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Ambient Air Quality of Chitrakoot During Diwali

***Dr. Sadhana Chaurasia **Dr. Raj Karan Gupta ***Mr. Dhanraj Gupta**
***Dept. of Energy and Environment M.G.C.G.V Chitrakoot M.P., **Junior Scientist Assistant M.P.P.C.B., Satna, M.P.**
*****Dept. of Energy and Environment, M.G.C.G.V. Chitrakoot M.P.**

ABSTRACT

Diwali has become an occasion of air and noise pollution, and the release of particulate matter and toxic gases has chronic and acute effects on people and their environment. Thus, an air quality assessment study was done by us covering the before-during-after Diwali 2023 period in the three locations (residential, commercial and Silence area) of Karwi, Chitrakoot. During Diwali maximum average 24-h concentration of PM_{10} (197.89 µg/m^3), $PM_{2.5}$ (88.27 µg/m^3), was significantly higher during Diwali, exceeding the National Ambient Air Quality Standards (NAAQS). The concentrations of SO_x and NO_x were 9.34 µg/m^3 and 17.01 µg/m^3. Air pollution was maximum on Diwali, resembling very poor air quality. This paper highlight the air quality assessment during Diwali in Chitrakoot. It is time to implement regulations on burning firecrackers for pollution reduction, aiming to achieve a sustainable atmosphere.

Key words: Pollution, Firework, Diwali, Particulate matter.

Introduction

Diwali, the festival of light, is celebrated all over India with much pump and ceremony by every community. It brings happiness, love, and prosperity to society. Nowadays, the matter of concern is that the festival of light has been converted into a pollution (both air and noise) inducing event. The primary reason behind the toxicity of this beautiful celebration is the overuse of firecrackers.

Firecrackers consist of four parts: fuel, oxidizers, colorants, and binders. Charcoal and sulphur are used as fuel during fireworks. [1] Oxidizers are used with fireworks since they require a lot of oxygen to ignite. They release free oxygen, which helps in the improvement of explosion. The three most frequently utilized oxidizers are nitrates, chlorates, and perchlorates. The combination of fuel and oxidizers creates a blast during a firework [5]. Gunpowder is the principal element of firecrackers [4]. Different metals like Na, Ba, Sr, Al, and Cu are used as colouring materials to create yellow, green, purple, white, and blue, respectively. It has been reported that burning firecrackers causes air pollution by producing different toxic gases like sulfur dioxide, carbon dioxide, carbon monoxide, particulate matter (PM_{10} and $PM_{2.5}$), and traces of metals According to a report, up to 23–33% of the ambient PM_{10} is contributed by aerosol from fireworks. As a result, it produces short-term cardiovascular illnesses and chronic exposure diseases, affecting the population [2]. Wheezing, respiratory infections, bronchial asthma flare-ups, and chronic obstructive pulmonary disease instances have all increased by 30–40% during the Diwali celebration in India. When fireworks are set off at a greater altitude, the pollutants they release are diluted before they reach people, which can positively impact their health. However, ground-level fireworks have an immediate negative influence on public health. Not only air pollution but also noise pollution is caused during the Diwali period. Compared to non-festive days respectively.

Chitrakoot, a city, is situated in Madhya Pradesh [12]. It experiences dry summers (March to mid-June), wet monsoons (mid-June to October), and winters (November to February) [3]. Most of the time faces Chitrakoot air pollution issues due to particulate matter. The people of Chitrakoot welcome every festival; during Diwali, the celebration lasts for 5 days, which alters the ambient air quality due to burning more firecrackers [8]. Based on the above view, we have carried out an ambient air quality assessment of Chirakoot) for (before-during-after Diwali) based on three strategic locations (identified as residential, commercial and silent area) [10]. The objectives were particulate pollutant (PM_{10} and $PM_{2.5}$) gaseous pollutant (SO_X, NO_X).

This paper offers information in all these dimensions and reports on of study covering before-during-after Diwali [11]. This paper is the first of its kind highlighting the air quality assessment during the mega festival Diwali in Chitrakoot [14]. emerging pollutants detection and AQI for Diwali have been addressed in this paper.

Material and method

Sampling locations

The air sampling locations during before-during-after Diwali were carried out at three different areas of Karwi, Chitrakoot. The three locations are categorized into residential, commercial and silence area respectively.

PM_{10}

Particulate Matter (PM_{10}) was monitored using respirable dust sampler. The PM_{10} was measured by the gravimetric method using Whatman filter paper (20.3 × 25.4 cm). Air is drawn through a filter at a flow rate typically 1.132 L/min. The filter collects parts with aerodynamic diameters less than the cut-point of the inlet. The mass of these particles is determined by the difference in filter weights before and after sampling. The concentration of PM_{10} in the designated size range is calculated by dividing the weight gain of the filter by the volume of air sampled.

$PM_{2.5}$

$PM_{2.5}$ was monitored using The fine dust sampler $PM_{2.5}$ by a gravimetric method. An electrically powered air sampler takes ambient air into a specifically constructed inertial particle size separator (i.e., cyclones or impactors) where the suspended particulate matter in the PM2.5 size range is separated for collection on a 47-mm polytetrafluoroethylene (PTFE) filter over a microprocessor over a specified sampling period. Each filter is weighed before and after sample collection to determine the net gain due to the particulate matter. The mass concentration in the ambient air is computed as the total mass of collected particles in the $PM_{2.5}$ size ranges divided by the actual volume of air sampled and is expressed in $\mu g/m^3$.

SO_2

The SO_2 was measured by the West and Gaeke method (IS 5182 part 2 method of measurement of air pollution: sulfur dioxide) (CPCB, 2013). Sulfur dioxide from air is absorbed in a potassium tetrachloromercurate (TCM) solution. A dichlorosulphitomercurate complex, which resists oxidation by the oxygen in the air, is formed. Thirty milliliters of absorbing solution were placed in impinger with a 1 L/m flow rate for eight hours. Once formed, this complex is stable to strong oxidants such as ozone and nitrogen oxides; therefore, the absorber solution may be stored for some time before analysis. The complex reacts with pararosaniline and formaldehyde to form the intensely colored pararosaniline methyl sulphonic acid. The absorbance of the solution is measured at 560 nm using spectrophotometer.

NO_2

The NO_2 was measured by the modified Jacob and Hochheiser method (IS 5182 Part 6 Methods for Measurement of Air Pollution: Oxides of nitrogen) (CPCB, 2013). Air bubbles are passed through a sodium hydroxide and sodium arsenite solution to collect ambient nitrogen dioxide. Reacting the nitrite ion with phosphoric acid, sulfanilamide, and N-(1-naphthyl)-ethylenediamine dihydrochloride (NEDA) and measuring

the absorbance of the intensely colored azo-dye at 540 nm, the concentration of nitrite ion produced during sampling is determined using a spectrophotometer.

Result and discussion

Diwali is a mega event celebrated nationwide. The general public starts the celebration 2 days before Diwali and continues for the next 2 days. In this study data was collected from selected sampling station before during and after Diwali. The result obtain are discussed below:

The particulate matter (PM_{10} and $PM_{2.5}$) is significantly higher than the National Ambient Air Quality Standards (NAAQS) prescribed by the CPCB. average values of PM_{10} and $PM_{2.5}$ are given in Table 1,2. The toxic gases like SO_X and NO_X of Karwi are more than the permissible value. From Table-3and4 we can assume the severity of air pollution occurred due to over-burning crackers nationwide during Diwali. The average values for various parameters are given in Table 1,2,3,4. Comparatively, the pollutant concentration has been decreasing in recent years, which may be due to increasing awareness of pollution among people.

Particulate pollutants

PM_{10}

When the pollutant concentration in the atmosphere becomes high, it becomes hazardous and causes an acute effect on humans and the environment. The air quality monitoring before-during-after Diwali, 2023 is monitored, and the result is shown in Table-1. Before Diwali The maximum average concentration of particulate matter (PM_{10}) was found to be 162.69 µg/m^3 in sampling location commercial area. during Diwali The maximum average concentration was found 197.89 µg/m^3 in commercial area. After Diwali The maximum average concentration was found 149.1 µg/m^3 in commercial area The resulting values were higher than the NAAQS for PM_{10} particulate matter. which highlights the pollution caused due to burning of firecrackers? The PM_{10} concentration was two times higher than in the Before-Diwali period. The comparative PM_{10} result from before-during-after Diwali is shown in Fig-1. The aerosol is released into the ambient air due to crackers burning and persists in the atmosphere for a long time and enhances the PM_{10} mass during Diwali.

$PM_{2.5}$

The average 24-h particulate matter having a size of $PM_{2.5}$ or less was observed to be very high during Diwali compared to the Before-Diwali event. During Diwali, the maximum value of $PM_{2.5}$ were observed 88.27 µg/m^3, in commercial area which is alarming, very high than the NAAQS, i.e., 60 µg/m^3. The trend of $PM_{2.5}$ from before-during-after Diwali is displayed table-2 and fig-2. Generally, Diwali falls with the start of the winter season where adverse ambient situations like high humidity, decreasing temperature, and calm winds were observed; moreover, decreasing mixing height prevents the distribution of the pollutants.

Table 1- PM_{10} before, during and after Diwali at different locations in 2023

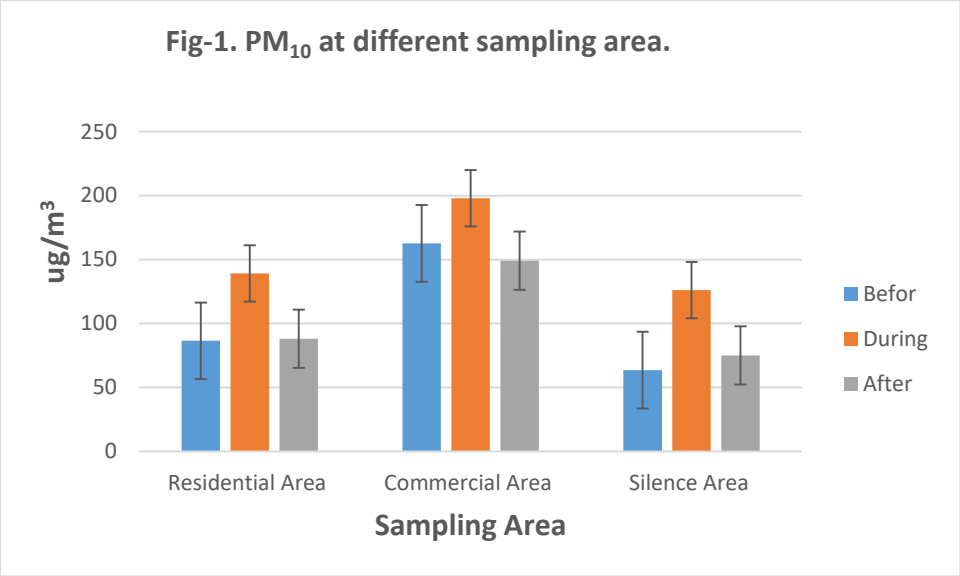
	S.No.	Residential Area	Commercial Area	Silence Area
Before	1	86.42	165.79	63.62
	2	85.81	162.82	63.44
	3	87.34	159.45	63.56
	Mean	**86.52**	**162.69**	**63.54**
	±SD	**6.72**	**0.75**	**1.58**
During	1	146.18	198.64	127.76

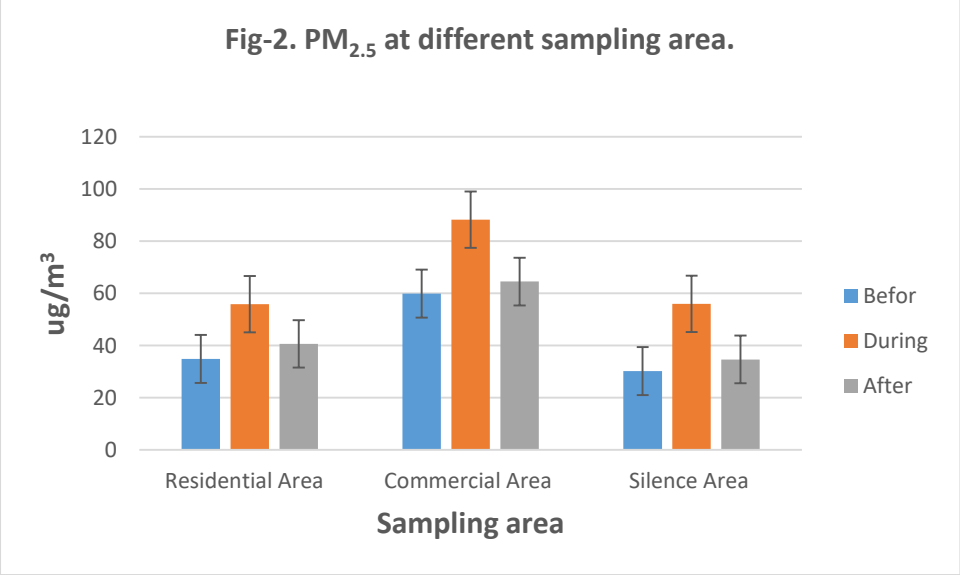
	2	138.88	197.89	124.61
	3	132.75	197.15	126.34
	Mean	**139.27**	**197.89**	**126.23**
	±SD	**6.72**	**0.75**	**1.58**
After	1	88.31	153.88	75.72
	2	87.62	141.91	75.21
	3	88.37	151.51	74.27
	Mean	**88.1**	**149.1**	**75.07**
	±SD	**0.42**	**6.34**	**0.74**

Table 2- $PM_{2.5}$ before, during and after Diwali at different locations in 2023.

	S.No.	Residential Area	Commercial Area	Silence Area
Before	1	35.47	60.52	30.94
	2	34.53	59.82	30.03
	3	34.74	59.33	29.63
	Mean	**34.91**	**59.89**	**30.2**
	±SD	**0.49**	**0.6**	**0.67**
During	1	56.42	88.77	56.12
	2	55.77	88.57	55.98
	3	55.35	87.49	55.69
	Mean	**55.84**	**88.27**	**55.93**
	±SD	**19.94**	**31.2**	**20.55**
After	1	34.95	62.7	34.9
	2	45.45	66.6	34.57
	3	41.56	64.35	34.52
	Mean	**40.66**	**64.55**	**34.66**
	±SD	**5.30**	**1.96**	**0.27**

Fig-1. PM_{10} at different sampling area.





Gaseous pollutants

SOx

While burning the firecrackers, trace gases like, SO_X, were observed, The ambient 24-h average SO_X concentration in the atmosphere of Karwi, from before-during-after Diwali, 2023, is given in Table-3 The SO_X 9.34 µg/m^3(commercial area) concentrations during Diwali were higher compared with the before and after Diwali.of Karwi, the presence of particulate matter, higher SO_X would create harmful effects. The SO_X accumulates on the surface of the fine particles and gets the way to enter our body through the lungs. The SO_X concentration was high during Diwali but all the values with in the permissible limit.

NOx

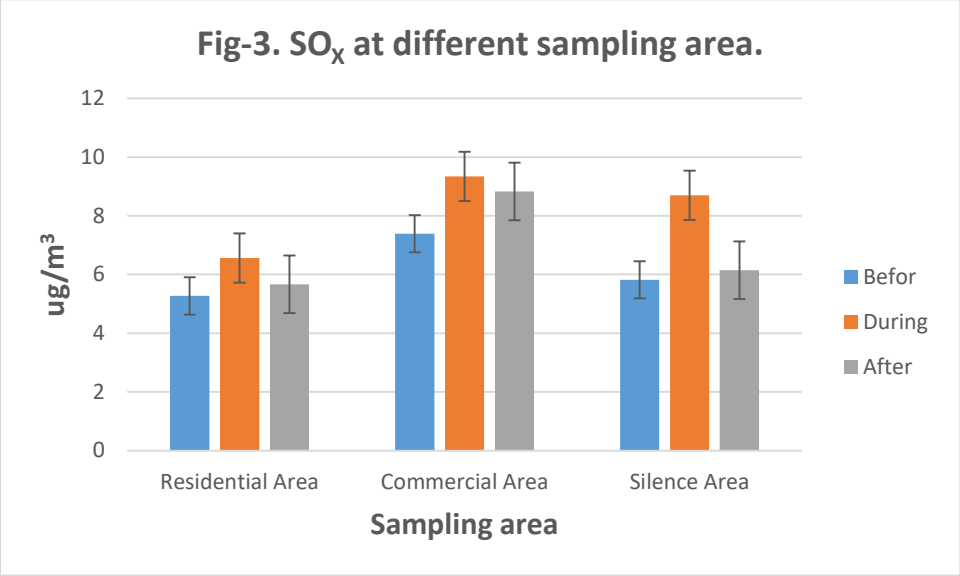
Before Diwali The maximum average concentration of NOx was found to be 16.09 µg/m^3 in sampling location commercial area. during Diwali The maximum average concentration was found 17.01 µg/m^3 in commercial area. After Diwali The maximum average concentration was found 18.36 µg/m^3 in commercial area is given Table-4 and fig-4

Table-3. So_x before, during and after Diwali at different locations in 2023.

	S.No.	Residential Area	Commercial Area	Silence Area
Before	1	4.29	6.65	4.25
	2	5.6	8.46	6.41
	3	5.93	7.06	6.8
	Mean	**5.27**	**7.39**	**5.82**
	±SD	**0.87**	**0.95**	**1.37**
During	1	7.26	11.19	9.49
	2	6.87	8.97	8.74
	3	5.57	7.86	7.88
	Mean	**6.56**	**9.34**	**8.7**
	±SD	**2.14**	**3.17**	**2.81**
After	1	5.89	7.31	5.52
	2	5.29	9.51	6.16
	3	5.83	9.66	6.79
	Mean	**5.67**	**8.83**	**6.15**
	±SD	**1.94**	**1.32**	**2.44**

Table-4. No_x before, during and after Diwali at different locations in 2023

	S.No.	Residential Area	Commercial Area	Silence Area
Before	1	9.58	16	7.19
	2	10.71	17.76	13.13
	3	10.31	14.51	9.53
	Mean	**10.2**	**16.09**	**9.95**
	±SD	**0.57**	**1.63**	**2.99**
During	1	18.71	21	18.9
	2	14.1	18.97	13.06
	3	15.43	14.8	11.98
	Mean	**12.72**	**17.01**	**11.96**
	±SD	**2.37**	**3.16**	**3.72**
After	1	11.7	18.44	12.03
	2	10.64	17.18	10.17
	3	11.32	19.46	11.96
	Mean	**11.22**	**18.36**	**11.39**
	±SD	**0.54**	**1.14**	**1.05**



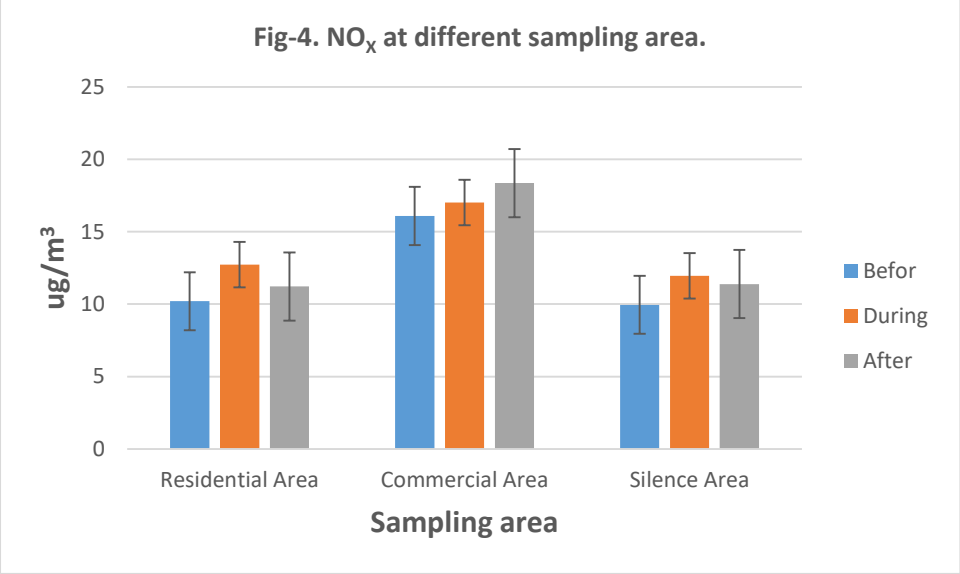


Table-5. National ambient air quality standards of air pollutants prescribe by Central Pollution Control Board (CPCB), India.

S.No.	Pollutants	Time weighted average	Concentration in ambient air µg/m3
1	SO_X	Annual 24-h	50 80
2	NO_X	Annual 24-h	40 80
3	PM_{10}	Annual 24-h	60 100
4	$PM_{2.5}$	Annual 24-h	40 60

Conclusion

The outcomes of this study show that during the 5 days of study (before-during-after Diwali), the ambient air quality of Karwi was worse due to the over-burning of firecrackers and sparkles, with maximum pollution on

day 3 (Diwali). The average 24-h concentration of PM_{10} (197.89 µg/m^3), $PM_{2.5}$ (88.27 µg/m^3), was significantly higher during Diwali than the NAAQS. The concentrations of SO_X and NO_X were 9.34 µg/m^3 and 17.1 µg/m^3. We were observed from PM_{10} in higher concentrations during the study. Simultaneously, showing the self-cleansing activity of nature and the dispersion of pollutants. We were detected in $PM_{2.5}$ compared to PM_{10}, highlighting the hazardousness of fine particles. The air quality data was validated using statistical techniques like analysis of variance, LSD, correlation, and PCA. The release of particulate and gaseous pollutants due to the Diwali celebration persists in the atmosphere for a longer time, affecting public health and damaging the ecosystem. Thus, people should create awareness to celebrate the Diwali festival in an eco-friendly way. It is the need of the hour to implement regulations on burning firecrackers for pollution control and achieving a sustainable atmosphere.

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