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Research article

Health risk assessment of four important ambient air pollutants in Hyderabad

Botla Bixapathi[1], Prof. V. Venkateswara Reddy[2] , Dr. M. Subba Rao[3], , Dr. T. Raghavendra[4]

[1]Research Scholar, Centre for Environment, IST, JNTUH University.
[2]. Professor in Civil Engineering, JNTUH, Principal at JNTUH-CEJ.
[3] Academic Advisor, IST, JNTUH
[4]Quality Manager, K N Laboratory, Hyderabad.

Abstract

This research focuses on the exposures of key ambient air contaminants in ambient air samples obtained in several Hyderabad localities. India, in recent years, significant effort has been made in India to reduce air pollution. A systematic risk assessment approach was made to assess the exposure intake risk from PM10, PM2.5, and NOx. The Telangana state pollution control board (TSPCB) provided information for more than 20 locations from there we have collected the data for the years 2011, 2015, 2020, and 2021. These data were being used to assess the hypothetical health risks of ambient air sample exposures using the hazard quotient (HQ) for non-carcinogenic lifetime cancer risk and lifetime excess risk of cancer for carcinogenic pollutants. The exposure and dose related methodologies for inhalation dose were collected from USEPA, ASTDM, and ICRP websites. One of most polluting component of the atmosphere found to be PM10, followed by PM2.5 and NOx. Vehicle emissions and tyres abrasion are both responsible for high NOx levels. Re-suspension of road dust and particles created by industrial pollutants may contribute to high PM10 and 2.5 levels. Assessments of possible risk from hypothetical exposure to three hazardous pollutants in adults, children, and infants were determined to be significantly below the permissible limits, indicating no risk of cancer. Exposures to NOx, PM10, and PM 2.5 resulted in consistent exposures and HQ and HI values of 1 or less, indicating a lower likelihood of non-carcinogenic hazards. The calculation of cancer risk (ECR) of exposures of air pollutants indicated that children had higher chances of getting risk of cancer than adults in study area. Cancer risk calculations from inhalation dose to air pollutants indicate that children are more likely to develop cancer risk than adults in the study area.

Key words: Ambient air quality monitoring, Air pollutant, Excess cancer risk, Inhalation dose, Non – carcinogenic cancer risk.

Introduction

Hyderabad is the capital and most populous city in the Indian state of Telangana (coordinates: 17°21′42′′N 78°28′29′′E). According to the 2011 Census of India, Hyderabad is India's fourth-most populous city, with 6.9 million individuals within the city limits and 9.7 million in the municipal zone, making it the country's sixth-most populous metropolitan region. With a GDP of US$74 billion, Hyderabad is India's fifth-largest city economy.

In late October, the air quality in Hyderabad begins to fade. In terms of air pollution, the winters are the worst season. In Hyderabad, the current average PM2.5 concentration is 6 (g/m^3). The World Health Organization (WHO) suggests a criterion level of 25 g/m3. The level is presently 0.24 percent of the recommended daily limit.

Because of growing urbanization and growing financial activity, industrial waste, air, noise, and water pollution have all increased in Hyderabad. Cars produced 20–50 percent of air pollution in 2006, with 40–70 percent coming from a combination of vehicle emissions and road dust, 10–30 percent from industrial emissions, and 3–10 percent from garbage burning. Each year, 1,700–3,000 people were predicted to die because of particulate matter in the atmosphere. [1]

Air pollution is still a major environmental issue were identified as a serious community health threat. Concurrently, this risk for health and safety has received lot of media attention and social alarm, prompting the government to adopt active measures to reduce air pollution. [2]. According to the World Health Organization (WHO), outdoor and indoor air pollution cause 4200 and 3800 fatalities per year, respectively, primarily from smoke from cook stoves and fuels [3]. Long & short term exposure to particulate matter has been demonstrated to increase mortality and reduce life expectancy.

It is estimated that by 2050, air pollution-related deaths due would have doubled, and poor air quality is regarded as one of the world's most serious environmental health risks. Raises in death rates, mortality rates, and premature death, circulatory and respiratory diseases, lung cancer, and adverse effects on the activity of the central nervous system resulting in cognitive impairment are some of the negative effects of air pollution exposure, as are health consequences on fetal development and pregnancy.

Air pollution, particularly particulate matter (PM), has the potential to cause cancer in humans. Increased PM10 concentration by 10µg/m3 has been indicated to increase non-accidental mortality [4]. The study of the association between air pollution exposure and adverse public health impacts is necessitated by the aforementioned issues, as well as the rising focus on public health risks imposed by environmental pollutants. Currently, public health risk evaluations are performed by using the environmental health risk assessment methodology developed by the USEPA (US Environmental Protection Agency). This approach is a useful tool for calculating the risk of human health due to exposure to ambient air pollution statistically [5]. Furthermore, intake of various air particles by children and adults will result in inconsistent levels of health risk, as determined by the methodology outlined above [6]. Furthermore, the current implementation of this paradigm primarily considers those whohave had average or continuous exposure [7].

Many studies have looked into the geological and spatial distribution, chemical characteristics, prospective origins, and impacts of weather conditions studies were conducted on air pollution; however, many researches may have overlooked or neglected public health risk assessments. Furthermore, the proper spatial distribution of air contaminants will be critical to people's health. As a result, the current study tried to evaluate the public health risk levels of three important airborne pollutants in Hyderabad, as well as the risk modelled by ambient air pollutants to various age groups

Materials and Methods

Study Area:

Telangana's capital Hyderabad (Figure 1), In the Deccan Plateau, it extends for 650 square kilometres along the banks of the Musi River. Summer weather are warm and muggy, with average 30°C with rising temperature approaching 40 °C during April and June. Coldest months are the december and january, with temperatures as low as 10 ° C. May is the highest recorded, with everyday temperatures ranging between 26 to 39 ° C. Between June and October, the south-west summer monsoon dumps a lot of rain. On August 24, 2000, 241.5 mm (10 in) of rain fell in a 24-hour period for the first time since records began in November 1891. On 2 June 1966, the highest temperature ever recorded was 45.5 degrees Celsius, and on 8 January 1946, the lowest temperature was 6.1 degrees Celsius. The city receives 2,731 hours of sunlight per year, with the highest daily solar exposure in February.

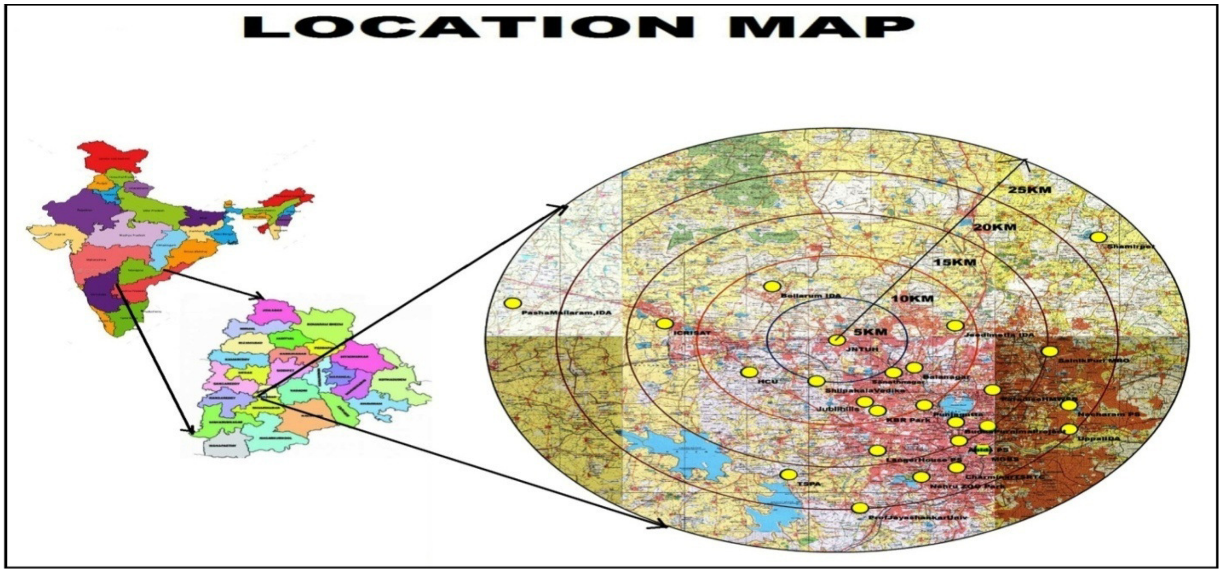

Figure 1: Sampling locations for the AAQ monitoring in Hyderabad

Data collection

The TSPCB and the CPCB collected data on four air pollutants (SO2, NO2, PM10, and PM2.5) from 24 important locations with continuous ambient air monitoring stations (Fig. 1). From the TSPCB air quality monitoring sites, a total 24 continuous monitoring stations were chosen. As a daily average, the collected data covers a ten-year period (2011–2021).

Health Risk Assessment methodology:

The USEPA entails the following methodology: The various exposure routes are defined in the risk evaluation study: inhalation, ingestion, and dermal exposure. Inhalation was explored in our study because it is the fastest way to be exposed. In our calculations, we used the risk assessment approach used by the USEPA, as explained below. The hazard quotient was used to determine non-carcinogenic risk (HQ). When risk values were less than one, suggesting that there was no detrimental health effect on people, the upper limit of the non-carcinogenic risk value was set at one [8]. The reference values for those pollutants, such as the reference dose (RfD) for NO2 and PM10 and the reference concentration (RfC) for PM2.5, were accessible in toxicological databases, non-carcinogenic risk was computed [9-11].

Individuals' exposure possibilities were investigated as part of the study. The following subpopulations were considered in each exposure scenario: adults (24 years), children (6 years), and infants (1year). Depending on the given reference values, exposure concentration (EC) or average daily dose (ADD) values were calculated to get the daily intake of pollutants through the inhalation exposure pathway:

$$\mathrm{ADD} = \frac{\mathrm{C\ X\ IR\ X\ ET\ X\ EF\ X\ ED}}{(\mathrm{BW\ X\ AT})} \qquad (1)$$

where EC(mg/m^3)- Exposure Concentration; ADD(mg/kg-day)- Average Daily Dose; C - Pollutant Concentration in air; IR- inhalation rate (m^3/h); ET- Exposure Time (h/day); EF- Exposure Frequency (days/year); ED- Exposure Duration (years); BW- Body Weight (kg); AT- Averaging Time; ED- In years (365 days/year X 24 h/day, in hours).

Table 1: Exposure parameters used for the risk assessment calculations in the study.

Exposure Parameters	Adult	Child	Infant	References
IR: Inhalation rate per person (m^3/h)	0.83	0.31	0.19	[13,14]
ET: Exposure Time per person (h/day)	24	24	24	[15]
ED: Exposure duration (years)	24	6	1	[16]
EF: Exposure frequency (days/year)	365	365	365	[8]
BW: Body weight (kg)	70	16	10	[15]
AT: Averaging time (hours)	210240	52560	8760	[15]

Despite the fact that all of the pollutants studied were considered harmful, only non-carcinogenic risk was computed using the hazard quotient (HQ) values, as described in Equations (3) [12], in relation to the toxicological data:

$$HQ = ADD/RfD \qquad (3)$$

Where HQ, hazard quotient (unit less); EC, exposure concentration (mg/m3); ADD, average daily dose (mg/kg-day); RfD, reference dose (mg/kg-day).

The following RfD values were used for calculations: NOx: 1.1 X 10^{-2} (mg/kg-day), PM10: 1.1 X 10^{-2} (mg/kg-day) [9]. The following RfC value was used for calculations: PM2.5: 5.00 X 10^{-3} (mg/m3) [10].

Combined carcinogenic and non-carcinogenic risk rates

The total non-carcinogenic risk from inhalation of many pollutants at the same time was calculated using the hazard index (HI) factor. It was determined using the equitation method (4) [8].

$$HI = HQ_1 + HQ_2 + \cdots + HQ_n \qquad (4)$$

Where, 1–n: specified pollutants in the air.

Results and Discussion:

Variations in ambient air quality parameters:

Table 2: variations in the air pollutants during the study period

Parameter	**PM10** (μg/m^3)	**PM 2.5** (μg/m^3)	**SO_X** (μg/m^3)	**NO_X** (μg/m^3)
2011	79	51	5.0	24
2015	93	39	6.0	30
2020	81	33	4.0	30
2021 up to November	82	35	4.0	32

As shown in Table 2, the frequency distribution of air pollutants (PM10, PM2.5, SOx, and NOx) concentrations in 2011, 2015, 2020 and 2021 were observed. The values of the PM10 in the year 2011 were range from 35 µg/m^3 to 108 µg/m^3 with average value of 79 µg/m^3, from 41 µg/m^3 to 177 µg/m^3 with an average value of 93 µg/m^3 in the year 2015, from 47 µg/m^3 to 120 µg/m^3 with an average value of 81 µg/m^3 in the year 2020, from 46 µg/m^3 to 136 µg/m^3 with an average of 82 in the year 2021 were observed. The concentrations of PM 2.5 monitoring were started in the year 2015 which ranged from 32 µg/m^3 to 51 µg/m^3 with average value of 39 µg/m^3, from 23 µg/m^3 to 49 µg/m^3 with an average value of 33 µg/m^3 in the year 2020, from 27 µg/m^3 to 43 µg/m^3 with an average value of 35 µg/m^3 in the year 2021 were observed. In 2011, SOx levels ranged from 4 g/m3 to 15 g/m3 with an average value of 5 g/m3, from 4 g/m3 to 11 g/m3 with an average value of 6 g/m3 in 2015, from 2 g/m3 to 12 g/m3 with an average value of 4 g/m3 in 2020, and from 2 g/m3 to 14 g/m3 with an average value of 4 g/m During the study period, no significant departures or increases in sox levels were identified. The NOx levels in the year 2011 were range from 14 $\mu g/m^3$ to 42 $\mu g/m^3$ with average value of 24 $\mu g/m^3$, from 16 $\mu g/m^3$ to 68 $\mu g/m^3$ with an average value of 30 $\mu g/m^3$ in the year 2015, from 14 $\mu g/m^3$ to 51 $\mu g/m^3$ with an average value of 30$\mu g/m^3$ in the year 2020, from 13 $\mu g/m^3$ to 65 $\mu g/m^3$ with an average of 32 $\mu g/m^3$ in the year 2021 were observed.

Due to significant pollution, greater quantities of air pollutants were reported in 2015 during the course of four years of monitoring data. The government has implemented strong air pollution mitigation strategies, which have resulted in a progressive decrease in air pollution since 2018. Due to the Covid 19 lockdown, there was a considerable reduction in all air pollutants, which gradually increased to normal levels when the lockdown ended due to the reopening of industries and public movement and transportation [17].

Human Health Risk Assessment

Estimation of Average Daily Dose:

The human average daily dosage rates obtained from equation 1 (Table 3) showed that all of the levels were substantially below the allowable values set forth in the USEPA Regulation on the levels of certain pollution in the air [18]. The average daily dosage rates for PM10 were found to be highest in children with a value of 1.80E-03 in the year 2015. In the year 2011, a minimum daily consumption level of 9.37E-04 was discovered in adult men. PM2.5 Among the year 2011, the 2.5 average daily dosage rates were found to be at their highest in children, with a value of 9.88E-04. In the year 2020, a minimum daily consumption level of 3.91E-04 was discovered in adult men. A similar pattern can be seen in the intake dosage values of NOx levels, where the highest levels were discovered in children with 6.20E-04 in the current year and the lowest levels were found in adult men with 2.85E-04 in 2011. Child > Infant > Adult woman > Adult male was the overall average daily dosage trend for all three air pollutants in descending order.

Non-carcinogenic risk of ambient air inhalation:

The calculated average daily dose rates and the reference values of RfD doses were used to generate the hazard quotient (HQ) values. Non-carcinogenic risk refers to all negative health outcomes generated by sources other than cancer in the individual. The permissible non-carcinogenic risk is such that HQ 1. If HQ>1, on the other hand, a greater health risk occurs [19]. All three air contaminants' HQ values were found to be significantly below one. It's worth mentioning that the non-carcinogenic risk rates calculated don't cover all types of pollution because not all of them are observed at sampling sites, and the RfD toxicological variables may not be accessible at all of them. Calculations, on the other hand, necessitate the use of such values. Only the toxicological parameter values for PM10, PM2.5, and NO2 were provided. As a result, the hazard quotient (HQ) values for those three pollutants were determined. Table 3 shows the HQ values calculated for individual contaminants. The overall non-carcinogenic risk was estimated as a Hazard index (HI) by adding the HQ values for PM2.5, PM10, and NOx, all of which were much lower than the target risk value of 1. (Figure 2). The child category in 2011 had the maximum HI value of 3.79E-01. The risk estimates did not depend on the body weight component, according to the exposure methods used to describe the average daily dose of air contaminants. As a result, all communities were exposed in the same way when it came to inhaling.

Furthermore, the HQ levels were observed to be below their maximum levels in the inhalation exposure pathway, despite the fact that people breathe every day for the rest of their lives.

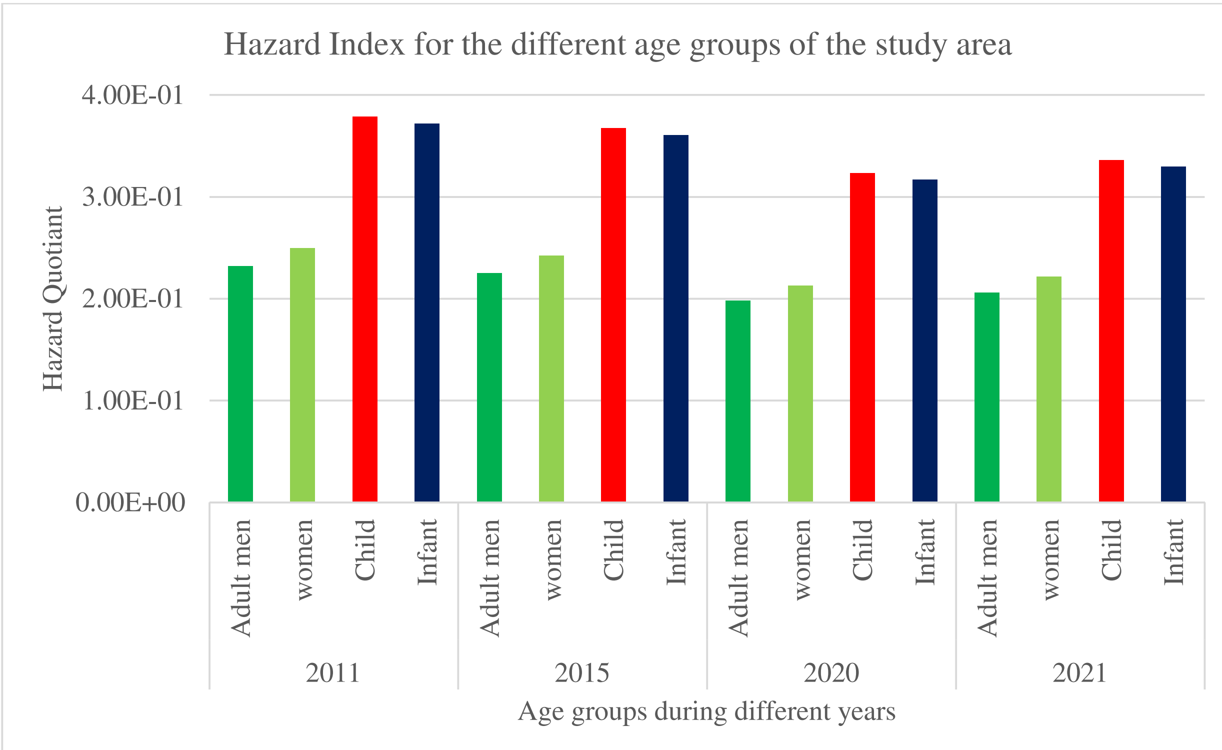

Figure 2: Hazard Index for the different age groups of the study area

Excess Cancer Risk (ECR) of ambient air pollutants inhalation

The overall average ECR values of air pollution exposure for the age groups of adult, children, and infants for the four years were found to be more than 1 $X10^{-6}$, indicating a potential cause for alarm. The average ECR values of air pollutants for adult men and women were determined to be 5 $X10^{-2}$. The above-mentioned values for children and infants were determined to be 5.73 $X10^{-1}$ and 1.46 $X10^{-1}$, respectively. The assessment of the excess cancer risk (ECR) of air pollution exposures revealed that children have a higher risk of cancer than adults do in the research area, which could be ascribed to higher ADD values in children than in adults. Similar findings were reported in the study, which calculated the risks of cancer from PM1-associated metals (Cr(VI) and Cd) in Kanpur (India)[20].

Table 3: Average daily dose and HQ values for the different age groups of the study area.											
2011											
PM10				**PM2.5**				**Nox**			
Adult men	women	Child	Infant	Adult men	women	Child	Infant	Adult men	women	Child	Infant
Average daily dose (ADD)											
9.37E-04	1.01E-03	1.53E-03	1.50E-03	6.05E-04	6.51E-04	9.88E-04	9.69E-04	2.85E-04	3.06E-04	4.65E-04	4.56E-04
Hazard quotient (HQ)											
8.52E-02	9.17E-02	1.39E-01	1.36E-01	1.21E-01	1.30E-01	1.98E-01	1.94E-01	2.59E-02	2.79E-02	4.23E-02	4.15E-02
2015											
PM10				**PM2.5**				**Nox**			
Adult men	women	Child	Infant	Adult men	women	Child	Infant	Adult men	women	Child	Infant
Average daily dose (ADD)											
1.10E-03	1.19E-03	1.80E-03	1.77E-03	4.62E-04	4.98E-04	7.56E-04	7.41E-04	3.56E-04	3.83E-04	5.81E-04	5.70E-04
Hazard quotient (HQ)											
1.00E-01	1.08E-01	1.64E-01	1.61E-01	9.25E-02	9.96E-02	1.51E-01	1.48E-01	3.23E-02	3.48E-02	5.28E-02	5.18E-02
2020											
PM10				**PM2.5**				**Nox**			
Adult men	women	Child	Infant	Adult men	women	Child	Infant	Adult men	women	Child	Infant
Average daily dose (ADD)											
9.60E-04	1.03E-03	1.57E-03	1.54E-03	3.91E-04	4.21E-04	6.39E-04	6.27E-04	3.56E-04	3.83E-04	5.81E-04	5.70E-04
Hazard quotient (HQ)											
8.73E-02	9.40E-02	1.43E-01	1.40E-01	7.83E-02	8.43E-02	1.28E-01	1.25E-01	3.23E-02	3.48E-02	5.28E-02	5.18E-02
2021											
PM10				**PM2.5**				**Nox**			
Adult men	women	Child	Infant	Adult men	women	Child	Infant	Adult men	women	Child	Infant
Average daily dose (ADD)											
9.72E-04	1.05E-03	1.59E-03	1.56E-03	4.15E-04	4.47E-04	6.78E-04	6.65E-04	3.79E-04	4.09E-04	6.20E-04	6.08E-04
Hazard quotient (HQ)											
8.84E-02	9.52E-02	1.44E-01	1.42E-01	8.30E-02	8.94E-02	1.36E-01	1.33E-01	3.45E-02	3.71E-02	5.64E-02	5.53E-02

Table 4: The Excess cancer risk values for the different age groups of the study area.

Year	Age Group	Excess Cancer risk
2011	Adult men	8.68E-03
	women	8.68E-03
	Child	9.93E-02
	Infant	2.53E-02
2015	Adult men	1.45E-02
	women	1.45E-02
	Child	1.66E-01
	Infant	4.23E-02
2020	Adult men	8.12E-03
	women	8.12E-03
	Child	9.28E-02
	Infant	2.37E-02
2021	Adult men	1.69E-01
	women	1.69E-01
	Child	1.93E+00
	Infant	4.93E-01

Different thresholds of carcinogenic risk have been adopted in different nations, based on still-in-development methodologies; but, in practice, risk levels ranging from 1.00E-04 to 1.00E-06 are tolerable in many countries. It means that, depending on the country, there is social consent for one more instance of cancer per 1000 to 10,000 people in the investigated population. Furthermore, a risk level of 1.00E-03 is clearly undesirable, and such a circumstance necessitates remedial action to lower that level. Based on cautious risk estimates, this study considers one additional case of cancer in a population of one million individuals (1.00E-06) to be an acceptable risk level. In our research on carcinogenic pollutants among children, adults, and infants in the study region, we discovered unacceptable risk levels (Table 4).

Conclusions

The investigation proposed a method for adding ambient air contaminants into risk estimation. Calculations were made to determine the non-cancerous and malignant risks of air pollution exposure. The following are some of the study's key findings:

1. Determined for four years (2011, 2015, 2020, and 2020) the concentration levels of measured ambient air pollutants. PM10, PM2.5, SOx, and NOx concentrations were determined to be 41-177 g/m3, 23-60 g/m3, 2-33 g/m3, and 12-68 g/m3, respectively.

2. Under a hypothetical exposure scenario, this study employed concentration values of these pollutants to estimate the risks of non-cancerous and malignant consequences.

3. Non-cancer exposures' computed hazard quotient (HQ) values were found to be far below the permitted level of 1. The total hazard index (HI) levels of exposures, which were determined by adding the HQ values of each pollutant, followed a similar pattern and were found to be less than 1.

4. Excess cancer risk (ECR) estimates were derived for three air contaminants, found to be greater than $1X\ 10^{-6}$. The calculation of the excess cancer risk (ECR) of air pollutants exposures over four years revealed that children in the study area had a higher risk of cancer than adults.

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Conflict of Interest

The authors confirm that there are no known conflicts of interest related to this publication, and that no significant financial assistance for this work has influenced its conclusion.

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