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A case study of ambient air quality of Tonk

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Abstract
At present, pollution is a very serious problem due to which serious changes are being seen in the Air Quality Index. Which is affecting human health and other living beings and the climate /environment. The major changes in AQI due to Weather Conditions: Temperature, humidity industrialization, urbanization, Industrial, Agricultural Burning and Vehicular Emissions and wind speed also play a role in determining AQI. This study reports the analysis of the Air Quality Index in Tonk, Rajasthan for simplified public information and data interpretation by using An Air Quality Index (AQI) on the basis of, five important parameters such as Particulate Matter (PM2.5 and PM10), NO2, CO & O3 at housing board location in Tonk.

Keywords: CAAQM, air quality index (AQI), PM2.5 and pm10, NO2, CO and O3

Introduction

Tonk is a distinguished city located in the Tonk district of Rajasthan, India, situated approximately 95 kilometers south of Jaipur, the state capital. With a rich history dating back to the 17th century, Tonk is renowned for its cultural significance, remarkable architectural heritage, and captivating natural beauty. Nestled in the southeastern part of Rajasthan within the scenic Banas River valley, the city is further enhanced by the surrounding Aravalli Range hills, which contribute to its stunning landscape. In recent years, however, Tonk has encountered challenges related to air quality. The Air Quality Index (AQI) serves as a vital metric for evaluating environmental health, making it essential to understand its current status for the community's well-being. With an average annual rainfall of 650 mm (26 inches) and approximately 12% of the district's area covered by forests, there is significant potential for implementing sustainable practices and encouraging environmental awareness to improve air quality and overall ecological conditions. This article aims to provide a polished overview of Tonk's air quality, spotlight contributing factors, and explore viable solutions for enhancement at present time due to rapidly increasing population, industrialization, urbanization variation in level of AQI has seen. (Kuldeep *et al*., 2022 [5]; A. Kumar *et al*., 2011 [6]; Lal *et al*., 2023 [10]; Neelima & Dhavan, 2014) [12] Numbers of pollutants are emitted in ambient air due to anthropogenic activities which primarily includes PM2.5 and PM10, NO2, CO and O3. (Sarella Anjali Khambete PG Student Associate Professor & Vallabhbhai, 2015; M. Sharma, 2020) [15, 17] These pollutants play significant role in affecting air quality of ambient air. Generally residential areas observe lesser pollution level as compared to industrial and commercial area but still some pollutants dominate in residential areas too and affecting its air quality. (Suman, 2021) [19]. The Air Quality Index (AQI) acts as a valuable tool for monitoring air quality and identifying solutions to address air pollution in Tonk. Developed by the Central Pollution Control Board (CPCB) in New Delhi under the Ministry of Environment, Forest & Climate Change, the AQI offers a standardized measure for assessing air quality (Kumar Rai, 2016 [8]; Suman, 2021) [19]. The AQI is categorized into six distinct levels: Good, Satisfactory, Moderately Polluted, Poor, Very Poor, and Severe. These categories are determined based on the ambient concentration values of various air pollutants and their associated health impacts, known as health breakpoints (Dutta & Pal, 2022 [2]; Gupta & Singla, 2023 [3]; P. Kumar *et al*., 2021 [7]; Williams *et al*., 2022) [20]. The AQI sub-index includes health breakpoints for six main pollutants: PM10, PM2.5, NO2, SO2, CO, and O3, for which short-term (up to 24-hours) National Ambient Air Quality Standards have been established (Manna & Anitha, 2022 [11]; Sahaya Sakila & Kavitha, 2022) [14]. Moreover, weather conditions such as temperature, humidity, and wind speed significantly influence the AQI, affecting the dispersion and concentration of pollutants in the atmosphere.

AQI categories and health breakpoints for the six pollutants are as follow:

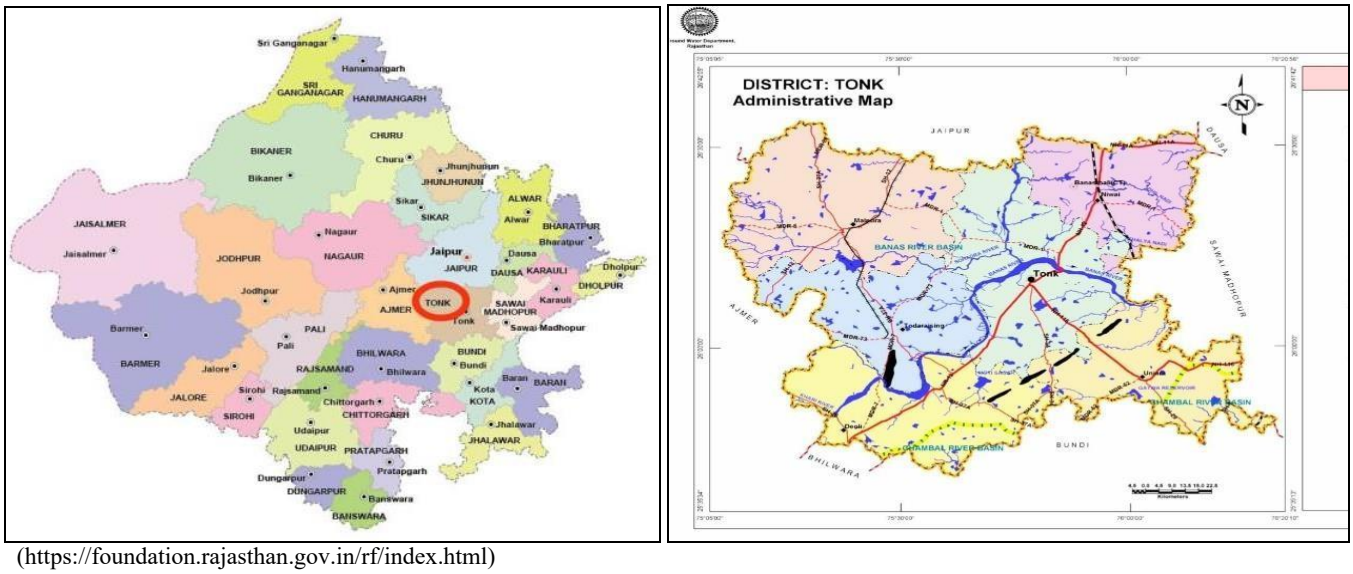
Break Points of Various Pollutants								
AQI Category	AQI	Concentration range of pollutant						Impact
		PM10 (µg/ m^3)	PM2.5 (µg/m^3)	SO2 (µg/m^3)	NO2 (µg/m^3)	O3 (µg/m^3)	CO (mg/m^3)	
Good	(0–50)	00-50	0-30	0-40	0-40	0-50	0-1.0	Minimal Impact
Satisfactory	(51–100)	51-100	31-60	41-80	41-80	51-100	1.1-2.0	Minor breathing discomfort to sensitive people
Moderate	(101–200)	101-250	61-90	81-380	81-180	101-168	2.1-10	Breathing discomfort to the people with lung, heart disease, children and older adults
Poor	(201–300)	251-350	91-120	381-800	181-280	169-208	17-Oct	Breathing discomfort to people on prolonged exposure
Very Poor	(301–400)	351-430	121-250	801-1000	281-400	209-748	17-34	Respiratory illness to the people on prolonged exposure
Severe	(>401)	430+	250+	1000+	400+	748+	34+	Respiratory effects even on healthy people

The Air Quality Index (AQI) is a crucial tool for monitoring air quality and identifying effective solutions to combat air pollution in Tonk. Developed by the Central Pollution Control Board (CPCB) in New Delhi, under the Ministry of Environment, Forest & Climate Change, the AQI provides a standardized measure for assessing air quality (Kumar Rai, 2016; Suman, 2021) [7, 8, 19]. The AQI is divided into six distinct categories: Good, Satisfactory, Moderately Polluted, Poor, Very Poor, and Severe. These categories are established based on the ambient concentration values of various air pollutants and their associated health impacts, known as health breakpoints (Dutta & Pal, 2022 [2]; Gupta & Singla, 2023 [3]; P. Kumar *et al*., 2021 [7]; Williams *et al*., 2022) [20]. The AQI sub-index includes health breakpoints for six key pollutants: PM10, PM2.5, NO2, SO2, CO, and O3, for which short-term (up to 24-hour) National Ambient Air Quality Standards have been defined (Manna & Anitha, 2022; Sahaya Sakila & Kavitha, 2022) [11, 14]. Moreover, weather conditions such as temperature, humidity, and wind speed significantly impact the AQI, influencing the dispersion and concentration of pollutants within the atmosphere. Recently, numerous researchers have conducted surveys on Air Quality Index (AQI) levels in various locations across different cities. Shiv Lal and Shulbha Kothari (2018) [9] performed a comparative study of air pollution in major cities of Rajasthan, India (Lal & Kothari, 2018) [9]. Their findings revealed that the levels of PM10, PM2.5, NO2, SO2, CO, and O3 in six selected cities were within the prescribed limits, with Udaipur exhibiting the least pollution. Conversely, P. Kumar *et al*. (2021) [7] reported that levels exceeded prescribed limits in Jodhpur, Jaipur, Pali, Ajmer, and Alwar, noting that PM10 levels were only above limits in Jodhpur and Pali. In another study, Gowtham Sarella and Mrs. Dr. Anjali K. Khambete (2015) analyzed ambient air quality using the AQI in Vapi, finding that the AQI values fell within the"moderately polluted" category (101 – 200) (Sarella & Khambete, 2015). Nitish Kumar Rai (2016) [8] also conducted a comparative study of ambient air quality based on the AQI in the residential areas of Jodhpur City (Kumar Rai, 2016) [8]. Additionally, D. K. Sharma, Deepak Mathur, and Himanshu Sharma carried out a case study on the ambient air quality of Jaipur City (D. K. Sharma *et al*., n.d.). These studies underscore the variations in air quality across different locations, highlighting the importance of ongoing monitoring and efforts for improvement.

Material and method

1. Site selection

The selected site for the Continuous Ambient Air Quality Monitoring System (CAAQMS) is located in the Housing Board area of Tonk, where it measures real-time levels of PM2.5 and PM10 air pollution in India. This system delivers continuous data that monitors and evaluates air pollutants in the region. The Rajasthan Pollution Control Board (RPCB) has installed online pollution measurement equipment at this location, enabling easy access to observations through the Central Pollution Control Board's website in New Delhi (Ministry of Environment, Forest & Climate Change). As shown in Fig. 1, the Housing Board CAAQMS site is highlighted by bullets on the map of Rajasthan.



(https://foundation.rajasthan.gov.in/rf/index.html)

Fig 1: Housing Board CAAQMS, Tonk

2. Observations

The observations can be collected from Housing Board CAAQM central pollution control board (CPCB) website Online Monitoring and Analysis Platform. (https://www.aqi.in/in/dashboard/india/rajasthan/tonk), which provides historical data queries and analysis starting in November 2024 to December 2024.The sampling of the above pollutants was recorded continuously for 24-hours on four days in each.

Results and Discussions

This study analyzes the Temporal characteristics variation in the concentration level and variations in concentration of pollutants such as PM10, PM2.5, NO2, SO2, CO, and O3at Housing Board CAAQM of Tonk city were collected from 2020 to 2025 /October 2024 to Novembe2024 and draws the following main conclusions.

The concentration level and variations in concentration of pollutants such as PM10, PM2.5, NO2, SO2, CO, and O3at Housing Board CAAQM of Tonk city were collected from October 2024 to November 2024. The concentration level data of pollutants of Housing Board CAAQM, which is taken from AQI App and Rajasthan Pollution Control Board (RPCB- November 2024) department.

The monthly average and mean of these pollutants were calculated and compared with the CPCB standards. The analysis of data shows that SO2 and NO2 are within the permissible limits while PM10 is found to be above the permissible limits at Housing Board CAAQM.

1. Fluctuation and Current AQI Status of Tonk

As of the latest available data, the current AQI of Tonk Minimum 94 and Maximum193 with statistically significant with p = 0.005767, which falls under the "satisfactory and moderate" category. The monthly average of AQI at Housing Board CAAQM locations has been presented in Figure 1

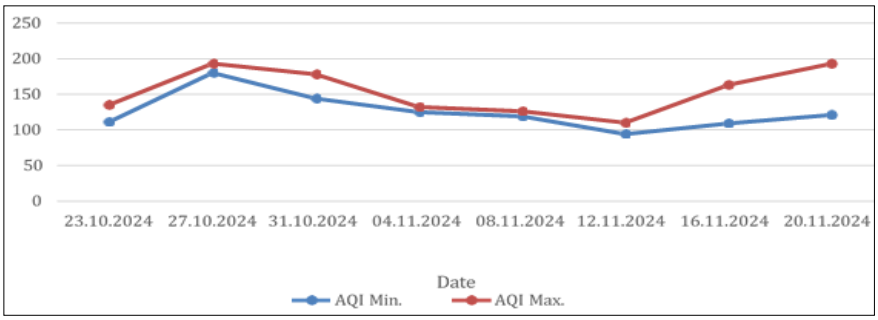


Fig. 1: Concentration of AQI

2. Fluctuation in Concentration of PM2.5 and PM10 Pollutant

Based on the latest available data, the minimum concentration of PM10 is recorded at 101, while the maximum concentration reaches 195, with a statistically significant p-value of 0.009796. This categorizes PM10 levels as "moderate." In terms of PM2.5, the minimum concentration is 43, and the maximum is 87, also with a statistically significant p-value of 0.009796, placing these levels in the "satisfactory" to "moderate" categories. The monthly average concentrations of PM2.5 and PM10 at the Housing Board CAAQM site are presented in Figure 2.

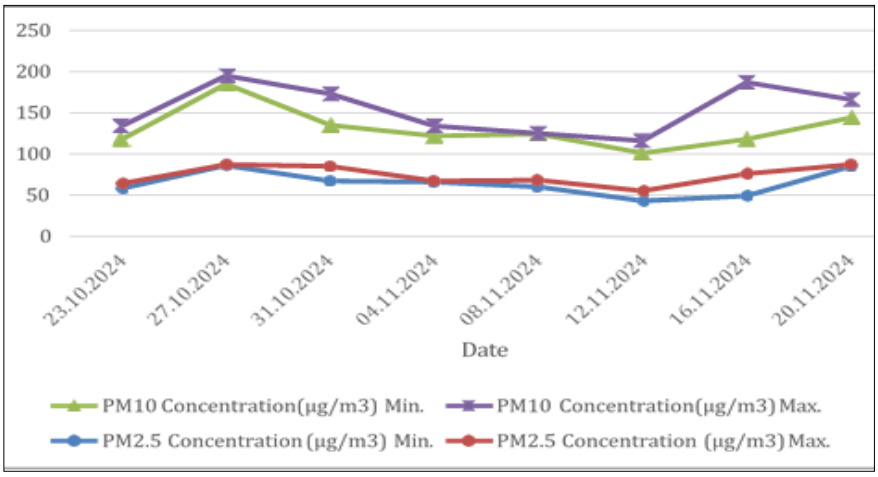


Fig. 2: Concentration of PM2.5 and PM10

3. Fluctuation in Concentration of NO2, SO2 and O3 Pollutant The monthly average of NO2, SO2 and O3 Pollutant concentration at Housing Board CAAQM locations has been presented in Figure 3.

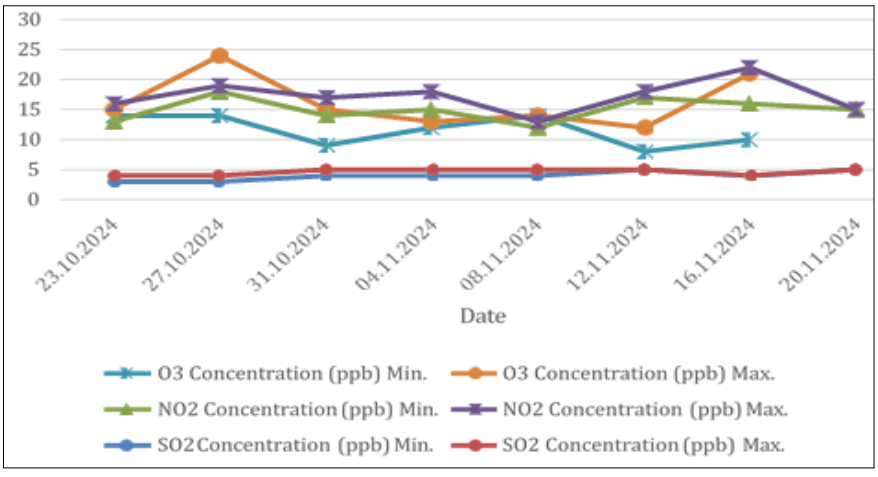


Fig 3: Fluctuation in Concentration of NO2 Pollutant

As of the latest available data, the Minimum concentration of NO2 12 and Maximum 22 with statistically significant p = 0.006258, which falls under the " moderate" category and, the Minimum concentration of SO2 3 and Maximum 5 with statistically significant p = 0.005601, which falls under the " moderate" category. the Minimum concentration of O3 8 and Maximum 24with statistically significant p = 0.006398, which falls under the " moderate" category.

4. Annual Air Quality Changes Trends in AQI, PM2.5, PM10, SO2, NO2, O3 and CO from year 2020 – 2025 (https://www.aqi.in/in/dashboard/india/rajasthan/ton).

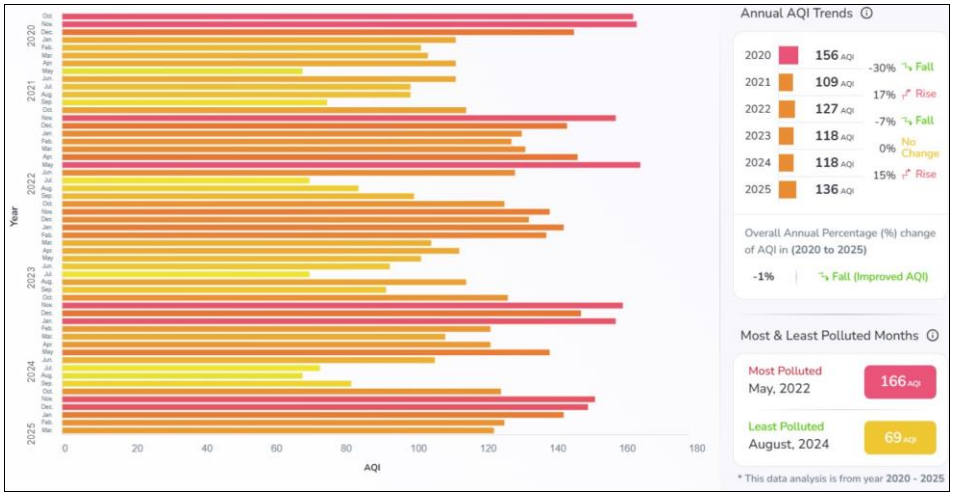


Fig 4: Annual Air Quality Changes Trends in AQI from year 2020 – 2025

Overall Annual Percentage (%) change of AQI in (2020 to 2025): There is 2% increase in the Air Quality Index (AQI) highlights an urgent need for enhanced efforts to improve air quality. May 2021 was recorded as the most polluted month, in contrast to August 2024, which exhibited the best air quality.

Fig 5: Annual Air Quality Changes Trends in PM2.5, and PM10 from year 2020 – 2025

Overall Annual Percentage (%) change of AQI in (2020 to 2025): There is 2% increase in the Air Quality Index (AQI) highlights an urgent need for enhanced efforts to improve air quality. May 2021 was recorded as the most polluted month, in contrast to August 2024, which exhibited the best air quality.

Fig 6: Annual Air Quality Changes Trends in SO2, and NO2 from year 2020 – 2025

The overall annual percentage change in SO2 levels from 2020 to 2025 is rise by 16%, indicating a decline in air quality. The highest concentration of SO2 was recorded in April 2024 at 6 ppb, while the lowest level was observed in September 2023 at 3 ppb. These trends highlight the challenges in managing air quality and underscore the need for ongoing efforts to mitigate pollution. In contrast, the investigated overall annual percentage change in NO2 levels from 2020 to 2025 is a decrease of 5%, signifying an improvement in air quality. The peak concentration of NO2 occurred in April 2024 at 32 ppb, while the lowest level was documented in August 2024 at 7 ppb. These trends reflect significant progress in addressing air pollution and present opportunities for further enhancements in air quality.

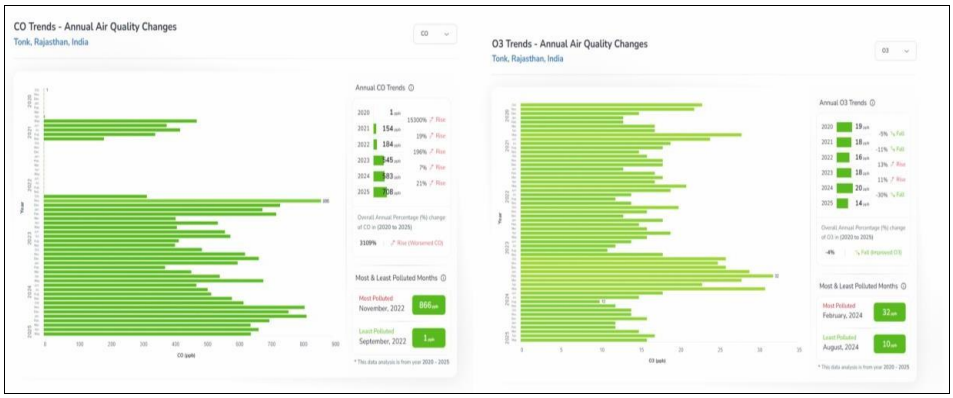


Fig 7: Annual Air Quality Changes Trends in O3 and CO from year 2020 – 2025

Similarly, the anticipated overall annual percentage change in O3 levels from 2020 to 2025 is decline by 5%, indicating an improvement in air quality. The highest O3 concentration was recorded in February 2024 at 32 ppb, while the lowest level was observed in August 2024 at 10 ppb. These trends demonstrate noteworthy advancements in managing air pollution and underscore the potential for further improvements in air quality. Conversely, the overall annual percentage change in CO levels from 2020 to 2025 is shown in figure 7, reflecting a significant decline in air quality. The peak concentration of CO was noted in January 2025 at 882 ppb, while the lowest level was registered in September 2022 at 91 ppb. These trends emphasize the serious challenges involved in managing air pollution and highlight the urgent need for enhanced measures to improve air quality.

5. Health Impacts of Poor AQI

Prolonged exposure to poor air quality can have severe health impacts, including:

Respiratory problems: Poor air quality can exacerbate respiratory issues such as asthma and chronic obstructive pulmonary disease (COPD).

Cardiovascular diseases: Exposure to poor air quality can increase the risk of cardiovascular diseases, including heart attacks and strokes.

Other health issues: Poor air quality can also lead to other health issues, including lung cancer, neurological damage, and birth defects**.**

Conclusions

The AQI of Tonk is a significant concern, with the city experiencing poor air quality. To mitigate this issue, it is essential to address the factors contributing to air pollution, including industrial activities, vehicular emissions, and agricultural activities. The government, industries, and individuals must work together to implement effective strategies to reduce air pollution and improve the AQI of Tonk.

Weather Conditions: Temperature, humidity, and wind speed also play a role in determining AQI. Currently, the temperature is 26°C, humidity is 22%, and wind speed is 4 km/h [1].

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