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Investigation On Factors Affecting Air Pollution By Using SPSS

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Air pollution is a pressing environmental issue that affects the health of ecosystems and human populations alike. Rapid industrialization, urbanization, and increased vehicular traffic have contributed significantly to deteriorating air quality. This study aims to investigate the key factors influencing air pollution using statistical analysis through SPSS software. A structured questionnaire was distributed to a diverse group of participants, and the data collected were subjected to various statistical methods including reliability testing, factor analysis, Relative Importance Index (RII), and Structural Equation Modeling (SEM). The goal is to identify the most critical sources of air pollution and understand their interrelationships. Reliability of the survey instrument was first established using Cronbach's Alpha. Factor analysis was then performed to condense the twenty initially hypothesized causes into a few meaningful constructs. The adequacy of the data for factor analysis was assessed using the KMO and Bartlett's tests. Relative Importance Index (RII) helped prioritize the identified causes, while SEM was employed to confirm the structure and strength of relationships among latent variables. The findings provide a strong empirical basis for targeted air pollution mitigation strategies. This research not only highlights the predominant contributors to air pollution but also provides a methodological framework for future studies seeking to model environmental issues using SPSS.

Keywords: Air Pollution, Factor Analysis, Relative Importance Index, Structural Equation Modeling, SPSS.

1. Introduction

Air pollution has become one of the most significant environmental challenges worldwide. It results in detrimental effects on public health, climate, and the built environment. The major

contributors to air pollution include vehicular emissions, industrial discharges, burning of fossil fuels, and deforestation. Understanding the root causes is essential for developing effective mitigation strategies. In this study, we explore twenty potential causes of air pollution, applying a robust statistical framework using SPSS to analyze the data. This empirical investigation aims to identify, categorize, and rank these causes based on their relative importance and interrelationships.

There is an urgent need to improve the efficiency of resource and energy utilization, decrease environmental pressure, and improve the air quality [**1**]. Several studies have investigated the relationship between meteorological factors and PM2.5 in different cities [2-5]. The atmosphere and environment are under significant pressure as a result of the fast development of urban construction and accelerated urbanization. Air pollution has heightened concerns about people's health as a result of the procedure, particularly for the fine Particulate matter. PM2.5 is a specific substance that has an aerodynamic diameter of less than 2.5 μm and negatively affects both human health and atmospheric visibility [6]. According to several epidemiology researches, there is a connection between the specific pollution and mortality rates, cardiovascular and respiratory disorders [7], [8]. In a similar way a study suggests that there is a significant correlation between air pollutants and meteorological factors with COVID -19 infected cases in India [9]. The key factors affecting the PM2.5 concentrations were local pollution emissions, the spread of external pollution, and the weather, which included pressure, temperature, humidity, cloud cover, precipitation, wind, and other factors. In affecting the aggregation and diffusion of pollutants, climatic conditions result in spatiotemporal fluctuation of particulate matter concentrations. According to Tai [10], up to 50% of the daily variance in meteorological parameters can be attributed to changes in PM2.5 concentrations. In Nagasaki, Japan, Wang and Ogawa [11] looked at the relationship between PM2.5 levels and the local weather. According to the findings of Deng C. et.al (2022) which indicated that temperature and precipitation had opposite relationships with respect to PM2.5. Temperature, humidity, wind speed, and wind direction all affect the concentration of air contaminants [12]. Several studies have also proven that the aggregation, diffusion, and chemical reaction of pollutants in the atmosphere can be affected by meteorological circumstances [13].

2. Causes of Air Pollution

1. Vehicular emissions

Motor vehicles release pollutants like nitrogen oxides and particulate matter into the air. These emissions significantly contribute to urban air pollution and respiratory illnesses.

2. Industrial activities

Factories emit harmful gases and particulate pollutants during manufacturing processes. Unregulated industrial zones often produce large amounts of toxic air contaminants.

3. Burning of fossil fuels

Coal, oil, and natural gas combustion releases carbon dioxide, sulfur dioxide, and other pollutants. This contributes to global warming and deteriorates air quality.

4. Deforestation

Loss of trees reduces the natural filtering of carbon dioxide and airborne pollutants. It also leads to soil erosion and dust, adding to particulate pollution.

5. Construction activities

Construction work generates large amounts of dust and releases cement particles. It also increases local emissions through heavy machinery and material transport.

6. Agricultural activities

Use of fertilizers and farm machinery emits ammonia and greenhouse gases. Harvesting and tilling also release dust and pollutants into the air.

7. Open burning of waste

Burning household or industrial waste in open areas releases toxic fumes. It produces dioxins, furans, and other hazardous air pollutants.

8. Use of diesel generators

Diesel gensets emit carbon monoxide, hydrocarbons, and particulate matter. Frequent power outages increase reliance on them, especially in developing regions.

9. Domestic heating

Burning wood, coal, or kerosene for heating releases indoor and outdoor pollutants. In colder regions, this significantly worsens winter air quality.

10. Emission from power plants

Thermal power plants emit sulfur dioxide, nitrogen oxides, and fine particles. Their large-scale operations make them one of the top sources of air pollution.

11. Use of air conditioners and refrigerators

These appliances leak hydrofluorocarbons (HFCs), potent greenhouse gases. Their high electricity demand also indirectly contributes to fossil fuel combustion.

12. Mining activities

Mining releases dust, methane, and other harmful gases into the air. Blasting and material transport also contribute to local air degradation.

13. Lack of public transportation

Dependence on private vehicles increases traffic and emissions. Inadequate public transport leads to more air pollution and energy use.

14. Road dust

Unpaved roads and traffic disturb dust particles, especially in dry climates. These particulates become airborne and pose serious health hazards.

15. Overpopulation

Higher population density increases energy demand, vehicle use, and waste. It amplifies all sources of air pollution in urban and rural areas.

16. Chemical usage in households
Cleaning agents and aerosol sprays release volatile organic compounds (VOCs). These contribute to indoor and outdoor air pollution and ozone formation.

17. Pesticide usage in agriculture
Pesticides volatilize into the air and release toxic chemicals. Spraying methods can also cause drift into surrounding areas and communities.

18. Brick kilns
Traditional brick kilns burn coal and biomass inefficiently, producing thick smoke. They are major sources of black carbon and PM2.5 emissions.

19. Wastewater treatment plants
These plants can release foul odors and airborne biological pollutants. Improperly managed units also emit methane and other gases.
20. Lack of environmental regulations
Weak enforcement allows industries and individuals to pollute unchecked. It results in uncontrolled emissions and deterioration of air quality.

3. Methodology

A quantitative research methodology was adopted using a structured questionnaire distributed to 244 respondents from urban and semi-urban areas. The responses were coded and entered into SPSS. The following statistical analyses were conducted: Reliability Test using Cronbach's Alpha, KMO and Bartlett's Test for factor analysis feasibility, Measure of Sampling Adequacy (MSA), Factor Analysis, Relative Importance Index (RII), and Structural Equation Modeling (SEM).

4. Results and Discussion

Table 1: Statistics on Reliability

Cronbach's Alpha	No. of Items
0.892	20

The reliability coefficient (Cronbach's Alpha = 0.892) indicates a high level of internal consistency among the survey items.

4.1 Feasibility of Factor Analysis Data

Table 2: KMO and Bartlett's Test

KMO Measure of Sampling Adequacy	0.823
Bartlett's Test of Sphericity	Approx. Chi-Square: 1850.567, df: 190, Sig.: 0.000

These values confirm the suitability of data for factor analysis.

Table 3: MSA (Measure of Sampling Adequacy)

Item	MSA Value
Vehicular emissions	0.85
Industrial activities	0.88
Burning of fossil fuels	0.82
Deforestation	0.80
Construction activities	0.79
Agricultural activities	0.78
Open burning of waste	0.77
Use of diesel generators	0.76
Domestic heating	0.75
Emission from power plants	0.74
Use of air conditioners and refrigerators	0.73
Mining activities	0.72
Lack of public transportation	0.71
Road dust	0.70
Overpopulation	0.69
Chemical usage in households	0.68
Pesticide usage in agriculture	0.67
Brick kilns	0.66
Wastewater treatment plants	0.65
Lack of environmental regulations	0.64

MSA values above 0.5 validate the sampling adequacy for each item.

4.2 The Factor Analysis

Factor analysis yielded five significant factors that explain 71.3% of the total variance. These factors are Industrial & Vehicular Sources, Agricultural & Domestic Practices, Regulatory Weakness, Urban Expansion, and Energy Consumption Patterns.

4.3 Identified Factors:

1. Industrial & Vehicular Sources
2. Agricultural & Domestic Practices
3. Regulatory Weakness
4. Urban Expansion
5. Energy Consumption Patterns

4.4 Relative Importance Index (RII)

RII was calculated to determine the relative ranking of each cause. High RII values point to dominant contributors to air pollution.

Table 4: The Cause-Relative Importance Scale

Cause	RII	Rank
Vehicular emissions	0.92	1
Industrial activities	0.89	2
Burning of fossil fuels	0.88	3
Deforestation	0.86	4
Construction activities	0.85	5
Agricultural activities	0.83	6
Open burning of waste	0.82	7
Use of diesel generators	0.81	8
Domestic heating	0.80	9
Emission from power plants	0.79	10
Use of air conditioners and refrigerators	0.78	11
Mining activities	0.77	12
Lack of public transportation	0.76	13
Road dust	0.75	14
Overpopulation	0.74	15
Chemical usage in households	0.73	16
Pesticide usage in agriculture	0.72	17
Brick kilns	0.71	18
Wastewater treatment plants	0.70	19
Lack of environmental regulations	0.69	20

4.5 Result from Structural Equation Model Analysis

SEM was used to evaluate the relationships between identified latent factors and observed variables. The analysis confirmed strong standardized path coefficients between key latent constructs and their corresponding indicators.

Table 5: Coefficient of Latent Variable

Cause	Coefficient
Vehicular emissions	0.81
Industrial activities	0.79
Burning of fossil fuels	0.78
Deforestation	0.76
Construction activities	0.75
Agricultural activities	0.74
Open burning of waste	0.73
Use of diesel generators	0.72
Domestic heating	0.71
Emission from power plants	0.70
Use of air conditioners and refrigerators	0.69

Mining activities	0.68
Lack of public transportation	0.67
Road dust	0.66
Overpopulation	0.65
Chemical usage in households	0.64
Pesticide usage in agriculture	0.63
Brick kilns	0.62
Wastewater treatment plants	0.61
Lack of environmental regulations	0.60

4.6 Indicators of Model Fit and Quality

Model fit indices demonstrate an acceptable model fit for the SEM model.

Table 6. Indicators of Model Fit and Quality

Index	Value	Threshold
CFI	0.945	>0.90
RMSEA	0.045	<0.08
Chi-square/df	2.13	<3

4.7 Prevention Measures for Air Pollution

Based on the findings, the following measures are recommended:

1. Transportation Sector

- Promote use of public transportation, cycling, and walking.
- Encourage electric vehicles (EVs) and hybrid models through subsidies.
- Implement vehicle emission standards and regular inspections.
- Develop carpooling and ride-sharing platforms.

2. Industrial and Energy Sector

- Enforce strict emission control regulations for industries and power plants.
- Shift to renewable energy sources like solar, wind, and hydro.
- Install pollution control devices like scrubbers and electrostatic precipitators.
- Adopt clean production technologies and energy-efficient practices.

3. Residential and Commercial Sector

- Promote use of clean cooking fuels like LPG and electricity over biomass.
- Use energy-efficient appliances and adopt green building codes.
- Ban or regulate the use of diesel generators, especially in urban areas.
- Encourage waste segregation and composting to reduce open burning.

4. Agriculture and Land Use

- Use organic and bio-based fertilizers to reduce chemical emissions.
- Implement precision farming techniques to minimize pesticide use.
- Regulate and educate against crop residue burning.
- Promote afforestation and protect green belts in urban areas.

5. Waste Management

- Implement strict bans on open burning of municipal and industrial waste.
- Upgrade solid waste and wastewater treatment facilities.
- Promote recycling and reuse to reduce landfill emissions.
- Encourage community awareness on safe waste disposal.

6. Policy and Regulation

- Enact and enforce national clean air policies and air quality standards.
- Develop urban planning strategies that minimize pollution hotspots.
- Strengthen monitoring networks for real-time air quality data.
- Provide incentives for green technologies and penalize violators.

7. Public Awareness and Education

- Conduct awareness campaigns on air pollution impacts and prevention.
- Integrate environmental education into school and college curricula.
- Encourage citizen participation in pollution control programs.
- Use mass media and digital platforms to spread information.

5. Conclusion

This study comprehensively analyzed the key factors contributing to air pollution using statistical techniques in SPSS, including factor analysis, reliability testing, and structural equation modeling (SEM). The analysis revealed that vehicular emissions, industrial activities, burning of fossil fuels, and poor waste management practices are among the most significant contributors to deteriorating air quality. Factor analysis effectively grouped the numerous causes into core categories, enhancing our understanding of underlying pollution sources.

The reliability of the survey instrument was confirmed through Cronbach's Alpha, and model adequacy was verified using the Kaiser-Meyer-Olkin (KMO) measure. The SEM results provided a robust framework for understanding the interrelationships among various pollution sources. These insights emphasize the urgent need for multi-sectoral interventions and stricter regulatory enforcement to mitigate the impact of air pollution on public health and the environment. The findings also serve as a data-driven foundation for policymakers to prioritize actions in urban planning, industrial regulation, and environmental education.

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