

**BEFORE THE HON'BLE NATIONAL GREEN TRIBUNAL
PRINCIPAL BENCH, NEW DELHI
(Through Video Conferencing)**

**Original Application No.92/2018 (WZ)
[Earlier O.A. No.1A/2018(WZ)]**

Vanshakti & Ors.

... Applicants

v/s

MPCB & Ors.

... Respondents

Submission of Final Report in compliance of Order dated 01/07/2020 passed by this Hon'ble NGT.

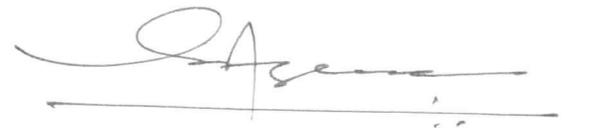
- (1) In compliance of Order dated 01/07/2020 passed by this Hon'ble Tribunal, the Respondent Board had issued Work Order dated 31/12/2020 to The Energy and Resources Institute (TERI) for Assessment of Ambient Air Quality in the nearby vicinity of brick kilns in Thane and Palghar Districts, Maharashtra.
- (2) As per the said Work Order, the Theoretical Report of July, 2021 submitted by TERI regarding Assessment of Ambient Air Quality in the nearby vicinity of brick kilns in Thane and Palghar Districts, Maharashtra was filed before this Hon'ble Tribunal in the month of July, 2021.
- (3) Thereafter, TERI has submitted Baseline Report of December, 2021 regarding Assessment of Ambient Air Quality in the nearby vicinity of brick kilns in Thane and Palghar Districts, Maharashtra, which was filed before this Hon'ble Tribunal on 7/3/2022.
- (4) Now, the TERI has submitted the Final Report of April, 2022 about the Assessment of Ambient Air Quality in the nearby vicinity of

brick kilns in Thane and Palghar Districts, Maharashtra. The conclusion of the Report is as follows :-

- (i) The results of the ambient air quality monitoring carried out at different locations in Palghar and Thane indicated that the levels of gaseous pollutants such as SO₂ and NO₂ were within the specified limits. However particulate matter (both PM₁₀ and PM_{2.5}) levels were above the limits prescribed by CPCB. Although the results showed a slight increase in pollutants concentrations during the period when the kilns were in operation compared to the baseline.
- (ii) Though there are different sources such as dust generated from various activities including road dust and windblown dust, industries, transport, residential biomass burning, agricultural residue burning, DG sets, restaurants, etc. which are contributing to the prevailing ambient PM levels of a region.

A copy of the Final Report of April, 2022 about the Assessment of Ambient Air Quality in the nearby vicinity of brick kilns in Thane and Palghar Districts, Maharashtra prepared by the Energy and Resources Institute (TERI) is enclosed herewith and marked as an **Annexure-‘I’**.

For and on behalf of Maharashtra
Pollution Control Board


(Dr.V.M. Motghare) 13/4/2022
Joint Director(APC)

Place : Mumbai
Date : 13/4/2022

Final Report

April 2022

Assessment of ambient air quality in the nearby vicinity of brick kilns in Thane and Palghar district, Maharashtra



Submitted to

Maharashtra Pollution Control Board (MPCB)

Prepared by

The Energy and Resources Institute (TERI)



The Energy and Resources Institute

*...towards global
sustainable development*



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Background

The Hon'ble NGT via its Original Application No.1A/2018 (WZ) –date of hearing: 01.07.2020 has directed Maharashtra Pollution Control Board (MPCB) and the District Collector, Palghar to inspect the area where the illegal brick kilns are said to be operating and if upon inspection, it is found that the brick kilns are indeed operating without the necessary consent to operate and other clearances under the Rules, appropriate action to be taken against them in accordance with law.

Further to this, MPCB has issued the work order No.BO/JD (APC)/Brick Kilns/TB-2-B-201231-FT5-0105 to The Energy and Resources Institute (TERI) on 31st December 2020 for carrying out an "Assessment of ambient air quality in the nearby vicinity of brick kilns in Thane and Palghar district, Maharashtra".

As part of this project, MPCB & TERI mutually defined the below project objectives:

Project Objectives:

- 1) To conduct site survey of selected operational brick kilns in consultation with MPCB for Thane and Palghar district to understand:
 - ✓ Geographical Location (Rural/Urban/Peri-Urban)
 - ✓ Capacity of brick kiln
 - ✓ Scale of Operation
 - ✓ Duration of Operation
 - ✓ Technology adopted
 - ✓ Raw Material
 - ✓ Fuel type and Consumption
 - ✓ Consent and NOC from other departments
- 2) To carry out ambient air quality monitoring in the vicinity of brick kilns in Thane and Palghar districts
- 3) To carry out stack emission monitoring of selected brick kilns
- 4) To compare the results with existing ambient air quality/emissions standard prescribed by Central Pollution Control Board (CPCB)
- 5) Scope of fly ash utilization in brick manufacturing
- 6) To submit a report on the monitoring carried out and infer upon the monitored status with the prescribed standard limits for the various parameter, wherever applicable.
- 7) To submit suggestions on how brick kilns can be allowed and criteria for fixing such numbers in the region without damaging the air quality.

Methodology

To evaluate the air quality in and around brick kiln area, high volume air sampler was used. The main pollutants considered for the study include Particulate matter (PM₁₀, PM_{2.5}), SO₂ and NO₂.

The sampling instrument was set up 3 meters above ground and 24 hourly values for all pollutants were measured at each site for continuous 2 days.

Below conditions were taken into consideration while selecting the monitoring sites

1. Distance of the bricks kilns from Tungareshwar WLS (*Refer to Annexure 1: Details of AAQM sites across Thane and Palghar District*)
2. Continuous power supply at all these locations at the time of monitoring.
3. The wind direction during the time of sampling (Wind rose during baseline and interim stage assessment of AAQM (*Provided in Annexure 2 Wind rose during baseline and interim stage of AAQM*)).

The wind direction in the specified zone is towards the East from the West and South-West direction. Therefore a specific location in the upwind direction with respect to the Brick Kiln clusters was chosen to provide a baseline/ control reading at each region which includes Bhiwandi (B1), Wada (W1) and Vasai (V1) henceforth referred to as the Control Locations (CLB1, CLW1 and CLV1 respectively). It was also ensured that there were no brick kilns in the nearby areas or upward of this Control Location.

The methods followed are strictly in accordance with the guidelines laid down by the CPCB and Bureau of Indian Standards (BIS). The summary of the sampling and monitoring techniques is given below in Table: 2

Table No. 1 : Summary of sampling and monitoring techniques

Pollutant	Sampling and measurement Techniques	Method
PM ₁₀ /PM _{2.5}	PM ₁₀ /PM _{2.5} Sampler	Gravimetric
SO ₂ , NO ₂	Absorption and analysis by wet chemical methods(modified West & Gaeke method for SO ₂ & Jacob & Hochheiser modified Na- Arsenite method for NO ₂	SO ₂ – IS 5182 (Part 2): 2017 NO ₂ – IS 5182 (Part 6): 2017

Ambient Air Quality Monitoring (AAQM) sites

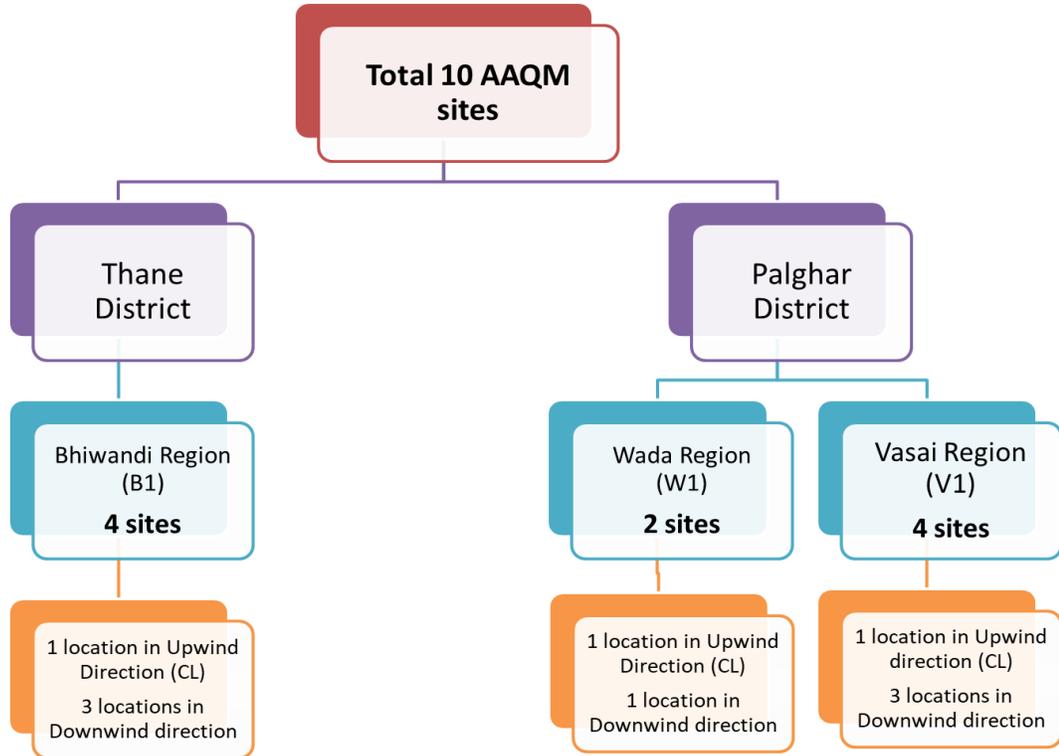


Figure No. 1 : AAQM sites at Thane and Palghar District

Note: CL: Control Location

- The details of site locations are represented in Table No. 6 of Annexure 1
- District wise representative photos of Brick kilns and Monitoring machines during operational phase and non-operational phase are represented in Annexure 3.

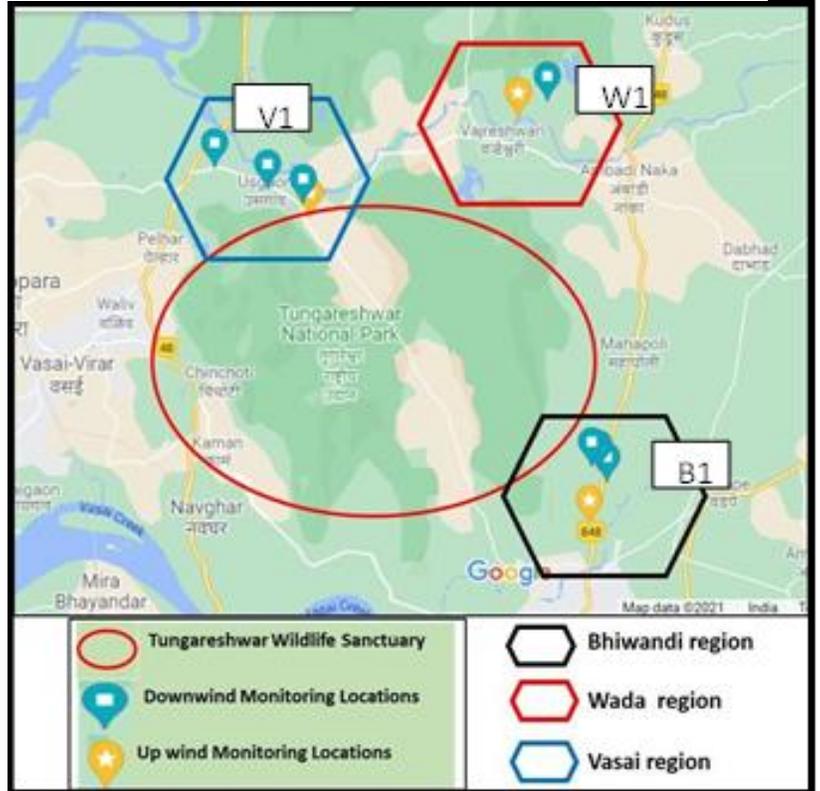


Figure No. 2 : Map representing ambient air quality monitoring locations around Tungreshwar Wildlife sanctuary



The monitoring schedule of monitoring is given in Table No.3

Table No. 2 : Monitoring schedule of monitoring for Brick kilns during operational and non-operational phase

Particulars				Monitoring dates for Baseline Assessment-initial stage (Brick kilns in the non-operational phase) December 2021					Monitoring Dates for interim stage (Brick Kilns in Operational Phase) March 2022									
No.	District	Region	Location	8	9	10	11	12	1	2	3	9	10	11	15	16	17	
1	Thane	Bhiwandi	Bhiwandi-Wada Road,Koliwali,Bhiwandi															
2			Kawad Village,Koilwali (3 Nos.Brick kilns)															
3			Kawad Village ,Koliwali															
4			Ambika City (Upwind)															
5	Palghar	Wada	Dakiwali village															
6			Sai Mandir,Keltan (Upwind)															
7		Vasai	Shimla Dhudh Dairy															
8			Stelmech Industry															
9			Aqua water filter factory															
10			Sarpanch Home (Upwind)															

Objective 1:**To conduct site survey of selected operational brick kilns in consultation with MPCB for Thane and Palghar district to understand:**

- **Geographical Location (Rural/Urban/Peri- Urban)**
- **Capacity of brick kiln**
- **Scale of Operation**
- **Duration of Operation**
- **Technology adopted**
- **Raw Material**
- **Fuel type and Consumption**
- **Consent and NOC from other departments.**

TERI had several interactions with MPCB officials to get information about the active brick kilns in the Thane and Palghar District.

- 1st Site survey (for obtaining basic information) of 20 locations (14 in Palghar and 6 in Thane district) dated 12th July, 2021 - Survey report submitted on 16th July, 2021 – Attached as Attachment – *Progress Report (July 2021) - Assessment of ambient air quality in the nearby vicinity of brick kilns in Thane and Palghar district, Maharashtra.*
- 2nd site visit (to finalize brick kiln locations) dated 1st – 2nd November, 2021 – Survey report submitted on 9th November, 2021- Attached as attachment – *Progress Report (November 2021).*

Objective No.2 : To carry out ambient air quality monitoring in the vicinity of brick kilns in Thane and Palghar districts.

The ambient air quality monitoring for 10 locations of the brick kilns across Thane and Palghar Districts was carried out in 2 sets.

A) Set 1 (Henceforth referred as Scenario 1):

- When the brick kilns were **not in operation phase** ie: initial stage - Baseline study in the month of December 2021 (8th to 12th December 2021).
- Based on the fuel quantity and production data provided by RO, Kalyan for the Brick kilns of Wada as an indicative example of the clamp kilns in the Thane and Palghar districts, TERI has theoretically estimated emission levels for SO₂, NO_x, PM₁₀ and PM_{2.5}. The estimated values are represented in Annexure 4.

B) Set 2 (Henceforth referred as Scenario 2)

- When the brick kilns were in operational phase ie: interim stage in the month of March 2022.
 - Bhiwandi region :1st March to 3rd March 2022
 - Wada Region : 9th March to 11th March 2022
 - Vasai Region :15th March to 17th March 2022

A) Scenario 1: Initial stage - Baseline study (Brick kilns not in operation) of Ambient Air Quality Monitoring in the vicinity of the brick kilns in Thane and Palghar District

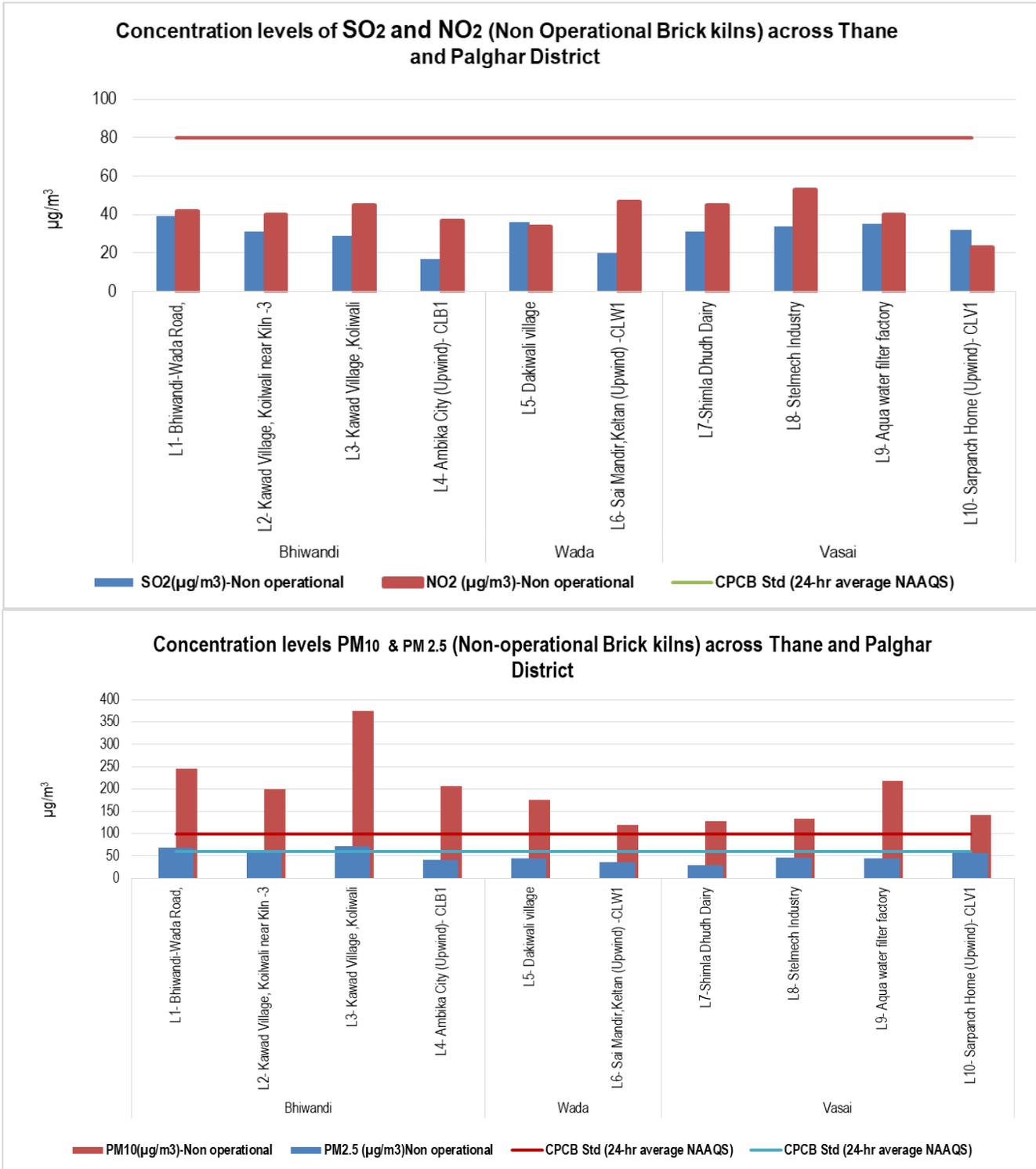


Figure No. 3 : Concentration levels of SO₂ NO₂, PM₁₀, PM_{2.5} across the 10 brick kilns in Thane and Palghar District –Non-operational phase

B) Scenario 2: Interim stage (Bricks kilns are in operational) Ambient Air Quality Monitoring in the vicinity of the brick kilns in Thane and Palghar Districts

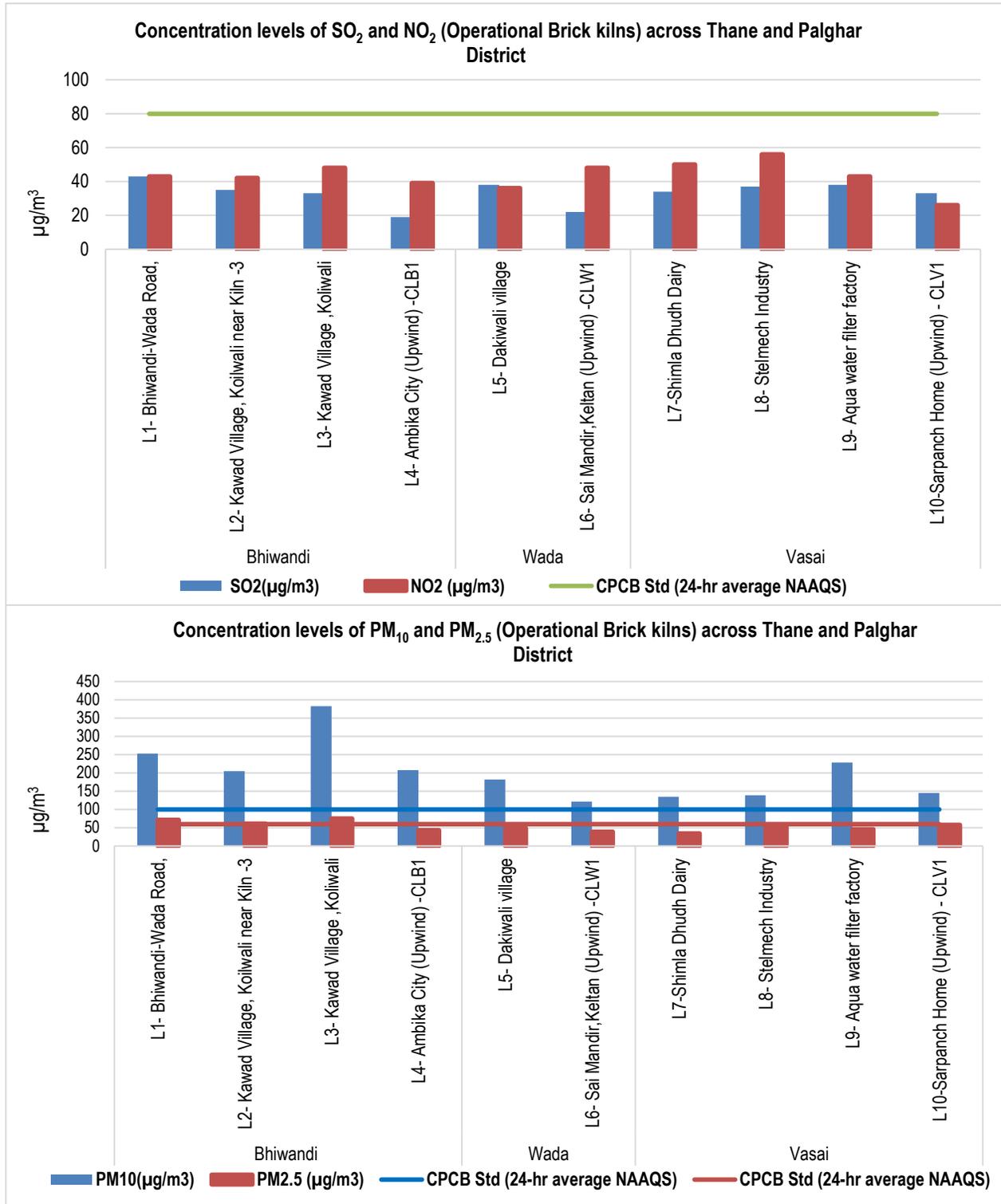


Figure No. 4: Concentration levels of SO₂ NO₂, PM₁₀, PM_{2.5} across the 10 brick kilns in Thane and Palghar District – Operational phase

Objective 3: To carry out stack emission monitoring of select brick kilns

There are only **clamp type of brick kilns** listed in the specified districts hence stack monitoring will not be possible.

Objective 4: To compare the results with existing ambient air quality/emissions standard prescribed by Central Pollution Control Board (CPCB)

The details of the concentration levels during operational and non-operational brick kilns across 10 brick kilns at Thane and Palghar District as Annexure 5 and represented in Figure No.5 & Figure No.6

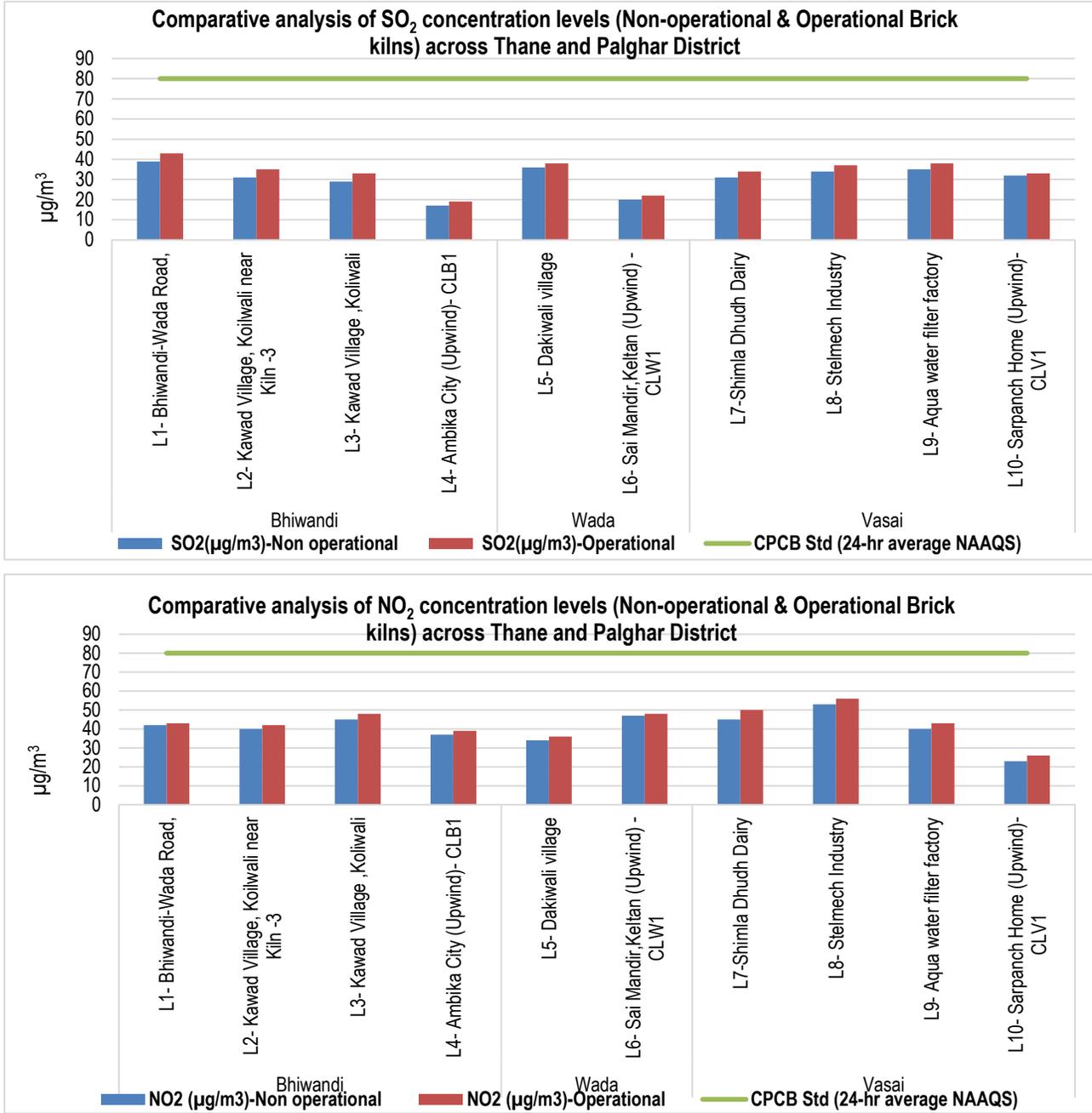


Figure No. 5 : Comparative analysis of SO₂, and NO₂ –Non-operational and operational phase

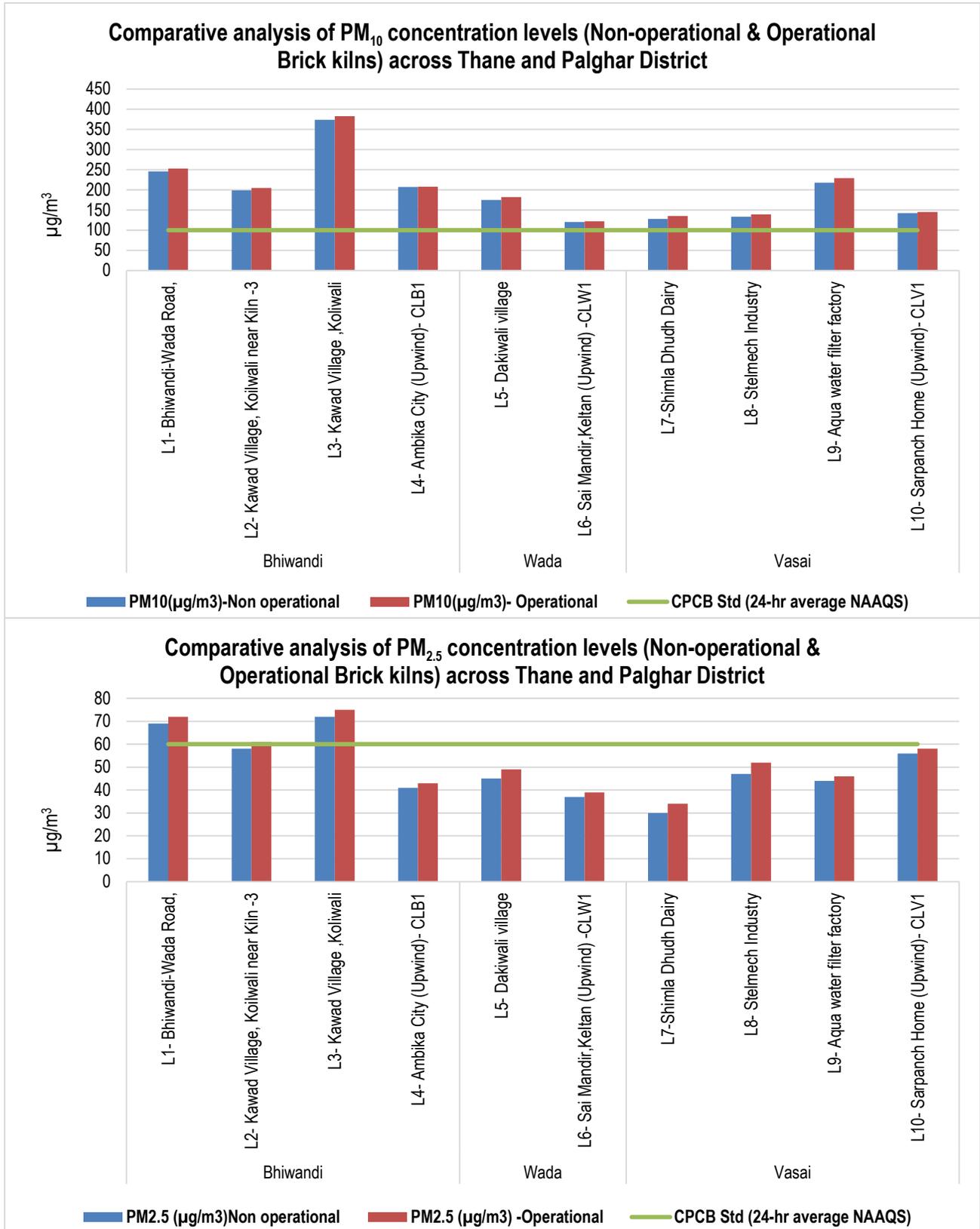


Figure No. 6: Comparative analysis of Particulate Matter (PM₁₀ & PM_{2.5}) – Non –operational & Operational brick kilns

Objective 5: Scope of fly ash utilization in brick manufacturing

Review has been submitted dated 17th April 2021. (Attached as “*Report on Potential Utilization of Fly ash in Brick Manufacturing*”)

Objective 6: To submit a report on the monitoring carried out and infer upon the monitored status with the prescribed standard limits for the various parameter, wherever applicable.

The assessment was carried out in 2 steps:

- Baseline- To monitor the level of pollutants when the kilns were not operational. (Dec 2021) –Submitted on 22nd December 2021 (Attached as “*Baseline Report - Assessment of ambient air quality in the nearby vicinity of brick kilns in Thane and Palghar district, Maharashtra*”)
- Interim stage when the kilns were operational (March 2022) – The current report

Objective 7: To submit suggestions on how brick kilns can be allowed and criteria for fixing such numbers in the region without damaging the air quality.

TERI had clearly stated in its acceptance of the work order that a separate set of study is required to fulfill this objective.

Discussion

The brick kilns in Thane and Palghar districts are operational usually from January till June of each year. To assess the impact of Brick kilns on the ambient air quality of the region, TERI has conducted ambient air quality monitoring at 2 stages. The first monitoring was conducted in the month of December 2021 when the brick kilns were non-operational which is considered as initial stage to provide a baseline and the second in the month of March 2022 during which the kilns were operational which has provided a reading for an interim stage. It is to be noted that this year the brick kilns in Thane and Palghar districts started commencing operations in the month of January 2022 after monsoon and pandemic related restrictions.

Comparison of the results obtained from the initial stage (December 2021) and the interim stage (March 2022), the pollutant concentration levels were shown to be slightly increased as the kilns started the operation. It is important to study the trend of air quality over a complete operational season and at periodic time intervals to get a better idea regarding the impact of operational brick kilns on ambient air quality.

A comprehensive study of the selected locations in the context of source apportionment is yet to be carried out for the complete duration of the operational stage, which would provide better estimate of the pollutant load contributed by the Brick Kilns. Moreover it is also important to assess the trend of pollutant levels during the operation of the Brick kilns. Since there is an increase in the pollutant levels in the interim stage of the operation, it may be possible to project an upward trend at Thane and Palghar based on other similar studies carried out in various climatic zones. Table No.4 summarizes the observation of 4 case studies related to Brick kilns where it is observed that the particulate matter has shown 96% to 4414% increase, SO₂ around 197%-769% increase and NO_x in the range of 38%-435% increase. The detail information about these research studies are provided in *Annexure 6*.

Table No. 3 Review of Published Research

Year	Institute/ Location	Non-operational	Operational	Parameter	Non operational (µg/m ³)	Operational (µg/m ³)	% increase Non Operational to Operational Phase
2012	The Centre of Research for Development, University of Kashmir ¹ . Panzan village, Budgam district of Jammu and Kashmir state	April & May	June - September	RSPM	37.50	258.33	~588
				SO ₂	14.42 ± 2.63	125.39 ± 6.18	~769
				NO _x	20.46 ± 2.20	109.44 ± 5.05	~435
2015	Amarendra Jamatia, Sumanta Chakraborti ² in Jirania, Tripura	August-October	November to March	PM ₁₀	74.54-142.31	145.94 - 278.39	~96
				SO ₂	8.63-26.91	25.64 - 82.76	~197-207
				NO ₂	10.31-16.65	14.27 - 34.11	~38--104

¹ <https://www.longdom.org/open-access-pdfs/brick-kilns-cause-of-atmospheric-pollution-2375-4397.1000112.pdf>

² http://trpenvis.nic.in/test/doc_files/Air.pdf

Year	Institute/ Location	Non-operational	Operational	Parameter	Non operational ($\mu\text{g}/\text{m}^3$)	Operational ($\mu\text{g}/\text{m}^3$)	% increase Non Operational to Operational Phase
2018	Wageningen University and Research ³ (Thesis by Shahhaj Rahman)	May to August	November to January	PM ₁₀	150	500	~233.3
				PM _{2.5}	50	300	~500
2020	Institute of Environmental Science, University of Rajshahi, Bangladesh at Rajshahi and Gazipur Districts ⁴	-----	January-April		Rajshahi	Gazipur	
				PM _{2.5}	57	2573	~4414
				PM ₁₀	287	3875	~1250
				SPM	519	1950	~275

In the present study, a comparative analysis of air quality parameters for both operational and non-operational brick kilns has been carried out. It was observed that in the case of SO₂ and NO₂ concentration levels, an upward trend was recorded at all the 10 monitoring locations as compared to baseline assessment, however, the recorded levels were found to be much lower than the 24 hour average national ambient air quality standard of 80 $\mu\text{g}/\text{m}^3$; prescribed by CPCB. Thus SO₂ and NO₂ related air pollution is not a major concern in the area and the operations of brick kilns may not be significantly contributing to levels of these pollutants.

Out of 10 locations, only 3 locations namely L1- Bhiwandi-Wada Road (72 $\mu\text{g}/\text{m}^3$), L2- Kawad Village, Koliwali near Kiln - 3 (61 $\mu\text{g}/\text{m}^3$) and L3 - Kawad Village, Koliwali (75 $\mu\text{g}/\text{m}^3$) recorded PM_{2.5} concentration levels (24hr average) exceeding the 24 hr average standard level of 60 $\mu\text{g}/\text{m}^3$ specified by NAAQS of CPCB. As compared to the concentration levels recorded during the baseline assessment, these levels were found to be increased by about 4% - 5%.

PM₁₀ concentration levels were found to be exceeding the 24 hr average standard (100 $\mu\text{g}/\text{m}^3$) as prescribed by CPCB. However, it is to be noted that these levels were already above the standard limits even during the baseline assessment. During the interim assessment study, the highest concentration levels of PM₁₀ were found to be recorded at L3 - Kawad Village, Koliwali (383 $\mu\text{g}/\text{m}^3$ = 3.8 times higher than the standard CPCB limit of 100 $\mu\text{g}/\text{m}^3$) followed by L1- Bhiwandi-Wada Road (253 $\mu\text{g}/\text{m}^3$ = 2.5 times higher) and L9- Aqua water filter factory (229 $\mu\text{g}/\text{m}^3$ = 2.3 times higher).

On the other hand, in comparison with the baseline assessment, the highest % increase in PM₁₀ levels was recorded at L7-Shimla Dhudh Dairy (~5.5%, 128 $\mu\text{g}/\text{m}^3$ to 135 $\mu\text{g}/\text{m}^3$) followed by L9- Aqua water filter factory (~5%, 218 $\mu\text{g}/\text{m}^3$ to 229 $\mu\text{g}/\text{m}^3$) and L8- Stelmeh Industry (~4.5%, 133 $\mu\text{g}/\text{m}^3$ to 139 $\mu\text{g}/\text{m}^3$).

However the increase in levels was not substantial enough to tell anything about the impact of kiln operation on the ambient air quality. This may indicate the contribution from other sources in the study area which needs to be identified and studied further.

³ <https://edepot.wur.nl/536151>

⁴ https://www.researchgate.net/publication/352197322_Impacts_of_Brick_Kiln_Emissions_on_Air_Quality_around_Kiln_Areas

Conclusion

- The results of the ambient air quality monitoring carried out at different locations in Palghar and Thane indicated that the levels of gaseous pollutants such as SO₂ and NO₂ were within the specified limits. However particulate matter (both PM₁₀ and PM_{2.5}) levels were above the limits prescribed by CPCB. Although the results showed a slight increase in pollutants concentrations during the period when the kilns were in operation compared to the baseline, however, the levels were not substantial enough to arrive at a conclusion on the contribution of kilns operation to the ambient air quality of the region. Thus it is advised to conduct a comprehensive ambient air quality monitoring over a prolonged period of time to assess the overall impact of brick kiln operations on the surrounding environment.
- Though there are different sources such as dust generated from various activities including road dust and windblown dust, industries, transport, residential biomass burning, agricultural residue burning, DG sets, restaurants, etc. which are contributing to the prevailing ambient PM levels of a region, the sources may vary from region to region and it will be difficult to identify the specific source contributing to the air quality without a detailed scientific study. Therefore a detailed scientific study needs to be carried out to understand the sources contributing to the air quality of the region. Further to this, it is recommended to conduct calculations for carrying capacity of Particulate Matter (PM) of the study area to further identify the sources of air pollution and extent of their contribution.

Annexure 1: Inventory of Brick kilns across Thane and Palghar District

Table No. 4 : Inventory of Brick kilns across Thane and Palghar District

List of Brick Kilns

Thane District			
Sr. No.	Name and Address of Brick Kiln Owner	Remarks	Comments from RO
1.	Raju Patil, At Usgaon, Post. Ganeshpuri, Tal. Bhiwandi, Dist. Thane	Ambient monitoring is not carried out.	Closed since Jan 21
2.	Hasmukhbhai (Potter), At Usgaon, Post. Ganeshpuri, Tal. Bhiwandi, Dist. Thane	Ambient monitoring is not carried out.	Cell number-9545599844
3.	Sailesh (Potter), At Usgaon, Post. Ganeshpuri, Tal. Bhiwandi, Dist. Thane	Ambient monitoring is not carried out.	
4.	Damajibhai, At Usgaon, Post. Ganeshpuri, Tal. Bhiwandi, Dist. Thane	Ambient monitoring is not carried out.	Cell number-9637425740
5.	Ananta Gharat, At Usgaon, Post. Ganeshpuri, Tal. Bhiwandi, Dist. Thane	Ambient monitoring is not carried out.	
The above list of brick kilns is received on 17.02.2021 to TERI by MPCB			

Update List of Brick Kilns at Thane District received on 12th July 2021 from MPCB RO Kalyan		
Sr. No.	Address of bricks kiln	Name of the owner
1	Kawad Village, Koliwali ,Bhiwandi	Mr. Santosh Ghurav
2	Kawad Village, Koliwali ,Bhiwandi	Mr. Manubhai Goghari
3	Kawad Village, Koliwali ,Bhiwandi	Mr. Nitin Prajapati
4	Kawad Village, Koliwali ,Bhiwandi	Mr. Prajapati
5	Kawad Village, Koliwali ,Bhiwandi	Mr. Rajan Tandel
6	Bhiwandi - Wada Rd, Koliwali, Bhiwandi	

Taluka wise list of brick kilns at Palghar			
Sr. No	Ward	No. of Brick kilns	Taluka wise Total brick kilns
Talasri			13
1	Talasri	11	
2	Jhari	2	
Dahanu			32
1	Dahanu	5	
2	Chinchdi	NA	
3	Saiwan	3	
4	Kasa	5	
5	Malyan	19	
Vikramgarh			65
1	Vikramgarh	40	
2	Aalonde	12	
3	Maale	5	
4	Talwada	8	
Jawhar			3

Assessment of ambient air quality in the nearby vicinity of brick kilns in Thane and Palghar district, Maharashtra

1	Jawhar	3	
2	Sakharkhet	0	
Palghar			91
1	Manor	74	
2	Agarvadi	7	
3	Boisar	10	
Wada			6
	Kelthan	6	
Vasai			10
1	Parol	3	
2	Shirvali	2	
3	Saiwan	3	
4	Bhinar	2	
Total brick kilns			220

Details of Brick Kilns visited on 12 th July 2021				
Site No.	Taluka	Address	Latitude	Longitude
Palghar District				
1	Dahanu	Vivalvedhe Village	19.94105	72.93517
2		Dhaniwari	19.97655	72.92082
3		Mukam Varauti Post Kasa	19.9086	72.96132
4	Manor	Dahisar Tarphe	19.64808	72.89332
5		Nandgaon Takwar Survey No 114-(3 brick kilns)	19.72484	72.92165
6		Nandgaon Survey No 121	19.72497	72.9219
7		Sakhare village (2 brick kilns)	19.64306 19.64338	72.87399 72.87425
8	Vasai	Mandvi virar.	19.47727	72.90595
9		Shivam Sai Village	19.47636	72.9079
10		Parol village	19.4719	72.92088
11	Wada	Dakivali Vullage	19.486525	73.074043
12		Chamble Village	19.484459	73.048088
13		Ambiste Khurd Village	19.608017	73.04348
14		Borande Village	19.613348	73.037621
Thane District				
15	Bhiwandi	Kawad Village ,Koliwali	19.35543	73.06942
16		Kawad Village ,Koliwali	19.355947	73.067024
17		Kawad Village ,Koliwali	19.355936	73.066376
18		Kawad Village ,Koliwali	19.355637	73.067017
19		Kawad Village ,Koliwali	19.350082	73.072464
20		Bhiwandi - Wada Rd, Koliwali, Bhiwandi	19.349869	73.071472

List of AAQMS monitoring sites during the initial (December 2021) and interim stage (March 2022)

Table No. 5 : Details of AAQM sites across Thane and Palghar district

No.	District	Region	Location code	Location	Brick Kiln		AAQ Machines		Approx Distance between Brickkiln and monitoring machine (Km)	Approx.Distance between Monitoring machines and boundary of Tungareshwar WLS (Km)
					Latitude	Longitude	Latitude	Longitude		
1.	Thane	Bhiwandi	L-1	Bhiwandi-Wada Road, Koliwali, Bhiwandi	19.350161	73.072365	19.3501278	73.0729444	0.04	2.83
2.			L-2	Kawad Village, Koliwali (3 Nos. Brick kilns)*	19.35643	73.066582	19.356419	73.066579	0.01	2.22
					19.355936	73.066376				
					19.355947	73.067024				
3.		L-3	Kawad Village, Koliwali	19.355337	73.06958	19.355301	73.0695641	0.02	2.50	
4.		CLB1 (L-4)	Ambika City (Upwind)	Control reading		19.333184	73.065514	2.2 km from L-3	2.30	
5.	Palghar	Wada	L-5	Dakiwali village	19.504011	73.047569	19.504302	73.047389	0.05	4.63
6.			CLW1 (L-6)	Sai Mandir, Kelantan (Upwind)	Control reading		19.497513	73.034961	2 km from L-5	3.59
7.		Vasai	L-7	Shimla Dhudh Dairy	19.470418	72.923757	19.477246	72.903457	2.3	1.69
8.			L-8	Stelmech Industry	19.470389	72.923729	19.468865	72.926444	0.35	0.91
9.	L-9		Aqua water filter factory	19.470344	72.923819	19.462653	72.941908	2.2	0.91	
10.		CLV1 (L-10)	Sarpanch Home (Upwind)	Control reading		19.457044	72.944817	2.5 km from L-9	0.67	

CL: Control reading

Annexure 2- Wind rose during initial stage and interim stage of AAQM

Scenario 1: Wind rose when brick kilns were not operational

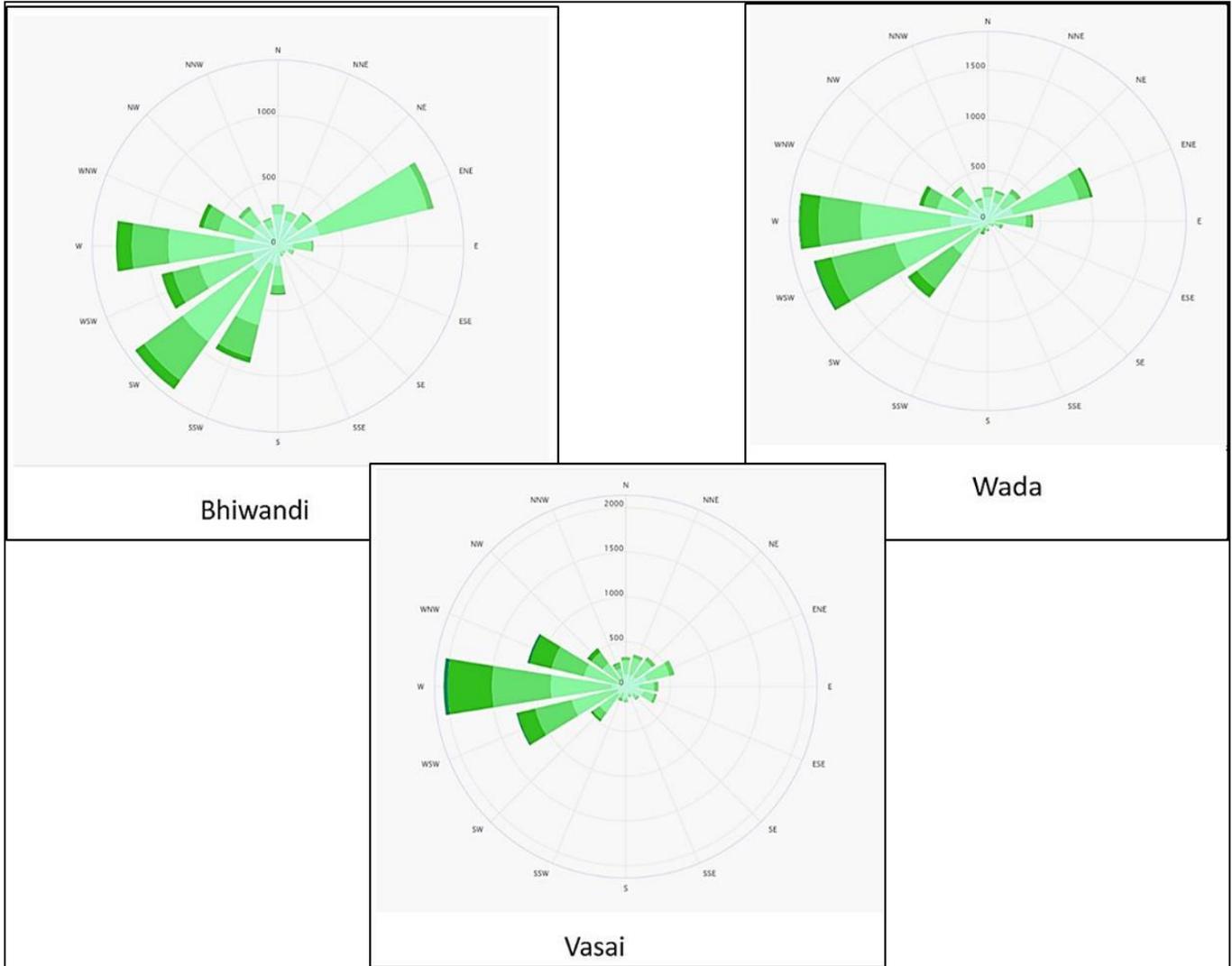


Figure No. 7 : Wind rose when brick kilns were not operational

Scenario 2: Wind rose when brick kilns were in operational phase

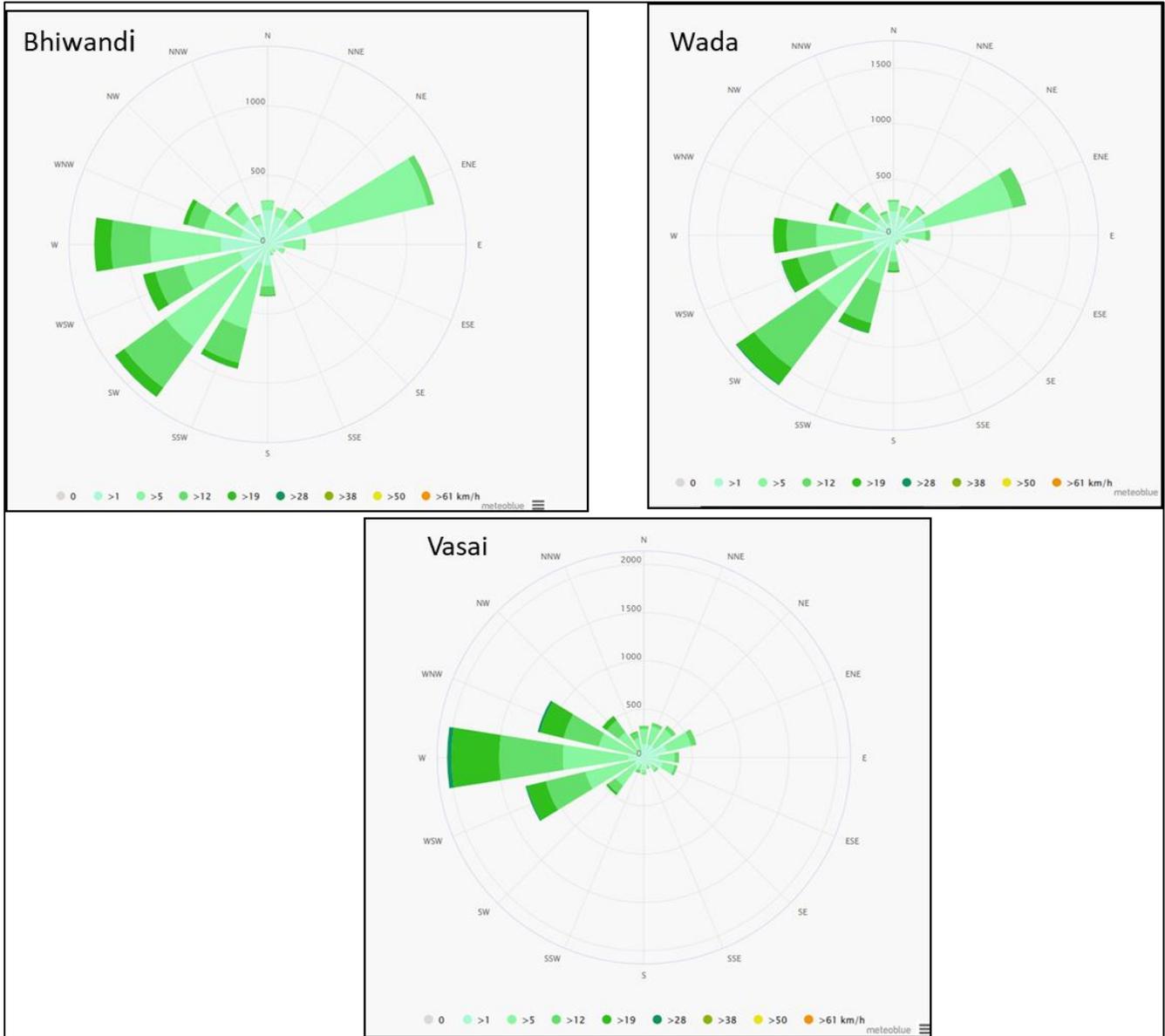


Figure No. 8: Windrose across the Bhiwandi, Vasai and Wada region during operational phase of brick kilns
 Source: https://www.meteoblue.com/en/weather/historyclimate/climatemodelled/v%c4%81da_india_1253610

Annexure 3- District wise representative photos of Brick kilns and Monitoring machines

Thane District

Monitoring Locations at Bhiwandi

Location 1 (L1): Bhiwandi-Wada Road, Koliwali, Bhiwandi



Picture No. 1 : Brick kiln (left) and Monitoring Equipment set up in the vicinity of L1 (right)

Palghar District

a) Monitoring Locations at Wada

Location 5: (L5) Dakiwali Village, Wada



Picture No. 2 : Brick kiln (left) and Monitoring Equipment set up in the vicinity of L5 (right)

b) Monitoring locations at Vasai

Location 7 (L7): Shimla Dhudh Dairy, Vasai



Picture No. 3 : Brick kiln (left) and Monitoring Equipment set up in the vicinity of L7 (right)

Annexure 4- Indicative examples -Calculation for emissions (t/year) for 5 locations as per the data obtained from MPCB.

Table No. 6: Projected Emission values of Brick Kilns at Wada Taluka, Palghar estimated by TERI based on secondary data.

@ Post Kelthan, Tal- Wada, Dist- Palghar	Production per batch	No of batch	total production/ year	wt of fired brick (kg)	Total wt of fired brick (kg)	Projected estimates				
						PM ₁₀	PM _{2.5}	SO ₂	NO _x	CO
Jitendra Patil, At Nimbawali,	85000	4	340000	3	1020000	1.326	1.02	0.306	0.000153	10.2
Pundalik Patil	400000	4	1600000	3	4800000	6.24	4.8	1.44	0.00072	48
Datta Patil,	400000	4	1600000	3	4800000	6.24	4.8	1.44	0.00072	48
Daulat Patil,	400000	4	1600000	3	4800000	6.24	4.8	1.44	0.00072	48
Bhalchandra Kasar, At- Lohope,	200000	4	800000	3	2400000	3.12	2.4	0.72	0.00036	24
			59,400,00	Total emissions (t/year)		23.16	17.82	5.34	0.00267	178.2

Table No. 7:: Published values of air pollutants emitted from the Brick Kilns of Pune, Raigad, Ahmednagar, Satara and Sangli of Maharashtra

Location	Production of Bricks	Wt of fired brick (kg)	Total wt (kg)	Published values				
				PM ₁₀	PM _{2.5}	SO ₂	NO _x	CO
Hinjewadi, Pune	3000000	3	9000000	11.7	9	2.7	0.00135	90
Khopoli, Raigad	1500000	3	4500000	5.85	4.5	1.35	0.000675	45
Islampur, Sangli	82500000	3	247500000	321.75	247.5	74.25	0.037125	2475
Miraj Road, Ankali	200000000	3	600000000	780	600	180	0.09	6000
Pimpalwadi	160000000	3	480000000	624	480	144	0.072	4800
Total	4,470 lakhs		Total emissions (t/year)	1743.3	1341	402.3	0.20115	13410

Source: Rahul Kumar and Nivit Kumar Yadav 2018, Unclamping India: How to deal with polluting clamp-type kilns, Centre for Science and Environment, New Delhi

The methodology followed by TERI for estimation of emissions is as given below.

$$\text{Emissions} = \text{Activity data} \times \text{Emission factor}^5$$

Activity data = Production of Bricks (*data provided by MPCB*)

We assumed the weight of fired brick as 3 kg based on TERI's experience in this field. For the theoretical calculation of emission factor, methodology followed is same as used in SA six cities, CPCB.

⁵ <https://www.teriin.org/project/spatially-resolved-air-pollution-emissions-inventory-india>

Annexure 5- Details of the concentration levels across 10 brick kilns at Thane and Palghar District (Operational & Non-operational Brick kilns).

Table No. 7 : Results of ambient air quality monitoring

Region	Location code	Location	Non-operational phase				Operational Phase			
			PM _{2.5} µg/m ³	PM ₁₀ µg/m ³	SO ₂ µg/m ³	NO ₂ µg/m ³	PM _{2.5} µg/m ³	PM ₁₀ µg/m ³	SO ₂ µg/m ³	NO ₂ µg/m ³
Standard - 24-hr average NAAQS			60	100	80	80	60	100	80	80
Bhiwandi	L1	Bhiwandi-Wada Road,	47-91 (69)	240-252 (246)	35-43 (39)	40-43 (42)	50-94 (72)	246-260 (253)	39-46 (43)	40-45 (43)
	L2	Kawad Village, Koilwali near Kiln-3 Nos.	28-88 (58)	196-202 (199)	25-37 (31)	26-55 (40)	32-91 (61)	200-210 (205)	30-40 (35)	28-56 (42)
	L3	Kawad Village, Koliwali	57-86 (72)	320-428 (374)	21-37 (29)	44-45 (45)	60-90 (75)	326-439 (383)	24-42 (33)	46-49 (48)
	CLB1 (L4)	Ambika City (Upwind)	35-48 (41)	140-275 (207)	15-18 (17)	33-41 (37)	37-49 (43)	141-274 (208)	17-20 (19)	34-43 (39)
Wada	L5	Dakiwali village	32-58 (45)	132-218 (175)	32-40 (36)	33-34 (34)	33-64 (49)	138-225 (182)	35-41 (38)	35-37 (36)
	CLW1 (L6)	Sai Mandir, Keltan (Upwind)	30-45 (37)	104-135 (120)	18-22 (20)	45-48 (47)	32-45 (39)	107-137 (122)	19-25 (22)	46-50 (48)
Vasai	L7	Shimla Dhudh Dairy	23-37 (30)	115-141 (128)	28-34 (31)	42-48 (45)	25-42 (34)	126-143 (135)	32-36 (34)	45-54 (50)
	L8	Stelmech Industry	31-62 (47)	130-135 (133)	34-34 (34)	51-55 (53)	35-68 (52)	136-142 (139)	35-38 (37)	53-59 (56)
	L9	Aqua water filter factory	38-51 (44)	212-224 (218)	31-39 (35)	37-44 (40)	40-52 (46)	218-239 (229)	33-42 (38)	40-46 (43)
	CLV1 (L10)	Sarpanch House	49-63 (56)	132-151 (142)	31-34 (32)	18-28 (23)	50-65 (58)	130-159 (145)	31-35 (33)	20-31 (26)

*values are in the form Min-Max (Mean)

Control reading highlighted in blue.

Annexure 6: Review of Published Research Studies

Case Study 1: Brick kilns: Cause of Atmospheric Pollution

Conducted by the Centre of Research for Development, University of Kashmir in 2012 during non-operational phase (April & May) and Operational phase (June - September) in the Panzan village, Budgam district of Jammu and Kashmir state, India⁶

The main objective of this study was to estimate the levels of criterial air pollutants during the non-operational and operational phases of brick kilns and to suggest possible mitigation measures to minimize the emission levels of air pollutants. The total ambient air quality monitoring period was spanned over 6 months; out of which, 2 months (April to May) were considered as Non-Operational phases (brick kiln) whereas 4 months (June - September) were considered as Operational phases. In this study, the statistical analysis (Figure No. 7) estimated a multifold increase in concentration levels of major air pollutants. The average concentration of SO₂ shown to increase from $14.42 \pm 2.63 \mu\text{g}/\text{m}^3$ (Non Operational phase) to about $125.39 \pm 6.18 \mu\text{g}/\text{m}^3$ (Operational phase). A similar increase was recorded in the NO_x ($20.46 \pm 2.20 \mu\text{g}/\text{m}^3$ to $109.44 \pm 5.05 \mu\text{g}/\text{m}^3$) and RSPM levels from $37.50 \mu\text{g}/\text{m}^3$ to $258.33 \mu\text{g}/\text{m}^3$). Thus, there is a considerable increase in the concentration levels of pollutants over a period of time. Similar pattern of air quality may be evident in the Palghar and Thane districts. Hence a robust study and air quality assessment over a prolonged period would be recommended.

⁶ <https://www.longdom.org/open-access-pdfs/brick-kilns-cause-of-atmospheric-pollution-2375-4397.1000112.pdf>

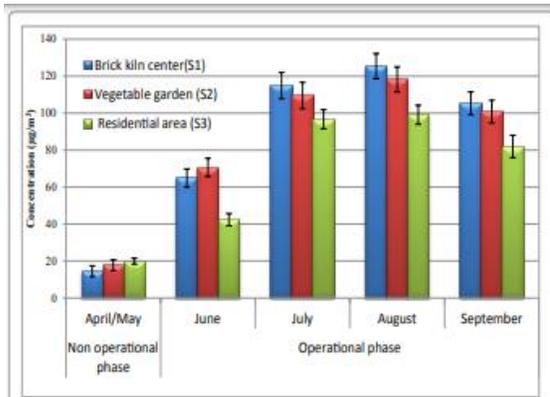


Figure 3: Average variation in concentration of SO₂ (µg/m³) in and around brick kiln area of Panzan village.

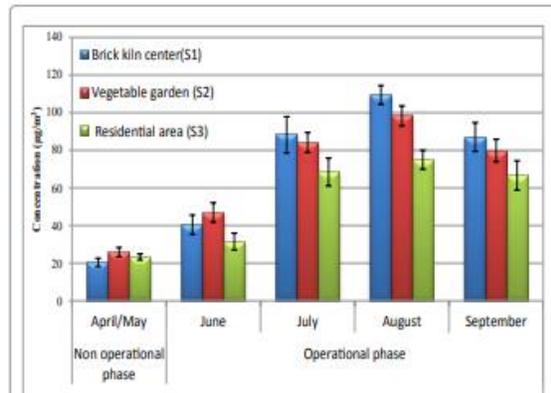


Figure 4: Average variation in concentration of NO₂ (µg/m³) in and around brick kiln area of Panzan village.

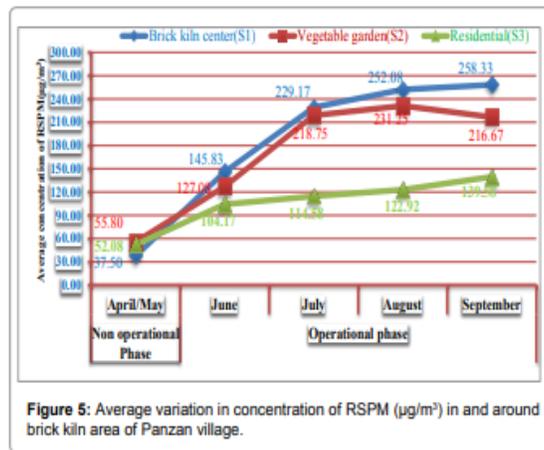


Figure 5: Average variation in concentration of RSPM (µg/m³) in and around brick kiln area of Panzan village.

Figure No. 9: Variation in concentration levels of pollutants (monthly) in and around brick kiln areas of Panzan village – Budgam district, Jammu and Kashmir

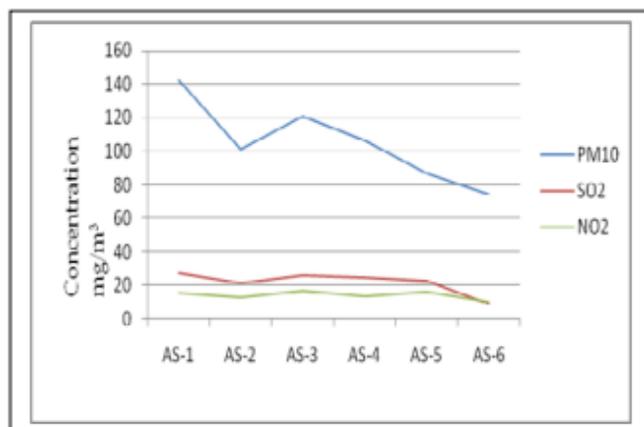
Case Study 2 Air Quality Assessment of Jirania Brick Industries Cluster: A Case Study⁷

Conducted by: Amarendra Jamatia, Sumanta Chakraborti in April 2015 during non-operational phase (August-October) & Operational (November to March)

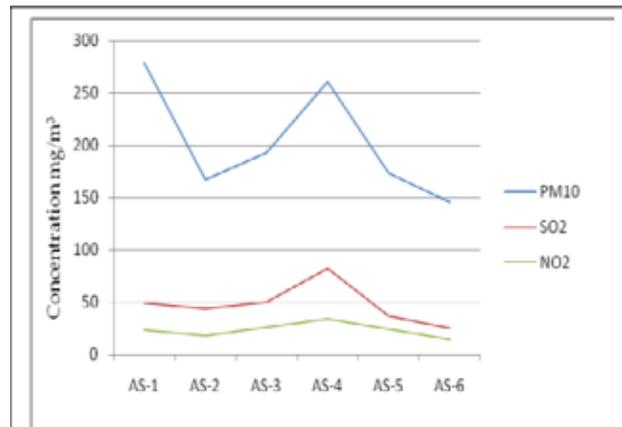
The present study is aimed to estimate the quantum of significant air pollution loads that arising out from the brick industries of a small cluster located at Jirania, Tripura, India. For assessing seasonal variations of concentration of particulate matter and other gaseous pollutants, air quality monitoring was carried out at 6 locations in Jirania Brick Industries Cluster before starting brick manufacturing and also during brick production seasons. The concentration of PM₁₀, SO₂ and NO₂ in the ambient air during bricks production was compared with the baseline ambient air quality data that were generated before starting the brick production. During pre-manufacturing season (August-October), PM₁₀ concentration was found in the ranges of 74.54 - 142.31 µg/m³. On the other hand, the PM₁₀ concentration was found between 145.94 - 278.39 µg/m³ during brick manufacturing season (November to March). Secondary information and field level survey data revealed that activities associated with green bricks production, movement of vehicles, loading & unloading of vehicle on approach road, firing of bricks, huge brick

⁷ http://trpenvis.nic.in/test/doc_files/Air.pdf

industries in a small area, close proximity of National Highway etc. are somewhat responsible to contribute certain amount of PM₁₀ concentration in ambient air in and around the cluster. The value of SO₂ ranges 8.63 µg/m³ to 26.91 µg/m³ during pre-production season and 25.64 µg/m³ to 82.76 µg/m³ during bricks production. Similarly, the analytical value of NO₂ ranges 10.31 µg/m³ to 16.65 µg/m³ during pre-production season and 14.27 µg/m³ to 34.11 µg/m³ at the time of production season.



Pollutant concentration before production of Bricks



Pollutant concentration during production of Bricks

Case Study 3: Air Quality and health effects of kilns' emissions on brick field workers in northern Dhaka, Bangladesh

Conducted by: Wageningen University and Research (WUR)-Thesis by Ms. Shahanaj Rahman in 2018

This study determines the concentrations of particulate matter (PM) from different brick kiln types and the health impact on the workers working in the brick field in northern Dhaka. The result shows that the brick-kiln emissions contribute to lower air quality and affect the brick-workers health condition. The measured PM₁₀ concentration (150 to 500 µg/m³) and PM_{2.5} concentration (50 to 300 µg/m³) exceeded the 24h limit value 3-4 times for PM₁₀ and up to 4 times for PM_{2.5}. The ambient air concentration around the brick kilns exceeded the limit of the National ambient air quality standards.

Case Study 4: Impacts of Brick Kiln Emissions on Air Quality around Kiln Areas⁸

Conducted by: Institute of Environmental Science, University of Rajshahi, Bangladesh in Jan 2020 (Brick production season -January-April)

The study attempted to identify the ambient air pollutants and their impacts on air quality around the kiln areas. The study was conducted at 12 selected brick kiln clusters in Rajshahi and Gazipur Districts. The results showed that most of the parameters exceeded the permissible standard for ambient air quality parameters. All of the criteria air pollutants (CO, SO₂, NO_x, and PM 2.5, and 10, SPM) except CO exceeded the National Ambient Air Quality Standard (NAAQS) limits. The concentrations of particulate matter including PM 2.5 and 10, and SPM were ranged from 57 to 2573, 287 to 3875, and 519 to 1950 µg/m³, respectively. Some important parameters of air quality monitoring such as CO₂, ambient temperature (AT), relative humidity (RH), and C₆H₆ were found above the permissible standard, which influenced the entire conditions of the ambient air quality. The gaseous pollutants such as CO, H₂S, C₈H₆, and TVOC were found in higher amounts at all locations indicating that the ambient air of the areas was harmful.

⁸https://www.researchgate.net/publication/352197322_Impacts_of_Brick_Kiln_Emissions_on_Air_Quality_around_Kiln_Areas



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