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Popular Tourist Destinations in India

Air Quality Overview

July 25, 2024

New Delhi

Overview

As the holiday season arrives, people across India are planning their vacations. When choosing a destination, it's important to remember the quality of the air we breathe. Good air quality is essential for a healthy and pleasant travel experience, making it a crucial factor to consider.

This study aims to compare the air quality in some of India's most popular tourist spots. By analyzing air quality data, we aim to understand the environmental conditions in these regions and how they might affect tourists. Our goal is to provide useful information for travelers who want to enjoy not only the beauty and adventure of their destinations but also a healthy environment.

Air quality data was analyzed to describe the environmental conditions in five regions, popular among Indian tourists, according to CNBC research [1]:

1. Goa
2. Kerala
3. Northeast India
4. Himachal Pradesh
5. Kashmir

In this study, we examined the air quality conditions in these locations, identified seasonal trends, key factors determining air pollution, and assessed compliance with the National Ambient Air Quality Standards. The locations were also charted based on the air quality index.

Data

The data was collected from the Central Pollution Control Board's (CPCB) website [2] for a six month period, from January 1, 2024, to July 1, 2024 (182 days). The data resolution was set to be 24 hours. The list of locations and the stations used to analyze the air quality in the popular tourist destinations are presented in the table below.

Comments:

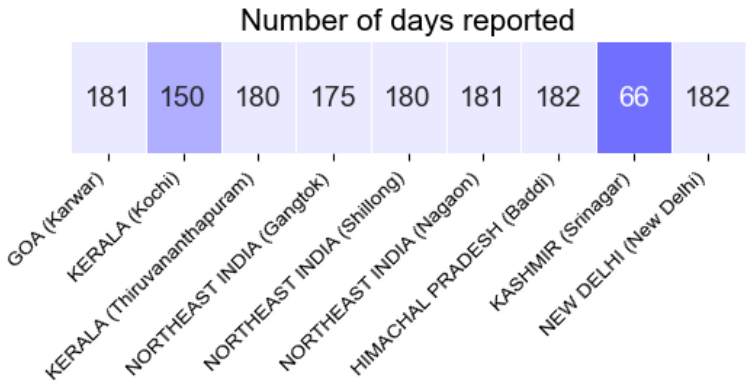
- GOA: CPCB does not have an open access station in the GOA state, so to analyze the air in this location, the nearest station from the Karnataka state was used (Karwar, 12 km to the Karnataka-Goa border).
- KERALA: Two popular tourist destinations with CPCB stations were chosen for the analysis: Kochi in central Kerala and Thiruvananthapuram in the south of the state.
- NORTHEAST INDIA: CPCB stations from three states most popular among tourists (Sikkim, Meghalaya and Assam) were chosen for the research.
- HIMACHAL PRADESH: CPCB station was located near the south border of the state in Baddi city. Baddi is an industrial center with multiple sources of air pollution, which may

affect the accuracy of air quality estimates. However, this is the only available CPCB station in the state, so we have settled for what's available and used it for the analysis.

- KASHMIR: Only one CPCB station was available in this state, in Srinagar. The data provided by this station was severely incomplete, with only 66 days covered over the 6-month period.
- NEW DELHI: One CPCB station (ITO Delhi) in New Delhi was used as a reference station to estimate the air quality in the big city.

Tourist destination	State	Location	CPCB station
GOA	Karnataka	Karwar	KHB Colony, Karwar, KSPCB
KERALA	Kerala	Kochi	Udyogamandal, Eloor, Kerala PCB
KERALA	Kerala	Thiruvananthapuram	Plammoodu, Thiruvananthapuram, Kerala PCB
NORTHEAST INDIA	Sikkim	Gangtok	Zero Point GICI, Gangtok, SSPCB
NORTHEAST INDIA	Meghalaya	Shillong	Lumpyngngad, Shillong and Meghalaya PCB
NORTHEAST INDIA	Assam	Nagaon	Christianpatty, Nagaon, PCBA
HIMACHAL PRADESH	Himachal Pradesh	Baddi	HIMUDA Complex Phase-1, Baddi, HPPCB
KASHMIR	Kashmir	Srinagar	Rajbagh, Srinagar, JKSPCB
NEW DELHI	New Delhi	New Delhi	ITO, Delhi, CPCB

Below, the data completeness is reported. The data was processed over a 6-month period (182 days). Most of the stations have shown good data completeness close to this range.



Methods

Air Quality Standards:

Five main pollutants were analyzed: PM2.5, PM10, NO_2, NH_3, and SO_2. Those will be further referred to as AQ parameters. The concentration of each pollutant was considered in the context of NAAQS standards [3]. The recommended time-averaged concentrations of the targeted pollutants are presented in the table below:

	PM2.5; μg/m^3	PM10; μg/m^3	NO_2; μg/m^3	NH_3; μg/m^3	SO_2; μg/m^3
24-h **	60	100	80	400	80
Annual *	40	60	60	100	50

The table is accompanied by the following comments:
* Annual arithmetic mean of minimum 104 measurements in a year at a particular site taken twice a week 24 hourly at uniform interval.

** 24 hourly 08 hourly or 01 hourly monitored values, as applicable shall be complied with 98% of the time in a year. 2% of the time, they may exceed the limits but not on two consecutive days of monitoring.

NOTE: Whenever and wherever monitoring results on two consecutive days of monitoring exceed the limits specified above for the respective category, it shall be considered adequate reason to institute regular or continuous monitoring and further investigation. [© NAAQS 2019, [2]]

Air Quality Index (AQI)

For calculating the air quality index (AQI), the AQIPython library was used (released under the MIT License). The standard for calculating AQI: ‘IN’ (oriented on Indian air quality standards). AQI was calculated as the maximum of the partial AQI calculated for the key pollutants: ‘PM2.5’, ‘PM10’, and ‘NO2’.

Results

1. Incident Days

Air quality is a matter that is widely regulated, with multiple air quality standards and recommendations implemented at the level of states, national agencies, and international organizations. Thus, air quality standards may differ from one state to another. The main regulatory document used in this research is the Indian National Ambient Air Quality Standard (NAAQS), with the latest version published by CPCB in 2019-20 [2].

We begin with an estimation of how the ambient air quality conditions in the studied locations meet the NAAQS requirements. The table below lists the number of days when the 24-hour average air quality failed to meet the NAAQS recommended level for at least one AQ parameter. For brevity, these occurrences will be further referred to as “incidents," and days with at least one such occurrence will be referred to as “Incident days”.

According to the NAAQS requirements, the proportion of incident days within a year should not exceed 2%. For the 182 days observed, this translates to fewer than 4 incident days .

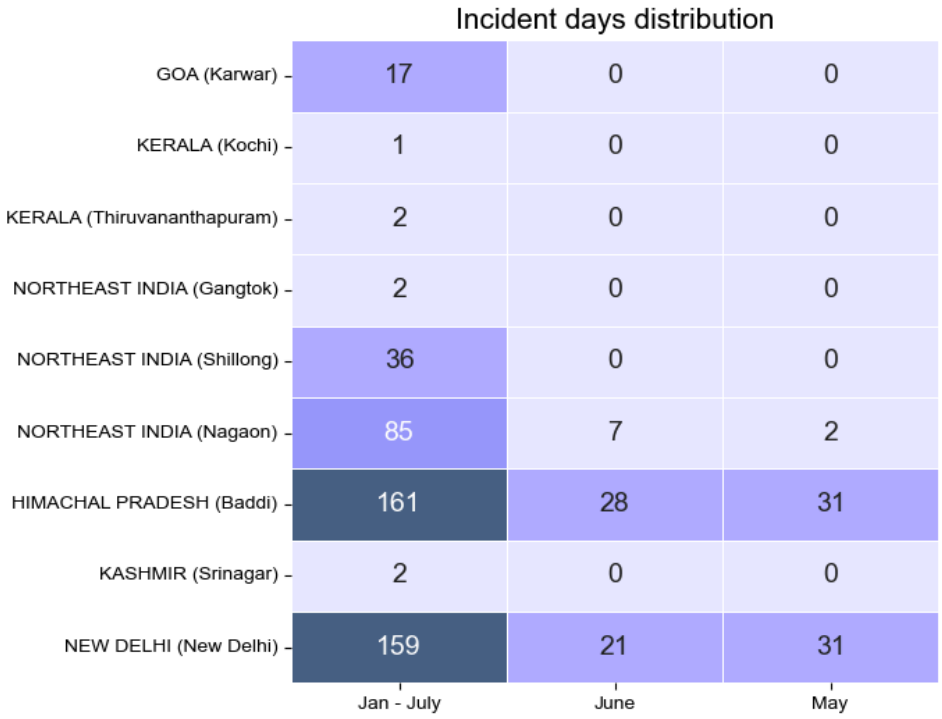


Figure 1. Number of incident days for the first six months, June and May 2024.

NAAQS stipulates that the 24-hour average threshold may only be exceeded 2% of the time. However, throughout the first six months of 2024, this requirement was significantly exceeded for Goa [9%], Northeast India (Shilong [20%], Nagaon [47%]), Himachal Pradesh (Baddi) [88%], and New Delhi [87%].

For the majority of the studied locations, no incident days took place in June or May, despite the fact that the total number of incident days over the first 6 months of 2024 was never zero.

2. Componential Analysis. Key Pollutants

An important feature of air quality is the key pollutant. Knowing that gives us the opportunity to target the causes of pollution and improve air quality effectively.
To estimate the key contributors to the insufficient AQ conditions, we compare the total number of incidents for each AQ parameter for all the locations studied:

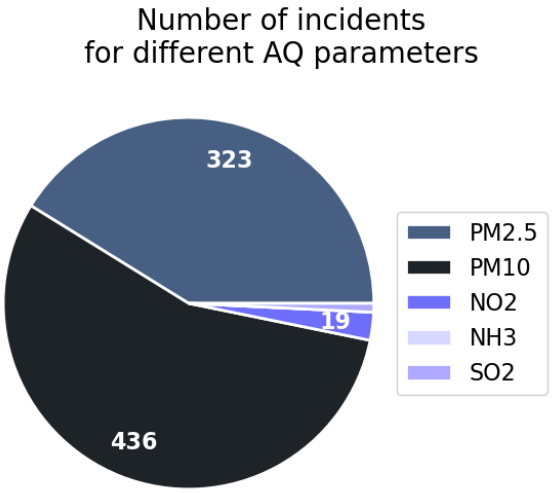


Figure 2. Number of days when NAAQS recommendations were exceeded for different AQ parameters.

The total number of incident days observed over the first six months of 2024 (Figure 1) is less than the sum of incidents by individual AQ parameters, as one incident day may feature multiple violations by several AQ parameters. It can be seen that the air pollution in the investigated areas is mainly determined by PM pollution.

3. Componential Analysis. Mean Values

NAAQS, like many other standards, relies on the mean values of the AQ parameters as air quality indicators. There are two thresholds for the AQ parameters studied in this review: the 24-hour threshold and the annual average threshold. As there is no recommended level for the six-month period, we have compared the time-averaged values with both the thresholds (see the graphs below). The bars representing locations where the 6-month average exceeded the 24-hour threshold are colored orange.

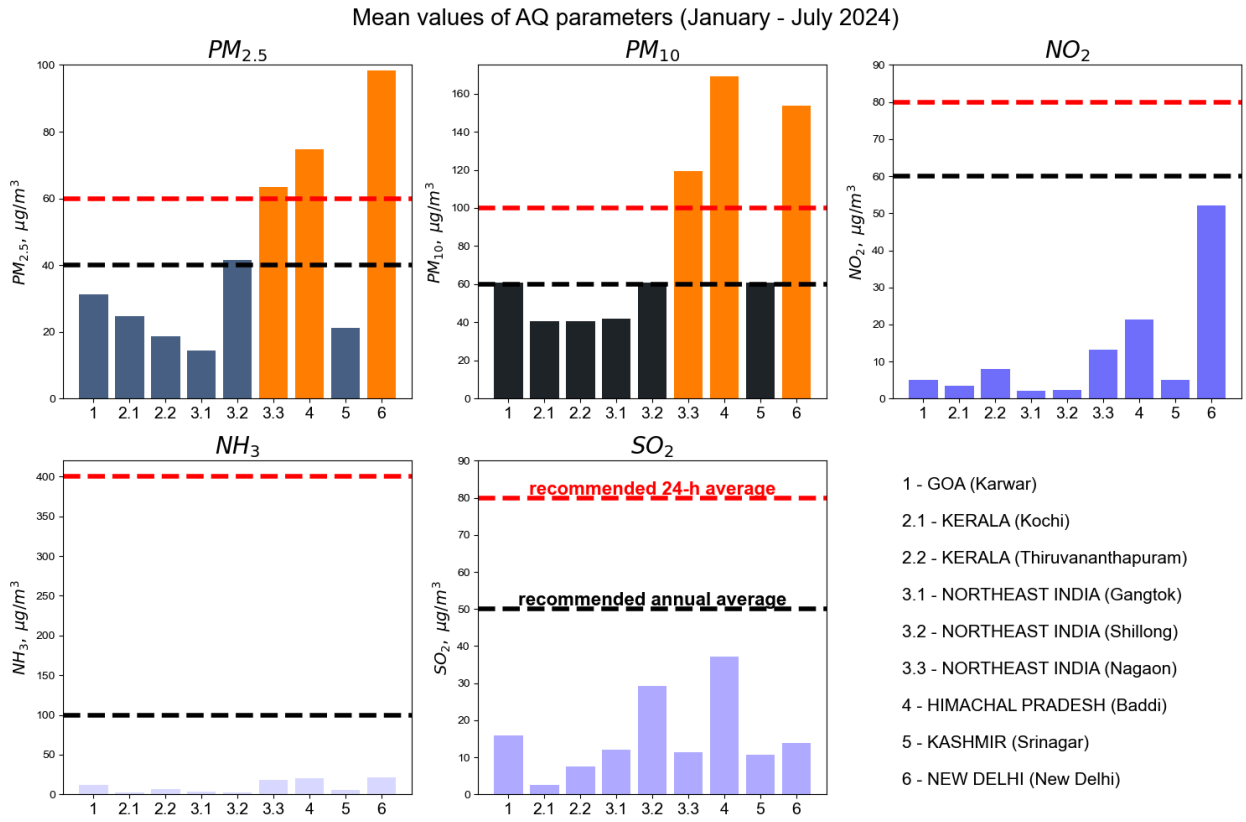


Figure 3a. Mean values of AQ parameters over the first 6 months of 2024

It can be seen once again that AQ pollution is mainly determined by PM pollution and less by NO_2 pollution. The main source of NO_2 is fuel combustion, which explains why its concentration is usually elevated in big cities, such as New Delhi.

To estimate the current air quality conditions as of mid-summer 2024, data collected in June 2024 was analyzed. The coloring principle is kept the same as in Figure 3.a.

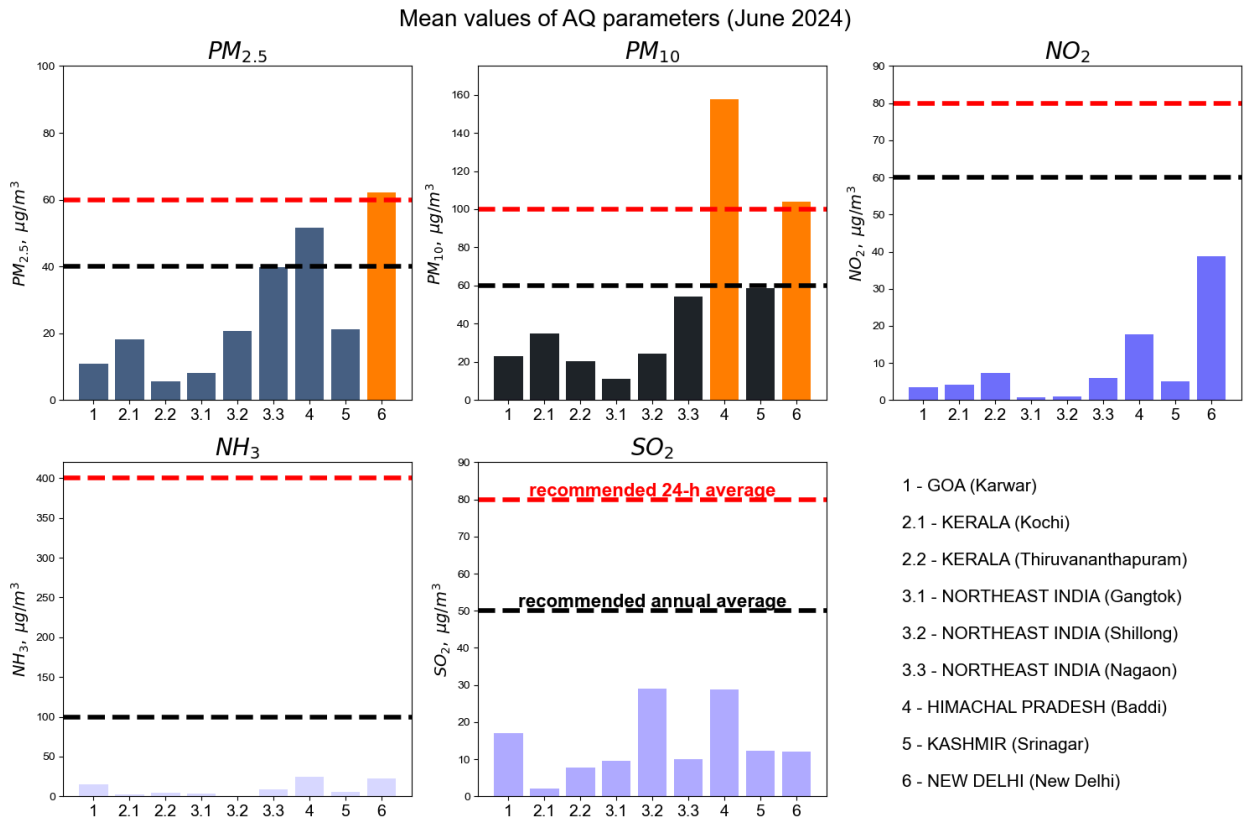


Figure 3b. Mean values of AQ parameters over in June 2024

Based on the data from Figures 3a and 3b, it can be seen that air quality tends to improve towards the beginning of summer. To illustrate this process, the difference between the mean values of the AQ parameters in May and June is presented in the table below (Figure 4).

Figure 4 illustrates the tendency towards the improvement of air quality in all the locations in the beginning of summer. Mean values of nearly all parameters have decreased, which is especially pronounced for the particulate matter — a determining component in AQ pollution.

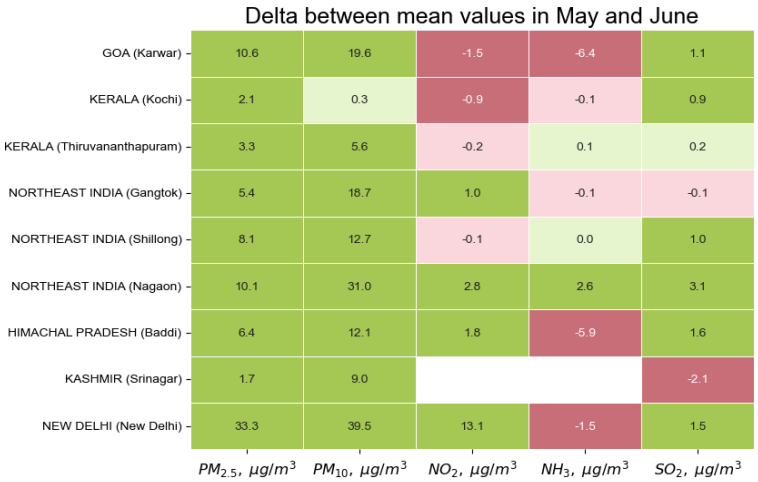


Figure 4. Difference in the mean values of AQ parameters in May and June 2024. Green represents improvement; red represents deterioration of air quality.

4. Air Quality Index (AQI)

To compare air quality in the studied locations, the Air Quality Index (AQI) was calculated for the mean values of AQ parameters in June 2024. It should be noted that the AQI is determined as the maximum value of the partial air quality indices calculated for the AQ parameters. Since the PM level was elevated far more often than the other parameters, it was the main contributor to the calculated AQI.

	AQI
NORTHEAST INDIA (Gangtok)	14
KERALA (Thiruvananthapuram)	21
GOA (Karwar)	23
NORTHEAST INDIA (Shillong)	34
KERALA (Kochi)	35
KASHMIR (Srinagar)	59
NORTHEAST INDIA (Nagaon)	67
NEW DELHI (New Delhi)	108
HIMACHAL PRADESH (Baddi)	139

Air Quality Index (AQI) in June 2024.

Discussion

Limitations of Research

One significant limitation of this research is the limited data access. While big cities like New Delhi have a high density of air quality monitoring networks, this is not the case for remote regions that are popular tourist destinations. Often, entire states are represented by a single monitoring station, leading to low data reliability and potentially inaccurate representations of air quality conditions in those states.

In this study, the data from the monitoring stations in Himachal Pradesh and Kashmir may not be fully representative:

- **Himachal Pradesh**: The CPCB station is located near the southern border of this large and mountainous state, which may not accurately reflect the air conditions in the northern parts of the state. Additionally, Baddi, where the CPCB station is located, is an industrial center with multiple sources of air pollution. This may significantly affect the representativeness of the measurements.
- **Kashmir**: Despite the station's central location, the data may be unreliable because the station was offline for nearly 60% of the time during the first half of 2024. Since this station is the only CPCB station in the state, the data cannot be substituted.

These limitations highlight the need for more comprehensive and reliable monitoring networks in remote regions to ensure accurate and representative air quality data.

Conclusions

In this overview, we have examined the air quality in popular tourist destinations, as determined by a CNBC review. Using open data from the Central Pollution Control Board, we compared the air quality in five popular destinations in India — (1) Goa, (2) Kerala, (3) Northeast India, (4) Himachal Pradesh, and (5) Kashmir — and compared it with a reference station in New Delhi. Where possible, we have taken data from multiple stations to get a more complete picture of the air quality distribution over the studied locations.

The collected data was analyzed from the perspective of the NAAQS regulation. It turned out that many locations in Goa, Northeast India, and Himachal Pradesh failed to meet the strict NAAQS standards for the 24-hour averaged values of air quality pollutants. For Himachal Pradesh, the prescribed duration of insufficient air quality was exceeded 40-fold over the first six months of 2024, with 161 days of insufficient air quality, while only four days were allowed according to the NAAQS.

Among the five main pollutants studied — PM2.5, PM10, NO_2, NH_3, and SO_2 — particulate matter (PM) pollution was the main contributor to insufficient air quality. We have also studied the trends in air quality over the first six months of 2024 and have found a strong trend towards the improvement of air quality over the winter and pre-monsoon periods, with July-August promising to be the months with the best air quality throughout the year.

Finally, the studied locations were ranked by the Air Quality Index, calculated for June 2024. Remarkably, the chart ranking popular tourist destinations by air quality closely mirrors the one ranking them by popularity among Indian tourists. The exception is Himachal Pradesh (Baddi), where high PM pollution results in worse air quality than in New Delhi.

Acknowledgments

We sincerely thank the Central Pollution Control Board (CPCB) for providing access to air quality data, which was essential for this study. We also appreciate the efforts of all individuals and organizations dedicated to improving air quality, as their work has greatly contributed to our work.
We also thank our partners and collaborators for their valuable insights and expertise, which enriched this report. Their support motivates us to keep working on improving air quality and promoting sustainable practices across India.

About Airvoice

Airvoice develops and manufactures innovative software and hardware solutions for air quality monitoring and management. Founded in 2021, the company has rapidly evolved to address global air quality challenges. Its commitment to advancing science-backed technologies is demonstrated through strategic partnerships with major universities and research institutions worldwide. These collaborations, including partnerships with the Indian Institute of Tropical Meteorology, the University of Arizona, Nanyang Technological University in Singapore, and many others, enhance Airvoice's robust research in atmospheric physics and AI technology, establishing it at the forefront of the emerging clean air industry.

Airvoice.India, launched in 2022 as a collaborative venture between Airvoice Global and Col. Bhawani Singh, is dedicated to revolutionizing air quality management across India. With its advanced technologies and extensive experience, the company is adept at providing solutions that cater to the unique air quality needs of various sectors, including urban environments, industries, and residential areas.

Focusing on sustainability and innovation, Airvoice.India has quickly become a leader in air quality solutions, contributing to national smart city initiatives and events like the B20 Sustainability Summit in Delhi. The company’s strategic initiatives aim to position India as

a central hub for developing and deploying air quality improvements throughout Southeast Asia.

Links and References

[1] CNBC research: Top 5 domestic and foreign destinations where Indians are headed for a holiday this summer. (2024, May 9). https://www.cnbctv18.com/photos/travel/destinations/top-5-domestic-and-foreign-destinations-where-indians-are-headed-for-a-holiday-this-summer-19409404.htm

[2] Central Pollution Control Board. (accessed July 2024). Air quality dashboard. https://airquality.cpcb.gov.in/ccr/#/caaqm-dashboard-all/caaqm-landing

[3] Central Pollution Control Board. (2020, September 23). National ambient air quality status & trends 2019 (NAAQMS/45/2019-2020). Ministry of Environment, Forest & Climate Change, Government of India. https://www.cpcb.nic.in