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Influence of temperature on particulate matter concentration in ambient air of Ranchi city

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Abstract : The concentration of air pollutants in ambient air is governed by the meteorological parameters such as atmospheric wind speed, wind direction, relative humidity, and temperature. This study analyses the influence of temperature on ambient PM_{10}, and SPM concentrations at Ranchi city during monsoon, post-monsoon, summer, and pre-monsoon seasons for 2010 using regression analysis. The results of the study show that PM_{10} and SPM had positive correlation with temperature in all the seasons.

Key words: Particulate matter; Ambient air; SPM; PM_{10}

INTRODUCTION

Air pollution is generally associated with human activities and depends on the level of economic development. Air pollution from anthropogenic factors has its origin from the period when man first lighted fire. Subsequently with the rapid increase in fossil fuel burning the problem aggravated. Today air pollution is one of the most important environmental problems, and concentrates mostly in cities. Rapid urbanization brings about qualitative and quantitative changes in the ecosystem and creates imbalance in the different components of ecosystem. The environmental problems are much greater in the cities of developing countries, due to the overwhelming scale and speed of urbanization[1].

Air pollution affects climate, and climatic factors affect air quality by perturbing ventilation rates (wind speed, mixing depth, convection, frontal passages), precipitation scavenging, dry deposition, chemical production and loss rates, natural emissions, and background concentrations. Air pollutants are let out into the atmosphere from a variety of sources, and the concentration of pollutants in the ambient air depends not only on the quantities that are emitted but also the ability of the atmosphere, either to absorb or disperse these pollutants.

The consequences of air pollution were recognized at the middle of 20th century. Even before epidemiological studies confirmed the existence of association between air pollution and human health, laws were proposed to control the burning of fuels in London. Prior to 1981, there were no specific standards for Ambient Air Quality (AAQ) in India, and after enforcement of Air (Prevention and Control of Pollution) Act 1981, the first Ambient Air Quality standards were adopted in November 1982 and revised in April 1994 and again in November 2009 [2].

The pollution concentration in an urban area is a function of mixing depth, wind speed, and physical size of the city. The seasonal variation in climate has a profound influence on the concentration of pollutants. In case of particular matter the effect of ambient air temperature is found to have great influence on its concentration. The concentration of particulate pollutants during winter was observed to be higher than that in other seasons, irrespective of the monitoring sites at urban region of

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Kolkata (India), because of the longer residence time of particulates in the atmosphere during winter due to low winds and low mixing height [3]. In Haridwar (India) also, the concentrations of air pollutants were high in winter in comparison to summer or monsoon seasons [4]. Dominick *et al*. [5] studied the influence of meteorological parameters such as temperature, relative humidity, and wind speed on a daily average computation of PM_{10} and NO_2 at three selected stations in Malaysia and found that temperature has a positive correlation with the concentration of PM_{10}.

This study examines the influences of temperature on concentration of suspended particulate matter (SPM), and respirable suspended particulate matter (PM_{10}) in ambient air of Ranchi city with respect to seasonal variation in the year 2010.

MATERIALS AND METHOD

Description of Study Area. Ranchi city is the capital of Jharkhand state. It is located at 23.23^{0}N latitude & 85.23^{0}E longitude and is around 654 meters above mean sea level. The total area covered by Ranchi urban agglomeration is 35 sq. km. The city has witnessed a tremendous increase in population during the last two decades. The Census 2001 Ranchi figures for population was 8, 47,093, which increased to 1,056,724 in the year 2011, making it the 37th largest urban city of India. The growth in urban area is mostly unplanned because of a lack of Master Plan for the city. This has led to highly irregular growth pattern. Air pollution has been one of the major problems in Ranchi, due to its high population, high vehicle density and industries.

The state of Jharkhand experiences summer from March to May, followed by monsoon season from June to September. The periods October to December are the post-monsoon season and winter is from January to February. The average annual rainfall in Ranchi city is 1460 mm. The average temperature of Ranchi city ranges between 18.1 and 29.3^{0}C.

Meteorological, Ambient Air Quality Data, and Analysis.

The meteorological data has been obtained from IMD and the data on suspended particulate matter (SPM) and respirable suspended particulate matter (PM_{10}) has been collected by using Respirable dust sampler (RDS, Envirotech model APM 460 BL). The RSPM and SPM concentration was observed continuously for 8 hrs in a day. For the purpose of the present study three different localities were selected, namely, Kantatoli Chowk, Ashoknagar housing colony, and Tupudana Industrial area. The features of the study area can be outlined as below:

Kantatoli Chowk: It is one of the busiest traffic intersections of the City. The National Highway 33 and the National Highway 23 intersects at this chowk and converges with the arterial roads of the city. Since no bypass roads are available, hundreds of heavy vehicles carrying goods also cross this intersection daily. Close to the chowk is the private bus stand and the buses coming out of this stand are routinely found idling on the roadside. There are a number of shops and establishments, private clinics, nursing homes, and hospitals in the vicinity of this chowk.

Ashoknagar: This place is a developed residential part of the city. It is a posh area. Some banks and general stores are situated here. The development of this residential area has been done in a planned manner. The roads are wide and metalled. There are trees lining both flanks of the roads. The upkeep of the houses is good and most of the residential plots have well maintained garden.

Tupudana: This is located in the fringe area of the city. A large number of medium and small scale industries are functional in the Tupudana Industrial Estate. The notable ones are, Pragati Refractories, Ajanta Bottlers, Gondwana Refractories, Chotanagpur Refractories, etc. There are also several brick kilns close to the industrial estate.

In the present study, regression analysis procedure was attempted.

RESULTS AND DISCUSSION

The monthly average concentration of SPM, during the period from January 2010 to December 2010, varied between 65.00 and 396.00 ìg/m^3 in Kantatoli, 79.00 and 168.50 ìg/m^3 in Ashoknagar, and 97.00 and 316.40 ìg/m^3 in Tupudana. The PM_{10} values for the same period varied between 20.15 and 201.50 ìg/m^3 in Kantatoli, 24.00 and 78.45 ìg/m^3 in Ashoknagar , and 24.00 and 168.00 ìg/m^3 in Tupudana.

The meteorological data and the SPM and PM10 values are presented in Table 1.

The temperature recorded in the study area ranged between 26.3 – 31.1^{0}C during monsoon, 22.4-26.8^{0}C during post-monsoon, 28.4-33.2^{0}C during pre monsoon and 22.5-27.0^{0}C during winter season. The vertical distribution of temperature in the atmosphere varies with season and location in latitude and longitude, as well as from day to night. The temperature variations and its influence on concentrations of PM_{10}, and SPM in the ambient air were analyzed for monsoon, post monsoon, and pre-monsoon seasons, and the results of the regression study are presented in Table 2.

The SPM had a positive correlation with temperature in winter, pre monsoon, monsoon seasons at Kantatoli, Ashoknagar, and Tupudana . In pre monsoon season the r^2 values at Kantatoli, Ashoknagar, and Tupudana was 0.05, 0.54, and 0.26, respectively; in the monsoon season the corresponding values were 0.90, 1.00, and 0.95.In monsoon the correlation was found to be very strong and positive.

The post monsoon correlation gave mixed results. In case of Kantatoli there was positive correlation (r^2=0.32), while for Ashoknagar and Tupudana the correlation was negative (r^2= 0.11, and 0.09 for the two sampling stations).

In winter the correlation was positive.

PM_{10} values were found to have positive correlation with temperature in winter, pre monsoon, and post monsoon in Kantatoli (r^2= 1.0, 0.02, 0.88, and 0.34 for the four seasons). In case of Ashoknagar, the correlation was found to be positive during winter, pre monsoon, and monsoon season (r^2= 1.0, 0.95, 0.96). At Tupudana the correlation was found to be positive during all seasons (r^2= 1.0, 0.47, 0.80, and 0.02 for winter, pre monsoon, and monsoon, and post monsoon respectively).Only at Ashoknagar, PM_{10} was negatively correlated with temperature during post monsoon season (r^2=0.18).

The suspended particulate matter are subjected to scrubbing process during precipitation and thus the concentration of these two criteria pollutants in ambient air shows reduction in monsoon season and on rainy days. Girija Jayaraman [6] has studied the effects of seasonal variation on the concentration of particulate matter in Delhi where SPM was positively and significantly associated with temperature.

Table 1: Month wise concentration of SPM and PM10 in 2010 at select sampling stations

Month	Air Temp ^{0}C	Kantatoli		Ashoknagar		Tupudana	
		SPM	PM_{10}	SPM	PM_{10}	SPM	PM_{10}
January	27.0	334.50	165.00	98.00	24.00	222.00	79.50
February	22.5	196.75	88.90	123.00	48.00	268.50	110.00
March	28.4	165.00	79.00	78.70	34.12	196.00	80.50
April	33.2	196.40	87.20	136.25	76.00	316.40	168.00
May	31.2	396.00	201.50	163.15	67.25	113.25	58.50
June	31.1	316.00	153.00	168.50	78.45	188.12	96.00
July	27.5	65.00	20.15	98.00	33.00	101.20	45.00
August	27.4	11.25	65.15	101.20	38.30	98.50	24.00
September	26.3	88.50	28.50	79.00	31.15	97.00	42.70
October	24.8	128.45	69.75	148.20	58.50	298.00	113.50
November	22.4	228.15	114.55	113.45	43.00	213.00	86.00
December	26.8	288.12	143.78	92.12	29.31	176.25	89.12

Table 2: Correlation coefficient between temperature and particulate matter

Season	Temp range 0C	Sample site	SPM		PM_{10}	
			r	r^2	r	r^2
Pre Monsoon	28.4-33.2	Kantatoli	0.22	0.05	0.16	0.02
		Ashoknagar	0.74	0.54	0.97	0.95
		Tupudana	0.51	0.26	0.69	0.47
Monsoon	26.3-31.1	Kantatoli	0.95	0.90	0.94	0.88
		Ashoknagar	1.00	1.00	0.98	0.95
		Tupudana	0.97	0.95	0.89	0.80
Post Monsoon	22.4-26.8	Kantatoli	0.32	0.10	0.34	0.12
		Ashoknagar	-0.33	0.11	-0.42	0.18
		Tupudana	-0.30	0.09	0.16	0.02

CONCLUSION

The influences of temperature and relative humidity on the concentration of pollutants were evaluated for summer, pre monsoon, monsoon, and post-monsoon at three sampling stations representing commercial, residential, and industrial area using regression analysis and it was observed that both SPM and PM_{10} show positive correlation with temperature in winter, pre monsoon, and monsoon season. In post monsoon season, negative correlation was seen at residential and industrial sites, which may be due to local factors. The positive correlation indicates that the rise in temperature can accelerate the concentration of both SPM and PM_{10} in ambient air, if all other factors exhibit natural behaviour.

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