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***Review Paper***

# Effect of Air Pollution in Kanpur and Unnao, UP, India

**Rajesh Kumar[1*], Parijat Srivastava[2] and Om Hari[1]**
[1]Department of Applied Chemistry, Dr. AITD Kanpur, India
[2]Department of Mechnical Engineering, HBTU Kanpur, India
raj1978hbti@gmail.com

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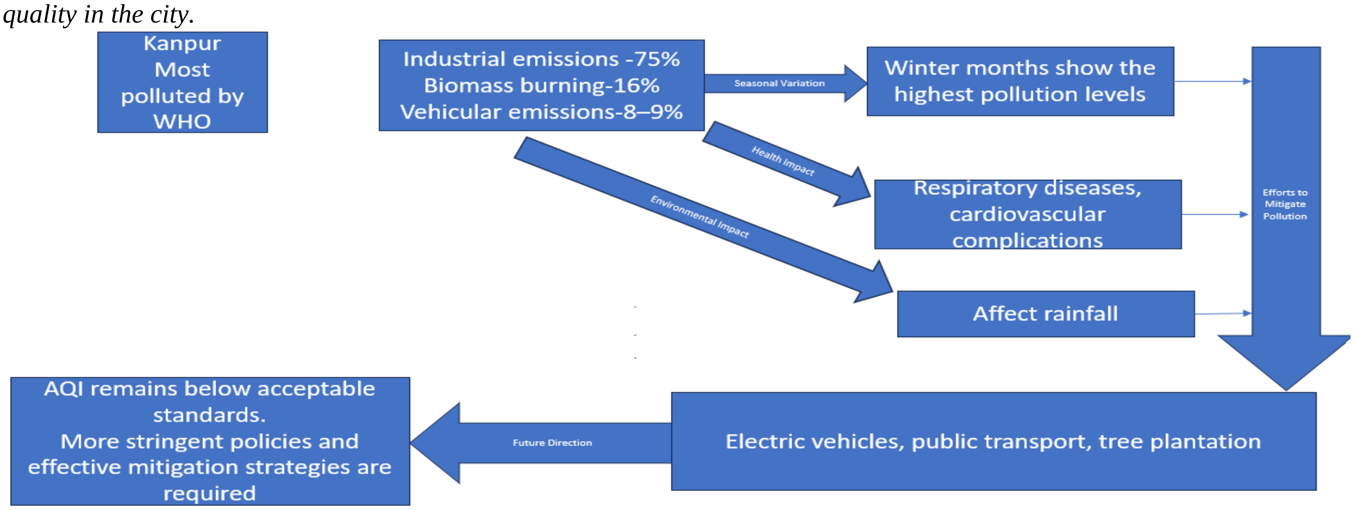
## Abstract

*At present, the air quality index (AQI) in Kanpur has significantly deteriorated due to the rapid expansion of industrial activities. While industrialization has played a crucial role in economic growth, it has also led to severe environmental consequences, with air pollution being one of the most pressing concerns. The World Health Organization (WHO) has reported that India is home to several highly polluted cities, with approximately 14 to 15 cities ranking among the worst in terms of air quality. Kanpur, in particular, has been identified as one of the most critically affected cities, experiencing dangerously high levels of air pollution in recent years. Observations over the past few years indicate that industrial sectors are a major contributor to the city's worsening air pollution, surpassing even population-driven pollution sources. Among the key pollutants, particulate matter (PM) is the most dominant, comprising about 75% of total air pollutants, primarily in the form of dust and soot. Additionally, around 16% of air pollution is attributed to biomass burning, while vehicle emissions account for approximately 8–9%. However, seasonal variations also influence pollution levels. During the summer months, particulate matter contributions decrease to around 36%, with vehicular emissions playing an equal role in air pollution. This study analyzes pollution data from different areas during moderate weather conditions, revealing that approximately 20–80% of these areas experience severe pollution, particularly during winter. The colder months exacerbate pollution levels due to atmospheric conditions that trap pollutants closer to the ground, leading to the presence of toxic substances in the air. This phenomenon not only affects rainfall patterns and the overall environment but also poses significant health risks. Prolonged exposure to air pollution has been linked to numerous adverse health effects, including respiratory diseases, cardiovascular complications, neurological disorders, premature births, increased mortality rates, and chronic irritation. Recognizing the gravity of the situation, various institutions and local communities have initiated efforts to mitigate pollution levels. Measures such as promoting the use of electric vehicles, encouraging carpooling and public transportation, planting more trees, and implementing stricter industrial emission regulations have been introduced. However, despite these ongoing efforts, the AQI in Kanpur remains well below acceptable standards. This paper aims to examine the underlying causes, sources, and impacts of air pollution in Kanpur, utilizing available data and literature to provide an in-depth understanding of pollution trends. Furthermore, it explores existing mitigation strategies and suggests potential solutions to improve air quality in the city.*




**Keywords:** Air pollution, Air Quality Index, Particulate matter, pollutants, season, climate.

## Introduction

Over the past few years, Kanpur has implemented several initiatives aimed at reducing air pollution. Efforts have been made to strengthen the "Pollution Under Control" system by introducing advanced monitoring equipment and stricter vehicle emission norms. The city has promoted the use of compressed natural gas (CNG) for public transport, including buses, tempos, and other vehicles, while also phasing out more than 1,600 outdated vehicles. Additionally, authorities have shut down 12 highly polluting industries and undertaken various measures to improve air quality.

Despite these interventions, pollution levels continue to rise. At the end of the year 2000, the annual average concentration of respirable suspended particulate matter (RSPM or PM10) in Kanpur was recorded at 210 micrograms per cubic meter (µg/m³). Between 2004 and 2006, this level showed a slight decline, ranging between 176 and 190 µg/m³. However, in 2008, pollution levels surged again, reaching 211µg/m³—approximately 3.45 times higher than the recommended safety standard. With the onset of winter, pollution levels are expected to rise even further.

Although nitrogen oxide (NOx) concentrations remain within permissible limits, there has been a noticeable upward trend in its levels. According to an analysis by environmental experts, the revised air quality standards set by the Union Ministry of Environment, Forest and Climate Change have highlighted deteriorating conditions in Kanpur. Areas such as Sharda Nagar, Deputy Ka Parao, Kidwai Nagar, and Fazal Ganj have been identified as critically polluted due to high levels of particulate matter. Additionally, nitrogen dioxide concentrations in these locations have shifted from low to moderate levels, raising further concerns about air quality in the city.

In this paper the study showed about 60-70 per cent of the geographical area of the city has facing a pollution problem, with a highly polluted air and others city core. In a case study some of the studies was done by the GSVM Medical College and the Central Pollution Control Board (CPCB), which represents the show lower lung function for people living in the Vikas Nagar and Juhilal Colony areas, than those living from living in cleaner environment. In the recorded history by UPENVIS, about 0.4 million disability faced life years are lost every year in Uttar Pradesh due to air pollution[1]. From this study the costs the state about more than Rs 2.5 billion.

In Kanpur there are different types of the air pollution is coming from its increasing number of vehicles, and the prsence of number of industrial activities and use of diesel generators. Approximetely 23 per cent of the killer particles are from motor vehicles and 34 per cent are from industry similarly nitrogen oxides 48 per cent of from petrol engine vehicles and 41 per cent from industry was reported by IIt Kanpur and UPPCB.Most of the rapid effect is seeen from vehicles because vehicle emissions take place within the breathing zone of the people and they increases daily large number of deadly dose of toxins.In Kanpur city CSE point out that there are anoter cause of early signs of a mobility crisis building up.In Kanpur city has 6,43,245 motorised vehicles with a 2.5-million strong population. Every year, the city is registering more than 38,000 new vehicles; in which at approxemetly 150 two-wheelers and cars and more than 20 commercial vehicles are registered daily. Till 2025 encreasing number of registered vehicle will seen which will produce large number of toxic materials in the air.

Now in these days personal vehicles is rising steadily. In 2021 two-wheelers are 85 per cent of the fleet, while cars make up more than 20 per cent. Now in these days people are now buying more cars: the annual growth rate of cars in Kanpur city is higher (12 per cent) than that of two-wheelers (8 per cent). According to this data of the growing congestion, peak hour traffic is slowing down and causes more air pollution. As the governed decided in crowed area and in city side the maximum speed of 40 km/hour, but the average speed in Kanpur has observed to 17-20 km/hour and even slower. In a study for the year 2008 by the Union ministry of urban development,the traffic volumes have exceeded,for this reason the designed capacity of roads in more than 30 per cent of Kanpur’s road length. In some cases of trafiic area which have more traffic than designed include Meston Road, Canal Road, Halsey Road and the Kidwai Nagar Road near Ghantaghar side.

Motor vehicles either two or four wheelers not only pollute the air; they also are the measure problem of energy security. In the city of Kanpur, during the case studie it was observed that cars and two-wheelers together use more than 80 per cent of the total energy consumption of 0.15 million tonne of oil equivalent per year in the transport sector[2]. No in these days there are the personal vehicles if continues to increase, oil consumption will go up by three times by 2030. It will be the worst report for a country which imports more than 72 per cent of its crude oil.Now in these days increasing energy use, in its turn, can take emissions of heat-trapping carbon dioxide ($CO_2$) leading to more global warming. Personal vehicles in Kanpur account for the highest $CO_2$ emissions more than 84 per cent in the transport sector, it was reported by New Delhi-based air pollution research and modeling body SIM Air.

## Functions/Parameters used to define Air Pollution

**AQI:** Air Quality Index defined daily air quality. How clean or polluted our air is, it clearly define also it is used what associated health effects might be a concern for you. Five major air pollutants regulated by the Clean Air Act: sulphur dioxide, ground-level ozone, particle pollution (also known as particulate matter), carbon monoxide, and nitrogen dioxide.

**SPM:** Suspended particulate matters are finely divided solids or liquids that may be dispersed through the air from combustion processes, industrial activities or natural sources.

**Total SPM:** Total Suspended Particulate Matter is the concentration when a high-volume bulk sampling is done on a filter substrate.

**Repairable SPM:** Repairable Suspended Particulate Matter is the fraction of another pollutant which involved readily inhaled by humans through their respiratory system and in general, considered as particulate matter with their diameter (aerodynamic) less than 2.5 micrometers. Larger particles would be filtered in the nasal duct.

**PM:** Particulate matter also known as particle pollution. This is the complex mixture of small particles and liquid droplets that get into the air. Once inhaled, these particles can affect the heart and lungs and cause serious health effects.

**PM10:** This is a subset of total Suspended Particulate Matter and also described particulate matter with aerodynamic diameter less than 10 micrometer.

**PM 2.5:** This is also a subset of Total Suspended Particulate Matter and stands for particulate matter with aerodynamic diameter less than 2.5 micrometer. PM 2.5 is particulate matter 2.5 microns and below. Those are small particles floating in the air. Those particles are obtained from lots of sources, some of the examples as dust blown up from the wind, pollen from plants ,coal particles from power plants and home heating, , and car exhaust. Here's different types of Air quality index is given with their numerical values:

RSPM refers to particulate matter with diameter of less than or equal to 10 micrometers. They are produced from combustion process, vehicles and industrial sources. For the purpose of monitoring air pollution, the state pollution control board has set up three stations in residential areas and one each in industrial and commercial areas. The RSPM of different areas are given in Table-1.

**Table-1:** Air quality index levels.

| Air Quality Index Levels of Health Concern | Numerical Value | Meaning |
|---|---|---|
| Good | 0 to 50 | Air quality is considered satisfactory, and air pollution poses little or no risk. |
| In between low and High | 50 to 100 | In this case quality of air is acceptable; but, for some pollutants in a small number of people effected who are unusually sensitive to air pollution. |
| Unhealthiness for Seniors Groups | 100 to 149 | Sensitive persons may cause disease and un healthy, while the general public is not affected. |
| Unhealthy Schedule | 149 to 199 | Sensitive persons may experience more serious health effects. |
| More Unhealthy found | 199 to 299 | Every one causes un healthy feeling and disease. |
| More Hazardous | 299 to 501 | The whole population is badly affected. |

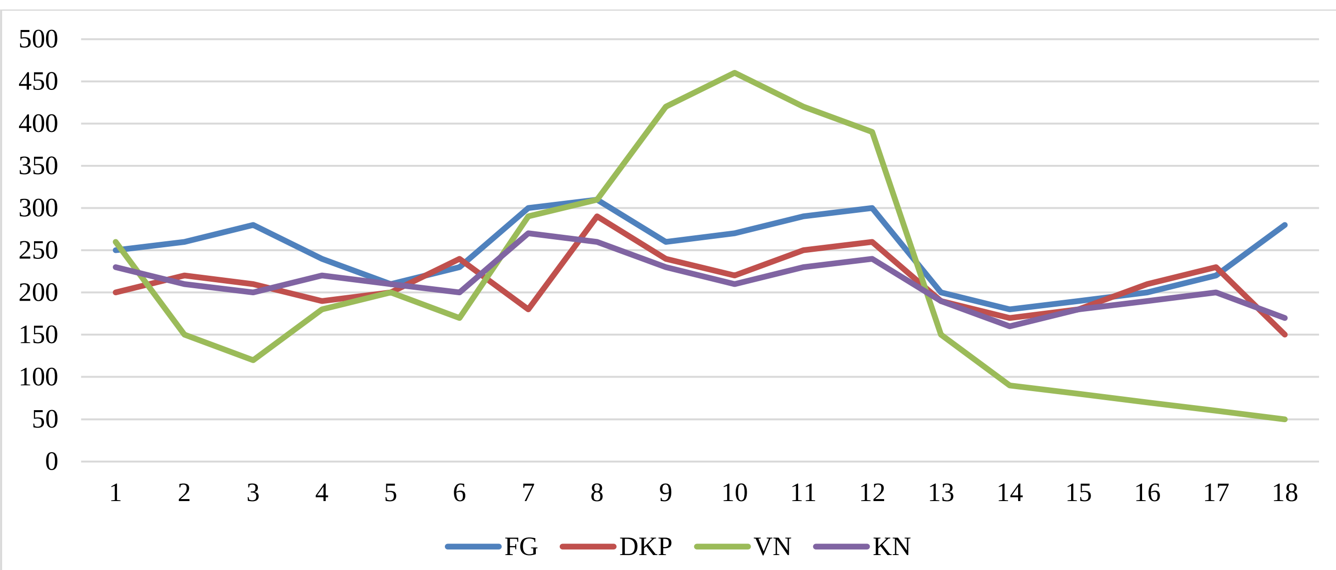



**Figure-1:** RSPM in Kanpur.

Figure-1 clear that the first 6 weeks correspond to winter, followed by the 6 weeks of summer and the 6 weeks of monsoon periods in Kanpur. Fazal Ganj (FG) is an industrial area whereas Deputy Ka Parao (DKP), Vikas Nagar (VN) and Kidwai Nagar (KN) are residential areas. The pollution load in tons per day was also recorded in the Kanpur city from kinds of fuel and vehicles, which are listed in Table-2.

The air pollution from industrial area can be quantified from the amount of fossil fuel burnt in boilers. In the Kanpur city the different data and pollution status has been shown here, quantity of fuel used in each area and the different types of emissions released from different sources which effected the air pollution was observed areawise[3]. Fuel consumption in each of the industrial area and prominent point source emissions in the city is provided in the Table-3.

**Emissions from Domestic Fuels:** Fuels that is a substance that is burned to provide nuclear energy, heat or power. Fuels Such as wood, coal, kerosene, domestic gas, cow dung etc. are used in our homes for cooking purposes. These fuels are very sensitive for environment and produces harmful gases etc[4,5]. In the Table-4 here a study was done by using domestic fuels and their emission rate per kg per day. It was observed from the table the harmful gas CO is released much by using coal, while the LPG was found better than others in all such parameters.

**Effects of Air Pollution:** In Table-4 effect of different Pollutants and their impact on human health is categorized.

**Table-2:** Estimated Loads of Pollutants of Different Vehicles in Kanpur[21].

| Vehicle Type | Veh- kms (In Lakhs) | Pollution Loads in Tons Per Day | | | |
|---|---|---|---|---|---|
| | | CO | $NO_x$ | HC | PM |
| Cars + Taxis | 16.34 | 10.45 | 10.69 | 4.9 | 6.70 |
| Two Wheelers | 60.42 | 55.54 | 6.44 | 83.97 | 25.03 |
| Auto Diesel | 12.56 | 20.71 | 27.82 | 0.22 | 26.46 |
| Auto Petrol | 1.04 | 2.65 | 0.09 | 4.43 | 0.84 |
| Goods Inter City | 4.52 | 6.92 | 30.46 | 3.09 | 23.35 |
| City Bus | 0.66 | 0.5 | 6.57 | 0.35 | 4.14 |
| Inter City Bus | 0.85 | 0.76 | 9.72 | 0.56 | 7 |
| Goods Local | 3.61 | 2.47 | 8.2 | 0.79 | 6.47 |
| Total | 48.18 | 28.73 | 7.25 | 11.70 | 1.91 |

**Table-3:** Fuel consumption. Point Source Emissions in (kg./hr.).

| Source | $SO_2$ | $NO_x$ | SPM |
|---|---|---|---|
| Fazal Ganj Industrial Area | 71 | 28 | 585 |
| Dada Nagar Industrial Area | 134 | 101 | 180 |
| Panki Industrial Area | 254 | 112 | 2600 |
| Jajmau Industrial Area | 55 | 50 | 607 |
| Industrial Estate | 21 | 9 | 195 |
| Fertilizer Unit | 91 | 62 | 162 |
| Power Plant, Panki | 1090 | 751 | 3900 |
| Textile Mills | 63 | 44 | 682 |
| Lalimli | 5 | 6 | 97 |
| Sarvodaya Nagar Industrial Area | 3 | 2 | 65 |

**Effects of Air Pollution on Climate:** Due to increase in air pollution most of the time climate effected the monsoon[6,7]. The average temperature during whole year was observed due to climate change.

From the Figure-2 it is clear that due to effect of pollution the Minimum temperature was observed $7^0$C in December and Maximum in May i.e. $37^0$C. This result is meet with Kankaria, A.[8].

**Table-4:** Emissions from Domestic Fuels.

| Sources / Type of fuel | Consumption/day | Emission Rate (kg/day) | | | |
|---|---|---|---|---|---|
| | | PM | $SO_2$ | NOx | CO |
| Coal (Tons) | 70 | 350 | 532.00 | 104 | 3132 |
| Kerosene (KL) | 105 | 213 | 357.00 | 163 | 21 |
| LPG (Tons) | 91 | 38 | 0.04 | 164 | 40 |
| Wood and related fuel (tons) | 30 | 205 | 15.00 | 150 | 30 |

**Table-5:** Effects of Air Pollution.

| Impact Category | Pollutant / Burden | Effects |
|---|---|---|
| Human health – mortality | PM2.5, PM10, SO2, NOx, O3<br>Benzene, Benzo-[a]-pyrene, 1,3-butadiene, Diesel particles<br>Noise | Reduction in life expectancy<br>Cancers<br>Loss of amenity, impact on health |
| Human health – morbidity | PM2.5, PM10, O3, SO2<br>PM2.5, PM10, O3<br>PM2.5, PM10, NOx, CO<br>Benzene, Benzo-[a]-pyrene, 1,3-butadiene, Diesel particles<br>PM2.5, PM10, O3, NOx<br>Noise | Infection in lungs effected respiration,<br>Controlled way of activity<br>Heart attack<br>Risk of canser<br>Cardio and Cerebro-vascular admissions,<br>Chronic bronchitis, Cough in children, Cough in asthmatics, respiratory infections symptoms, Asthma attacks<br>Myocardial infarction<br>Angina pectoris<br>Hypertension<br>Sleep disturbance |

**Table-6:** Mean Maximum, Minimum and Average Temperature $^0$C.

| Months | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Maximum | 22.3 | 25.4 | 32 | 38 | 39.8 | 39 | 33.8 | 33.2 | 33.1 | 32.5 | 28.6 | 24.4 | 31.9 |
| Minimum | 8.2 | 10.6 | 15.6 | 21.1 | 25.1 | 27.2 | 26.4 | 26.1 | 24.8 | 19 | 12.8 | 8.7 | 18.8 |
| Average | 15.25 | 18 | 23.8 | 29.55 | 32.45 | 33.1 | 30.1 | 29.65 | 28.95 | 25.75 | 20.7 | 16.55 | 25.35 |

**Table-7:** Mean Monthly and Annual Rainfall in mm.

| Months | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Rainfall (mm) | 9.2 | 9.2 | 2.9 | 2.7 | 8.2 | 61.8 | 185.3 | 191.7 | 138.1 | 33.9 | 3.4 | 2.1 | 648.5 |

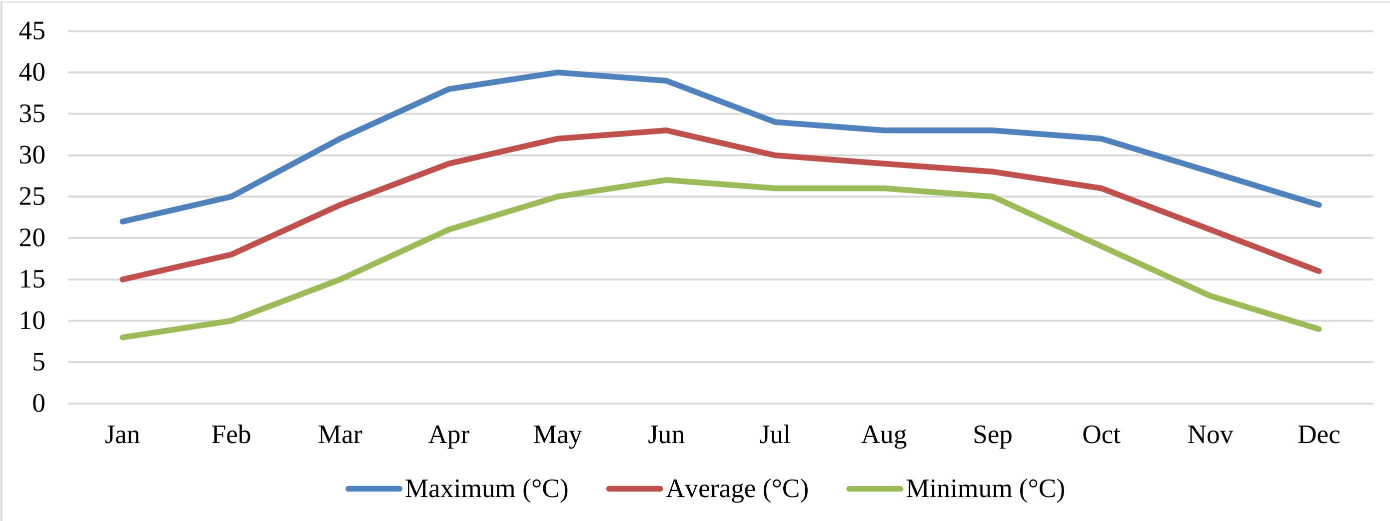



**Figure-2:** Yearly temperature variation graph.

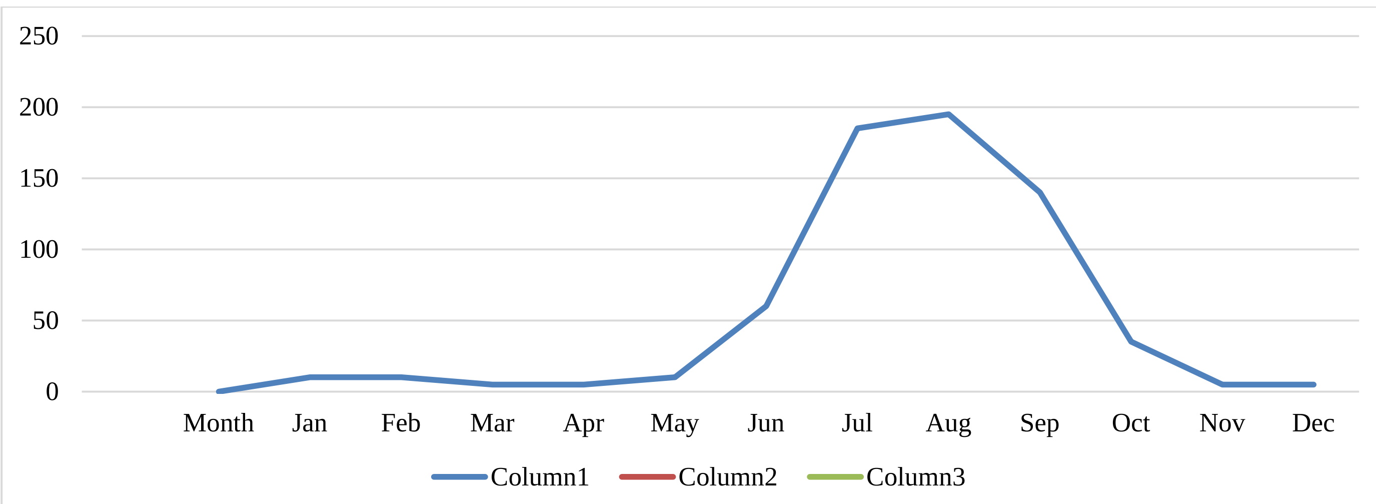



**Figure-3:** Annually rainfall variation.

From the above Table-7 and Figure-3, the Annual rainfall was also affected during the year due to climate change and air pollution. So it is necessary to control the change. Area of city is 403.70 $km^{2}$[29]. Kanpur, sitting at an average elevation of 126 m, is Uttar Pradesh's second most populous city after Lucknow, with one of the fastest-growing urban agglomerations in India[10]. To alleviate traffic congestion and redistribute travel loads, it is imperative to develop Kanpur into a strategic road and rail hub, alongside establishing a fully operational domestic airport, facilitating efficient connectivity and reducing excess intra- and inter-state travel.

The city's globally renowned leather and tanning industry, largely based in Jajmau, comprises nearly 400 tanneries, making it one of India's largest clusters. These facilities discharge effluents laden with heavy metals—especially hexavalent chromium (Cr(VI)), cadmium, lead and copper—into the River Ganga via untreated or inadequately treated wastewater, posing severe ecological and public health hazards[11].

Studies from 2023 to 2025 confirm that chromium levels in water and soil in Kanpur's industrial zones exceed permissible limits by several-fold, triggering chronic health issues—skin diseases, liver disorders, lung ailments, and detectable heavy metal accumulation in residents' blood and tissues[12-14]. Recent analyses suggest that structural interventions—such as unitization of tanneries (i.e. controlled consolidation)—may marginally reduce pollution but often raise leather prices and reduce social welfare unless coupled with strict enforcement of environmental norms[15,16].

Therefore, it is essential to modernize and regulate the tannery industry via the following measures: i. Mandatory installation and periodic audit of Common Effluent Treatment Plants (CETPs) and chromium recovery units. Many tanneries currently lack adequate systems for solid and effluent management, contributing to toxic leakage into water, air, and soil[17,18]. ii. Strict enforcement of CPCB and UPPCB guidelines, including regular inspection, legal penalties for non-compliance, and incentives for cleaner technologies. iii. Promotion of sustainable tanning alternatives—such as bio-tanning, microbial chromium reduction techniques, and resource-efficient wastewater treatment approaches[19,20]. Reducing pollution levels in Kanpur's leather hub is not simply desirable—it is indispensable. Industries must rigorously comply with pollution control board regulations, while state authorities should reinforce infrastructure, health interventions, and sustainability-focused policy.

## Action Plan

The study recommends that the following control options, identified as most effective in improving air quality, should be implemented in a progressive and systematic manner. These include the adoption of CNG/LPG for commercial vehicles, improvement in the inspection and maintenance of vehicles, and the banning of private vehicles older than 15 years. The installation of particulate control systems in industries and the promotion of natural gas/LPG for domestic use are also essential. In addition, unpaved roads should be converted into paved roads, and regular sweeping and watering using mechanized systems should be carried out to reduce dust emissions. Ensuring uninterrupted power supply to minimize the use of diesel generator sets, along with strict enforcement of bans on open burning, is necessary. Furthermore, encouraging shared transportation for common destinations and implementing alternate-day movement of taxis and four-wheelers can help reduce vehicular emissions. Finally, large-scale plantation of trees such as rubber, bamboo, and palm should be promoted to enhance air quality and environmental sustainability.

Severe Air Quality Deterioration:
Kanpur's Air Quality Index (AQI) has significantly worsened due to rapid industrial expansion.
The city is among the most polluted in India, as reported by the World Health Organization (WHO).

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Major Sources of Air Pollution:
Industrial emissions contribute 75% of air pollutants (mainly dust and soot).
Biomass burning accounts for 16% of pollution.
Vehicular emissions contribute 8–9%, but their impact increases in summer (equal to particulate matter).

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Seasonal Variation in Pollution:
Winter months show the highest pollution levels due to atmospheric conditions that trap pollutants closer to the ground.
Pollution in moderate seasons affects 20–80% of different areas, worsening in colder months.

↓

Health Impacts:
Air pollution is linked to respiratory diseases, cardiovascular complications, neurological disorders, premature births, increased mortality, and chronic irritation.
Toxic pollutants in the air also affect rainfall and the broader environment.

↓

Efforts to Mitigate Pollution:
Use of electric vehicles, public transport, and carpooling is being encouraged.
Tree plantation initiatives and industrial emission control measures have been introduced.

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Challenges and Future Directions:
Despite ongoing efforts, AQI remains below acceptable standards.
More stringent policies and effective mitigation strategies are required to improve air quality in Kanpur.

## Conclusion

From the above discussion, it can be concluded that Kanpur experiences a sub-tropical monsoon climate, characterized by significant seasonal variations in climatic elements such as temperature, rainfall, relative humidity, and wind patterns. Among these factors, temperature and rainfall play a crucial role in shaping the region's climatic conditions.

The summer months witness extreme temperatures, particularly in the southern plateau areas, where prolonged heating leads to intense atmospheric conditions. On the other hand, rainfall is predominantly concentrated during the southwest monsoon season, with the highest precipitation recorded in August. These climatic fluctuations directly influence the dispersion and accumulation of air pollutants, further exacerbating environmental challenges.

To combat deteriorating air quality, regular air monitoring is conducted by city boards, ensuring that pollution levels are systematically assessed. However, controlling air pollution also requires strict enforcement of environmental regulations, particularly within industrial sectors. Monitoring emissions at the source—especially in industrial zones—is critical to ensuring compliance with pollution control norms.

When industries are found violating air quality standards, regulatory authorities take necessary actions based on the observed reports. Initially, a show-cause notice is issued to non-compliant industries, mandating them to justify or rectify their practices. If violations persist, authorities enforce stringent measures, including closure of industries under the Air (Prevention and Control of Pollution) Act, 1981.

While monitoring and enforcement efforts are in place, continued public awareness, policy interventions, and sustainable industrial practices are essential for achieving long-term air quality improvements in Kanpur. Strengthening regulatory frameworks and promoting cleaner production technologies, green energy alternatives, and a forestation programs can contribute significantly to mitigating the adverse impacts of air pollution in the region.

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