International Journal of Research Studies in Science, Engineering and Technology
Volume 6, Issue 7, 2019, PP 22-32
ISSN : 2349-476X

Air Quality Assessment and Dispersion of Air Pollutants from Brick Kilns in and Around Gandhinagar Region (16km*16km) Using CALPUFF

Pushkar Patel[*], Paresh Chavda, Madhavi Pimparkar

Gujarat Environment Management Institute, Gujarat, India.

Correspondence Author: *Pushkar Patel, Gujarat Environment Management Institute, Gujarat, India, pushkar.gemi@gmail.com*

ABSTRACT

*Brick manufacturing is traditionally unorganized sector and fully dependant on Coal and Biomass. Air pollutants, i.e. Particulate Matter (PM_{10}), Nitrous Oxide (NO_x), Sulphur Dioxide (SO_2), and Carbon Monoxide (CO) were mainly emitted during the brick firing process. The area of Gandhinagar region (16kmx16km) was observed to have high numbers of the operating kilns. The main objective of this study was to develop a database of emission of air pollutant (PM10, NO_x, SO2, CO) from brick kilns in the model domain (16 km x 16 km) in and around Gandhinagar region, its atmospheric dispersion and thereby assessing the ambient air quality dispersion of pollutants using CALPUFFF model. Modeled values of pollutants were compared with National Ambient Air Quality Standards (NAAQS, 2009) and World Health Organization (WHO). Estimated emissions for PM_{10}, NO_x, SO_2 and CO in Gandhinagar region (16km*16km) were 373.61, 314.93, 133.43 and 231 MT/cycle respectively. For CALPUFF modelling application, simulated maximum concentrations for 24-hour and 4months average were as follows: PM10 (15.9, and 6.30 $\mu g/m^3$, respectively); NO2 (5.66, and 2.25 $\mu g/m^3$, respectively); SO2 (13.4, and 5.31 $\mu g/m^3$, respectively). CO (9.06 and 3.598 $\mu g/m^3$, respectively).The overall assessment showed that the concentrations of pollutants (PM_{10}, NO_x, $SO_2$and CO) met the NAAQS of India. However, for long term health impact reduction, the appropriate prevention and mitigation measures should be implemented to control the concentrations of air pollutants from brick kilns in the Study area.*

Keywords: *Brick Kiln, Pollutants, Modeling, Dispersion, CALPUFF, Gandhinagar, India*

INTRODUCTION

Brick is one of the primary building materials known to the mankind that constitute major portion of total building material cost. The brick manufacturing is the unorganized sector in India and fully dependent on coal and biomass. The process of manufacturing of brick also has not undergone much change over centuries across the nation. India being the second largest brick producer (China dominates with 54% share) in the world, producing about 250 billion bricks per year with annual growth rate of 5%, providing nearly 15 million employments , Out of 250 billion bricks,74% bricks are manufactured using Bull's TrenchKilns. (Aswale, Sanjay, 2015). The Central Pollution Control Board, Delhi (CPCB) has already recognized the brick producing industry as highly resource and energy intensive as well as polluting industry, which is mostly due to obsolete traditional production technologies employed in India. Cluster of brick kilns are source of local air pollution affecting local population, agriculture and vegetation. Air pollutants, particularly Particulate Matter (PM), Nitrogen Oxide (NO_x), Carbon Monoxide (CO), and Sulphur Dioxide (SO_2) are products of the combustion processes produced during the brick firing operations (AP-42 US-EPA, 1997; Kanabkaew & Buasing, 2015). Exposures to these pollutants were observed to have caused increases in morbidity and mortality (Muhammad Waseem Khan et al., 2019; Suman Kumar Pariyar et al., 2013). Lack of emission control devices enhances the possibility of contact with the air pollutants. Further, the land area near the kiln is subjected to high temperature making it unfit for agricultural activities after being abandoned.

At Gandhinagar region, there were a total of seventy two brick kilns in the area (16 km x 16 km) located in five villages (Uvarsad, Vavol, Pundrasan, Shertha, and Adalaj) has been operating since last 10 years. Although, these kilns are essential for the economy of Gandhinagar district, however, being conventionally unorganized industry and substantial aggregation of these kilns, they do significantly contribute to local air pollution. Without surface air quality monitoring stations in all receptors and limited information on air quality data in the area, impact assessment of brick kiln pollution on human health would be inaccessible. Thus to estimate air pollutant emissions from these brick kiln and its dispersion, modeling has been carried out using CALPUFF for a period of four months from January to April 2018.This period were considered as brick kiln firing period.

In this study, Dispersion modeling has been carried out by CALPUFF software, to predict ground level concentrations of pollutants at selected receptor villages in the specified model domains/ area. CALPUFF is intended for use on modeling domains, from tens of meters to hundreds of kilometers from a source. It is an advanced multi-layer, multispecies, non-steady-state puff dispersion model for assessing long range transport of pollutants (CALPUFF View-2003-2017).

The main objective of this study was to develop a database of emission of air pollutant (PM10, NO_x, SO2, CO) from brick kilns in the model domain (16 km x 16 km) in and around Gandhinagar region, its atmospheric dispersion and thereby assessing the ambient air quality dispersion of pollutants using CALPUFFF model. Modeled values of pollutants were compared with National Ambient Air Quality Standards (NAAQS, 2009) and ambient air quality and health of World Health Organization (WHO).

MATERIALS AND METHOD

Study Area

The study area was set up to be (16 km * 16 km) covering brick manufacturing units (kilns) in Gandhinagar region with center point having geographical coordinate's 23.223°N 72.650°E. There were around 72 brick kilns located in study area. Google earth image of study area showing brick kilns is given in figure 1. About 40 villages and 6 towns fall under this study area. Gandhinagar has a tropical wet and dry climate with three main seasons: summer, monsoon and winter. During study period, min and max temperature varies from 12-23 °C and 28-40 °C respectively with January being coldest month.

This study area is located between twin cities Ahmadabad and Gandhinagar. In last 10 years, this area has witnessed rapid Urbanization, which has led to tremendous demands for bricks and construction materials. Approx. 2.31 Lakh people reside in and around study area.

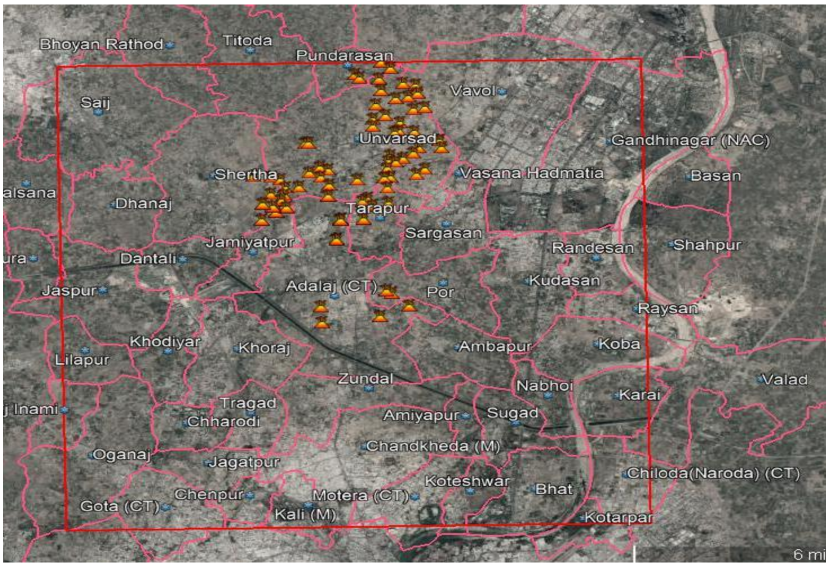


Figure1. *Google Earth image of study area*

All brick kilns found in Study area were of Fixed Chimney Bull's Trench Kiln (FCBTK) type as shown in figure 2. Green bricks were fed inside the kiln and lignite coal was burnt in the fire tunnel. The firing processes in tunnel kilns were started by brick drying, preheating, firing and cooling which were continuously and simultaneously processed (Palash Patra et al., 2015). Duration of brick firing is of four months starting from January to April.

Figure2. *Field photograph of brick kiln*

During the field survey, Brick production and manufacturing process details were collected along with stack attributes such as stack height, diameter, exit temperature, velocity which are summarized in Table 1.

Table1. *Details of Brick kiln*

Particulars	Source
Kiln type	Fixed Chimney Bull's Trench Kiln (FCBTK)
Source of water	Ground water
Main Raw material	Clay
Other raw material	Paddy bison, ash
Source of clay	Nearby agricultural field
Operational period/cycle	January to April (4months)
Type of Fuel used	Lignite coal
Consumption of Fuel	1 ton per 6000 bricks
Diameter	1.4 – 1.6 M
Height	76-86M
Exit Temperature (range)	353 K - 701 K
Velocity (range)	2.1 m/s - 3.1 m/s

Geographical coordinates and kiln wise production details were given in Table 2.

Table2. *Geographical Coordinates and production details of brick kiln*

Sr. no.	Location ID	X Coordinate	Y Coordinate	Approx. bricks Production/per cycle*
Uvarsad Village				
1	USD_1	253706.6388	2567763.533	4000000
2	USD_2	253592.2921	2569533.316	5000000
3	USD_3	254335.5083	2569630.892	5000000
4	USD_4	254322.228	2569378.118	3000000
5	USD_5	254734.6066	2570096.126	3000000
6	USD_6	255051.9742	2570142.906	700000
7	USD_7	254187.2059	2569298.172	700000
8	USD_8	254739.7287	2569320.441	600000
9	USD_9	254855.5156	2568786.075	600000
10	USD_10	255482.5696	2568755.438	500000
11	USD_11	254705.8971	2568597.413	3000000
12	USD_12	254397.0162	2568411.996	4000000
13	USD_13	255430.0874	2569023.759	700000
14	USD_14	255431.0874	2569022.759	1000000
15	USD_15	254073.9151	2568519.825	2000000
16	USD_16	254219.8981	2568298.581	2500000
17	USD_17	254013.0092	2568311.851	4000000
18	USD_18	255004.9929	2568033.867	4000000
19	USD_19	254764.7723	2567854.698	2500000

20	USD_20	253897.6779	2567720.36	1500000
21	USD_21	253960.5565	2567410.925	1200000
22	USD_22	253979.5233	2566871.691	3000000
23	USD_23	253275.4327	2566945.826	600000
24	USD_24	253433.1048	2567051.859	500000
25	USD_25	253563.3074	2566787.782	3000000
26	USD_26	253140.4026	2567707.36	3000000
27	USD_27	252338.7932	2567150.67	500000
28	USD_28	252662.2646	2566327.514	1000000
29	USD_29	254093.2645	2567487.523	700000
30	USD_30	252157.7567	2567811.724	1400000
31	USD_31	251831.9279	2567960.891	500000
32	USD_32	251824.6247	2568972.392	800000
33	USD_33	251063.608	2567032.828	1000000
34	USD_34	251192.0953	2566770.601	1400000
35	USD_35	250904.2634	2566607.057	500000
36	USD_36	250817.0949	2566804.884	4000000
37	USD_37	250553.1447	2566912.106	3000000
38	USD_38	250784.9772	2567248.633	2000000
39	USD_39	251144.5308	2567193.062	1000000
40	USD_40	251034.9728	2567719.054	2500000
41	USD_41	250780.91	2567838.112	3500000
42	USD_42	250301.8005	2567872	2900000
43	USD_43	250516.1001	2566348.554	800000
44	USD_44	252547.4324	2565649.841	600000
45	USD_45	253952.0471	2569905.619	5000000
46	USD_46	253611.7854	2569782.603	2000000
47	USD_47	253694.1178	2570270.61	1000000
48	USD_48	254247.9538	2570460.266	600000
49	USD_49	254594.7183	2570530.557	800000
50	USD_50	254852.6039	2570662.03	2000000
51	USD_51	254852.6039	2570662.03	3500000
52	USD_52	253859.5068	2570758.78	4000000
53	USD_53	253808.9323	2571156.963	2000000
54	USD_54	253159.7557	2571322.55	900000
55	USD_55	253257.3277	2571203.356	4500000
56	USD_56	252353.1264	2568028.843	5000000
Vavol Village				
57	VVL_1	253296.456	2566343.151	4000000
Pundrasan Village				
58	PDS_1	252137.6571	2568125.074	700000
59	PDS_2	251547.3625	2567463.029	1000000
Shertha Village				
60	SHT_1	254072.4009	2567757.174	2500000
61	SHT_2	253972.9395	2568073.677	500000
62	SHT_3	254465.9916	2571002.97	4000000
63	SHT_4	251751.1923	2568970.232	3000000
64	SHT_5	251170.0316	2567441.942	3000000
Adalaj Village				
65	ADJ_1	252078.1876	2563339.432	3000000
66	ADJ_2	252105.7083	2562769.578	1000000
67	ADJ_3	253708.3692	2562964.617	500000
68	ADJ_4	253874.151	2563869.823	800000
69	ADJ_5	254020.6164	2563778.15	4500000
70	ADJ_6	254511.1898	2563326.863	2500000
71	ADJ_7	252554.716	2565642.949	2000000
72	ADJ_8	252671.5204	2566336.594	1000000

*(*cycle- brick kiln firing period)*

Methodology

Emission estimation was the foremost step to obtain the emissions of pollutants (PM_{10}, NO_X, SO_2, CO). In the next step, CALMET were run to produce meteorological fields and terrain data. Finally, CALPUFF, the core module, was then compiled from the emission data (loading rates), stack data, meteorological data and terrain data to produce the pollutant concentrations in the specified (16 km x 16 km) modelling domains in Gandhinagar region. The methodology framework is indicated below in Figure 3.

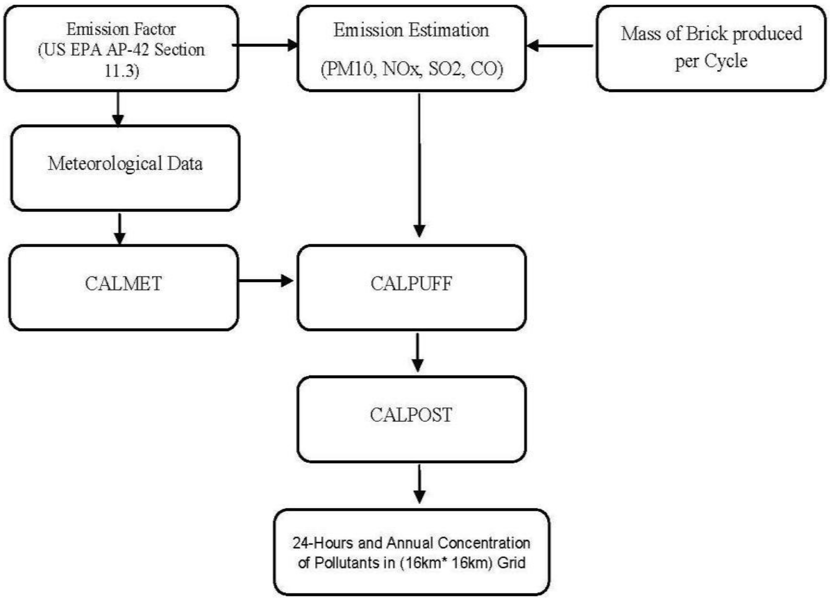


Figure3. *Framework of Methodology*

Emission Estimation

For estimation of emissions of pollutants from Brick kilns, an emission factor of USEPA were referred. A kiln wise emission was calculated by multiplying emission factor with mass of brick produced using below equation-

Emi = Σ (ARi x EFi)

Table3. *Emission factors used for brick kiln emission estimation*

Pollutants	EF* for Coal (kg/MT)
PM_{10}	0.70
NO_X	0.25
SO_2	0.59
CO	0.40

(us epa emission factor of the ap-42 section 11.3 for uncontrolled emission from coal-fired kilns)*

Where, i is type of pollutant; Emi is emission of pollutant i (mass per time); ARi is Mass of fired bricks produced per unit of timei (activity unit per time); EFi is emission factor for pollutant i (mass per activity unit) [3]. Emission factors (EFs) are expressed in the unit of kg/Metric ton. Emission factors used for brick kiln emission estimation (AP-42 US-EPA, 1997) are indicated in Table 3.

Table4. *Emission Estimation for brick kiln*

Sr. No.	Source ID	Emission Estimate (MT/ Cycle)			
		PM_{10}	SO_2	NO_X	CO
Uvarsad village					
1	USD_1	9.80	8.26	3.50	5.60
2	USD_2	12.25	10.32	4.37	7.00
3	USD_3	12.25	10.32	4.37	7.00
4	USD_4	7.35	6.19	2.62	4.20
5	USD_5	7.35	6.19	2.62	4.20
6	USD_6	1.71	1.45	0.61	0.98
7	USD_7	1.71	1.45	0.61	0.98
8	USD_8	1.47	1.24	0.52	0.84

9	USD_9	1.47	1.24	0.52	0.84
10	USD_10	1.22	1.03	0.44	0.70
11	USD_11	7.35	6.19	2.62	4.20
12	USD_12	9.80	8.26	3.50	5.60
13	USD_13	1.71	1.45	0.61	0.98
14	USD_14	2.45	2.06	0.88	1.40
15	USD_15	4.90	4.13	1.75	2.80
16	USD_16	6.13	5.16	2.19	3.50
17	USD_17	9.80	8.26	3.50	5.60
18	USD_18	9.80	8.26	3.50	5.60
19	USD_19	6.13	5.16	2.19	3.50
20	USD_20	6.13	5.16	2.19	3.50
21	USD_21	1.22	1.03	0.44	0.70
22	USD_22	3.67	3.10	1.31	2.10
23	USD_23	2.94	2.48	1.05	1.68
24	USD_24	7.35	6.19	2.62	4.20
25	USD_25	1.47	1.24	0.52	0.84
26	USD_26	1.22	1.03	0.44	0.70
27	USD_27	7.35	6.19	2.62	4.20
28	USD_28	7.35	6.19	2.62	4.20
29	USD_29	9.80	8.26	3.50	5.60
30	USD_30	1.22	1.03	0.44	0.70
31	USD_31	2.45	2.06	0.88	1.40
32	USD_32	1.71	1.45	0.61	0.98
33	USD_33	3.43	2.89	1.22	1.96
34	USD_34	1.71	1.45	0.61	0.98
35	USD_35	2.45	2.06	0.88	1.40
36	USD_36	1.22	1.03	0.44	0.70
37	USD_37	1.96	1.65	0.70	1.12
38	USD_38	2.45	2.06	0.88	1.40
39	USD_39	3.43	2.89	1.22	1.96
40	USD_40	1.22	1.03	0.44	0.70
41	USD_41	9.80	8.26	3.50	5.60
42	USD_42	7.35	6.19	2.62	4.20
43	USD_43	4.90	4.13	1.75	2.80
44	USD_44	2.45	2.06	0.88	1.40
45	USD_45	6.13	5.16	2.19	3.50
46	USD_46	8.57	7.23	3.06	4.90
47	USD_47	7.10	5.99	2.54	4.06
48	USD_48	1.96	1.65	0.70	1.12
49	USD_49	1.47	1.24	0.52	0.84
50	USD_50	12.25	10.32	4.37	7.00
51	USD_51	4.90	4.13	1.75	2.80
52	USD_52	2.45	2.06	0.88	1.40
53	USD_53	1.47	1.24	0.52	0.84
54	USD_54	1.96	1.65	0.70	1.12
55	USD_55	4.90	4.13	1.75	2.80
56	USD_56	8.57	7.23	3.06	4.90
Vavol village					
57	VVL_1	9.80	8.26	3.50	5.60
Pundrasan village					
58	PDS_1	4.90	4.13	1.75	2.80
59	PDS_2	2.45	2.06	0.88	1.40
Shertha village					
60	SHT_1	3.67	3.10	1.31	2.10
61	SHT_2	2.21	1.86	0.79	1.26
62	SHT_3	11.02	9.29	3.94	6.30
63	SHT_4	9.80	8.26	3.50	5.60
64	SHT_5	12.25	10.32	4.37	7.00

Adalaj village					
65	ADJ_1	7.35	6.19	2.62	4.20
66	ADJ_2	7.35	6.19	2.62	4.20
67	ADJ_3	7.35	6.19	2.62	4.20
68	ADJ_4	2.45	2.06	0.88	1.40
69	ADJ_5	1.22	1.03	0.44	0.70
70	ADJ_6	1.96	1.65	0.70	1.12
71	ADJ_7	11.02	9.29	3.94	6.30
72	ADJ_8	6.13	5.16	2.19	3.50

Emission inventory plays an important role in air quality management programs and serves as the necessary input for model simulations.

However in present study, data related to activity rates were gathered by field survey for the key parameters, i.e. types of fuel utilization, tonnes of bricks produced, control devices and periods of firing processes, and other relevant data i.e. stack parameters (temperature, velocity, dimensions and coordinates). Estimated emissions of pollutants for (PM10, SO2, NOx, CO) in tons per cycle are shown in Table 4.Total emissions of brick kilns including PM10, NOx,SO2, and CO were 373.61, 133.43, 314.93 and 231 MT/cycle respectively. To include the emission estimates into CALPUFF modelling system, per cycle estimation data were converted to loading rates (kg/hr) for each pollutant of all 72 kilns. Thus, PM10, NOx, SO2, and CO loading rates ranged between 1.22-12.25, 0.44-4.37, 1.03-10.32, and 0.70-7.0 kg/hr respectively.

CALPUFF Model

CALPUFF (California Puff Model) was developed by Sigma Research Corporation (currently part of Earth Tech, Inc.) sponsored by California Air Research Board. CALPUFF is a multilayer, multispecies, non-steady-state Lagrangian puff dispersion model for assessing long range transport of pollutants. It consists of three main components:

CALMET (a diagnostic 3-dimensional meteorological model)

CALPUFF (an air quality dispersion model)

CALPOST (a post processing package)

Configuration of CALPUFF Model

The configuration of the CALPUFF model View V8.5; was divided into five stages, following the order requested by the software.

First Step: geophysical data insertion, containing all the information configured in the computational mesh.

Second Stage: Description of pollutants to be analysed in the study, in this case, PM10 NOx, SO2, CO.

Third Step: Insert the CALMET output file, CALMET.DAT, containing all simulated weather data.

Fourth Step: Definition of source type of the study, in this case a point source. Insertion of the location data (UTM) Brick Kiln details, along with the information in Table 1, 2 and 3.

Fifth Stage: Choice of the receptor, being selected a gridded. An option to provide the values of simulated daily average concentration has been selected for air pollutants. After setting all parameters the CALPUFF model was executed, generating the output files: control data and verification of the simulation (CALPUFF.LST) and simulated concentrations data in specified domain (CALPUFF.DAT).

To perform the processing of results the CALPUFF post-processor was applied, termed CALPOST. In this case, the simulated average daily concentrations and annual average concentration for PM10 NOx, SO2, CO. were reproduced illustratively, using maps and graphics, for a better interpretation of the phenomenon.

RESULT AND DISCUSSION

The annual prevailing wind directions as per wind rose diagram of study area for study period is shown in Figure 4, Prevalent wind direction was SE with dominant wind speeds of 2.10–5.70 m/s (average wind speed 2.80 m/s).In terms of spatial analysis, the dispersion pattern of the pollutant is shown for PM10, NOx,SO2 and CO in (µg/m3) from brick kilns for (a) 24-hours average and (b) annual average as indicated in Figure 5, 6, 7, and 8 respectively.

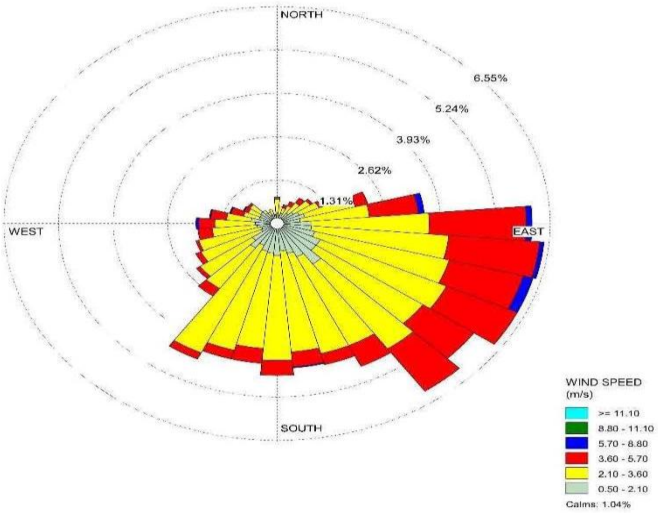
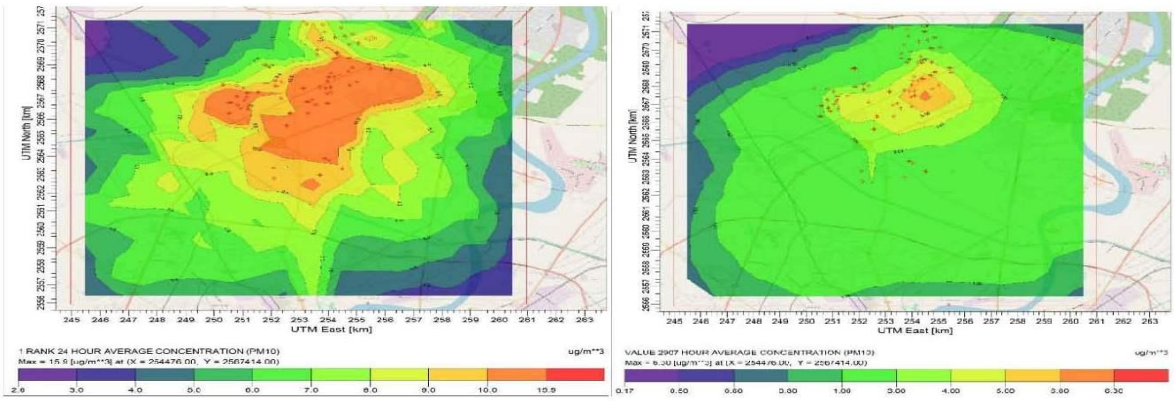
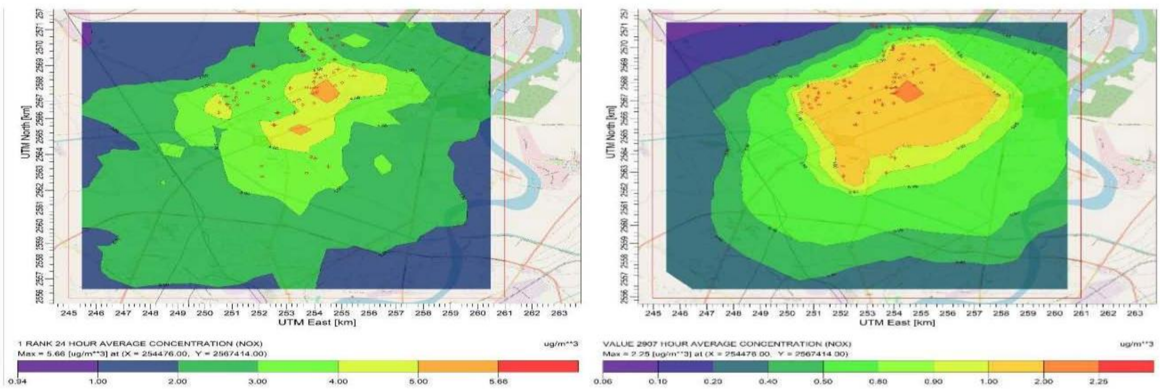


Figure4. *Wind rose diagram of Study area*



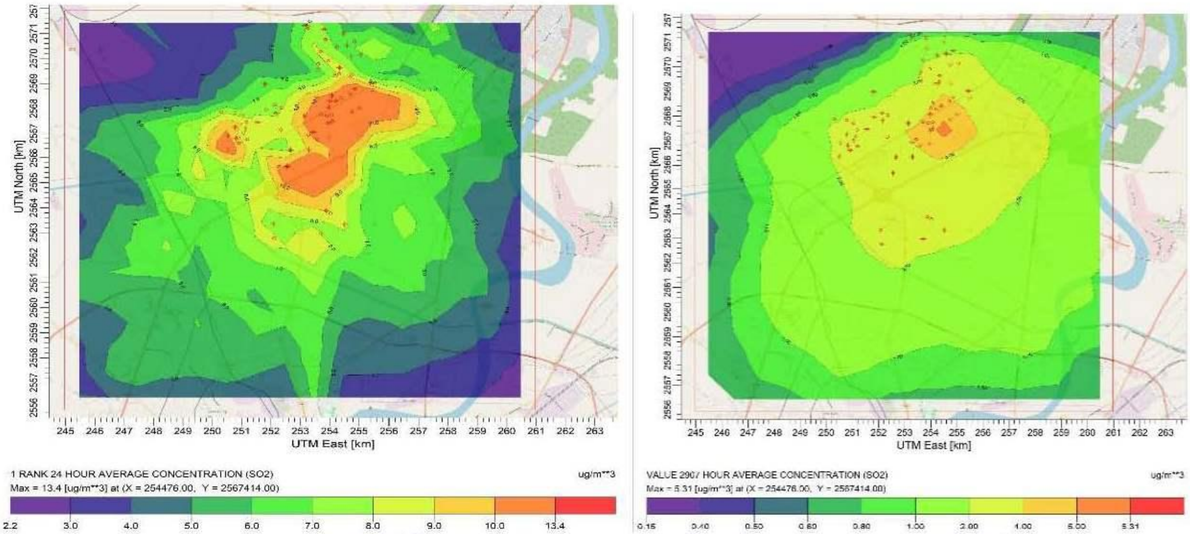
(a) **(b)**

Figure5. *Dispersions of PM10 concentrations (µg/m3) from brick kilns (16 km x 16 km) for (a) 24 Hrs.Average and (b) annual Average*



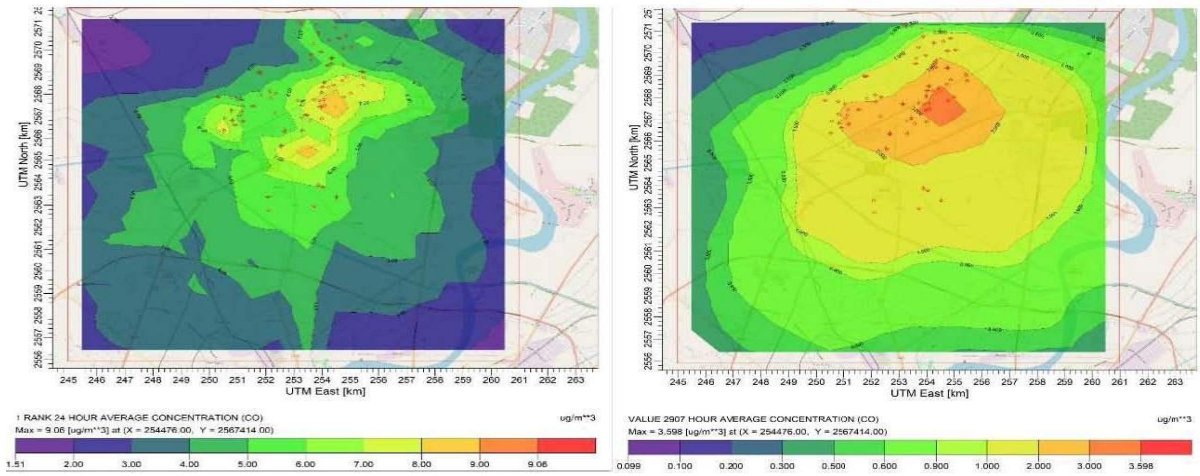
(a) **(b)**

Figure6. *Dispersions of simulated NO2concentrations (µg/m3) from brick kilns (16 km x 16 km) (a) 24-hr average and (b) annual average*



(a) (b)

Figure7. *Dispersions of simulated Sulfur Dioxide concentrations (μg/m3) from brick kilns (16 km x 16 km) for (a) 24-hr average and (b) annual average*



(a) (b)

Figure8. *Dispersions of simulated CO concentrations (μg/m^3) from brick kilns(16 km x 16 km) for (a) 24-hr average and (b) annual average*

The simulated concentrations for PM10, NOx, SO2 and CO for 24 hours average and annual average along with NAAQS India and WHO air quality guidelines are summarized in below table 5.

Table5. *Summery of CALPUFF result*

Pollutants	Maximum Concentration (μg/m^3)	
	24-hour average	**Annual average**
PM_{10}:		
Simulation	15.9	6.30
NAAQS	100	60
WHO	20	50
NO_X:		
Simulation	5.66	2.25
NAAQS (NO_2)	80	40
WHO (NO_2)	n.s.	40
SO_2:		

Simulation	13.4	5.31
NAAQS	80	50
WHO	20	n.s.
CO:		
Simulation	9.00	3.598
NAAQS	n.s.	n.s.
WHO	n.s.	n.s.

n.s. = not specified.

From above table, it can be seen that maximum simulated PM10 concentrations accounted for around 15.9 % of standard value for 24-hour average (NAAQS) and around 79.5% of standard value for 24-hour average (WHO). For SO2, maximum simulated concentration for 24-hour average was 13.4 µg/m3, accounted for around 16.7 % of standard value for 24-hour average (N AAQS) and around 67 % of standard value for 24-hour average (WHO). Simulated NO2 concentrations for 24-hour and annual average were rather low when compared with NAAQS and WHO guidelines. Simulated CO concentrations for 24-hour and annual averages were range between 9.06 and 3.589 µg/m3.

Ground level concentration of pollutants PM10, NOx, SO2 and CO at Receptor villages in (16km*16 km) of Gandhinagar region is shown in below table 6.

Table6. *Ground level concentration of Pollutants at Villages and towns in (16Km*16 Km) Gandhinagar region*

Sr. No.	Population	Name of receptor Villages	PM10 ($\mu g/m^3$)		NO_2 ($\mu g/m^3$)		SO_2 ($\mu g/m^3$)		CO ($\mu g/m^3$)	
			24-hr average	Annual average	Annual average	24-hr average	24-hr average	Annual average	24-hr average	Annual average
1	12628	Vavol	4-15.9	0.6-4	0.2-2	1-5	3-13.4	0.6-4	2-8	0.3-3
2	10172	Unvarsad	4-15.9	0.6-6.3	0.2-2.25	1-5.66	4-13.4	0.5-5.31	2-9	0.3-3.598
3	292000	Gandhinagar	3-15.9	0.6-4	0.2-2	1-4	3-13.4	0.5-4	2-7	0.3-3
4	8728	Shertha	3-15.9	0.17-5	0.1-2	1-4	3-13.4	0.4-4	2-8	0.2-3
5	4312	Sarghasan	7-15.9	1-6	0.9-2	2-4	5-13.4	2-5	4-9	1-3.598
6	11957	Adalaj	6-15.9	1.0-5	0.5-2	2-5	4-13.4	1-4	3-9	0.9-3
7	5069	Por	7.0-15.9	1.0-4.0	0.5-2.0	2.0-4.0	6.0-13.4	1.0-4.0	4.0-8.0	1.0-2.0
8	3387	Ambapur	6-10	1-3	0.5-0.9	2-4	5-8	1-4	3-6	0.9-2
9	7019	Kudasan	5-9	1-3	0.5-2	1-2	4-9	1-4	3-5	1-2
10	6105	Khoraj	6-9	1-3	0.4-0.9	2-3	5-8	1-2	3-6	0.6-2

Maximum 24-hr average Simulated Concentration of PM10, NO2, SO2 and CO are 15.9 µg/m3, 5.66 µg/m3, 13.4 µg/m3 and 9.0µg/m3 respectively.

Although the preliminary simulated pollutants from 72 brick kilns in this study were well below the NAAQS and WHO air quality guidelines, Locations of maximum simulated concentrations such as Vavol, Unvarsad, Gandhinagar, Shertha, Sarghasan, Adalaj, Por, Kudasan, Khoraj were found to be near the sources. However, this study used estimated emissions for modelling input that could be a source of uncertainty. Future investigation should focus on emission monitoring to obtain the actual emissions. Modelling applications for different years would be another suggestion to produce the concrete dispersion pattern.

CONCLUSION

Estimated emissions for PM10, NO2, SO2 and CO in Gandhinagar region (16km*16km) were 373.61, 314.93, 133.43 and 231 MT/cycle respectively. For CALPUFF modelling application, simulated maximum concentrations for 24-hour and4months average were as follows: PM10 (15.9, and 6.30 µg/m3, respectively); NO2 (5.66, and 2.25 µg/m3, respectively); SO2 (13.4, and 5.31 µg/m3, respectively). CO (9.06 and 3.598 µg/m3, respectively). All simulated concentrations were well below the NAAQS of India and WHO air quality guidelines.

Determining the air pollutants, and interpreting and examining their dispersion and environmental effects will help in future planning. This study will help in predicting the upcoming adverse effects and development of measures for mitigation. As urbanization in Gandhinagar districts has increasing at rapid pace, this study also provides the hot spot area where highest pollutant concentration observed which may help in future town planning.

ACKNOWLEDGEMENT

Authors are thankful to Forest and Environment Department. Government of Gujarat (F&ED, GOG) for providing financial assistance for the current project.

REFERENCE

[1] EPA (ENVIRONMENT PROTECTION AGENCY), 1997. AP-42, Emission Factor Documentation for AP-42Section 11.3 Brick and Structural Clay Product Manufacturing, MRI Project No. 4604-02, 91 pages.

[2] P.B.Wanjule, Dr. S.B. Chandanshiv, Dr. Sanjay Aswale, 2015. A Study of Rural Bricks Industries with Special Reference to Maharashtra Region. International Journal of Social Science & Interdisciplinary Research. IJSSIR. 4, 20-24.

[3] P.B. Wanjule, Dr. S.B. Chandanshiv, Dr. Sanjay Aswale, 2015. Brick Making In India – History. International Journal of Financial Services Management. 4, 11-16.

[4] Lakes Environmental Software, 2003-2017. CAL PUFF View User Guide, 941 pages.

[5] Muhammad Waseem Khan, Yousaf Ali, Fabio De Felice, Aneel Salmand, Antonella Petrilloe, 2019. Impact of brick kilns industry on environment and human health in Pakistan. Science of the Total Environment. 678, 383-389.

[6] CPCB (Central Pollution Control Board, India), 2009. NATIONAL AMBIENT AIR QUALITY STATUS & TRENDS IN INDIA-2010, NAAQMS/35/2011-2012, Delhi, 172 PAGES.

[7] https://www.cpcb.nic.in/openpdffile.php?id=UmVwb3J0RmlsZXMvMzJfMTQ1ODEyNjU5MV9OZXdJdGVtXzE5Ml9OQUFRU1RJLnBkZg==.

[8] Palash Patra, Avijit Guray, Sandipan Ganguly, 2015. A Study on Brick Kiln Industry in Pursura Block of Hooghly District, West Bengal. International Journal of Applied Research. 1(9), 95-99.

[9] Suman Kumar Pariyar, Tapash Das, Tanima Ferdous, 2013. Environment and Health Impact For Brick Kilns In Kathmandu Valley. INTERNATIONAL JOURNAL OF SCIENTIFIC & TECHNOLOGY RESEARCH. 2(5), 184-187.

[10] T. Kanabkaew & K. Buasing, 2015. Assessment of air pollution concentrations from brick kilns using an atmospheric dispersion model. WIT Transactions on Ecology and the Environment, 198, 27-37.

[11] WHO (2018), https://www.who.int/news-room/fact-sheets/detail/ambient-(outdoor)-air-quality-and-health

Citation: *Pushkar Patel, Paresh Chavda, Madhavi Pimparkar, "Air Quality Assessment and Dispersion of Air Pollutants from Brick Kilns in and Around Gandhinagar Region (16km*16km) Using CALPUFF ", International Journal of Research Studies in Science, Engineering and Technology, vol. 6, no. 7, pp. 22-32. 2019.*