Journal of Harbin Engineering University
ISSN: 1006-7043

Vol 46 No. 7
July 2025

A Comprehensive Study on the Assessment of Air Quality Index of Delhi using historical data

Md Moyeed Abrar[1], Dr. Syed Jawid Hussain[2], Mohammed Naveeduddin[3], Zeenath Sultana[4], Asra sarwath[5], Nikhat fatima[6]

[1]Assistant Professor, Department of Computer Science and Engineering, Faculty of Engineering & Technology, Khaja Bandanawaz University, Kalaburagi.

[2]Assistant Professor, Department of Civil Engineering, Faculty of Engineering & Technology, Khaja Bandanawaz University, Kalaburagi.

[3]Assistant Professor, Department of Computer Science and Engineering, Faculty of Engineering & Technology, Khaja Bandanawaz University, Kalaburagi.

[4]Assistant Professor, Department of Computer Science and Engineering, Faculty of Engineering & Technology, Khaja Bandanawaz University, Kalaburagi.

[5]Assistant Professor, Department of Computer Science and Engineering, Faculty of Engineering & Technology, Khaja Bandanawaz University, Kalaburagi.

[6]Assistant Professor, Department of Computer Science and Engineering, Faculty of Engineering & Technology, Khaja Bandanawaz University, Kalaburagi.

Abstract

Many developed nations have established and used AQI as a basis for classifying the ambient environment. The area's daily air quality index (AQI) is used to report how clean or dirty the air is and the health impacts that are linked to it. The research presented in this paper is the assessment of air quality index of the capital city of India, Delhi. The historical data of AQI and six pollutants PM2.5, PM10, NO2, SO2, CO and O3 were collected for a period of 5 years from 2020 to 2024 through Kaggle App. The monthly and annual averages were calculated. The computed monthly averages shows that the AQI is less in the months of July, August and September whereas it is more in the months of November, December, January and February. Moderate AQI values were noticed in the months of March, April, May and June. A reduced life expectancy as well as cardiovascular and respiratory disorders has been related to Delhi's poor air quality. The paper also explores the precautionary measures that Delhi city should implement to improve the AQI.

Introduction: An indicator number used to report the daily or hourly air quality in a region or locale is called the Air Quality Index (AQI). AQI's main goal is to safeguard the general public's health particularly that of vulnerable groups likes the elderly, young children, and asthmatics. The public is informed by regulatory bodies about the quality of the air in their surroundings and the health consequences that come with it.

Objectives: The main objective of the proposed research work is to assess the air quality index (AQI) of Delhi, the capital of India, using historical data. The data for a period of 5 years from 2020-2024 was gathered through the kaggle app. Furthermore the paper also explains the precautionary steps that Delhi should incorporate to improve the AQI.

Methods: The monthly and annual averages of Delhi City's air quality index (AQI) were calculated using the daily data collected during a five-year period from 2020 to 2024. Data on six pollutants—PM2.5, PM10, NO2, SO2, CO, and O3—were also gathered for the same study period in addition to the AQI data.

Results: The computed monthly averages show that the AQI is lower in July, August, and September and higher in November, December, January, and February. AQI levels were moderate in March, April, May, and June. Another significant finding is that, in comparison to the previous years of the study period, the yearly averages of the AQI and the six pollutants—PM2.5, PM10, NO2, SO2, CO, and O3—are lower for 2020. This is explained by the fact that Delhi was placed under total lockdown in 2020 as a result of COVID 19.

Conclusions: Delhi is in the news because of its persistently poor air quality index (AQI) measurements, especially in the winter. High Air Quality Index (AQI) readings are concerning since they frequently approach "severe" or even "severe-plus" levels. Due to a variety of issues, including industrial pollution, construction dust, vehicle emissions, and—most importantly—stubble burning in nearby states, Delhi's air quality index (AQI) regularly rises above the advised safe limits, with some readings reaching levels deemed detrimental to human health. The results presented in this paper demonstrate how AQI varied during the study period from 2020 to 2024. Low AQI values were observed especially in the year 2020. The reason for the decrease in AQI was due to less pollution levels as lockdown was implemented in the city. However from 2021 to 2024 there was a rapid rise in AQI due to more pollution. Delhi can greatly enhance its air quality and provide a better atmosphere for its citizens by putting the precautionary steps outlined in this paper into practice.
Keywords: Air quality index, historical data, health impacts, Delhi, pollutants, precautionary measures.

- **Introduction**

To determine each air pollutant's pollution level, the Pollutant Standard Index is a sub-index of the AQI [1]. Higher air pollution levels and increased health risks are indicated by higher AQI values. For instance, excellent air quality is indicated by an AQI value of 50 or below, and hazardous air quality is indicated by an AQI value of 300 or higher. Good, Satisfactory, Moderately Polluted, Poor, Very Poor, and Severe are the six AQI classifications. Every category has a distinct colour. The colour makes it simple to assess if the air quality is getting worse to the point where it is dangerous for humans [2], [3]. The concentration values of air contaminants and their probable health effects are used to determine each category. Eight pollutants—PM_{10}, $PM_{2.5}$, NO2, SO2, CO, O3, NH3, and Pb—for which short-term (up to 24 hours) national ambient air quality criteria are recommended have developed AQ sub-indices and health breakpoints [4], [5].

1.1 Air Pollution and its impact

Air pollution and its effects on human habitation are the most difficult problems that require immediate attention. There are a variety of sources of air pollution, including anthropogenic activities and both natural and man-made activities. The amount and quantity of air pollutants vary by region, depending on the kinds of industrial and other activities that ultimately result in different kinds of health risks. Air pollution's short and long-term health impacts have caused a lot of worry, but so have the negative effects that frequently rely on environmental factors, dosage, and personal vulnerability [10], [11].

Short-term effects are transient and can range from mild discomfort like eye, nose, skin, and throat irritation to more severe conditions including asthma, pneumonia, bronchitis, lung and heart issues, wheezing, coughing, and chest tightness. Extended long-term exposure to the pollutants can exacerbate these issues, as it damages the neurological, reproductive and respiratory systems and can lead to cancer and, in rare cases, death. Long-term consequences are chronic and may endure for years or for the rest of one's life and may even result in death. Additionally, the long-term toxicity of a number of air contaminants may cause a range of malignancies. Significant harm to the respiratory system is caused by dust, benzene, particulate matter (PMs), and oxygen. In the event that a respiratory condition like asthma already exists, there is an additional danger. Individuals who are more vulnerable include children, the elderly, and individuals with lung conditions [12], [13].

Strategies for preventing air pollution
1) Wear face masks outside
2) Limit your outside activities
3) Ventilate our house
4) Take a steam bath
5) Take public transportation

- **Objectives**

The primary goal of the planned study is to use historical data to evaluate Delhi, the Indian capital,'s air quality index (AQI). The Kaggle app was used to collect the data during a five-year period, from 2020 to 2024. Additionally, the report outlines the preventative measures Delhi should take to raise the AQI.
For the case study six pollutants were chosen PM2.5, PM10, NO2, SO2, CO and O3. The details of these six pollutants are as follows:
Particulate matter, which are microscopic particles suspended in the air, is referred to as PM2.5 and PM10. The diameter of PM2.5 particles is 2.5

micrometres or less, whilst PM10 particles are 10 micrometres or fewer in diameter. Although both are detrimental to human health, PM2.5 is usually regarded as more hazardous due to its ability to enter the bloodstream and lungs more deeply. PM2.5 is frequently linked to combustion sources such as industrial emissions and vehicle exhaust, but PM10 can originate from a broader range of sources, such as construction sites, unpaved roads, and agricultural operations [6], [7], [8].

Fossil fuel combustion, energy generation, vehicle emissions, and many industrial activities all release nitrogen dioxide (NO2) into the atmosphere [9]. The dangers of nitrogen dioxide intoxication are equal to those of carbon monoxide poisoning. It can seriously harm the heart when inhaled and cause inflammation, irritation of the airways, and absorption by the lungs. Nitrogen dioxide has an adverse effect on the environment, including causing smog and harming plants.

Sulfur dioxide (SO2) is corrosive and acidic, and it can combine with other substances in the environment to produce sulfuric acid and other sulfur oxides. The release of sulfur dioxide into the atmosphere is caused by emissions from factories, vehicles, burning fossil fuels, energy production, and other sources. In addition to reacting and forming particulate matter, sulfur dioxide is a key contributor to haze generation, acid rain, and damage to buildings, monuments, and vegetation. In people, it results in cardiac problems, respiratory distress, asthma, irritation of the eyes, nose, and throat, and airway inflammation [6].

Carbon monoxide (CO) is a colourless gas that is released into the atmosphere by gas stoves, kitchen chimneys, generators, fires, automotive emissions, smoking, and wood-burning devices. In humans, exposure to carbon monoxide results in carbon monoxide poisoning (interference with oxygen-hemoglobin binding), heart illness, chest pain, blurred vision, diminished mental capacity, and smog formation [6].

The environment and the human beings are seriously harmed by ground ozone (O3). Industries, vehicle emissions, fuel vapors, solvents, chemicals, and electronic equipment all emit it. Ground ozone is also influenced by overall volatile organic compounds (tVOCs) and nitrogen oxides (NOx). Reduced lung function, airway inflammation, and irritation of the eyes, nose, and throat are all observed when humans inhale ozone [6].

Methods

The identified eight contaminants' AQI values, matching ambient concentrations are shown in table 1.

Table 1 AQI category for eight pollutants and matching ambient concentrations.

AQI category, Pollutants and Health Breakpoints								
AQI category (Range)	PM_{10} 24-hour	$PM_{2.5}$ 24-hour	NO_2 24-hour	O_3 8-hour	CO 8-hour (mg/m^3)	SO_2 24-hour	NH_3 24-hour	Pb 24-hour
Good (0-50)	0-50	0-30	0-40	0-50	0-1.0	0-40	0-200	0-0.5
Satisfactory (51-100)	51-100	31-60	41-80	51-100	1.1-2.0	41-80	201-400	0.5-1.0
Moderately polluted (101-200)	101-250	61-90	81-180	101-168	2.1-10	81-380	401-800	1.1-2.0
Poor (201-300)	251-350	91-120	181-280	169-208	10-17	380-800	801-1200	2.1-3.0
Very Poor (301-400)	351-430	121-250	281-400	209-748*	17-34	801-1600	1200-1800	3.1-3.5
Severe (401-500)	430+	250+	400+	748+*	34+	1600+	1800+	3.5+

The related probable health effects based on the AQI values for the identified eight pollutants are illustrated in table 2.

Table 2. Probable health effects depending on AQI

AQI	Related health impacts.
Good (0-50)	Minimal effect
Satisfactory (51-100)	May cause sensitive people to have mild respiratory discomfort.
Moderately polluted (101-200)	May make it difficult for those who have lung conditions like asthma to breathe, as well as for those who have heart problems, youngsters, or elderly people.
Poor (201-300)	May make persons with heart disease uncomfortable and create breathing problems for those exposed for an extended period of time.
Very Poor (301-400)	May result in respiratory ailments for those who are exposed for an extended period of time. People with heart and lung conditions may experience a more noticeable effect.
Severe (401-500)	Serious health effects on those with heart or lung disease, as well as respiratory effects on healthy persons, may be felt even when engaging in mild physical exercise.

The assessment of AQI of Delhi city was done by computing the monthly and annual averages of AQI from the collected daily data of AQI for a period of five years from 2020 to 2024. Apart from the AQI data, the data of six pollutants PM2.5, PM10, NO2, SO2, CO and O3 were also collected for the same study period. The historical data was collected from the kaggle app. Delhi city was considered for the case study as it experiences worst AQI in India [14]. The latitude and longitude of Delhi city are 28.61ºN and 77.23ºE.

- **Results & Discussion**

Figure 1 and 2 illustrates the monthly and annual averages of AQI from 2020 to 2024.

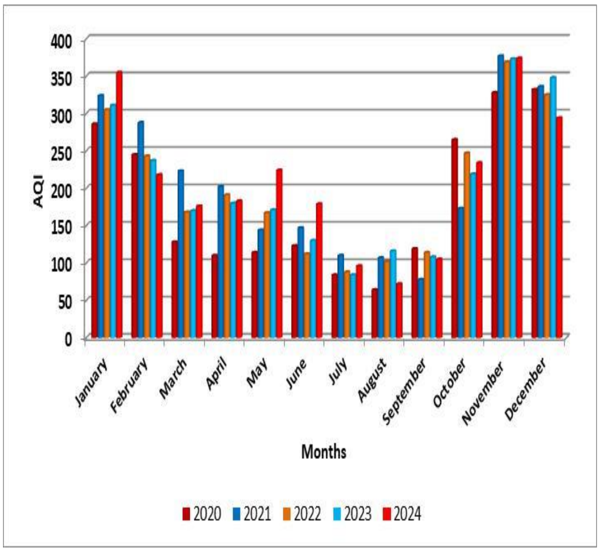

Figure 1. AQI monthly averages for the study period

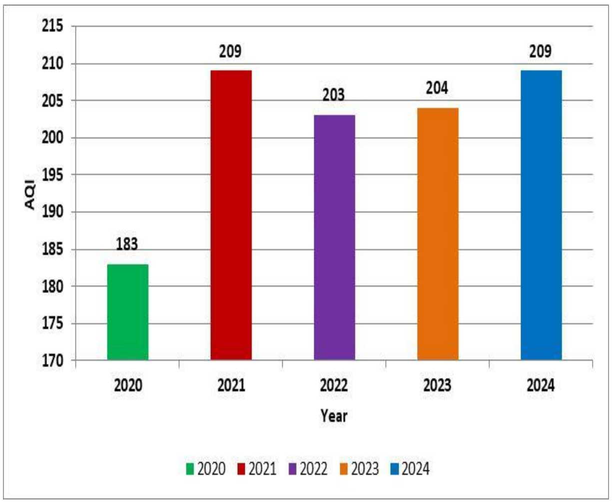

Figure 2. AQI annual averages for the study period

The annual averages for the six selected pollutants PM2.5, PM10, NO2, SO2, CO and O3 are depicted in figures 3, 4,5,6,7 and 8 respectively.

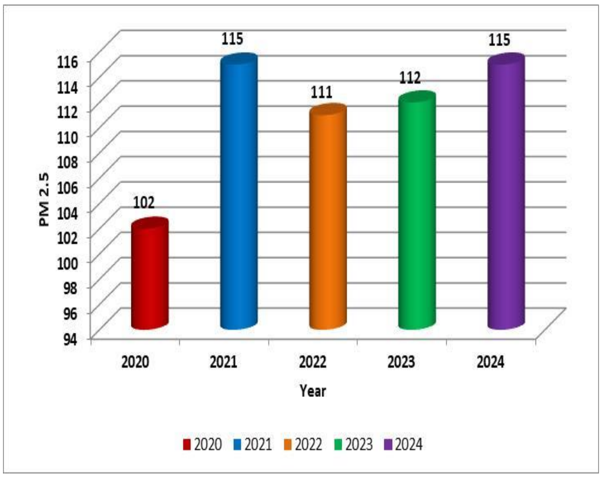

Figure 3. PM 2.5 annual averages for the study period

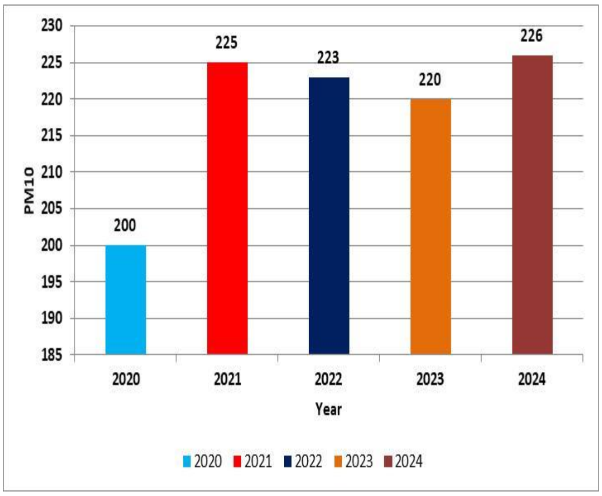

Figure 4. PM 10 annual averages for the study period

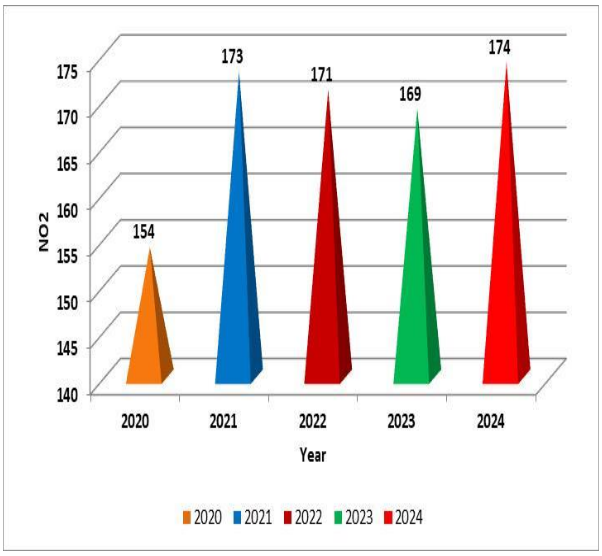

Figure 5. NO2 annual averages for the study period

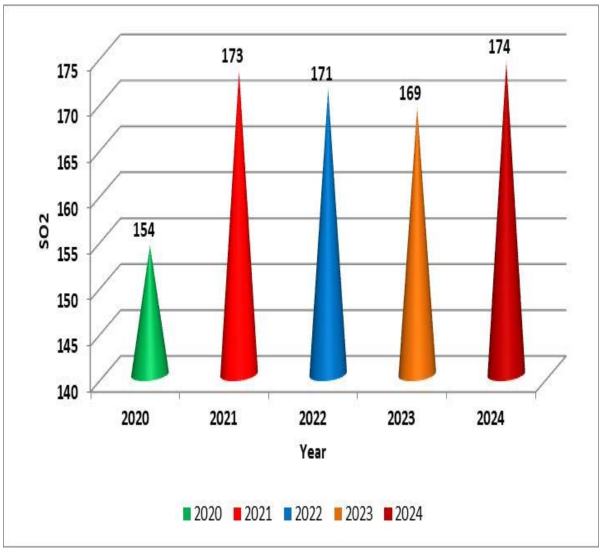

Figure 6. SO2 annual averages for the study period

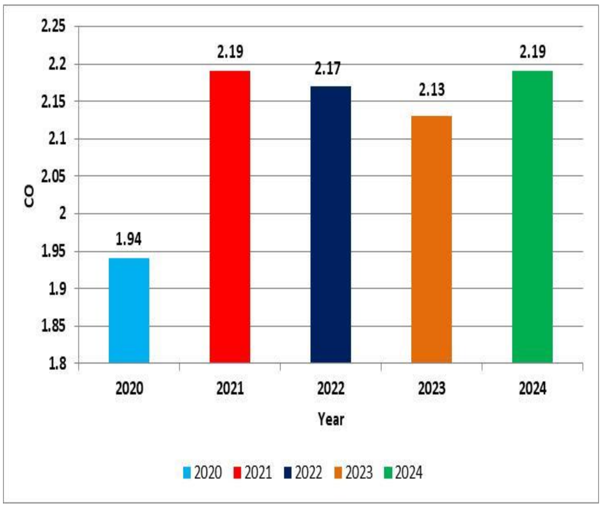

Figure 7. CO annual averages for the study period

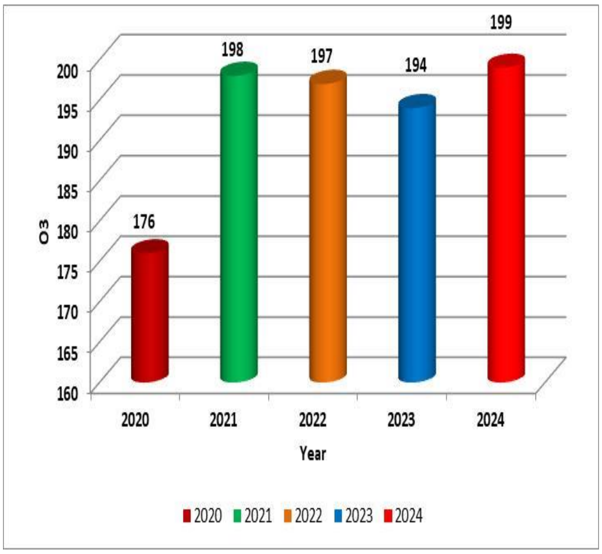

Figure 8. O3 annual averages for the study period

According to the calculated monthly averages, the AQI is higher in November, December, January, and February and lower in July, August, and September. The months of March, April, May, and June showed moderate AQI levels.

Another noteworthy observation is that for the year 2020 the annual averages of AQI as well the six pollutants PM2.5, PM10, NO2, SO2, CO and O3 is less compared to the remaining years of the study period. This can be attributed to the fact that in the year 2020 complete lockdown was implemented in Delhi due to covid 19 [15].

.1 Reasons for Poor Air Quality Index in Delhi

a) Vehicle Emissions: There are a lot of cars in Delhi, and motorbikes, buses, and cars all contribute significantly to air pollution.

b) Construction and Industrial Activities: Dust from building sites and industrial pollutants are two more factors causing the city's air quality issues.

c) Stubble Burning: The burning of agricultural leftovers in adjacent states like Punjab and Haryana during the autumn harvesting season contributes greatly to Delhi's haze, especially during periods of low wind speed and cold temperatures that trap pollutants.
d) Factors related to geography: The fact that Delhi is bordered by landlocked areas may make the effects of pollution worse.

- **Precautionary measures to be adopted to improve AQI in Delhi**

Delhi requires a multifaceted strategy that focuses on lowering emissions from multiple sources and encouraging cleaner alternatives in order to enhance its Air Quality Index (AQI). This entails encouraging greener energy sources and sustainable practices, investing in public transit, and enforcing rules more strictly.

.1 Cutting Down on Vehicle Emissions

a) Encourage public transportation by developing and growing options such as buses and the metro, making them more accessible and reasonably priced.
b) Promote electric vehicles by investing in charging infrastructure and providing incentives for the purchase of electric automobiles.
c) Reduce industrial emissions by enforcing more stringent laws and encouraging greener industrial processes.
d) Promote carpooling and optimize traffic light timings as ways to improve traffic management and cut down on idling and congestion.

.2 Administering waste and burning of biomass

a) Strict sanctions should be enforced for burning trash, and appropriate waste management techniques should be encouraged.
b) Promote sustainable agriculture by persuading farmers to use crop residue for bioenergy production as an alternative to burning it.
c) Enhance landfill management: To reduce methane emissions, landfills should adopt improved waste management procedures.

.3 Green Initiatives and Infrastructure

a) Boost green cover: To absorb pollutants and enhance air quality, plant more trees and make green areas.
b) Encourage renewable energy: To lessen dependency on fossil fuels, make investments in wind and solar energy.
c) Enhance infrastructure: To promote walking and bicycling, make investments in better roads, sidewalks, and bike lanes.

.4 Schemes and imposition

a) Tougher rules: Implement new air quality restrictions as needed and enforce current ones.
b) Campaigns for public awareness: Increase knowledge of the causes and effects of air pollution and encourage individual efforts to cut pollution.

By taking these steps, Delhi can greatly enhance the quality of its air and give its citizens a healthier living space.

Refrences

[1] Suman, "Air quality indices: A review of methods to interpret air quality status", Materials Today: Proceedings, https://doi.org/10.1016/j.matpr.2020.07.141
[2] Air Quality Index – "A Comparative Study for Assessing the Status of Air Quality", Shivangi Nigam, B.P.S. Rao, N. Kumar, V. A. Mhaisalkar, Research J. Engineering and Tech. 6(2): April-June, 2015.
[3] Gaurav Kumar, Saurabh Kumar, Dr Suman, "Air quality index – A comparative study for assessing the status of air quality before and after lockdown for Meerut" Materials Today Proceedings 49(2), 2021, https://doi.org/10.1016/j.matpr.2021.05.575
[4] Nigam, B.P.S. Rao, N. Kumar, V. A. Mhaisalkar Shivangi, "Air Quality Index – A Comparative Study for Assessing the Status of Air Quality", Research J. Engineering and Tech. 6(2): April-June, 2015.
[5] Kaushik. C. P., Ravindra K., Yadav K., Mehta S. and Haritash A.K."Assessment of ambient air quality in urban centres of Haryana (india) in relation to different anthropogenic activities and health risks". Environment Monitoring and Assessment. 122; 2006:27-40.

[6] Sultan Ayoub Meo, Mustafa A Salih, Joud Mohammed Alkhalifah, Abdulaziz Hassan Alsomali, Abdullah Abdulrahman Almushawah, Environmental pollutants particulate matter (PM2.5, PM10), Carbon Monoxide (CO), Nitrogen dioxide (NO2), Sulfur dioxide (SO2), and Ozone (O3) impact on lung functions, Journal of King Saud University - Science 36 (2024) 103280. https://doi.org/10.1016/j.jksus.2024.103280

[7] Lin, Y.C., Li, Y.C., Shangdiar, S., Chou, F.C., Sheu, Y.T., Cheng, P.C., 2019. Assessment of PM2.5 and PAH content in PM2.5 emitted from mobile source gasoline-fueled vehicles in concomitant with the vehicle model and mileages. Chemosphere 226, 502–508.

[8] Zhilong Guo, Xiangnan Jing, Yuewei Ling, Ying Yang , Nan Jing , Rui Yuan & Yixin Liu, "Optimized air quality management based on air quality index prediction and air pollutants identification in representative cities in China", Scientific Reports (2024) 14:17923 https://doi.org/10.1038/s41598-024-68972-w

[9] Chakraborty P (2020) Exposure to nitrogen dioxide (NO2) from vehicular emission could increase the COVID-19 pandemic fatality in India: a perspective. Bull Environ Contam Toxicol 105(2):198–204

[10] Bert Brunekreef, Stephen T Holgate, Air pollution and health, Lancet 2002; 360: 1233–42

[11] Ronit Peled, Air pollution exposure: Who is at high risk? Atmospheric Environment 45 (2011) 1781e1785, https://doi.org/10.1016/j.atmosenv.2011.01.001

[12] Abdulmuhsin S. Shihab, "Assessment of Air Quality through Multiple Air Quality Index Models – A Comparative Study", Journal of Ecological Engineering 2023, 24(4), 110–116, https://doi.org/10.12911/22998993/159398

[13] Johannson KA, Balmes JR, Collard HR (2015) Air pollution exposure: a novel environmental risk factor for interstitial lung disease? Chest 147(4):1161–1167

[14] Mohammad Sarmadi, Sajjad Rahimi, Mina Rezaei, Daryoush Sanaei and Mostafa Dianatinasab, "Air quality index variation before and after the onset of COVID-19 pandemic:a comprehensive study on 87 capital, industrial and polluted cities of the world", Environmental Sciences Europe (2021) 33:134.

[15] Kumar P et al (2020) Temporary reduction in fine particulate matter due to 'anthropogenic emissions switch-off' during COVID-19 lockdown in Indian cities. Sustainable Cities Society. 62:102382.