Internship Training

at

IIHMR

Comparative Study on Air Quality Index and Air Pollution Levels in three select cities of the World

by

Name : **Deepali Bhardwaj**

Enroll No. : **PG/21/027**

Under the guidance of

Dr. Ratika Samtani

PGDM (Hospital and Health Management)

2021-23

International Institute of Health Management Research

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Abstract

This study contained the detailed comparison of Air Quality Index had been done of 3 cities across the world i.e. Delhi, London, and Mexico City from Jan 2021 to Dec 2023. It has been observed that every indicator of AQI was high in Delhi except in Monsoon seasons, where Delhi's AQI showed some dip.

The variables that had taken in consideration were population, population density, number of petroleum motor vehicles, Road Dust, and Smoke emission industries and how they contribute to air pollution. Delhi showed rapid increase in population in last decade while, London and Mexico city were showed less growth in pollution as well as in population density. Delhi also showed sudden increase of petroleum vehicles in a span of 10 years which ultimately resulting in building more and more roads which are the two major factors for air pollution.

There are various non communicable diseases by air pollution like, Asthma, COPD and Lungs Cancer. As Delhi showed poorest Air Quality, it also showed highest number of cases of these diseases. The government had taken various initiatives to tackle this problem, but it didn't seems enough and other solutions would also be taken in consideration.

Completion of Dissertation

The certificate is awarded to

DEEPALI BHARDWAJ

in recognition of having successfully completed her

Internship

and has successfully completed her Project on

Comparative Study on Air Quality Index and Air Pollution Levels in three select cities of the World

Date 30th May, 2023.

IIHMR Delhi

She comes across as a committed, sincere & diligent person who has a strong drive & zeal for learning.

We wish her all the best for future endeavors.

Dr. Bipinkumar Rathod
Zonal Head

TO WHOMSOEVER IT MAY CONCERN

This is to certify that *DEEPALI BHARDWAJ* student of PGDM (Hospital and Health Management) from International Institute of Health Management Research, New Delhi has undergone internship training at *IIHMR Delhi,* from 1st February 2023 to 31st May 2023.

The Candidate has successfully carried out the study designated to her during internship training and her approach to the study has been sincere, scientific and analytical.

The Internship is in fulfillment of the course requirements.

I wish her all success in all her future endeavors.

Dr. Sumesh Kumar

Associate Dean, Academic and Student Affairs

IIHMR, New Delhi

Dr. Ratika Samtani

Mentor

IIHMR, New Delhi

Certificate of Approval

The following dissertation titled **"Comparative Study On Air Quality Index and Air Pollution Levels in the three select Cities of the World"** at "IIHMR DELHI" is hereby approved as a certified study in management carried out and presented in a manner satisfactorily to warrant its acceptance as a prerequisite for the award of PGDM (Health Management) for which it has been submitted. It is understood that by this approval the undersigned do not necessarily endorse or approve any statement made, opinion expressed or conclusion drawn therein but approve the dissertation only for the purpose it is submitted.

NAME	Signatures
1. PRAVEEN KUMAR	
2. VINAY	
3. SUKESH BHARDWAJ	

Certificate from Dissertation Advisory Committee

This is to certify that **Miss. DEEPALI BHARDWAJ ,** a graduate student of the **PGDM (Hospital & Health Management)** has worked under our guidance and supervision. She is submitting this dissertation titled " Comparative Study on Air Quality Index and Air Pollution Levels in three select cities of the World" under "Dr. Bipinkumar Rathod" in partial fulfillment of the requirements for the award of the **PGDM (Hospital & Health Management).**

This dissertation has the requisite standard and to the best of our knowledge no part of it has been reproduced from any other dissertation, monograph, report or book.

Dr. Ratika Samtani
Assistant Professor
IIHMR, Delhi

Dr. Bipinkumar Rathod
BSc, MBA (Health Informatics),
RGN(UK).
Digital Health Specialist, UNICEF.

INTERNATIONAL INSTITUTE OF HEALTH MANAGEMENT RESEARCH, NEW DELHI

CERTIFICATE BY SCHOLAR

This is to certify that the dissertation titled *" Comparative Study on Air Quality Index and Air Pollution Levels in three select cities of the World"* and submitted by *DEEPALI BHARDWAJ* Enrollment No. *PG/21/027* under the supervision of …*Dr. Bipinkumar Rathod* for award of PGDM (Hospital & Health Management) of the Institute carried out during the period from *1st February, 2023* to *31st May, 2023*.

It embodies my original work and has not formed the basis for the award of any degree, diploma associate ship, fellowship, titles in this or any other Institute or other similar institution of higher learning.

Signature

FEEDBACK FORM

Name of the Student: Deepali Bhardwaj

Name of the Organization in Which Dissertation Has Been Completed:
Personal Capacity as Digital Health Specialist in UNICEF(DICE)

Area of Dissertation: Air Pollution
Global Comparison

Attendance: 90%

Objectives achieved: yes

Deliverables: Find the relevant Statistics from The database, Statistical Comparison of AQI

Strengths: Excellent Communication in English and narrative of Concepts

Suggestions for Improvement:
Schedulin her tasks, priority Setting

Suggestions for Institute (course curriculum, industry interaction, placement, alumni):
Digital Component in Public health Curriculum

Date:

Place: Nuneaton Warwickshire,

Signature of the Officer-in-Charge/ (Organization Mentor)

ACKNOWLEDGEMENT

It is my pleasure to present this Dissertation Report by thanking everyone who helped me. I would like to express my sincere gratitude towards my nodal person Dr. Bipinkumar Rathod (Digital Health Specialist), who helped me immensely throughout the tenure of my dissertation and Dr. Jacob M Puliyel (MBBS, MD - Pediatrics) who inspired me greatly and helped me with his valuable guidance, support, interest, encouragement, involvement, and advice.

I would also like to express my special thanks to Dr. Sutapa Bandyopadhyay Neogi (Director, IIHMR Delhi), my mentor Dr. Ratika Samtani (Assistant Professor, IIHMR Delhi) and Mr. Tanuj Kaushik (Senior, IIHMR Delhi) who have been a constant support in improving the quality of my dissertation and making it meaningful and for providing such a great opportunity which helps me to grow and learn about many interesting aspects.

I would like to thank the whole IIHMR Delhi Team for providing me with this great opportunity to work in this ample organization and gain experience and make this dissertation possible.

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1. INTRODUCTION

Since the beginning of Industrial Revolution in late 1700s, London is facing the problem of Air pollution. And in 21st century, in London alone, air pollution contributes to in excess of 9,400 premature deaths every year, and costs the health system between £1.4 and £3.7 billion per year, as well damaging buildings and biodiversity through the formation of pollutants into acid rain. The major reason is the heating of homes and road vehicles as they produce nitrogen oxides and tiny particles of rubber and metal which can't be seen with the naked eye and can harm human health and the environment we live in. And all these are human-made air pollution and have a huge impact on our health such as-

- short term exposure let's say for a few hours to high levels of Nitrogen oxide can irritate the airways and cause severe coughing and exacerbate existing respiratory illnesses, which is uncomfortable at best, and dangerous at worst for vulnerable people (for instance- sick and older or younger people).

- Long-term exposure can contribute to someone developing many illnesses, such as asthma, pulmonary disease and lung cancer. It has also been shown to stunt the growth of children's lungs. This is particularly worrying, as around one-third of London's schools be close to busy roads that suffer illegal levels of NO2 pollution.

For our survival, the lungs supply our bodies with oxygen, which is necessary but as one breathes in oxygen, they also take in a lot of pollutants which are harmful to the respiratory system.

A person having a sensitive respiratory system will react to inhaling pollutants and exhibit immediate symptoms such as coughing, wheezing and teary eyes.

Even people without immediate sensitivity will succumb to the negative effects of air pollutants in the long run. For instance, Asthma is a condition that causes swelling in the respiratory tract and interferes with normal breathing. It is one of the conditions prevalent in people who live in areas with heavy air pollution.

Some research even suggests that there is a link between air pollution and dementia, although the understanding of this issue is in the early stages and it is stressed that more research must be completed. It is clear, however, that poor air quality has significant effects on human health and needs to be addressed as a matter of urgency.

Since the time of the Industrial Revolution, this problem of air pollution has been aggravating at a higher rate but solutions can be brought up by getting the support of all the citizens, and government parties to tackle air pollution by-

* Reducing exposure of Londoners to harmful pollution across London – especially at priority locations like schools – and tackling health inequality

* Achieving legal compliance with UK and EU limits as soon as possible, including by mobilising action from the London boroughs, government and other partners

* Establishing and achieving new, tighter air quality targets for a cleaner London, meeting World Health Organization (WHO) health-based guidelines by 2030 by transitioning to a zero-emission London.

2. **Literature Review**

In the study **".Mortality and morbidity during the London fog of December 1952.London:HMSO,1954."** by **Ministry of Health, UK.** This report provides a detailed analysis of the health effects of the Great Smog of London in 1952. The report found that the smog caused an estimated 4,000 additional deaths in Greater London, with the highest death tolls among the elderly, the poor, and those with respiratory conditions. The report also found that the smog caused an increase in respiratory illness, such as bronchitis and pneumonia. This report was a landmark study in the field of air pollution epidemiology and helped to raise awareness of the health risks of air pollution.

In the study **"Air pollution and its effects on the immune system."** by **Glencross, Drew A et al.** This review article provides a comprehensive overview of the effects of air pollution on the immune system. The authors discuss how air pollution can affect different immune cell types, such as particle-clearing macrophages, inflammatory neutrophils, dendritic cells that orchestrate adaptive immune responses, and lymphocytes that enact those responses. They also discuss how air pollution can dysregulate immune responses, leading to increased susceptibility to infection, allergic reactions, and autoimmune diseases.

The authors conclude that air pollution is a major environmental risk factor for immune dysfunction, and that further research is needed to understand the mechanisms underlying these effects and to develop strategies for prevention and treatment. Air pollution is a major environmental risk factor for asthma. It can trigger asthma attacks, worsen asthma symptoms, and increase the risk of developing asthma in the first place. The mechanisms by which air pollution causes harm to people with asthma are not fully understood, but they are likely to involve oxidative stress, inflammation, and changes in gene expression.

"Air Pollution and Asthma: Mechanisms of Harm and Considerations for Clinical Interventions." by **Pfeffer, Paul E et al.** This study provides a comprehensive overview of the mechanisms by which air pollution can harm people with asthma. The authors discuss the evidence from a wide range of studies, and they highlight the need for further research on this important topic. Air pollution can increase the production of pro-inflammatory cytokines, which can lead to airway inflammation. Air pollution can damage the lining of the airways, making them more susceptible to infection. It can impair the function of the airways' natural defenses, making it harder to clear allergens and irritants. It can increase the risk of developing asthma in children. The review article by Pfeffer et al. provides a valuable resource for researchers and clinicians who are interested in the effects of air pollution on asthma. The authors highlight the need for further research on this important topic, and they suggest that studies should

focus on understanding the mechanisms underlying the effects of air pollution on asthma and developing strategies for prevention and treatment. In addition to the mechanisms mentioned above, air pollution can also affect the gut microbiome, which can have a negative impact on asthma symptoms. Air pollution can also increase the risk of developing allergic sensitization, which is a risk factor for asthma.

The study by **"Oxidative Stress, Environmental Pollution, and Lifestyle as Determinants of Asthma in Children." Vincenzo et al. (2023)** investigated the role of oxidative stress, environmental pollution, and lifestyle in the development of asthma in children. The authors conducted a comprehensive review of the literature and found that all three factors can contribute to the development of asthma. Oxidative stress occurs when there is an imbalance between the production of reactive oxygen species (ROS) and the body's ability to remove them. ROS are produced naturally by the body, but they can also be produced by environmental pollutants. When ROS levels are too high, they can damage cells and tissues, which can lead to inflammation and other problems. Environmental pollutants, such as traffic exhaust, cigarette smoke, and ozone, can also contribute to the development of asthma. These pollutants can irritate the airways and trigger an allergic reaction. Finally, lifestyle factors, such as a poor diet, lack of exercise, and exposure to secondhand smoke, can also increase the risk of developing asthma.

The study by **"A hybrid deep learning framework for air quality prediction with spatial autocorrelation during the COVID-19 pandemic."** by **Zhao et al.** (2023) developed a hybrid deep learning framework for air quality prediction with spatial autocorrelation during the COVID-19 pandemic. The authors used a combination of spatial autocorrelation (SAC) and deep learning to predict air quality in Wuhan and Shanghai during the pandemic. SAC is a statistical technique that measures the degree of correlation between neighboring observations. This technique was used to capture the spatial dependence of air quality data. Deep learning is a machine learning technique that can learn complex patterns from data. This technique was used to learn the temporal dynamics of air quality data. The authors found that the hybrid deep learning framework was able to improve the accuracy of air quality prediction during the COVID-19 pandemic. The framework was able to reduce the prediction error by about 47% for Wuhan and 67% for Shanghai. The study by Zhao et al. (2023) is a valuable contribution to the field of air quality prediction. The authors have developed a novel framework that can be used to improve the accuracy of air quality prediction during the COVID-19 pandemic and other periods of social disruption.

3. Objectives/Key Research Questions.

i. To analyze and compare trends in air quality in three cities across geographies- UK (London), India (Delhi) and Mexico (Mexico City).

ii. To analyse the Root cause and effects on Health due to Poor AQI in Delhi, London and Mexico City.

iii. To analyse the initiatives taken by the Government and Industry in Delhi, London and Mexico City to ensure cleaner air.

4. Methodology

Study area and population- It is descriptive, quantitative research study.

Geographical location used in study in limited to three Cities Around the world i.e. Delhi, London, Mexico City.

This study had utilize the air quality index (AQI) data from the respective Air Quality Monitoring Stations for the year 2021-2022.

The daily and Monthly data on air pollutants obtained from the online portal of the Central Pollution Control Board (CPCB), particularly the data for , and

Inclusion criteria- PM10 (size of particulate matter <10 microns), PM2.5 (size of particulate matter <2.5 microns), SO2, NO2, CO and Ozone, Climate, Monsoon and Western Disturbance

Population, Population Density, Number of Petrol/Diesel Motor Vehicles in the city, number of smoke emission industries.

Lung Cancer, COPD, Asthma

Exclusion Criteria- Other meteorological parameters.

Migration, Kms of Road Build, No. of Construction Siities, Number of Heavy Vehicles in city, ire Crackers.

Strokes, Pneumonia, Heart Diseases, Diabetes, Skin Irritation, Effect on Crops.

Duration- January 2021 - December 2022

Materials and methods- Extracting data from the portal.

Extracting data from other researhes.

General tabulation is the format for data analysis.

WPS Excel is used for the data analysis.

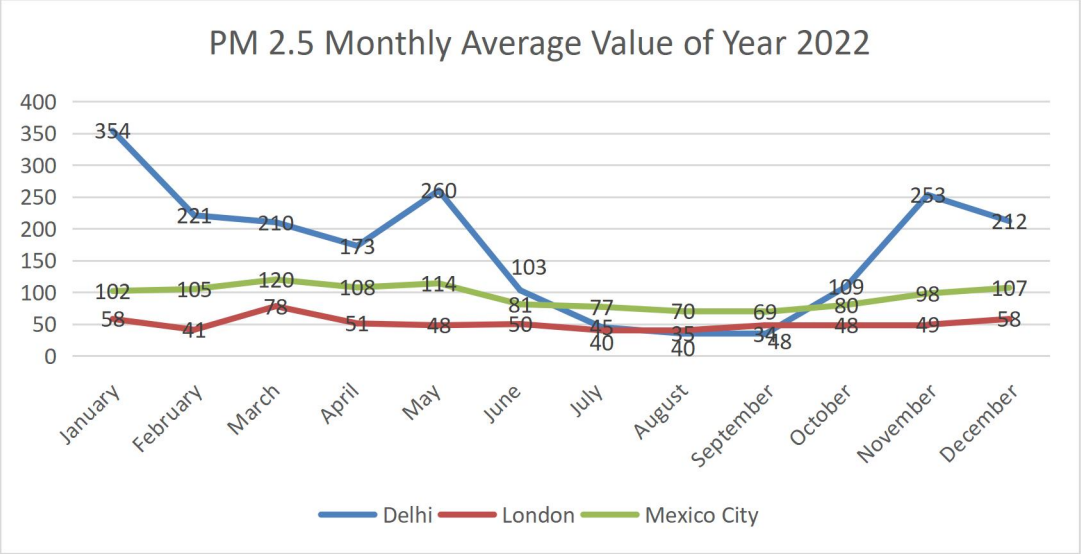
Outcome measures- This study shows the comparison of air pollution in different cities located far away in the world, i.e., London, Mexico City and New Delhi.

The outcome shows which city has the highest value of PM 2.5, PM 10, SO2, CO, O3 and NO2 and which city has the least and why in different period of time.

This also addresses which city has major impact of pollution in public health and in which cities there are higher number of diseases (COPD, lung cancer, asthma, etc.) caused by air pollution.

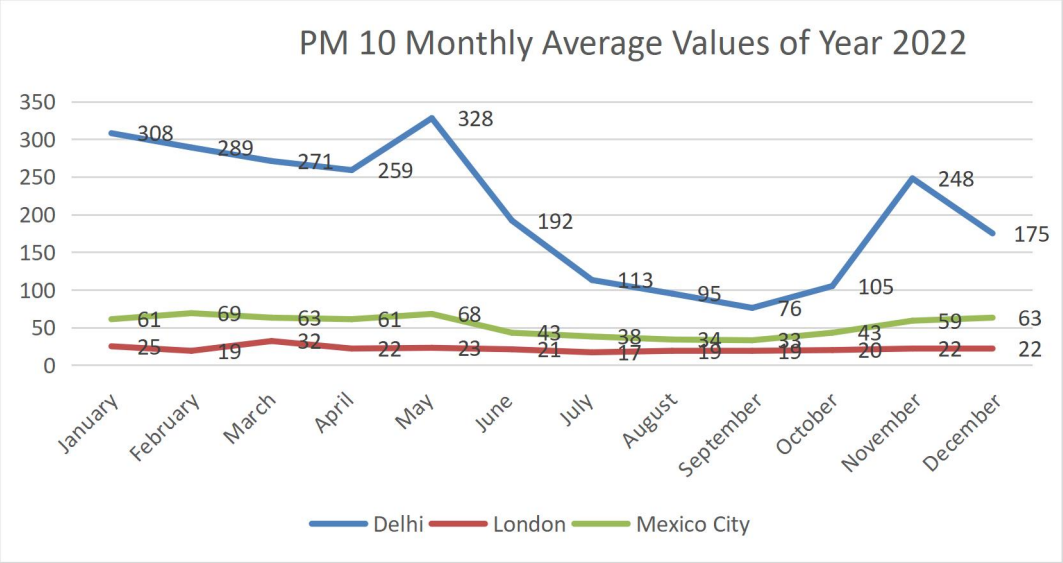
5. RESULTS

5.1) AQI Analysis of Year 2022



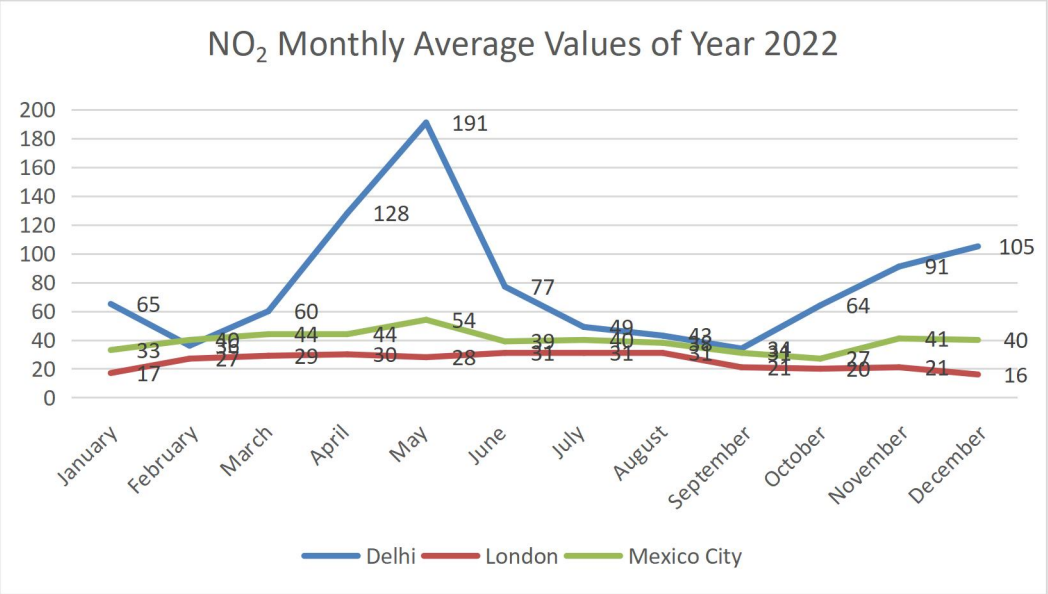
(Fig. 5.1.1) Comparison of PM2.5 Monthly Average Values of Delhi, London and Mexico City of Year 2022.

Fig 5.1.1 shows comparison of PM2.5 between cities of Delhi, London and Mexico City in Year 2022. In fig 5.1.1, it is shown that Delhi has highest value for PM 2.5, but from July 2022 to September 2022, was at lowest level. In Delhi, the highest value of 354 in the month of January and lowest at the month of September I.e., 34 . While Mexico City was showing a constant range of PM 2.5 with highest value of 120 at the month of march and lowest of 69 in the month of September. Similarly, London had the highest and lowest values for PM 2.5 was 58 and 40 respectively.



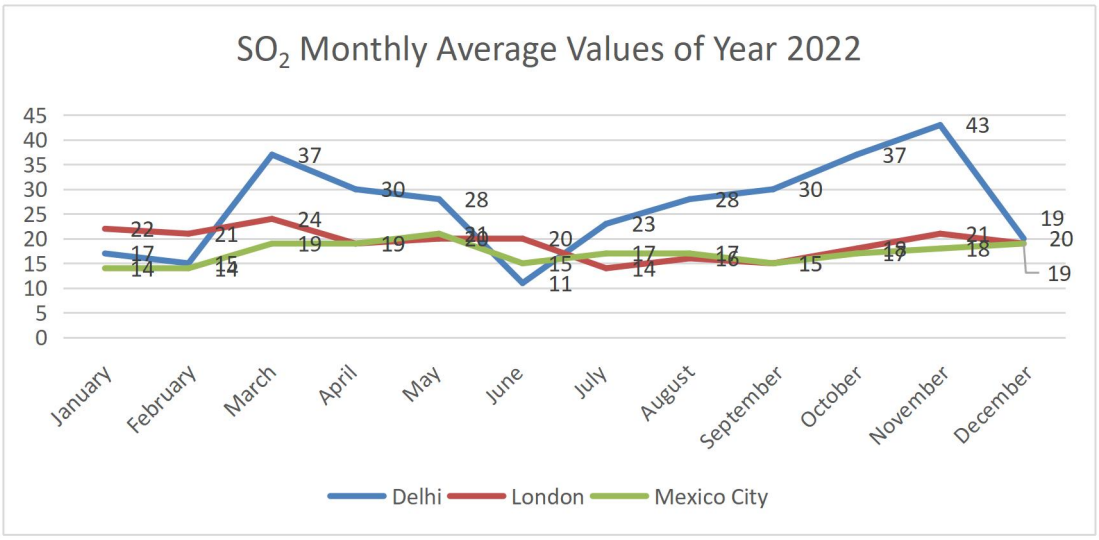
(Fig. 5.1.2) Comparison of PM 10 Monthly Average Values of Delhi, London and Mexico City of Year 2022.

Fig 5.1.2 shows comparison of PM 10 between cities of Delhi, London and Mexico City in Year 2022. In fig 5.1.2, it is shown that Delhi had highest value for PM 10 in May, but in September 2022, it was at lowest level. In Delhi, the highest value of 354 in the month of January and lowest at the month of September I.e., 76. While Mexico City and London was showing a constant range of PM 10 from July to September. Mexico City's highest value of PM 10 was 68 in the month of May and lowest of 33 in the month of September. Similarly, London had the highest and lowest values for PM 10, i.e., 32 in March and 15 in September, respectively.



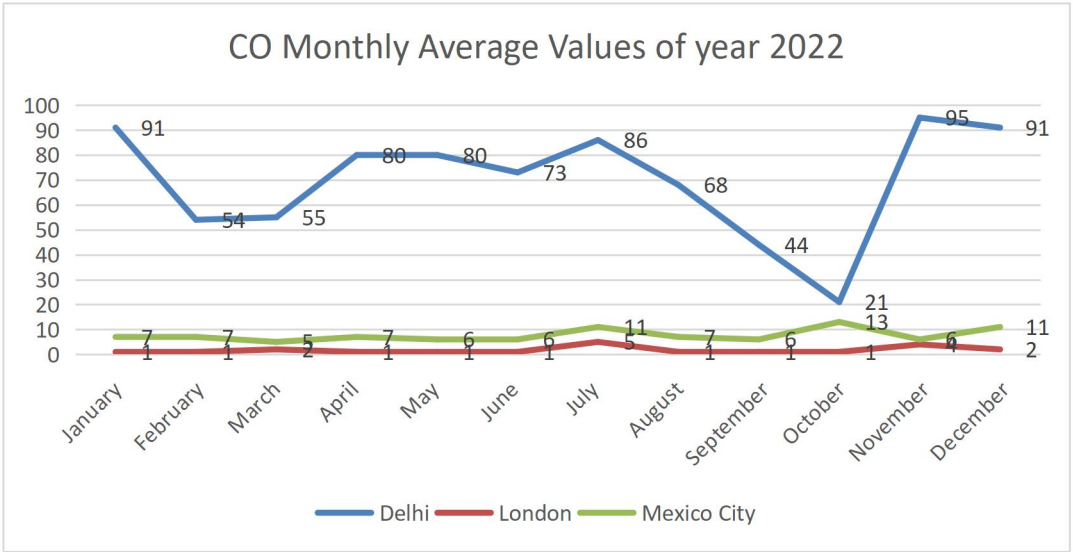
(Fig. 5.1.3) Comparison of NO_2 Monthly Average Values of Delhi, London and Mexico City of Year 2022.

Fig 5.1.3., shows that Delhi's NO_2 level was the highest with 191 in May and lowest with 34 in September. While Mexico City's highest level of NO_2 was 54 and the lowest was 27 in October. Whereas in London, the highest level of NO_2 was 31 for three months in continuity (June, July and August) and the lowest was 16 in December.In this figure, London had the lowest level of NO_2 as compared to Delhi and Mexico City.



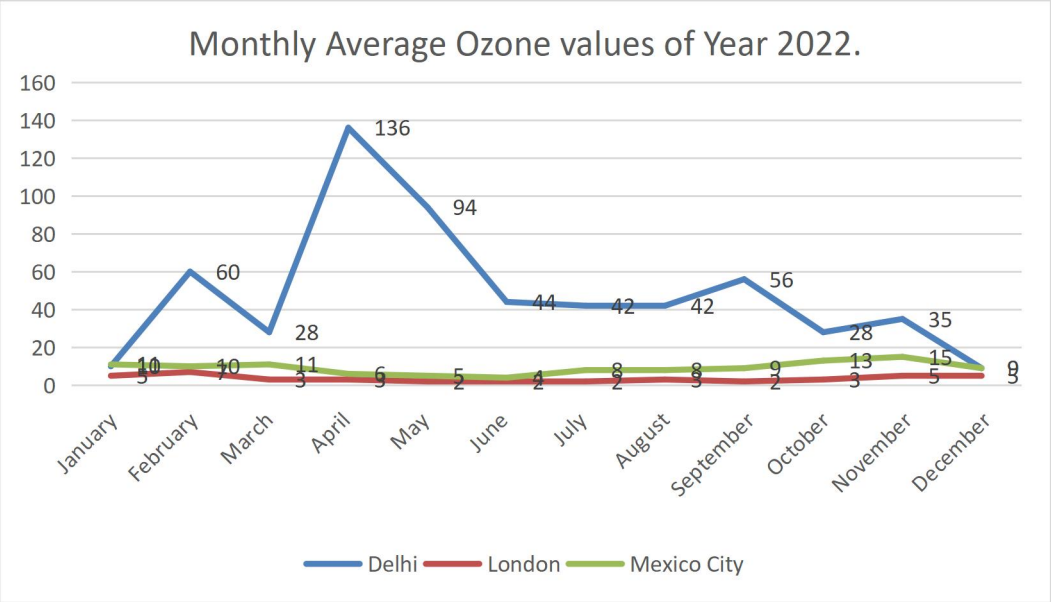
(Fig. 5.1.4) Comparison of SO_2 Monthly Average Values of Delhi, London and Mexico City of Year 2022.

Fig 5.1.4., shows that Delhi has the highest value of SO_2 i.e., 43 in the month of November and the lowest at 11 in the month of June. As per the figure, London's highest value of SO2 is 24 and the lowest is 14. Mexico City's highest level of SO2 was 20 and the lowest level of SO2 was 14.



(Fig. 5.1.5) Comparison of CO Monthly Average Values of Delhi, London and Mexico City of Year 2022.

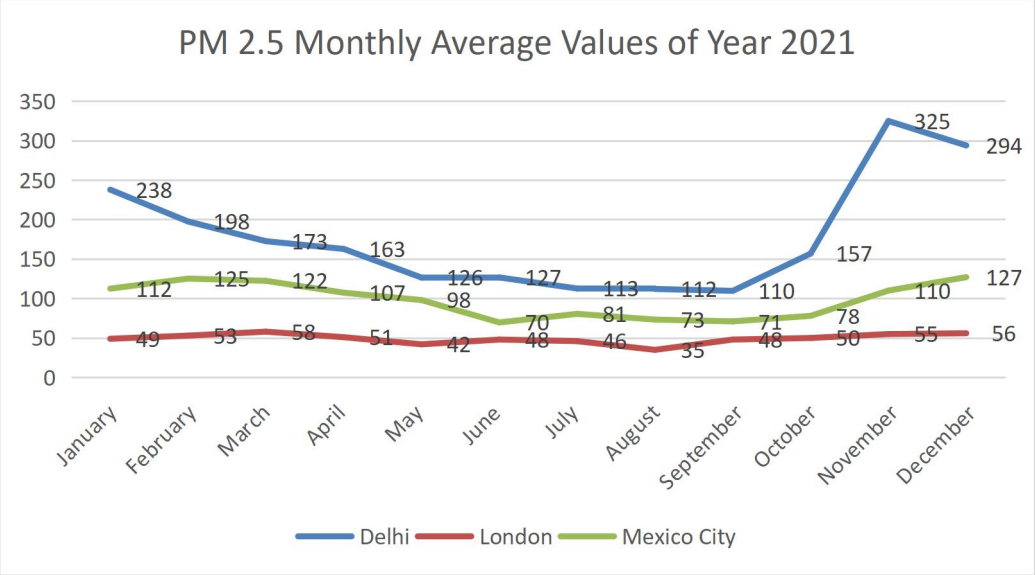
In this figure Fig5.1.5, Delhi has the highest level of CO as compared to London and Mexico City. Delhi's highest level of CO is 95 in the month of November and the lowest is 21 in the month of October. Whereas, Mexico City's highest level of CO has been 13 and the lowest level has been 5 in the month of March. London has been in the constant range with the lowest level of CO i.e., 1 and the highest has been 5 in the month of July.



(Fig. 5.1.6) Comparison of Ozone Monthly Average Values of Delhi, London and Mexico City of Year 2022.

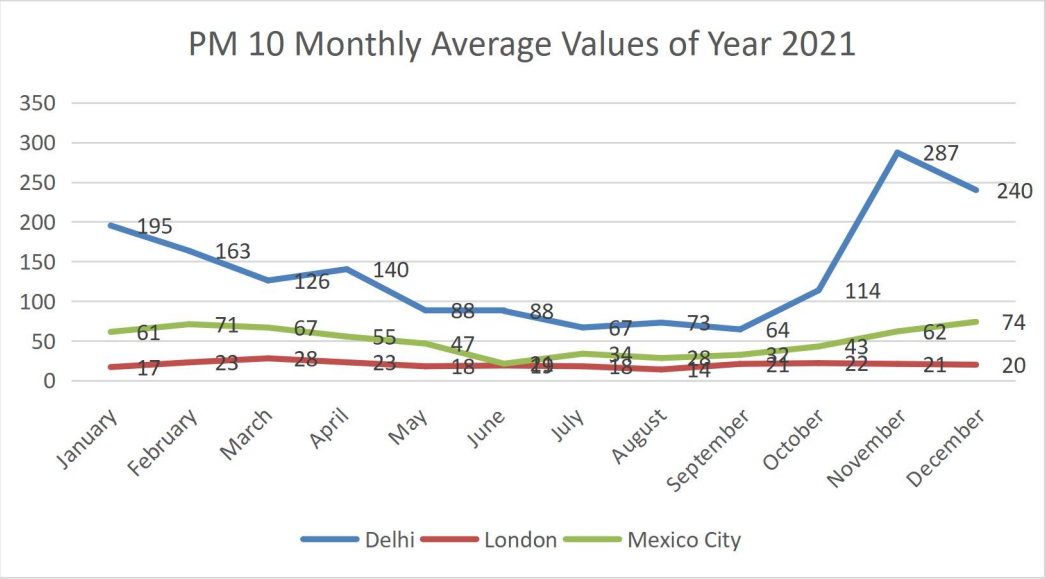
Figure 5.1.6 shows that Delhi has the highest Ozone level with 136 in April and the lowest with 9 in October. London's highest Ozone level is7 in February and the lowest is 2 for the month of May, June, July and September. Whereas, Mexico City's highest level of Ozone is 15 in November and the lowest is 4 in the month of June.

5.2) AQI Analysis of Year 2021



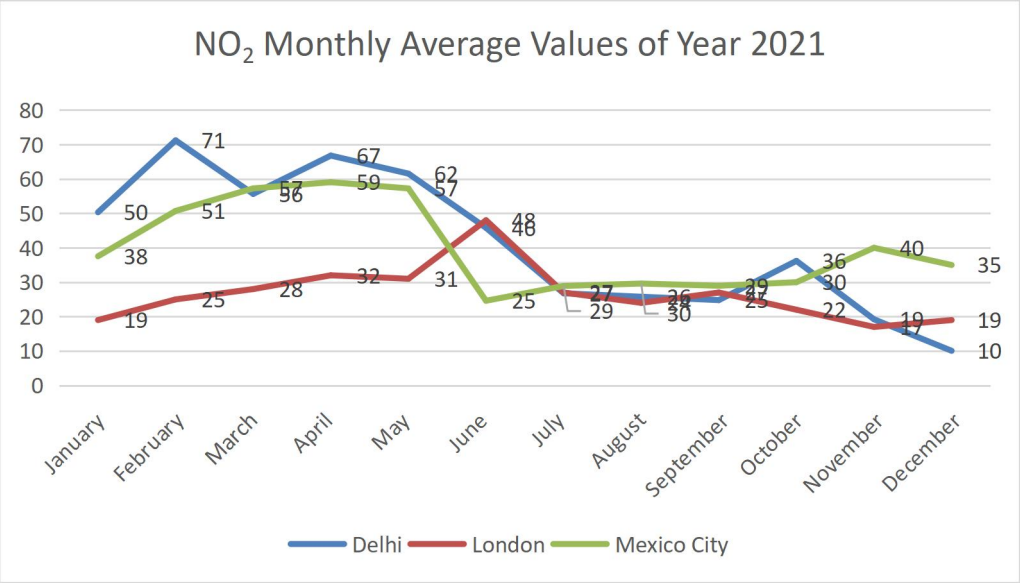
(Fig. 5.2.1) Comparison of PM2.5 Monthly Average Values of Delhi, London and Mexico City of Year 2021.

In figure 5.2.1., Shows the comparison of PM 2.5 level of Delhi, London and Mexico City in 2021. It is shown that Delhi has the highest level of PM 2.5 with 325 in the month of November and the lowest level with 110 in the month of September in 2021. Mexico City's highest level of PM 2.5 has been 127 and the lowest has been 70 in the month of June. Whereas, London's highest level of PM 2.5 was 58 in the month of March and the lowest was 35 in the month of August. Delhi, London and Mexico saw a constant decline between June and September.



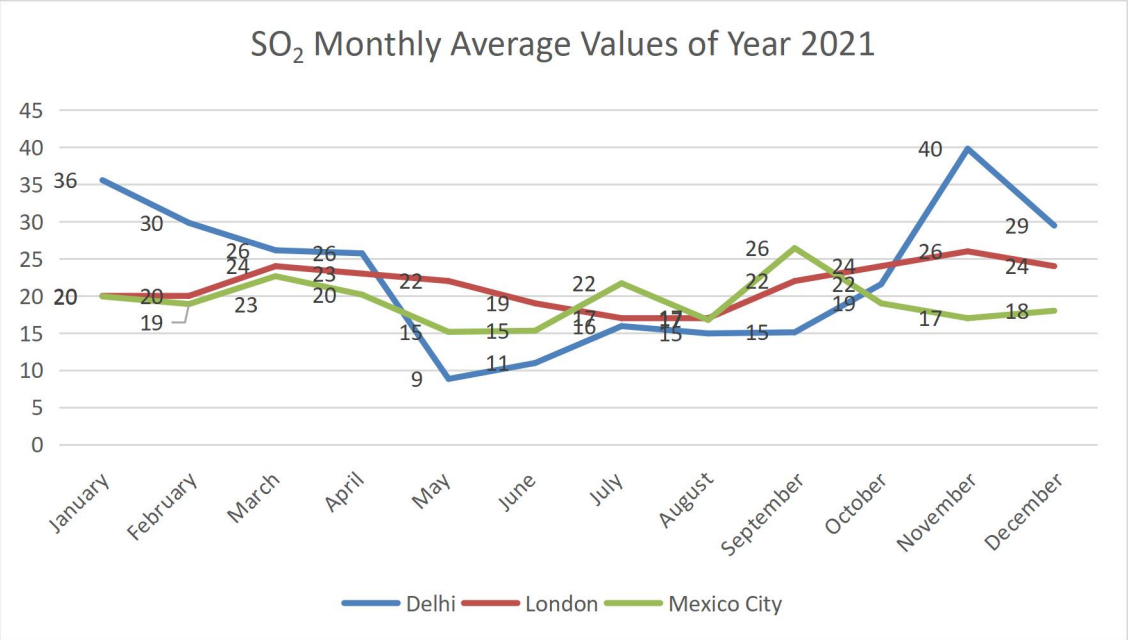
(Fig. 5.2.2) Comparison of PM10 Monthly Average Values of Delhi, London and Mexico City of Year 2021.

Fig 5.2.2 shows comparison of PM 10 level between the cities Delhi, London and Mexico City in Year 2021. In fig 5.2.2, it is shown that Delhi has highest value for PM 10 which is 287 and the lowest has been 64 but from June 2021 to September 2021, PM 10 was at a constant range of low level. In London, the PM 10 level was highest at the value of 28 in the month of January and lowest in the month of August I.e.,14 . Mexico City had the highest value of 74 in the month of December and lowest was 21. London and Mexico has been showing constant range of PM 10 from June to September and has been lower as compared to Delhi. Out of the 3 cities, Delhi has the highest level of PM 10 and London has the lowest level of PM 10.



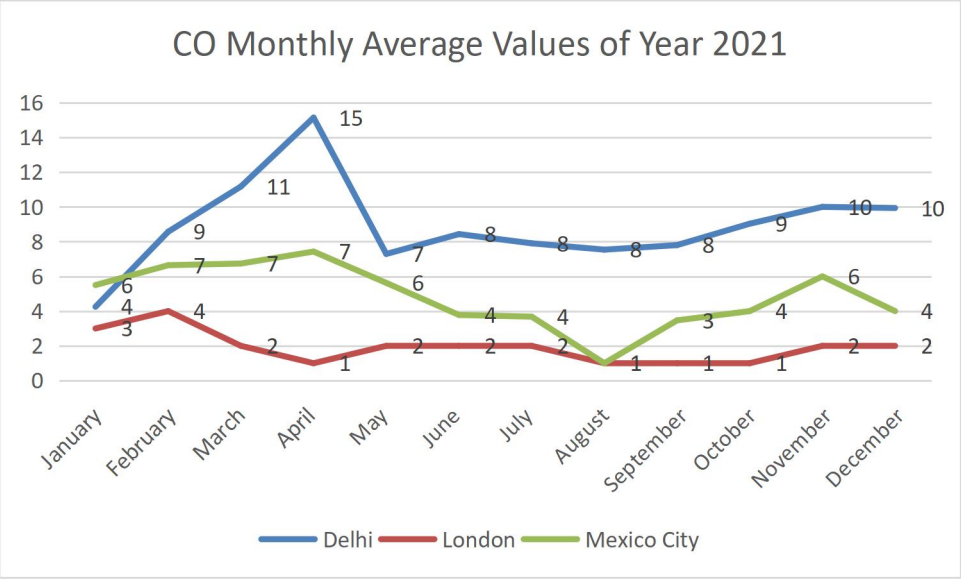
(Fig. 5.2.3) Comparison of NO_2 Monthly Average Values of Delhi, London and Mexico City of Year 2021.

Fig 5.2.3 shows comparison of NO_2 level between the cities Delhi, London and Mexico City in Year 2021. In fig 5.2.3, it is shown that Delhi has highest value for NO_2 which is 71 and the lowest has been 10 in the month of December but from July 2021 to September 2021, NO_2 was at a constant range of low level. In Mexico City, the NO_2 level was highest at the value of 59 in the month of April and lowest in the month of June and August I.e.,25. Whereas London had the highest value of NO_2 with value 48 in the month of June and lowest was 19 in the month of January and December.Delhi, London and Mexico has been showing constant range of NO_2 from June to September. Out of the 3 cities, Delhi has the highest and the lowest level of NO2 in 2021, i.e., 71 and 10, respectively.



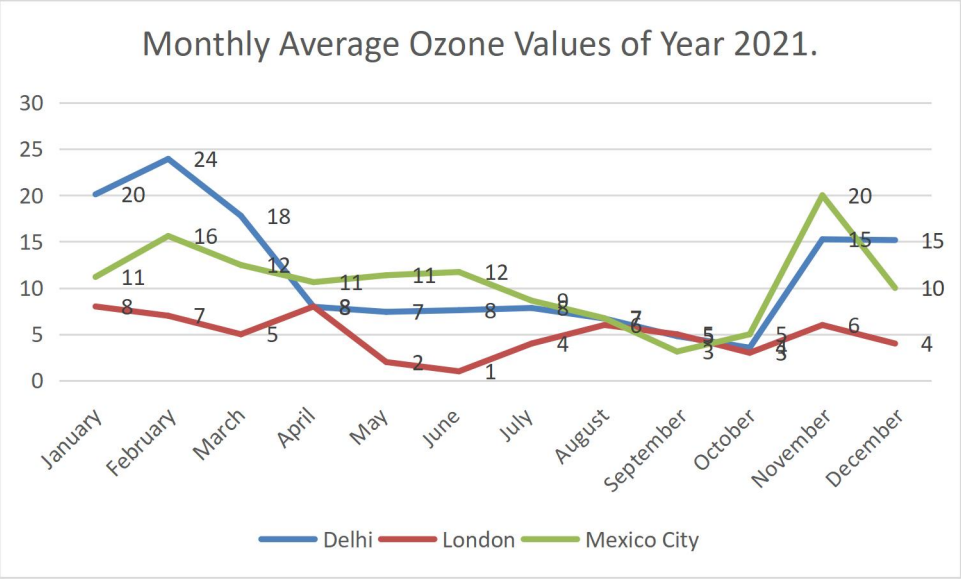
(Fig. 5.2.4) Comparison of SO_2 Monthly Average Values of Delhi, London and Mexico City of Year 2021.

Fig 5.2.4 shows comparison of SO_2 level between the cities Delhi, London and Mexico City in Year 2021. In fig 5.2.4, it is shown that Delhi has highest value for SO_2 which is 40 and the lowest has been 9 in the month of May but from May 2021 to September 2021, SO2 was at a constant range of low level. In Mexico City, the SO_2 level was highest at the value of 26 in the month of April and lowest in the month of May and June i.e.,15. Whereas London had the highest value of SO_2 with value 26 in the month of November and lowest was 17 in the month of July and August. Out of the 3 cities, Delhi has the highest and the lowest level of SO_2 in 2021, i.e., 40 (in November) and 9 (in May), respectively.



(Fig. 5.2.5) Comparison of CO Monthly Average Values of Delhi, London and Mexico City of Year 2021.

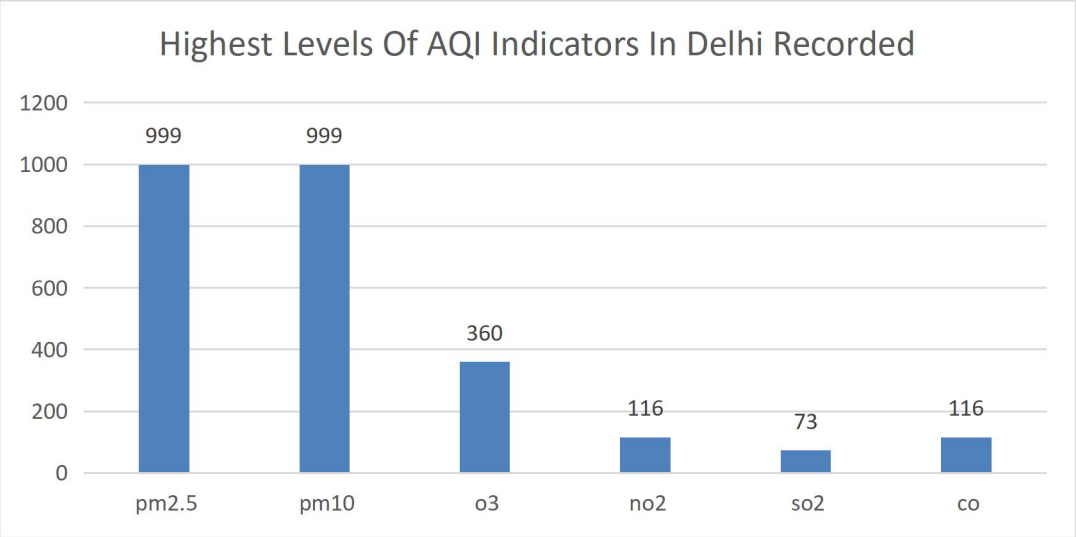
Fig 5.2.5 shows comparison of CO level between the cities Delhi, London and Mexico City in Year 2021. In fig 5.2.5, it is shown that Delhi has highest value for CO which is 15 in the month of April and the lowest has been 4 in the month of January but from June 2021 to September 2021, CO was at a constant range, i.e., 8. In London, the CO level was highest at the value of 4 in the month of February and lowest in the month of April, August, September, October and November, i.e.,1. Mexico City had the highest value of 7 in the month of February, March and April and lowest was 1. London has been showing constant range of CO from August to October and has been lower as compared to Mexico City and Delhi.



(Fig. 5.2.6) Comparison of Ozone Monthly Average Values of Delhi, London and Mexico City of Year 2021.

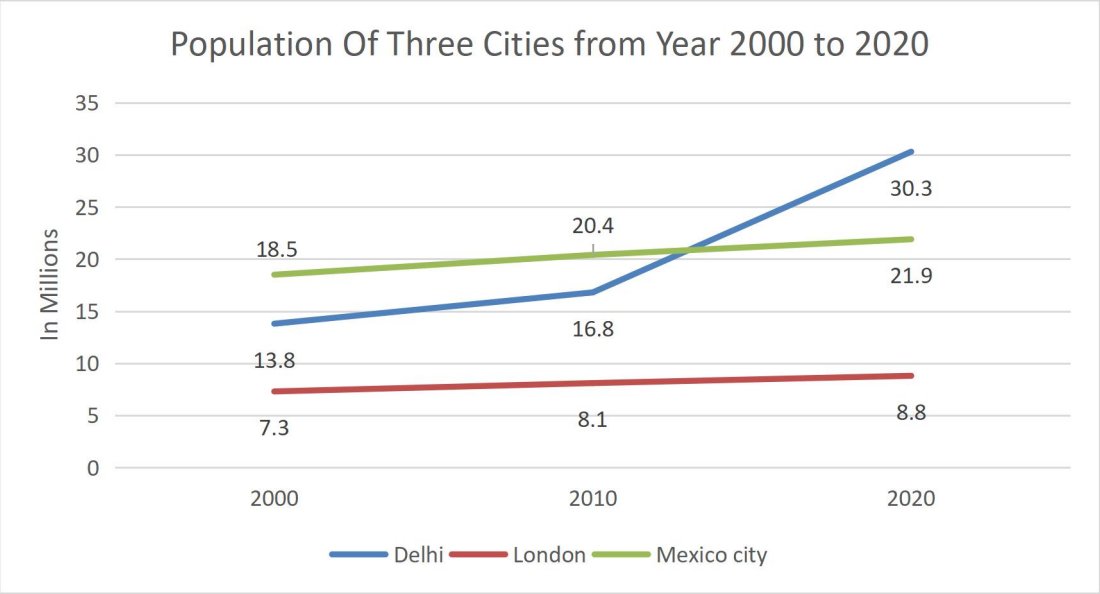
Fig 5.2.6 shows comparison of Ozone level between the cities Delhi, London and Mexico City in Year 2021. In fig 5.2.6, it is shown that Delhi has highest value for Ozone which is 24 in the month of February and the lowest has been 4 in the month of October but from April 2021 to October 2021, Ozone has been declining. In London, the Ozone level was highest at the value of 8 in the month of January and lowest in the month of June i.e.,1. Mexico City's Ozone level had the highest value of 20 in the month of November and lowest was 3 in the month of September. London's Ozone level has been the lowest as compared to Mexico City and Delhi.

5.3) Analysis of Various Pollution Causing Factors.



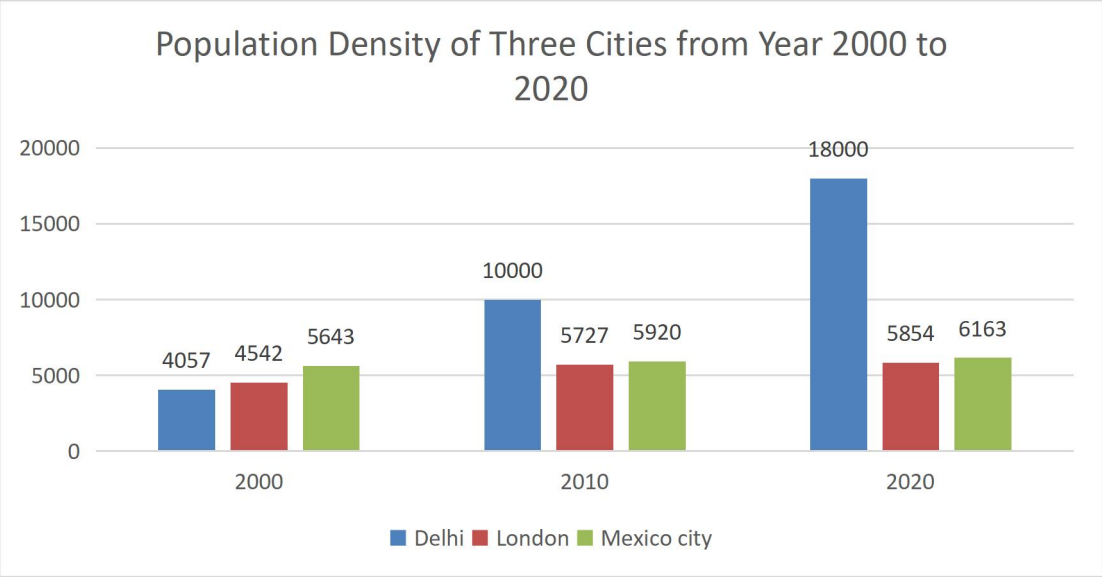
(Fig. 5.3.1) Highest level of AQI indicators recorded in Delhi

The Fig 5.3.1 shows the highest level of AQI indicators recorded in Delhi, Though in Years 2014, 2016, 2018, 2019 Delhi had recorded AQI levels of 999 in some times throughout the year, which means the air pollution level was up to the level where even the machine can not able to read it, but the very first time this happened was on 12th November 2014 where PM 10 touched 999, similarly, on 7th November 2016 PM 2.5 reached 999. Highest value of Ozone, NO2, SO2 and, CO was 360, 116, 73 and 116, respectively were recorded in Delhi.



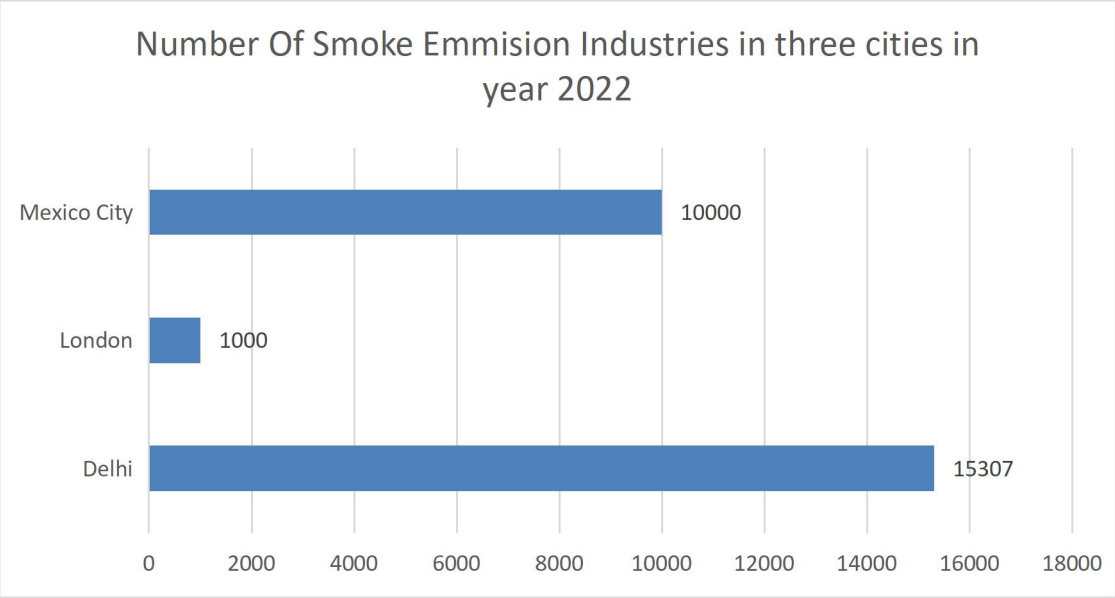
(Fig. 5.3.2) Comparison of Population of Delhi, London and Mexico City in Year 2000, 2010, and 2020.

The Fig 5.3.2 represents, the population of the cities after interval of a decade. As, it is shown that during the start of 21st century, Mexico city has highest population with 18.5million people, where as Delhi had 13.8 million and London had 7.3 million. In the year 2010, Mexico City's population only increased to 20.4 millions, London's population reached to 8.1 million and Delhi had increase of 22 %, which is 16.8 million. But, after a decade in 2020, Delhi showed a hugh spike with increase of 80.3%, which is 30.3 million, and even keep on increasing resulted 3.3 million in 2023. Meanwhile, other two cities London and Mexico City showed almost constant increase reached to 8.8 million and 21.9 millions respectively, till 2020.



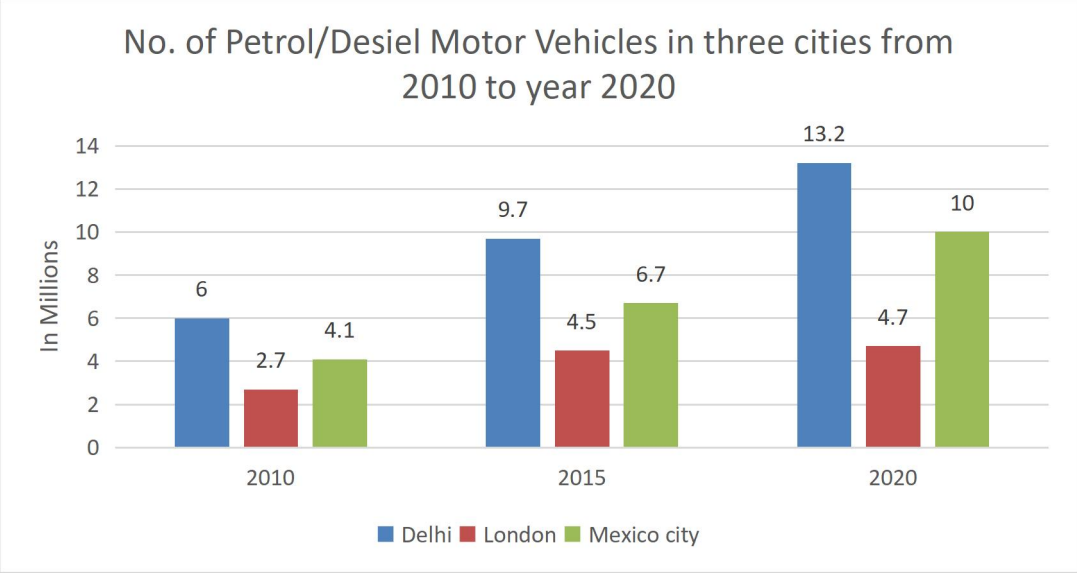
(Fig. 5.3.3) Comparison of Population Density of Delhi, London and Mexico City in Year 2000, 2010, and 2020.

The Fig 5.3.3 represents, the population Density with number people per square kilometers of the cities after interval of a decade. This figure showed that in the year 2000, Mexico city has highest population density with 5643 people per square km, where as Delhi had 4057 people per square km and London had 4542 people per square km. After a decade in 2010, Delhi population Density increased to 10000 people per square km, Mexico City's population density increased to 5920 people per square km. And London's population density reached to 5727 people per square km. But, after a decade in 2020, Delhi showed a spike with increase of 80%, which reached to 18000 people per square km. Meanwhile, other two cities London and Mexico City showed almost constant increase reached to 5854 people per square km and 6163 people per square km, till 2020.



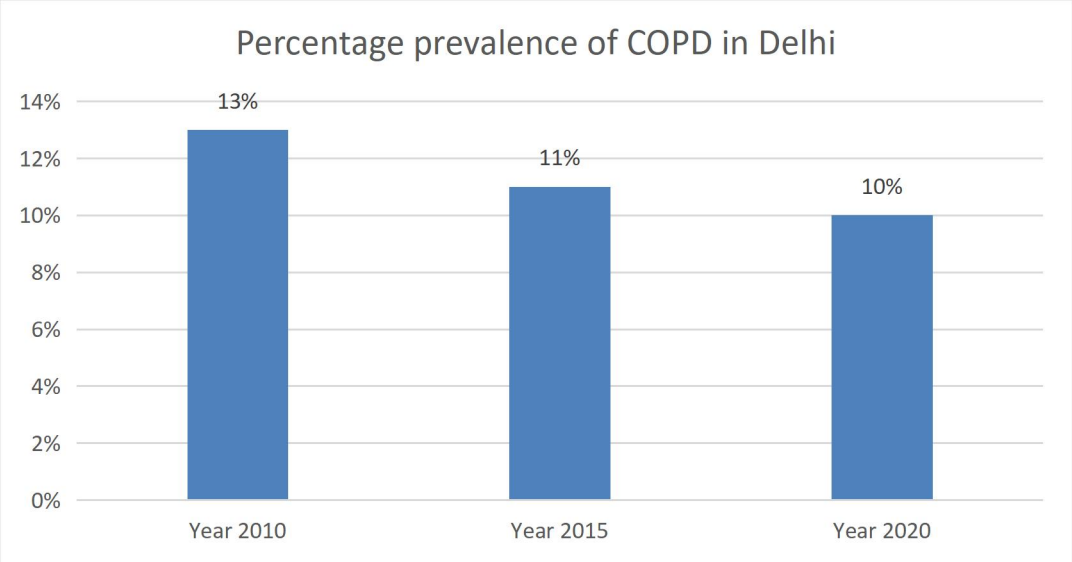
(Fig. 5.3.4) Comparison of number of smoke emission industries in Delhi, London and Mexico City in Year 2020.

In the Fig 5.3.4, It represents number of smoke emission industries in the cities in the year 2022. Where Delhi has highest number of smoke emission industries with 15307, while Mexico City has approx 10,000 industries and with strict regulations in London, it was less than 1000 industries.



(Fig. 5.3.5) Comparison of number of Petrol/Diesel Motor Vehicles in Delhi, London and Mexico City in Year 2010, 2015, and 2020.

This Fig 5.3.5 showed number of Petrol/Diesel Motor Vehicles in the city after interval of 5 years. During the year 2010, Delhi already had highest number with 6 million motor vehicle, while Mexico city and London had 2.7 millions and 4.1 million motor vehicles respectively. In year 2015, motor vehicles in Delhi increased to 9.7 millions, while in London and Mexico City, it had reached to 4.5 and 6.7 millions. In 2020, Delhi had more than double number of Petrol/Diesel Motor Vehicles compared to 2010 with the figure of 13.2 millions. While, Mexico city showed the similar results with 10 millions Petrol/Diesel Motor Vehicles, which is 143 % more than 2010. But London had only increased 0.2 millions Petrol/Diesel Motor Vehicles.



(Fig. 5.3.6) Percentage prevalence of COPD in Delhi at 2010, 2015 and 2020

There are many diseases caused by air pollution like, Lung Cancer, COPD, Asthma, Pneumonia, Heart Diseases, Diabetes, Skin Irritation etc. This study emphasis on COPD, Lungs Cancer and Asthma. The fig XX represents the

increase in prevalence of COPD cases in Delhi from 2010 to 2020. Though percentage prevalence of COPD decreases throughout the decade, but as population increased rapidly in this decade, it is really alarming. Mexico City had increased of 350000 cases in this decade, meanwhile, London had same number of COPD cases throughout the decade.

In case of Lung Cancer, in 2015 Delhi had seen the growth of 35.9% from 2010 and then in 2020, the growth of lung cancer cases was 37 %. While in London the growth of lung cancer case were 85.5% in 2022 as compared with 2010.

If looked into Asthma, in Delhi percentage of prevalence were same throughout the decade of 2010s. But as shown above, with rapid increase of population, it is concerning. Meanwhile, London and Mexico City showed decline in number of cases for Asthma.

5.4) THE GREAT SMOG OF LONDON

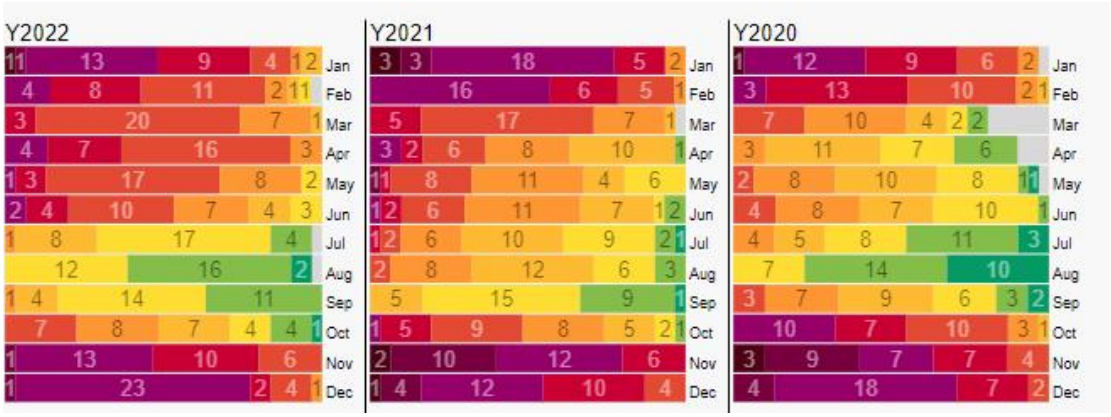
In 1952, publicly no one used to wear masks except the ones working in laboratories such as doctors or scientists. It was during that time when people noticed the adversities of air pollution and learned how important masks are. Smog was a severe air pollution event that affected the lives of the people in British capital of London from 5 to 9 December 1952. This layer of smog killed nearly 1000s of people that lasted for 5 days.

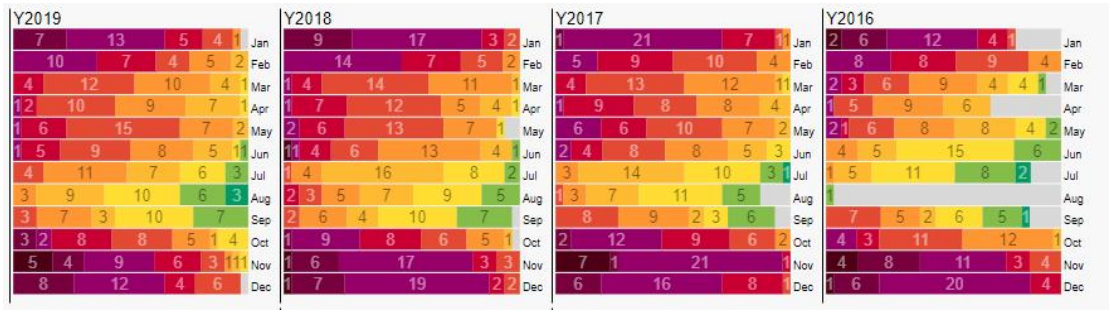
This was considered to be the worst air pollution event in the history of UK and the most significant in terms of its effect on environmental research. Many government regulations were made and Clean Air Act was introduced after this severe air pollution event in the UK. UK citizens were becoming aware of the link between the air pollution and health and how their actions such as burning coal and using vehicles aggravated air pollution that impacted their health.

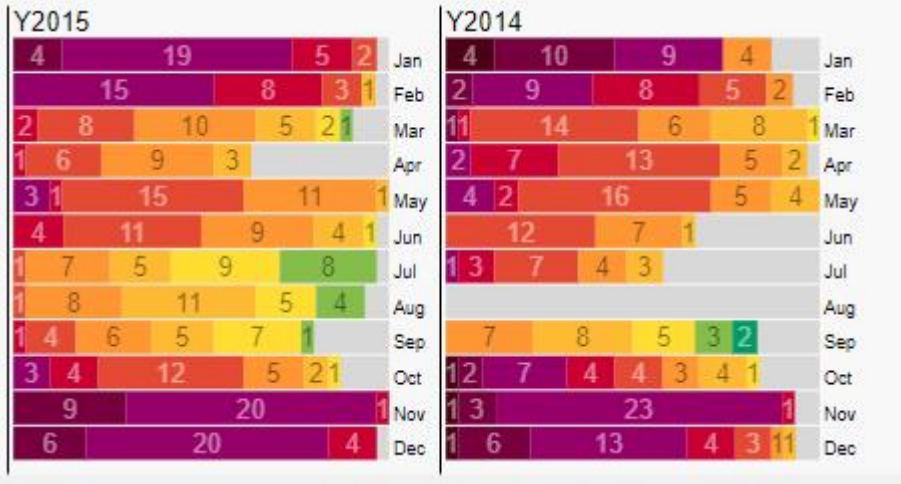
Conditions were that worse that people couldn't even cross the road or they couldn't even see their own hands while walking down the road. Visibility was less than 1 feet. So, many people got killed due to road accidents, public law and order situation was collapsing or getting. Affected badly .

5.5) Delhi Air Pollution

From the above Results, It was stated that Delhi's AQI had always been a concern since the start of 21st Century, which was getting worse an worse as the year passes by. Not only its common in Delhi for AQI to be in hazardous levels but, also many times Delhi's AQI had reached 999 which was alarming for Delhi, for India and for whole world. It was trend in Delhi where every year from November to January, Delhi's AQI was above 300 from past few years. Delhi's AQI was cleanest during the Time of Lockdown due to Covid 19.







(Fig. 5.5.1) AQI of Delhi from Year 2014 to 2022

AQI	Air Pollution Level	Health Implications	Cautionary Statement (for PM2.5)
0 - 50	Good	Air quality is considered satisfactory, and air pollution poses little or no risk	None
51 -100	Moderate	Air quality is acceptable; however, for some pollutants there may be a moderate health concern for a very small number of people who are unusually sensitive to air pollution.	Active children and adults, and people with respiratory disease, such as asthma, should limit prolonged outdoor exertion.
101-150	Unhealthy for Sensitive Groups	Members of sensitive groups may experience health effects. The general public is not likely to be affected.	Active children and adults, and people with respiratory disease, such as asthma, should limit prolonged outdoor exertion.
151-200	Unhealthy	Everyone may begin to experience health effects; members of sensitive groups may experience more serious health effects	Active children and adults, and people with respiratory disease, such as asthma, should avoid prolonged outdoor exertion; everyone else, especially children, should limit prolonged outdoor exertion
201-300	Very Unhealthy	Health warnings of emergency conditions. The entire population is more likely to be affected.	Active children and adults, and people with respiratory disease, such as asthma, should avoid all outdoor exertion; everyone else, especially children, should limit outdoor exertion.
300+	Hazardous	Health alert: everyone may experience more serious health effects	Everyone should avoid all outdoor exertion

(Fig. 5.5.2) Colour Coding of AQI

The Fig 5.5.1 Shows the AQI of Delhi from 2014 to 2022, where the pattern is clearly visible, that Delhi's AQI was worst in Winters, I.e. from October to January End.

6. **DISCUSSION**

6.1) LONDON

As of Great Smog of London. To learn as to how and why this situation came into existence. It wasn't like the air quality of London had always been very clean and clear and suddenly the smog came, London has been suffering from air pollution since the 13th century which got worse in the 1600s. Earlier, the population was less (around 1 lakh) and so the situations back then were manageable. In the 18,19 and 20 century, London saw a rise in their population. In fact, in 1951 London's population crosses 80 lakhs as per London 1951 Census.

The main reason behind the 13th century air pollution was usage of coal. Earlier, people used to burn woods but when coal was getting used publicly, as it was available at a cheaper rate and was easily available in the market. Since 13th century, people started burning coal instead of woods. In London, the temperature goes down to 1-2 degrees and sometimes in the minus during winters. So in order to keep their houses warm, they used to have furnace and through chimneys, the smog was coming out. Although the smog was coming out of the houses, during the industrial revolution in 18 and 19 century, coal plants came into existence through which the electricity used to be made. There were many factories too burning the coal. So, air quality since 13th century to 16th century were getting worse. London has been infamous during 16 and 20 century for their fog.

But type -1952 fog was strange as it had yellow-black colour and was thicker than the foggy climate being noticed earlier. The smell of the fog was like that of a smoky , and full of chemical smells.

It was a shock for the citizens.

Reasons for the great smog of 1952 were Cold weather, anticyclone depression, windless conditions, airborne pollutants arising from the use of coal, steam locomotives and diesel-fuelled buses.

Although there was good quality of coal as well but they used to export it to get good money for it. And the low quality coal which would be of sulphurous variety, after burning would release sulphur dioxide was sold in the open market for the domestic consumption. So since it was cheaper , people were using it excessively and that was also leading to increase in the air pollution.

There were also coal-fired power stations in the greater London area. Although most of them are shut down. And they all were within the London.

So, on 4 Dec 1952, there was temperature inversion due to an anticyclone that settles over a windless London, the cold air was trapped under a lid or layer of warm air. And with this fog comes into existence which gets mixed with smoke, particulates and other pollutants such as sulphur dioxide, formed a persistent smog as there was no wind and the pollution remained there covering the whole city in smog.

6.2) DELHI

The Fig 5.5.1 Shows the AQI of Delhi from 2014 to 2022, where the pattern is clearly visible, that Delhi's AQI was worst in Winters, I.e. from October to January End. And the Cleanest, from May end to September. The possible explanation for this pattern is, the Monsoon acts as blessing for the city of Delhi. As the rain pours down it clears all the particulate matters along with NO2, SO2 and CO. And during Monsoon, all the constructions were also put on hold which also contributes in lowering down the AQI of Delhi.

There are various factors which are responsible for high air pollution levels in Delhi, the first is, in winters as the temperature drops down, the air pressure on the ground increases, which makes the atmosphere dense and mainly responsible for fog. The particles such as PM 2.5, PM 10 and various other small particles which generally get dispersed in air, get stuck with heavy air and resulted in smog. Basically smoke + fog = Smog, which is very harmful for our health. Another factors were resume in construction working, Diwali and a major one was agricultural stubble burning in Haryana and Punjab, coupled with north-westerly winds also affects Delhi's air quality since the 1980s when crops are being harvested. Due to Western Disturbance, Rainfall in January also helps in reducing the Air pollution in Delhi.

Meanwhile the constant cause of air pollution from emission of air pollutants by Petrol/Diesel Motor vehicle, smoke emission industries, particles emission from Tyre and concrete and other various reasons also played an important roles.

From Fig 5.3.2 and Fig 5.3.3 it was shown that population and Population Density Delhi had increased rapidly, while the area of Delhi remained the same. As the population increased, it also needed motor vehicles for their travel thus in fig ZZ the sudden increase of motor vehicle in Delhi is clearly visible. Hence, air pollution in Delhi gotten worse if compared to London and Mexico.

Vehicular emissions contribute to 63 percent of the air pollution in Delhi. Burning of petrol and diesel to run automotive vehicles releases greenhouse gasses. Delhi is flooded with more than seven millions cars and 1400 new ones are added to this tally everyday. Introduction of CNG-fuelled vehicles at the beginning of the century had “cleaned the city’s air”, but statistics show that Delhi’s pollution has increased five times from 2015 to 2022. Moreover, thousands of trucks that make way into the city late at night are responsible for 65 percent of the total particulate matter in Delhi’s air. Most of them enter the city unregulated, despite a Supreme Court order to keep them out of the capital. Two more relating factors that cause air pollution are the fuel pumps and sale of adulterated fuel in Delhi. The fuel pumps don’t have a Vapor Recovery System (VRS) that helps in limiting the release of pollutants into the air like in Western countries, while use of adulterated fuel increases emissions.

While the high number of population requires sufficient amount of house to live, offices to work in, roads to drive and other buildings which resulted in high number of construction sites in Delhi. Apart from high range of PM in Delhi air, constructions were responsible for various other contaminants in Delhi's Air. "Nickel and cadmium have been found in Delhi's air…main source of these metals is industries…factories are not in abundance in Delhi, but they have emerged as a big source of health concern," said T.K. Joshi, director, Occupational and Environmental Program.

6.3) MEXICO CITY

Back in the 1980s and 1990s lead, ozone, sulphur and carbon were so common that residents used to say that birds would fall from the sky because of it.

It is recognised that cargo transportation (of which more than 700,000 units are registered) is essential for the country's economy but is highly polluting, as it causes problems of road traffic, increased noise and emissions of black carbon and fine particles.

The cars in general used in Mexico City are of poorer quality than their USA counterparts. It is estimated that they create 8 - 10 times more pollution than USA vehicles due to the strict rules and regulations there.

6.4) Contrast

In the results, the quality of air pollution in Delhi has been deteriorating over the years whereas cities such as London and Mexico City have been working on improving their AQI by passing the law to tackle air pollution by increasing the use of cleaner fuels, electric based or based chimneys are to be used, reducing the transport by promoting the use of bicycle and walking. Charges were increased for parking cars so people start to use fewer personal vehicles and more public transportation.

7. CONCLUSION

In this study, the detailed comparison of Air Quality Index had been done of 3 cities across the world i.e. Delhi, London, and Mexico City from Jan 2021 to Dec 2023. It has been observed that every indicator of AQI was high in Delhi except in Monsoon seasons, where Delhi's AQI showed some dip.

The variables that had taken in consideration were population, population density, number of petroleum motor vehicles, Road Dust, and Smoke emission industries and how they contribute to air pollution. Delhi showed rapid increase in population in last decade while, london and mexico city were showed less growth in pollution as well as in population density. Delhi also showed sudden increase of petroleum vehicles in a span of 10 years which ultimately resulting in building more and more roads which are the two major factors for air pollution.

There are various non communicable diseases by air pollution like, Asthma, COPD and Lungs Cancer. As Delhi showed poorest Air Quality, it also showed highest number of cases of these diseases. The government had taken various initiatives to tackle this problem, but it didn't seems enough and other solutions would also be taken in consideration.

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