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Imapct Of Covid-19 On Air Quality Of Dehradun City Of Uttarakhand, India

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Abstract
One of the biggest catastrophes of the twenty-first century has emerged as a result of the COVID-19 epidemic. The novel SARS-CoV-2 coronavirus, which is the cause of COVID-19, has been quickly circulating over the entire world. In order to stop the fast spreading virus, the Indian government was compelled to proclaim a national lockdown. Examining air pollution trends in the city of Dehradun, Uttarakhand, is the aim of this study. Monitoring and predicting air quality measurements are becoming more and more important academic topics as urbanisation and industrialization continue to develop. Since employing this method would make it possible to determine the present and future effects of air pollution, effective air quality parameter modelling is essential. This study examined the effects of a brief lockdown over three chosen locations in Dehradun city from October 2019 to September 2020 on the air concentrations of SO_2, PM_{10}, $PM_{2.5}$, and NO_2. The outcomes demonstrate that the lockout significantly lowered the levels of SO_2, PM_{10}, $PM_{2.5}$, and NO_2 in the atmosphere.

1. Introduction:

In response to the People's Republic of China's outbreak of the new coronavirus 2019 (COVID-19) infectious disease in December 2019, the World Health Organization (WHO) declared a pandemic (Huang et al., 2020). All nations should be ready for containment, isolation, case management, contact tracing, and prevention, according to one of the WHO's primary recommendations. As a result, the majority of nations implemented stringent regulations to limit the infection's spread. As COVID-19 spread initially, various levels of lockdowns were implemented in many nations and localities. The majority of nations enforced population confinement or "lockdown," which had a considerable negative impact on industrial processes, goods transit, and vehicle movements. Financial, commercial, and industrial slowdowns were brought on by this.

Monitoring air quality is crucial for reducing pollution (Camastra et al. 2019). Rapid development over the past 20 years has caused a progressive worsening in air quality in many developing nations, including India. Particularly in many large cities in developing nations, the concentrations of air pollutants in urban and peri-urban areas are rapidly increasing (UNEP, 1999). The number of automobiles, urban population, usage of unfriendly fuels, badly maintained roadways, and weak environmental legislation are all contributing to India's fast rising urban air pollution (Agrawal et al. 2003).

Each year, billions of people are affected by the critical issue of air pollution (Louati et al. 2018; Son and Louati 2016). The World Health Organization (WHO) estimates that pollution may be directly responsible for more than 25% of deaths globally (Amal et al. 2018). The World Health Organization's Air Pollution Program (WHO, 2018) estimates that 4.2 million people die from air pollution each year, and that 91% of the world's population breaths it. In big cities, where it might be difficult to balance air quality and the environment, pollution is especially bad.

India is a developing nation and one of the top 10 developed nations in the world. Research indicates that India's urban areas have significant air pollution issues (Chauhan et al. 2010). One of the biggest issues that both industrialised and developing nations face is air pollution. (Chauhan and Pawar, 2010). Emissions from home, industrial, and motor vehicle use are all factors that contribute to air pollution in India. Cities in India have the highest levels of air pollution in the world, which is primarily caused by tiny particulate matter (PM2.5) and has a detrimental effect on human health. 4 of the top 10 cities with the greatest concentrations are in India, according to the World Health Organization (WHO, 2016a).

Concentrations of SO_2 and NO_2 are constantly below Indian air quality guidelines at Haridwar and Dehradun. However, the region's PM10 and SPM concentrations are above the Indian Air Quality Guidelines (Joshi et al., 2006; Joshi and Chauhan, 2008; Chauhan, 2008; Chauhan and Joshi, 2010; Chauhan, 2010). Therefore, it is important to assess any changes in the air quality in the Uttarakhand valleys of Haridwar and Dehradun.

The term "particulate matter" (SPM) describes the mixture of solid and liquid airborne particles.

It broadly refers to compounds found in the atmosphere that are divided into particles with a lower limit of 10^{-3}µm and an upper limit of 100 µm. SPMs are omnipresent air pollutants with anthropogenic and natural origins that are a complex mixture of organic and inorganic materials.

Respirable particulate matter (RSPM), often known as PM10, is defined as particulate matter (PM) with a diameter of 10 m or less. The three modes of RSPMs are typically ultrafine (size range 0.1 m), fine (0.7 m), and coarse (1 m) (Fenger, 1999; Mohanraj and Azeez, 2004).

2. MATERIAL AND METHODS

2.1 Study area

Dehradun City

With elevations ranging from 410 m (1,350 ft) in Clement Town to over 700 m (2,300 ft) in Marsi, which is 15 km (9.3 mi) outside the city, Dehradun is predominantly situated in the Doon Valley.

However, the average height above sea level is 450 metres (1,480 feet). The Small Himalayas and Mussoorie may be reached from Marsi. His Jaunsar Bawar Hills in the Dehradun region rise to a height of 3,700 m (12,100 ft). The hills of Mussoorie rise between 1,870 and 2,017 m (6,135 and 6,617 feet) above sea level. It is susceptible to several natural dangers due to its geomorphological and climatic characteristics. Along with earthquakes, the area frequently experiences landslides, torrential rain, flash floods, cold spells, and hailstorms.

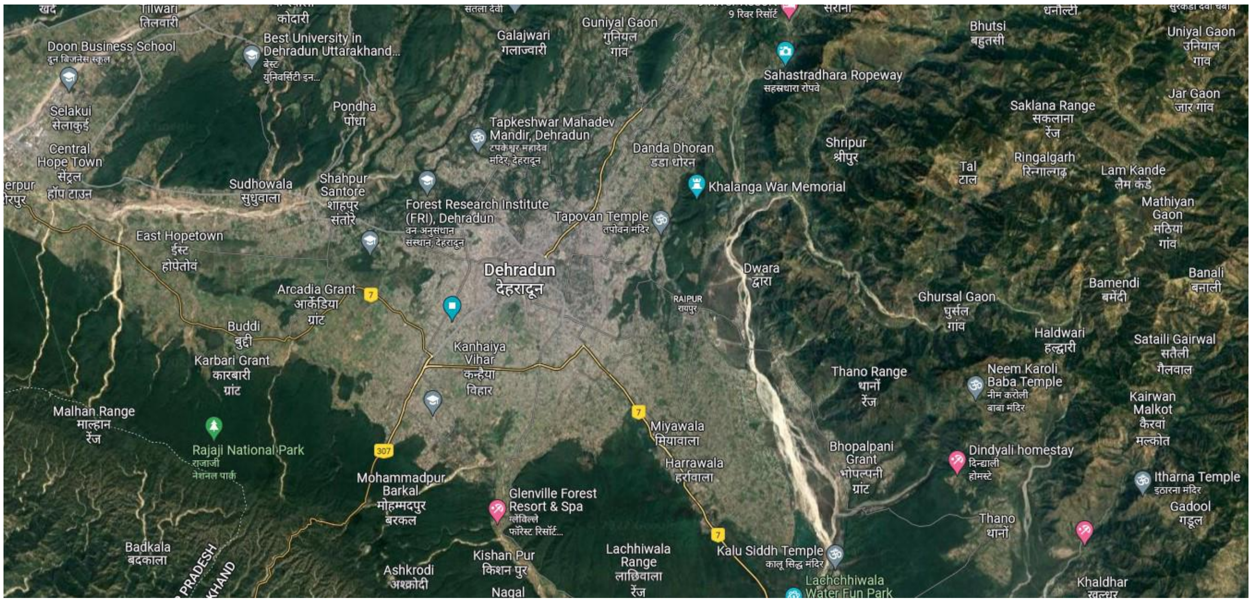

Fig-Showing the map of Dehradun City

Air Pollutants Monitoring

Concentration of air pollutants viz. NO_x, SO_2, SPM and RSPM was measured with the help of RDS. The data of air pollutants for Dehradun City were collected from Uttarakhand Environment Protection and Pollution Control Board website. AQI (air quality index) is then calculated with the concentration values using the following equation (Rao & Rao, 1998). AQI (air quality index) is then calculated with the concentration values using the following equation (Rao & Rao, 1998).

$AQI = 1/3 \, [(SO_2)/S_{SO_2} + (NOx)/S_{NOX} + SPM/S_{SPM}] \times 100$

3.0 RESULTS AND DISCUSSION

Table 1- National Ambient Air Quality Standards of India

Pollutant	Time Weighted Average	Concentration in Ambient Air	
		Industrial, Residential, Rural, and Other Areas	Ecologically Sensitive Area (notified by Central Government)
Sulphur dioxide (SO_2), $\mu g/m^3$	Annual 24 hours	50 80	20 80
Nitrogen dioxide (NO_2), $\mu g/m^3$	Annual 24 hours	40 80	30 80
Particulate matter (< 10 µm) or PM_{10}, $\mu g/m^3$	Annual 24 hours	60 100	60 100
Particulate matter (< 2.5 µm) or $PM_{2.5}$, $\mu g/m^3$	Annual 24 hours	40 60	40 60
Ozone (O_3), $\mu g/m^3$	8 hours 1 hour	100 180	100 180
Lead (Pb), $\mu g/m^3$	Annual 24 hours	0.50 1.0	0.50 1.0
Carbon monoxide (CO), mg/m^3	8 hours 1 hour	02 04	02 04
Ammonia (NH_3), $\mu g/m^3$	Annual 24 hours	100 400	100 400
Benzene (C_6H_6), $\mu g/m^3$	Annual	05	05
Benzo(α)Pyrene (BaP) – particulate phase only, ng/m^3	Annual	01	01
Arsenic (As), ng/m^3	Annual	06	06
Nickel (Ni), ng/m^3	Annual	20	20

Table-2: Rating scale of AQI values

Sr. No.	Index Value	Remarks
1	0-25	Clean air (CA)
2	26-50	Light air pollution (LAP)
3	51-75	Moderate air pollution (MAP)
4	76-100	Heavy air pollution (HAP)
5	Above 100	Severe air pollution (SAP)

Table-3: Monthly variation in AQI and its rating scale at four monitoring sites

Location	**Site-1 Clock Tower**		**Site-2 Rajpur Road**		**Site-3 Near ISBT**	
Months	**AQI**	**RATING SCALE**	**AQI**	**RATING SCALE**	**AQI**	**RATING SCALE**
Oct-19	79. 6	Heavy air pollution (HAP)	57.66	Moderate air pollution (MAP)	79	Heavy air pollution (HAP)

Nov-19	78	Heavy air pollution (HAP)	63.34	Moderate air pollution (MAP)	89.33	Heavy air pollution (HAP)
Dec-19	77	Heavy air pollution (HAP)	62.66	Moderate air pollution (MAP)	85	Heavy air pollution (HAP)
Jan-20	78.66	Heavy air pollution (HAP)	63.33	Moderate air pollution (MAP)	83.33	Heavy air pollution (HAP)
Feb-20	111.6	Severe air pollution (SAP)	65	Moderate air pollution (MAP)	94	Heavy air pollution (HAP)
Mar-20	80.33	Heavy air pollution (HAP)	54.33	Moderate air pollution (MAP)	89.66	Heavy air pollution (HAP)
Apr-20	31	Light air pollution (LAP)	31	Light air pollution (LAP)	34.66	Light air pollution (LAP)
May-20	57	Moderate air pollution (MAP)	46.66	Light air pollution (LAP)	51	Moderate air pollution (MAP)
Jun-20	59	Moderate air pollution (MAP)	48.33	Light air pollution (LAP)	51	Moderate air pollution (MAP)
Jul-20	46	Light air pollution (LAP)	46.33	Light air pollution (LAP)	49.33	Light air pollution (LAP)
Aug-20	49.33	Light air pollution (LAP)	44.66	Light air pollution (LAP)	50.33	Moderate air pollution (MAP)
Sep-20	53.66	Moderate air pollution (MAP)	50.33	Moderate air pollution (MAP)	55	Moderate air pollution (MAP)

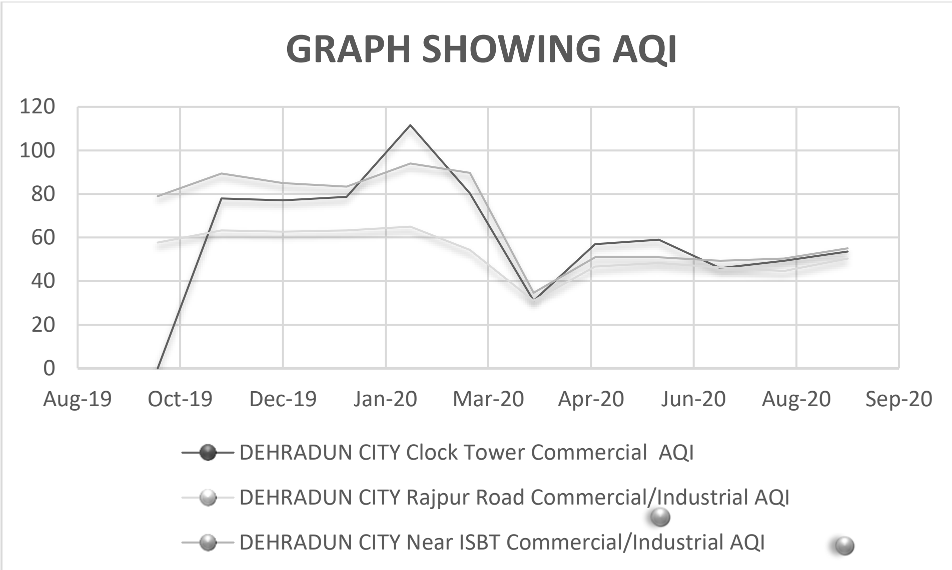

Fig-1, Showing the AQI at selected sites.

3.1 Air quality index (AQI):

Information regarding the quality of the air is provided by the Air Quality Index (AQI). The US Environmental Protection Agency (EPA) created the Air Quality Index (AQI) to gauge levels of pollution from key air contaminants. It is one of the crucial tools for assessing and integrating the state of the air. Key contaminant concentrations were tracked, translated to AQIs (Table -2) using formulae, and rating scales were also calculated (Table-3). More air pollution is indicated by a higher index value. SPM, NOx, and SO_2 values for all four of the chosen study sites were used to generate AQIs.

Site 1 (Clock Tower) showed air quality index (AQI) varied from 31.0 (April) to 111.6 (February) and rating scale as Light air pollution (LAP), MAP "Moderate Air Pollution", HAP "Heavy Air Pollution" and SAP "Severe Air Pollution" during study period. Site 2 (Rajpur Road) showed air quality index (AQI) varied from 31.0 (April) to -63.34 (November) and rating scale as LAP "Light Air Pollution" and MAP "Moderate Air Pollution" during study period. Site 3 (ISBT) air quality index (AQI) varied from 34.66 (April) to 94.0 (Feb) and rating scale as LAP "Light Air Pollution", HAP "Heavy Air Pollution" and MAP "Moderate Air Pollution" during study period.

3.2 Variation in PM_{10} concentration at selected sites

This study depicts the concentration of air pollutants and air quality index of three selected sites i.e. clock tower, ISBT and Raipur road at Uttarakhand. The selected routes predominantly shows the commercial, commercial/industrial sites. The routes were chosen because of its large amount of passenger commuting. The highest PM_{10} concentration at sites clock tower, Raipur road and ISBT were observed highest in the month of March 2020 (175.77 μg/m3), February 2020 (130.23 μg/m^3) and February 2020 (214.13 μg/m^3) respectively. While, the lowest concentration at three sites were observed in the month of April 2020 i.e. 73.51 μg/m^3, 76.58 μg/m^3 and 79.34 μg/m^3 respectively.

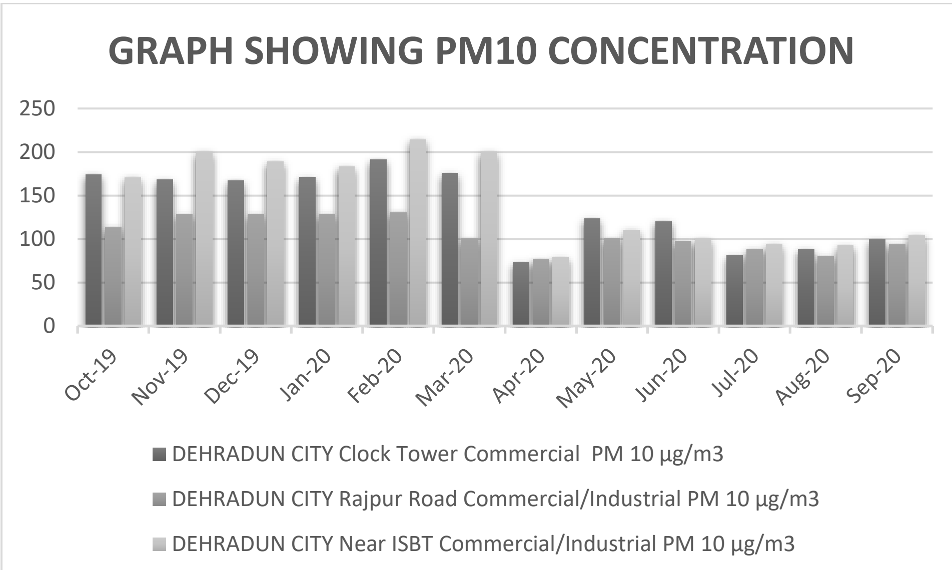

Fig 1: graph showing variation of PM_{10} concentration before lockdown and after lock down.

3.3 Variation in $PM_{2.5}$ concentration at selected sites

The $PM_{2.5}$ concentration were noticed higher at three sites i.e. clock tower, Rajpur road and ISBT in the month of November 2019 (104.85 μg/m^3, (92.58 μg/m^3) and (112.86 μg/m^3) respectively. On the other hand, the lowest concentration at above mentioned three sites were observed in the month of April 2020 (47.62 μg/m^3), (37.1 μg/m^3) and (41.48 μg/m^3) respectively.

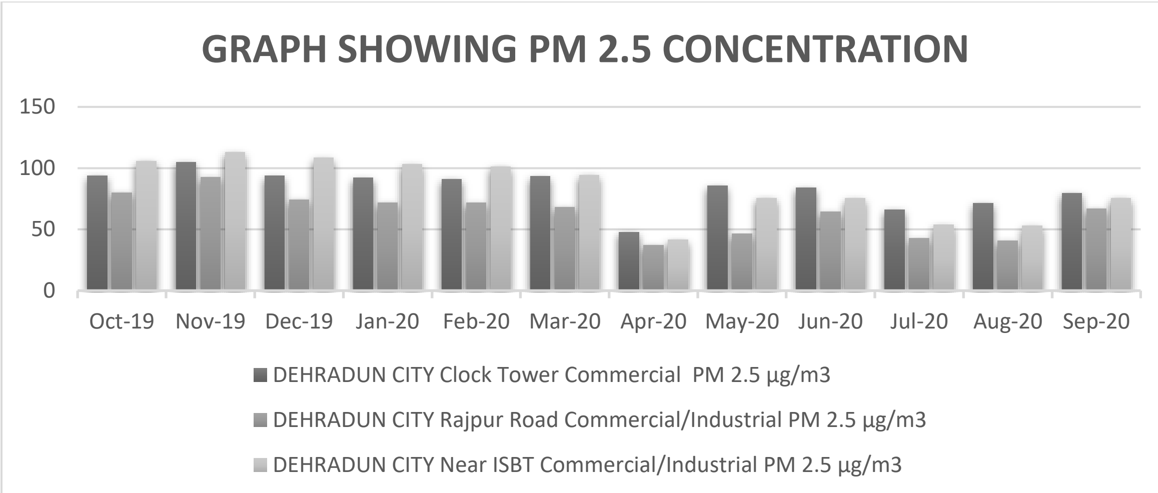

Fig 2: graph showing variation of PM $_{2.5}$ concentration before and after lockdown

Variation of SO_2 and NO_2 concentration at selected sites

The highest concentration of SO_2 at the three sites i.e. clock tower, Rajpur road and ISBT were observed in the month of February 2020 (25.12 µg/m^3), February 2020 (24.54 µg/m^3) and march 2020 (25.97 µg/m^3) respectively. Whilst, lowest concentration were observed at the three sites in the months of April 2020 (7.42 µg/m^3, 6.73 µg/m^3 and 9.16 µg/m^3) respectively. On the other hand, NO_2 concentration were observed high in the month of February 2020 (29.28 µg/m^3), (28.19 µg/m^3) and march 2020 (29.92 µg/m^3) respectively. While, lowest concentration were observed in the month of April 2020 (8.93 µg/m^3, 7.87 µg/m^3 and 11.63 µg/m^3) respectively.

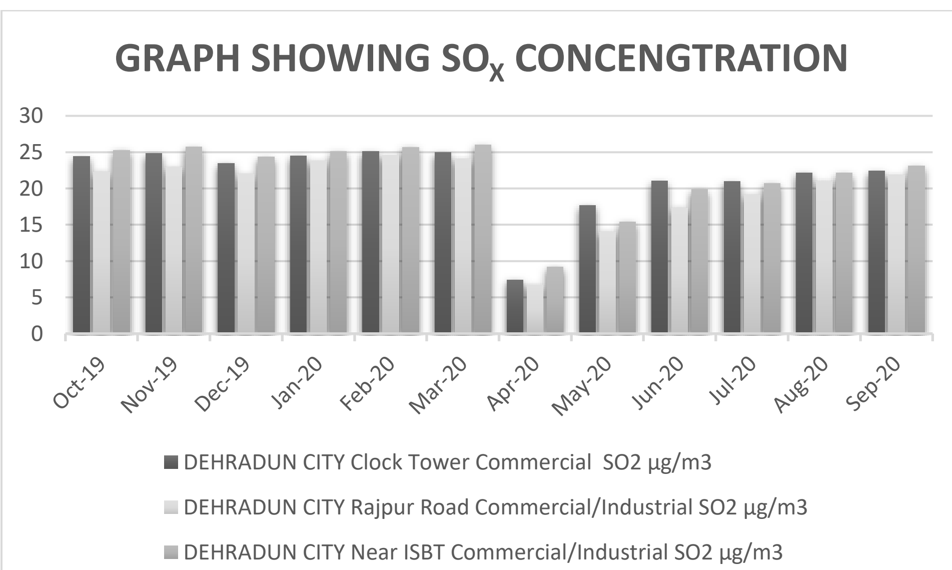

Fig 3: graph showing variation in SO_2 concentration before and after lockdown

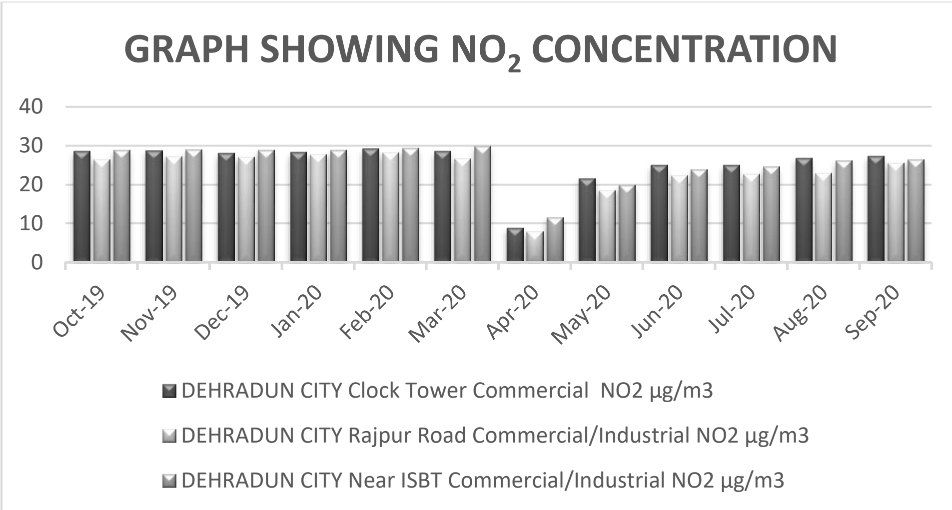

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Fig 4 : Graph showing variation in NO_2 concentration before and after lockdown

The results clearly show the influence of lockdown on air quality since there has been a significant decrease in the concentration of air pollutants at specific locations in Dehradun. For a full year, we've shown the statistics from October 2019 to September 2020. India went under lockdown on March 24, 2020. However, as we all know, the lockdown period began on March 24, 2020, and monitoring was done prior to that date, the concentration of air pollutants for PM_{10}, PM $_{2.5}$, SO_2, and NO_2 are greater in March 2020. The study time has been divided into two equal parts: the lockdown phase, which runs from April 2020 to September 2020, and the prior lockdown period, which runs from October 2019 to March 2020.

In Uttarakhand, Dehradun is a popular tourist destination. The capital of Uttarakhand is Dehradun, which has a large population growth, a large car expansion, narrow streets, parking issues, and inefficient law enforcement. In practically every transportation centre in Dehradun, problems like traffic jams are a common occurrence due to all these factors. Tricycles are also prevalent. The majority of these tricycles are diesel-powered, badly maintained, overloaded with passengers, and in terrible shape.

According to estimates, diesel combustion emits 84 g/km of particulates as opposed to 11 g/km for CNG (Nylund and Lawson, 2000). Automobiles produce a variety of particles, both directly through the dust produced by brakes, clutch discs, and tires, and inadvertently through the resuspension of particles on the road surface by moving cars (Watkins, 1991). In Northern California, heavy diesel automobiles generate 24 times more particulate matter than light gasoline vehicles, according to a research by Kirchstetter et al. (1999).

In contrast to yearly growth rates of 2-5% in Canada, the United States, the United Kingdom, and Japan over the past 30 years, the number of vehicles in many Asian countries has doubled within 10 years (Walsh (1994; Faiz et al., 1992). In the city of Delhi, home pollution

(9%) and industrial (19%) are the two main sources of air pollution, respectively (CPCB, 2001).

While three cities—Barcelona, Valencia, and Seville—saw large declines in PM 10 levels during lockdown, Barcelona did not experience a significant decrease. The size of the city and the activities that take place there can be blamed for this effect. Through transportation, agriculture, and industry, larger cities have greater anthropogenic consequences (combustion, automobile emissions, etc). (Wang et al., 2020). Ozone concentrations rose in certain cities during lockdowns, which is consistent with earlier findings (Tobas et al., 2020; Uttamang et al., 2020; Wang et al., 2020). This is so because lower values are linked to NO_2 and CO.

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