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Research Article

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Role of Particulate Matter in Exacerbating Asthmatic Conditions: A Winter Study

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ABSTRACT

Punjab, with four major cities viz., Amritsar, Ludhiana, Khanna and Gobindgarh are major contributors of outdoor air pollution among all Indian states. Due to bad quality of inhalable fraction of air, consequence of asthma cases among schoolchildren in Punjab has been increasing at alarming rate. To determine the load of roadside urban suspended particulate matter in Amritsar city, using high volume sampler and metrological parameters were procured using underground site on same days of sampling period. This is gravimetrical analysis of suspended particulate matter study over winter season in six sampling sites of urban Amritsar, city. The data was analyzed using Pearson correlation matrix to know the relation of suspended particulate matter with climatic conditions where $P \leq 0.05$ was considered as level significance in the present study. The results indicate high content of mean particulate matter ($\mu g/m^3$) in order of Ram bag site > Railway station > Crystal chowk > Bhandari bridge > Ranjit avenue > Garden colony sampling sites of present study. The temperature was found to be positively correlated to content of particulate matter as of increase in asthmatic symptoms especially, in winter season. Epidemiologic studies reported high risk of asthma in Amritsar, city Punjab. Increase in continuous emission of automobile exhaust, traffic jams, construction demolition has markedly raised the prevalence of childhood asthma. The content of suspended particulate matter and its relation with temperature indicates significant risk factor for exacerbating asthmatic mortalities.

Keywords: Risk factors; Metrological parameters; Construction demolition; asthma

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INTRODUCTION

Asthma is the most prevalent respiratory disease and the cause of respiratory disability among children. About 300 million people worldwide have been documented to be affected due to asthma and over 100 million children are expected to get affected by the year 2025 [1]. The report also indicated that worldwide deaths from asthma were expected to be 2, 50,000 persons per year all over the world. Children and adolescents were considered to be more susceptible to urban air pollution effects like asthma morbidity than the adults [2]. Increased number of deaths and adverse health effects were well associated with increase in the air pollution [3,4].

Among different air pollutants, presence of particulate matter is a major air quality concern because of its adverse effects on respiratory system. It is well established that particulate matter can lead to both bronchitis and asthma. The content of particulate matter has its direct association with traffic emissions. While finding the relation between traffic exposure and inception of atopy, Nicolai T, et al. [5] observed that effects of traffic on the prevalence of asthma and atopy at school age were common among the representative population. Mar TF, et al. [6] have evaluated the association between mortality outcomes in elderly individuals and particulate matter (PM) using daily data of 3 years (1995-1997), obtained from the U.S. Environmental Protection Agency (EPA), National Exposure Research Laboratory Platform, in central Phoenix of varying aerodynamic diameters of particulate matter *viz.*, PM_{10}, $PM_{2.5}$, and PM_{CF} (PM_{10} minus $PM_{2.5}$) and gaseous phase pollutants like carbon monoxide, nitrogen dioxide, ozone and sulfur dioxide from the EPA Aerometric Information Retrieval System Database in Phoenix, Arizona. Laden Fl

et al. [7] observed good association of fine particulate matter from different sources with daily mortality in six cities of United States. They found that 10 μg/m^3 increase in $PM_{2.5}$ from mobile sources accounted for a 3.4% increase in daily mortality while the equivalent content from coal combustion sources accounted for an increase of 1.1%.
Particulate matter concentration directly depends on meteorological conditions. Mortality due to respiratory distress was directly related to varied climate conditions *viz.*, environmental temperature, humidity fog along with presence of particulate matter [8]. Apart from mortality, morbidity was also linked with long term exposure to varied particulate matter due to unexpected climatic conditions that induced decreased lung function [9], increased respiratory symptoms or illness [10] increased symptoms in children of asthma [11], increased hospitalizations or emergency room visits of persons with asthma [12] and low birth weight [13]. Asthma exacerbations were reported to be associated with inflammatory reactions of PM toxicity [14-21]. Majority of the studies conducted worldwide to know the exposure effects of particulate matter in causing asthma were measured at the fixed site whereas very few studies were confined to personal exposure to particulate matter [15]. Considering all in mind, the present study was planned to evaluate the particulate matter (PM10) of Amritsar city and to correlate the content of particulate matter with meteorological conditions on particular days of sampling.

EXPERIMENTAL SECTION

Sampling

High volume sampler is used to monitor ambient air quality and air pollution. It is widely used all over the world to measure air pollution, especially, in industrial areas, urban areas, near monuments and others sensitive areas *viz.*, hospitals, schools and research institutions. It is a vital tool for studies related to consequences of air pollution. In these samplers, air born particulates are measured by passing air at a high flow rate of 1.1 to 1.7 cubic meters per minute through a high efficiency glass fiber filter paper which retains the particles. The instrument measures the volume of air sampled. The content of particulate matter collected is determined by change in weight of the filter paper as a consequence of the sampling. In the present study, sampling was done from six sites as mentioned in Table 1.

Table 1: Characteristic features of sampling sites and their codes

S No	Sampling site	Site code	Coordinates	Characteristic features of the site
1	Ram Bag	RB	31° 37' 50.84" E 74° 52' 40.66" N	Site near to bus stand; a crowded place with small scale industries and shops
2	Crystal junction	CC	31 38' 8.77" E 74 52' 32.75"N	Site exposed to heavy traffic loads with frequent traffic jams; a crowded place with open barbeques and shops
3	Railway station	RS	31 38' 3.57"E 74 52' 5.6" N	Site near Amritsar railway station having heavy transportation and frequent traffic jams; crowded with open restaurants
4	Bhandari bridge	BB	31 37' 49.44" E 74 52' 25.25"N	Site with underlying railway lines; exposed to heavy and prolonged traffic jams.
5	Garden colony	GC	31°38'44.1540"E 74 52' 55.6559"N	Residential site exposed to vehicular emissions, dust from constructions and demolitions; commercial complex
6	Ranjit Avenue	RA	31°39'33.780" E 74 51' 18.7740"N	Residential site near to bypass link road exposed to vehicular emissions; site with hospitals, shops, food courts with open hearths and parking places.

Estimation of TSPM

Total suspended particulate matter (TSPM) was collected on EPA glass fiber filter paper (20.3 x 25.4 cm^2) using High Volume Sampler (Envirotech, India). Filter papers were oven dried at 450 °C for 4 h and then kept in desiccators for 2 - 3 h. Weight of filter paper was taken before sampling and then it was taken to site of sampling after wrapping in aluminum foil to avoid contamination. After sampling, filters with TSPM were brought back to laboratory and were kept in desiccators for 2 - 3 h before taking the final weight. The samples were weighed gravimetrically in an air conditioned laboratory using microbalance (Model BSA224S-CW, Sartorius, Sensitivity 0.0001g) before and after sampling. Filter papers were handled using plastic tweezers to avoid contamination from fingers.

Calculations

Gravimetric analysis of filter paper was done using the following calculations:

Weight of suspended particulates (W) = W_2-W_1 (µg)

W_2= Weight of the filter paper after sampling (µg)

W_1= Weight of fresh filter paper (µg)

Volume of Air Sampled (V) = Q (m^3/min) x T (min)

Q =Average sampling rate

T = Sampling Time

Average sampling rate (Q) = (Q_1+Q_2)/2

Q_1 = Initial sampling rate indicated by orifice meter at the start of sampling.

Q_2 = Final sampling rate indicated by orifice meter at the end of sampling.

Concentration of suspended particulate matter = W/V (µg/m^3)

Meteorological parameters

Different meteorological parameters *viz.*, temperature, wind velocity, dew point, humidity, rainfall were recorded for the days of sampling using wunderground site (www.wunderground.com).

Statistical analysis

Meteorological parameters were correlation with direct Total Suspended Particulate Matter (TSPM) using Pearson correlation.

RESULTS AND DISCUSSION

TSPM content

The content of particulate matter (µg/m^3) was found to be in order of Ram bag site (462.27) > Railway station (324.90) > Crystal chowk (283.73) > Bhandari bridge (274.80) > Ranjit avenue (207.34) > Garden colony (196.41) as shown in Table 2.

Table2: Content of total suspended particulate matter collected from different sites of Amritsar city

S No	Sample code	Coordinates	Type of site	Sampling	SPM	
					(µg/m3)	Mean ± S.E.
1	RB	31°38'18"N 74°52'45"E	Heavy Traffic prone zone	I sampling	467.26	462.27±11.465
				II sampling	440.4	
				III sampling	479.17	
2	CC	31°38'8"N 74°52'33"E	Traffic prone + commercial area	I sampling	400.3	283.73±65.387
				II sampling	276.79	
				III sampling	174.11	
3	RS	31°37'57"N 74°52'1"E	Heavy Traffic prone + commercial area	I sampling	345.24	324.90±24.152
				II sampling	352.68	
				III sampling	276.79	
4	BB	31°38'1"N 74°52'26"E	Traffic prone area	I sampling	261.9	274.80±51.100
				II sampling	193.45	
				III sampling	369.05	
5	RA	31°38'58"N 74°51'22"E	Residential area	I sampling	226.19	207.34±20.354
				II sampling	166.67	
				III sampling	229.17	
6	GC	31°38'42"N 74°52'37"E	Residential area	I sampling	197.92	196.41±12.461
				II sampling	217.2	
				III sampling	174.11	

RB: Ram Bag; CC: Crystal Chowk; RS: Railway station; BB: Bhandari Chowk; RA; Railway Avenue: GC: New Garden Colony

Meteorological parameters

Meteorological data for the days of sampling was procured using wunderground site (Table 3 and Figure 1). The obtained data was used to correlate content of particulate matter using Pearson correlation matrix. The results revealed significant correlation of particulate matter with temperature (r = 0.9317) (Table 4).

The existence of high particulate matter in Amritsar city is a matter of concern due to its direct acute and chronic toxicities. Various earlier studies have reported the incidences of asthma and lung cancer in Punjab region with special reference to Amritsar [22,23]. Analyzed 155 blood samples of asthmatic patients visiting Rai Bahadur Sir Gujjarmal and Kesradevi Tuberculosis Sanatorium (TB and Chest Hospital), Amritsar and Sri Guru Ram Das Institute of Medical Sciences and Research, Amritsar and reported the strong prevalence of asthma in the region. Chand et al. [23] conducted a study on young children in Amritsar (India) on the basis of questionnaire and observed that out of 795 students participated, about one hundred (13.4 %) were asthmatic. Singh M et al. [24] found prevalence of asthma in both urban, rural areas and reported that group of school children (age of 5 –17 years) was the most vulnerable group in Amritsar, city. Although, no significant difference was observed among urban and rural area children yet, the prevalence of asthma was high among rural population. Pandhi N et al. [25] reported while studying the clinicopathological profile of patients with lung cancer, visiting chest and TB Hospital of Amritsar, that cough (80%) and breathlessness (65%) were the common symptoms among lung cancer patients.

Table 3: Metrological parameters of Amritsar, Punjab, India

S No	Sample Site/Sample code	Date of sampling	Temperature (°C)		Humidity (%)		Wind speed (Km/h)	
			Max.	Min.	Max.	Min.	Max.	Min.
1	Ram Bagh (RB)	November 2, 2013	27	13	100	29	18	3
		December 2, 2013	25	9	100	37	13	3
		January 2, 2014	18	0	100	68	74	5
2	Crystal chowk (CC)	November 5, 2013	26	11	100	33	9	1
		December 5, 2013	24	6	100	30	9	1
		January 6, 2014	17	0	100	72	11	1
3	Railway station (RS)	November 8, 2013	22	11	100	62	15	2
		December 6, 2013	25	8	100	28	6	0
		January 7, 2014	16	0	89	66	15	2
4	Bhandari bridge (BB)	November 11, 2013	25	9	100	39	15	2
		December 9, 2013	23	6	100	54	13	2
		January 8, 2014	12	3	93	70	17	4
5	Ranjit avenue (RA)	November 13, 2013	25	9	100	31	11	2
		December 11, 2013	22	6	100	44	18	2
		January 10, 2014	17	0	100	61	83	3
6	Garden colony (GC)	November 15, 2013	25	7	100	23	13	2
		December 12, 2013	22	7	100	45	22	4
		January 11, 2014	17	0	100	60	15	2

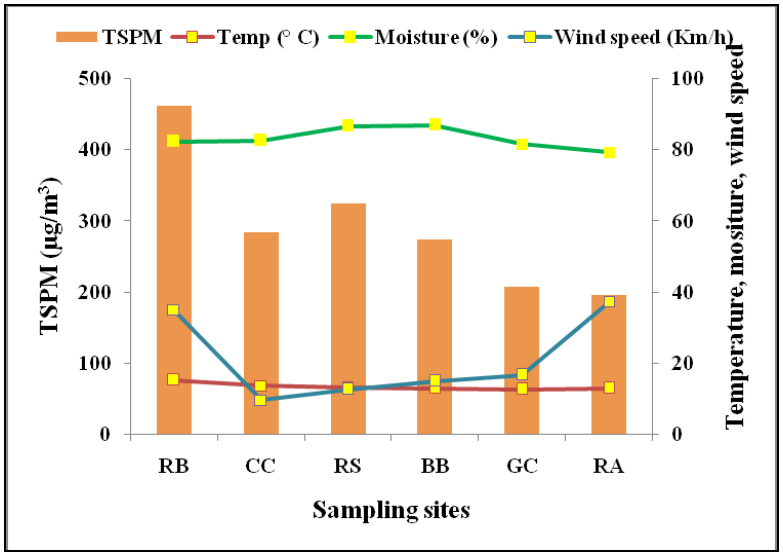

Figure 1: Content of TSPM and different metrological parameters of six sites of Amritsar, Punjab (India)

Similar facts were also given by [26,27]. The actual reasons for cough and breathlessness were reported to be due to changes in inner lining (mucosa) induced by the tumor while cough has been widely associated with soot along with benzene and NO_2 Arora et al. also reported in a study that 7.5% of school children (age groups 5–8 years) were asthmatic in the urban schools of Ludhiana (Punjab). The study was based on questionnaires and pulmonary function tests for estimating childhood asthma [28].

Thakur et al. [29] reported high cancer risk among two blocks *viz*., Talwandi Sabo and Chamkaur Sahib of Bathinda and Roop Nagar districts, respectively in Punjab state during a survey report. They reported that cancer cases per 100,000 population were observed to be 125 (107/85315) in Talwandi Sabo and 72 (71/97928) in Chamkaur Sahib. Punjab, one of India's most flourishing states, at present is under burden of cancer disease and has become cancer capital of India. About 90 patients for every 100,000 population in Punjab were reported to be suffering from cancer. Furthermore, the survey conducted by the Punjab government in 2013 revealed that the incidence of cancer in the state was higher than even the national average of cancer incidence i.e. 80 per 100,000 persons [30].

Table 4: Pearson Correlation Matrix between TSPM, temperature, humidity, wind speed of Amritsar, Punjab (India)

Parameters	TSPM	Temperature	Humidity	Wind speed
TSPM	1			
Temp	0.931	1		
Moisture	0.28	-0.066	1	
Wind speed	0.192	0.411	-0.639	1

The increased suspended particulate matter during the present study was mainly observed to be due to traffic emissions and all aged group people residing/visiting the study areas or nearby areas were exposed to these contaminants. However, children travelling in open diesel vehicles (auto rickshaws, school bus vans) were observed to be more exposed to TSPM while stuck in prolong traffic jams. Janice JK et al. [31] conducted the East Bay Children's Respiratory Health Study (EBCRHS) in the San Francisco Bay Area, California a cross-sectional study of current asthma and other respiratory symptoms in children (n=1,080) living at varying distances. It was highly urbanized region of the United States and ranked among the top four metropolitan areas with the worst traffic congestion as major source of air pollution [32]. For several traffic metrics, children whose residences were in the highest quintile of exposure had approximately twice the adjusted odds of current asthma (i.e. asthma episode in the preceding 12 months) as compared to children whose residences were within the lowest quintile. The highest risks were among those living within 75 m of a freeway/highway. The findings provided evidence that even in an area with good regional air quality, proximity to traffic was associated with adverse respiratory health effects and asthma in children.

Although many studies on respiratory problems have been conducted for Amritsar region, yet, no report is available on the estimation of particulate matter of the region. The present study is of importance being the first such report on estimation of TSPM. The study is in line with [33] who also indicated that temperature was positively correlated with particulate matter concentrations in United States. Dawson et al. [34] reported variability among temperature, relative humidity (RH), precipitation and wind circulation and considered these parameters as important predictors of air quality. Temperature was also found to be positively correlated to existence of other air pollutants like sulfate, organic carbon (OC) and elemental carbon (EC). The present study did not reveal any significant correlation of TSPM with other metrological parameters.

CONCLUSION

Well-being of human health is basic upshot of medical care. We recommend continuous monitoring of air quality so that pediatrics can implement and suggest necessary clinical measures to combat with asthma relating causalities in Punjab, India. Further studies are recommended to cover other factors that might contribute significant role in clinical trials and help in improving urban air quality.

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