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Air Pollution in the Industrial belts of Odisha: Its Health Impacts with Mitigation Measures

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KEYWORDS

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ABSTRACT:

Introduction: Odisha, a state with a thriving industrial sector, faces a serious problem with industrial air pollution. There have been considerable emissions of dangerous pollutants like particulate matter (PM), Sulphur dioxide (SO_2), nitrogen oxides (NOx), and more due to explosive growth of industries, including steel, power, cement, and mining. These substances can cause illness, human death, environmental harm to other living things like food crops, as well as harm to the built environment or the natural environment.

Objectives: To study in detail about the pollutants like NO_2, SO_2, $PM_{2.5}$ and PM_{10} in some industrial belt of Odisha and their impact on public health and to create an awareness among the people about the expenses of these pollutants on the living beings and to mitigate the measures.

Methods: Data of the pollutants selected in the proposed areas are collected through Odisha State Pollution Control Board (OSPCB), Bhubaneswar and we analysed the result by graphical analysis.

Results: Among all these locations, Brajraj Nagar has the highest average $PM_{2.5}$ concentration (47.79 µg/m^3) and Beleipada has the highest PM_{10} concentration (138.60 µg/m3) whereas NO_2 and SO_2 are under control.

Conclusions: To achieve this delicate balance and ensure a cleaner and healthier future for Odisha, there must be cooperation highly essential among government, corporate businesses, academic institutions, industries and civil society.

1. Introduction

The term "pollution" refers to the introduction of particles, biological molecules, or other dangerous gasses into the atmosphere of the planet, which can lead to illness, human death and environmental harm to other living things. Both artificial and natural factors can contribute to pollution. [1] Contaminants are introduced into the environment to cause pollution. Pollution comes in many different forms, including air, land, sound, and water pollution [2]. In cities, human-made factors are primarily to blame for the air pollution. Beginning and non-point source pollution are the two types of pollution that are measured. There are two categories of mobile sources: point sources, such as factories and electric power plants, and mobile sources, such as motor vehicles, trucks, airplanes, and marine motors. In industrialized nations' major cities, road traffic is currently the biggest source to air pollution [3]. The eastern Indian state of Odisha is well-known for its industrial endeavours, particularly in the mining, cement, steel, electricity, and chemical industries. They discharge a variety of pollutants into the environment, they also contribute to industrial air pollution [4]. The state's immense natural resources have contributed to the rapid industrialization, drawing big enterprises to Odisha. Additionally, there has been an increase in the emissions of air pollutants including Particulate Matter (PM) throughout this economic boom. These pollutants are emitted at various times during industrial processes, from the gathering of raw materials and manufacturing to the transportation and trash disposal [5]. They permeate the

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atmosphere, causing a decline in air quality that adversely affects both human health and ecological harmony. Engineering's contribution to this field, which shared the goal of increasing machining process efficiency, the machining process has significantly improved [6]. The heavy industrialization plays the vital role in the growth of economy of Odisha, that includes towns like Talcher, Beleipada, Keonjhar, Rourkela, Brajaraj Nagar, and Tensa. However, the presence of industry in certain locations increased air pollution. Here we focussed on few elements that affect air quality in Odisha's industrial region [7]. A variety of industrial activity that produce air pollution are mentioned below.

a. **Emissions from Steel Industry**: The steel industry in Odisha is especially located in Rourkela, Jharsuguda, and Angul. Pollutants such as particulate matter (PM), sulfur dioxide (SO_2), nitrogen oxides (NOx), carbon monoxide (CO), carbon dioxide (CO_2) and volatile organic compounds (VOCs) are released during the manufacture of steel [8].
b. **Emissions from Power Plants**: In Odisha, the thermal power plants that are used to produce electricity are the main contributors of industrial air pollution. Pollutants such as SO_2, NOx, PM, and CO_2 are released by these plants.
c. **Emissions from Cement Industry**: During manufacturing and transportation, the cement industry in Odisha, which is mostly concentrated in Sundargarh, Kalinganagar, and Jajpur, generates particulate matter, sulfur dioxide, nitrogen oxides, and carbon dioxide.
d. **Emissions from the Aluminium Industry**: During the smelting and refining procedures, the aluminium industry, which is in Angul and Jharsuguda, generates fluorides, PM, and other pollutants [9].
e. **Mining**: Due to the abundance of mineral resources in Odisha, mining operations contribute to air pollution by releasing dust and particulates during mineral extraction, transportation, and processing.

Industrial air pollution in Odisha has a huge impact and serious repercussions. Exposure to industrial air pollution can cause the surrounding population to have respiratory illnesses, cardiovascular problems, asthmatic flare-ups, and other health issues [10]. About 80% of SO_2 emissions come from fossil fuels like coal and fuel oil, both of which include sulphur. The atmosphere receives many of these emissions. The environment suffers due to electricity generation, and the market for heating systems due to expansion of diesel/ petrol vehicles [11]. Around 50% of NOx emissions were caused by road traffic, followed by agriculture / forestry, manufacturing, and energy conversion [12]. The practice of stubble burning in agriculture is in full swing in all over India including Odisha, but it is more in the states of Punjab, Haryana, and Uttar Pradesh. It is a highly unhealthy practice which is a common sight in Indian paddy waste management. It fills the air with soot, dispels nutrients out of the soil, and leads to several other ecological complications.

Efforts to reduce pollution have always been a major problem. Because of this, exercising caution is always a superior method of reducing air pollution. **[**13**]** Implementing and enforcing air quality laws and emission standards, promoting cleaner production methods, encouraging the use of renewable energy sources, improving monitoring and enforcement, and increasing public awareness of the value of good air quality for human health and the pure environment are all part of efforts to reduce industrial air pollution in Odisha [14]. To properly handle this urgent high alarming issue, cooperation among governmental entities, industries, and communities is essential.

2. Objectives

To study in detail about the pollutants *like* NO_2, SO_2, and PM in the industrial belt of Odisha and their impact on public health and to create an awareness among the people about the expenses of these pollutants on the living beings and to mitigate the measures.

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Fig 1 Industrial map of Odisha

3. Methods

This research was conducted taking into account the seven industrial belts in Odisha, indicated in the map (Fig. 1). The data are collected from the sites of Odisha State Pollution Control Board (OSPCB), Bhubaneswar.

Rourkela: Home to one of India's major steel factories, the Rourkela Steel Plant, run by the Steel Authority of India Limited (SAIL).

Keonjhar:. Numerous iron ore mines are located in the area, which greatly boosts the state of Odisha's mining industry.

Talcher: In the coal mining and power generation industries, organizations like the National Thermal Power Corporation (NTPC) and Mahanadi Coalfields Limited (MCL) are crucial.

Tensa: It is principally recognized for its iron ore mining operations. Iron ore mining are run in this area by businesses like JSW Steel, which helps the iron and steel sector.

Brajaraj Nagar: A significant area that is home to thermal power plants and coal mines.

Rairangpur: The main economic sectors in Rairangpur are small-scale manufacturing, mining, and agriculture.

Beleipada: One of the main crops grown in the area is rice, along with pulses, oilseeds, vegetables, and oilseed products.

With a concentration on mining operations including the extraction of coal, iron ore, and manganese as well as their subsequent use in the production of steel, these regions collectively represent the varied industrial landscape of Odisha [15].

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Data collection:

From June 1, 2023, to June 30, 2023, the data were collected daily in the following locations: Beleipada, Brajaraj Nagar, Keonjhar, Rairangpur, Rourkela, Talcher, and Tensa. Online emission monitoring systems (EMS) are used by the Odisha State Pollution Control Board (OSPCB) to gauge industrial air pollution. Additionally, the OSPCB built an eight-station State Ambient Air Quality Monitoring Network (SAAQM). To identify specific pollutants, air quality monitors employ sensors. The density of particulate matter in a cubic meter of air is scanned by certain monitors using lasers [16]. The energy that the Earth emits or reflects can also be measured using satellite imagery. Nephelometers, Spectrometry, and Chromatography are further equipment that are used to measure air pollution. In this analysis, we have used data, which is collected from OSPCB, Bhubaneswar with their permission. The data is re-arranged and analysed according to the requirement of this present work [17]. We have collected data for four pollutants i.e., NO_2, SO_2, $PM_{2.5}$ and PM_{10}.

Table 1 Pollutant NO_2 in the industrial belt of Odisha

DAYS	BELEI PADA	BRAJARAJ NAGAR	KEONJHAR	RAIRANGPUR	ROURKELA	TALCHER	TENSA
01-Jun-23	10.02	59.82	6.66	19.99	15.35	30.91	26.54
02-Jun-23	12.36	68.97	6.62	18.27	17.07	30.9	24.88
03-Jun-23	9.37	20.8	5.65	19.2	11.01	30.91	26.08
04-Jun-23	8.65	29.54	4.33	17.31	13.63	30.9	28.03
05-Jun-23	10.61	21.02	6.02	16.62	12.52	30.95	28.52
06-Jun-23	10.95	30.92	7.56	21.35	16.47	31.39	26.28
07-Jun-23	10.3	31.74	6.44	18.87	15.62	31.43	41.97
08-Jun-23	11.08	14.24	6.42	24.02	17.66	31.47	42.73
09-Jun-23	13.07	26.28	7.05	17.13	17.58	31.46	46.48
10-Jun-23	9.29	29.21	4.31	15.12	14.35	31.45	29.01
11-Jun-23	8.8	18.26	4.71	15.34	14.16	31.44	23.18
12-Jun-23	10.85	18.18	6.15	15.3	14.4	31.27	30.1
13-Jun-23	6.03	21.67	2.79	9.03	13.39	31.26	28.72
14-Jun-23	9.19	27.58	3.8	38.04	15.52	31.28	22.85
15-Jun-23	6.57	14.64	3.77	23.65	15.85	31.27	25.98
16-Jun-23	8.6	17.87	3.86	28.88	15.35	31.24	32.49
17-Jun-23	8.42	15.88	4.17	19.15	14.98	31.26	35.5

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18-Jun-23	6.64	20.24	4.17	17.86	11.54	31.28	25.92
19-Jun-23	6.25	14.33	4.76	26.59	12.4	31.32	24.21
20-Jun-23	7.09	9.89	3.85	23.38	12.14	31.31	24.69
21-Jun-23	5.91	18.65	4.13	20.33	13.74	31.27	23.1
22-Jun-23	6.23	14.86	4.25	21.92	10.74	31.34	25.95
23-Jun-23	6.1	18.87	4.44	19.88	12.87	31.43	27.47
24-Jun-23	6.99	16.76	4.5	19.33	11.15	31.49	23.12
25-Jun-23	6.89	14.94	4.3	17.45	10.09	31.48	20.89
26-Jun-23	4.95	13.98	4.04	15.91	8.33	31.46	6.08
27-Jun-23	4.47	2.57	3.54	15.45	7.71	31.51	7.08
28-Jun-23	4.71	4.26	3.95	17.05	8.91	31.48	15.99
29-Jun-23	5.23	9.87	3.94	18.4	9.21	31.48	18.7
30-Jun-23	5.62	17.76	6.15	18.33	11.91	31.46	24.41

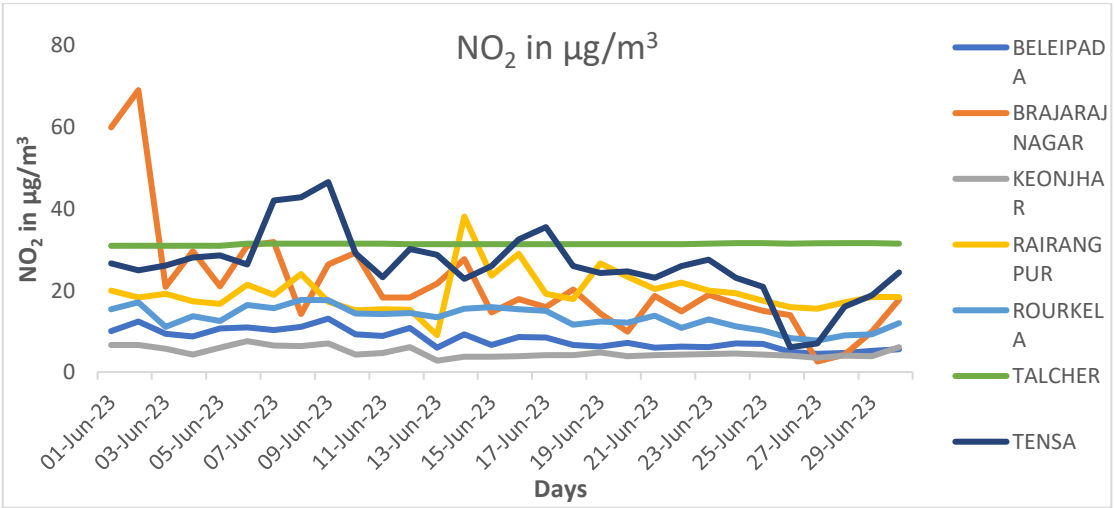

Figure 2 Graph for Pollutant NO_2 in industrial belt of Odisha

Table 2 Pollutant SO_2 in the industrial belt of Odisha

DAYS	BELEI PADA	BRAJARAJ NAGAR	KEONJHAR	RAIRANGPUR	ROURKELA	TALCHER	TENSA
01-Jun-23	16.05	26.91	4.02	7.76	1.52	2.77	5.76
02-Jun-23	20.56	27.11	3.93	8.26	2.5	3.98	11.83

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03-Jun-23	18.02	26.79	4.22	9.07	1.98	1.64	8.86
04-Jun-23	18.49	26.78	3.74	8.31	0.43	1.79	5.49
05-Jun-23	21.26	26.81	3.46	9.64	1.6	6.06	4.89
06-Jun-23	24	26.76	1.51	12.74	1.64	2.12	13.66
07-Jun-23	25.37	26.74	1.95	3.9	1.05	2.47	6.35
08-Jun-23	25.99	26.87	3.24	4.44	2.9	1.87	7.72
09-Jun-23	28.02	26.89	7.76	3.43	2.25	6.89	3.81
10-Jun-23	25.27	27.23	7.57	0.16	1.91	1.5	8.45
11-Jun-23	27.04	27.19	8.45	2.91	0.97	9.2	13.63
12-Jun-23	27.57	27.16	8.6	3.7	1.23	16.77	6.27
13-Jun-23	48.14	26.99	0.36	8.11	2.1	19	7.41
14-Jun-23	38.03	26.96	1.48	10.2	0.46	20.63	8.2
15-Jun-23	30.4	26.92	0.95	7.13	0.52	21.28	6.93
16-Jun-23	30.05	26.76	0.35	3.66	0.51	21.75	11.36
17-Jun-23	28.12	26.8	0.93	6.78	1.43	21.38	10.42
18-Jun-23	26.39	26.99	2.11	9.82	2.05	20.03	11.15
19-Jun-23	23.25	26.79	2.36	7.38	0.81	20.65	7.34
20-Jun-23	18.62	26.8	2.9	7.25	1.3	20.23	11.54
21-Jun-23	18.49	26.69	2.96	6.05	0.31	20.2	9.6
22-Jun-23	23.83	26.59	3.37	6.46	0.18	18.75	10.01
23-Jun-23	26.04	26.74	3.5	6.3	0.42	19.13	9.71
24-Jun-23	29.4	26.92	3.46	6.39	0.62	21.01	5.06
25-Jun-23	25.72	26.14	3.02	6.59	0.35	21.04	1.53
26-Jun-23	24.65	27.12	2.2	6.74	0.81	19.4	1.72
27-Jun-23	24.17	27.52	1.34	6.92	0.63	19.68	0.87
28-Jun-23	30.47	27.43	3.25	6.98	0.89	19.33	2.52
29-Jun-23	30.4	27.29	3.5	8.23	0.48	17.93	5.35
30-Jun-23	30.41	27.11	3.17	7.79	0.46	18.36	4.49

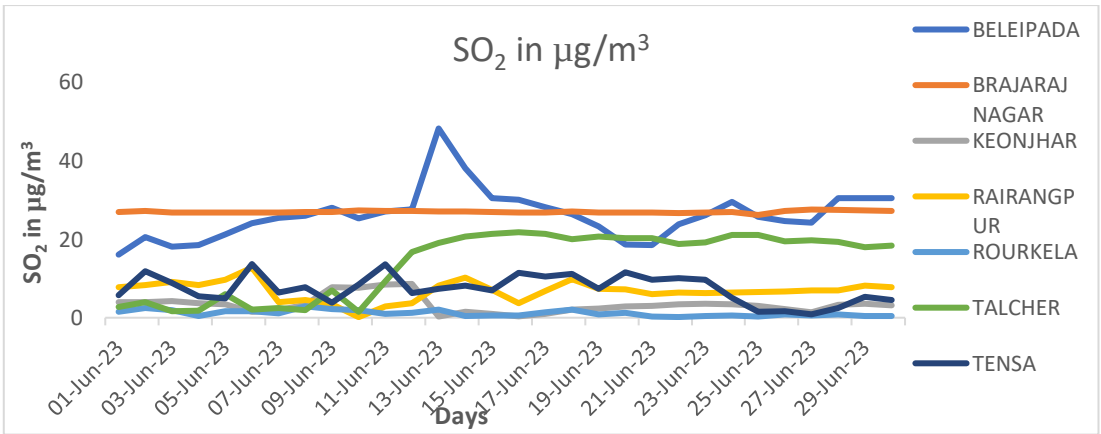

Figure 3 Graph for Pollutant SO_2 in industrial belt of Odisha

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Table 3 Pollutant $PM_{2.5}$ in the industrial belt of Odisha

DAYS	BELEIPADA	BRAJARAJ NAGAR	KEONJHAR	RAIRANG PUR	ROURKELA	TALCHER	TENSA
01-Jun-23	60.17	38.63	50.11	45.36	53.14	38.15	34.31
02-Jun-23	63.84	43.53	57.89	43.26	48.94	49.75	33.89
03-Jun-23	65.25	54.69	55.16	48.68	47.64	26.23	40.72
04-Jun-23	60.06	35.51	36.56	35.75	43.44	27.88	33.27
05-Jun-23	55.18	44.79	37.28	34.71	45.98	55.16	27.1
06-Jun-23	63.13	27.78	50.33	40.6	55.95	45.08	37.54
07-Jun-23	69.88	36.84	60.79	51.34	43.87	31.41	41.12
08-Jun-23	69.05	2.95	58.98	52.03	49.28	64.35	43.3
09-Jun-23	74.63	34.41	49.78	44.66	37.51	55.33	40.75
10-Jun-23	61.25	75.46	47.78	37.35	46.74	29.02	41.45
11-Jun-23	60.56	43.18	43.7	35.43	60.36	59.01	40.55
12-Jun-23	70.78	36.86	50.62	36.58	66.18	60.5	39.04
13-Jun-23	53.88	32.62	39.83	39.94	48.31	32.07	37.66
14-Jun-23	42.88	26.37	38.13	35.79	52	35.17	28
15-Jun-23	44.07	27.97	33.57	33.22	39.28	37.62	30.55
16-Jun-23	48.43	30.59	39.23	33.11	62.56	27.78	37.24
17-Jun-23	50.19	40.76	38.88	38.19	46.66	29.74	44.1
18-Jun-23	47.26	66.84	41.63	43.83	57.81	22.22	39.54
19-Jun-23	43.58	24.76	26.86	30.93	52.06	36.52	22.71
20-Jun-23	48.43	22.67	37.58	34.95	47.54	14.2	18.58
21-Jun-23	41.62	37.23	34.61	33.14	71.63	21.78	20.89
22-Jun-23	42.35	21.64	34.45	32.14	74.75	36.12	30.33
23-Jun-23	44.21	46.3	36.37	31.6	77.11	24.1	31.81
24-Jun-23	42.22	23.47	28.34	26.37	54.12	20.02	24.54
25-Jun-23	26.26	75.94	19.82	17.84	46.32	16.81	16.68
26-Jun-23	18.48	355.36	16.17	11.72	16.88	11.86	11.88
27-Jun-23	18.6	66.45	13.93	7.72	17.65	18.22	12.01
28-Jun-23	22.49	69.49	16.11	15.79	25.95	17.82	11.85
29-Jun-23	35.95	25.8	24.09	26.64	37.53	18.39	12.91
30-Jun-23	31.61	28.56	32.07	37.64	42.04	21.48	12.89

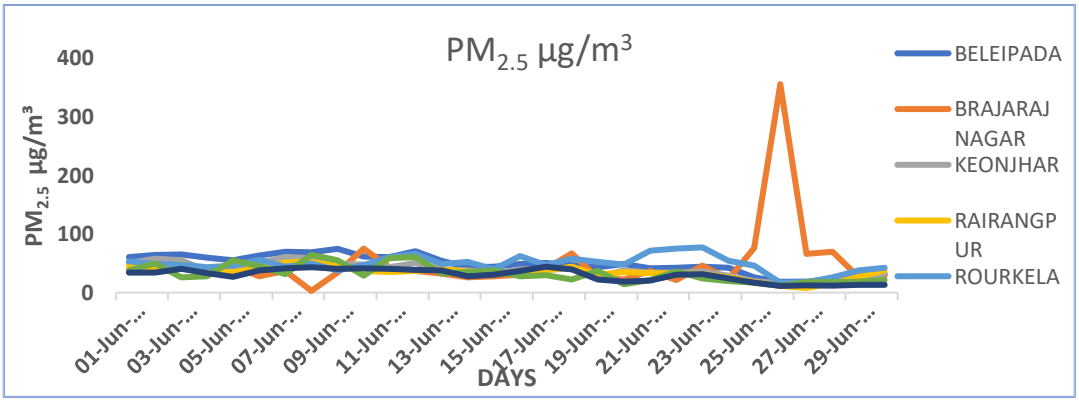

Fig 4 Graph for Pollutant $PM_{2.5}$ in industrial belt of Odisha

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Table 4 Pollutant PM_{10} in the industrial belt of Odisha

DAYS	BELEIPADA	BRAJARAJ NAGAR	KEONJHAR	RAIRANG PUR	ROURKELA	TALCHER	TENSA
01-Jun-23	186.06	94.39	110.92	76.58	133.88	72.85	79.58
02-Jun-23	205.63	96.65	119.64	86.65	118.48	89.36	73.59
03-Jun-23	189.52	80.14	109.49	85.18	116.33	39.78	103.27
04-Jun-23	181.64	62.45	81.42	66.44	78.07	51.47	79.68
05-Jun-23	159.87	73.27	76.69	65.33	106.23	104.13	64.14
06-Jun-23	173.88	78.29	100.42	75.62	121.91	69.69	79.28
07-Jun-23	200.23	106.35	98.72	75.65	94.71	76.11	100.04
08-Jun-23	197.57	102.95	101.88	87.55	131.1	117.21	108.28
09-Jun-23	251.65	77.16	136.68	87.06	110.13	114.14	129.98
10-Jun-23	177.65	172.57	92.28	63.57	129.48	45.47	117.55
11-Jun-23	169.29	97.49	100.27	83.9	171.9	178.22	98.23
12-Jun-23	223.3	82.77	113.97	102.4	184.52	116.43	100.74
13-Jun-23	116.66	72.93	79.51	73.94	126.72	58.52	90.94
14-Jun-23	124.75	58.41	93.33	64.48	128.09	65.58	64.14
15-Jun-23	130.94	62.14	76.6	52.53	116.13	85.4	70.61
16-Jun-23	153.25	68.21	97.02	56.41	127.82	71.79	97.69
17-Jun-23	155.34	91.89	92.01	58.21	120.04	67.69	111.49
18-Jun-23	144.42	152.62	89.03	71.19	143.82	42.43	89.94
19-Jun-23	106.5	54.7	56.02	45.78	93.07	18.25	66.99
20-Jun-23	135.68	49.8	77.27	64.26	106	19.65	73.79
21-Jun-23	107.9	58.94	71.53	59.17	114.5	19.14	71.4
22-Jun-23	108.67	47.41	63.95	45.15	96.67	44.69	68.36
23-Jun-23	112.83	104.81	65.05	60.36	99.2	41.19	62.2
24-Jun-23	92.62	72.67	52.32	59.64	79.64	26.85	56.37
25-Jun-23	69.17	48.7	36.26	43.28	59.87	17.46	46.69
26-Jun-23	42.18	439.47	30.5	34.96	30.48	13.34	17.88
27-Jun-23	35.03	151.61	27.36	37.01	59.9	28.32	18.37
28-Jun-23	54.6	44.75	34.69	60.67	63.08	31.68	22.03
29-Jun-23	98.79	58.81	44.41	97.03	97.63	26.69	31.35
30-Jun-23	116.22	81.84	49.81	135.44	115.69	25.5	30.3

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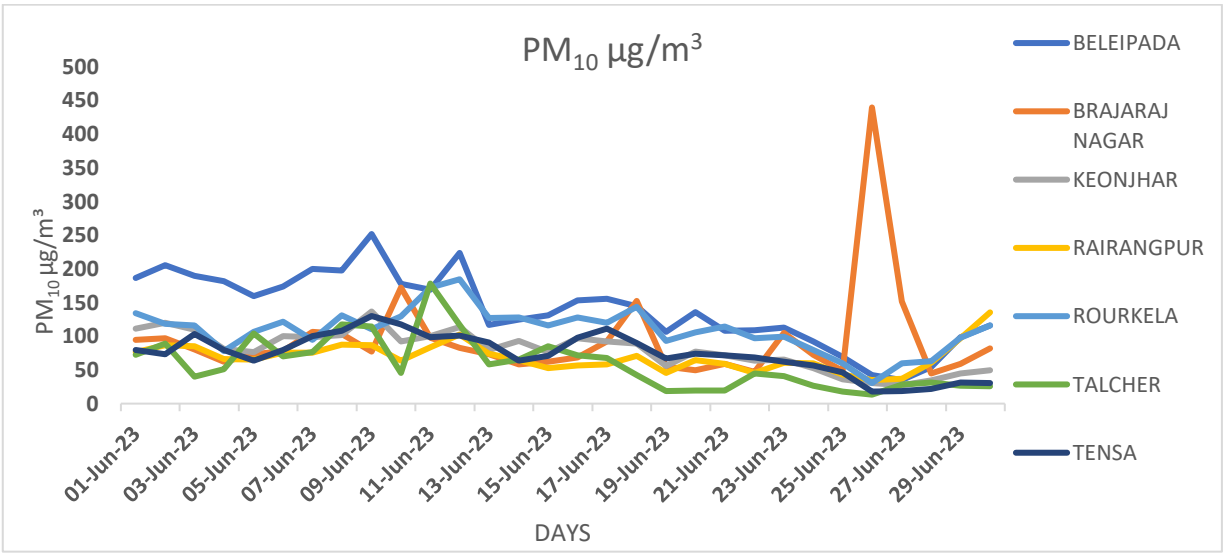

Fig 5 Graph for Pollutant PM_{10} in industrial belt of Odisha

4. Results and discussion

For different pollutants like NO_2, SO_2, $PM_{2.5}$ and PM_{10}, four different graphs (Fig. 2-5) are plotted with data of seven different places [18]. According to the Indian National Ambient Air Quality Standard (NAAQS) of $PM_{2.5}$ concentration is 40 µg/m^3 and the average PM_{10} concentration 60 µg/m^3, whereas the average NO_2 and SO_2 concentrations are 40 µg/m3 and 50 µg/m^3, respectively. The graphs are analysed and the results are discussed as follows.

It was found from graph that in Beleipada, the average NO_2 concentration and SO_2 concentration were determined to be 8.05µg/m^3 and 26.15µg/m^3 respectively, much lesser than the NAAQS data. The maximum value for NO_2 concentrations is 13.07 µg/m3 and a minimum value of 4.47 µg/m$_3$. Similar to this, the maximum and minimum value of SO_2 concentrations is 48.14µg/m^3 and 16.05µg/m^3 respectively. The average $PM_{2.5}$ concentration and PM_{10} concentration were determined to be 47.18 µg/m^3 and 138.60 µg/m^3 respectively, much higher than the NAAQS data. The maximum value for $PM_{2.5}$ concentrations is 72.60µg/m^3 and a minimum value of 16.45µg/m^3. Like this, the maximum and minimum value of PM_{10} concentration is 249.52µg/m3 and 32.01µg/m3, respectively.

It was found from graph that in Brajaraj Nagar, the average NO_2 and SO_2 concentration were determined to be 21.46 µg/m^3 and 26.93 µg/m^3 respectively, much lesser than the NAAQS value. The maximum value for NO_2 concentration is 68.97µg/m3 and a minimum value of 2.57µg/m^3. Like this, the maximum and minimum value of SO_2 concentrations is 27.52µg/m^3 and 26.14µg/m^3 respectively. The average $PM_{2.5}$ concentration and PM_{10} concentration were determined to be 47.79 µg/m^3 and 92.78 µg/m^3 respectively, much higher than the NAAQS data. The maximum value for $PM_{2.5}$ concentrations is 353.23µg/m^3 and a minimum value of 0.82µg/m^3. Like this, the maximum and minimum value of PM_{10} concentrations is 437.44 µg/m^3 and 42.72 µg/m^3, respectively.

- It was found from graph that in Keonjhar, the average NO_2 and SO_2 concentrations are determined to be 4.88 µg/m^3 and 3.33 µg/m^3 respectively, much lesser than the NAAQS data. The maximum value for NO_2 concentrations is 7.56 µg/m^3 and a minimum value of 2.79 µg/m$_3$. Like this, the maximum and minimum values of SO_2 concentrations are 8.60µg/m^3 and 0.35µg/m^3 respectively. The average $PM_{2.5}$ and PM_{10} concentration are determined to be 36.40µg/m3 and 77.35µg/m3 respectively, lesser than the NAAQS data. The maximum value for $PM_{2.5}$ concentrations is 58.83µg/m^3 and a minimum value of 11.97µg/m^3. Like this, the maximum and minimum value of PM_{10} concentrations are 134.72µg/m^3 and 25.40µg/m^3, respectively.
- It was found from graph that in Rairangpur, the average NO_2 and SO_2 concentrations are determined to be 19.64µg/m^3 and 6.77µg/m^3 respectively, much

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lesser than the NAAQS data. The maximum value for NO_2 concentrations is 38.04µg/m^3 and a minimum value of 9.03µg/m^3. Like this, the maximum and minimum values of SO_2 concentrations are 12.74µg/m3 and 0.16µg/m3 respectively. The average $PM_{2.5}$ and PM_{10} concentration are determined to be 32.57µg/m^3 and 67.21µg/m^3 respectively, $PM_{2.5}$ is lesser than the NAAQS whereas PM_{10} has much higher value than the NAAQS data. The maximum value for $PM_{2.5}$ concentrations is 50.05µg/m^3 and a minimum value of 5.74µg/m^3. Like this, the maximum and minimum values of PM_{10} concentrations are 133.46 µg/m^3 and 32.98 µg/m^3, respectively.

- It was found from graph that in Rourkela, the average NO_2 and SO_2 concentrations are determined to be 13.19 µg/m^3 and 1.15 µg/m^3 respectively, much lesser than the NAAQS data. The maximum value for NO_2 concentrations is 17.66 µg/m^3 and a minimum value of 7.71 µg/m^3. Like this, the maximum and minimum values of SO_2 concentrations are 2.90µg/m^3 and 0.18µg/m^3 respectively. The average $PM_{2.5}$ and PM_{10} concentration are determined to be 46.99µg/m^3 and 107.18µg/m^3 respectively, much higher than the NAAQS data. The maximum value for $PM_{2.5}$ concentrations is 75.12µg/m^3 and a minimum value of 14.98µg/m^3. Like this, the maximum and minimum value of PM_{10} concentrations are 182.53 µg/m^3 and 28.49 µg/m^3, respectively.
- It was found from graph that in Talcher, the average NO_2 and SO_2 concentrations are determined to be 31.31µg/m^3 and 13.90µg/m^3 respectively, much lesser than the NAAQS data. The maximum value for NO_2 concentrations is 31.51µg/m^3 and a minimum value of 30.90µg/m^3. Like this, the maximum and minimum values of SO_2 concentrations are 21.75µg/m^3 and 1.50µg/m^3 respectively. The average $PM_{2.5}$ and PM_{10} concentration are determined to be 30.78µg/m^3 and 57.29µg/m^3 respectively, lesser than the NAAQS. The maximum value for $PM_{2.5}$ concentrations is 62.33µg/m^3 and a minimum value of 9.84µg/m^3. Like this, the maximum and minimum value of PM_{10} concentrations are 176.20 µg/m3 and 11.32µg/m3, respectively.
- It was found from graph that in Tensa, the average NO_2 and SO_2 concentrations are determined to be 26.24µg/m^3 and 7.40µg/m^3 respectively, much lesser than the NAAQS data. The maximum value for NO_2 concentrations is 46.48µg/m^3 and a minimum value of 6.08µg/m^3. Like this, the maximum and minimum values of SO_2 concentrations are 13.66µg/m^3 and 0.87µg/m^3 respectively. The average $PM_{2.5}$ and PM_{10} concentration are determined to be 27.85µg/m^3 and 72.11µg/m^3 respectively. PM_{10} is much higher than the NAAQS data. The maximum value for $PM_{2.5}$ concentrations is 42.04µg/m^3 and a minimum value of 9.79µg/m^3. Like this, the maximum and minimum value of PM_{10} concentrations is 127.92µg/m^3 and 15.82µg/m^3, respectively.

Overall, these findings indicate that there is a serious issue with air pollution in the industrial area of Odisha and that quick action is needed to lower the levels of pollutants and safeguard the health of the state's citizens [19]. Among these seven locations, Brajaraj Nagar has the highest average $PM_{2.5}$ concentration (47.79 µg/m^3) and Tensa has the lowest (27.85 µg/m^3). Similar results were obtained for PM_{10}, where Beleipada had the highest average concentration (138.60 µg/m^3) and Talcher had the lowest (57.29 µg/m^3). Talcher had the highest average NO_2 concentration (31.31µg/m^3) and Keonjhar has the lowest (4.88 µg/m^3). Similar results were obtained for SO_2, where Brajraj Nagar has the highest average concentration (26.93µg/m^3) and Rourkela has the lowest (1.15µg/m^3). The average concentration of $PM_{2.5}$ in Brajaraj Nagar, Beleipada, and Rourkela is found to be higher than the NAAQS of 40 µg/m^3, and the average concentration of PM_{10} in these locations is also higher than the NAAQS of 60 µg/m^3, although Talcher has a slightly lower average concentration of 59.31µg/m^3 whereas NO_2 and SO_2 are also under control in all the studied regions.

Health Impacts due to pollutants like NO_2, SO_2, and PM:

The pollutants released in the industrial belts of Odisha and their health impacts are

- Respiratory Issues: NO_2 irritates the respiratory tract, causing coughing, wheezing, shortness of breath, and exacerbation of asthma and other respiratory conditions [20].
- Decreased Lung Function: Prolonged exposure to NO_2 can impair lung's function, especially in children and individuals with pre-existing respiratory diseases [21].

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- Respiratory Problems: SO_2 exposure can cause respiratory irritation, difficulty in breathing, and aggravation of existing respiratory conditions.
- Asthma Exacerbation: People with asthma are particularly sensitive to SO_2 and may experience increased asthma attacks due to exposure [22].

Particulate matter (PM):

A kind of air pollution known as particulate matter (PM) is made up of minute particles suspended in the atmosphere [23]. A particle's diameter determines its classification, with $PM_{2.5}$ denoting those with a diameter of 2.5 μm or less and PM_{10} denoting those with a diameter of 10 μm or fewer [24]. Inhaling these particles can have a negative impact on a person's health [25]. The following are the effects of $PM_{2.5}$ and PM_{10} on health:

- Respiratory and cardiovascular problems can be brought on by or made worse by $PM_{2.5}$ since it can get deep inside the lungs and even reach the bloodstream. It can result in illnesses like lung cancer, bronchitis, asthma, and chronic obstructive pulmonary disease (COPD)[26]
- Lung-Related Diseases: Prolonged exposure to $PM_{2.5}$ can retard adolescent and child lung development and diminish lung function growth [27].
- Neurological Effects: According to some research, exposure to $PM_{2.5}$ may cause dementia, memory loss, and other neurological problems [28].
- Eye and throat irritations are brought on by PM_{10} particles, which can also irritate the nose and throat [29].

Measures to Reduce Air Pollution:

For bettering air quality and public health, $PM_{2.5}$ (particulate matter with a diameter of less than 2.5 μm must be reduced in places like Brajaraj Nagar, Beleipada, and Rourkela [30]. Here some steps may be followed to lower $PM_{2.5}$ levels in these areas:

- It is necessary to set up a thorough air quality monitoring system in order to regularly gauge the concentrations of PM $_{2.5}$ and other contaminants.[31]
- The public must be given access to real-time air quality data in order to increase awareness and encourage behavioural changes [32].
- Control of Industrial Emissions: We need to impose strict emission restrictions on businesses, especially on those that generate pollutants that contribute to PM.
- To ensure adherence to emission restrictions and punish offenders, we must perform routine inspections and audits.
- In order to lessen our reliance on fossil fuels, we must promote the use of clean, renewable energy sources like solar, wind, and hydroelectricity [33].
- To encourage households and businesses to switch to cleaner energy sources, we must offer incentives and subsidies.
- Tree planting and creation of green spaces in city areas should be encouraged which act as natural air filters and absorb air pollutants [34].
- Educate the public about the risks of exposure to air pollutants and to reduce pollution by implementing awareness campaigns and educational initiatives [35].
- In Odisha, industrialized regions are facing a complicated and urgent challenge from industrial air pollution that requires ongoing care. Strong air pollution is a negative side effect of Odisha's rapid industrial boom, which was powered by vast natural resources and supportive policies. Particulate matter (PM), sulfur dioxide (SO_2), nitrogen dioxide (NO_2), and other harmful gases are all released and mixed with the atmosphere (coal-fired power plants, steel mills, mining operations, and chemical factories). The public's health is severely impacted by the effects of industrial air pollution. Unmistakably connected to respiratory illnesses, cardiovascular problems, neurological effects, and even premature mortality are exposure to these contaminants. Children, the elderly, and people with pre-existing medical disorders are among the vulnerable populations who are disproportionately impacted [36].
- Government actions, such as the implementation of strict emission standards, the control of industrial practices, and investments in cleaner technology, are essential. It is essential to launch public awareness and education initiatives to ensure that businesses and communities take an active role in reducing air pollution. In order to achieve this delicate balance and ensure a cleaner and healthier future for Odisha, cooperation among the government, corporate businesses, industries academic institutions, and civil society will be essential.

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