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Assessment of Ambient Air Quality Status at Different Railway Bridge Construction Sites

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ABSTRACT

Assessment of the ambient air quality status near three railway bridges, namely, the Tangari, Ghaggar and Markanda in the state of Haryana, India, was done according to the standard procedures. After sampling, air quality parameters like $PM_{2.5}$, PM_{10}, NO_2, SO_2, CO and the noise levels were analyzed and presented numerically. All the permissible limits were considered as per NAAQS limits (prescribed by CPCB) and compared with the observed values. The observed concentrations of NO_2, SO_2 and CO were found below the permissible limits. However, in most cases, the observed concentrations of other air quality parameters like $PM_{2.5}$, PM_{10} and noise levels, at different sampling locations, were found above the permissible limits of NAAQS as prescribed by CPCB.

Key words: Railway bridge, air quality, $PM_{2.5}$, PM_{10}, NAAQS, CPCB

INTRODUCTION

Air pollution, in general, refers to any undesirable changes in the quality of air that may be harmful to any living organism and is one of the most significant risk factors for human health. Air pollution is a silent killer which lurks around us, influencing both younger and older generations (Bala *et al.*, 2021). It is a major concern in the assessment of the global burden of disease (GBD), and the World Health Organization (WHO) estimates that it accounts for 6.7% of all mortality and 7.6% of disability-adjusted life years (DALYs) globally, as well as the fourth most important risk factor for premature death (Brauer, 2016). Lung cancer, chronic obstructive pulmonary disease and respiratory infections, including heart disease, stroke and pneumonia, are the most affected pathologies (dos Santos *et al.*, 2022). Nine out of 10 people breathe polluted air, which penetrates deep into lung tissue as well as the cardiovascular system (Tiotiu *et al.*, 2020; Sekar *et al.*, 2021). However, epidemiological cohort studies suggest that the health effects are dependent on the presence of long-lived ambient particulate matter and related risk factors may differ from region to region (Maji *et al.*, 2017). Some significant findings suggest that when the air becomes polluted with dust, the prevalence of cardiac and pulmonary diseases rises (Khaniabadi *et al.*, 2019; Tajudin *et al.*, 2019) and long-term exposure to particulate matter reduces life expectancy (Sarkodie *et al.*, 2019). Clinical studies also suggest that the cells of the respiratory system are remedied or replaced at a slower rate than those of the body's other organs (for instance the coating cells of the digestive system). Moreover, studies suggest that millions of people worldwide die prematurely as a result of cardiovascular and respiratory diseases caused by air pollution (Viegi *et al.*, 2020).

Rapid industrialization and urbanization in India have caused significant economic changes in the last decade and become one of the world's fastest growing economies (Franco *et al.*, 2017). However, this growth has come at a significant cost to the country's public health and environment (Maji *et al.*, 2017). Rapidly expanding urban areas account for 44% of India's carbon emissions and currently facing a number of environmental challenges, including air pollution, lack of clean water, river water pollution, deforestation and desertification (Maji *et al.*, 2017). High levels of air pollution have a negative impact on the health system and the economy, resulting in negative health outcomes (Chadetrik *et al.*,

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2015; Taghizadeh-Hesary and Taghizadeh-Hesary, 2020). From the literature, it was evident that air pollution is severely threatening mankind's health in both developing and developed countries. Immense amounts of pollutants are emitted from vehicles, construction and industrial activities, residential areas, etc., making air unfit to breathe, thus causing respiratory problems. During railway bridge construction generation of dust/particulate matter from construction work, and gaseous emissions (SO_2, NO_2, CO, etc.) from vehicles and machinery pollute the surrounding air. Therefore, a systematic study was planned and conducted to assess the ambient air quality status at different railway bridges, namely, the Tangari, Ghaggar and Markanda, in the Ambala district of Haryana state, India.

METHODOLOGY

In order to assess the ambient air quality status of some railway bridge construction sites over the rivers Tangari, Ghaggar and Markanda air sampling was done and analyzed (Table 1 and Fig. 1). The parameters measured were $PM_{2.5}$, PM_{10}, NO_2, SO_2 and CO. Particulate matters like $PM_{2.5}$ and PM_{10} were measured gravimetrically using air sampler. NO_2 and SO_2 were measured (on 24 h basis) volumetrically. CO concentration was measured by sensor based on non-dispersive infra-red spectroscopy (NDIR) principle (on 01-h basis). For sampling and analysis, all instructions and precautions as per the IS-5182 Part 6 and 14 (2005 and 2006) were adhered to. A total of three air sampling stations were selected (one for each railway bridge) during site visits and one sample was taken per station at a suitable distance (Fig. 1). The primary data collection was done, involving three sampling periods, one in January 2019, second in June 2019 and third in November 2019. A total of 63 air samples were collected near the construction bridge sites.

Fig. 1. Ambient air and noise sampling locations.

The ambient noise levels were measured at three different locations (one for each bridge) around 50 m away from the existing railway bridge during the day (06:00-22:00) and night time (22:00-06:00). Measurements were taken using a sound level meter for 12 h in the day and 08 h in the night time. A total of 27 (24 h) noise readings were taken near the sampling locations (Table 1 and Fig. 1).

RESULTS AND DISCUSSION

The concentration of $PM_{2.5}$ in the ambient air at Tangri railway bridges was 59.84, 63.61 and 65.31 μg/m^3 observed during the months of January, June and November 2019, respectively (Table 2). $PM_{2.5}$ reached maximum

Table 1. Description of truss well-type railway bridges where air and noise sampling were done

Bridge	No. of spans	Span length (m)	UTM coordinates		District
			X (Easting) m	Y (Northing) m	
Tangari	3	46.5	679030	3354424	Ambala
Ghaggar	6	30.0	666077	3364359	Ambala
Markanda	6	47.24	689435	3347580	Ambala

during the month of November and minimum during the month of January 2019. The average value was 62.92 µg/m^3 with standard deviation of 2.80. Except in the month of January 2019, all the observed values were found above the NAAQS limits i.e. 60 µg/m^3 as prescribed by CPCB. The values of $PM_{2.5}$ in the ambient air at the Ghaggar railway bridge were 68.40, 64.60 and 63.67 µg/m^3 observed during the months of January, June and November 2019, respectively. $PM_{2.5}$ reached maximum during the month of January 2019 and minimum during the month of November 2019. However, the average $PM_{2.5}$ was 65.56 µg/m^3 with a standard deviation of 2.51. All the observed values exceeded the NAAQS limits i.e. 60 µg/m^3 as prescribed by CPCB. The values of $PM_{2.5}$ in the ambient air at the Markanda railway bridge were 57.85, 57.90 and 70.34 µg/m^3 observed during the months of January, June and November 2019, respectively. $PM_{2.5}$ reached maximum during the month of November 2019 and minimum during the month of January 2019. The average value was calculated as 62.06 µg/m^3 with a standard deviation of 7.20. In the month of November, the observed values exceeded the NAAQS limits but in the months of January and June found to be below the NAAQS limits i.e. 60 µg/m^3 as prescribed by CPCB.

Construction activities near the railway bridge construction sites resulted in higher $PM_{2.5}$ concentrations (Table 1). Epidemiological studies revealed that $PM_{2.5}$ can enter the lung and irritate and corrode the alveolar wall, impairing lung function (Xing *et al.*, 2016). Therefore, it is advised that workers should use masks during working hours to avoid various respiratory problems.

The observed concentrations of PM_{10} in the ambient air at the Tangri railway bridge construction site were 92.14, 112.10 and 115.21 µg/m^3 during the months of January, June and November 2019, respectively (Table 2). PM_{10} concentration reached maximum during the month of November 2019 and minimum during the month of January 2019. The average value was calculated as 106.48 µg/m^3 having a standard deviation of 12.52 µg/m^3. Similarly, the concentrations of PM_{10} in the ambient air at the Ghaggar railway bridge construction site were found 107.76, 118.80 and 119.35 µg/m^3 during the months of January, June and November 2019, respectively. PM_{10} concentration reached maximum during the month of November 2019 and minimum during the month of January 2019. The average value was calculated as 115.30 µg/m^3 having a standard deviation of 6.54. The concentrations of PM_{10} in the ambient air at the Markanda railway bridge construction site were 138.40, 108.00 and 122.34 µg/m^3 observed during the months of January, June and November 2019, respectively. PM_{10} reached maximum during the month of January 2019 and minimum during the month of June 2019. The average value was calculated 122.91 µg/m^3 having standard deviation of 15.21. All the observed PM_{10} concentrations at the Tangri, Ghaggar and Markanda railway bridge construction sites exceeded the NAAQS limits of 100 µg/m^3

Table 2. Ambient air quality at Tangri, Ghaggar and Markanda railway bridges

S. No.	Railway bridge	Parameter	January 2019	June 2019	November 2019	Average	NAAQS* limits
1.	Tangri	$PM_{2.5}$	59.84	63.61	65.31	62.92±2.80	60
	Ghaggar		68.40	64.60	63.67	65.56±2.51	
	Markanda		57.85	57.90	70.34	62.06±7.20	
2.	Tangri	PM_{10}	92.14	112.10	115.21	106.48±12.52	100
	Ghaggar		107.76	118.80	119.35	115.30±6.54	
	Markanda		138.40	108.00	122.34	122.91±15.21	
3.	Tangri	NO_2	24.85	30.50	36.45	30.60±5.80	80
	Ghaggar		23.72	36.75	34.21	31.56±6.91	
	Markanda		26.96	28.90	32.43	29.43±2.77	
4.	Tangri	SO_2	11.36	23.56	25.97	20.30±7.83	80
	Ghaggar		9.89	24.87	27.31	20.69±9.43	
	Markanda		9.84	19.57	24.45	17.95±7.44	
5.	Tangri	CO	0.81	1.15	1.45	1.14±0.0.32	04
	Ghaggar		0.70	1.50	1.29	1.16±0.0.41	
	Markanda		0.63	1.60	1.30	1.18±0.0.50	

*All the values in µg/m^3 (24 h) except CO in mg/m^3 (01 h).

as prescribed by CPCB except in the month of January near the Tangri site. Scientific studies revealed that when exposed to high concentrations of PM_{10}, it can cause a variety of health effects ranging from coughing and wheezing to asthma attacks and bronchitis, as well as high blood pressure, strokes, heart attacks and premature death (Maheswari *et al.*, 2020). Therefore, it is recommended that workers should take necessary precautions during working hours to avoid serious health problems.

The NO_2 concentration in the ambient air near the Tangri railway bridge construction site was observed as 24.85, 30.50 and 36.45 µg/m^3 during the months of January, June and November 2019 (Table 2). The NO_2 values reached maximum during the month of November 2019 and minimum during the month of January 2019. The average value was calculated as 30.60 µg/m^3 with a standard deviation of 5.80. The NO_2 concentration in the ambient air near the Ghaggar railway bridge construction site was observed as 23.72, 36.75 and 34.21 µg/m^3 during the months of January, June and November 2019, respectively. The NO_2 concentrations reached maximum during the month of June 2019 and minimum during the month of January 2019. The average concentration was calculated as 31.56 µg/m^3 with a standard deviation of 6.91. The NO_2 concentration in the ambient air near the Markanda railway bridge construction site was observed as 26.96, 28.90, and 32.43 µg/m^3 during the months of January, June and November 2019, respectively. The NO_2 construction reached maximum during the month of November 2019 and minimum during the month of January 2019. The average value was calculated as 29.43 µg/m^3 with a standard deviation of 2.77. Thus, the concentration of NO_2 near the Tangri, Ghaggar and Markanda railway bridge construction sites (Fig. 1) was found within the NAAQS limits of 80 µg/m^3 as prescribed by CPCB.

The SO_2 concentration in the ambient air near the Tangri railway bridge construction site was observed as 11.36, 23.56 and 25.97 µg/m^3 during the months of January, June and November 2019, respectively (Table 2). It was observed that the SO_2 concentration reached maximum during the month of November 2019 and minimum in January 2019. The average concentration of SO_2 was calculated as 20.30 µg/m^3 with a standard deviation of 7.83. The SO_2 concentration in the ambient air near the Ghaggar railway bridge construction site was observed as 9.89, 24.87 and 27.31 µg/m^3 during the months of January, June and November 2019, respectively. The observed results clearly showed that the SO_2 concentration reached maximum during the month of November 2019 and minimum in January 2019. The average concentration of SO_2 was calculated as 20.69 µg/m^3 with a standard deviation of 9.43. The SO_2 concentration in the ambient air near the Markanda railway bridge construction site was observed as 9.84, 19.57 and 24.45 µg/m^3 during the months of January, June and November 2019, respectively. The obtained results clearly showed that the SO_2 concentration reached maximum during the month of November 2019 and minimum in January 2019. The average concentration of SO_2 was calculated as 17.95 µg/m^3 with a standard deviation of 7.44. Overall, the concentration of SO_2 near the Tangri, Ghaggar and Markanda railway bridge construction sites was found within the NAAQS limits i.e. 80 µg/m^3 as prescribed by CPCB.

The CO concentration in the ambient air quality near the Tangri railway bridge construction site was observed as 0.81, 1.15 and 1.45 mg/m^3 during the months of January, June and November 2019, respectively (Table 2). The maximum concentration was noticed during the month of November 2019 and minimum during the month of January 2019. The average concentration of CO was calculated as 1.14 mg/m^3 with a standard deviation of 0.32. Moreover, a clear upward trend of CO concentration in the ambient air quality near the Tangri bridge construction was noticed. The CO concentration in the ambient air quality near the Ghaggar railway bridge construction site was observed as 0.70, 1.50 and 1.29 mg/m^3 during the months of January, June and November 2019, respectively. The maximum concentration was noticed during the month of June 2019 and the minimum during the month of January 2019. The average concentration of CO was calculated as 1.16 mg/m^3 with a standard deviation of 0.41. The CO concentration in the ambient air quality near the Markanda railway bridge construction site was observed as 0.63, 1.60 and 1.30 mg/m^3 during the months of January, June and November 2019,

Table 3. Ambient noise level at Tangri, Ghaggar and Markanda railway bridges

Railway bridge	January 2019		June 2019		November 2019		Average		Residential area		Remarks
	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	
Tangri	51.69	39.85	68.90	57.40	69.1	56.4	63.23±9.99	51.22±9.86	55	45	Exceeding the limits
Ghaggar	52.14	39.69	69.60	55.75	68.9	56.7	63.55±9.88	50.71±9.56			
Markanda	52.40	42.81	65.30	54.60	73.68	63.37	63.79±10.72	53.59±10.32			

All values are in dB (A) Leq.

respectively. The maximum concentration was noticed during the month of June 2019 and the minimum during the month of January 2019. The average concentration of CO was calculated as 1.18 mg/m^3 with a standard deviation of 0.50. Overall, the CO concentration in the ambient air quality at Tangri, Ghaggar and Markanda railway bridge construction sites was found well below the NAAQS limits i.e. 4 mg/m^3 as prescribed by CPCB.

The observed equivalent noise levels (Leq) at the Tangri railway bridge construction site during the day and night time were 51.69 (day) and 39.85 (night), 68.90 (day) and 57.40 (night) and 69.1 (day) and 56.4 dB (A) (night) for the months of January, June and November 2019 respectively (Table 3). The Leq noise level for daytime was observed maximum during November 2019 and minimum during January 2019, while the Leq noise level for night time was highest during June 2019 and lowest during January 2019. The mean noise level for the day and nighttime was calculated as 63.23±9.99 and 51.22±9.86, respectively. The equivalent noise level (Leq) at the Ghaggar railway bridge construction site during day and night time was 52.14 (day) and 39.69 (night), 69.60 (day) and 55.75 (night) and 68.9 (day) and 56.7 dB (A) (night) for the months of January, June and November 2019, respectively. The observed Leq noise level for day time was maximum during June 2019 and minimum during January 2019, while the Leq noise level for night time was highest during November 2019 and lowest during January 2019. The mean noise level for the day and night time was 63.55±9.88 and 50.71±9.56, respectively. The equivalent noise level (Leq) at the Markanda railway bridge construction site during the day and night time for the months of January 2019, June 2019 and November 2019. 2019 was 52.40 (day) and 42.81 (night), 65.30 (day) and 54.60 (night) and 73.68 (day) and 63.37 dB (A) (night), respectively. The observed Leq noise level for daytime was maximum during November 2019 and minimum during January 2019, while the Leq noise level for nighttime was highest during June 2019 and lowest during January 2019. The mean noise level for the day and night time was calculated as 63.79±10.72 and 53.59±10.32, respectively. All the averaged noise levels at different sites (Table 1) exceeded the standard noise limits (For residential areas i.e. 55 and 45 dB (A) Leq for day and night time, respectively) as prescribed by CPCB.

CONCLUSION

The ambient air quality parameters such as NO_2, SO_2 and CO were observed below the permissible limits, whereas $PM_{2.5}$ and PM_{10} were found to be above the permissible limits at sampling locations. During the construction phase of the project, the noise levels of the study areas exceeded the allowable limits during the day and night time. Therefore, it was recommended that proper mitigation measures be implemented as notified by the Ministry of Environment, Forest and Climate Change (MoEFCC) and CPCB for a better working environment as well as to avoid serious health problems.

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