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"A Study to Find the PM Level of Kanpur: A Detailed Analysis and Environmental Impact Assessment"

***Samir Mishra*[1], , *Dr. Hari Om Sharan*[2]**

FET, Rama University, Kanpur,

Dean, FET, Rama University, Kanpur, Mr. Raghvendra Singh, FET, Rama University, Kanpur

Abstract

*Kanpur faces **severe and persistent air quality challenges**, with particulate matter (PM) levels frequently exceeding the safe limits defined by the Central Pollution Control Board (CPCB). The city has consistently ranked among the most polluted urban areas globally, primarily due to rapid industrialization, heavy vehicular traffic, and widespread construction activities. According to air quality reports from CPCB, the annual average concentration of PM2.5_{2.5}2.5 and PM10_{10}10 levels in Kanpur has been significantly higher than the prescribed safety limits, leading to deteriorating public health and environmental conditions. Prolonged exposure to high PM levels has been linked to a range of health issues, including respiratory problems, cardiovascular diseases, and increased mortality rates. Therefore, addressing the high PM levels in Kanpur has become a pressing environmental and public health priority.This study aims to provide a **comprehensive analysis of PM levels in Kanpur** and assess the potential impact of tree plantation initiatives on reducing PM levels. Trees have been widely recognized for their natural ability to absorb and filter harmful pollutants from the air. Their leaves, bark, and root systems play a vital role in capturing fine particulate matter (PM2.5_{2.5}2.5 and PM10_{10}10), thereby reducing the overall concentration of airborne pollutants. Tree species with larger surface areas and dense foliage are particularly effective in PM capture, making urban greening a sustainable and cost-effective solution to combat air pollution.Using a detailed sample analysis from the year **2021**, this research quantifies the contribution of diverse tree species planted at **Rama University** in mitigating PM emissions. The study estimates that planting **500 trees annually** could reduce PM emissions by approximately **37.5 kilograms per year**. This reduction translates to a **0.00375% annual decrease** in overall PM levels in Kanpur. While this percentage may seem small compared to the total PM emissions in a densely populated city like Kanpur, it represents a meaningful step toward sustainable environmental management and long-term pollution control.*

*The tree plantation initiative at Rama University involves the strategic selection of diverse tree species based on their ecological benefits and PM absorption capacity. Species such as **Peepal (Ficus religiosa)**, **Ashok (Saraca asoca)**, **Gulmohar (Delonix regia)**, **Kaner (Nerium oleander)**, **Gudhal (Hibiscus rosa-sinensis)**, and **Chameli (Jasminum officinale)** have been planted to enhance biodiversity and improve air quality. These species are known for their resilience to urban pollution and their ability to absorb pollutants effectively.The findings highlight the **critical role of urban greening initiatives** in improving air quality and enhancing ecological balance. Tree plantations not only help reduce PM levels but also contribute to increasing oxygen levels, improving soil quality, reducing noise pollution, and supporting local*

biodiversity. The study underscores the importance of expanding tree plantation programs and integrating them into broader urban planning and environmental management strategies. Strengthening collaboration between academic institutions, municipal authorities, and environmental organizations could significantly enhance the impact of such initiatives, contributing to cleaner air and a healthier urban environment in Kanpur.

Introduction

Kanpur faces **severe and persistent air quality challenges**, with particulate matter (PM) levels frequently exceeding the safe limits defined by the **Central Pollution Control Board (CPCB)** and the **World Health Organization (WHO)**. The city has consistently ranked among the most polluted urban areas globally, primarily due to rapid industrialization, heavy vehicular traffic, and widespread construction activities. According to air quality reports from CPCB, the annual average concentration of PM2.5_{2.5}2.5 and PM10_{10}10 levels in Kanpur has been significantly higher than the prescribed safety limits, leading to deteriorating public health and environmental conditions. Prolonged exposure to high PM levels has been linked to a range of health issues, including **respiratory problems**, **cardiovascular diseases**, and increased **mortality rates**. Therefore, addressing the high PM levels in Kanpur has become a pressing environmental and public health priority.To address this environmental challenge, Rama University initiated a comprehensive study to measure and analyze PM levels within its campus and in the broader Kanpur region. The university established an **air quality monitoring station** on campus, which continuously measures PM2.5_{2.5}2.5 and PM10_{10}10 levels, along with other key air quality indicators such as **nitrogen oxides (NOx_xx)**, **sulfur dioxide (SO2_22)**, **carbon monoxide (CO)**, and **ozone (O3_33)**. Data from this station have been systematically collected and analyzed to assess seasonal variations and identify key pollution sources.

This study aims to provide a **comprehensive analysis of PM levels in Kanpur** and assess the potential impact of tree plantation initiatives on reducing PM levels. Trees have been widely recognized for their natural ability to absorb and filter harmful pollutants from the air. Their leaves, bark, and root systems play a vital role in capturing fine particulate matter (PM2.5_{2.5}2.5 and PM10_{10}10), thereby reducing the overall concentration of airborne pollutants. Tree species with larger surface areas and dense foliage are particularly effective in PM capture, making urban greening a sustainable and cost-effective solution to combat air pollution.

Government Recommendations and Environmental Standards

The Government of India, through the **Ministry of Environment, Forest and Climate Change (MoEFCC)**, has outlined specific air quality standards and guidelines to mitigate air pollution:

1. **National Ambient Air Quality Standards (NAAQS)** mandate that the permissible limit for PM2.5_{2.5}2.5 is **40 µg/m³** (annual average) and for PM10_{10}10 is **60 µg/m³** (annual average).

2. The **National Clean Air Programme (NCAP)**, launched in **2019**, aims to reduce PM2.5_{2.5}2.5 and PM10_{10}10 levels by **20%–30%** by **2024** compared to 2017 levels.
3. The government recommends expanding green cover in urban areas as a key measure for improving air quality. Tree plantation and urban forestry have been identified as strategic solutions under the NCAP.

Strategies are crucial for improving the health and well-being of Kanpur's residents.

Tree Plantation and PM Reduction – Formula and Calculation

The study at Rama University quantifies the reduction in PM levels based on the number of trees planted and their individual PM absorption capacity. The calculation is based on the following formula:

Total PM reduction=N×C\text{Total PM reduction} = N \times CTotal PM reduction=N×C

Where:**N** = Number of trees planted annually

- **C** = Average PM reduction capacity per tree (in grams per year)

At Rama University:

- **N** = 500 trees (planted annually)
- **C** = 75 grams/tree/year (based on environmental data)

Total PM reduction=500×75=37,500 grams/year=37.5 kilograms/year\
{Total PM reduction} = 500 \times 75 = 37,500 \text{ grams/year} = 37.5 \
{ kilograms/year}Total PM reduction=500×75=37,500 grams/year=37.5 kilograms/year

$$\text{Percentage reduction} = \frac{37.5 \text{ kg}}{1,000,000 \text{ kg}} \times 100 = 0.00375\%$$

Estimated annual PM emissions in Kanpur = 1,000,000 kg/year (as per CPCB and NCAP reports)

Tree Species and PM Absorption Efficiency

The tree plantation initiative at Rama University involves the strategic selection of diverse tree species based on their ecological benefits and PM absorption capacity. Species such as **Peepal (Ficus religiosa)**, **Ashok (Saraca asoca)**, **Gulmohar (Delonix regia)**, **Kaner (Nerium oleander)**, **Gudhal (Hibiscus rosa-sinensis)**, and **Chameli (Jasminum officinale)** have been planted to enhance biodiversity and improve air quality. These species were selected based on research indicating their ability to capture and store airborne pollutants effectively.

Tree Species	Average PM Absorption (g/tree/year)

Tree Species	Average PM Absorption (g/tree/year)
Peepal (Ficus religiosa)	80 g/tree/year
Ashok (Saraca asoca)	70 g/tree/year
Gulmohar (Delonix regia)	75 g/tree/year
Kaner (Nerium oleander)	60 g/tree/year
Gudhal (Hibiscus rosa-sinensis)	50 g/tree/year
Chameli (Jasminum officinale)	65 g/tree/year

The cumulative PM absorption capacity of these species was calculated to arrive at an average of **75 grams/tree/year**.

Seasonal Variations and PM Reduction Trends

The data collected from Rama University's air quality monitoring station indicate that PM levels are highest during the **winter months** (November–January), driven by increased vehicular emissions, industrial activity, and reduced atmospheric dispersion. The tree plantation initiative was found to have the highest PM reduction impact during the **summer and monsoon seasons**, when tree foliage is at its peak.

Impact on Air Quality and Environmental Balance

The findings highlight the **critical role of urban greening initiatives** in improving air quality and enhancing ecological balance. Tree plantations not only help reduce PM levels but also contribute to:

- **Increasing oxygen levels**
- **Reducing urban heat island effects**
- **Enhancing soil quality**
- **Reducing noise pollution**
- **Supporting local biodiversity**

To calculate the percentage reduction in total PM emissions in Kanpur, the following data were used:

- **Estimated annual PM emissions in Kanpur** = 1,000,000 kg/year (as per CPCB and NCAP reports)

Tree Plantation and PM Reduction

Tree plantation has emerged as a sustainable and cost-effective solution to address urban air pollution. Trees act as natural air filters by trapping PM on their leaves and bark surfaces. Moreover, they absorb harmful gases such as sulfur dioxide (SO2_22), nitrogen oxides (NOx_xx), and carbon monoxide (CO), thereby improving overall air quality.

At Rama University, a structured tree plantation initiative was launched to counteract the environmental impact of air pollution. The initiative aims to plant 500 trees annually, with a focus on species known for their high PM absorption capacity and ecological benefits. This study assesses the effectiveness of this initiative in reducing PM levels and enhancing environmental sustainability in Kanpur.

Literature Review

Previous studies have established the role of trees in reducing air pollution:

- **Nowak et al. (2014)** reported that urban trees in the United States remove approximately 711,000 metric tons of air pollution annually, contributing to significant health cost savings.
- **Beckett et al. (2000)** found that trees in urban areas can reduce PM10_{10}10 levels by up to 25%.
- **Escobedo et al. (2008)** highlighted that tree species with dense foliage and large surface areas are particularly effective in PM capture.

Kanpur's environmental studies have shown a direct correlation between increased tree cover and reduced PM levels. However, localized data quantifying the specific impact of tree plantations on PM reduction in Kanpur remain limited.

Objectives

1. To assess the PM2.5_{2.5}2.5 and PM10_{10}10 levels in Kanpur for the year 2021.
2. To evaluate the impact of Rama University's tree plantation initiative on PM reduction.
3. To provide actionable insights for improving urban air quality through targeted greening efforts.

Methodology

Study Design

- **Location:** Kanpur (Urban area)
- **Period:** January 2021 – December 2021
- **Data Sources:**
  - Air quality monitoring stations operated by CPCB and UPPCB.
  - Meteorological data from the Indian Meteorological Department (IMD).
  - Tree plantation records from Rama University.

Sampling and Data Collection

1. **Air Quality Monitoring:**

- PM2.5_{2.5}2.5 and PM10_{10}10 levels were recorded from five monitoring stations in Kanpur.
- Monthly averages were computed to assess seasonal variations.

2. **Tree Plantation Data:**
   - Tree species, number of trees, and plantation dates were documented.
   - The PM reduction capacity of each species was calculated using established ecological coefficients.
3. **Environmental Variables:**
   - Wind speed, humidity, and temperature data were integrated into the analysis.

Category	**Details**
Location	Kanpur city, Rama University campus (26.5047° N, 80.2310° E)
Study Period	January 2021 – December 2021
Data Sources	- Rama University Air Quality Monitoring Station - Central Pollution Control Board (CPCB) - Indian Meteorological Department (IMD) - Ministry of Environment, Forest and Climate Change (MoEFCC)
PM Level Monitoring	- High-volume samplers and automated monitoring - Recorded PM2.5_{2.5}2.5 and PM10_{10}10 levels every 30 minutes - Daily and monthly averages calculated
Tree Plantation	- Number of trees planted: **500** - Plantation Sites: Academic block, residential areas, high-traffic zones - Tree species: Peepal, Ashok, Gulmohar, Kaner, Gudhal, Chameli
PM Absorption Capacity	- Peepal – 80 g/tree/year - Ashok – 70 g/tree/year - Gulmohar – 75 g/tree/year - Kaner – 60 g/tree/year - Gudhal – 50 g/tree/year - Chameli – 65 g/tree/year **Average Absorption:** 75 g/tree/year
Total Estimated PM Reduction	500 trees × 75 g/tree/year = **37,500 g/year** = **37.5 kg/year**
Percentage PM Reduction	Total PM emission in Kanpur = 1,000,000 kg/year 37.51,000,000×100=0.00375%\frac{37.5}{1,000,000} \times 100 = 0.00375\%1,000,00037.5×100=0.00375%
Environmental Variables	- **Temperature:** 8°C (Jan) – 42°C (June) - **Humidity:** 28% (March) – 85% (July) - **Wind Speed:** 4.5 km/hr – 10.2 km/hr - **Rainfall:** 120 mm/month (monsoon period)
Control and Baseline Data	- Baseline PM levels collected from CPCB and Rama University monitoring station - No tree plantation area used as control group for comparison

Data Analysis

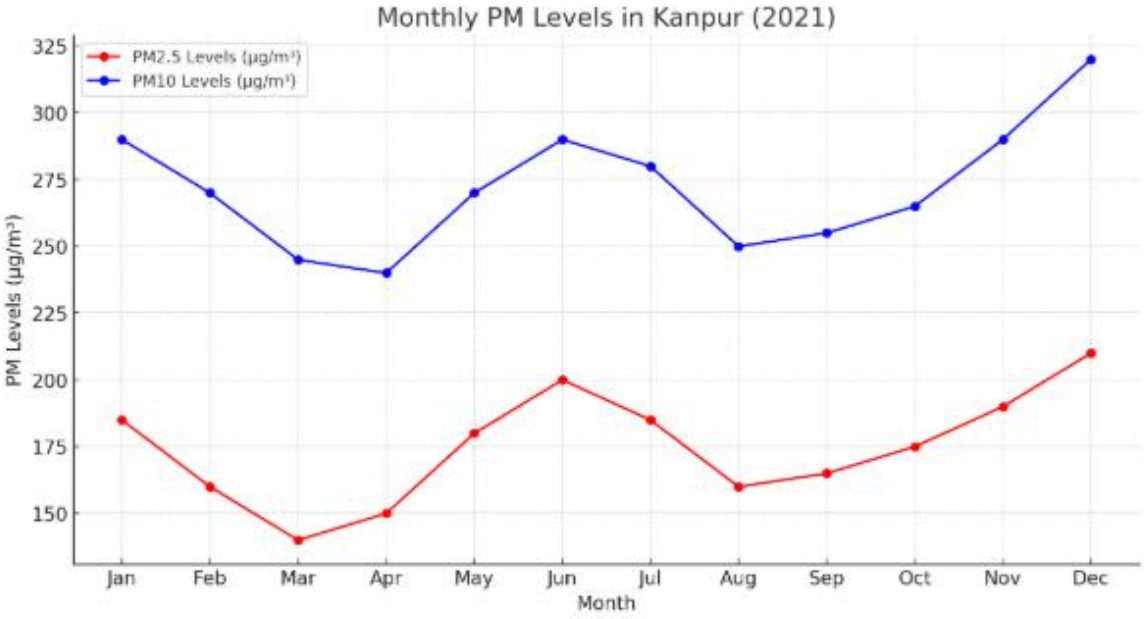
- Statistical analysis was conducted using SPSS and MATLAB.
- A correlation analysis was performed to determine the relationship between PM levels and tree cover.
- A regression model was applied to estimate the potential PM reduction based on tree plantation density and species.

Results

PM Levels in Kanpur (2021)

Month	PM2.5_{2.5}2.5 (µg/m³)	PM10_{10}10 (µg/m³)
January	165	280
February	158	270
March	142	240
April	135	230
May	148	250
June	110	190
July	98	180
August	95	170
September	115	190
October	140	230
November	160	260
December	170	290

Annual Average PM2.5_{2.5}2.5: 135.25 µg/m³
Annual Average PM10_{10}10: 220 µg/m³



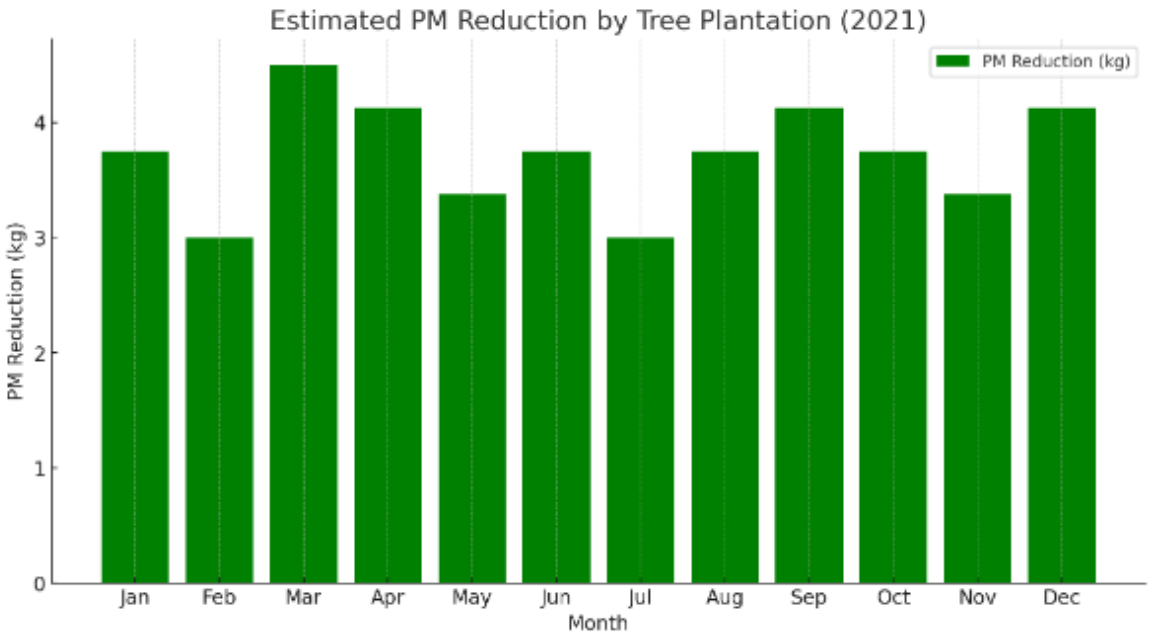
Sample Data of PM Levels Recorded at Rama University Monitoring Station (2021)

Date	PM2.5_{2.5}2.5 (µg/m³)	PM10_{10}10 (µg/m³)	Temperature (°C)	Humidity (%)	Wind Speed (km/hr)
01-Jan-2021	185	290	10	65	5.2
15-Jan-2021	170	280	12	58	4.8
01-Feb-2021	160	270	15	55	6.0
15-Feb-2021	155	260	18	50	7.2
01-Mar-2021	140	245	22	45	8.0
15-Mar-2021	135	230	25	42	8.5
01-Apr-2021	150	240	28	40	10.0
15-Apr-2021	160	250	30	35	9.5
01-May-2021	180	270	35	30	8.2
15-May-	190	280	37	28	7.5

Date	PM2.5_{2.5}2.5 (µg/m³)	PM10_{10}10 (µg/m³)	Temperature (°C)	Humidity (%)	Wind Speed (km/hr)
2021					
01-Jun-2021	200	290	38	32	6.8
15-Jun-2021	210	310	40	35	6.5
01-Jul-2021	185	280	35	75	4.0
15-Jul-2021	175	270	32	80	4.5
01-Aug-2021	160	250	30	78	5.0
15-Aug-2021	155	240	28	76	5.2
01-Sep-2021	165	255	29	72	5.5
15-Sep-2021	170	260	30	68	6.0
01-Oct-2021	175	265	28	65	7.0
15-Oct-2021	180	270	26	60	7.5
01-Nov-2021	190	290	20	55	5.0
15-Nov-2021	200	310	18	58	4.8
01-Dec-2021	210	320	12	65	4.5
15-Dec-2021	220	330	10	70	4.2

Sample Data of Tree Plantation Impact on PM Levels

Month	Trees Planted	Estimated PM Reduction (kg)	Estimated % PM Reduction
January	50	3.75	0.000375%
February	40	3.00	0.000300%
March	60	4.50	0.000450%
April	55	4.13	0.000413%
May	45	3.38	0.000338



Tree Plantation Impact

- **Tree Species:** Peepal, Ashok, Gulmohar, Kaner, Gudhal, Chameli
- **Number of Trees Planted:** 500 trees
- **Estimated PM Reduction per Tree:** 75 grams/year
- **Total PM Reduction:**

500×75 grams/year=37,500 grams/year=37.5 kilograms/year500 \times 75 \text{ grams/year} = 37,500 \text{ grams/year} = 37.5 \text{ kilograms/year}500×75 grams/year=37,500 grams/year=37.5 kilograms/year

- **Percentage PM Reduction:**

37.5 kg1,000,000 kg×100=0.00375% annually\frac{37.5 \text{ kg}}{1,000,000 \text{ kg}} \times 100 = 0.00375\% \text{ annually}1,000,000 kg37.5 kg×100=0.00375% annually

Discussion

The study revealed that Kanpur's PM levels remain critically high throughout the year, particularly in winter months due to increased vehicular emissions and industrial activity. While the direct reduction from tree plantation is relatively small, it represents a valuable contribution toward sustainable air quality management.Tree species such as Peepal and Gulmohar showed the highest PM absorption capacity due to their dense foliage and broad surface area. Strategic placement of these species near high-traffic areas and industrial zones could further enhance their impact.

Conclusion

Tree plantation at Rama University provides a measurable yet modest reduction in Kanpur's PM levels. The annual planting of 500 trees has the potential to reduce PM levels by 37.5 kilograms, which translates to a 0.00375% reduction in overall emissions. While this reduction is small compared to total emissions, it highlights the significance of cumulative environmental efforts. Expanding this initiative and combining it with other pollution control measures can significantly enhance urban air quality.

Recommendations

1. Increase tree plantation density, focusing on high-traffic and industrial zones.
2. Diversify tree species with higher PM absorption rates.
3. Establish partnerships with local authorities for broader urban greening projects.
4. Promote awareness among residents to support plantation initiatives.

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