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RESEARCH ARTICLE

STUDY OF SEASONAL CONCENTRATION OF SPM, RSPM, SO_2 AND NO_X IN THE AMBIENT AIR OF REWA CITY (M.P.), INDIA

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ABSTRACT

This study was undertaken to assess the ambient air quality status and seasonal variations of ambient air pollutants SPM, RSPM, SO_2 and NO_X at eleven different sites in Rewa city. According to air quality surveys the levels of average value of RSPM, SO_2 and NO_X in sampling site are well within prescribed limits, whereas average concentrations of SPM in the ambient air of the Rewa city are above the permissible limits as per National Ambient Air Quality Standards (NAAQS) and Central Pollution Control Board (CPCB). Concentrations of all the pollutants were found to be highest during winter season followed by summer and least during post monsoon season.

INTRODUCTION

Air pollution is considered to be primarily an urban problem as the rate of industrialization and unsystematic urbanization increases day by day. It has become a major environmental problem faced by the people globally in both developing and developed countriesin recent times (Nagdeve2004, Barman *et al*.2010, Chaudhary *et al*.2013, Charan and Sahel 2014 and Ahmad and Bano 2015) and India is one of them. Rapid industrialization for economic development to meet the specific requirements of the ever-increasing population is proving to be extremely dangerous for human life, ecosystems and cultural assets. (Agrawal and Agrawal 1990, Joshi *et al*.1991, Banerjee *et al*.2007 and Song *et al*. 2016). Ambient air quality in India have progressively deteriorated due to anthropogenic sources like rapid urbanization, industrialization, uncontrolled increase of vehicles on poor road conditions, construction debris, garbage burning, lack of public awareness, domestic cooking/heating and seasonal causes such as dust storms. (Mangalekar *et al*. 2013, Tsang *et al*. 2008, Chaurasia *et al*. 2013 andSharma and Sharma 2016). SPM, RSPM, SO_2, and NO_2 are regarded as major air pollutants in India (Aihara *et al*. 1996, Beckett *et al*. 1998, Agarwal and Singh2000). The automobile emissions constitute a major source of environmental pollution in Indian cities.

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Petrol and diesel engine driven motor vehicles release a wide variety of pollutants particularly benzene, carbon monoxide, organic compounds, oxides of nitrogen, sulphur dioxide and suspended particulate matters like ultra fine primary particles, smoke, metals (Cd, Co, Cu, Pb, etc.) and inert dust. Also the ultra-fine particles when released quickly coagulate to form larger particles, through reaction with other pollutants like ammonia, sulphur dioxide, nitrogen oxides and volatile organic compounds (Street *et al*. 1996, Nolte *et al*. 2002, Sharma *et al*.2006, Chaurasia *et al*. 2013 andShrivastava *et al*. 2013). In order to monitor the ambient air quality of Rewa city based on suspended particulates, sulphur dioxide (SO_2) and oxides of nitrogen (NO_X) a fact-finding study was conducted for a period of two years i.e. 2013-14 and 2014-15. The concentrations of different pollutants is compared with the standard limits prescribed by Central Pollution control Board (CPCB) and air quality parameters are also worked out on that basis.

MATERIALS AND METHODS

Study area- The present study was conducted in Rewa city, which is situated on the north east border of Madhya Pradesh, central part of India. It is located at 24º18' and 25º12' north latitudes and 81º2' and 62º18' east longitudes and 316 meters above mean sea level (MSL), with a total geographical area 6,314 kilometers having a population about 3.0 lakhs .The climate is humid subtropical with cold, misty winter, a hot summer and a humid monsoon season.

Sampling

Air quality monitoring at eleven selected sites of Rewa city have been carried out viz; Sirmour square, Saman square, Hospital square, Transport nagar, Stadium square, PTS square, Jaistambh square, Nagar nigam, Prakash square and Civil lines along with control site (APS University Campus) of Rewa City for two years. Sampling was carried out at the eleven different locations using Respirable Dust sampler (Envirotech model APM 460 BL-411) for 8 hours in a day at an average flow rate of 1.5 LPM as per the standards of Central Pollution Control Board (India).Monitoring is carried out once in a month at sampling site during 2013-14 and 2014-15. Suspended particulate matters (SPM) and respirable suspended particulate matters (RSPM) were collected on the dust cup and glass fabric filter paper respectively. Samples for determination of gaseous pollutants (SO_2 and NO_x) were collected by bubbling air samples in Sodium tetra chloromercurate and Sodium hydroxide-Sodium arsenate absorbent solutions respectively in impingers at flow rate of 1.5 LPM. These samples were analyzed for SO_2 and NO_X spectrophotometrically.

RESULTS AND DISCUSSION

Table-1 represents the seasonal average concentrations of air pollutants in the ambient air of sampling site have been computed from the basic data. Result indicated higher concentrations of air pollutants in winter months as (SPM 407.88±136.88µg/m^3, RSPM90.25±30.95µg/m^3, SO_2 29.24±6.48 µg/m^3, NO_X37.79±13.79µg/m^3) as compared to summer (SPM 260.18±65.99 µg/m^3, RSPM 79.88±29.35µg/m^3, $SO_2$21.89±4.90 µg/m^3,NO_X 27.31±9.34 µg/m^3) and rainy (SPM 179.14±27.59 µg/m^3, RSPM 46.95±13.40 µg/m^3, SO_2 16.72±3.60 µg/m^3, NO_X21.47±6.80 µg/m^3) months during 2013-14. There concentrations were computed as (SPM 421.13±150.05 µg/m^3, RSPM 94.04±31.26 ,$SO_2$30.89±7.13, NO_X41.60±13.30 µg/m^3) in winter followed by (SPM 265.98±70.07 µg/m^3, RSPM 81.32±31.60 µg/m^3, $SO_2$23.38±5.48 µg/m^3, NO_X30.38±9.35 µg/m^3) in summer and (SPM 180.51±28.97 µg/m^3, RSPM 46.15±16.71 µg/m^3, $SO_2$17.88±3.86 µg/m^3, NO_X21.76±5.29 µg/m^3) in rainy months of 2014-15 respectively. This trend of seasonal variation in pollutant concentrations under present investigation supports the findings of other workers (Joshi *et al*. 1991, Bhaskar and Mehta 2010, Guttikunda and Jawahar 2011, Nair *et al*. 2014 and Jhamaria and Jadon 2016). The higher concentration of pollutants during winter season can be attributed to low temperature, increasing the density of air and reducing the dispersion of pollutants. The basic data have been computed with suitable statistical approach (ANOVA) to observe the inter as well as intra-sites seasonal differences in concentrations of various pollutants for both the year (Table-2 and Table-3).

Results revealed that there was significant difference in SPM, RSPM, SO_2 and NO_X concentrations in ambient air of Rewa city between three seasons. Similarly, the observed pollutants concentrations varied significantly between different studied sites as well as within sites with respect to three seasons. A comparison has been made between overall annual average concentrations of air pollutants of two years (Fig.1). Results revealed slightly higher concentrations of SPM, RSPM, SO_2 and NOx in the ambient air of Rewa city during the year 2014-15 than those of 2013-14. Result determined the average annual concentrations of air pollutants such as (RSPM 72.35 µg/m^3, $SO_2$22.62 µg/m^{3}and NO_x 27.52 µg/m^{3}during 2013-14 and RSPM 73.84 µg/m^{3}µg/m^3, $SO_2$24.05 µg/m^{3}µg/m^{3}and NOx 31.25 µg/m^{3}in 2014-15) in the ambient air of selected site

Table-1 Seasonal average concentrations of air pollutants (µg/m^3) in the ambient air of sampling sites of Rewa city observed during the year 2014 and 2015

S.No.	Pollutants (µg/m^3)	Year 2013-14			Year 2014-2015		
		W	S	R	W	S	R
1.	SPM	407.88±136.88	260.18±65.99	179.14±27.59	421.13±150.05	265.98±70.07	180.51±28.97
2.	RSPM	90.25±30.95	79.88±29.35	46.95±13.40	94.04±31.26	81.32±31.60	46.15±16.71
3.	SO_2	29.24±6.48	21.89±4.90	16.72±3.60	30.89±7.13	23.38±5.48	17.88±3.86
4.	NO_X	37.79±13.79	27.31±9.34	21.47±6.80	41.60±13.30	30.38±9.35	21.76±5.29

Table-2 One way ANOVA showing the significant seasonal changes during the year 2013-14 and 2014-15

Pollutants	Year 2013-14		Year 2014-15.	
	F-Value	P-value	F-Value	P-value
SPM	18.61	P<0.0001 ***	17.37	P<0.0001 ***
RSPM	08.437	P=0.0012 **	9.004	P=0.0009 ***
SO_2	16.51	P<0.0001 ***	14.62	P<0.0001 ***
NO_X	06.973	P=0.0033 **	11.16	P=0.0002 ***

* Significant

'F' value at 2 and 30 d.f. on 0.05% level is 3.32

Table-3 Two way ANOVA showing inter-site and intra-seasonal (P_C-value) with inter site seasonal changes (P_R-value) during the year 2013-14 and 2014-15

Pollutants	Year 2013-14				Year 2014-15			
	F-value		P-value		F-value		P-value	
	C	R	P_C	P_R	C	R	P_C	P_R
SPM	44.50	5.173	P<0.0001 ***	P=0.0009 ***	38.67	04.67	P<0.0001 ***	P=0.0016 **
RSPM	52.52	16.67	P<0.0001 ***	P<0.0001 ***	68.47	20.81	P<0.0001 ***	P<0.0001 ***
SO_2	63.16	09.47	P<0.0001 ***	P<0.0001 ***	79.69	14.29	P<0.0001 ***	P<0.0001 ***
NO_X	43.41	16.67	P<0.0001 ***	P<0.0001 ***	40.89	09.05	P<0.0001 ***	P<0.0001 ***

* Significant

'F' value at 2 and 10 d.f. on 0.05% level is 3.32

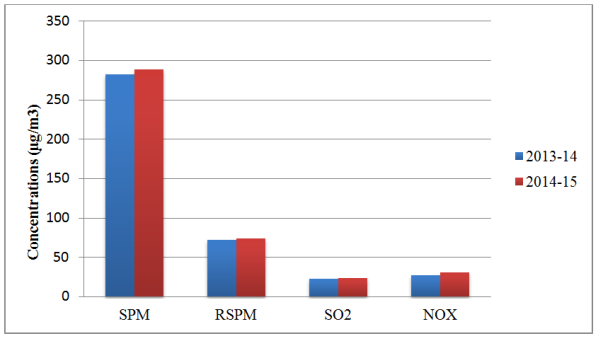

Fig.1 Annual average concentration of the ambient air of sampling site during 2013-14 and 2014-15

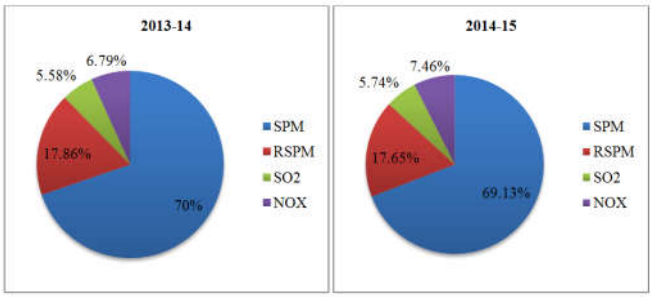

Fig.2: Percent contribution of each pollutant to the ambient air of Rewa city observed during 2013-14 and s2014-15

during both the years have been observed lower than the standard value prescribed by CPCB, New Delhi (100 µg/m^3 for RSPM and 80 µg/m^3 for SO_2 and NO_x for residential and rural uses). Whereas results shows higher concentrations of SPM (282.40 µg/m^3 in 2013-14 and 289.21 µg/m^3 in 2014-15) in the ambient air than the standard value of 200 µg/m^3 , prescribed by CPCB, New Delhi for the residential and rural uses. Higher concentrations of SPM are also observed by many other workers. (Watkins 1991,Meenakshi and Saseetharan 2003, Yadav *et al*. 2012,Shukla *et al*. 2010,Mohammed *et al*. 2014, Gohain and Kalita 2016, Rai and Mishra 2015, Balashanmugam,` 2012 and Nandanwar, 2014).

Fig-2 shows percentage concentration of each pollutant to the total pollutants observed in the ambient air of sampling site during 2013-14 and 2014-15. Results indicate maximum contribution of SPM (69.74% in 2013-14 and 69.13% in 2014-15) to the ambient air. RSPM contributed about (17.86% in 2013-14 and 17.65% in 2014-15) to the total pollutants of the ambient air during both the years. There was lesser contribution of gaseous pollutants (NOx and SO2). Nitrogen oxides had contributed to the total air pollutants in the ambient (6.79% during 2013-14 and 7.46% during 2014-15) and other hand, SO_2 contributed about (5.58% in 2013-14 and 5.74% in 2014-15) to the total pollutants in the ambient air of sampling site during monitoring period.

Result of the study for Rewa city is similar with research for other cities of India as the concentration of particulate matter is also high in other cities. High particulate concentration is due to heavy transport activity in study area, apart from industrial emissions, dust from paved roads, garbage burning in open and other domestic purposes. All pollutants were observed to be high in concentration during winters as compared to summer and monsoon, due to slow dispersion and dilution of pollutants.It can be summarized that air pollution at the study site is primarily because of vehicular emissions by heavy traffic.

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