Original Research paper

Assessment of Ambient Air Quality and Air Quality Index (AQI) in Kakinada, Andhra Pradesh, India

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ABSTRACT

Monitoring air quality in urban environments is crucial due to its direct impact on public health. The Air Quality Index (AQI) serves as an effective tool by translating concentrations of various air pollutants into a single value that reflects overall air quality. Key pollutants of concern, including particulate matter (PM_{10} and $PM_{2.5}$), carbon monoxide (CO), ozone (O_3), nitrogen dioxide (NO_2), and Sulphur dioxide (SO_2), are known to pose significant health risks. In this study, concentration of prime air pollutants (PM_{10}, $PM_{2.5}$, SO_2 and NO_2) were measured at four different monitoring locations in the Kakinada region. The observed ranges for the pollutants of PM_{10}, $PM_{2.5}$, SO_2 and NO_2 at all the four stations were ranging from 67 to 75, 26 to 32, 7.6 to 8.6 and 15.2 to 16.3 µg/m3, respectively. While PM_{10} levels slightly exceeded the Central Pollution Control Board (CPCB) prescribed limits, the levels of $PM_{2.5}$, SO_2, and NO_2 remained within acceptable standards. AQI values for these stations ranged from 57.47 to 68.65, placing them in the **"**Satisfactory" category as per CPCB guidelines.

Keywords: Air quality Index, Air Quality, Kakinada area

INTRODUCTION

In urban areas, air pollution has become a significant global issue, largely driven by factors such as Urbanization, transportation, industrialization, power generation and anthropogenic activities. To help assess and communicate the status of air pollution and its potential impact on health of human, the Air Quality Index (AQI) is used, this index presents, reporting air quality is a single number for the entire air quality with respect to its effects on the heath of human. The presence of pollutants in the air is influenced not only by the amount released from different sources but also by atmospheric conditions that affect how these pollutants are dispersed or absorbed.

The rapid and unplanned expansion of cities, combined with a surge in vehicle use, has significantly degraded air quality. Key air pollutants that pose serious health risks include particulate matter, ozone, nitrogen dioxide, carbon monoxide and sulphur dioxide. When the levels of these pollutants exceed safe thresholds, they can have harmful effects on human health (WHO, 2000; USEPA, 2008). According to the World Health Organization (2005), urban air pollution—largely from the combustion of solid fuels—contributes to over two million premature deaths annually. Notably, populations in developing nations bear more than half of the global health burden caused by pollution-related illnesses (WHO, 2005). In the urban environment 60 to 70% of the pollution is found due to the higher levels of SPM, RSPM, SO_2, NO_2 and other organic and inorganic pollutants in the environment (Jagrutiben Arunkumar Patel et al 2017).

The CPCB is implementing a nationwide initiative called the National Air Quality Monitoring Programme (NAMP) to monitor ambient air quality across India. As of November 19, 2024, this monitoring network includes 966 active stations spread across 419 towns and cities in 28 states and 7 Union Territories. Under the NAMP, four key air pollutants are regularly tracked at all locations: Sulphur Dioxide (SO_2), Nitrogen Oxides (measured as NO_2), Particulate Matter (PM_{10}), and Fine Particulate Matter ($PM_{2.5}$).

In recent decades, air pollution has emerged as a major risk to health of human, prompting extensive research efforts both globally and within India. The present study focuses on evaluating ambient air quality in the Kakinada region, a rapidly developing industrial zone in the Kakinada District of Andhra

Pradesh. Specifically, the study aims to monitor concentrations of key pollutants, including PM_{10}, $PM_{2.5}$, nitrogen dioxide (NO_2) and Sulphur dioxide (SO_2).

MATERIALS AND METHODS

Study area: Kakinada, located on the central eastern coastline of India, serves as the administrative capital of the Kakinada District in Andhra Pradesh. This study focuses on evaluating the air quality and determining the AQI within various regions of Kakinada, Andhra Pradesh.

Table 1: Identified Locations for Ambient Air Quality Monitoring in Kakinada

Station. No	Code	Monitoring Station
1	A 1	On the Terrace of APPCB Regional Office Building, IDA, Ramanayyapeta, Kakinada.
2	A 2	On the terrace of Gram Panchayati Building, Suryaraopeta, Kakinada.
3	A 3	On the Terrace of MEE SEVA/ MEPMA Building, Salipeta, Kakinada.
4	A 4	Top of the building of Petro Chemical Engineering Dept. of JNTUK Campus, Kakinada.

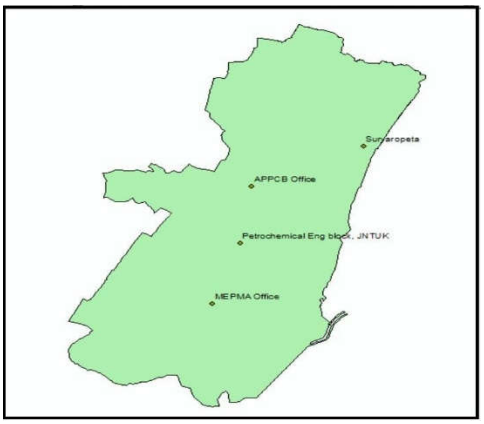

Figure 1: Identified Locations for Ambient Air Quality Monitoring in Kakinada

Kakinada is located at approximately 16˚57' North latitude and 82˚15' East longitude. For this study, four monitoring sites were strategically selected in and around the Kakinada region to assess the concentrations of significant air pollutants (PM_{10}, $PM_{2.5}$, SO_2 and NO_2). The monitoring was conducted across four different locations during the year 2023. A detailed overview of these monitoring sites is provided in Table:1 and visually represented in Figure:1.

Ambient Air Quality Monitoring: Ambient air samples were collected using a combined instrument operating at a rate of air flow 2.3 m^3/hr for PM_{10} and 1.0 m^3/hr for $PM_{2.5}$. For gaseous pollutants such as SO_2 and NO_2, a specialized gaseous pollutant sampler was employed. Absorbing solutions used included sodium arsenite and sodium hydroxide for capturing NO_2, and potassium tetrachloromercurate for SO_2. The monitoring was conducted from January to December 2023, with samples collected once per week. After sampling, the samples were conducted to the laboratory analysis, where the concentrations of the individual pollutants were measured**.**

The concentrations of NO_2 and SO_2 were determined using the modified Jacob--Hochheiser method and the modified West and Gaeke method, respectively. Particulate matter ($PM_{2.5}$ and PM_{10}) was analyzed using the gravimetric technique, the procedures outlined in the *Manual Sampling and Analyses Guidelines* issued by the CPCB. In this study region the air quality was assessed using AQI. Although various approaches and formulas exist for calculating AQI, this study employed the method proposed by Zlauddin and Siddiqui (2006) and later referenced by Joshi and Semwal (2011) for AQI assessment.

$$AQI = ¼ \times (IPM_{10}/SPM_{10} + IPM_{2.5}/SPM_{2.5} + ISO_2/SSO_2 + INO_2/SNO_2) \times 100$$

Here, SPM_{10}, $SPM_{2.5}$, SSO_2, and SNO_2 denote the standard limits for air quality as defined by the CPCB of India, while IPM_{10}, $IPM_{2.5}$, ISO_2, and INO_2 refer to the measured concentrations of the respective pollutants obtained from the sampling process.

RESULTS AND DISCUSSION

The ambient air quality data for PM_{10}, $PM_{2.5}$, SO_2, and NO_2, collected from four monitoring stations in Kakinada between January and December 2023, are shown in Table 2. Table 3 and Figure 2 present the estimated concentrations of these pollutants across the same locations. The observed concentration ranges for PM_{10}, $PM_{2.5}$, SO_2 and NO_2 at all the 4

Table 2: Ambient Air Quality Levels (PM_{10}, $PM_{2.5}$, SO_2, and NO_2) Recorded at Four Monitoring Stations in Kakinada from January to December 2023

Ambient Air Quality Data of Kakinada in Andhra Pradesh - 2023													
Sulphur Dioxide (ug/m^3)													
Station Code	**Jan-23**	**Feb-23**	**Mar-23**	**Apr-23**	**May-23**	**Jun-23**	**Jul-23**	**Aug-23**	**Sept-23**	**Oct-23**	**Nov-23**	**Dec-23**	**Average**
A1	8	7.7	8.8	9	8	7	8	7	8	8	9	9	**8.1**
A2	8.9	8.6	9	10	9	8	8	7	8	8	9	10	**8.6**
A3	8.1	8.4	8.6	8	8	7	8	7	7	8	9	8	**7.9**
A4	7.9	7.4	8.3	8	8	7	8	7	7	7	8	7	**7.6**
Nitrogen Dioxide (ug/m3)													
Station Code	**Jan-23**	**Feb-23**	**Mar-23**	**Apr-23**	**May-23**	**Jun-23**	**Jul-23**	**Aug-23**	**Sept-23**	**Oct-23**	**Nov-23**	**Dec-23**	**Average**
A1	15.3	17.4	15.5	18	14	15	16	15	16	16	16	17	**15.9**
A2	15	18.9	15.8	19	15	14	16	15	16	17	17	17	**16.3**
A3	14.6	17.5	15.2	17	15	14	16	15	15	16	17	16	**15.7**
A4	14.8	16.2	15.6	15	14	14	15	15	15	16	17	15	**15.2**
Particulate Matter -PM_{10} (ug/m3)													
Station Code	**Jan-23**	**Feb-23**	**Mar-23**	**Apr-23**	**May-23**	**Jun-23**	**Jul-23**	**Aug-23**	**Sept-23**	**Oct-23**	**Nov-23**	**Dec-23**	**Average**
A1	104	99	84	75	54	57	42	50	58	79	102	99	**75**
A2	108	105	97	89	61	65	53	58	68	87	99	95	**82**
A3	101	95	89	67	51	60	47	55	56	82	100	97	**75**
A4	95	84	75	61	46	54	41	47	43	72	94	88	**67**
Particulate Matter - $PM_{2.5}$ (ug/m3)													
Station Code	**Jan-23**	**Feb-23**	**Mar-23**	**Apr-23**	**May-23**	**Jun-23**	**Jul-23**	**Aug-23**	**Sept-23**	**Oct-23**	**Nov-23**	**Dec-23**	**Average**
A1	36	36	30	29	24	30	18	20	19	34	37	40	**29**
A2	42	37	35	33	28	32	23	27	27	35	34	_	**32**
A3	---	33	31	29	22	26	21	24	22	34	32	40	**29**
A4	---	---	---	26	20	24	17	18	18	30	42	39	**26**

stations were in the range from 67 to 75, 26 to 32, 7.6 to 8.6 and 15.2 to 16.3 µg/m3, respectively.

Table 3: Estimated concentration of air pollutants (PM_{10}, $PM_{2.5}$, SO_2, and NO_2) in µg/m³ recorded at the four monitoring locations within the Kakinada region.

Station Code	PM_{10}	$PM_{2.5}$	SO_2	NO_2
A 1	75	29	8.1	15.9
A 2	82	32	8.6	16.3
A 3	75	29	7.9	15.7
A 4	67	26	7.6	15.2

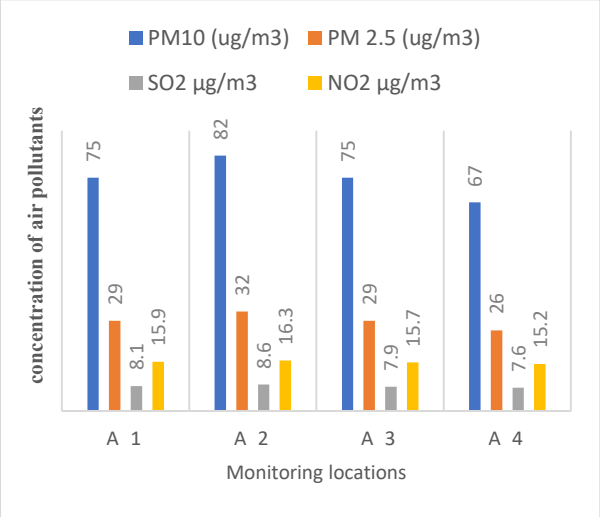

Figure 2: Concentration of air pollutants of Kakinada area

In this study, the PM_{10} concentration ranged between 67 to 75 µg/m3, exceeding the CPCB's recommended limit of 60 µg/m³ in residential and industrial areas at all four monitoring stations. Conversely, the concentrations of $PM_{2.5}$, SO_2, and NO_2 remained within the permissible limits set by the Central Pollution Control Board of India, which are 40 µg/m³ for $PM_{2.5}$, 40 µg/m³ for NO_2 and 50 µg/m³ for SO_2 in residential and industrial zones.

The AQI serves as an effective indicator and proxy for assessing the status of air quality in ambient air. In this study, AQI values were derived using the measured concentrations of PM_{10}, $PM_{2.5}$, SO_2, and NO_2. The AQI values across the four monitoring stations in the Kakinada region ranged from 57.47 to 68.65, as presented in Table:4 and demonstrated in Figure:3. According to CPCB classification, these values fall under the "Satisfactory" category (50 to 100 µg/m³), this may cause minor breathing discomfort to sensitive people.

Table 4: Category Air quality based on AQI of four station of Kakinada area (CPCB).

Station Code	AQI	AQI Category
A1	63.36	Satisfactory.
A2	68.65	Satisfactory.
A3	63.14	Satisfactory.
A4	57.47	Satisfactory.

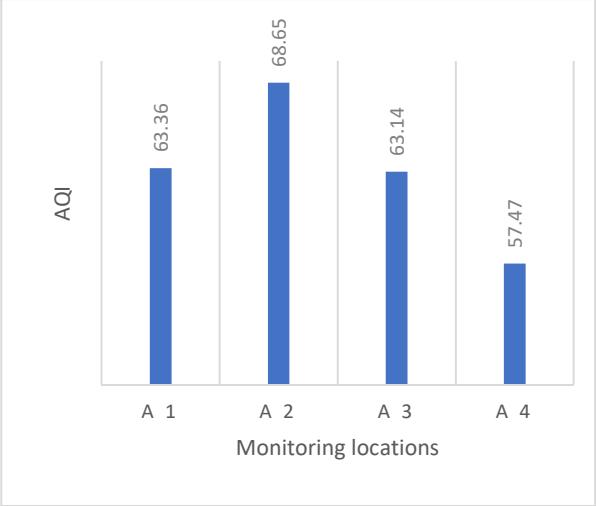

Figure 3: AQI of Kakinada Area during year of 2023

CONCLUSIONS

The Kakinada area experienced controlled and moderate levels of air pollution. Although PM_{10} concentrations exceeded the prescribed standards at all monitoring sites, the levels of $PM_{2.5}$, SO_2, and NO_2 remained within the permissible range. According to the AQI results, Kakinada was classified under the "Satisfactory" category, which may cause minor breathing discomfort to sensitive people. Overall, air quality in Kakinada was found to be in stable and acceptable environment. To ensure this status is maintained in the future, regular monitoring and assessment of air pollutant levels are essential.

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