowing the level of air pollution, especially those who frequently walk or cycle the same route. (M.Rafiepourgatabi, 2021) In India, the consequences of emissions from different forms of transportation were assessed byPandey, Apoorva, Venkataraman, & Chandra(2014). When

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compared to other forms of transportation, study concluded that on-road mobility contributed over 97 percent of the expected emissions in India.

(Goel, 2015) studies the impact of air pollutants exposure on different modes and investigated that travelling in auto rickshaw leads to 30% higher exposure rate than in an off-road location. Also, inside air-conditioned cars and metro carriages, the exposure rate is the lowest. The exposure of cyclists to ultrafine particles was evaluated along commuter routes. Reis and Oroz, (2019)did study on the factors that the overall concentration of UFP on the road influenced by traffic, construction sites, and the presence of bicycle infrastructure along the route, influences the percentage of particles that actually come into contact with the cyclist due to their relative position on the road.

(Xu, 2017), investigated both long-term, short-term temporal variation where the ratio of PM2.5 and PM10 reaches the maximum in winter because of stable atmospheric conditions. There are apparent night-day differences of daily variation of the ratio, which increases at night in all seasons in consequence of temperature inversion and declines in the daytime with a moderate rise in the afternoon.

(Suthar, 2018), calculated the amount of air pollutants produced by DG sets used in Jaipur City, India's wedding gardens, malls, and retail centres. The quantity of fuel a DG set uses, how long it has been in service, and how often it is maintained all affect how much air pollution it emits. The solid particles that make up the fumes from diesel engines cause serious disease as well as oncological problems when they are present in the air.

III. JAIPUR PROFILE

1) Rajasthan's capital city, Jaipur, is the center of the state's socioeconomic and political activity.
2) It is the tenth largest city and one of the fastest growing cities in India.
3) It is the hub of both conventional and modern industry and a tourist attraction for its historical architecture and cultural heritage. It witnessed fast growth both physical and demographical.
4) Current Population of Jaipur in 2021, 40.67 lakh. Sex Ratio in Jaipur, 909 females per 1,000 males.
5) Jaipur City forms part of the famous “Golden Triangle”, “Golden Quadrilateral” and “Delhi Mumbai Industrial Corridor”.

A. Need of The Present Study

Jaipur is one of the highly polluted cities in Rajasthan, India. Emission level, measured in terms of annual mean value of PM10, PM2.5 has consistently been higher than the specified limits by NAAQS and much higher than WHO benchmark. High level of air pollution contributed by growing traffic is a major challenge to the sustainability of city transportation system.

B. Choosing A Site

State capital of Rajasthan, Jaipur, is situated 435 metres above sea level at 26°55′10″N and 75°47′16″E. The city's population has surpassed 4.1 million as per the latest recent data. The city is surrounded by the Nahargarh Hills to the north and Jhalana to the east. All around the city, there are isolated, erratic hillocks. The city of Jaipur is located in a semi-arid region. In order to track ambient air quality in Jaipur, three Continuous Ambient Air Quality Monitoring Stations are located at the Police Commissionerate (M.I. Road), the Regional Science Centre (Shastri Nagar), and the Psychiatric Centre (Adarsh Nagar) shown in figure 2.

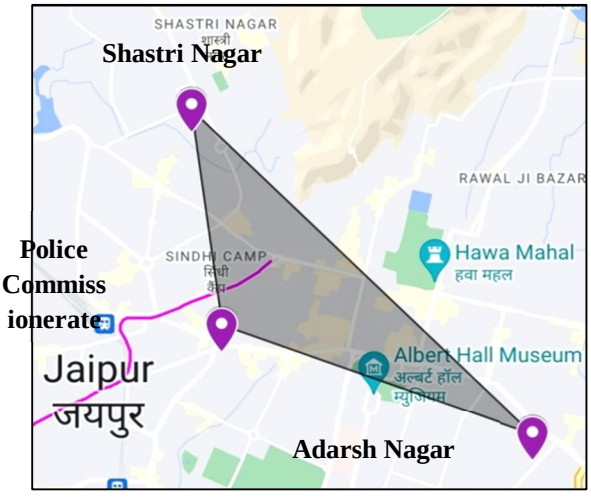


Figure 2: CAAQMS Stations in Jaipur.

These stations continually record meteorological data such as temperature, humidity levels, wind speed, wind direction, pressure, and sun irradiation in addition to particulate matter (PM10 and PM2.5), gaseous pollutants such as SO2, NOx, O3, CO, VOC, and NH3, and other pollutants. Furthermore, as part of the National Air Quality Monitoring Program, the State Board installed 9 manual units at the following locations: (CPCB)

1) RSPCB Office, Jhalana Dongari,
2) RIICO Office MIA, Jaipur
3) PHD Office, Ajmeri Gate
4) Office of the District Educational Officer, Chandpole
5) RSPCB, RO, Vidyadhar Nagar
6) VKIA, Jaipur (Road no.-6)
7) Nagar Nigam Office, Mansarovar, Jaipur
8) RIICO Office, Baees Godam Ind. Area, Jaipur
9) RIICO Office, Sitapura Industrial Area, Jaipur

C. Air Quality of Jaipur

Hourly and daily data were downloaded in the form of a CSV file from the CPCB portal, which provides real-time air quality data in its online dashboard from all the continuous monitors, in order to choose a survey selection site. PM2.5 was considered for this investigation because to its prevalence and significant health risk that is linked to long-term health impacts. For the purpose of choosing the study site, the retrieved data are examined in two steps:

1) Hourly ambient air quality level for April 2021

For the month of April 2021, the hourly PM2.5 data from each of the three continuous monitoring stations were retrieved. A line diagram is constructed to determine the highest concentration of areas with bad air quality, and it is discovered that the Police Commissionerate in Jaipur is the monitoring station with the highest monthly air quality index (CPCB, 2021).

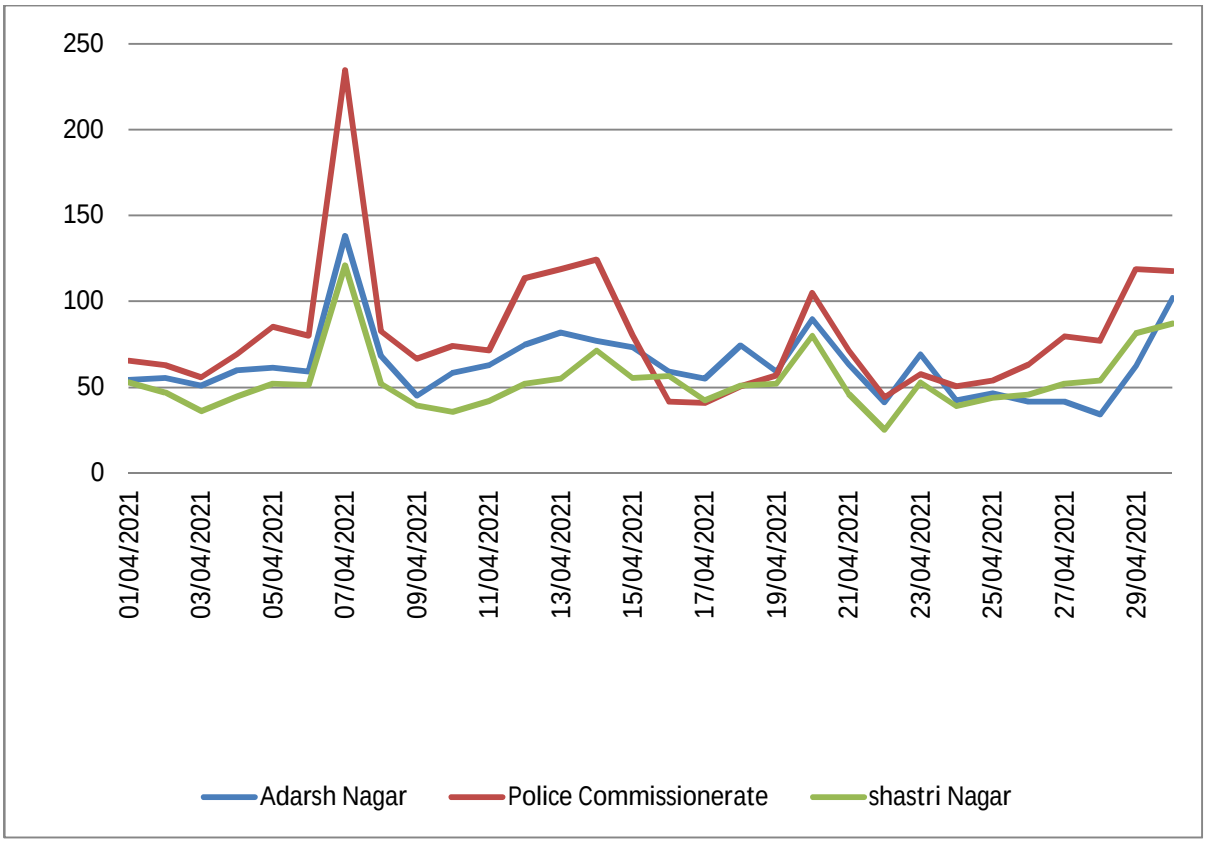


Figure 3: Hourly PM2.5 (µg/m³) analysis (April 2021)

2) Annual ambient air quality level from March 2020 to March 2021

The Police Commissionerate in Jaipur is considered to be a crucial place for this study, it may be inferred from the data gathered. However, since concentration levels vary with weather season variation, the same might not apply to the remaining months. PM2.5 data for three monitoring stations from March 2020 to March 2021 is downloaded to determine which station has the highest concentration level on any given day (CPCB, 2021).

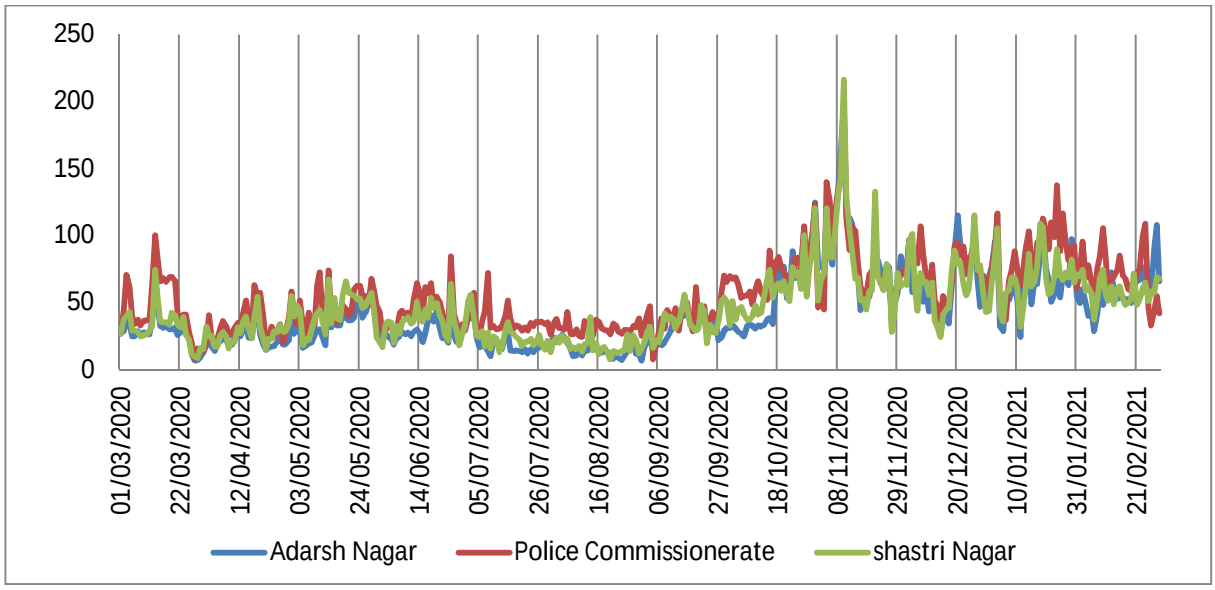
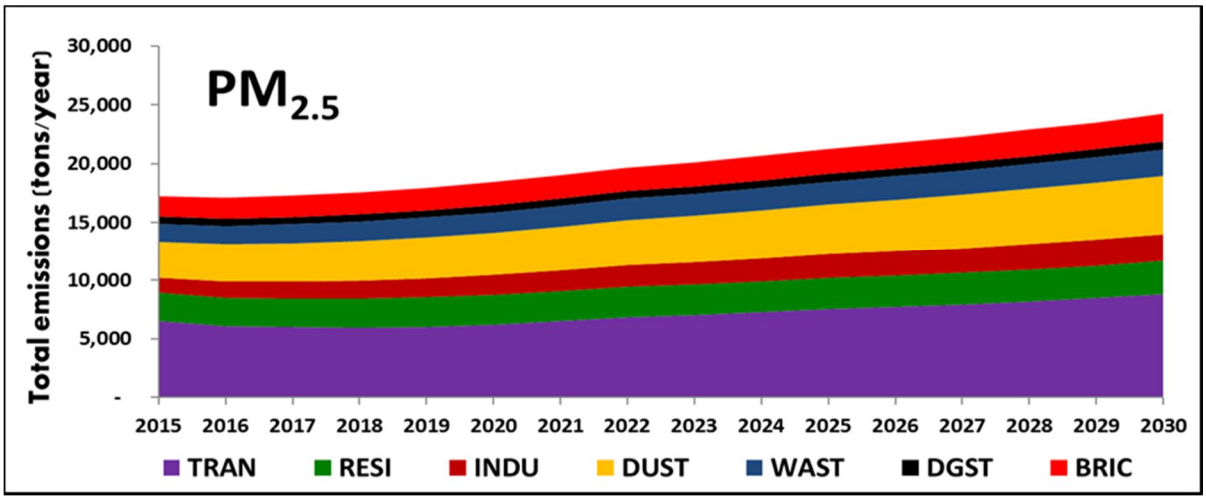


Figure 4: Severity of yearly air pollution (in Adarsh Nagar, Police Commissionerate & Shastri Nagar)

After analyzing throughout the year, the concentration at Police Commissionerate in Jaipur is the highest among all 3 stations.

The state of the city in terms of air pollution is not very encouraging according to the issued World Health Organization (WHO) report on pollution. 500 new non-commercial vehicles, including two-wheelers and four-wheelers, are registered in Jaipur each day, according to the regional transport office (RTO). (TOI, 2014); (Urban Emissions.info, 2015).



TRAN = transport emissions; RESI = residential emissions; INDU = industrial emissions; DUST = dust emissions; WAST = open waste burning emissions; DGST = diesel generator set emissions; BRIC = brick kiln emissions (Urban Emissions.info, 2015).

Figure 5: Total PM2.5 Emissions by Sector 2015-2030

Urban Emissions.info, 2015 compiled an emissions inventory for the Jaipur region for based on the available local activity and fuel consumption estimates. The figure given below represents the various sectors responsible for increase of fine Particulate Matter (PM) with size fraction less than 2.5 μm, for year 2015 and projected to 2030 (Fig 5).

Comparing Hourly variations in Jaipur from 1 June 2022 to 1 July 2022 with CPCB 2019 standards and guideline values prescribed by WHO for parameters of Particulate Matters PM2.5 and PM10.

- *PM2.5(µg/m³)*

WHO Guideline values states that the annual mean concentration of Fine particulate matter (PM2.5) should not exceed 5 µg/m^3, while 24-hour average exposures should not exceed 25 µg/m^3 (WHO global air quality guidelines, 2021).

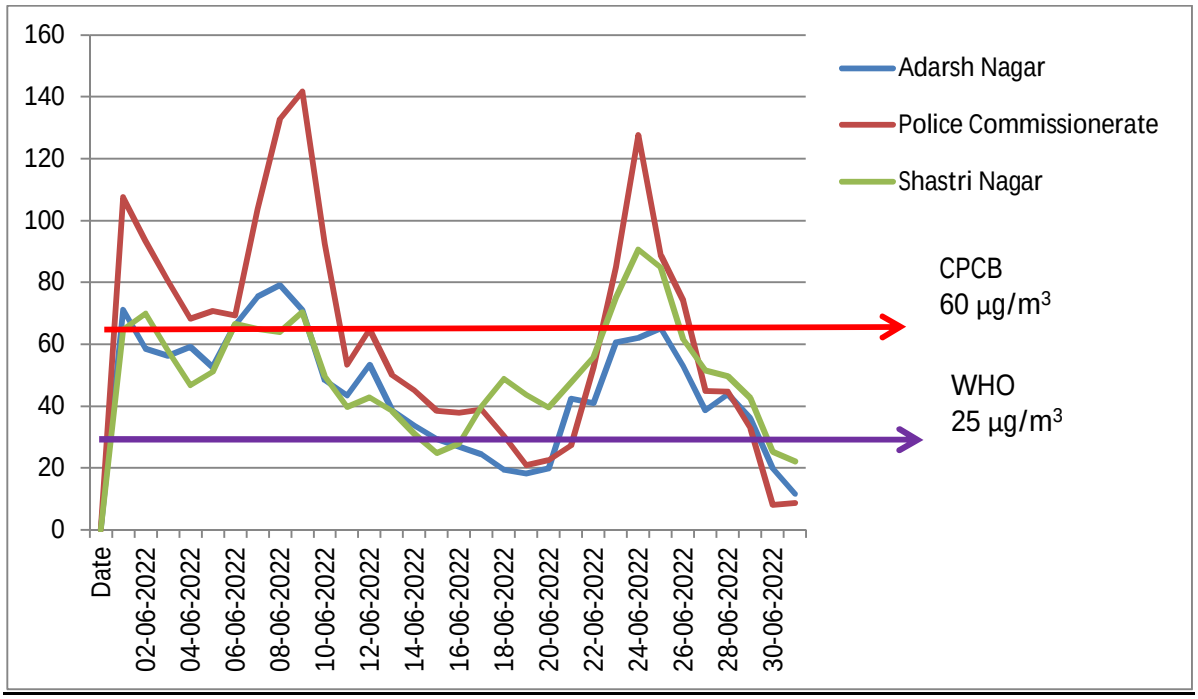


Figure 6: Comparison of PM2.5 content in June-July 2022

- *PM10(µg/m³)*

As per the WHO guidelines the annual average for Coarse particulate matter (PM10) is 15 µg/m^3 and 24-Hour mean is 50 µg/m^3, whereas according to CPCB it should not increase 100 µg/m^3 hourly exposure (WHO global air quality guidelines, 2021).

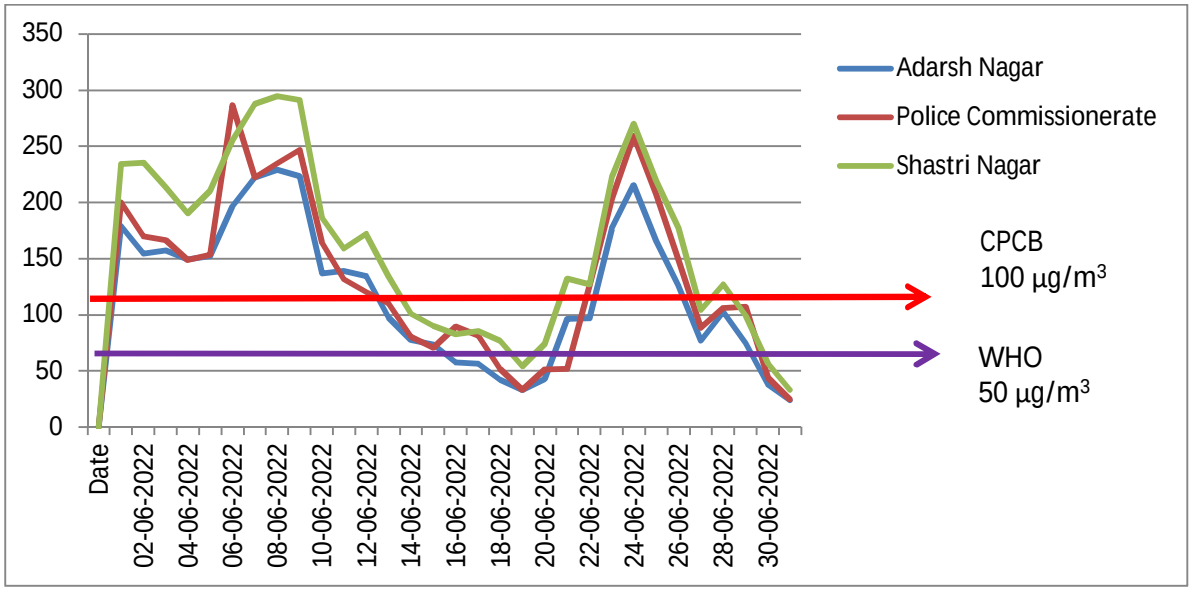


Figure 7: Comparison of PM10 content in June-July 2022

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The top four contributors to PM10 emissions are road dust (71%), industries (8%), vehicles (8%) and construction (4%); these are based on annual emissions. Seasonal and daily emissions could be highly variable.

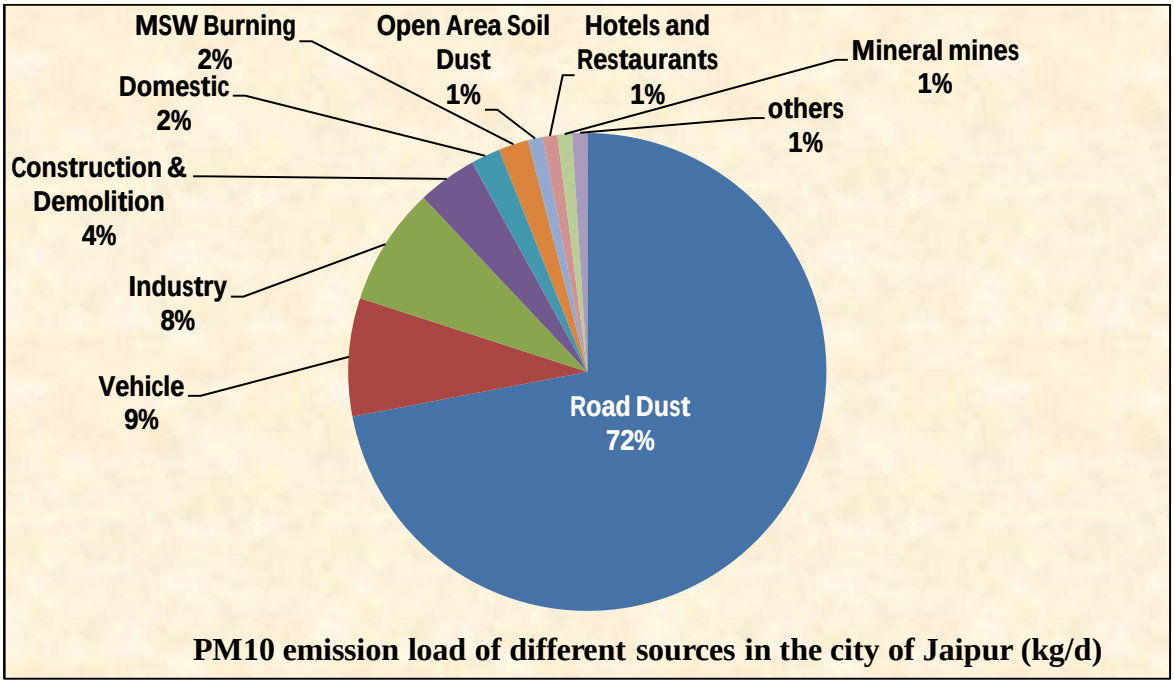


Figure 8: Category Wise PM10 Emissions from All Sources

Road dust (46 percent), automobiles (20 percent), industry (19 percent), and home fuel combustion (5 percent) are the top four sources of PM2.5 pollutants, according to annual emissions. Daily and seasonal emissions may vary greatly.

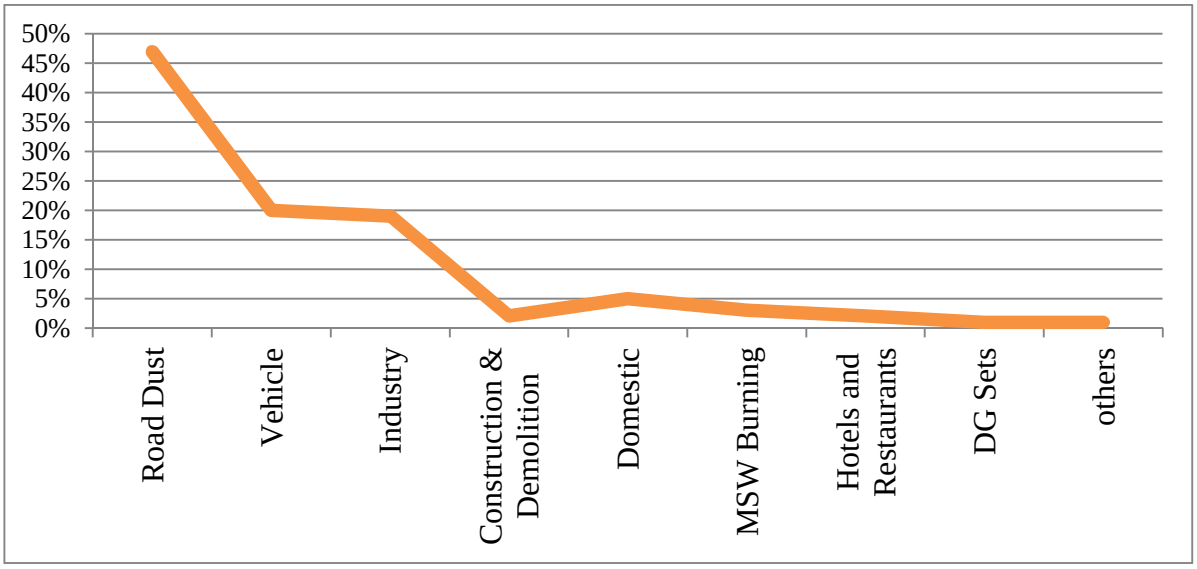


Figure 9: Category Wise PM2.5 Emissions from All Sources

IV. CONCLUSIONS

The present study highlights that the air pollution become a major problem for the Jaipur city during last decade. This study reveals that both the particulate pollutants, PM 10 and PM2.5 are mostly above permissible limits at study site It is observed that there is no gradual increasing or decreasing trend in the studied air pollutants i.e. PM10 and PM2.5. From Figure 4, it can be observed that there is drastic increase in PM2.5 in winters as compared to summer season. The year 2020 in winters had seen worst Air Quality Index for PM2.5 when compared to previous years.(Mandowara, 2019)

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A. Findings and Recommendations

- Expanding air quality monitoring network enables better understanding of air quality
- Understanding pollution sources
- Road dust

One of the main sources of PM10 and PM2.5 emissions, soil and road dust emissions consistently contribute to ambient air concentration. To lessen the emissions of dust on main roadways, the following control measures are advised:

- ❖ Create paved roads from unpaved ones and keep them free of potholes.
- ❖ Application of truck loading regulations; installation of suitable truck enclosures and gravel paving on all haul routes.
- ❖ Increase plantation and green space. Greening efforts should be made in public spaces, community spaces, schools, and housing societies.

- Vehicular pollution

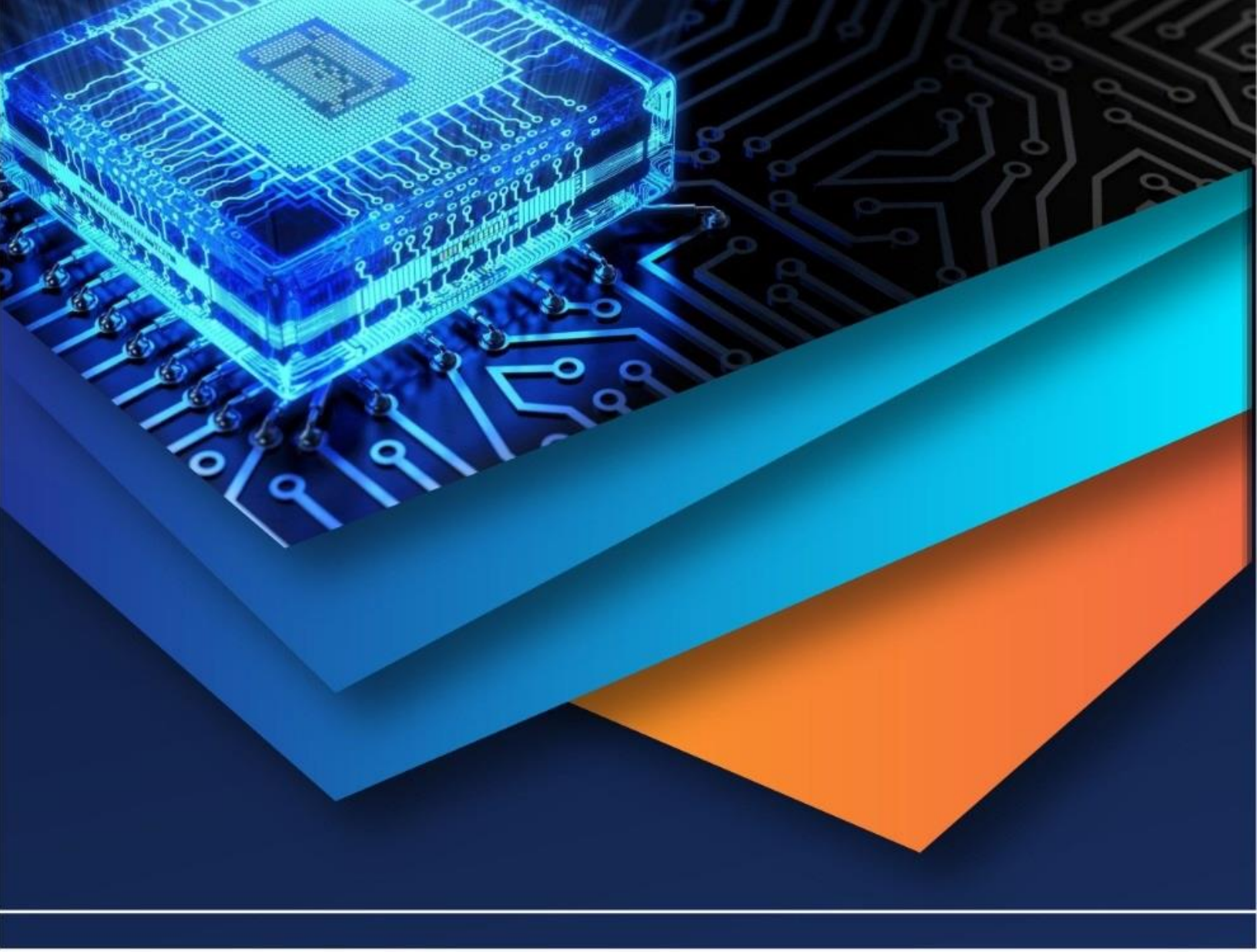
Solutions that can be followed to reduce the impact of automobile emission as vehicles play a significant role in increasing the percentage of pollutants.

 • Moving People Rather than Vehicles	Encouraging Public Transport and car pools.
 • Integrating Land Use and Urban Transportation	Introducing BRTS effectively and efficiently.
 • Priorities to Non-Motorized Transport	Constructing footpaths and cycle tracks.
 • Switching to More Efficient Fuel	Introduction of cleaner fuels (e.g. CNG)
 • Introduction of electric and hybrid vehicles	Less gas and oil required. Eco-friendly
 • Implementation of BS VI engines	Equipped with fuel infusion resulting in better throttle response & fuel efficiency.

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