Environment Conservation Journal 14(1&2)113-119 , 2013
ISSN 0972-3099 (Print) 2278-5124 (Online)
Abstracted and Indexed

Ambient air quality of Katra Town (J&K): A Study with Reference to atmospheric particulates

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Received: 22.01.2013 **Accepted: 28.03.2013**

Abstract

The monitoring of ambient air quality of Katra (one of the important town of Jammu from economic as well as religious point of view), at selected locations of residential areas, commercial areas and traffic crossings with respect to particulate matter (both respirable and non-respirable) has been conducted for a period of two years i.e. July 2010 – June 2012. Large variations in ambient particulate matter concentrations have been observed throughout the study period. Seasonally, the particulate matter exhibited low values during monsoon period and high values during post-monsoon period. The concentration of particulates (both respirable and non-respirable) in post monsoon season exceeded the concentrations than that of other seasons at most of the sites, thereby signifying the impact of local factors on pollutant concentrations, besides the impact of meteorological factors. Higher concentrations have been recorded in the year 2011-2012 as compared to 2010-2011 at all the sites except traffic crossings.

Keywords *Ambient air quality, Katra town, RSPM, TSPM, seasonal variations*.

Introduction

Mankind's relations with the environment are becoming more complex with the scientific and industrial revolution as a result environment has become the most obvious sink for various pollutants like sulphur dioxide, nitrogen dioxide, hydrocarbons, carbon monoxide and particulates released during various activities (Raina and Sharma, 2006). RSPM (both PM_{10} and $PM_{2.5}$), SO_2, NO_2, CO, O_3 and Lead) has been identified by United State Environment Protection Agency (USEPA) as six criteria pollutants which have to be considered important from public health viewpoint. Air borne particulate matter is the recent focus of the world community as it penetrates the respiratory system of human beings and causes many disorders. It has also been shown through worldwide studies that the urban population is at risk due to elevated levels of particulate matter in the ambient air (Mohanraj and Azeez, 2004). Therefore, it is important to know particulate matter concentration in the ambient air. Both respirable and non-respirable particulate matter is major ubiquitous particulate contaminants of the air.

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Several activities like construction and demolition, vehicular traffic, movement of public, meteorological conditions etc. contribute for the particulate matter. The adverse effects of air borne particulates upon health are well recognised. These particles can penetrate deep into the respiratory system and studies indicate that smaller the particle, more severe the health impacts (Dockery and Pope, 1994). Short term exposure to particulate matter contributes to respiratory symptoms, adverse effects on cardio-vascular system, increase in medication usage, hospital admissions and mortality. Effects related to long term exposure include increase in Chronic Obstructive Pulmonary Disease (COPD) and reduction in lung function in adults and children (Dockery, 2002). Atmospheric particulate matter is the major air pollutant in India. Several studies have been carried out in India to highlight the air quality status in relation to total suspended particulate matter (Sharma *et al.*, 2005; Bhaskar and Mehta, 2010; Dahabi *et al.*, 2010; Vanadeep and Krishnaiah, 2011). In many Indian cities, the level of particulate pollutants in the ambient air has been found to be above the permissible limits (Mohanraj and Azeez, 2004). In Katra (latitude 32^0 59'N , longitude 74^0 55'E, altitude 2840 ft) , religiously and economically important town of Jammu, construction and demolition for providing better infrastructure to tourists is a growing trend. Also, the number of vehicles along with other sources of pollution is constantly increasing because of continuous increase in the number of tourists. So far, no systematic study has been carried out to monitor the concentration of atmospheric particulate matter in the ambient air of the Katra town.

Material and Methods

To estimate the ambient air quality with respect to particulate matter, three residential areas (Paharganj, Gopal Nagar and Keshav Nagar), three commercial areas (Main bazaar, Chintamani and Hospital road) and three traffic crossings (Bus stand, Railway road and Serli) have been identified after a thorough survey of the town. Air sampling was carried out by using High Volume Air Sampler (Envirotech Model 460 BL) based on the method IS 5182, part IV. The sampling instrument was fixed at a breathing height of 1.5-2m above the ground level. The sampling has been carried out on monthly basis during day time for 8 hours for a period of 2 years i.e. July 2010 to June 2012. The respirable fraction (RSPM or PM_{10}) was collected on pre-weighed Whatman glass microfiber filter paper (G/F, 20.3 x 25.4 cm). Particles in the size range of (10-100µm) were collected in a separate sampling bottle placed under hopper assembly of the cyclone fitted in the APM-460 BL sampler to separate the coarse particles from air stream before filtering it on the glass microfiber filter. The filter paper and sampling bottle were re-weighed after sampling in order to determine the mass of particles collected. Finally, the TSPM (Total suspended particulate matter) concentration was calculated by summing up the RSPM (PM_{10}) and NRSPM (PM_{10-100}) concentrations.

Results and Discussion

The monthly data on particulate matter concentration (RSPM, NRSPM and TSPM) of residential areas, commercial areas and traffic crossings for the study period has been depicted in Table 1. In the residential areas, the average concentration of RSPM , NRSPM and TSPM during the first year of study period (July 2010 to June 2011) varies between 20.0 µg/m³ to 93.65µg/m³, 39.97 µg/m³ to 252.51 µg/m³ and 59.97 µg/m³ to 329.82 µg/m³, respectively whereas during the second year (July 2011 to June 2012), their values varies between 23.79 µg/m³ to 113.03 µg/m³, 42.49 µg/m³ to 225.01 µg/m³ and 67.19 µg/m³ to 337.52 µg/m³, respectively. In the commercial areas, the average concentration of RSPM, NRSPM and TSPM varies between 29.47 µg/m³ to 187.47 µg/m³, 74.02 µg/m³ to 301.09 µ/m³ and 112.6 µg/m³ to 477.86 µg/m³, respectively, during the first year and between 35.03 µg/m³ to 194.05 µg/m³, 81.09 µg/m³ to 491.01 µg/m³ and 127.36µg/m³ to 685.06 µg/m³, respectively, during second year. At traffic crossings, the average concentration of RSPM, NRSPM and TSPM during the first year of study period varies between 40.32 µg/m³ to 293.02µg/m³, 91.73µg/m³ to 848.29 µg/m³ and 132.05µg/m³ to 1060.89 µg/m³, respectively and between 10.40 µg/m³ to 288.11, 100.85µg/m³ to 863.91µg/m³ and 145.23 µg/m³ to 1152.02 µg/m³, respectively during the second year. The concentration of particulates has been observed to be always higher in traffic crossings and commercial areas in comparison to residential areas. According to Vanadeep and Krishnaiah (2011), the traffic generated emissions are accounting for more than 50% of the total particulate matter emissions in the urban areas. The number of vehicles in Jammu is increasing tremendously due to the growing tendency of the public to own a vehicle and this has resulted in the increase in vehicular population. The growing number of vehicles, outdated engine designs, defective and deficient road network, erratic driving patterns and congested slow moving traffic contribute to tremendous increase in air pollution problems in most of the developing countries like India (Dutta and Meena, 2008). At traffic crossings, higher levels of particulates have been recorded at Railway Road, which can be attributed to heavy traffic flow especially heavy vehicles (buses and trucks) and re-suspension of road dust. The quality of road pavement and streets is very poor at this location and a large quantity of dust accumulates in the air by wind and traffic movement. Vehicles

Table 1: Monthly values of RSPM, NRSPM and TSPM ($\mu g/m^3$) at different sites during 2010-2012

Sites	Pollutants	Months											
		July	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June
2010-11													
A. Residential Area													
Paharganj	RSPM	30.58	33.87	40.13	62.95	71.39	93.65	89.98	63.97	74.49	52.30	47.52	77.31
	NRSPM	75.73	41.53	93.17	92.90	163.47	165.07	101.53	98.30	89.34	140.23	149.65	252.51
	TSPM	106.31	75.4	133.3	155.85	234.86	258.72	191.51	162.27	163.83	192.53	197.17	329.82
Gopal Nagar (Kun Drorian)	RSPM	39.21	20.0	42.36	65.73	81.63	80.04	59.87	58.45	66.30	20.37	62.33	50.76
	NRSPM	95.37	39.97	79.13	109.87	149.79	151.01	97.61	91.09	151.90	109.80	131.29	215.13
	TSPM	134.58	59.97	121.49	175.6	231.42	231.05	157.48	149.54	218.2	130.17	193.62	265.89
Keshav Nagar	RSPM	43.08	25.34	48.43	68.02	86.31	77.42	64.63	60.69	63.62	23.76	58.76	59.92
	NRSPM	89.37	67.09	82.75	101.08	155.79	147.13	98.72	92.17	113.76	127.11	137.27	202.0
	TSPM	132.45	92.43	131.18	169.1	242.1	224.55	163.35	152.86	177.38	150.87	196.03	261.92
B. Commercial Areas													
Main Bazaar	RSPM	86.47	44.87	53.97	101.03	75.63	127.47	151.5	92.70	95.79	102.38	87.31	187.47
	NRSPM	105.36	89.07	207.39	179.0	141.50	246.98	217.64	139.71	145.09	187.37	176.0	201.72
	TSPM	191.83	133.94	261.36	280.03	217.13	374.45	369.14	232.41	240.88	289.75	263.31	389.19
Chintamani	RSPM	82.63	38.58	49.82	71.25	93.48	156.8	147.3	84.28	90.03	96.20	81.29	179.4
	NRSPM	101.79	74.02	92.15	171.40	189.97	197.78	181.50	192.07	203.61	211.70	197.33	298.46
	TSPM	184.42	112.6	141.97	242.65	283.45	354.58	328.80	276.35	293.64	307.9	278.62	477.86
Hospital Road	RSPM	73.96	29.47	41.05	67.43	84.74	133.7	135.83	79.40	53.25	87.49	75.04	163.26
	NRSPM	108.10	97.37	113.17	125.53	133.71	301.09	289.06	294.13	177.55	202.71	194.01	269.53
	TSPM	182.06	126.84	154.22	192.96	218.45	434.79	424.89	373.53	230.08	290.2	269.05	432.79
C. Traffic Crossings													
Bus Stand	RSPM	80.96	40.32	54.48	123.4	97.17	247.61	156.10	89.73	94.57	107.24	89.04	194.50
	NRSPM	119.73	91.73	96.15	217.41	198.64	401.7	164.4	129.71	210.54	253.14	231.92	205.83
	TSPM	200.69	132.05	150.63	340.81	295.81	648.61	320.05	219.44	305.11	360.38	320.96	400.33
Railway Road	RSPM	197.06	151.84	156.97	203.14	148.13	222.62	293.02	200.32	203.13	253.02	245.11	212.60
	NRSPM	500.04	405.36	407.01	524.10	301.09	738.03	525.8	419.1	769.37	707.0	719.36	848.29
	TSPM	697.1	557.2	563.98	727.24	449.22	960.65	818.82	619.42	972.5	960.02	964.47	1060.89
Serli	RSPM	51.13	67.18	62.9	101.17	86.61	157.7	177.36	167.03	89.75	107.47	121.52	169.17
	NRSPM	99.78	197.05	115.2	311.07	214.08	586.9	201.07	304.13	213.87	219.05	252.31	407.46
	TSPM	150.91	264.23	178.1	412.24	300.69	744.6	378.43	471.16	303.52	326.52	373.83	576.63
2011-12													
A. Residential Area													
Paharganj	RSPM	34.67	37.98	56..37	67.49	85.02	113.03	62.13	69.74	41.26	27.77	49.86	62.13
	NRSPM	82.73	80.64	91.71	97.66	170.60	224.49	106.90	101.18	103.07	108.74	167.67	123.65
	TSPM	117.4	118.62	148.08	165.15	255.62	337.52	169.03	170.92	144.33	136.51	217.53	185.78
Gopal Nagar (Kun Drorian)	RSPM	42.82	24.70	31.02	77.75	92.74	78.56	93.33	68.87	54.07	25.70	68.06	54.89
	NRSPM	101.65	42.49	67.13	117.37	153.25	158.95	185.84	116.71	160.42	111.38	138.30	225.01
	TSPM	144.47	67.19	98.15	195.12	245.99	237.51	279.17	185.58	214.49	137.08	206.36	279.90
Keshav Nagar	RSPM	47.07	29.33	51.79	73.64	89.12	98.71	71.08	73.91	61.31	23.79	57.47	59.17
	NRSPM	99.71	77.03	86.63	101.71	149.07	167.14	129.71	111.37	175.28	129.51	149.14	158.04
	TSPM	146.78	106.36	138.42	175.35	238.19	265.85	200.79	185.28	236.59	153.3	206.61	217.21
B. Commercial Areas													
Main Bazaar	RSPM	93.62	46.27	106.96	76.39	106.28	194.05	149.26	95.31	99.64	106.30	111.49	181.43
	NRSPM	166.38	81.09	189.17	161.36	244.28	491.01	296.96	149.42	217.26	156.58	163.13	209.14
	TSPM	260.0	127.36	296.13	237.75	350.56	685.06	446.22	244.73	316.9	262.88	274.62	390.57
Chintamani	RSPM	85.83	44.96	51.37	70.30	123.73	139.03	114.14	161.47	103.28	87.11	108.38	132.10
	NRSPM	202.00	171.13	185.57	190.01	195.37	196.64	208.88	286.79	279.01	224.34	251.54	226.66
	TSPM	287.83	216.09	236.94	260.31	319.1	335.67	323.02	448.26	382.29	311.45	359.92	358.76
Hospital Road	RSPM	76.39	35.03	48.37	65.36	91.28	184.00	129.36	83.26	59.71	69.29	83.83	153.64
	NRSPM	115.63	95.17	81.39	128.53	169.48	253.06	231.97	143.04	149.72	183.05	217.47	301.3
	TSPM	192.02	130.2	129.76	193.89	260.76	437.06	361.33	226.3	209.43	252.34	301.3	454.94
C. Traffic Crossings													
Bus Stand	RSPM	10.40	48.48	98.48	79.18	100.29	114.35	71.93	82.48	97.82	94.34	82.55	90.82
	NRSPM	134.83	131.74	100.85	268.25	297.27	228.34	105.59	109.62	224.46	247.18	254.02	340.62
	TSPM	145.23	180.22	199.33	347.43	397.56	342.69	177.52	192.1	322.28	341.52	336.57	431.44
Railway Road	RSPM	218.55	166.86	201.02	247.54	155.77	153.13	241.31	182.40	288.11	195.85	176.30	165.06
	NRSPM	598.86	470.43	479.17	618.25	394.11	362.82	486.11	379.04	863.91	608.10	418.64	486.60
	TSPM	817.41	637.29	680.19	865.79	549.88	515.95	727.42	561.44	1152.0	803.95	594.94	651.66
Serli	RSPM	69.15	72.39	93.06	86.61	100.22	115.71	76.99	74.29	157.57	96.85	53.46	99.53
	NRSPM	108.79	219.64	223.19	355.13	215.32	274.04	159.60	149.37	258.33	294.03	113.59	336.61
	TSPM	177.94	292.03	316.25	441.74	315.54	389.75	236.59	223.66	415.9	390.88	167.05	436.14

with large engine size emit more pollutant (Mathew,2012).There were more construction activities because of newly developed railway station near this site which has also resulted in higher emissions of coarse particulate matter. Namedo and Bell, (2005) has also reported higher emissions of coarse particulate matter due to construction activities. Also, indiscriminate burning and dumping of municipal solid waste in open near this point contributes towards higher concentrations of particulate matter.In commercial area, the maximum concentration of particulates has been recorded at Main bazaar. Heavy traffic flow, frequent traffic jams and slow speed of vehicles, presence of auto-rickshaw stand for passengers etc. contributes for the higher particulate matter concentrations at this site. Traffic jams are common at this site as the roads are narrow and congested and also because of heavy rush of tourist for shopping, free flow of traffic is often interrupted. Tom and Mathew (2012) have also reported the increase in emissions of particulate matter with the decreasing speed of vehicles. In addition to vehicular exhaust, re-suspension of road dust, presence of small restaurants, use of coal and wood as a fuel in nearby eateries (*dhabhas*), bakery shops and prominent shopping complexes for tourists as well as for locals and large number of construction activities also increases the concentration of particulate matter. Use of diesel-powered generators during frequent electricity supply cuts, also contribute for the increase in concentration. Moreover, tall buildings on both sides of the road prevent wind speeds from being sufficiently strong to be able to disperse the pollutants.Ambient particulate concentrations has been recorded lowest in residential areas as compared to other study sites; however in this category lowest concentrations have been recorded in Gopal Nagar which may be attributed to comparatively lower number of inhabitants, less construction, lesser number of vehicles and presence of vegetation around this site. This area has not been commercialized as compared to other sites.During the study period, most of the times, the concentration of particulates (both respirable and non-respirable) at commercial sites and traffic crossings has been found to be above the permissible limits as stipulated by CPCB (Table 3).Month wise variation of total suspended particulate matter concentration has shown highest values in March, 2011 (1060.89µg/m³) and June, 2012 (1152.02µg/m³), respectively. The higher concentration of particulates in March has been attributed to Navratra festival being held at Katra , increased number of tourists in navratras and strengthening of winds associated with monsoon currents whereas higher concentrations in the month of June may be attributed to increase in vehicular traffic because of heavy rush of tourists in summer holidays and also the increased construction activities due to favourable weather conditions. The lowest concentration of total suspended particulate matter has been recorded in the month of August, 2010 (59.97µg/m³) and July, 2011 (10.40µg/m³), respectively. Heavy rainfall during this period has resulted in washing out of pollutants and cleaning the atmosphere. Seasonal variation of RSPM and TSPM show low value during the monsoon period at all the selected locations and high values during post monsoon, winter and summer season (Table 4).

Table 3: National ambient air quality standards , CPCB

Location Type	Permissible limits in µg/m³	
	RSPM (PM_{10})	SPM
Industrial	100*	500**
Residential	100*	200**
Ecologically sensitive areas	100*	100**

* denotes revised standards (2009)

** denotes old standards since SPM parameter has been excluded in the revised standards.

Table 4: Seasonal average of RSPM, NRSPM and TSPM at different sites during the study period

Sites	Pollutant	Seasons			
		Summer	Monsoon	Post-Monsoon	Winter
A. Residential Areas					
Paharganj	RSPM	48.86	46.63	82.25	71.45
	NRSPM	126.45	105.20	152.36	101.97
	TSPM	175.31	151.83	234.62	173.43
Gopal Nagar (Kun Drorian)	RSPM	49.46	38.21	79.40	70.13
	NRSPM	133.84	108.23	140.04	122.81
	TSPM	183.31	146.45	219.57	192.94
Keshav Nagar	RSPM	48.11	45.51	82.20	67.57
	NRSPM	138.67	107.82	136.95	107.99
	TSPM	186.79	153.34	219.18	175.57
B. Commercial Areas					
Main Bazaar	RSPM	100.48	100.13	113.47	122.2
	NRSPM	174.19	156.16	244.02	200.92
	TSPM	274.22	256.29	357.49	323.12
Chintamani	RSPM	94.38	83.08	109.09	126.79
	NRSPM	227.92	168.97	190.19	217.30
	TSPM	322.3	252.06	299.29	344.10
Hospital Road	RSPM	71.43	77.64	104.41	106.96
	NRSPM	187.41	147.70	185.23	239.54
	TSPM	258.73	225.35	289.64	346.51
C. Traffic Crossings					
Bus Stand	RSPM	94.26	77.3	127.0	100.05
	NRSPM	236.87	152.68	268.6	127.3
	TSPM	331.13	229.99	395.48	227.27
Railway Road	RSPM	226.91	183.74	188.38	229.26
	NRSPM	681.06	524.51	489.7	452.51
	TSPM	907.98	708.21	678.12	681.78
Serli	RSPM	104.43	85.56	108.0	123.91
	NRSPM	225.19	213.46	326.09	203.54
	TSPM	329.61	229.02	434.09	327.46

The relatively high values in the summer season especially after March can be attributed to the strengthening of winds associated with the monsoon currents. The strong and medium winds creates turbulent conditions and local disturbances in the environment which cause frequent dust storms and hazy conditions that build up high particulate matter levels in the ambient air. The summer maxima owe to a great increase in vehicular traffic because of heavy rush of tourists in summer holidays and also the increased construction activities due to favourable weather conditions. Low humidity and higher wind speeds also aggravate the condition and contribute towards the higher concentration of particulates in summer. The sharp fall in particulate concentration in the monsoon season shows the effect of rain on clearing the atmosphere. Particulate matter absorbed by clouds and /or raindrops get washed down during rainfall (Ravindra *et al.*, 2003) which contributes to the cleaning of atmosphere. In rainy season due to humidity, the suspended particulates present in the atmosphere also settle down. Because of rainfall, the soil become damprestricting the possibility of soil derived particles being released. Low values of particulates during the monsoon period is also in line with the findings of Mishra *et al.*, (2011) and Bhaskar and Mehta, (2010). During post- monsoon season, their concentration has been found to be higher. The reason may be increased October heat and very heavy flow of tourists and vehicles due to Navratras and festival activities like Dusshera and Diwali.The concentration of these pollutants has increased significantly in 2011-2012 as compared to 2010-2011 in commercial and residential areas while at two of the traffic crossings, their concentrations has shown a decrease in 2011-2012 as compared to 2010-2011. The decrease in concentration at two of the selected traffic crossings has resulted due to the diversion of routes of inter-state buses during this period of heavy rush.Dispersion and transportation of particulates is also affected by meteorological parameters. Several studies have revealed that meteorological parameters like wind speed, relative humidity, precipitation and temperature affect the distribution of particulates (Sharma *et al.*, 2005; Bhaskar and Mehta, 2010 and Mishra *et al.*, 2011). Relative humidity, ambient temperature and precipitation are inversely correlated with particulates. Low wind speed inhibit dilution whereas high wind speed lead to increased soil dust mobilisation (Mkoma and Mjemah, 2011). Reduced dispersion on account of low wind velocity and low temperature contributes towards the high concentration of particulates (respirable and non-respirable) in winter. Burning of fuel wood and fossil fuel on a large scale for cooking and for heating in winter also contributes to the problem. Moreover, winter received much less rainfall in comparison to other seasons. As a result, removal of atmospheric particulates by wet scavenging is much reduced during this period. Similar results have also been reported by Sharma *et al.*, (2005); Bhaskar and Mehta (2010); Dahabi *et al.*, (2010) and Majumder *et al.*, (2012).Thus, the present study revealed the significant seasonal variations of particulate matter concentrations at all the selected locations with higher concentrations during post monsoon, winter and summer season and lower during monsoon season. Their concentrations have often crossed the National Ambient Air Quality Standards as stipulated by CPCB at many sites. Continuous rise in concentration of particulates reflect the ever increasing trend of vehicular population and development activities in the town.

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