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An Assessment of Ambient Air Quality and Air Quality Index For Ahmedabad, Gujarat, India

Una evaluación de la calidad del aire ambiental y el índice de calidad del aire para Ahmedabad, Gujarat, India

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ABSTRACT

Most cities throughout the world are suffering from severe air pollution as a result of fast economic expansion and urbanization. Long-term air pollution data with high temporal and geographical resolutions are required to assist the study of the physical and chemical processes that determine air quality, as well as the health hazards associated with them. The study was performed to assess the air pollution status of Ahmedabad and its impact on the air quality index and human health. The gaseous pollutants NO_2, SO_2, NH_3, $PM_{2.5}$, and PM_{10} were measured using HVAS for the Post-monsoon, Pre-Monsoon and Monsoon seasons in three different study areas (Industrial, Urban, and Rural) of Ahmedabad. All the gases and particulate matter concentration values were observed in exceeding amounts as per the CPCB standards which may lead to various health effects like respiratory infections, Chronic obstructive pulmonary disease (COPD), stroke and lung cancer.

Keywords: Air pollution, Ambient Air Quality, Air Quality Index, Particulate Matter

RESUMEN

La mayoría de las ciudades del mundo sufren una grave contaminación del aire como resultado de la rápida expansión económica y la urbanización. Se requieren datos de contaminación del aire a largo plazo con resoluciones temporales y geográficas altas para asistir en el estudio de los procesos físicos y químicos que determinan la calidad del aire, así como los peligros para la salud asociados con ellos. El estudio se realizó para evaluar el estado de contaminación del aire de Ahmedabad y su impacto en el índice de calidad del aire y la salud humana. Los contaminantes gaseosos NO_2, SO_2, NH_3, $PM_{2.5}$ y PM_{10} se midieron utilizando HVAS para las estaciones posmonzónicas, premonzónicas y monzónicas en tres áreas de estudio diferentes (industrial, urbana y rural) de Ahmedabad. Todos los valores de concentración de gases y partículas se observaron en cantidades superiores a los estándares de CPCB, lo que puede provocar diversos efectos en la salud, como infecciones respiratorias, enfermedad pulmonar obstructiva crónica (EPOC), accidente cerebrovascular y cáncer de pulmón.

Palabras clave: Contaminación del aire, Calidad del aire ambiente, Índice de calidad del aire, Material particulado

INTRODUCTION

Current trends in Climate change and Air pollution have attracted the attention of scientists and researchers throughout the world Ravindra et al., (2019) as it is a major kind of pollution that can be harmful to environment and mankind. There are various air pollutants which are released into the atmosphere in form of gases or particles and getting constantly mixed, transformed, and transported across borders, making local air quality unstable Kaushik et al., (2006). India has the highest level of air pollution worldwide Balakrishnan et al., (2019) and the major sources of ambient particulate matter pollution are coal burning for thermal power production, industry emissions, construction activity and brick kilns, transport vehicles, road dust, residential and commercial biomass burning, waste burning, agricultural stubble burning, and diesel generators CPCB, (2018).

Air pollutants, mainly nitrogen oxides (NO_x), sulfur dioxide (SO_2), Ammonia (NH_3) and particulate matter (PM), have been linked to negative health consequences Rajak & Chattopadhyay, (2020). Sulfur dioxide (SO_2) is a short-lived atmospheric air pollutant that is released or generated in the atmosphere as a result of natural and human processes. Once released, SO_2 can either deposit on the surface or be chemically converted into Particulate matter (i.e., sulfate aerosol). Due to its adverse health effects like respiratory irritation coughing, mucous secretions, and chronic bronchitis, it is considered a major air pollutant in many countries Kharol *et. al.,* (2017). Transportation, industrial operations, and energy generation are the primary anthropogenic sources of NO_2 emission. Nitrogen dioxide (NO_2) is generated when nitrogen combines with oxygen at high temperature. It has serious health impacts like respiratory and cardiovascular disease. High NO_2 levels in the atmosphere can result in acid rain and eutrophication Patterns, (2020). Ammonia (NH_3) is the third most common nitrogen-containing gas in the atmosphere, after N_2 and N_2O Kotnala et al., (2020). NH_3 is a very active gas when it is constantly transported between the atmosphere and the biosphere. Animal husbandry, nitrogenous fertilizers, manure management, and other soil and water management practices are the principal contributors to NH_3 in the air Kuttippurath et al., (2020). The quick reaction of atmospheric NH_3 with acid gases (such as SO_2 and NO_2) to form ammonium salts ($(NH_4)_2$, SO_4 and NH_4, NO_3) has negative consequences for regional and global air quality, human health, and climate change Chen et al., (2020). Everyday 70 kg adult inhales around 20 m^3 of air Berne *et. al.*, (1998). $PM_{2.5}$ air pollution is the third leading cause of mortality in India, with an estimated 1.1 million mortality each year Tonne & Marshall, (2018). In India, ambient air pollution is a major risk factor for respiratory diseases. Ambient $PM_{2.5}$ is predicted to be the fourth biggest cause of death, accounting for 7,00,000 fatalities in 2017, while $PM_{2.5}$ and ozone together were responsible for 8% of overall mortality in 2017 Brauer et al., (2019). Pathak et al. (2014) studied the Ambient air quality status of Ahmedabad and Gandhinagar city respectively and concluded that there has been a rapid growth of population leading to increase automobile transportation in both the cities, contributing various air pollution problems. Major air pollution disorders include respiratory infections, Chronic obstructive pulmonary disease (COPD), stroke, lung cancer WHO (2014) and hypertension, raised lipids, atherosclerosis, oxidative stress, insulin resistance, endothelial dysfunction, enhanced propensity toward coagulation, inflammation, and stroke, all of which also raise risk of cognitive decline and dementia Peters et al., (2019). Therefore, the present study was undertaken to assess the Ambient Air Quality by analysing various parameters like NO_2, SO_2, NH_3, $PM_{2.5}$ and PM_{10} and Air Quality Index status in Ahmedabad, Gujarat.

MATERIAL AND METHODS

Study area: Gujarat's economy is based on agricultural and industrial activities. Gujarat is one of the for most industrialized states in the country, with major industries such as pharmaceuticals, chemicals, refineries and petrochemicals, ceramics, textiles, and automobiles. The Golden Quadri lateral is a national highway system that connects India's key industrial centers. According to the most recent socioeconomic survey, Gujarat has 4,412 industrial units producing chemicals and chemical products. The chemical belt is tightly packed from Vapi via Ankleshwar to Ahmedabad, and it is known as the Gujarat Golden Corridor. Ahmedabad city was selected for the present study which is located at 23.0225° N, 72.5714° E (Fig. 1). The study sites selected included the Industrial area [A-1], Urban area [A-2] and Rural area [A-3].

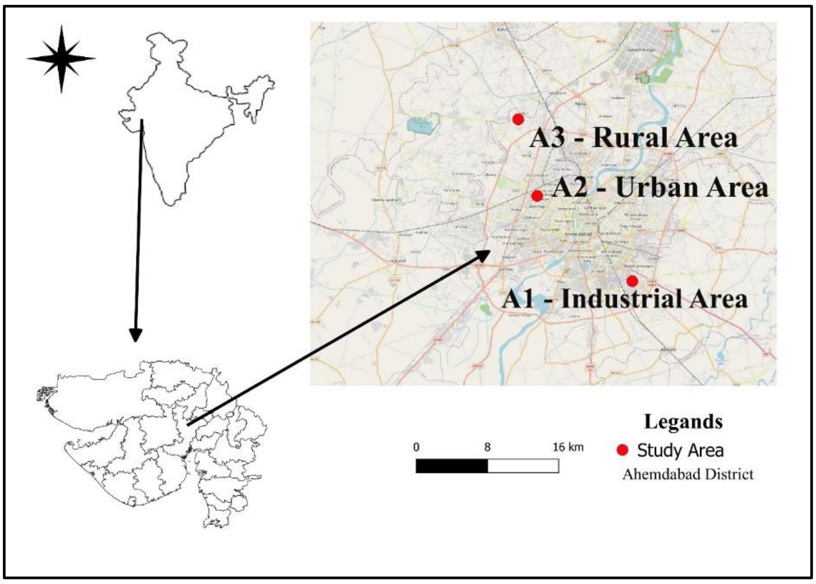

Fig. 1 : Study area of Ahmedabad showing A-1, A-2, A-3 sites

Methodology: The air samples were collected from all three sites A-1, A-2 and A-3 using Combo HVAS sampler with a flow rate of 0.5 LPM. Different absorbing solutions such as Potassium tetrachloromercuate, Sodium hydroxide and Sodium arsenite, Sulphuric acid were placed in individual impingers for the collection of gaseous pollutants like Sulphur dioxide (SO_2), Nitrogen dioxide (NO_2) and Ammonia (NH_3) respectively. Particulate matter was collected in Micro Glass Fiber Filter paper (GF/1). After sample collection, samples were transported to the laboratory, and stored in the refrigerator until the analyses were completed Patel et al., (2017). Later, the concentration of gaseous pollutants SO_2, NO_2, and NH_3 were analyzed using Improve West and

Gaeke method, Modified Jacob and Hochheiser method, and Indophenol Blue method respectively and the quantity of particulate pollutants ($PM_{2.5}$ and PM_{10}) was measured by Gravimetric Method CPCB, (2013).

The Air Quality Measure (AQI) is a standard environmental index that represents the total ambient air quality and trend of a given location. It is a method for converting the values of individual air pollutants into a single number or group of numbers. Because it depicts the cumulative influence of all contaminants, the total ambient air quality of a given location may be properly analyzed and quantified in terms of AQI. The air quality index may also be used to develop alternative strategies for air pollution prevention or to create control equipment that, for example, reduces the level of some pollutants while increasing the level of others. The AQI is calculated using a variety of methods and formulas. In present study, the following formula was applied to get the AQI value: $AQI = 1/3\ [(SO_2)/SSO_2 + (NO_x)/SNO_X + SPM/SSPM] \times 100$ Chauhan, (2010). AQI categories have been created based on the AQI range to evaluate the overall health condition of a place (https://cpcb.nic.in/) (Table:1).

Table 1: AQI Range and Category:

AQI	Remark	Color Code	Possible Health Impacts
0-50	Good		Minimal impact
51-100	Satisfactory		Minor breathing discomfort to sensitive people
101-200	Moderate		Breathing discomfort to the people with lungs, asthma and heart diseases
201-300	Poor		Breathing discomfort to most people on prolonged exposure
301-400	Very Poor		Respiratory illness on prolonged exposure
401-500	Severe		Affects healthy people and seriously impacts those with existing diseases

RESULTS AND DISCUSSION.

The concentrations of five major air pollutants namely NO_2, SO_2, NH_3, $PM_{2.5}$ and PM_{10} for Post-Monsoon, Pre-Monsoon, and Monsoon season from three locations as Industrial area (A-1), Urban area (A-2), and Rural area (A-3) are shown in Fig. 2, 3 & 4.

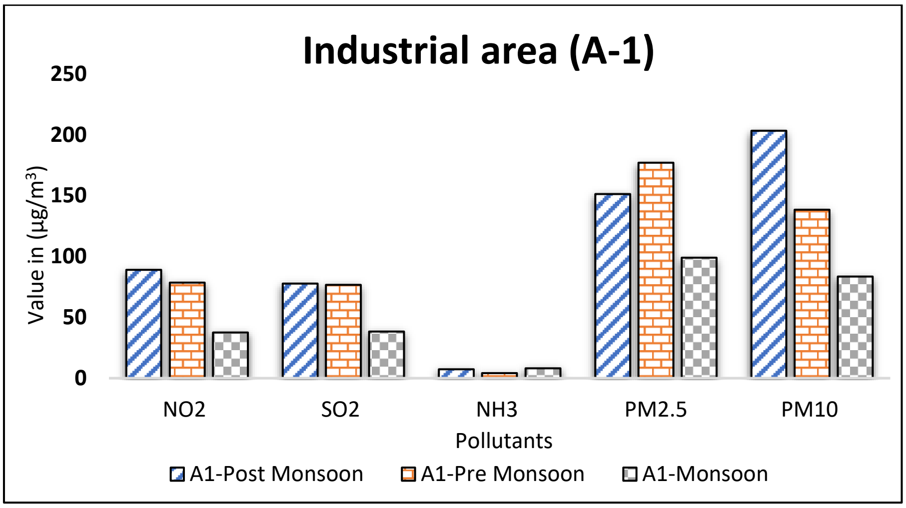

Fig. 2. Temporal variation in the concentrations of Ambient Air at Ahmedabad A-1

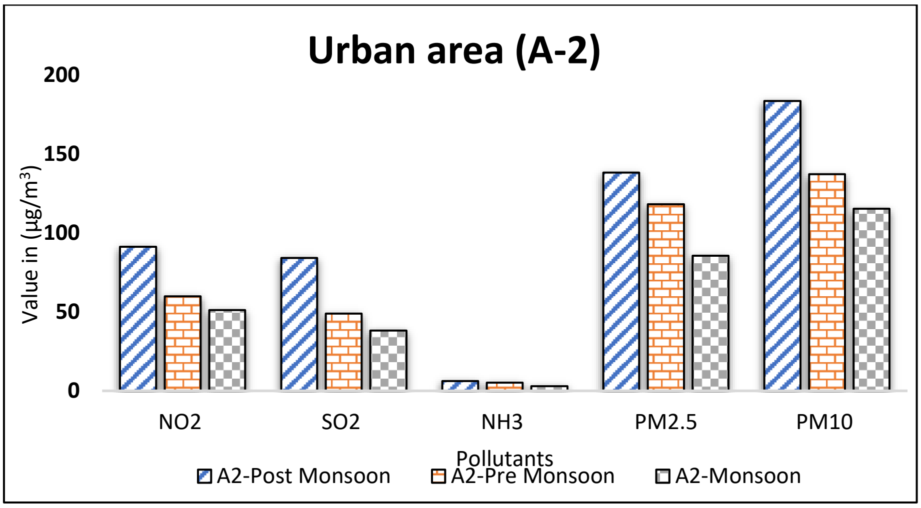

Fig. 3. Temporal variation in the concentrations of Ambient Air at Ahmedabad A-2

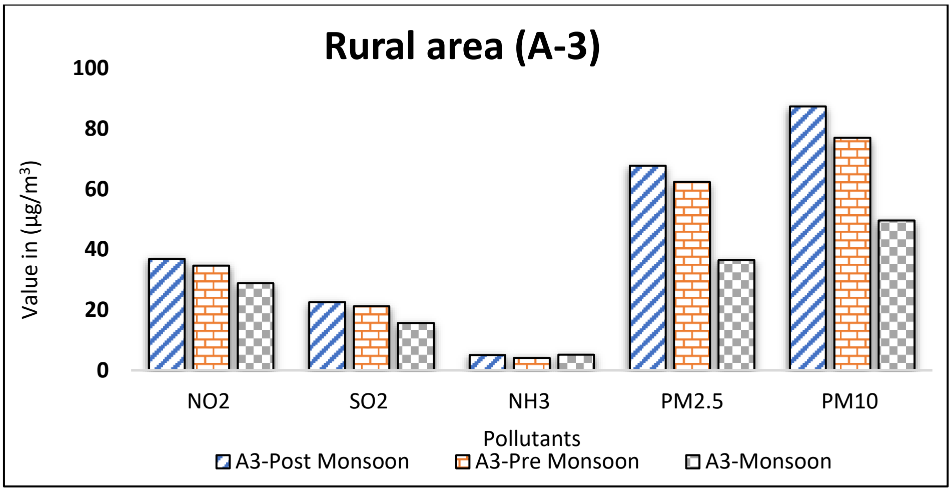

Fig. 4. Temporal variation in the concentrations of Ambient Air at Ahmedabad A-3

Gaseous Pollutants (NO_2, SO_2 & NH_3): The NO_2 concentration ranged between 28.84µg/m^3 (A-3 during monsoon season) to 91.24µg/m^3 (A-2 during post-Monsoon season). The burning of fossil fuels (coal, gas, and oil), particularly the fuel used in automobiles, is the largest source of nitrogen dioxide originating from anthropogenic activity. Additionally, it is created by the production of nitric acid, explosive applications, welding, metal and oil refining, commercial manufacturing, and food production Ministry for the Environment, (2021).

The SO_2 is emitted from different types of sources like Fossil fuel-burning stationary sources, power plants, Metals, steel mills, and pulp and paper mills and refineries. Besides this sulphur is present in diesel fuel and to a lesser extent gasoline, which upon burning results in SO_2 emissions. Sulphur dioxide is easily dissolved in water and turns into sulfuric acid. Acid rain mostly consists of sulfuric acid. Acid rain may harm trees and crops, alter the pH of soils, and turn lakes and streams into acidic environments that are unhealthy for fish to live in. Furthermore, sulphur dioxide speeds up the deterioration of painted surfaces, construction materials, and even statues and monuments West and Gaeke, (1956); Environmental Protection Agency, (2022). During the study period, SO_2 concentration ranged between 15.61 (A-3 during monsoon season) to 84.27 µg/m^3 (A-1 during post-Monsoon Season).

The NH_3 concentration ranged between 3.04 to 8.13µg/m^3. In the industrial area (A-1) the NH3 concentration was (8.13) during monsoon season and the Urban area (A-2) was the lowest concentration (3.04) during the Monsoon season. NH_3 from Agriculture, particularly animal husbandry, and the use of NH_3-based fertilizers are the main source of NH_3 emissions. Industrial processes, vehicle emissions, and volatilization from soils and oceans are among other sources of NH_3 Behera et al., (2013).

Particulate Matter ($PM_{2.5}$ & PM_{10}): There are many sources of $PM_{2.5}$ emission which include wood-burning stoves, forest fires, diesel engines, natural sources, non-road vehicles, agricultural burning, and fugitive emissions of industries Simon et al., (2008); WHO, (2000); (2005). At industrial area (A-1) $PM_{2.5}$ ranged between 98.86 (Monsoon season) to 176.88 (Post-monsoon Season) µg/m^3, Urban area's (A-2) ranged between 85.72 (Monsoon season) to 138.34 (Pre-Monsoon season) µg/m^3 and rural area (A-3), it ranged between 36.49 (Monsoon season) to 67.79 (Post-monsoon Season) µg/m^3.

The PM_{10} concentration ranged at Industrial area (A-1) between 83.45 (Monsoon season to 203.17 µg/m^3 (post-monsoon season), Urban area's (A-2) ranged between 115.44 (Monsoon season) to 183.72 (Pre-Monsoon season) µg/m^3 and rural area, it ranged between 49.61 (Monsoon season) to 87.37 (Post-monsoon Season) µg/m^3. All the study area A-1, A-2, and A-3 revealed the maximum values in post-monsoon season and the minimum values during monsoon season.

Among all the study areas, the highest PM_{10} and $PM_{2.5}$ values were recorded for Industrial Area (A-1) during post monsoon season and the lowest values were recorded in Rural area (A-3) during monsoon season. A Gradual decline in PM values from post-monsoon to pre-monsoon season and then monsoon season was recorded. Unburned cooking techniques, vehicular emissions, industrial dust, and incomplete combustion are the main causes of PM_{10} in the environment, along with secondary sources including atmospheric chemical processes USEPA, (2008); WHO, (2000).

Higher values for all pollutants in the Industrial area during the post-monsoon season may be due to pharmaceutical, petrochemical, steel recycling, auto parts manufacturing, beverage production, and textile industrial units in this area being the most air pollution-producing industries. including the notable industrial region of Vatva on the city's periphery. Along with gaseous pollutants from industries, nearby slum areas also produced large volumes of unburned carbon, particulate matter (PM), and gaseous pollutants Pathak et al., (2015). Urban areas are primarily affected by Vehicular emissions and ongoing construction sites responsible for enhancement of pollutants' level Nihalani & Kadam, (2020).

Air Quality Index: The Air Quality Index (AQI) may act as an important tool which helps to determine ambient air quality and the health status of environment Zlauddin and Siddique, (2006). The values of AQI in the study were derived using a concentration of NO_2, SO_2, NH_3, $PM_{2.5}$, and PM_{10}. The AQI value ranged from 94.12 to 367.26. The highest AQI value recorded was 367.26 (Very poor) at Site A-1 during post monsoon season and the lowest value recorded was 94.12 (Satisfactory) at site (A-3) during monsoon season (Table: 2). The interpretation of AQI result indicates very poor Air quality in (A-1) and (A-2) both industrial and urban areas. This may lead to serious health problems such as Respiratory illness, Breathing discomfort and asthma on prolonged exposure among residents of those areas (Table:1) CPCB, (2013).

Table: 2 Air Quality Index (Calculated as per table: 1)

Study area	Season	Latitude ° N Longitude° E	AQI	Remarks on Air Quality
Industrial area A-1	Post-Monsoon	22.9785, 72.6314	367.26	Very poor
	Pre-Monsoon		341.98	Very poor
	Monsoon		188.21	Moderate
Urban area A-2	Post-Monsoon	23.0748, 72.5356	351.66	Very poor
	Pre-Monsoon		258.98	Poor
	Monsoon		204.71	Poor
Rural area A-3	Post-Monsoon	23.1424, 72.5146	152.48	Moderate
	Pre-Monsoon		139.04	Moderate
	Monsoon		94.12	Satisfactory

CONCLUSION

The industrial area revealed highest concentration of all pollutants and AQI values during post monsoon season. The pollutants were considerably reduced during monsoon season. The concentration of pollutants was recorded as Industrial area > Urban area > Rural area. Based on the study it is concluded that Particulate Matter are causal air pollutants at study areas and the gaseous pollutants are above the permissible limits prescribed by NAAQS which may cause severe health effect. The study clearly indicated that it would be more appropriate to consider AQI rather than individual air pollutant level, while planning prevention of air pollution in and around industrial areas and Urban areas.

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