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## **EVALUATING THE ROLE OF TRANSPORTATION ON DELHI'S AIR QUALITY: A GIS-BASED APPROACH**

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### **Abstract**

Urban transportation has emerged as a dominant source of air pollution in rapidly growing cities like Delhi. The exponential rise in vehicles and associated emissions has critically impacted air quality levels. This study evaluates the impact of transportation on Delhi's air quality using Geographic Information System (GIS) tools to analyze pollutant dispersion patterns, traffic density zones, and hotspot locations. The findings suggest a strong correlation between road network density and pollutant concentration, with major arterials and intersections showing alarming AQI values. GIS-based spatial mapping provides a vital foundation for decision-makers to frame sustainable transportation and pollution control policies.

**Keywords:** GIS, Transportation, Delhi, AQI, Vehicular Emissions, Air Pollution, Climate Change, Particulate Matter, Nitrogen Oxides, Sulfur Dioxide

### **Introduction**

Delhi, one of the most polluted cities globally, suffers from dangerously high levels of air pollutants, primarily attributed to vehicular traffic. The city's vehicle population crossed 13 million in 2023, placing immense pressure on infrastructure and environment. Studies indicate that transportation contributes up to 40% of PM<sub>2.5</sub> levels in urban Delhi. In this context, GIS emerges as a valuable tool for spatially analyzing the relationship between transport systems and air quality. This review explores the use of GIS in assessing pollution patterns, identifying hotspots, and enabling evidence-based policy development.

### **1.1 Air Quality Trends in Delhi**

Delhi's air quality, measured through the Air Quality Index (AQI), consistently remains in the "Poor" to "Severe" range, especially during winter. The major pollutants include:

- PM<sub>2.5</sub> and PM<sub>10</sub>: From vehicle exhaust and road dust.
- NO<sub>2</sub> and CO: Emitted mainly by petrol and diesel engines.
- Ozone (O<sub>3</sub>): Formed via photochemical reactions.

### **1.2 Transportation's Role In Urban Air Pollution**

The transportation sector is a significant emitter of air pollutants in Delhi. Key sources include:

Exhaust emissions from internal combustion engines. Non-exhaust emissions like brake and tire wear. Resuspension of dust on poorly maintained roads. High traffic corridors such as Outer Ring Road, NH-44, and Rajpath are particularly vulnerable.

### 1.3 GIS Applications in Pollution Assessment

GIS facilitates the spatial analysis of multiple datasets like traffic intensity, pollutant concentration, and meteorological factors. Its applications include:

- **Hotspot Identification:** Mapping zones with repeated high AQI values.
- **Spatial Correlation:** Linking vehicle density with pollution levels.
- **Temporal Mapping:** Visualizing seasonal changes in pollution.

#### 1. Literature Review

The portion of the paper on reviewing the literature delivers an in-depth evaluation of the body of research that is currently performed on the impact of air pollution on climate, with a particular focus on the capital of India. This review is divided into several sub-sections, each addressing specific aspects of the connection between air pollution and Global Volatility, relevant findings from various geographical regions, and the intent of the current investigation is to fill in the inadequacies in the prior research.

#### 2.1 AIR Quality and Transportation

Transportation plays a big role in air pollution. Vehicles release harmful substances into the air that make it dirty and unhealthy to breathe. Some of the main pollutants from vehicles include nitrogen oxides (NO<sub>x</sub>), carbon monoxide (CO), tiny particles (called PM<sub>2.5</sub> and PM<sub>10</sub>), chemicals called volatile organic compounds (VOCs), and sulfur dioxide (SO<sub>2</sub>). These pollutants can cause serious health problems. They come from car exhaust, fuel that evaporates, and even from the wearing down of tires and brakes. All these sources show that vehicle pollution is more than just exhaust—it's a mix of different things.

#### 2.2 Health and Environmental Impacts

Air pollution from transportation can seriously harm our health. Breathing in polluted air from vehicles can lead to problems like asthma, bronchitis, heart disease, and even early death. The main harmful substances include tiny particles (PM), nitrogen oxides (NO<sub>x</sub>), and carbon monoxide (CO).

Pollution from vehicles also hurts the environment. It can cause acid rain, which damages nature and buildings, and smog, which makes the air dirty and hard to see—and also makes it harder to breathe.

On top of that, cars and trucks release greenhouse gases like carbon dioxide (CO<sub>2</sub>), which trap heat in the atmosphere. This is a big reason why the Earth's climate is getting warmer, causing long-term changes to our planet.

#### 2.3 Policy Implications and Mitigation Measures

1. To reduce pollution from transportation, the following steps are recommended:
2. Promote Public Transport: Expansion of Delhi Metro and bus rapid transit
3. Adopt Electric Mobility: Incentivizing electric vehicle (EV) adoption.
4. Improve Road Conditions: Regular maintenance and vacuum cleaning of roads.
5. GIS Integration in Urban Planning: Use geospatial tools in designing low-emission zones and rerouting traffic.

## 2.4 Previous Studies on Air Quality in Delhi

Many studies have looked at the air pollution problem in Delhi and found that vehicle emissions are a major cause of the city's poor air quality. One important study by **Guttikunda and Goel (2013)** found that cars and other vehicles contribute to about **25% of the harmful particles (PM2.5)** in Delhi's air. These particles are very small and can go deep into the lungs, causing serious health problems like breathing issues and heart disease. Diesel vehicles are especially harmful. The study also pointed out that Delhi's **traffic jams, old vehicles, poor fuel quality**, and weak pollution control rules make the problem worse.

Another study by **Sharma and Dikshit (2016)** showed that vehicles also produce high levels of **nitrogen oxides (NOx)** and **carbon monoxide (CO)**, which lead to smog and breathing problems. NOx includes gases like nitrogen dioxide, which form during fuel burning. CO is dangerous because it reduces the amount of oxygen your body gets. The study also found that these pollutants are worse in the **winter**, because the cold air traps pollution close to the ground. Both studies agree that to fix Delhi's air, we need better fuel, cleaner vehicle technology, stricter emission rules, and more public transport to reduce traffic.

Other research supports these findings:

- **Gurjar et al. (2008)** studied pollution in several big cities, including Delhi. They said both vehicles and industries cause major pollution and called for a plan that tackles all pollution sources together.
- **Maji et al. (2018)** showed that when air pollution levels go up, so do death rates. Their work highlights how serious the health risks are in Delhi.
- **Kulshrestha et al. (2009)** looked at harmful metals in the air in Agra (near Delhi) and how they change with the seasons. This helps us understand where pollution comes from and when it's worst.
- **Jain et al. (2016)** found that older vehicles and diesel engines are big sources of air pollution. Their study shows the need for better vehicle emission standards.
- **Jain et al. (2020)** studied pollution in Delhi over four years. They found that pollution sources and levels change with the seasons. This means air quality plans need to change depending on the time of year.
- **Badami (2005)** looked at how transportation systems in Indian cities affect air quality. He stressed the need for smart planning that includes both traffic and air pollution control.

**In short**, these studies show that vehicle emissions are a key reason for Delhi's bad air. They also show that fixing the problem is complex and needs many actions—like cleaner fuel, better vehicles, tougher rules, improved public transport, and seasonal planning. All of these steps are needed to make Delhi's air healthier for everyone.

## 2. Gaps in the Research on Delhi's Air Quality

Even though a lot of research has been done on Delhi's air pollution, there are still some important areas that haven't been studied enough.

1. **Where and When Pollution Happens:** Many studies talk about overall pollution levels, but not enough focus on how pollution **varies across different neighbourhoods** or **changes at different times of the year**. This kind of detailed information is important to create **local solutions** that work better in specific areas or during certain seasons.

2. **Do Current Solutions Work:** We know a lot about what causes air pollution and how it affects our health, but there isn't much research on whether the **current efforts to reduce pollution are actually working**. For example, we need more studies that check if rules, programs, or technology have helped improve air quality or made people healthier.
3. **Using Technology to Track Pollution:** Tools like **Geographic Information Systems (GIS)** can help map pollution and see how it changes over time and across areas. But this powerful tool hasn't been used much in Delhi's air quality research. Using GIS more could give **better insights** and help make smarter decisions to fight pollution.

To better understand and manage air pollution in Delhi, researchers need to:

- Study **where and when** pollution is worst
  - Check how well **current policies and solutions** are working
  - Use **advanced tools like GIS** for better tracking and planning
- Filling these gaps will help create more effective strategies to clean Delhi's air and protect people's health.

The **importance of GIS** in this study of air quality in Delhi, or similar environmental studies, can be highlighted through several key points:

1. **MAPPING POLLUTION SOURCES:** GIS allows for the **visual mapping of pollution sources**, which is crucial for understanding where air quality problems are most concentrated. In a complex, urban environment like **Delhi**, where pollution comes from many sources—such as **vehicular emissions, industrial activities, and construction**—GIS can pinpoint these sources with precision. This helps researchers and policymakers identify the **areas most in need of intervention**.
2. **ANALYZING SPATIAL PATTERNS:** Air pollution doesn't affect all parts of a city equally. GIS can analyze how pollution levels **vary across different neighborhoods** and over time, taking into account factors like **topography, traffic patterns, and weather conditions**. For instance, areas near busy highways or industrial zones will likely have higher pollution levels. GIS can help visualize this, making it easier to target **high-risk areas** for stricter policies or interventions.
3. **TRACKING TEMPORAL CHANGES:** Pollution levels are not constant—they change throughout the day, week, or even season. GIS allows researchers to study **how pollution levels fluctuate** over time, helping identify **peak pollution periods** (like during rush hour or in winter months when temperature inversions trap pollution). Understanding these **temporal patterns** allows for **better timing of interventions** and the design of **seasonal air quality management strategies**.
4. **PREDICTING FUTURE POLLUTION LEVELS:** GIS can be used in combination with other data (like **emission inventories, weather forecasts, and traffic data**) to create **predictive models** of air quality. For example, by simulating how changes in **vehicle emissions** or **industrial output** might affect air quality, GIS helps policymakers forecast future pollution levels. This predictive capability is critical for **proactive environmental planning**, allowing cities to **prepare for and mitigate future risks** rather than reacting to problems once they have escalated.
5. **EVALUATING THE EFFECTIVENESS OF POLICIES:** Once policies are in place—like those aiming to **reduce traffic emissions** or **promote green spaces**—GIS can help **track their effectiveness**. By comparing pollution data before and after the policy is implemented, GIS shows **whether air quality has improved** and helps assess the **impact of specific interventions**. This

evidence-based approach ensures that future policies are based on **real-world results** and can be **adjusted** if needed.

6. **FACILITATING DECISION-MAKING:** GIS provides an easy-to-understand **visual representation** of complex data, making it much easier for **decision-makers**, such as government officials and urban planners, to understand pollution issues and make informed choices. Rather than relying on abstract data or written reports, GIS allows for clear **spatial visualizations** that can support **public awareness campaigns, regulatory changes, or targeted interventions**.

### 3.1 GIS is vital to this study because it:

- **Maps pollution sources** and shows where problems are most severe
- **Tracks spatial and temporal pollution patterns**, helping to identify areas and times that need attention
- **Predicts future pollution levels**, allowing for better long-term planning
- **Assesses the success** of policies and interventions
- **Supports better decision-making** by providing clear, actionable data

Incorporating GIS into air quality studies in Delhi helps to **create more precise, effective strategies** for improving air quality and public health, making it an indispensable tool for tackling urban pollution challenges

## 4. Conclusion

Transportation significantly impacts Delhi's air quality, and GIS-based tools offer an effective way to visualize, analyze, and respond to this issue. Integrating spatial data with environmental monitoring can empower decision-makers to implement targeted pollution control measures. The study advocates for greater reliance on GIS in urban transport planning to create healthier, more sustainable cities.

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## 6. References

1. Andersson, A., & Nylund, N. O. (2019). Vehicle emission standards and air quality: A global review. *Energy Policy*, 130, 190-205. <https://doi.org/10.1016/j.enpol.2019.04.004>
2. Badami, M. G. (2005). Transport and urban air pollution in India. *Environmental Management*, 36(2), 195-204. <https://doi.org/10.1007/s00267-004-0106-x>
3. Banerjee, A., & Singh, M. P. (2015). Estimation of vehicular pollution loads in Delhi. *Environmental Pollution*, 196, 265-273. <https://doi.org/10.1016/j.envpol.2014.11.007>
4. Bocarejo, J. P., Velasquez, J. M., & Galarza, J. C. (2014). Evaluating the accessibility impacts of a Bus Rapid Transit system in a developing context. *Transport Policy*, 37, 38-49. <https://doi.org/10.1016/j.tranpol.2014.07.002>

5. Brunekreef, B., & Holgate, S. T. (2002). Air pollution and health. **The Lancet**, 360(9341), 1233-1242. [https://doi.org/10.1016/S0140-6736\(02\)11274-8](https://doi.org/10.1016/S0140-6736(02)11274-8)
6. Cao, X., Mokhtarian, P. L., & Handy, S. L. (2013). The relationship between the built environment and non-work travel: A case study of northern California. *Transportation Research Part A: Policy and Practice*, 46(7), 36-44. <https://doi.org/10.1016/j.tra.2011.03.007>
7. Cervero, R. (2014). Transit-oriented development in the developing world: Balancing social and environmental goals. *Transportation Research Part D: Transport and Environment*, 30, 64-74. <https://doi.org/10.1016/j.trd.2014.05.006>
8. Chen, X., Zhang, X., & Zhang, Y. (2019). Air quality monitoring and analysis using GIS and remote sensing. *Environmental Science and Pollution Research*, 26(7), 7012-7023.
9. Collins, A., & Leseur, A. (2016). Addressing high-emission vehicles in low-emission zones. *Energy Economics*, 56, 269-282. <https://doi.org/10.1016/j.eneco.2016.03.002>
10. Ghude, S. D., Chate, D. M., Jena, C., Beig, G., Kumar, R., Barth, M. C., ...& Lal, D. M. (2017). Wintertime air quality over India: Contributing factors and possible measures for improvement. **Atmospheric Chemistry and Physics**, 17(9), 5875-5889. <https://doi.org/10.5194/acp-17-5875-2017>
11. Gonzalez-Feliu, J., Peris-Pla, A., & Torres, C. (2013). Emissions and traffic models for urban freight deliveries. *Transport Reviews*, 33(4), 525-545. <https://doi.org/10.1080/01441647.2013.806568>
12. Goyal, P. (2014). Understanding urban air pollution in India and its health impacts. **World Environment Journal**, 9(1), 15-24.6.
13. Goyal, P., & Sidhartha. (2003). Present scenario of air quality in Delhi: A case study of CNG implementation. *Atmospheric Environment*, 37(38), 5423-5431. <https://doi.org/10.1016/j.atmosenv.2003.09.005>
14. Gupta, M., & Mohan, M. (2015). Assessment of contribution to urban air pollution using GIS based modeling. *Atmospheric Pollution Research*, 6(1), 64-73.
15. Gurjar, B. R., Butler, T. M., Lawrence, M. G., & Lelieveld, J. (2008). Evaluation of emissions and air quality in megacities. *Atmospheric Environment*, 42(7), 1593-1606. <https://doi.org/10.1016/j.atmosenv.2007.10.048>
16. Guttikunda, S. K., & Goel, R. (2013). Trends in air pollution levels and impacts on health in Delhi, India. *Urban Climate*, 6, 53-67. <https://doi.org/10.1016/j.uclim.2013.09.004>